

4. Wardaman Country: Physiography and Climate Change

Wardaman Country is a region of spectacular mesas, deep and unscalable gorges, broad black soil plains and gently rolling hills and woodlands. Standing above the plains in places are red sandstone outliers, deeply weathered by time and the ravages of the tropical climate. These outcrops provide numerous overhangs, crevices and declivities that have offered shelter to people and preserved their artistic activities over thousands of years. In places among the rocky hills and gorges, and on the flood plains, water holes dot the landscape and act as loci for human and animal habitation alike in what is otherwise a hot, brown region for most of the year, and an often flooded and verdant one for the remaining few months.

This chapter presents an overview of the physiography and record of climate changes for the study region. From this a number of predictions are developed about the likely responses of human foragers to the opportunities and constraints offered by the nature and structuring of resources in the region over the last 15,000 years. These predictions are based on the principles of optimization in settlement, subsistence and technology presented in Chapter 2.

Overview of the Region

Wardaman Country is roughly 8,932km² in area and is located ~120 km southwest of Katherine. It is bordered by the Victoria River in the southwest, which drains the southern half of the region, the Flora River to the north, draining the northern and eastern areas into the Daly River, and is bordered on the eastern edge by the Sturt Plateau. This is roughly the country claimed by Wardaman Aboriginal people today as defined by Merlan (1989), and loosely represents the distribution of Wardaman speakers and the outer boundary of clan estates as it probably existed around the time of European contact in the late 19th Century (Figure 4.1).

The main access to the region today is via the Victoria River Highway, which cuts the study area approximately in half. There are no towns in this area and the closest are Katherine to the northeast and Timber Creek to west; both of which are roughly 60km from the edge of Wardaman Country.

Climate

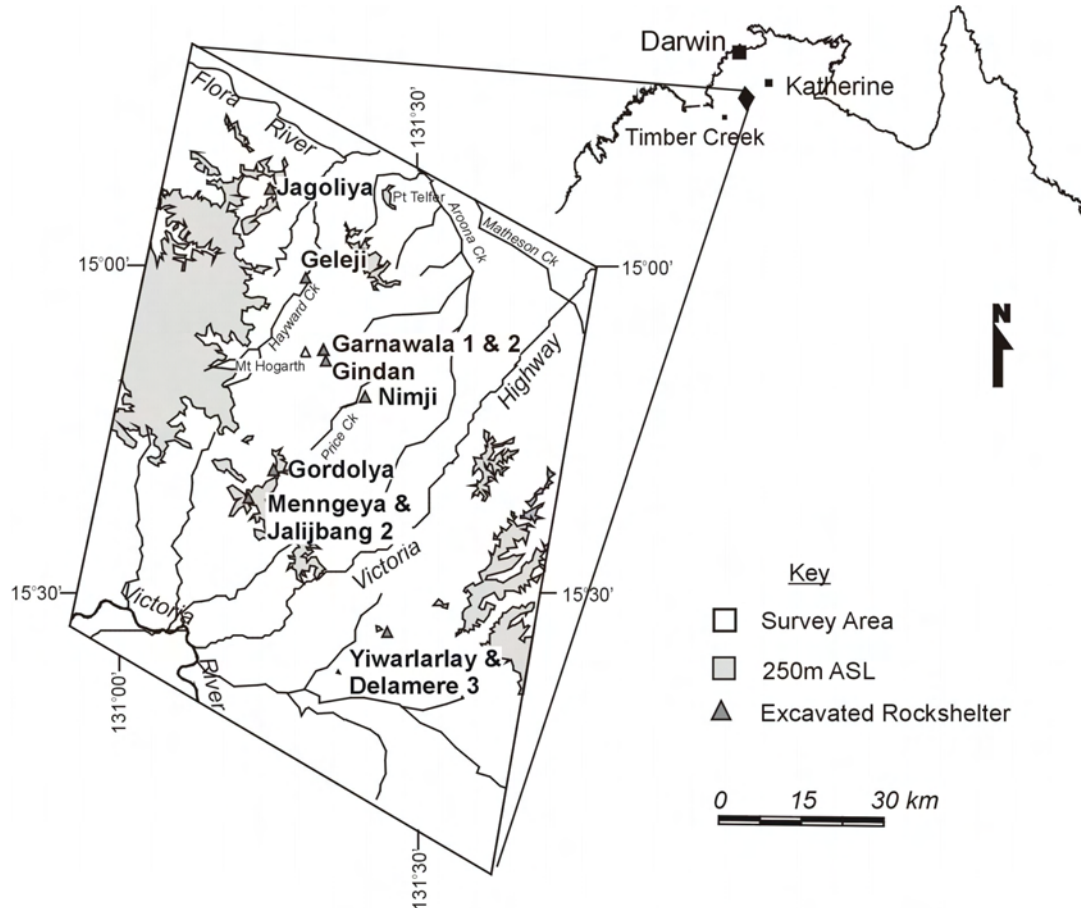
Wardaman Country has a warm dry monsoonal climate, receiving almost all of its rainfall between November and March, most of which falls in January and February. The region receives 900mm annual rainfall in the northwest and around 650mm in the southeast where rainfall becomes less intense and reliable (Sweet 1972:3), and vegetation and soils become increasingly typical of semi-arid to arid lands (Slayter 1970). Temperatures range from a mean of around 29°C in June and July, to about 38°C in November and December. Minimum temperatures range from 10°-13°C in winter to between 21°-24°C in summer. Rainfall is the primary factor effecting vegetation growth, which is generally restricted to the short wet season.

