1 INTRODUCTION

In a series of papers between 1971 and 1977 three fundamental questions for archaeological research in the arid zone were defined (Golson 1971; Mabbutt 1971; Gould 1971, 1977; Allen 1972, 1974; Bowler 1976; Bowdler 1977). These concern the timing of human dispersal and colonisation in the region, the adaptations that were necessary for this to take place and the subsequent maintenance of human groups in a marginal environment. More specifically these studies posed the following questions. Was the arid interior of the Australian landmass settled as part of an initial dispersal of humans into the continent from the Indo-Malaysian region; or did the aridity of the region pose particular problems for these early human groups? To what extent did the ability to use the new plant resources of the region, such as grass and acacia seeds, affect the timing of initial settlement; and what was the role of these resources in the ecology of subsequent settlement? Can we identify an ebb and flow of population across the region in response to the climatic pulses that periodically reactivated its fossil river systems and lakes; or was settlement of the region stable and narrowly circumscribed by the limited opportunities of a desert environment?

These are basic questions about the human biogeography of the Australian arid zone. But they are of more than just regional importance as the arid zone encompasses nearly 60% of the

Australian landmass. As Jones (1987:666) has succinctly put it, having mastered the capacity to cross water, the true barrier to the colonisation of the Australian continent lay not in the occupation of the tropical north but in the ability to establish and maintain human settlement in the arid country to the south.

Both Gould (1971, 1977) and Bowdler (1977) framed answers to some of these questions. Together their respective theories provide a rather elegant account of desert prehistory. Bowdler's view was that the first human movements into the arid zone took place as late as 10-12,000 yrs BP and she noted that this neatly intermeshed with Gould's account of a distinctive desert culture, already in place by 10,000 yrs BP and stable throughout the Holocene. Mabbutt (1971) and Bowler (1976) provide quite a different perspective. Bowler assumed that colonisation of the continental interior would have taken place before the last glacial maximum, at a time when the wetter conditions of the lacustral phase offset any problems that might have been posed by aridity. Given a palaeoenvironmental record showing periodic intensification and relaxation of arid conditions both Mabbutt (1971) and Bowler (1976) argued that there would have been significant fluctuations in population density in the arid zone and also changes in the distribution of the human population about the better watered ranges and riverine tracts.

One result of Bowdler's influential 1977 paper was to direct further fieldwork towards the search for evidence of Pleistocene settlement in the arid zone. Apart from the work presented in this thesis the most systematic pursuit of this question has been by Lampert and Hughes in the southeastern part of the arid zone (Hughes and Lampert 1980; Lampert and Hughes 1980, 1987; Lampert

1985). However concern with the timing of settlement has also drawn attention away from the other items on the research agenda, notably the development of an economy focussed upon the intensive use of wild seeds, and the question, initially raised by Gould (1971), of long term cultural stability in the desert.

An empirical foothold on these issues has been hindered by the practical difficulties attached to fieldwork in the region. Foremost amongst these is the difficulty of establishing a chronological framework in circumstances where material for radiocarbon dating is often absent, where the stone artefacts show broad technological continuity and where stratified archaeological deposits are rarely found.

When I began my fieldwork in 1982 the Central Australian ranges were widely regarded as having the best prospects for investigating some of these research questions. The ranges consist of a comparatively well watered upland isolated in the centre of the arid zone. They were known to have supported relatively high ethnohistoric population densities and they could be presumed to have been remote from the complicating effects of events on the periphery of the arid zone.

As it turns out, the results of my research bear on all three aspects of desert prehistory. I will present evidence to show that the central part of the arid zone was occupied by 20,000 yrs BP and to show that the subsequent settlement has not been as stable as portrayed by Gould (1977) in his Desert Culture model. In particular, there is evidence for a substantial increase in population at about 1400-600 yrs BP. In the published papers that support this thesis I also present my research into the antiquity of seed-gathering economies. I argue that they are a late Holocene development unconnected with the first human moves into the desert.

Some comments on the structure of the thesis are warranted. Chapter 2 reviews the various ideas about desert prehistory in more detail and looks at the processes that may have operated to bring about changes in the economy and population density of human groups occupying the arid zone. The core of the thesis is essentially made up of a series of excavation reports - in chapters 4-9 - presenting details of the stratigraphy, chronology and sequence of occupation at 16 sites - 10 of which I excavated under the aegis of this project. These chapters have a common format and focus upon changes in site use. I have also set out to summarise what I have been able to learn of the cultural landscape surrounding the excavated sites as this is important for understanding the significance of these changes. Chapter 3 is the key to using the excavation reports. In it I have set out my rationale for the analysis and have described the methods used in the fieldwork. It also includes a description of the research area and the environmental setting of the sites. In the final chapter I have set out to integrate the Central Australian sequence with the archaeological evidence presently available from other parts of the arid zone.

2 A REVIEW OF THEORIES AND PROCESSES

In 1984 Tjapaltjarri walked out of the Gibson desert. With a small group of relatives he had been marooned by the progressive depopulation of the area and isolated from other people for more than twenty years - in fact for most of his life. His aunts sent him south, with his brother, after they noticed a more consistent pattern in the smokes in that direction, indicating the presence of other people. These fires were set by Pintupi people moving out in 1984 to establish outstations west of the Kintore range, reoccupying country they had left in the 1960's. As it turns out, the people Tjapaltjarri met for the first time were his relatives.

There must have been many such events. Tjapaltjarri's story reflects some of the processes that I will argue have shaped desert prehistory. In this chapter I will begin by outlining the changes in environment that have taken place in the arid zone over the probable timespan of human occupation. Then I will examine various ideas about the processes acting upon human groups in the region with the aim of constructing a model of desert prehistory which can be tested against the archaeological evidence presented in the chapters that follow.

Overleaf **Figure 2.1 :** The northern margin of the Simpson dunefield showing widely spaced, parallel sandridges covered with *Triodia basedowii*, with scattered low trees and shrubs in the swales. Viewed from an altitude of 155 m near Lake Caroline. September 1984.

BACKGROUND

The Australian arid zone.

Mabbutt (1971), (1977); Gentilli (1972); Beard (1981); Jennings (1968); Morton (1986).

The arid zone occupies the centre and west of the Australian continent between latitude 20°S and 33°S. It encompasses an area of 4,600,000 km^2, nearly 60% of the Australian landmass. Its boundaries are ill-defined but those drawn by Gentilli (1972), from both annual rainfall and temperature data, align closely with the vegetation boundaries set out in Jessop (1981) and therefore appear to represent the natural boundaries of the region (these boundaries are shown in fig. 3.1 ~~3.5~~). Prior to European contact, this region was occupied by small numbers of Aboriginal people, scattered in household groups. Berndt (1959 cited in Gould 1969) estimates that the pre-contact population of the Western desert was 10-18,000 people. For Central Australia a figure of 10-12,000 people seems probable - see the estimated population densities given for various areas by Strehlow (1965), (1970); Layton (1983); Yengoyan (1968); O'Connell et al (1981); Long (1971); and Meggitt (1962).

The aridity of the region is a product of the large scale subsidence of stable air in low latitudes. This leads to low precipitation, low humidity and clear cloudless skies. This trend is reinforced by the region's remoteness from maritime influences and the absence of major mountain ranges. Under the present climate, mean annual rainfall is less than 250-350 mm and is highly variable - about 10% more variable than the world average for places with the same annual rainfall (Morton 1986:125). Some of this variability is the result of what Mandlebrot and Wallis (1968) picturesquely call the "Noah and Joseph effects", that is, unusual runs of both above and below long-term average rainfall together with isolated extreme events.

The driest part of the continent - dubbed by Gregory (1906) the "dead heart" of Australia - centres on Lake Eyre and the Simpson desert. These areas have less than 120 mm mean annual rainfall. To the north and east there is a belt of ~~predominately~~ predominantly summer rainfall deriving from incursions of the northern monsoonal system. This is the area where rainfall intensity and reliability are greatest.

These climatic controls favour grasslands in the north, and low woodlands and shrub-steppe in the south. The former include sclerophyllous hummock grasses such as spinifex (*Triodia* and *Plectrachne*) and perennial bunch grasses such as mitchell grass (*Astrebla*) or neverfail (*Eragrostis*). The low woodlands are composed of acacias, particularly mulga (*Acacia aneura*) whilst the shrub-steppe is composed of chenopods, mainly bluebush (*Maireana*) or saltbush (*Atriplex*). Throughout the region ephemeral sandy river channels support larger trees such as red gum (*Eucalyptus camaldulensis*), and floodplains or ephemeral swamps support coolibah (*E. microtheca*).

Structurally the arid zone is composed of two units: a) the shield desert, a region of uniformly low relief and uncoordinated drainage formed on a fragment of ancient Gondwanaland, and b) the central lowlands, a younger, low lying region with an extensive internal drainage network emptying into Lake Eyre. Superimposed on these landscapes is the huge anticyclonic swirl of longitudinal desert dunes (Jennings 1968), part of which forms the Simpson and Strzelecki dunefields (see fig. 2.1). Within the arid zone there are also ranges and uplands set island-like in broad sandplains or surrounded by dunefields. The most important of these are the Central Australian ranges and the Pilbara - both of which lie isolated within the region - and the Flinders ranges - which project into the arid zone from better watered country to the south. The uplands and the riverine corridors constitute the most favourable habitats for human settlement in the desert.

Palaeoenvironments.

Bowler _et al_ (1976); Thom and Wasson (1982); Chappell and Grindrod (1983); Bowler and Wasson (1984).

In order to construct a model of desert prehistory sufficiently detailed to derive specific archaeological predictions it is necessary here to look at the changes in palaeoenvironments in commensurate detail.

Lacustral phase

The _lacustral phase_ was a long period lasting from about 50,000 yrs BP to 25,000 yrs BP during which lakes in southern Australia held significantly larger bodies of freshwater. Dated sequences mainly come from southern and eastern Australia - see Bowler (1971) for the Willandra lakes and Bowler and Wasson (1984) for Lake Frome - but similar events took place in the monsoonal rainfall zone - in particular at Lake Gregory, Lake Woods and Lake Eyre (Bowler and Wasson 1984). The climate during this phase was marked by:

(a) an increase in summer rainfall (sufficient to have maintained Lake Eyre as a deep and relatively freshwater body).

