10 THE PATTERN AND TIMING OF SETTLEMENT IN THE ARID ZONE

It is now time to return to the basic questions, identified at the beginning of this thesis, about the pattern and timing of human settlement in the interior of the Australian landmass. In chapter 2 I have reviewed the various ideas that have been aired about the prehistory of the arid zone and about the processes controlling cultural change in the region. I went on to examine these against the detailed ethnography available and against the pattern of environmental change revealed in palaeoenvironmental data. It is now appropriate to review direct archaeological evidence from the arid zone. At present the only way to effectively integrate the patchy archaeological data is to rely upon an ecological framework - such as that established in chapter 2 of this thesis. Using this as my frame of reference I have set out to combine a synthesis of the data from Central Australia with a broad overview of the changes recorded in archaeological sequences from other parts of the arid zone.

EVIDENCE FOR WIDESPREAD PLEISTOCENE SETTLEMENT

The dispersal of human populations into the arid zone before 10-12,000 yrs BP is now well attested by pleistocene dates for occupation in a variety of regions; including montane and piedmont areas such as the Central Australian ranges, the Pilbara and the Flinders ranges; desert lowlands such as the Strzelecki dunefield; arid littoral regions such as the southern section of the

Nullarbor plain; and riverine or lacustral tracts such as the Willandra lakes. In figure 10.1 I have plotted the distribution of pleistocene sites against the extent of desert dunes in the interior of the continent. This serves to demonstrate that the interior was widely settled by 12,000 yrs BP.

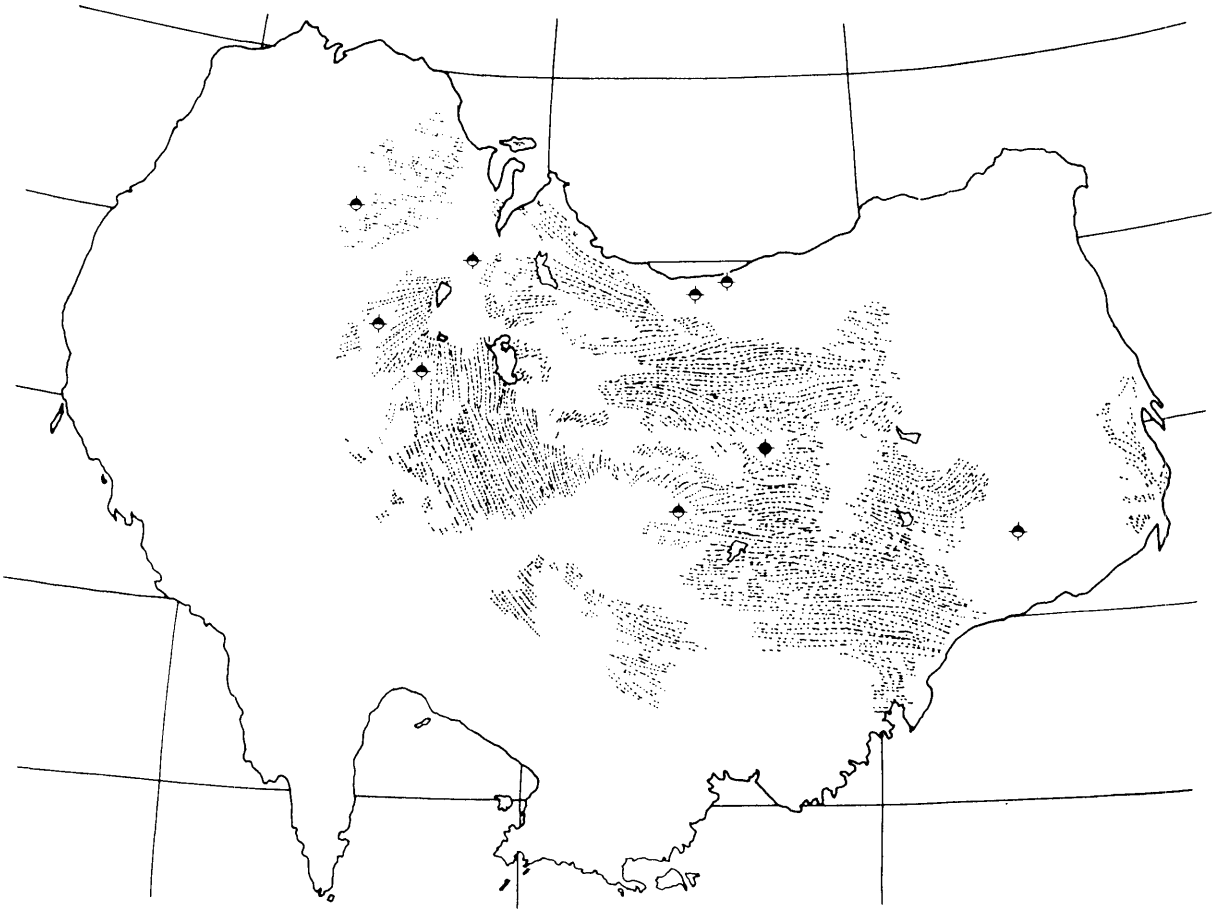
The timing of initial settlement.

The earliest dates for settlement in the arid zone, apart from those in the Willandra lakes/Darling basin region, fall in the period 20,000 - 30,000 yrs BP. This suggests that Bowler (1976) and Jones (1979) are correct in their view that the first human movements into the interior of the continent took place during the lacustral phase, when surface water was more freely available. A brief review of the evidence for occupation before 20,000 yrs BP is presented below.

Puritjarra rockshelter

The radiocarbon dates for occupation at Puritjarra rockshelter indicate that the central interior of the continent was settled by 22,000 yrs BP, about 12,000 years earlier than previous studies in this region (Gould 1977, 1978) have shown. This should now dispel the view that previous discoveries of pleistocene occupation elsewhere indicate only limited early settlement of the desert periphery.

Overleaf **Figure 10.1 :** The distribution of sites known to have been occupied before 12,000 yrs BP in the arid zone, plotted against the major continental dunefields. The distribution of the latter provides some measure of the maximum extent of arid conditions during the last glacial maximum. The site of Puntutjarpa, with a basal age of about 10,000 yrs BP, is included for general reference (shown as solid symbol).