Hydrology

A dry monsoonal climate means that Wardaman Country is a parched place for most the year, but is very wet during the monsoon season, when low lying country is often inundated and waterholes and ephemeral creeks fill and overflow. During the dry season, waterholes and creeks dry up, and permanent water is generally scarce with only a few exceptions. The Flora River and northern reaches of Hayward Creek in the north, for instance, are spring fed and maintain at least a weak flow throughout the year (Figure 4.2) (Pontifex and Mendum 1972:23), while the Victoria River, although stagnant during the dry season, maintains good water supplies in long reaches throughout the driest seasons (Sweet 1972:16) (Figure 4.3). Away from major rivers, most permanent waterholes are small and are found predominantly in the western and northern portions of the region as isolated pools amongst sandstone gorges, in creek beds in rocky areas and cut into the limestone along drainage lines. Apart

from these sources, only eight large permanent waterholes exist in Wardaman Country. These are the Yingalarri (Ingaladdi), Jinginya (Johnston Waterhole), Geberung, Wynbarr (Wynbara), as well as the Hayward Hole, Geleji and two other waterholes on Hayward Creek, all of which occur at least 10km apart in sandstone country. Wardaman country is today situated in a region of very high inter-annual variability in rainfall (Dewar 2003), and one in which the predictability of rainfall may have been low for a very long time.

Figure 4.1. Location of Wardaman Country, the survey region and sites discussed in the text.



Physiography

Wardaman Country is made up of four main physiographic units that broadly characterize the geology and geomorphology of the region (Figure 4.4). These are the *Victoria River Plateaux*, *Delamere Plains and Benches*, *Sturt Plateau* and the *Daly River Basin*.

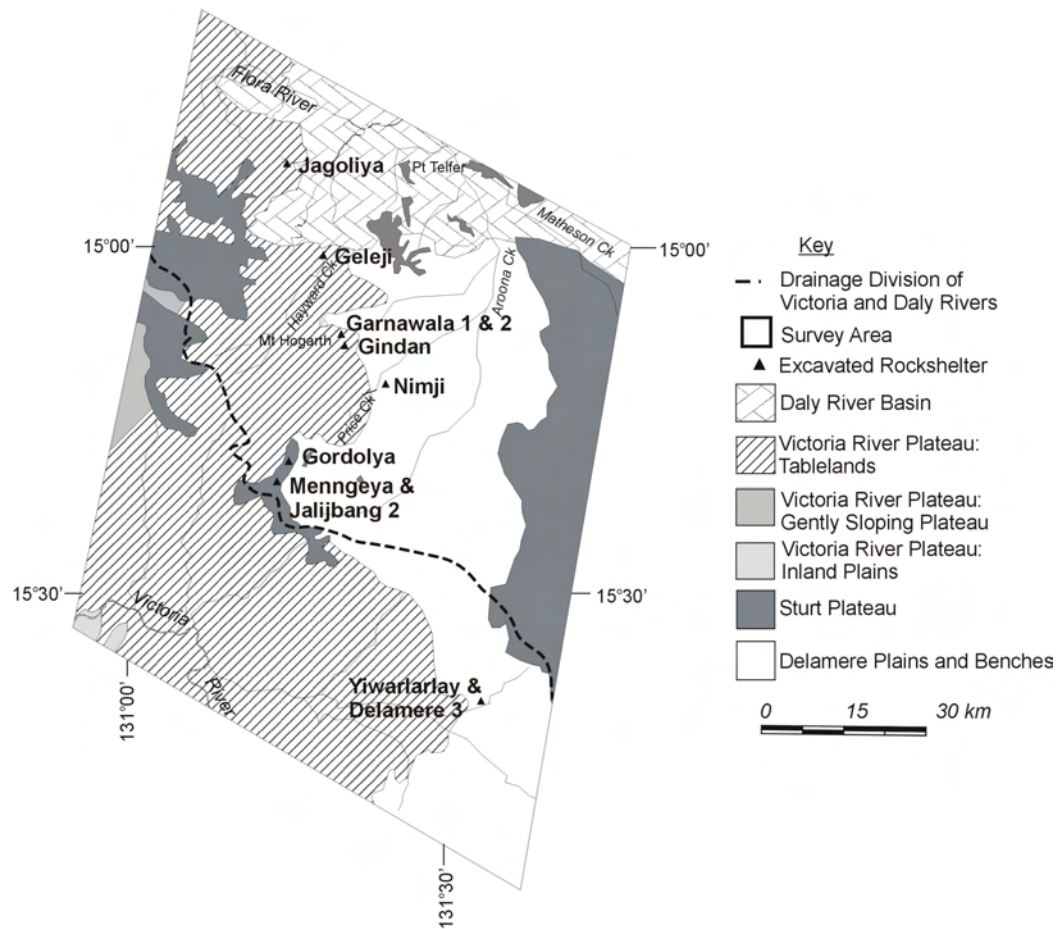
Victoria River Plateaux. This unit occurs as tablelands, inland plains and gently sloping plateau primarily along the western edge of Wardaman Country. The tablelands are 150 to 250m high and are capped by resistant Jasper Gorge Sandstone (Figure 4.5). The Victoria River and some of its tributaries are deeply incised into the tablelands in the southwest of the region and form spectacular gorges with walls up to 150m high (Sweet 1972:7). A gently sloping plateau occurs on the extreme central western margin of the region and forms an irregularly dissected scarp. Inland plains are found in the extreme southwestern corner of Wardaman Country in the Victoria River valley itself.

Figure 4.2. Permanent waterhole on the Flora River.



Figure 4.3. Large permanent waterhole along the Victoria River.



Figure 4.4. Location of the major physiographic units in Wardaman Country.

Delamere Plains and Benches. This unit is made up of plains with rounded and terraced low hills underlain by the Antrim Plateau Volcanics. This unit occurs primarily in a central band through Wardaman Country. The terraces are formed by resistant basalt and chert bands within the volcanics. Northwesterly trending ridges of aeolian origin are also formed by sandstone interbedded with the volcanics (Figure 4.6), and these are often cavernously weathered to form deep rockshelters and overhangs ideal for human habitation and the survival of rock art panels (Sweet 1972:7). Bands of quartzite often run alongside these sandstone ridges and result from contact with basalt lava flows. The weathering and disintegration of these sandstone outliers has also resulted in the formation of extensive sand sheets in some places.