(b) an increase in runoff from the southern highlands and the Flinders ranges.

(c) and, towards the end of this period, high saline water tables.

The actual climatic system that produced higher discharge in both summer and winter rainfall regions has not been reconstructed. In the Flinders ranges, Williams (1973) saw it as a cold dry period with bare unvegetated slopes, occasionally high intensity rainfall and associated flash-flooding, and local marshy areas. This phase is one in which the constraint of water as a determinant of settlement in the interior of the continent may have been considerably relaxed. However, lower temperatures in the south may have restricted the availability of important plant food species.

Last glacial maximum

From about 25,000 yrs BP the lacustral phase gave way to a cold, dry, windy period, peaking at 18,000 yrs BP, in which the great anti-clockwise swirl of dunes that dominates the heart of the continent was formed or expanded. By 16,000 yrs BP the lakes were dry. The formation of the dunefields continued until about 13,000 yrs BP in the Strzelecki and Simpson dunefields (Wasson 1983, 1984). The likely parameters of climates during this phase were:

(a) a minimum increase of windiness (expressed as a percentage of days experiencing winds above the sand moving threshold) by 20-30%. As a consequence rates of evaporation were significantly higher - sufficiently so to promote dry conditions even given the lower temperatures.

(b) rainfall was reduced by about half.

(c) mean annual temperatures were reduced by about 7° C.

(d) increased seasonal and diurnal contrasts (see Nix and Kalma 1972:85-6) and a shortened growing period due to frosty winters and hot dry summers.

(e) an expansion of the arid zone, at least on the southern side (see Bowden 1983; Beard 1982) and probably also on the northern side (see Jennings ~~1974~~ 1975).

(f) in places saline groundwater outcropped at least seasonally (Wasson 1983:192-3) assisting the formation of clay dunes.

Bowler and Wasson summarise their interpretation as follows;

> Whilst the summers were hot, dry and windy, the northerly migration of the high pressure belts in winter would have permitted cold Antarctic and Southern Ocean air masses to penetrate deeply into the continental interior, increasing the incidence of frosts and solid precipitation on uplands ...the growing season would have been considerably shortened by increased frost incidence in spring and by the onset of conditions of severe water stress in summer... (1984:204-205)

Under these conditions the distribution and reliability of water sources would have been drastically reduced. Saline groundwater would have posed additional problems. Plant foods would have been reduced to a few hardy species.

One might imagine a barren landscape but this scenario needs to be tempered with appropriate botanical information. For instance, the continued survival of relict species of cycads (*Macrozamia macdonnellii*) and palms (*Livistona mariae*) - restricted today to an area of about 60 km^2 in the Central Australian ranges (Latz 1975) - indicates that well-watered niches did persist in parts of the Central Australian ranges throughout this period (Jessop 1981). Similarly, Buckley (1982) examined phytogeographic evidence in an attempt to reconstruct Central Australian sand-ridge flora at 18,000 yrs BP and concluded that hummock-grasses such as *Triodia* and trees such as *Acacia aneura* were likely to have maintained their distributions across the region. Other plants, including perennial grasses and eucalypts, are likely to have survived on the margins of the continental dunefields.

Early Holocene

These arid conditions peaked at 18,000 yrs BP and thereafter the climate progressively ameliorated. Any interpretation of subsequent palaeoenvironments, especially during the Holocene, is complicated by a change in scale, both in terms of the smaller amplitude of the environmental fluctuations, perhaps of regional rather than global significance, and in the finer chronological resolution available for this period. The process was not a simple switch to a warmer and wetter climate in the early Holocene but a series of oscillations with optimal conditions reached about 6000-7000 yrs BP. The change is shown in the record of lake level fluctuations for temperate southeastern Australia - see for example Lake Keilambete (Bowler 1981) - and in changes to the distribution of karri (Eucalyptus diversicolor) forest in temperate southwestern Australia (Churchill 1968). In the southern part of the arid zone there is corroborative evidence for a moist landscape with the deposition of a piedmont plain at Belarabon from 6500-4500 yrs BP (Wasson 1976), the aggradation of the Mundi Mundi alluvial fans between 6500-3000 yrs BP (Wasson 1979), the formation of the Nacoona palaeosol in the Flinders ranges at this time (Williams 1973; Bowler et al 1976:383), and high water levels in Hawker Lagoon, an otherwise ephemeral swamp (Lampert and Hughes 1987).

The best evidence for contemporaneous changes in summer rainfall regions is from Lake Eyre and Lake Frome. Ancient shorelines show that these now dry salt-lakes contained substantial bodies of water between 13,000-6,000 years BP (Wasson pers. comm.). A pollen core from Lake Frome (Singh 1981) shows fluctuating wetter and drier phases from 10,000 to 7000 yrs BP and then warmer and wetter conditions maintained between 7000-4000 yrs BP. Corroborative evidence from the humid tropics, from crater lakes on Atherton tableland, shows an expansion of rainforest species between 9500 and 6000 yrs BP (Kershaw 1975).

Estimates of the magnitude of these changes in the arid zone are unavailable. For the Atherton Tableland Kershaw (1983:100-1) estimated an increase of rainfall by 50 percent. Nix and Kalma (1972:86-87) in their climatic simulation postulated a similar increase in precipitation, with evaporation at present values and mean air temperatures 1°C higher than present. The net result was an increase in surplus water of 30-40%. On these estimates the early Holocene is again a period when any constraints on human settlement, imposed by availability of water in the arid zone, would have been relaxed. As temperatures were higher than in the lacustral phase it is likely to have been a period favouring the growth of important plant food species. On these criteria the early Holocene is the optimal period for human settlement in the arid zone.

Late Holocene

From about 4000-5000 yrs BP palaeoenvironmental sequences show a progressively drier climate peaking at about 3000 yrs BP. For instance, in the southern part of the arid zone, dunes were active at Belarabon between 4500-2500 and 640 yrs BP (Wasson 1976) and the Mundi Mundi fans were dissected between 3000 and 850 yrs BP (1979).

This change is also reflected in summer rainfall regions. For instance, from 4200 yrs BP the Lake Frome pollen sequence (Singh 1981) shows a long dry period and near Alice Springs the aggradation of alluvial fans ceased shortly after 5300 yrs BP (Williams 1973:121). Wasson (1983:193) also notes that a late Holocene phase of reworking appears to have affected both pale and red-brown dunes in the Strzelecki dunefield. Similar changes are reflected further afield, in northwestern Australia, where the mangrove forest of 7500-6000 BP was replaced by short trees of narrower girth able to tolerate lower rainfall and a longer dry season (Jennings 1975). In the Great Sandy Desert, however, preliminary studies by Wyrwoll et al (1986) indicate that regional watertables have not been significantly depressed since the early Holocene though the distribution of Typha domingensis in the pollen profile of Dragon Tree Soak suggests some change in swamp conditions in mid to late Holocene times.

These changes appear to have been on a much smaller scale than the Pleistocene oscillations and conditions during the late Holocene are unlikely to have been as stressful for human populations. The overall impression of changes during this period is that they were changes in variability, that is in the frequency with which extreme events, whether floods or droughts, occurred. For instance, Wasson (1984) has suggested that the perturbing effects of extreme events, such as droughts or fires were sufficient to allow incremental dune accumulation during the late Holocene especially when the recovery times of vegetation had increased because of decreased rainfall.

The last 1500 years

From about 1500 yrs BP the climate again appears to have become slightly wetter, though the magnitude of the change is small and is poorly defined because it approaches the limits of geomorphic visibility. I wish to draw attention to it here because it is particularly important for understanding the changes in prehistoric landuse described later in chapter 10. This palaeoenvironmental adjustment is evident in the changes in sediment load/stream discharge relationships of streams contributing to alluvial fans in the southern and eastern part of the arid zone. For instance, the Thackaringa unit is deposited on the Mundi Mundi fans from about 1000 yrs BP after a significant interval when the fans were dissected (Wasson 1979). Similarly, alluvial fans on the Lake Torrens piedmont were dissected after 1800 yrs BP reflecting some change in the balance between sediment load and stream discharge (Williams 1973). The change is also marked by an increase in vegetation sufficient to stabilise the Belarabon dunes shortly before 640 yrs BP (Wasson 1976). Outside the arid zone, fluctuating lake levels and changes in pollen profiles register the same shift - see Churchill 1968; Bowler 1981; Dodson 1974; and Hope 1974).

The same pattern is registered in summer rainfall regions. The pollen profile for Lake Frome pollen core shows an amelioration of the dry conditions, sometime after 2000 yrs BP (an interpolated date), though Singh (1981) interprets this as due to additional winter rainfall. In Central Australia, a study of palaeofloods on the Finke river (Webb *et al* in press, G. Pickup pers. comm.) suggests that the latest series of large floods began at about 850 yrs BP, after an interval of 3,500 years without comparable events. Slack-water deposits indicate large palaeofloods at 4,400, 850, 650, 450, and 250 yrs BP and also register the modern floods of 1967, 1972 and 1974. Further down the same drainage system a series of shoreline shingle terraces around Lake Eyre are attributed by Dulhunty (1975) to a roughly comparable timeframe though no absolute dates are available. Increased precipitation in Central Australia is also reflected in a major recharge event at about 1400 yrs BP, registered by a discrete plug of ground water in the Mereenie aquifer, separated from an earlier water body dated to 5500 yrs BP (Calf 1978).

The overall impression is that high rainfall events were more closely spaced during the last thousand years than during the preceding 3000 years. A possible climatological mechanism for this change is available in a study of major floodings of Lake Eyre (~~Allen~~ Allan 1985) which establishes a link between lake fillings, summer monsoonal incursions and positive extremes of the El Nino Southern Oscillation.

This last climatic adjustment brings us to the environments in which the ethno-historical accounts of Aboriginal landuse are set.

THE ISSUES

In this section I have set out to review the wide range of theories that have been applied to desert prehistory, or which, if principally aimed at other environments, have important implications for the arid zone.

The timing of initial settlement.