The earliest occupation so far identified at Puritjarra, need not represent initial occupation of the region and there are several reasons for expecting that earlier evidence will ultimately be found.

Firstly, human use of the shelter first becomes archaeologically visible at a time when the favourable conditions of the lacustral phase are drawing to a close and when the interior is presumed to be progressively deteriorating as a human environment. This then is a period when throughout the interior of the continent we might expect human settlement to be contracting. It is an unlikely time for colonisation of the central interior of the continent to take place - unless one takes the view that such moves would be triggered by the contraction of favourable environments on the fringes of the desert. It is also a period when small populations attempting to colonise a new area might face a greater chance of extinction. It is more likely that the first use of Puritjarra, a site located near an important fall-back water, represents the type of adjustments to the harsh conditions of the last glacial maximum that I predicted in chapter 2. These would have lead to a settlement pattern increasingly tethered to reliable watering points in the ranges and hence an increase in archaeological visibility in sites such as Puritjarra rockshelter. The determinants of settlement before 22,000 yrs BP are likely to have been quite different and this is an issue that future work will need to address.

Secondly, there are practical limits on our ability to discover ancient sites using conventional field strategies. This is well illustrated in figure 10.2 which shows that the date of 22,000 yrs BP for occupation in Central Australia is now

comparable to the earliest dates for occupation yet found in many parts of eastern and northern Australia.

The Pilbara

The results from Central Australia complement earlier discoveries of pleistocene occupation at two rockshelter sites in the eastern part of the Pilbara (Brown 1987). These sites are on approximately the same latitude as Puritjarra and preserve a record of early occupation in a comparable montane and piedmont region on the opposite edge of the Gibson desert.

The first of the sites to be discovered was the Newman site - site P0187 in the Western Australian Museum system - excavated in 1976 by Maynard and Wright (Maynard 1980). Radiocarbon dates indicate a minimum basal age for the excavation of 20,740+/-345 yrs BP (SUA 1041) and deeper, as yet unexcavated, deposits are reported to be present. The unexpectedly early results from this excavation were corroborated by the discovery of a second site with pleistocene occupation (Troilett 1982; Brown 1987). This is a rockshelter in Ethel gorge - site P02055.2 - in which the lower levels of a small excavation produced evidence of occupation dated to 26,300+/-500 yrs BP (SUA1510). Here again the full depth of the deposit was not plumbed and older cultural remains are probable.

Both of these sites are located near the upper reaches of the Fortescue river - an intermittent river which drains into the Indian ocean - and are about 500 km from the 200 m isobath which

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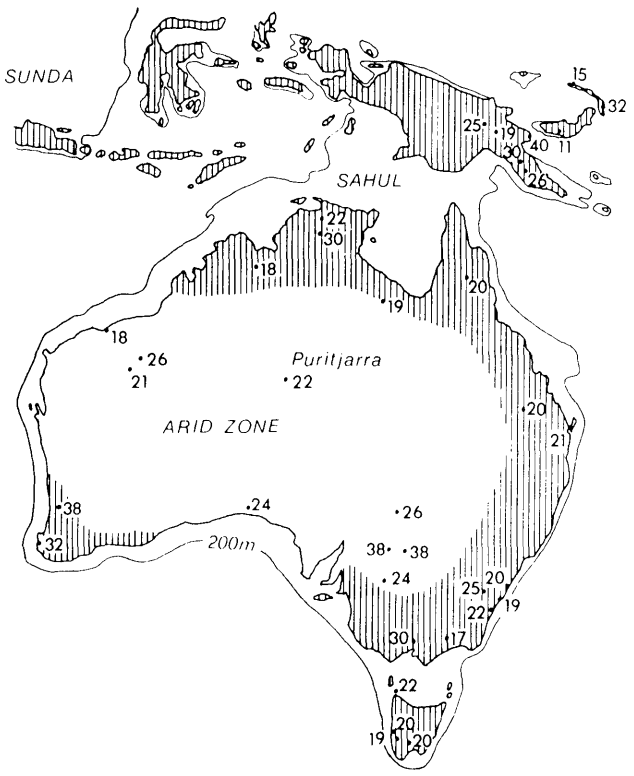
Overleaf **Figure 10.2 :** The earliest dates for human occupation in the various parts of Greater Australia, expressed in kyrs. After Jones (1987).


SUNDA
SAHUL
Puritjarra
ARID ZONE
200m
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32
25
19
40
11
30
26
22
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18
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20

approximates the pleistocene coastline at 20,000 yrs BP. Given this distance from the coast and their location on the western margin of the Gibson desert there should be little doubt that they represent evidence of the dispersal of human groups into the interior during the pleistocene.

Apart from this, however, the sites are not well situated to reflect changes in occupation of the region. Both sites are rockshelters eroded under the edge of the hard caprock on hills in the region and are well above the level of the local floodplains - where one presumes that most resources were to be found. As a result the rockshelters show only intermittent, light use - as one might be expect if they served as an occasional hunting station or wet weather bivouac. This low level of use is emphasised by the preservation of intact hearths throughout the stratigraphy of both sites, despite the low rates of sediment accumulation that have prevailed. Finally Brown (1987) reports that at both sites the number of artefacts is consistently low throughout the period of occupation and that no trends in artefact density over time can be detected.

Other early sites in the arid zone

Other early sites in the arid zone - such as those in the Darling basin or along the Nullarbor coast - are in situations where coastal and lacustral resources were available during the pleistocene. Although the extent to which these resources contributed to local subsistence is not known, it has raised the question as to whether these sites reflect an early adaptation to arid conditions or whether they simply record the use of favourable habitats on the fringes of the arid zone.

The arid coastal fringe of the Nullarbor plain has produced evidence of human occupation dating back to at least 22,000 yrs BP. High quality flint was quarried in Koonalda cave from 22,000 - 15,000 yrs BP (Wright 1971) and subsequent investigations have show occupation at another site - a limestone doline near Eucla called N145 - by at least 20,200+/-1000 yrs BP (ANU 1042) (Martin 1973). Both of these sites are presently within a narrow strip of arid woodland, about 30-35 km wide, sandwiched between the treeless plain to the north and the coast.