Sturt Plateau. This is a laterite-covered plateau that represents the remnants of a very extensive weathered peneplain (Figure 4.7). It is preserved largely on the eastern boundary of Wardaman Country, although remnants also occur as mesas in the centre and northwest of the region.

The *Daly River Basin* is a sub-mature basin in the northern part of the region, which has been retarded by a barrier of resistant sandstone at its north-western edge, beyond Wardaman Country. Soil and alluvial sand have developed over much of the basin, and stone outcrop is scarce (Figure 4.8) (Pontifex and Mendum 1972:6).

Figure 4.5. Remnant of the Victoria River Plateau.



Figure 4.6. Northwest trending sandstone ridges of the Antrim Plateau Volcanics within the Delamere Plains and Benches.



Figure 4.7. Edge of the Sturt Plateau.



Figure 4.8. View over the Daly River Basin toward the distant hills of the Victoria River Plateau.



The Distribution and Quality of Raw Materials

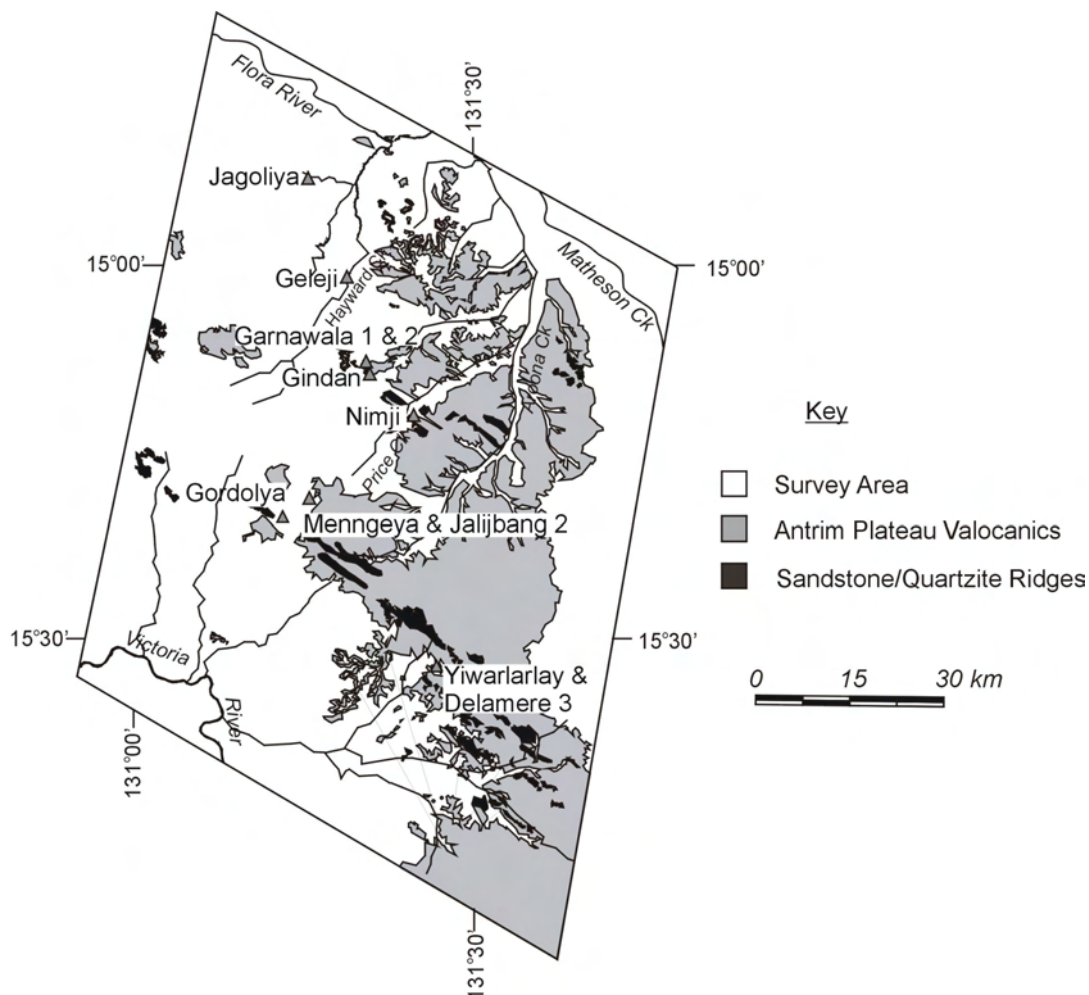
It has become axiomatic in studies of lithic technology to consider the effects that raw material distribution may have on the level of planning, transport and curation involved in maintaining a supply of stone tools where and when they are needed. In considering the human selection, transport and use of stone suited to implement manufacture, five variables are considered potentially significant. These are the location of flakable stone, nodule size, overall abundance, ease of extraction, and suitability to various forms of reduction. This section examines the 'lithic landscape' as it exists in

the study region to help identify possible discontinuities between the distribution of flakable stone and certain other critical resources.

The major forms of raw material found in Wardaman Country are quartzites from two geological formations, cherts from five limestone formations (only three of which actually outcrop in Wardaman Country), hydrothermal jasper and chalcedony, and silcrete from lateritic duricrusts.

Of these, a brown to grey coloured quartzite from the Antrim Plateau Volcanics is by far the most abundant raw material in Wardaman Country, and commonly occurs as ridges and gibbers throughout the region, particularly in association with the northwest trending sandstone formations that were likely metamorphosed into quartzite through contact with basalt flows (Figure 4.9). Bands and ridges of hydrothermal jasper and clear to milky white and yellow chalcedony sometimes occur alongside these quartzite outcrops. With the possible exception of the hydrothermal jasper, which tends to be of poor quality and small size, these sources generally provide abundant nodules, sometimes up to very large size, exhibit extremely good conchoidal fracture and are suited to most forms of reduction.