Dead heart hypothesis

Theories about the timing of the initial human settlement of the arid zone fall into two groups. The first of these is what one might call the dead heart hypothesis. The basic proposition here is that the region was settled under more favourable environmental conditions, in which the now relict drainage systems of the interior were active, and that the population subsequently had to cope with either progressive ~~dessication~~ desiccation of the landscape or with alternating wetter and drier phases. For instance, to Mulvaney, writing in 1961, the region was seen as having ideal conditions for human occupation in the late Pleistocene.

> ...reliable rainfall extended across the heart of the continent. Perennial rivers drained into inland seas...there was a spread of rain-forest flora over the centre of the continent... a diversified and predominantly herbivorous land fauna...(1961:63)

These conditions suggested an early movement into the region following the major inland drainage systems.

> ...from the Gulf...across to the inland drainage basin... down the Diamantina River or Cooper's Creek systems towards central Australia, or down the Darling River and tributaries to the south...(1961:62)

Other scholars, writing before 1960, shared these views (eg. Tindale 1959).

Birdsell (1957, 1977) also subscribed to early settlement of the interior but his model is based upon different assumptions about the palaeoenvironment. He assumed for the purposes of his calculations that the present weather systems were simply shifted latitudinally 500 miles to the north (1957:59-61) and quite explicitly he took no account of the problems that the arid zone posed for colonists. In his discussion he returns to this issue.

> There remains some question as to how long a shift in adaptedness to other types of environments [other than rainforest] might increase the time estimates derived from the model. A northerly shift in climate belts would increase the area and importance of grasslands in the island chains leading to either point of entry into Australia. It seems certain that some of the adaptive shift in culture would have been attained prior to reaching Australia, and so not affect our time estimates. (1957:65).

Birdsell's view that some degree of pre-adaptation to the arid zone would have been part of the baggage of the initial colonists finds some support in Golson's conclusion that "...man was in a position to obtain some of the ecological knowledge essential for successful settlement of central Australia during his prior sojourn in the more favourable conditions of northern Australia." (1971:206).

As more detailed palaeoenvironmental reconstructions became available archaeological interpretations changed. By 1969, Mulvaney had revised his views, noting that although lush conditions had once prevailed inland during the Tertiary, conditions were arid for much of the late Pleistocene. However, Gould writing in 1971 persisted with the earlier views. He saw the Australian Desert Culture as an adaptation to "...the onset and persistence of the rigorous environmental conditions of the last 10,000 years." (1971:175).

Modern versions of the dead heart hypothesis, based upon the detailed palaeoenvironmental data summarised above, are provided by Bowler (1976), Jones (1979), White and O'Connell (1982) and Lampert (1986). In these versions the abundance of fresh-water during the lacustral phase, during which many inland lakes held significant bodies of water, is seen as providing conditions conducive to early settlement of the interior. For instance,

> ...the Mungo Lacustrine Phase would have given major access to the reactivated river and lake systems which ringed the arid heart. (Jones 1979:453).

Similarly, White and O'Connell (1982:49-50) opt for widespread settlement of the continent before 20,000 yrs BP.

Apart from the timing of colonisation there remains the question of the rate at which human groups may have occupied the interior of the continent. Few details of the mechanics of colonisation are given in any of the scenarios - and detailed archaeological evidence is unlikely to be forthcoming given the presumed antiquity of the event. Horton (1981:22-23) has suggested that the process would be analogous to the colonization of islands, with the chances of establishing new settlements inversely proportional to the distance between permanent waters. However, given the conditions postulated for the lacustral phase one would expect the population to be largely free of these constraints and that occupation of riverine corridors and desert uplands would pose no particular difficulties. Birdsell (1957, 1977) has argued for the establishment of populations at ethno-historic densities within a few millennia of first landfall, assuming a rapid intrinsic rate of population growth. However, it is possible that factors other than the availability of land, or distribution of water, constrained the early growth of Pleistocene populations. For instance, White and O'Connell (1982:50) mention that mobility and prolonged lactation impose a certain spacing between births in hunter-gatherer populations and conclude that initial population growth may have been slow. Whatever rate of increase is assumed, the lacustral phase spans some 25,000 years and this is sufficient to see the widespread establishment of human populations across the interior.

Coastal colonisation hypothesis

The second group of theories are those that view the arid zone as a difficult human environment and postulate settlement of the region only after 10,000-12,000 yrs BP. The most notable of these is the coastal colonisation hypothesis (Bowdler 1977) which has set the research agenda for arid zone prehistory for a decade. It relies upon earlier work by Golson (1971) and Allen (1972).

Golson (1971:209) suggested that ancient patterns of plant exploitation from Sundaland would have channeled early settlement into northern and eastern Australia. Subsequent expansion into the arid zone would have necessitated a new pattern of plant use, in particular a greater reliance on seed foods rather than roots and tubers, and upon endemic Australian rather than Indo-Malaysian plant genera. The discovery of grindstones in the Darling basin (Allen 1972:228-44, 338-351) dating back to 12,000-15,000 years BP and their first appearance at a time when an extensive lake system was drying up suggested that this new pattern of plant use began as a response to environmental stress at the end of the Pleistocene.

Bowdler (1977) neatly summed up the available evidence. Her basic hypothesis was that Australia was colonised by people adapted to a marine environment - here Birdsell (1977:146-7) is in agreement - and that initial colonising routes were around the coasts and up the major river systems. The arid inland posed unspecified problems for settlement until economic and technological adjustments to the stressful events of the late Pleistocene fundamentally altered this situation. Populations dependent upon riverine or lacustrine resources on the northern or eastern fringes of the arid zone had to turn to new resources as existing ones disappeared in the face of a major arid phase at the close of the Pleistocene (1977:229-30, 236). These changes included the hunting of large macropods and the harvesting of wild seeds. A causal connection between the first use of seeds and the initial occupation of the arid zone is implied. O'Connell and Hawkes (1981:115) are more explicit on this point.

> We propose that the onset of arid conditions 17,000-18,000 BP led to critical reductions in the abundance of high-ranked foods and favoured the adoption of more expensive items, including seeds. Once the technology for processing seeds was available, it was possible for Aborigines to move to previously uninhabited or sparsely inhabited parts of the continent.

Archaeological work in the arid core (Gould 1971, 1977:174, 176) appeared to confirm this as grindstones, presumed to be seedgrinders, were present throughout all levels of the deposit at Puntutjarpa rockshelter dating back to 10,000 years BP. Bowdler (1977:230) suggested that the basal date from Puntutjarpa may not be far off the terminus post quem for true desert adaptation, for what Gould (1971:174, 1977) characterises as the Australian desert culture. Apart from changes in technology and economy, Bowdler (1977) also hints that occupation of the desert is facilitated by the amelioration of climate after 12,000 yrs BP.

To a greater degree than its rivals, Bowdler's coastal colonisation hypothesis deals with the likely limits upon settlement of the arid zone, and it also provides a cogent account of the factors determining the timing of settlement. Its main omission is that it does not extend to include events before the Last Glacial Maximum, a period when the interior of the continent may not have been a particularly difficult human environment. This is essentially the criticism that Jones (1979:453) has made.

The model proposed by Horton (1981) has similar implications for desert prehistory but is based on different premises. The distribution of freshwater is taken as the major determinant of population distribution during various periods and Horton (1981:26) approximates this by plotting the distribution of fossil megafauna. Accordingly he suggests that much of the continent was settled before 30,000 yrs BP, with the exception of the central part of the interior. From 25,000-12,000 the human population was restricted to coastal regions by the harsh conditions that prevailed across inland Australia. From 12,000 yrs BP,

> Man moved back, first into some of the areas previously occupied where sufficient water was now available again, then, with improving knowledge and technology, into the arid core itself, which had never previously been occupied. (1981:26).

Horton's version has a broader chronological sweep than Bowdler's but his reconstruction of the distribution of fresh-water before 25,000 yrs BP is unconvincing when measured against other palaeoenvironmental reconstructions.

Both Horton and Bowdler predict that archaeological sites older than 12,000 yrs BP will not be present in the arid zone. An early test of this proposition was provided by the discovery of Pleistocene sites in the Pilbara in the late 1970's (Maynard 1980; Troilett 1982; Brown 1987). However, these small enigmatic sites were poorly reported and did little to resolve the issue. As further archaeological work in the arid zone failed to turn up definite evidence for occupation before 12,000 yrs BP outside of the Darling basin (see for example - Lampert and Hughes 1980; Hughes and Lampert 1980; Bordes <u>et al</u> 1983; Davidson 1983; Smith 1983; Lampert 1985; Napton and Greathouse 1985) the <u>coastal</u>

colonisation hypothesis gained increasing credibility. However, Lampert and Hughes (1987) suggested that while it might be applicable in terms of a recolonisation of the arid zone after the harsh conditions of the Last Glacial Maximum, an earlier phase of occupation, greater than 30,000 yrs BP, could be expected. Conclusive evidence for Pleistocene occupation in the heart of the continent was not discovered until the excavation of Puritjarra rockshelter, as part of this project in 1986 (see chapter 4 and also Smith 1987).

Long-term cultural stability.

Australian Desert Culture hypothesis

Initial archaeological work in the arid zone emphasised a long period of cultural and economic stability beginning about 12,000-15,000 yrs BP. For instance, Allen initially stressed that the late Pleistocene economy in the Darling basin, one based on fish, shellfish, small mammals and seeds, was indistinguishable from that practiced by the Darling River Bagundji during the last century (1974:315-6). However, in more recent works he has moved away from this interpretation (Allen 1983:53).

The most detailed argument along these lines was that put forward by Gould (1971, 1977:168-182) in his *Australian desert culture* hypothesis. In this he proposed that Aboriginal groups occupying the arid zone were distinctive in terms of their organisation, economy and pattern of landuse and that this pattern had persisted without significant change for at least 10,000 years. In Gould's view the archaeological record from Puntutjarpa rockshelter provided;

> ...evidence for the success of this ancient desert culture adaptation throughout the post-Pleistocene of the Western Desert, culminating in the ethnographic desert culture of that region, in what must surely stand as one of the most dramatic cases of cultural conservatism on record. (1977:182)

The underlying reasons for this remarkable stability, as outlined in this hypothesis, were that a) the cultural pattern was tightly constrained by the poverty and unpredictability of the desert environment (1977:168-9, 179-80) and b) that this environment itself had been stable during the last 10,000 years (1977:173).