In the ethnohistoric period human populations in the region were dependent upon the resources of this woodland and of the adjacent coastline. From the information summarised in Wright (1971:1-6) it appears that coastal resources such as seals, penguins, fish and shellfish may have been as important as small game and plant foods in the subsistence economy. One feature of the region which serves to emphasise its distinctiveness from other parts of the arid zone is that wild seeds were not harvested or processed into flour, nor are seedgrinding implements present in local artefact assemblages. Another distinctive feature is that the population of the region was very low. It is estimated to have been about one person per 490 km^2 (Wright 1971:1) which is much less for instance than the 1 person per 200 km^2 estimated for the Pintupi in some of poorest parts of the interior (Long 1971:264).

At the time they were first used both Koonalda cave and N145 were about 160 km from the pleistocene coastline. Pollen evidence cited in Martin (1973) shows that both sites would have been surrounded by the treeless plain, which extended further southwards as the coastline, and the associated belt of woodland,

advanced onto the continental shelf. The treeless plain is known to have been a difficult environment for Aboriginal people to traverse (Wright 1971:11-12) as its aridity is accentuated by the karst landscape and the lack of drainage lines. Nevertheless both Koonalda and N145 were visited at the height of the aridity of the the last glacial maximum. This would have involved a foray of over 100 km from the edge of coastal strip where one presumes the pleistocene population must have been concentrated, and thus demonstrates some ability to use the resources of the arid hinterland.

From the Darling basin a series of archaeological sites - including burials, a cremation, hearths and small shell middens - provide evidence for occupation between 20,000 - 30,000 yrs BP (Bowler et al 1970; Allen 1972; Barbetti and Allen 1972; Bowler et al 1972, Hope et al 1983; Allen 1986). Whilst this area is arid or semi-arid the rivers that drain the Darling basin have their headwaters in well watered country in the eastern highlands. Bowdler (1977:223-224) was able to characterise early occupation of the region as a coastal economy "transliterated" to a freshwater situation. In support of this she pointed out that the numbers of fish, land mammals, lizards and birds from Mungo 1 - dated to 26,250+/-1120 yrs BP - form roughly the same proportion of the faunal assemblage as at the Bass Point shell midden on the New South Wales coast.

As the results of the first phase of archaeological work in the Willandra lakes region (see Shawcross and Kaye 1980) are still all that is available in any detail it is difficult to further evaluate the extent of the contribution of lacustral and riverine resources - such as fish, shellfish, crustaceans and waterfowl -

to the subsistence of these pleistocene groups. Most sites appear to represent ephemeral lakeshore camps and the archaeological remains range from thin bands of shell to complexes of thin shell middens, hearths and scatters of fish otoliths, crustacean gastroliths, and animal bone - the latter including small land mammals, lizards and birds. In addition archaeological surveys have essentially focussed on the sedimentary sequences provided by the lakes and ancient shorelines and the extent of pleistocene use of the arid hinterland is unknown. Lourandos (1985:394-395) concluded that the available evidence did not indicate intensive exploitation of lacustrine resources. A similar view is put by Allen (1986) in a recent review where he concluded that the Willandra lakes sites at this time were probably used by a small localised population with a generalised hunting and gathering economy, opportunistically tapping into the resources of the lakes and nearby plains. This is an aspect of the Darling basin sequence which the results of the later phases of fieldwork will presumably do much to clarify when they become available.

A similar situation is represented by the site at Lake Yantara on the extreme northwestern margin of the Darling basin (Dury and Langford-Smith 1970). Here a hearth dating to 26,200+/-1100 BP (GAK 2121) was found near the level of the highest strandline. The hearth is described as a hard indurated circular mound of charcoal and carbon-rich sand rising some 12 inches above an eroded area. Chipped stone artefacts were noted on the eroded surfaces nearby but no further work appears to have been carried out and the internal structure of the feature was not examined.

Discussion

The above review serves to underline the strategic importance of the discovery of pleistocene occupation in Central Australia. Without this, evidence for the early dispersal of human groups into the arid interior is equivocal. The Pilbara sites have evidence of only light, intermittent occupation. Occupation of the Nullarbor coast and the Darling basin could be construed as oriented towards particular aquatic habitats rather than the surrounding arid country. The evidence from Puritjarra however corroborates the earlier discoveries in the Pilbara and suggests that in fact human groups had dispersed throughout the arid zone by 22,000 yrs BP. From this perspective the evidence from the Nullarbor and the Darling basin could be seen as the regional expression of a generalised foraging economy rather than simply the extension of specialised coastal or riverine groups into favourable habitats on the margins of the arid zone.

Economic adaptations.

If the initial dispersal of human groups into the interior of the continent took place in the lacustral phase, as I have suggested, it is unlikely that any special adaptations were necessary for this settlement to take place. The aridity of the region can be presumed to have been offset by the widespread availability of freshwater, to the extent that the interior did not pose particular problems for settlement.

Apart from the Darling basin sites there is no direct evidence concerning the economic orientation of these colonists. As suggested by Golson (1971) some ecological knowledge about the plant species of the arid interior would have probably been gained

by a sojourn in northern Australia, where many important arid zone plant species are represented alongside the Indo-Malaysian elements of the flora. However, as I have shown elsewhere (Smith 1985, 1986a) there is no evidence to indicate that the first human movements into the arid zone were connected with the ability to use acacia and grass seeds. Certainly grindstones are present amongst pleistocene assemblages in northern Australia, the Darling basin and elsewhere, but it is not known at present whether they were used for processing plant foods. After examining the key specimens I concluded that their morphology and usewear identified them as expedient implements, with lightly abraded surfaces such as might result from the casual preparation of a variety of materials such as pigment, bush tobacco, cartilage and bone meal, pulped fruit or nuts, fibre, or from use as an abrasive implement in the finishing of wooden artefacts.

The lower temperatures that prevailed during the lacustral phase also suggest that some alternative plant foods such as Ipomoea would have had a more restricted distribution throughout the interior than today. Even today these tubers are restricted in their distribution to the northern half of the arid zone.