Figure 4.9. Location of the Antrim Plateau Volcanics and encapsulated sandstone ridges that are frequently associated with quartzite outcrops and gibbers.

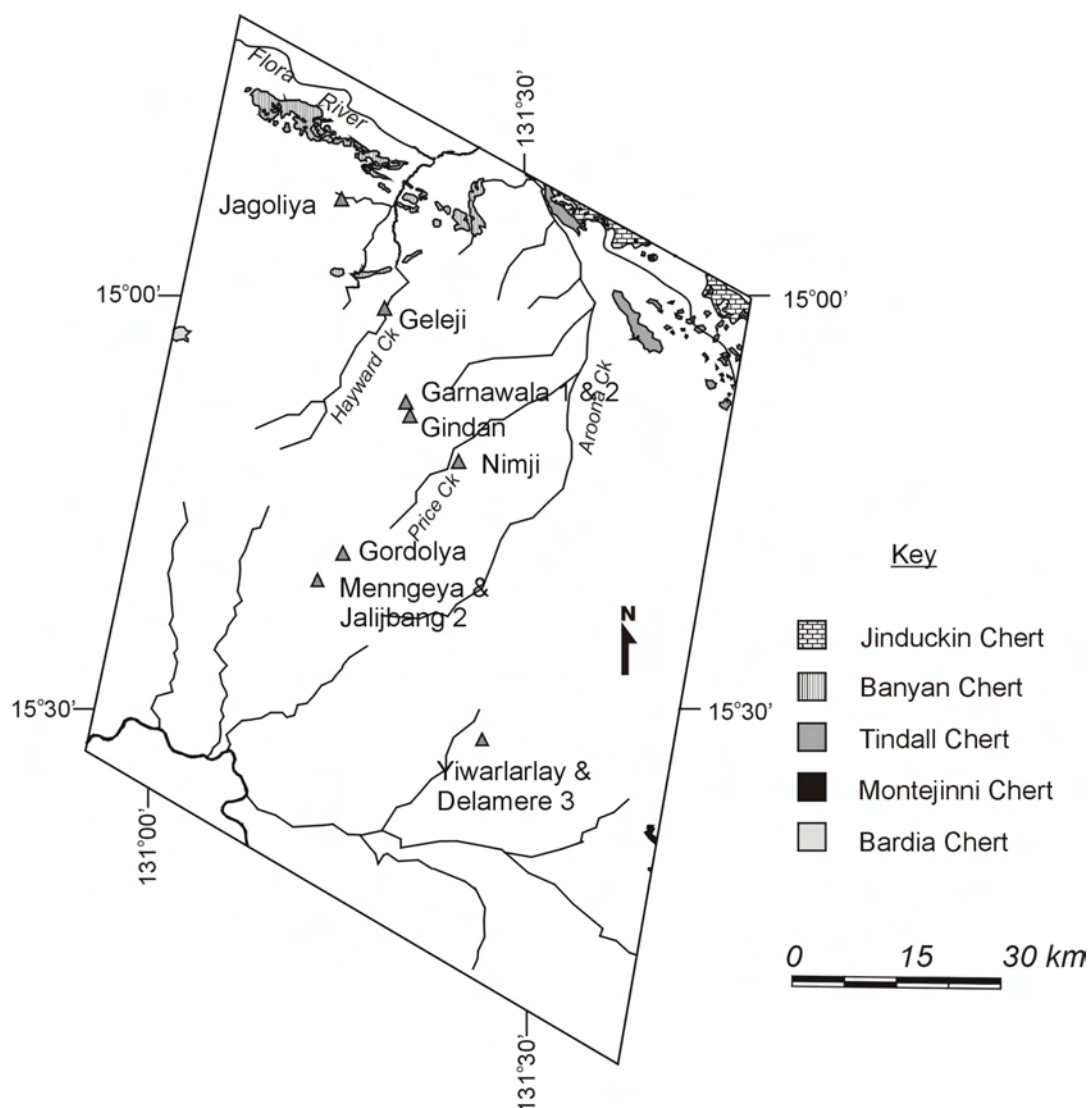


In addition to the numerous quartzite outcrops within the Antrim Plateau Volcanics, a particularly large and intensively quarried source of quartzite was located within the Jasper Gorge formation above a series of rockshelters at a place known to Wardaman people as Gongonmaya, 3.6 km southwest of Mt Hogarth. This consisted of a distinctive white quartzite with yellow and red mottles, with nodules of large size and excellent conchoidal fracture. Other sources of white quartzite likely exist in the Jasper Gorge formation, but these have not been located. The rarity of white quartzite in sites in Wardaman Country suggests that few sources of this material exist.

A number of small silcrete sources were located on the tops of laterite capped tablelands and mesas, but these do not appear to be particularly abundant. One source examined atop remnants of the Sturt Plateau in the western part of Wardaman Country revealed small amounts of a workable fine red silcrete of medium size, but requiring extensive preparation to remove a thick cortex.

Chert is particularly abundant in the Daly River Basin in terms of both the number of sources and the quantity of usable nodules that are usually of high quality and large size. Chert outcrops within the Banyan, Tindall, and Jinduckin limestones, and sometimes forms huge ridges standing tens of metres above the floodplains and stretching for several kilometers in length (Figure 4.10). A wide range of colours and cortex types are found in these chert formations, however, two distinctive and archaeologically visible forms of high quality exist. The first is a deep maroon chert, sometimes with purple or caramel veins, present in the Banyan Chert Member and outcropping as huge ridges at various points along Hayward Creek in the north of the study area. The second is a distinctive bright yellow chert from the Tindall Limestone that outcrops along Matheson Creek near the eastern edge of Wardaman Country. The differential occurrence of these materials in archaeological sites therefore acts as a guide to both the direction of travel and the relative importance of each of these sources in the past.