With the benefit of more detailed palaeoenvironmental information it is now obvious that there are problems with this interpretation. If the culture was tightly constrained by environmental conditions we might expect dramatic changes in the archaeological record, given that basic environmental parameters have fluctuated. On the other hand, if no change is evident in the archaeological record we might infer that desert groups had more latitude than the model presupposes. Gould, of course, was writing at a time when palaeoenvironmental reconstructions for the Holocene stressed that in "...the last 10,000 years climate has been relatively stable...(Bowler _et al_ 1976:359) and at a time when other archaeologists were also exploring equilibrium models for hunter-gatherer societies - see for example Hayden (1972), Jones (1977).

The concept of an _Australian desert culture_ has occasionally been used by other prehistorians - see for example Bowdler (1977:233) - but has not gained wide acceptance. Gould had some difficulty in finding archaeological correlates for his ethnographic model and largely based his interpretations upon the limited evidence for change in the Puntutjarpa sequence and on the presence of seedgrinding implements throughout the entire sequence of occupation (1977:168-175). This, he argued, amounted to archaeological evidence for stability and continuity. Whilst other scholars have also pointed to the long-term technological continuities in the manufacture of chipped stone artefacts (eg. Mulvaney and Joyce 1965; Morwood 1981; Fleniken and White 1985) Gould's bold interpretative leap in inferring a stable pattern of landuse has attracted criticism. This has been questioned on the grounds that most stone artefacts are poor indicators of economic or cultural change (Peterson 1971:243), or conversely, that the Puntutjarpa sequence does, in fact, show changes in technology and economy (Lourandos 1985:396). Other criticism has focussed on the chronology of the site - see Glover and Lampert (1969); Johnson (1979:131-134) and my comments in chapter 10 below.

A final question is whether desert groups were sufficiently distinctive in economy, material culture and organisation to justify the tag; Australian desert culture. On present evidence it seems unlikely. For instance, Peterson (1976) divides the arid zone into three or four culture-areas - suggesting regional differences in material culture - and in a later work he has outlined how various aspects of land-tenure systematically varied across the continent, in broad correlation with regional population density (Peterson 1986:151-153). Similarly, some plant food species - particularly tubers - vary from north to south across the continent, depending upon amount of summer rainfall and sensitivity to low temperatures (see Golson 1971; Latz 1982; Nix 1982). Thus systematic regional differences in subsistence, material culture and land tenure are likely and the concept of a distinctive desert culture is redundant except when used in a very general sense. One of the few common features of inland groups was their use of various sorts of seeds which were harvested and ground into flour.

The impact of environmental changes.

The quest to establish the age of human occupation in the arid zone deflected archaeological attention from the related problem of charting the fortunes of that occupation through at least 12 millennia. It fell to geomorphologists to speculate about the impact upon human populations of the changes reflected in the palaeoenvironmental record.

For instance, Mabbutt (1971) concluded that, against a record of periodic intensification and relaxation of desert climate;

> The favoured environments of upland and piedmont and riverine tracts would have persisted throughout, although with fluctuating limits and changes in relative importance which would lead to associated changes in the range and frequency of human migration into adjoining desert lowlands. (1971:78)

Similarly, Bowler stressed the likely impact of the severe aridity accompanying the Last Glacial Maximum,

> ...a change which would have imposed considerable stress on almost every element in the landscape including Man. ...Areas such as the continental interior that may previously have possessed meagre water resources may have become uninhabitable at this time of maximum aridity. (1976:72-73)

In Bowler's view the semi-arid and montane regions are the most climatically sensitive regions and it is in these that he sees the environmental changes as sufficient;

> ....to induce significant and, hopefully, detectable changes in the distribution and adaptation of human populations. (1976:74-75)

In the arid zone, he is prepared to accept that the environmental changes were within the adaptive capacity of human groups. He also tends to understate the likely effects of changes during the Holocene, though perhaps here he is already influenced by the archaeological picture of long-term stability put forward by Gould (1969, 1971, 1973).

There is strong ethnographic evidence in support of the premise that the distribution of human populations in the arid zone is controlled by the distribution and reliability of water sources. This is evident not only in the regional variation in population density but also in the annual pattern of dispersal and aggregation and in the response to drought.

Population distribution

Ethnographic information on the distribution of population shows that the highest densities occurred in the ranges and riverine corridors as one might expect. The few available figures show that population density ranged from about 1 person to 13 km^2 in the best parts of the Central Australian ranges (Strehlow 1965, 1970), through 1 person to 50 km^2 in other parts of the ranges (Layton 1983; Yengoyan 1968), to 1 person to 90-200 km^2 in the lowlands (Meggitt 1962; O'Connell *et al* 1983; Long 1971), with extreme areas such as the Simpson dunefield all but uninhabited at least in its northern half. Peterson (1986:44-46) also comments on how relatively densely populated the ranges were, with most people living in small groups of about 20 people, less than a day's walk from their neighbours and within easy sight of their hunting fires. A similar situation is reported for riverine corridors - see Strehlow (1947:70-71) for the lower Finke river and Allen (1974) for the Darling river. In contrast the numbers of people, and the size of the groups were much lower in the spinifex sandplain country.

In Central Australia the distribution of estates also conforms to this pattern.

> Since the existence of reliable water at a base camp is crucial to the persistence of an estate as a discrete unit, estates tend to be concentrated in the ranges, where outcrops yield more rock holes and where creeks capture surface run-off after rain to store in soaks along their normally dry, sandy beds. In all, 9 of the 15 estates in the Ayers Rock region lie along the chain of hills created by the Petermann and Bloods ranges, the Olia Chain and the Musgraves. In the ranges, the centre of estates also lie closer together....the average distance... is about 30 kilometres. (Layton 1983:19)

Pattern of landuse

In the arid zone, Aboriginal groups extended their foraging activities over any land to which they could establish some links and rights of access. This might be on the basis of descent, conception place, ritual knowledge or perhaps death of a parent or grandparent in the area. This foraging range centred on an estate, usually an area of 900-1500 km^2 containing at least one reliable water source, and in which a group of kin claimed primary tenure.

The pattern of landuse broadly follows the "pulse and reserve" strategy described for arid ecosystems (Noy-Meir 1973). In this, biological productivity is geared to discrete rainfall events and during dry periods the ecosystem remains in a state of very low activity. The general pattern for Aboriginal groups in the arid zone, was to take advantage of rain to visit outlying parts of a territory and to exploit the bush foods in these areas while they were accessible (O'Connell 1977; Gould 1969; Tindale 1972; Thomson 1964; W. Jones 1979; Kimber 1984; Allen 1972; Cane 1984). As the ephemeral water supplies which supported these visits dried up people would fall back to camps near the main waters. The bush foods around these camps would be left in reserve until foraging was restricted during the dry season to areas around the main waters.

This pattern underlines the point that population densities must have been related to the carrying capacity of the country around these fall-back areas and that, conversely, good years would have been marked by a super-abundance of bush foods. It also follows that both the distribution of watering points, and the dependability and range of bush foods accessible from those points in the landscape combined to control the level of population in the arid zone.

Response to drought

References to the movement of people in droughts, and to malnourishment and starvation, are sketchy but widespread in the literature - see for example Tindale (1959:325), (1974:42, 68-71); Meggitt (1962:24); Strehlow (1965:124); Petri and Petri-Odermann (1970:267-275); Berndt (1972:183); Leske (1977:46); Kimber (1982:20-21); Myers (1986:35). The response to drought appears to have been temporary abandonment of stricken areas, fissioning of local groups and a retreat to regions with better water resources. Population densities in the stricken areas dropped - both through migration and through mortality.

The probable sequence of events in a prolonged drought is described by Peterson (1986) as a fall back upon the main waters followed by disintegration into tiny groups moving completely opportunistically, and with groups melting away as individuals activated their divergent social networks to take up residence in neighbouring territory. For instance, in a protracted drought, the population from the Petermann Ranges would fall back upon the Musgrave ranges, to which they were linked geographically and culturally. Even during local droughts,

> ...some estates had to be abandoned. It was recognised that in harsh seasons people from Katajuta would move to Uluru, those from Kulpitjata to Apara, and those from Aputjilpi to Atila. (Layton 1983:20).

Similarly, the population in the eastern part of the Lake Eyre region would fall back on a few waterholes along the lower reaches of Warburton and Coopers Creek (Reuther 1981 IV/20 2767) and here a special term, pitaru kana, existed for "people who come in from a drought stricken area and settle down as guests".

The process of depopulation, group fissioning and mortality is illustrated by the observations of Duguid and Albrecht in the Petermann ranges in 1939 (Duguid 1972:133-137; Albrecht 1965:42-44 cited in Hamilton and Vachon 1985:68). In 1930-31 Gill (1968) describes meeting large numbers of Aborigines in this region. In 1939 at the end of a long drought Strehlow, Albrecht and Duguid travelled through the region and met only 26 people, living on "wild cucumbers and yelka". According to one Aboriginal man, a number of women, old people and children had perished when his group, misjudging the likelihood of rain, had prematurely moved away from permanent water (Albrecht 1965:44 cited in Hamilton and Vachon 1985:68). Duguid also records that in the prolonged drought many of the people had died and that others had decided it was better to leave their territory (1972:133). Corroborative information came later in the same trip when Duguid and Strehlow met a group of emaciated Petermann ranges people travelling towards Ernabella, in the Musgrave ranges. A similar example of part of the local population seeking refuge in neighbouring country, while others remain to weather the drought, is reported by Tindale (1974:70-71) for the western margin of Western desert.

It also seems likely that the process of withdrawing to refuge areas would leave more distant groups isolated in the midst of a depopulated area (cf. Evans and Long 1965:318), sometimes without the essential geographical knowledge that would enable them to leave. In support of this view Peterson (1986:35) points out that there is ample evidence to show that knowledge of the countryside was limited and that some of the desert groups contacted by Welfare Branch patrols between 1956-66 would have left the desert to join relatives in the settlements if they had been able to find the waters. A recent example is that of the group of 9 Aborigines isolated in an area west of Lake Mackay from 1961 until 1984, when they recognised smokes sent by other Pintupi people who were moving back into country immediately to the south (Peterson 1986:105).