Away from the Darling and Cooper river systems the interior of the continent was never rich in resources compared to the floodplain, swamp and estuarine environments of northern and eastern Australia. One element of the technology that may have been important in determining the rate at which settlement spread into the interior is fire. Many important plant and animal species in the arid zone are likely to have been favoured by the mosaic of habitats, in different seral stages, which is promoted by regular

human firing of the country. It is possible therefore that the rate at which human groups expanded into the region may have been governed by the time required for a productive "patchy" ecosystem to become established on the frontier of settlement. How long this might take in a virgin region where the flora and fauna were adapted to a different fire regime is open to conjecture.

The impact of the Last Glacial Maximum.

Environmental conditions during the height of the last glacial maximum, at about 18,000 yrs BP, would not have favoured human settlement in the interior of the continent. The period from about 22,000 - 15,000 yrs BP was marked by increased seasonal and diurnal contrasts, saline groundwater, strong winds, an intensification of aridity and significantly lower mean annual air temperatures. Bowler (1976:73) suggested that at this time parts of the arid zone would have become uninhabitable.

In chapter 2 I have examined in detail the likely effects of these environmental changes. They would have had a major impact upon two aspects of human settlement in the interior of the continent. Firstly, the thinning out of watering points would have left many parts of the arid zone inaccessible to human groups. Human populations would have largely been restricted to the major montane and piedmont regions or major riverine tracts - areas with the highest density of reliable watering points. The desert lowlands, in particular the major areas of sandy desert or stony plains, would have been abandoned. Secondly, the availability of both animal and plant foods per unit area would have decreased and opportunities for dispersing across the country to forage away from the major waters may have been rare. Therefore, the annual

subsistence round is likely to have involved frequent movement between major waters, rather than the ethnographic pattern of seasonal aggregation and dispersal around permanent watersources.

The net result of these changes would be that groups would be highly mobile and each would need a relatively large foraging territory, containing a suite of reliable waters. How well does the available archaeological evidence for the period 22,000 - 15,000 yrs BP support this scenario ?

Puritjarra rockshelter

I have already suggested above that the first use of this rockshelter is explicable in terms of a reorganisation of the pattern of settlement towards one tethered to major waters. This can be supported with the observation that Puritjarra is located in part of Central Australia where a network of permanent waters would have given pleistocene groups the ability to range over a substantial area even during the arid conditions that prevailed between 22,000 -15,000 yrs BP. For instance, the location of the site near Murantji rockhole places it on the western edge of a network of permanent waters spaced about 25-50 km apart - most of which served in more recent times as major fallback waters during protracted drought. To the northeast of Murantji are Putarti spring, Mt Liebig rockhole and Talipata spring. To the east lies the waterhole and soakage at Tjungkupu and from this, via springs and waterholes on the western end of the Gardiner range, the series of important waters along the George Gill range - at Lila, Ipidilkiti and Wanmara - are ultimately accessible. Less accessible to these pleistocene groups, except during a good season, would have been Ilpilli spring which lies 70-80 km to the

northwest in the Ehrenberg range.

The archaeological evidence from Puritjarra for the period 22,000 - 15,000 yrs BP suggests rather fleeting use of the shelter, with much lower artefact densities than at any stage during the Holocene. This is also in accord with the pattern of landuse we might expect at this time.

The final observation to be made about the pleistocene occupation at Puritjarra is that some use of the shelter continued throughout the period from 22,000 -15,000 yrs BP. This indicates that human groups continued to occupy the heart of the continent throughout the harsh conditions prevailing at this time.

Other montane and piedmont regions

In the Pilbara, both the Newman and Ethel gorge sites also show that occupation continued throughout this period, though neither site provides any useful information on changes in settlement patterns at this time. In addition to the radiocarbon dates reported for the Newman site by Maynard (1980) a further date - 9870+/-80 (SUA 2553) obtained obtained on charcoal from a hearth in spit 6 - confirms that the stratigraphy at this site preserves an uninterrupted record of deposition from at least 20,740+/-345 yrs BP (SUA 1041) to the present.

In the northern part of the Flinders ranges - which project into the arid zone from more temperate regions - Lampert and Hughes (1980, 1987, in prep; Hughes and Lampert 1980; Lampert 1985) have produced evidence which suggests that pleistocene settlement was restricted to the ranges at this time. This pattern was relaxed sometime between 15,000 - 10,000 yrs BP as the

climate ameliorated and people moved out onto the plains to occupy sites along the western edge of Lake Frome.

The key archaeological sequence is from Hawker lagoon. This is a large open site, near a swamp, with two distinct stone industries eroding from different strata in a lunette. The earlier industry is one characterised by distinctive large cores and block implements, known as the Kartan industry and thought to be largely terminal pleistocene in age. At Hawker lagoon the Kartan artefacts are provenanced to a horizon dated to 14,770+/270 yrs BP (SUA 2131). Above this there is an erosional disconformity. Given the absence of artefacts in a lag deposit on the erosional surface here Lampert and Hughes (in prep.) suggest that the Kartan occupation did not persist much after 15,000 yrs BP.

The evidence from Hawker lagoon is supplemented by data on the geographic distribution of the industry, which is restricted to the ranges and does not extend into the surrounding plains and dunefields. Thus Lampert and Hughes (1987, in prep.) argue that the comparatively well watered ranges were an outpost of human settlement in the region during the late pleistocene, with people making occasional forays into the surrounding plains as the stressful arid conditions of the last glacial maximum ameliorated.

Other regions

On the Nullarbor plain occupation of rockshelters and dolines fluctuated in line with eustatic changes. For instance, there is very little evidence at N145 for occupation between 17,000 and 15,000 yrs BP - a time when the coast with its strip of littoral woodland was at its most distant (Martin 1973:302). Use of N145 and other occupation sites such as Madura and Norina increased

sharply about 6,000 - 4,000 yrs BP as the coast stabilised at its present position, closer to these sites (Martin 1973; Milham and Thompson 1976).