Figure 4.10. Map showing the location of different chert sources in Wardaman Country.



While it is ideal in a study of technological provisioning and land use for raw materials to be isolated, discrete and to some degree distant from one another, this is not always the case in Wardaman

country, as many suitable raw materials co-occur in some places (e.g. chalcedony, hydrothermal jasper and quartzite). While this complicates the study of raw material rationing and technological responses to changing raw material supply, it nevertheless provides a common and complex scenario more typical of many regions in Australia. It also provides an opportunity to examine the interplay between the selection of raw materials given different combinations of the five variables listed above (location, size, abundance, ease of extraction and suitability), under conditions of more or less abundance rather than scarcity.

The Differential Distribution of Resources in the Landscape

It is possible to also briefly consider the overall distribution and co-occurrence of various resources in the landscape. A number of discontinuities and overlaps appear to exist that are likely to have had significant implications for foraging and land use in Wardaman Country. The first, and perhaps most significant of these is a general disjunction between the location of large permanent waterholes and that of raw materials. In the southern part of the study region, for example, quartzite usually occurs at least several kilometers from the major waterholes. On the other hand, quartzite, chalcedony and jasper often outcrop where shelter is abundant. This is not so true in the north of the study area where a rich and diverse range of floral, faunal and stone resources co-occurs in the Daly River Basin with large permanent waterholes and springs being particularly common. This is a combination that would likely have favoured human habitation of this region throughout longer, hotter, dry seasons.

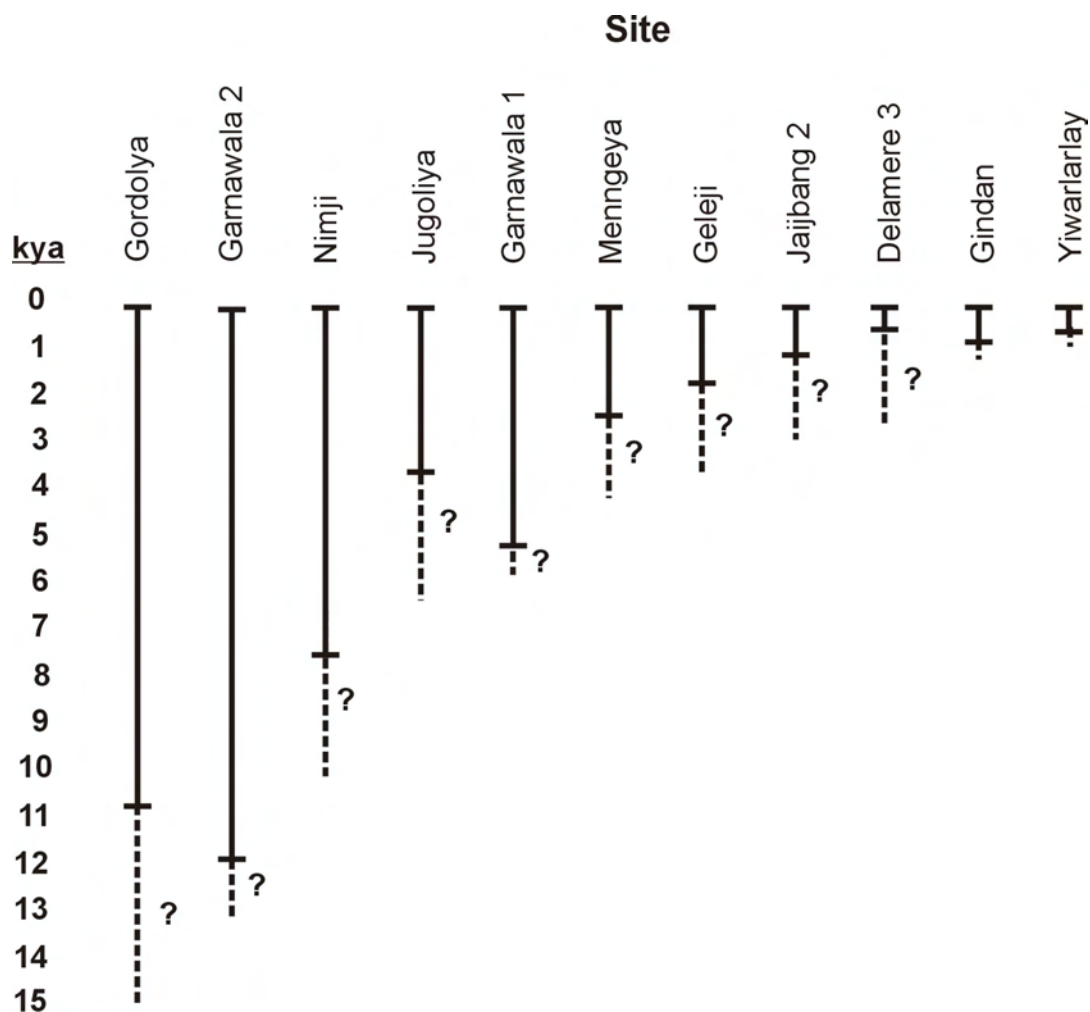
Climate Change

The Last Glacial Maximum (c. 22-17 kya) was experienced in Australia as a period of extreme aridity (De Deckker 2001:1), creating hydrological systems, vegetational communities and fluctuating climates with no modern analogue (Horton 1993; Lambeck and Chappell 2001). Aridity extended to the exposed continental shelf, with precipitation at around half that of today. This combination of factors would have created severe drought, cold and winds that led to massive dust storms and encouraged dune expansion while discouraging tree growth in many parts of Australia (Frakes *et al.* 1987). The draining of the extensive shallow water bodies in the Gulf of Carpentaria would likely have reduced the development and onshore movement of tropical cyclones bringing rain to the continental interior (Webster and Streten 1978). The LGM saw a massive outward expansion of the arid zone, with deserts literally meeting the coast in both northwestern and southern areas of Australia, as well as the northward migration of major vegetation zones in northern Australia during the LGM. Wardaman Country was then probably over 200 km further inland and likely also witnessed conditions much drier than today, with shrublands probably covering much of the landscape. With permanent water scarce in Wardaman Country even today, little water would probably have been available, even in the better watered sandstone gorges. Springs may also have dried up during the extreme aridity of the LGM, and it therefore may not be surprising that no signs of human habitation have been found in the study region during this period.