From the ethnography it is clear that population density and the pattern of landuse are sensitive to any change in distribution and reliability of waters and in the carrying capacity of the country around the main waters. Any environmental change which reduced the spread of waters would decrease access to resources in these tracts of land. Any change which decreased the reliability of the main waters would place the permanent occupation of certain estates in doubt. Any change that reduced the availability of bush food around the main waters would ultimately lead to lower population density. In brief, any environmental shift that affected (a) the number of reliable watering points in the landscape, (b) the distribution of watering points, and (c) the productivity of the country would have a significant impact upon the size and distribution of the population and upon the pattern of landuse. Even during the ethnohistoric period, droughts were sufficient to cause major changes in these aspects of Aboriginal groups in Central Australia. It is likely, therefore, that any sustained change to drier conditions, however small, would cause significant changes in population and landuse.

Economic intensification.

Any model of desert prehistory that simply viewed changes in population and landuse as directly tracking the palaeoenvironmental changes would be inadequate - see for example Ross (1981) on the lack of a consistent correlation between wet phases and periods of human occupation in the Victorian mallee. The human response to environmental changes can be expected to be more complex than this and is likely to be contingent upon many other factors - including historical end-products such as the existing technology and social structure.

An important consideration is the degree to which the effects of unfavourable environmental changes may be offset by changes in technology or landuse. Boserup (1965), in her influential study of agricultural intensification, views technology as a freely moving variable rather than a fixed quantity. Thus resource stress arising from population pressure or a diminishing resource base can be met by improvements in subsistence technology or organisation, a process we can call <u>economic intensification</u>. It follows that Malthusian limits will not be reached unless there is no feasible avenue for economic intensification or unless economic change is delayed because the changes involve a difficult reorganisation of society.

In the arid zone, changes in carrying capacity are likely to have accrued from improvements in technology which a) allowed greater access to country away from the main waters - such as skin water-bags, and wells - or b) which broadly increased or extended the productivity of the country around these waters - such as patch burning, dams to promote plant growth, storage pits for grain, and implements for processing wild seeds.

Of these developments, the most significant and also the most amenable to direct archaeological investigation is the intensive use of seeds. It is likely to represent an important recalibration of carrying capacity. A figure for the contribution of seed foods cannot be given but O'Connell and Hawkes (1981:115) comment that the ethnohistoric population densities would not have been possible without access to seeds. It is also a development that Allen (1972:228-44, 338-351) argues began as a response to increasing aridity around 12,000-15,000 yrs BP in the Willandra lakes region.

Seedgrinding implements have also been seen as having a key role in the colonization of the arid zone (Bowdler 1977:229-30; O'Connell and Hawkes 1981:115) and have served as an archaeological correlate of the <u>desert culture</u> (Gould 1977:168-175).

As seedgrinding is clearly an important factor in any model of desert prehistory I will review the relevant ethnographic and archaeological evidence below.

The exploitation of wild seeds

Aboriginal plant use in central Australia is extensively documented (see for example Cleland and Tindale 1954; Meggitt 1957; Gould 1977; Peterson 1977; Latz 1982; O'Connell and Hawkes 1981; O'Connell et al 1983). Edible seeds were harvested from more than 70 plant species including trees, shrubs, grasses and forbs. Of these, five are considered to have been staple foods - Acacia aneura, Eragrostis eriopoda, Panicum decompositum, Portulaca oleracea and Tecticornia verrucosa.

The techniques of harvesting, husking and winnowing various types of seeds are described by Tindale (1977), Brokensha (1975), O'Connell et al (1983), Latz (1982) and Smith (1985). Most seeds require some form of processing before consumption. Hard seeds like Acacia aneura were roasted in hot soil before grinding into a paste with water. Soft seeds such as grass seeds were directly ground with water into a paste and very hard seeds like A. victoriae or A. coriacea were roasted, and then pounded into a coarse meal before wet milling. These processes were carried out with distinctive types of grindstones, implements which survive well in archaeological contexts. In fact, for arid Australia seedgrinding implements are one of the few types of stone artefact directly connected to subsistence activities and this underlies their importance in any review of desert prehistory.

In arid Australia subsistence was underwritten by the use of seed foods. The period of greatest stress during the annual cycle was late in the dry season, when the population had been limited to exploiting country around the permanent waters for some time. Higher ranking bush foods were quickly depleted and seeds became particularly important. As Cane (1984:76) observes,

> Seed storage was a very important aspect of the economic strategy...Without it, survival during the last few months of each year would have been very difficult. Even with the benefit of seed storage supplies of vegetable food within the vicinity of the major waterholes often ran out. When this occurred the local Aborigines had to rely heavily on meat from stray catches of game and lizards.

Thomson (1964:402), describing the use of seeds by the Pintupi commented that "...the country around the watering places - close to the wells and rockholes - would not support even a small horde [group] for long" and that "...these people were strongly nomadic, except for short periods when they could depend on a harvest of certain seeds."

Information for the Lake Eyre/Coopers Creek region has been reviewed by W. Jones (1979) and Kimber (1984). Accounts of traditional subsistence in the region note the importance of seeds (see for example McKinlay 1862; Howitt 1878; Gason 1878; Horne and Aiston 1924; Reuther 1981; and W. Smith quoted in Kimber 1984:16). Pressure on resources at times when the population was tied to the riverine corridors seems to be reflected in the necessity to use ngardu (Marsilea quadrifolia) (Horne and Aiston 1924:52-57) which although present in the Central Australian ranges is not regarded as edible there. Other features discussed by Jones (1979:140-3) and Kimber (1984), such as the construction of earthen dams to flood larger areas, the excavation of deep wells to tap ground water and extend access to the surrounding dune country, the broadcasting of seed, the storage of seed in pits, and the introduction of seed species into new areas all suggest pressure to expand the resources available at this time.

Overleaf **Figure 2.2** : Emily Kngwarraye, an Anmatyerre woman grinding Acacia victoriae seeds. Ulwerrpwele waterhole, Utopia station. June 1983.

Seeds and drought

Any widespread drought would have placed considerable demands upon the bush foods in refuge areas. Here again seed foods, often those which were not normally used, were important. In some areas they were the only bush foods available at these times (Reuther IV/20 2767).

The importance of seed foods during poor seasons in the Lake Eyre region is emphasised by the Diyari word for drought, pitaru, which means "constantly to pound" (Reuther 1981 IV/19 2767). This is a reference to the use of hard-coated seeds which require heavy pounding on a mortar to make them edible and which were used when other bush foods had failed.

A cautionary note here is sounded by Pate (1986) who points out that many important seed foods would not be available during a drought, in particular those from perennial grasses such as Eragrostis eriopoda - see also the quote from Duguid above, who reports people living on fruits and bulbs, rather than seeds, during a prolonged drought.

Costs associated with using seed foods

Economic intensification is usually defined as the substitution of capital, labour and skills in a situation where additional land cannot be brought into production (cf. Brookfield 1972). The various costs associated with the use of seeds show that this development can legitimately be classed as a form of economic intensification.

Firstly, O'Connell and Hawkes (1981) have pointed out that because of the amount of time and labour required to gather and process seeds they are high cost resources. Estimates of the processing time required to produce a kilogram of flour from various grass or acacia seeds range from two to five hours (Brokensha 1975:25; O'Connell and Hawkes 1981:124-5; O'Connell _et al_ 1983:90-2; Cane 1984:79, Tables 4.3-4.7). Total collecting and processing time is roughly five to eight hours per kilogram of flour. On these figures it seems unlikely that seeds will be exploited if additional land can be brought into production.

Secondly, labour costs were not the only costs associated with using seed foods. In some areas the cost of the technology was substantial. Suitable stone was scarce and it was necessary to obtain seedgrinding implements through trade. For instance, in the Western Desert and in the Lake Eyre basin the supply of raw material for millstones was limited and suitable slabs were obtained by trade from other areas (Hamilton 1980:8-9; Reuther 1981:II/238 1081). In the Western Desert,

> Men travelled to the known sources of stone, utilizing kinship ties with people in these areas. ...The further diffusion of the stones depended on men replacing the grindstones of their wives, then appropriating the older ones and passing them on in trade to men of the west. (Hamilton 1980:8)

In both of these regions the large seedgrinding implements were scarce and valuable resources and were passed on either as collective property from female siblings to their daughters (1980:8) or as personal property from a man to his youngest brother (Reuther 1981 II/238 1081). In contrast, in other areas where suitable stone was more easily available a millstone would often be broken into pieces and scattered when the owner died (Cane 1984:143; De Graaf 1968:96).

Seedgrinding and colonisation of the arid zone

The suggestion that lack of the appropriate technology to process seeds may have delayed settlement of arid areas (Bowdler 1977; O'Connell and Hawkes 1981:115) is worth examining because it is a persuasive idea. There are of course numerous analogues from more complex societies where exploitation of a specific resource, or settlement of a particular environment, was only possible after a technological breakthrough. The crucial point to consider here is whether seedgrinding implements can be classed as a major technical innovation, one which permits the settlement of previously uninhabitable regions, or whether readily distinguishable seedgrinding implements are simply a byproduct of the shift to more intensive use of seeds. I would argue the latter.

Expedient grindstones are certainly part of Pleistocene assemblages at Malakunanya, Miriwun, Kenniff Cave, the Darling basin sites, Quininup Brook (see Smith 1985) and Nauwalabila (Jones and Johnson 1985:218). The exploitation of high-ranking seed-foods was probably also a feature of Pleistocene economies in much the same way that certain seeds, such as *Cycas media*, *Oryza fatua* and *Nymphaea gigantea*, are used in Arnhemland (Specht 1958), that is as a small part of an economy largely focussed on other types of resources. The development of specialised seedgrinding implements from a generalised grindstone technology was probably a response to the need to invest more time in processing this type of resource. From this perspective, arid zone seedgrinding implements simply represent an elaboration of an existing, indigenous technology rather than a major technical innovation.