This sharply contrasts with the pattern of use at Koonalda cave - a quarry rather than an occupation site. At Koonalda traces of human activity are present from 22,000 - 15,000 yrs BP (Wright 1971:28). Although this neatly coincides with the harsh conditions of the last glacial maximum the reason for use of the site at this time is unclear. It would have been at its greatest distance from the coastline and surrounded by the treeless plain. Permanent standing water was certainly accessible in a few deep caves, such as Koonalda, but Wright (1971:3-4) hinted that the potability of this underground supply may not have been good because of dissolved salts in the groundwater and lack of replenishment from rainfall at this time. As an alternative reason for use of the cave at this time he suggested that other sources of flint may not have been available until changes in sea level formed the present line of sea cliffs (1971:15). Perhaps, however, we should reconsider the possibility that it was the water that was sought at this time. Might not there have been a substantial time lag between the onset of arid conditions and any subsequent deterioration of water quality in the deep caves - especially when one considers that large reserves of freshwater may have been built up during the preceding lacustral phase ? Quarrying activity in the cave does not appear to have been intensive and so does not rule out the possibility that procurement of flint was secondary to the availability of water.

Colless creek rockshelter, located in semi-arid country near the junction of the Barkly tableland and the Carpentaria plain, also registers changes in site use between about 17,000 - 14,000 yrs BP (Hiscock and Hughes 1980; Magee and Hughes 1982; Hughes 1983; Hiscock 1984). This site is located in a gorge system with permanent water and tropical gallery forest. The deposits in the shelter consist of two stratigraphic units separated by a major disconformity. The upper unit began to accumulate shortly before 17,290+/-470 yrs BP (ANU 2331). The lower unit is undated but is estimated to be contemporary with the lacustral phase.

The most intensive use of the shelter occurred between 17,000 - 14,000 yrs BP (Hiscock 1984:147). During this period only locally available chert was used in the manufacture of stone artefacts. Other raw materials, such as quartzite and greywacke, from sources on the Carpentaria plain are not present in levels dating between 17,000 - 14,000 yrs BP. At this time Colless creek rockshelter lay within the bounds of an expanded arid zone and was about 900 km from the pleistocene coast. Hiscock (1984:135) suggests that the greater aridity would have posed logistic problems for the use of resources on the plains and plateau, outside the comparatively well-watered gorge system.

In the Darling basin, from 22,000 - 15,000 yrs BP the previously freshwater Willandra lakes system was in an oscillatory, highly saline phase. After 15,000 yrs BP the entire system became inactive. However, Allen (1986, 1972:329-338) was not able to detect any evidence for major changes in site use, faunal or artefact assemblages or in the location of sites over the period the lakes were operative. The one exception to this is that the majority of shell middens date to around 15,000 yrs BP -

the final drying phase of the lake system (Hope et al 1983:51-52).

Discussion

The new evidence from Puritjarra rockshelter corroborates earlier findings that human populations survived in certain favourable environments in the interior throughout the harsh conditions of the last glacial maximum. The persistence of human settlement throughout this time period provides some indication of the adaptability of these early human groups. That other, less favourable parts of the interior were abandoned seems likely but we lack any long archaeological sequences from the major areas of sandy or stony desert to test this suggestion. The best evidence at present to indicate that settlement contracted to certain favourable environments is the restricted distribution of the Kartan industry in the Flinders ranges, and the evidence from Colless creek rockshelter. However, further work towards resolving persistent problems with the identification, interpretation and chronology of Kartan assemblages (see Lampert 1981; Gorecki et al 1984; Draper 1987) may eventually alter the picture of the Kartan as a terminal pleistocene industry.

The low level of occupation of Puritjarra rockshelter during this period is consistent with its use by a small, highly mobile population. The pattern of landuse may have been structured along the lines that I have suggested but there is insufficient empirical evidence from either Puritjarra or contemporary sites in other montane and piedmont regions to test this.

In other parts of the arid zone the effects of the last glacial maximum upon settlement were varied. On the Nullarbor

plain the pattern of settlement has clearly responded to changes in the proximity of the coast and its strip of littoral woodland. For the Willandra lakes system the focus of archaeological work on lake margins makes it difficult to gauge the impact of environmental changes at this time. The lake system continued to be operative throughout this period and occupation of the lake shores continued until the system dried up around 15,000 yrs BP. Information as to whether use of the arid hinterland declined between 22,000 - 15,000 yrs BP and whether the population was increasingly dependent upon lacustrine resources at this time is not yet available.

AN EXPANSION OF SETTLEMENT IN THE EARLY HOLOCENE ?

From 15,000 - 7,000 yrs BP the arid conditions of the last glacial maximum were progressively relaxed. Bowdler (1977), Horton (1981) and Lampert and Hughes (1987) all agree that this is a period when we could expect an expansion of settlement in arid Australia, with people either recolonising previously abandoned parts of the region or occupying other areas for the first time. The conditions reconstructed for the early holocene suggest that optimal conditions for human settlement in the arid zone were reached around 6,000 - 7,000 yrs BP. The warm and moist climate at this time would have favoured an increase in the availability of plant foods. Thus it is a period when we could expect to find an increase in population density as well as in the range of human populations in the arid zone. The archaeological evidence reviewed below shows some changes along these lines but information for the early holocene is generally sparse.

Evidence for an increase in range.

The Puntutjarpa site (Gould 1968, 1971, 1977) lies near the Warburton ranges, in country that is generally acknowledged to be much poorer than the area around the MacDonnell ranges. Warapuju soak, about 10-12 km from the site is cited by Tindale (1974:70) as a major fall-back water but the region is otherwise poorly endowed with permanent water sources. There is no network of major waters comparable to that near Puritjarra rockshelter and it is unlikely that the Puntutjarpa area was habitable between 22,000 - 15,000 yrs BP. On this basis the beginning of occupation at Puntutjarpa rockshelter, at 10,170+/-230 yrs BP (I-5319), records an extension of settlement into a marginal area on the periphery of the Central Australian ranges.

The first use of the rockshelter at Walga rock (Bordes et al 1983), 800-900 km southwest of Puntutjarpa, may record a similar event on the western margin of the arid zone. Here the earliest definite occupation begins at 9950+/-750 yrs BP (LY 1847).