Immediately following the LGM, glacial melting took place at an irregular rate until around 7000 BP, by which time sea levels had more or less reached their present position (Lambeck and Chappell 2001). During this last marine transgression, sea levels rose very rapidly across the flat exposed continental shelves and probably resulted in drowning landscapes such as the Arafura plain (between northern Australia and New Guinea) at a lateral rate of up to a metre a week (Mulvaney and Kamminga 1999:121).

The late glacial period was one of rapid environmental change, including marked climatic reversals that saw the onset of very tropical conditions in some areas between 15,000 and 11,500 BP, and a rapid swing back toward full glacial conditions during the Younger Dryas between c. 10,800 and 10,200 radiocarbon years ago (centered on around 11,530 Cal BP) (Adams *et al.* 1999; Kershaw 1995). Although no firm radiocarbon dates are yet available for human occupation in Wardaman Country before c. 10,000 BP, extrapolation of age estimates to basal occupation of some sites suggests that people were moving into the region sometime around c. 15,000 years ago, presumably as the climate ameliorated (Figure 4.11).

Figure 4.11. Calibrated radiocarbon ages (solid line) for each of the excavated sites in the region based on the lowest date, as well as the estimated basal age (dashed line) of each site determined using linear regression.



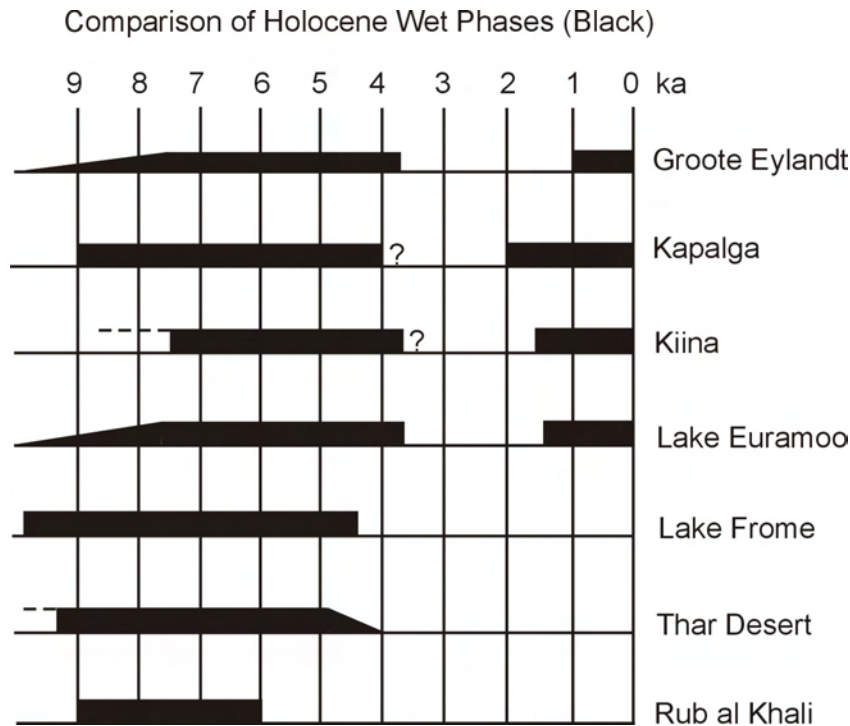
The Pleistocene-Holocene boundary was a time of rapid climatic amelioration marked by an increase in lake water levels in northern Australia and the southward movement of vegetative communities to their present position (Kershaw 1995).

Generally, the early Holocene in Australia is characterized as a period of increased precipitation (i.e. up to 50% wetter in northern Australia than in modern times), with an early to mid-Holocene optimum (that is, somewhere between 8,000 and 5,000 BP depending on exact location) of warmer and wetter conditions (Gagan *et al.* 1994; Kershaw 1983, 1995; Kershaw and Nix 1989; McGlone *et al.* 1992; Nix and Kalma 1972) with reduced interannual variability (Chappell 2001:177).

The middle to late Holocene is thought to have been a period of increasing aridity, although exactly when the onset of increased aridity occurs is not well documented and appears to vary with location. A number of studies point to a later onset of peak Holocene aridity in northern Australia than that found in more southern latitudes (McGlone *et al.* 1992; Schulmeister and Lees 1995) (Figure 4.12). For example, studies of north coastal cheniers are interpreted as indicating decreased wet season precipitation from 2,800 to 1,600 BP (Lees 1992a, b; Lees *et al.* 1990; Lees *et al.* 1992), whereas records of terrestrial floods from waterfalls in three locations in northern Australia spanning the last 30,000 years indicate extreme flood magnitudes between c. 8,000 and ~3,600 years ago, followed by floods of considerably smaller magnitude in the last 2,000 to 3,000 years (more recent deposits exhibited disturbance) (Nott and Price 1999). A pollen record from Groote Eylandt indicates a marked decline

in precipitation between 4,000 and 3,500 BP, with increased rainfall during the last thousand years (Schulmeister and Lees 1992).

Figure 4.12. The timing of major wet and dry phases for several regions of Australia and other selected locations during the Holocene (from Schulmeister and Lees 1995).