Whatever the case, a late Holocene date of 3000-4000 yrs BP for the earliest identifiable seedgrinding implements now shows that the development of this technology was not part and parcel of the first movements into the arid zone - see a recent review of the typology and chronology of seedgrinding implements by Smith (1985, 1986) in which the Pleistocene grindstones from the Willandra lakes are shown to be expedient and amorphous artefacts lacking formal similarity with the ethnographic seedgrinding implements. Settlement of the arid zone, even without taking into account the new evidence from Puritjarra, pre-dates the appearance of distinctive seedgrinding implements by 7 millennia.

The development of a seed-gathering economy

It is now worth returning to Allen's proposition that seedgrinding began as a response to increasing aridity (1972:228-44, 338-351).

The harvesting and processing of wild seeds represents a broadening of the resource base to include labour intensive bushfoods, and a move to exploit lower levels of the trophic pyramid. Optimal foraging models (O'Connell and Hawkes 1981) suggest that the most likely explanation for this change is a change in the procurement costs of alternative resources. The progressive scarcity of higher-ranking resources would increase the amount of time and effort required to obtain them and would make seeds more attractive for exploitation despite the labour involved in processing them.

An alternative suggestion that seed exploitation began as a response to new resource opportunities, such as a post-Pleistocene increase in grasslands (eg. Tindale 1959:49-50), can be discounted on two grounds. Firstly, it ignores the extensive use of seeds from other sources such as trees, shrubs, and succulents. Plants such as Acacia aneura and Portulaca oleracea were as important in Central Australia as grasses. Secondly, an increase in the abundance of grasses would not significantly reduce the time required to produce a kilogram of flour. It is the processing time, rather than collecting time, which makes seeds so costly. Nor would this reduce the cost of acquiring suitable stone for millstones.

Allen's argument that the harvesting of wild seeds began as a response to increasing aridity is plausible if we examine two key variables; population density and carrying capacity. Changes in either could create circumstances which would make the use of seeds necessary. The effects of increasing population density, or of decreasing carrying capacity due to an unfavourable environmental change, would be similar. Firstly, a more restricted foraging range, due to either demographic packing or a reduction in the number of permanent watering points. Secondly, pressure to intensify the use of existing resources or to diversify into new patterns of resource use. On this basis we might expect that the dry phases documented in the palaeoenvironmental record would have created considerable incentives and pressures towards using seeds. That this response appears to have actually occurred only during the latest of these arid phases highlights the point that the pattern of changes in the archaeological record is strongly directional rather than cyclical. The reasons for this are discussed below and are of fundamental importance for any model of the desert prehistory.

Production pressure.

Pressures for economic change can also derive from sources other than changes in the resource base.

In a study of Pacific agriculture Brookfield (1972) pointed out that population densities on various islands could not be closely correlated with agricultural intensity without taking into account the differing importance of trade production and production for ceremonial prestation. He points out that;

> ...man does not live by subsistence alone,...The satisfactions and security gained by participation in ritual and ceremonial life, and the access to wives, land support, refuge and security obtainable through the widely-ramified systems of reciprocity, and trading links, are also important. (1972:37)

Along similar lines, Bender (1981) has suggested that the demand for goods for ceremonial prestation is a major factor leading to other social and economic changes.

> In that ceremonial life lie the seeds of increased demands, more food for feasting, more goods for exchange, more intensive relations between elder and initiate, and between elder and wives. (1981:154)

This scenario has been applied in the Australian context in what has come to be known as the intensification hypothesis. It is important that this hypothesis be examined here because it makes specific reference to the arid zone. It also raises the question of whether changes arising from social competition and increased demand, transcend the impact of changes in the environment.

The intensification hypothesis

Production pressure - defined here as incentives or demands to produce a surplus beyond subsistence needs - has been proposed by Lourandos (1983a, 1985) as a prime factor underlying various changes in Australia in the late Holocene. In his view, economic growth is due;

> ...to a restructuring of social relations which placed increasing demands upon the economy and thus production. Such processes resulted in increases in the complexity of social relations and economic growth, sedentism and, by inference, population sizes. (1983:81)

This hypothesis can be broken down into a number of propositions. Firstly, that increasing demands for a surplus to consume in large ceremonies leads to greater production and new more efficient methods of production. Secondly, that these changes, aimed at first at production for social consumption, then spread to affect subsistence production resulting in population growth. Thirdly, that this process was sufficiently free of external constraints to result in an "...evolutionary spiral...in which social relations made demands on economy and subsequently were themselves transformed" (Lourandos 1985:407).

It is worth noting that by intensification Lourandos does not mean economic intensification in its strict sense. Rather he opts for a broader but less precise definition that encompasses any indication of growth - in population, economy or exchange networks - within the one concept. This is one difficulty faced in examining the hypothesis against ethnographic and archaeological data.

Lourandos (1985:391) lists the following as archaeological indices of intensification; any increase in a) intensity of site usage, b) rate of establishment of new sites, c) use of marginal environments, such as swamplands, arid and montane environments d) complexity of site economy and e) complexity of exchange systems (1985:391). In agricultural contexts increased use of marginal land would be classed as intensified production. However this is clearly not what Lourandos has in mind. Elsewhere he suggests that the expansion of settlement into marginal environments can be seen as an extension of "...developing social networks into new ground" (Lourandos 1983a:91). Thus, of the five indices, we can see that the first three are simply measures of population growth - or the expansion or redistribution of settlement - and are not intrinsically useful in determining whether there is some underlying change in production for "social consumption".

There is little evidence in the archaeological record to support the idea of continual pressure for improvements in economic production. If we turn to specific archaeological examples of economic intensification we could include the following; leaching of cycad nuts, seedgrinding implements, fishtraps, patch burning, and drainage channels. Of these techniques, leaching and seedgrinding techniques first appear in the archaeological record around 3000-4000 yrs BP (Beaton 1982; Smith 1986). Drainage channels to manage the production of eels in Victoria are described by Lourandos (1980). The latest phase of siltation in these channels dates to about 200 yrs BP but Lourandos (1983a) argues that they were initially constructed as a response to the environmental changes around 3000-4000 yrs BP. Thus, although there are several archaeological examples of intensified production the timing of these appears to coincide with significant changes in palaeoenvironment. Furthermore, there is no archaeological evidence to suggest that economic intensification was a continuing process throughout the late Holocene.

Production
~~production~~ for ceremonies

An alternative way of approaching this hypothesis is to examine the extent to which large ceremonies in the arid zone made demands upon production.

Throughout the arid zone the general strategy appears to have been to finance large ceremonies by a) timing them to take advantage of seasonally abundant or periodically abundant resources, b) leaving the bush foods in a particular area untouched in anticipation of a ceremonial gathering, c) small scale stockpiling of food and d) reliance to a large extent upon increased production of food by women. Examples of these factors in the context of a specific ceremony can be found in Kimber and Smith (1987).

It is also worth considering production pressure in terms of the use of seeds. The end of the wet season, autumn, was the time when abundant resources - particularly fruits and grass seeds - allowed large groups to gather for ceremonies. Spencer and Gillen (1912:259) commented on the importance of grass seeds in financing (cf. Hamilton 1980:14-15) the large ceremonial gatherings while Tindale noted that "...even the duration and scale of the most important of the men's initiation ceremonies are likely to be determined by the revolt of the women following the exhaustion of ready supplies of women-gathered foods within a radius of three to four miles" (1972:245). A similar situation is described by Kimber and Smith;

> As the days passed and the secondary seed foods - those requiring the greatest labour to collect and prepare - came into use, the senior and middle-aged women let their husbands know that the walking needed for seed gathering had become too much for them, and seed preparation was now a long and tiring process. The young

> men too, were finding large game difficult to procure. These were only gentle pressures, but the men of authority knew that they must not delay any ceremonies. There was a legend of young men who had rebelled, to remind the older men not to demand too much. (Kimber and Smith 1987:236).

From this we might conclude that the pressure that could be applied to women to increase production was limited.

An alternative strategy was storage. Small stores of seeds were often accumulated in preparation for these gatherings to forestall a premature end to the ceremonies. Various methods of storing grain for ceremonies were used - pits, wooden dishes on platforms, skin bags, parcels covered with mud and grass - and these show that the technological constraints were not insurmountable.

However, there was no major commitment to food storage. Such would clearly have posed logistic problems. For instance, grasses and forbs generally set seed when the population is dispersed to exploit outlying parts of their territory. Any stores of seed would have to be cached around predictable water sources and to gain any advantage the grain would have to be transported from areas normally outside of foraging range from these points. Alternatively storage of grain would have to be tied to storage of water.

In summary large gatherings in arid Australia were based upon opportunistic use of periodic natural surpluses rather than upon social production. There is no doubt that large ceremonies made great demands upon women to produce and that "...the seeds of increased demands..." were present but it appears that increased production was subject to strong environmental constraints. Technological solutions, such as large scale storage, that would have allowed increased production would also have entailed a major reorganisation of landuse and we might surmise that changes along these lines would meet significant resistance or inertia.

A final point to consider is that the main focus of ceremonial exchange appears to have been upon material items rather than food. For instance, in the arid zone Mulvaney (1976) notes that food was rarely exchanged and lists sandstone slabs, shell, ochre, pituri, stone, and wooden implements as items consumed by the ceremonial exchange cycle. Similarly, in north-east Arnhemland the appropriate goods included spears, belts of human hair, stone knives, exotic materials acquired from the Macassans, and boomerangs (Thomson 1949). Thus it appears unlikely that an increased demand for exchange goods would directly affect subsistence production, or population density, to the extent postulated in the intensification hypothesis.

Ecological consequences of large ceremonies

Changes in carrying capacity, or extractive efficiency, need not only derive from improvements in technology. Changes in organisation can often accomplish the same end.

In the arid zone it is postulated that reciprocal obligations, kinship networks and mythological links were established by large ceremonial gatherings and that both the ceremonies and the resulting social networks had particularly important economic consequences (Lourandos 1983a:89, 404-405; Bowdler 1981:109; see also Morwood 1986 for southeastern Queensland). These networks - known under the rubric alliance networks - are seen as having two important effects.