More secure evidence for an expansion of settlement at this time is provided by a series of sites along the western edge of Lake Frome. Here the main phase of occupation occurred during the early holocene, with typological and stratigraphic evidence indicating only sporadic visits after about 5,000 yrs BP (Lampert and Hughes 1987; in prep.). The principal sequence is from Balcoracana creek where the main occupation horizon is marked by cores and flakes eroding from carbonate-rich sands, TL dated to 9,900+/-2,200 yrs BP. These sands lay immediately above a palaeosol for which two radiocarbon dates on land snail shells are available - 13,660+/-600 yrs BP (ANU 2528) and 12,610+/-100 yrs BP

(ANU 2527). Other sites can be assigned to the same period on typological and geomorphic grounds - in particular one at Big John creek - but Balcoracana is the only site to have been investigated in any detail. Thus the extent of settlement during this period has yet to be established.

An Aboriginal hearth discovered in the core of the Strzelecki dunefield is broadly contemporary with the Lake Frome sites and suggests that there was a widespread movement into the plains and dunefields at this time rather than simply a local extension of foraging range on the part of populations in the Flinders ranges. The hearth, from a site known as JSN, is located in the dunefield about 20 km west of Strzelecki creek (Hughes and Lampert 1980:64; Wasson 1983:102-104, pers. comm.) It consists of a circular depression containing burnt clay, fragments of mussel shell, and charcoal - and dates to 13,850+/-190 yrs BP (ANU 2278). A second radiocarbon sample submitted from the underlying sediments gave the near identical date of 13,150+/-830 yrs BP (ANU 2279). Silcrete artefacts are reported to be scattered over the eroded surface nearby but it is not certain whether any of these were derived from the same strata (Hughes and Lampert 1980:64). The presence of mussel shells - presumably Velesunio - is intriguing as it demonstrates the presence of standing water in the area. On geomorphic evidence any water body on the extensive floodflats between the dunes would have been muddy and fairly saline (Wasson 1983:104). An analysis of shell shape could test this but it is not clear whether any of the mussel shells from the hearth are sufficiently intact. The main significance of this site is that it shows that people had penetrated the heart of the Strzelecki dunefield not long after the period of maximum aridity had passed

and while parts of the dunefield were still active.

In a case study from the semi-arid zone, (Ross 1981) shows that populations occupying the Murray valley extended their range into the northern half of the Victorian mallee during the period 12,000 - 7,000 yrs BP. A radiocarbon date is available for one site on Raak plains giving an age of 7,650+/-110 yrs BP (SUA 766) (Ross 1981:148). Other sites are assigned to this period on typological grounds and on the basis of their association with shallow lakes that were full in the early holocene, but dry after 6,000 yrs BP. Despite early settlement in the northern part of the mallee, widespread occupation of the region did not take place until the late holocene, probably after 2500 yrs BP. Ross (1981) concluded that the expansion of settlement in the early holocene was limited and that in the case of the southern mallee the heavily forested region of the Grampians blocked settlement from the south until after 3500 yrs BP.

In the Willandra lakes region we might also expect to find some evidence of an expansion of settlement between 10,000 and 6000 yrs BP. The lakes were dry by 15,000 yrs BP and the local area would have reverted to semi-arid plains and dunefield. In this context the area would have become more amenable to settlement under the moist climate that prevailed during the early holocene. However, there appears to have been little visible use of the area between 15,000 and 5,000 yrs BP (Clark and Barbetti 1982:144; Allen 1986). In fact most of the evidence - principally dated hearths and scatters of stone artefacts - is clearly late holocene in age (Allen 1986). Similarly, Burkes cave - located near a soakage about 30 km out from the Darling river - does not register substantial occupation until after 1850+/-240 yrs BP (ANU

704), when it shows a fourfold increase in the concentration of chipped stone artefacts (Allen 1972:138-218). In this case no radiocarbon dates are available for the lower levels of the site and it is not known whether the sequence spans the early holocene.

In contrast, riverine tracts in the Darling basin show abundant signs of early holocene occupation. For instance, Hope (1985:165) refers to a series of 150 sites along Teryawynia creek - mainly shell middens and open campsites - clustering in age between 8000 - 6000 yrs BP. Dates indicate initial flooding of the system at 7900 yrs BP with a progressive drying of the system over the succeeding 2000 years. If widespread rejuvenation of riverine tracts prove to be a feature of the early holocene in the Darling basin then perhaps it is not surprising to find that occupation of the semi-arid hinterland was so sparse. As Hope et al (1983:51) have pointed out in another context,

> The inter-relationships of climatic and hydrologic change, accessibility of aquatic resources, and variations in human foraging patterns in western New South Wales appear to be rather complex.

Changes in site use.

If the density and availability of plant foods increased during the early holocene one might expect that people would have less incentive to move camp frequently. This would lead to smaller annual foraging territories and some degree of demographic packing. In turn this should be reflected in an increase in occupation of sites during this period. Unfortunately we lack the basic information necessary to test this proposition as few sites have produced sequences spanning the crucial period from 15,000 - 5,000 yrs BP. For reasons already set out above the sites from the

Pilbara and from the Nullarbor are of little use here and this leaves only Puritjarra.

At Puritjarra, use of the rockshelter increased slightly around 12,000 yrs BP but no consistent trend could be identified across the excavation. At 6000 - 7000 yrs BP, coincident with the stratigraphic change from layer II to layer I, there was a substantial increase in artefact densities, sufficient to suggest much greater use of the shelter from this time onwards. The nature of the change is broadly consistent with the predictions but the timing is somewhat later than might have been expected. In comparison, Puntutjarpa rockshelter, some 500 km to the southwest, has evidence of major occupation from 10,170 +/-230 yrs BP until at least 6000 yrs BP.

Evidence for a decline in occupation after 6000 BP.

By about 4000 - 5000 yrs BP the comparatively moister conditions that prevailed during the early holocene appear to have come to an end. The decline in occupation at this time serves to place the events of the early holocene in better perspective.