These general trends toward increased aridity in the mid-Holocene are supported by records of flood deposits in the Kimberley (Gillieson *et al.* 1991) and by other indicators such as $\delta^{18}\text{O}$ records extracted from coral, foraminifera, varve, lake and sea bottom sediments from sites in Australian and the circum-Pacific region (Brookfield and Allan 1989; Hope and Golson 1995; Kershaw 1995; Koutavas *et al.* 2002; McCarthy and Head 2001; McGlone *et al.* 1992; McPhail and Hope 1985; Rodbell *et al.* 1999; Singh and Luly 1991).

Climatic Variability

Within these longer-term trends, the El Niño/Southern Oscillation (ENSO) phenomenon has exerted a strong influence on climatic patterns in tropical and eastern Australia for some time, although exactly how long and to what degree is the subject of ongoing research (Jones *et al.* 1999; McGlone *et al.* 1992; Schulmeister and Lees 1992). Today, ENSO constitutes the largest single source of interannual climatic variability on a global scale, especially within the dynamical core of the Indo-Pacific region (Allan *et al.* 1996; Diaz and Markgraf 1992; Glantz 1991; Glantz *et al.* 1991; Rowland 1999a). In recent times, ENSO events have had wide-ranging and often severe impacts on terrestrial and marine ecosystems. The worst of these (for example the 1957-8, 1972-3, 1982-3, 1987-88 and 1997-8 events) have caused considerable economic hardship and many fatalities through increased periods of drought, frosts, bushfires, cyclones, high temperatures, severe winds and storms (Allan *et al.* 1996; Anderson *et al.* 2006; Bourke 1998; Glantz 1996; Glantz *et al.* 1991).

The term ENSO refers to inter-annual reversals in ocean-atmosphere interactions of the Walker Circulation system that operates in the Indo-Pacific basin (Allan *et al.* 1996; Enfield 1989; Trenberth and Hoar 1996; Webster and Palmer 1997). ENSO embraces two distinct phases that tend to oscillate between two extremes - El Niño and La Niña - and occurs as a consequence of 'see-saw-like' reversals in sea-level pressure, ocean currents, sea surface temperatures and trade winds between the southeastern tropical Pacific and the Australian-Indonesian region (Diaz and Markgraf 1992). The state of the system

is typically monitored by the Southern Oscillation Index (SOI), which is the ratio of sea-level pressures between Tahiti and Darwin.

During El Niño events there is a weakening of sea-level pressure in the southeastern tropical Pacific, accompanied by a decrease in the strength of trade winds. This results in a weakening of the cool oceanic upwelling along the western coast of South America, in turn causing sea-surface temperatures to rise. Warmer sea surface temperatures give rise to increased evaporation and heating of the troposphere, resulting in increased convection and rainfall over the coast of Ecuador and Peru, over parts of the Andean cordillera, and to a lesser extent, the southern United States and central Chile (Allan *et al.* 1996; Diaz and Markgraf 1992; Enfield 1992). El Niño events result in bringing drought to many parts of Australia, southern Africa, northern India, Sahelian Africa, Indonesia and South-East Asia (Allan *et al.* 1996:22; Enfield 1992:97).

In contrast, La Niña events represent an intensification of the 'normal' ocean-atmosphere circulation pattern, and have impacts that are generally opposite to those of El Niño (Allan *et al.* 1996:22).

The structure and duration of ENSO events are highly variable (and no two events are exactly alike), but El Niño phases typically last between 12-18 months and tend to recur every 3-7 years. Quasi-cyclical changes in intensity at decadal and greater time-scales have also been noted (Anderson 1992; Kerr 1998, 1999; Trenberth and Hoar 1996).

Based on a review of long-term palaeoenvironmental proxy climate indicators, McGlone *et al.* (1992) have suggested that the ENSO phenomenon may have intensified in the last 5,000 years. Shulmeister and Lees (1995) also argue for the onset of Walker Circulation dominated climate with ENSO-scale variability embedded in the system after c. 4,000 BP. Records for variability in $\delta^{18}\text{O}$ isotopes linked to ENSO events also come from annually banded corals from Papua New Guinea, and point to greater variance in amplitude and more extreme ENSO events in the modern period and between 2 and 3,000 years ago. Although there are large gaps in this record (with short interannual sequences only available for seven distinct time periods: 130 ka, 112 ka, 85 ka, 38-42 ka, 6.5 ka, 2-3 ka and modern), later events show significantly greater amplitude in ENSO events than those recorded for the short interannual record dating to c. 6,500 years ago (Tudhope *et al.* 2001). In general, the onset of modern ENSO periodicities is identified by palaeo-ENSO records throughout the tropical Pacific region 5,000 years ago, with an abrupt increase in ENSO magnitude 3,000 years ago (Gagan *et al.* 2004). Evidence also exists from a number of locations world-wide for increased ENSO driven climatic variability from the mid-Holocene onwards (Andrus *et al.* 2002; Koutavas *et al.* 2002; Rodbell *et al.* 1999), with evidence that impacts of mid- to late Holocene climatic oscillations may have been far greater than any events recorded in the late-historical period (Ely *et al.* 1993; Graumlich 1993; Hughes and Brown 1992; Knox 1993; Rowland 1999a, b). ENSO-related climatic oscillations no doubt had significant impacts on prehistoric human groups through their effects on the long and short-term availability, stability and structuring of economic resources.

Implications of ENSO-Driven Variability for the Study Region

In Wardaman Country, it can be envisaged that the availability and predictability of surface water would have increased considerably during the early Holocene, that fringing communities and vine thickets may have expanded outward from their present refuges in deep gorges and around permanent waterholes, and that aquatic animals and vegetation might have radiated outward from now permanent waterholes to those that are ephemeral today. This may have created a greater diversity of plant and animal communities throughout Wardaman Country than is present in drier areas today, but may also have resulted in the introduction of new taxa, such as monsoon forest communities, into Wardaman Country which are absent today.