Firstly, extensive kinship networks provided the social basis for any redistribution of the population in the event of severe drought. With this proposition there is little disagreement - see Yengoyan (1976:128), Strehlow (1965:124) - though Peterson (1986:50) reminds us that these networks should not be seen exclusively as the product of large ceremonial gatherings. These networks were also important in maintaining the social and biological viability of desert populations.

Secondly, some scholars have postulated that large ceremonial aggregations promoted a more efficient use of periodically super abundant resources such as bunya nuts (*Araucaria bidwilli*), cycads and bogong moths (*Agrotis infusa*), by allowing maximum exploitation. This is a process that Lourandos (1983a:89) likens to a kind of "bank account" operating to convert an irregular resource surplus into widely ramified networks of reciprocity. It is argued that the benefits of this arrangement were sufficient to allow higher regional populations (eg. Morwood 1986) - with reciprocal access to irregular super-abundant resources supporting a pattern of dispersal and aggregation on a regional scale. In essence, what is proposed here is that changes in organisation resulted in a higher carrying capacity.

In addition, Lourandos (1983a:91, 1985) argues that the expansion of this system into the arid zone is associated with the beginning of intensive occupation in the region.

> The archaeologically sudden appearance of intensive and possibly ceremonially based occupation of marginal zones, for example wetlands, rainforests, highlands...and arid zones can be seen as an expansion of already developed and developing social networks into new ground. (1983a:91)

In contrast to this, Peterson (1986:50) states that although ecological conditions make ceremonial aggregations possible their immediate ecological consequences are small. He points out that rights of access to these resources were carefully circumscribed and that these resources were liable to great fluctuations and were not always predictable. Peterson concludes;

> Compared to the cultural intent and content of the ceremonies, the ecological significance...would appear to reside not in any short term adjustments but in ensuring the orderly reproduction of new households by families entering into long term obligations to find wives for their kinsmen. Of course, such gatherings allow people to extend and service their networks which they can draw on in times of need, whether social or economic; but the networks are not dependent on the ceremonial aggregations, whereas the arrangement of marriages is fundamental to the major initiation rites in the least predictable Australian environments. (1986:50).

In the arid zone effective access to localised super-abundant resources was irregular and the large ceremonies were not tied to single plant or animal foods. Thus, although widespread kinship networks enabled large groups to gather, the ceremonies themselves are unlikely to have acted as a mechanism allowing higher regional populations. Furthermore, whilst extensive kinship networks contributed to the social and biological viability of desert populations, these networks existed independently of large ceremonial gatherings - contrast this with southeastern Queensland where resource gluts and large ceremonies are seen as underwriting the social networks (Morwood 1986). Finally, the proposition that the advent of large ceremonial gatherings heralds major economic changes is unlikely to generally hold true for Australia except in unusual situations where resource gluts are complementary in timing, spatially discrete and highly predictable.

DESERT PREHISTORY : A WORKING HYPOTHESIS

In this section I wish to construct a model of desert prehistory based upon a consideration of the processes discussed above. Whilst no model can comprehensively predict the operation of a cultural system I intend it to serve as a heuristic device with which to examine archaeological sequences from the region. My basic premise is that changes in palaeoenvironment will be the dominant factor in structuring events in the arid zone. Some changes would provide new opportunities while other changes would present major difficulties for human groups in the arid zone. In the model I assume that the effects of production pressure do not transcend environmental constraints. My second premise is that population growth will follow a logistic rather than exponential pattern. Whatever methodological problems are attached to the concept of carrying capacity, some concept of population thresholds is fundamental given that resources are finite - see Brookfield (1976).

For convenience I have also constructed this model as if desert prehistory were not contingent upon changes in neighbouring more humid regions. That is, as if it were more or less closed to the effects of ecological changes in adjacent regions, such as eustatic fluctuations, or simply the off-loading of surplus population. Thus the model is most closely applicable to regions isolated within the arid zone - such as the Pilbara and the Central Australian ranges - rather than peripheral parts of the arid zone - such as the Nullarbor plain or the Victorian mallee.

Time frame of the model.

Given the palaeoenvironmental conditions reconstructed for the *lacustral phase* I assume that colonisation of the interior of the continent took place sometime before 30,000 yrs BP. I have therefore discounted the *coastal colonisation hypothesis* and also Horton's (1981) model.

Predicted impact of environmental changes on landuse.

If we ignore, for the moment, the changes in carrying capacity likely to have accrued from improvements in technology - such as skin water-bags, wells, patch burning, dams, and seed-grinding implements - we can estimate the impact of the palaeoenvironmental changes over the last 30,000 years. For the *lacustral phase*, with its abundance of freshwater but slightly depressed temperatures, access to land would be relatively free of the constraints imposed by the spatial and seasonal patterning of water resources and the pattern of landuse may well have been tailored to the seasonal availability of particular bush foods.

The conditions at 18,000 yrs BP - increased seasonal and diurnal contrasts, saline groundwater, strong winds, rainfall reduced by 50%, mean annual temperatures depressed by 7°C - would have imposed very strong constraints on human populations. The conditions of aridity and low temperatures are precisely those one would predict as creating the most hardship. Biological productivity would be lowered and the country accessible from the permanent waters would lack plant foods, and be deficient in small game including reptiles. Movement between watering points would be dictated by exhaustion of the food supply even if the water-supply itself was reliable. Access to country away from the main waters may have been infrequent as rainfall was low and the high rates of evaporation would quickly have depleted any shallow standing water. The same factors would also have reduced the number of reliable watering points in the landscape. Under these conditions the population, if any, would be restricted to foraging in areas with the most dense grid of reliable watering points and with the greatest diversity of micro-habitats - areas such as the major range systems (MacDonnell ranges, the Pilbara, southern Kimberleys and Flinders ranges).

The pattern of landuse would probably be of opportunistic movement between these reliable waters rather than the present pattern of aggregation and dispersal around them.

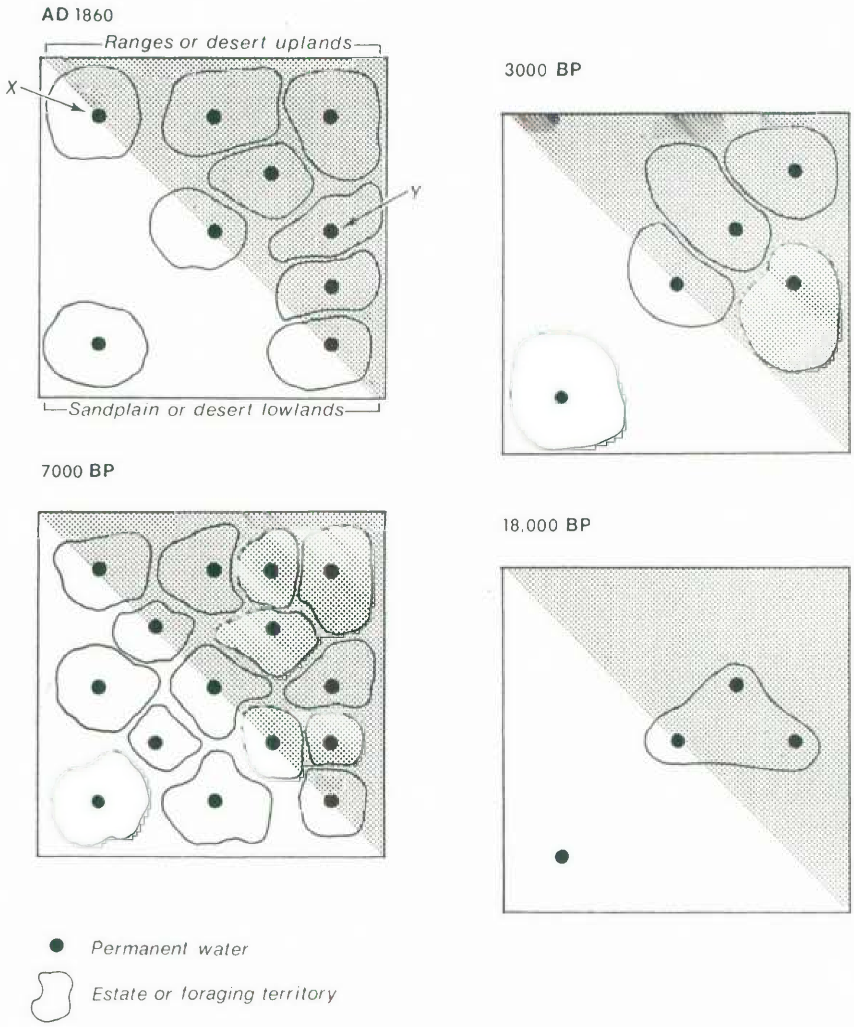
Overall, the population is likely to have been low and clustered in a few favourable regions. We do not have enough information to speculate on whether or not these populations would be demographically or socially viable.

The warmer and wetter conditions prevailing during the early Holocene are likely to have seen the establishment of a pattern of landuse similar to that in the ethnohistoric period. The distribution of reliable watering points would have been greater - some playa lakes contained large bodies of water - and biological productivity is likely to have been higher. We might also assume that access to outlying parts of a territory was more frequent. Under these conditions the imperative to move from a watering point, because the local bush foods are depleted, is reduced. It is likely that permanent occupation of most of the arid zone was possible, that estates or territories were more closely spaced, that mobility was reduced, and that the overall population density was high.

The late Holocene situation, from 4000-1500 yrs BP, involves a recalibration of the ethnohistoric pattern rather than any fundamental change. The period before 1500 yrs BP appears to lack the closely spaced high-rainfall events that mark the present regime, and extreme perturbing events such as droughts were more frequent. This suggests that some waters, which are identified as the focal points for estates in the ethnography, would have been less reliable before 1500 yrs BP. I envisage a restructuring of landuse after 4000 yrs BP such that the number of reliable watering points decreased somewhat, the number of estates correspondingly declined, and places that were previously base camps became simply temporary camps in the outlying parts of other estates. Accordingly one would predict a lower population for the period 4000-1500 yrs BP than for 10,000-4000 yrs BP. The establishment of the ethnographic pattern of settlement, after 1500 yrs BP, would have involved a partial reversal of this change, with some ephemeral camps again becoming base camps, with correspondingly more intensive occupation of the arid zone.