Firstly, the switch to drier conditions led to a contraction, or thinning out, of settlement in marginal areas. For instance, around Lake Frome (Lampert and Hughes 1987, in prep.) and in the Victorian mallee (Ross 1981) there is little evidence of occupation after about 6000 - 7000 yrs BP, until both regions register a substantial increase in use in the late holocene - with occupation at most dated sites falling within the last one or two thousand years. Secondly, sites in other parts of the arid zone also show either a decline in use after 6000 yrs BP, or - where the sequence does not extend into the early holocene -

comparatively low levels of use in the mid holocene. For instance at Walga rock, evidence of occupation decreases shortly after 7010+/-350 yrs BP (LY 1846) and remains low until just before 1040+/-180 yrs BP (LY 2098), when there is a two or threefold increase in artefact densities (Bordes et al 1983). There is corroborative evidence for low levels of use in the period from 6000 - 2000 yrs BP from other arid zone sites - such as Burkes cave in the Darling basin (Allen 1972:138-218), Hawker lagoon in the Flinders ranges (Lampert and Hughes 1987, in prep.) and in the Central Australian sites reported in chapters 5-9 of this thesis.

In contrast the level of use of Puritjarra rockshelter remained stable throughout the middle holocene, until the dramatic changes of the late holocene, when it registered a further substantial increase in occupation.

The chronology of the Puntutjarpa sequence is too uncertain to establish whether similar changes took place in the Warburton area and this merits extended comment below.

The Puntutjarpa sequence.

Until the excavation of Puritjarra the longest sequence from the central part of the arid zone was from Puntutjarpa rockshelter (Gould 1968, 1971, 1977). For many years this has stood as the master sequence for the prehistory of the arid zone, with its hallmarks of continuous occupation, technological continuity and a stable level of site use. Despite this, there are persistent problems with the chronology of the site (Glover and Lampert 1969; Johnson 1979:131-134; Stern and White n.d.). Eight radiocarbon dates are available from trenches 1 and 2. There is one seriously

anomalous date - 3810+/-160 yrs BP (I-3389) at a depth of 152-157 cm, compared with 10,170+/-230 yrs BP (I-5319) at a depth of 117-122 cm below the surface. The remaining radiocarbon dates show two reversals and consequently several alternative interpretions of the chronology are possible. It is unlikely that these problems can be resolved without further excavation at Puntutjarpa. Here I will simply present my interpretation of the available evidence, together with an assessment of what it reveals about changes in occupation during the holocene.

The archaeological deposit at Puntutjarpa contains "...a rich array of stone tools, debitage, faunal materials, and hearths ..." (Gould 1977:63) in a matrix of dark, charcoal rich sand. The deposit is divided by a layer of rockfall into an upper unit - zone A - and a lower unit - zones B and C. Gould (1977) concluded that the archaeological deposits recorded an uninterrupted sequence of occupation from about 10,000 yrs BP until the present. Johnson (1979:131-34) proposed an alternative interpretation in which the lower part of the deposit built up at a relatively slow rate from 10,000 to about 1000 yrs BP. This was followed by a period of rapid sedimentation with the rockfall layer acting to trap aeolian sand.

A close reading of the excavation report (Gould 1977) suggests a third possibility - that the deposits beneath the rockfall accumulated from about 10,000 - 6,000 yrs BP and that the rockfall rests unconformably on the surface of this layer and dates to within the last 1000 yrs BP. Under this scheme the layers beneath the rockfall are bracketed by the date of 10,170+/-230 yrs BP (I-5319) - from a hearth sealed between a large rock slab and bedrock - and by dates of 6710+/-125 yrs BP (I-5475) and 6740+/-

120 yrs BP (I-3387) from the upper part of zone B. To sustain this interpretation the date of 4010+/-105 yrs BP (I-5476), from a level below three dates of around 6500-6700 yrs BP, needs to be rejected as anomalously young. For the lower part of zone A there is a radiocarbon date of 435+/-90 yrs BP (I-5320), on charcoal from a hearth, indicating that zone A dates to within the last 1000 years.

The gap in the radiocarbon framework for this site also led Gould (1977:63, 171, 176) to consider the possibility that the rockfall rested unconformably on much older deposits.

> ...there is some possibility of wind scouring or some other natural factor that could have eroded away the surface of Zone B prior to the first phase of the Upper Rockfall. The interface between Zone B and the Upper Rockfall poses a stratigraphic and dating problem that is not easily resolved, since there is no apparent change in soil color and texture. (Gould 1977:176).

Ultimately, he dismissed this interpretation on the grounds that it was not supported by his analysis of the stone artefacts and because he saw no stratigraphic evidence in its favour. However, each of these objections can be balanced with evidence to the contrary.

Table 10.1 shows the stratigraphic distribution of backed blades and tula adzes in trench 2 at Puntutjarpa. It shows a sharp break in the cultural sequence between zone A and the underlying deposits. The few specimens from zone B are, in each case, from the 3" spit immediately underlying the rockfall and therefore do not provide irrefutable proof of the presence of these artefacts below the rockfall layer. The figures in table 10.1 are based upon my re-examination of the Puntutjarpa collection in 1984. I am satisfied that I examined all the backed blades and tula adzes

Table 10.1 : The stratigraphic distribution of backed blades and tula adzes, trench 2, Puntutjarpa.

zone	backed blades	tula adzes
A	35	89
B	3*	3*
C	-	-

* within 3" of the base of zone A.

from trench 2. To ensure this I took the precaution of reconciling the catalogue numbers on the artefacts with those in the 1977 report - including illustrated specimens - and with the entries for adzes and backed blades in Gould's field catalogue. As I have already noted in chapter 3, Gould's definition of an adze is much looser than other studies have shown is valid (see Sheridan 1979) and this has obscured the pattern of change at Puntutjarpa. There are similar problems with Gould's identification of backed blades at this site (see Glover and Lampert 1969). My reassessment of the distribution of these artefacts confirms that of Jones (cited in Johnson 1979:133).

The hearth from the base of zone A, dated to 435+/-90 yrs BP, lay upon a surface that has some of the characteristics of an erosional surface. Gould (1977:66) refers to it as the feature 7 living surface and describes it as more compact and redder in colour than the surrounding sediment. It lay directly below the rockfall layer in square 11 and in adjacent grid squares. Gould reports that he was able to peel back the overlying layer of rockfall - in this case noted to be mainly small rocks - and that,

> The floor of the feature was compact and hard throughout and was marked by a definite layer of cultural debris resting upon its surface. (1977:67).