Palaeoclimatic reconstructions for this region are extremely rare, as pollen and macrobotanic remains rarely survive in tropical soils. However, phytolith sequences spanning up to the last 15,000 years from three rockshelter located in Wardaman Country (Jagoliya, Gordolya and Nimji) suggest that wet adapted species and palms were common in this location before 3,500 years ago when they disappeared from the record and were replaced by grasses as the dominant local vegetation (Clarkson and Wallis

2003). A distinct wet phase is also registered at c. 5-7,000 BP and again at about 1,500 BP, with a distinct dry phase between these two periods (Bowdery 2005). This sequence lends credence to the argument that Wardaman Country was wetter and supported a more diverse range of taxa in the early and late Holocene than are presently found in the region.

The onset of ENSO driven inter-annual climatic variability at around 3,500 years ago in northern Australia, while not bringing about changes of the same magnitude as those witnessed during the LGM, could still have significantly altered the location and structuring of resources in Wardaman Country, with plants and animals perhaps having to endure severe droughts followed by severe floods in quick succession. The recent Katherine floods in 1996 showed how catastrophic such isolated, super-monsoons can be for the ecology and inhabitants of the region, and there is evidence that floods of this scale have occurred frequently in the past (Nott and Price 1999). This intensified regime, which probably lasted for another two thousand years or so, may well have transformed the region into its present form, and would likely have dramatically reduced the predictability of resource distribution and abundance from year to year, as game followed patchy rainfall and migrated to better watered areas (Ramp and Coulson 2002), waterholes dried up, plant foods failed to produce and aquatic animals perished or retracted to more permanent water sources, only to be reversed several years later. Variation on this scale would likely have triggered significant responses from humans, flora and fauna, with alterations to the range and abundance of plants and animals, and the rapid emergence of risk reduction strategies by people forced to cope with massive uncertainty in both the economic and social spheres of life, as food supplies waxed and waned and demographic adjustments took place. As climatic variability eased back toward that of the modern period, such risk management strategies may also have diminished in importance, or they may have transformed into significantly different socio-demographic entities. These issues will be explored at length later in this work.

Thus humans occupying the study region after 15,000 years ago would have experienced a colder, drier landscape than today, with marked fluctuations between cold and dry and tropical conditions between 15,000 BP and 10,000 BP. By 7,000-5,000 years ago, conditions were markedly improved, and people would have experienced a wet, stable climate that is probably otherwise relatively unparalleled for the duration of human occupation of the continent. Between c. 3,500 and 2,000 BP, conditions appear to have deteriorated again with the onset of intensified ENSO conditions, with pronounced interannual fluctuations in effective precipitation. The period registers as an arid phase overall, but interannual variation is likely to have been higher at this time than any other in the Holocene, with pronounced droughts resulting from failure of the summer monsoon likely followed by severe floods. By c. 1,500 years ago, climatic conditions appear to have relaxed back toward those of the present day, with interannual variation remaining a strong feature, but with much less severe fluctuations than those experienced previously.

Based on this review of climate and geography, it is possible to make a number of predictions about the likely effects of climatic change on human land use and provisioning over this period:

- The late Pleistocene/early Holocene period is likely to have seen low population densities as humans colonized the study region, possibly for the first time. We should expect high residential mobility during this period as people became familiar with local resources and maintained contact with homeland populations as a means of social storage to buffer against risk, and to find mates (MacDonald 1998). Overall environmental productivity is likely to have been lower than today, perhaps encouraging more mobile foraging regimes to counter frequent resource depression. Large oscillations between cold/dry and warm/humid may have introduced significant subsistence risk (although not if these shifts were gradual and stable within given periods). High mobility and less predictable resource availability might be expected to show up as a tendency toward low diversity individual provisioning.
- The mid-Holocene optimum at around 7,000 BP likely increased local productivity above and beyond that experienced at any time previously, and we might expect populations to have increased at this time, with higher encounter rates with high ranked resources and more predictable subsistence schedules. Mobility would also likely have reduced as local patches became more

productive and resource locations more stable. Increases in assemblage size and density and a shift toward place provisioning are expected at this time.

- The onset of ENSO conditions after 5,000 BP, and reaching their peak intensity between c. 3,500-2,000 BP, would likely have created a situation of high subsistence risk. Pronounced interannual variation would have increased the patchiness of the environment, caused higher mobility in large, high-ranked prey as water availability fluctuated, and caused resource depression during periods of prolonged drought. A decline in the human population might be expected under such conditions. Increased mobility and decreased predictability in the scheduling of subsistence activities would likely have caused a shift from place provisioning toward high diversity individual provisioning, with emphasis placed on technological strategies aimed at risk reduction and utility increase.
- Improved conditions by c. 1,500 BP would likely have alleviated some of the stress on subsistence, and although high residential mobility and the use of risk reduction strategies would probably have remained in place due to the continuation of climatic variability, conditions may have improved to the extent that populations increased again and subsistence activities could take on semi-predictable schedules.

These predictions can be tested by examining the sequence of technological changes in dated, stratified sites from the region described in the following chapter, and by examining changes in the specific technological correlates of mobility, risk and the degree of predictability in scheduling subsistence activities discussed in Chapter 2. This analysis will be undertaken in Chapter 6.

Conclusion

Wardaman Country is a rugged, hot, dry region with low overall rainfall that is highly seasonal. The structuring of most of its economic resources is strongly controlled by underlying geology and geomorphology. These factors create a range of constraints and opportunities for foragers inhabiting this region in the past. The inferred fluctuations in resource availability since the terminal Pleistocene help identify reasons why Wardaman Country was perhaps left unoccupied before about 15,000 years ago, as well as the constraints and opportunities placed on human occupation since that time. A sequence of changes in technologies is proposed that maps on to fluctuations in climate since the terminal Pleistocene on demography, subsistence and settlement patterns.