The predicted changes in settlement pattern and landuse are shown schematically in figure 2.3.

Overleaf **Figure 2.3 :** The gross impact of changes in environment upon landuse and settlement. **18,000 yrs BP :** the few permanent waters are concentrated in the ranges. Movement is between permanent waters. Some areas with permanent but isolated waters are unoccupied. **7000 yrs BP :** the widespread distribution of permanent waters allows the establishment of estates/foraging territories throughout the region. Movement now conforms to the ethnographic pattern of aggregation and dispersal around permanent waters. **3000 yrs BP :** the number of permanent waters is reduced. Some previously permanent waters are now ephemeral watering points in outlying parts of estates. **The ethnohistoric pattern :** Estates/foraging territories are focussed upon permanent watering points and are most closely spaced in the ranges. Some lowlands are not densely occupied. Some previously ephemeral waters have switched back to become permanent waters and are again the focus of an estate. An archaeological site near Y would show continuous occupation whilst the sequence from a site near X would show major fluctuations in use.


AD 1860
Ranges or desert uplands
X
Y
Sandplain or desert lowlands
3000 BP
7000 BP
18,000 BP
Permanent water
Estate or foraging territory

Effects of improvements in subsistence technology.

Any changes in carrying capacity accruing from improvements in technology will reduce the impact of the environmental changes upon population density. However, despite any trend towards economic intensification the population would still face the major problem of availability of water. Therefore I assume that the impact of the environmental changes will not be totally offset.

This brings us back to a consideration of how a hunter-gatherer population would respond in the long term to a decline in its resource base.

On one hand, there is the familiar scenario of a hunter-gatherer population stabilised at a level well below carrying capacity. Favourable environmental changes may increase the productivity of the environment allowing the population to stabilise at a higher level but the overall relationship between population density and resources is maintained. Jones (1985:294) provides an example from western Arnhemland where a substantial late Holocene increase in population is related to the development of large freshwater swamps in the region.

On the other hand, this scenario is rarely applied to a situation where an otherwise stable population is faced with a diminishing resource base. To judge from the palaeoenvironmental evidence, this must periodically have been the case in the arid zone. In this situation several outcomes can be postulated, depending upon the magnitude and speed of the environmental deterioration and upon the distribution and density of the population. Firstly, migration or redistribution of the population is an obvious response provided that opportunities for long-term re-settlement exist. If this is not possible and if faced with a major environmental change that occurs within a short span of time a catastrophic population crash is likely. Alternatively, a gradual or progressive deterioration would cause human groups to intensify their use of resources and their management of the land. The latter response involves a recalibration of the relationship between population levels and resources.

For the model I assume relatively low population densities and a patchy distribution of population before 25,000 yrs BP. This would have allowed greater opportunities for migration or redistribution, when faced with increasing aridity from 25,000-18,000 yrs BP.

Population growth in the early to mid Holocene may have resulted in demographic packing and closed off these options. The difficulties imposed by a diminishing resource base about 3000-5000 yrs BP would now have to be met in situ resulting in either mortality or some form of economic intensification. This is precisely the period in which one finds the beginnings of labour intensive techniques such as seedgrinding in the arid zone, the leaching of cycads in the Queensland highlands and the construction of eel traps in western Victoria. One might speculate that the sequence of population growth and expansion followed by environmental decline is likely to make this period one of the most interesting in the Holocene. Similar ideas have been proposed by Rowland (1983) and Lourandos (1983a) for western Victoria and (1983b) for Tasmania.

In the arid zone it is plausible that this sequence of events led to innovations such skin water-bags, deep wells, dams, and seedgrinding, although we only have direct archaeological information on the last. These are all developments which would either maintain access to outlying parts of a territory or which would increase the harvest of plant foods accessible from watering points. The intensive use of seeds would certainly result in higher population densities after 3000-4000 yrs BP than would have been predicted using the palaeoenvironmental data alone. It follows from this that the subsequent response to climatic amelioration from 1500 yrs BP might also be greater than otherwise assumed.

The predicted changes in population density are shown schematically in figure 2.4.

Factors acting to amplify the impact of environmental changes.

There are other factors that could be expected to accentuate or amplify the impact of the environmental changes - here I am thinking of what Clarke (1978:48) terms unstable equilibrium, that is a situation in which a small displacement from equilibrium gives rise to a cumulatively greater displacement.

The first of these is humanly-induced environmental degradation. One might expect that the time lag between the beginning of an arid phase and a fall in population density would lead to significant localised environmental degradation. This might include the denudation of areas around important waters of firewood. Animal species sharing the remaining fall-back waters

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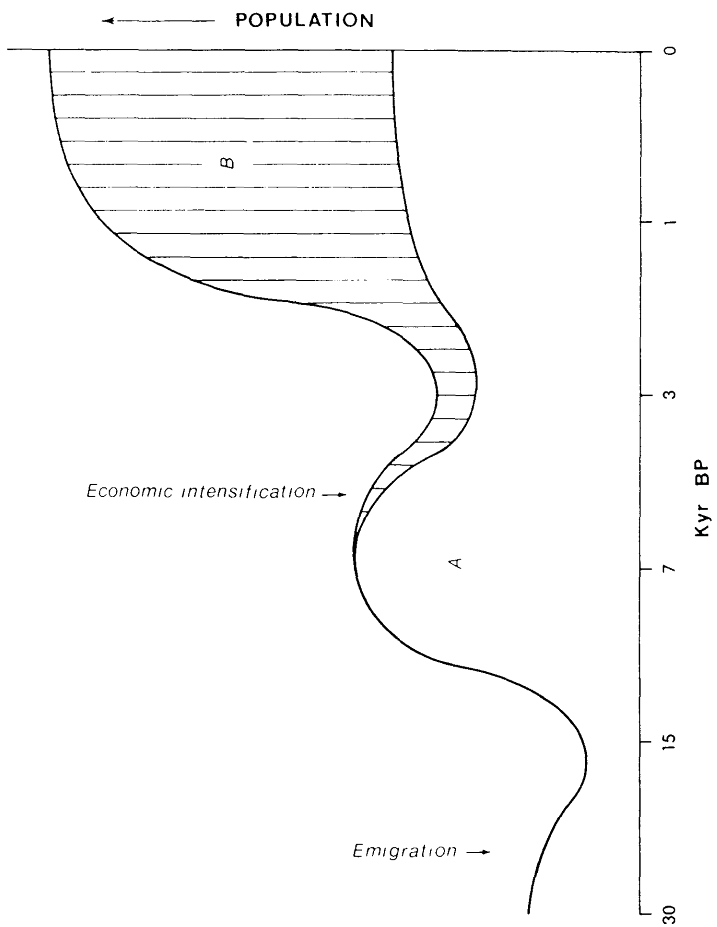
Overleaf **Figure 2.4 :** Predicted changes in population density in the arid zone. (A) represents gross changes resulting from environmental fluctuations. (B) represents the additional impact of improvements in subsistence technology.


POPULATION
Kyr BP
0
1
3
7
15
30
A
B
Economic intensification
Emigration

might face extinction. Excessive firing might prevent vegetation from regenerating - see Martin (1973) for an example of this at 4000 yrs BP on southern edge of the Nullarbor plain. The net result could well be that any climatically induced ~~environment~~ environmental deterioration was accentuated and accelerated so that the impact upon the human population would be greater than otherwise predicted.

The converse of this is that during periods of beneficial environmental change and of expanding population, human modification of the environment might increase its productivity. I have in mind here what Brookfield (1986:179) terms <u>landesque capital</u>. For instance, patch burning might create a mosaic of different habitats and thereby increase the number and diversity of useful plant and animal species. Once this mosaic is established it may only require a small amount of regular attention to maintain and it may represent a large increase in productivity. A population expanding into newly accessible areas may therefore set in train changes that amplify the new environmental opportunities.

Summary.

The following scenario is the baseline for the archaeological inquiry.

It is likely that the first human movements into the region took place in the Pleistocene, probably before 30,000 yrs BP, at a time when the interior of the continent did not pose any special problems for human settlement. These early populations may have been patchy in their geographic distribution but the nature of the environmental or demographic constraints operating at this remote time are not known. Increasing aridity, and lower temperatures, from 25,000-18,000 yrs BP would have had a considerable impact causing the population of the region to decline. Human groups would be small and highly mobile and their range would be restricted to the major desert uplands and riverine corridors.

A major expansion of occupation throughout the arid zone is likely to have taken place in the early Holocene, in response to optimal environmental conditions peaking around 6000-7000 yrs BP. The filling of the arid zone with Aboriginal groups foraging in all parts of the region would have closed off various options, such as migration, when arid conditions returned at 3000-4000 yrs BP. The problems caused by a diminishing resource base would now have to be met in-situ. Opportunities to diversify were probably few as a broad-spectrum subsistence pattern could be expected to be already in place. However, there were various technological avenues towards preserving the status quo, such as water bags, dams, wells and seedgrinding implements. More intensive use of seeds probably offset the falling productivity of land accessible from the permanent waters. Waterbags and deep wells maintained access to outlying country.

Despite this response, the combined effects of humanly induced environmental degradation and the decrease in number of watering points is likely to have caused a decline in population density, and some reduction in distribution. These effects would be more marked in the lowlands than in the desert uplands. The small amelioration of climate at 1500 yrs BP, characterised by more frequent high rainfall events, would allow the population to again reoccupy some, but not all, areas. The pattern of intensively exploiting seeds, begun several thousand years earlier, would now provide the basis for much higher population densities than the environmental conditions would otherwise allow.

Thus the prehistory of the arid zone is likely to register substantial changes in both population density and population distribution. The overall scenario is one of alternating periods of wetter and drier conditions operating to enlarge and contract the available living space for desert populations and affecting the quality of life within it. The process of abandoning and subsequently re-colonising parts of the desert is likely to have involved many small dramas such as that played out by Tjapaltjarri in 1984. Tentative contact between long separated groups of people may often have begun in a similar way. A family moves back into empty country and one night an unfamiliar voice just beyond the firelight softly frames one crucial word - kapi - water.