Although the horizontal extent of this surface was limited to about 6-7 m^2 it is possible that elsewhere it had been destroyed in antiquity by the sheer size of the boulders that fell upon it, and by the methods used to break up and remove these during excavation.

This evidence shows that there are grounds for reconsidering the proposition that there is a cultural and depositional hiatus in the Puntutjarpa sequence. This has important ramifications for

if deposits dating between 6000-1000 yrs BP are missing from the Puntutjarpa sequence - presumably removed by erosion - then the site can no longer stand as an exemplar of stability in the region. The archaeological evidence would simply record a period of major occupation in the early holocene and again in the late holocene, without providing information about whether use of the shelter declined or remain stable between 6000 - 1000 yrs BP.

With at least three plausible interpretations of its chronology Puntutjarpa will remain the bête noir of arid zone prehistory until it is reinvestigated.

Discussion.

The evidence reviewed above shows that there is a basic lack of information about the nature of events in the arid zone during the early holocene. This poses a major challenge for future fieldwork. On present evidence the predictions made in chapter 2 of a widespread expansion of settlement in the arid zone at this time are supported, though in some regions such as the Victorian mallee the extent of this may have been more patchy than expected.

The lack of sites with an uninterrupted record of occupation between 15,000 - 5,000 yrs BP makes it difficult to test the proposition that population density also increased at this time. Only Puritjarra rockshelter has a useful record of contiguous changes in site use at this time. Use of this rockshelter substantially increased at about 6000 - 7000 yrs BP, coincidental with optimal environmental conditions, but rather later than the evidence for an increase in the distribution of human populations elsewhere. This discrepancy raises the question of whether the two

responses necessarily occur in tandem, or whether it is reasonable to expect some time lag between them. For instance, might not an increase in population density in montane and piedmont regions be delayed until after the newly accessible plains and dunefields were fully occupied ?

The balance of the available evidence also supports the notion of a widespread decline in occupation after 6000 yrs BP. Here again archaeological information on the crucial period immediately after 6000 yrs BP is maddeningly sparse, though evidence for comparatively low levels of occupation in the mid to late holocene is widespread. At Puritjarra however there is no evidence for a decline in occupation. The level of use established at about 6000 -7000 yrs BP continues until the sequence records a further increase at about 600 yrs BP. In other Central Australian sites the level of use before about 1400-600 yrs BP is low but none have any useful information on the level of use as early as 6,000 yrs BP. If the pattern of change at Puritjarra were confirmed in other sites in the Central Australian ranges it would support my suggestion - in chapter 2 - that the effects of the environmental changes at this time would be more marked in the desert lowlands than in the montane and piedmont regions. If, however, the pattern of site use were duplicated in a site located amidst the dunefields or on the plains then the model put forward in chapter 2 could not be sustained. In this eventuality both the climatic reconstructions for this period as well as the nature of the factors that controlled the growth and distribution of prehistoric human populations in the arid zone would have to be re-assessed.

A final point to be made concerns the likely identity of the populations that re-occupied much of the arid zone in the early

holocene. We might imagine that groups moved into the desert from its margins - especially from northern Australia - as well as expanding outward from the montane and piedmont or riverine areas within the arid zone. Here evidence on the genetic distance between various Aboriginal populations is pertinent. Research on blood group antigens, serum protein systems and enzyme groups shows that populations in the Western desert, Central Australia and Port Hedland are genetically distinct from populations in the Kimberley region, Arnhemland and north Queensland (Kirk 1971; Balakrishnan et al 1975). The genetic distance is sufficient for Kirk (1971:335) to conclude that it,

> ...implies a long period of isolation without the benefit of fresh additions from outside. Indeed, the evidence from the gamma globulin group system indicates the complete absence of gene flow from the coast in toward the desert regions of the interior...(Kirk 1971:335).

The implication is that it was long established desert populations that expanded into the plains and dunefields of the arid zone during the early holocene. The reason for the lack of substantial inroads from groups resident on the fringes of the arid zone may be that the inhabitants of the desert simply responded more rapidly to the environmental changes and thus excluded outsiders.

THE LATE HOLOCENE IN THE ARID ZONE

Archaeologists working in the southeastern part of the arid zone have commented on the abundant traces of late holocene occupation in the region - see (Hughes and Lampert 1980; Lampert and Hughes 1987; Williams 1987) for the Strzelecki dunefield and Coopers creek area; (Lampert 1985) for campsites associated with mound springs along the western side of Lake Eyre; (Smith 1980) for the Olary upland; and (Ross 1981) for the Victorian mallee. In

the heart of the Simpson dunefield, N. B. Tindale reports evidence of late holocene occupation at a claypan near Geosurveys hill (Sunday Mail 3.11.62).

Except for the latter, these are all regions in which the age of the various landforms are comparatively well understood (Wasson 1983; Bowler and Wasson 1984) and in which archaeologists have worked closely with geomorphologists (eg. Hughes and Lampert 1980). Yet despite exposures of earlier sediments, most archaeological sites can be dated on typological as well as stratigraphic grounds to the late holocene period. Furthermore, although typological criteria allow an age up to about 4500 yrs BP for these sites, radiocarbon dates - wherever they are available - indicate occupation within the last 1000 - 2000 years.

The few excavated sites with sequences that span this period also record a major increase in occupation after 1000 - 2000 yrs BP. For instance, Burkes cave (Allen 1972:138-218) shows a fourfold increase in the density of retouched artefacts and a sixfold increase in the density of unretouched flakes after 1850+/-240 yrs BP (ANU 704). Hawker lagoon (Lampert and Hughes 1987) has,

> ...a few small tools in the middle level dated c. 5000 yrs BP, and a very rich small tool industry in the top level which was laid down in the last few centuries. (1987:30).

On the southwestern margin of the arid zone, Walga rock (Bordes et al 1983) records a two or threefold increase in artefact densities just before 1040+/-180 yrs BP (LY 2098). The results of the archaeological field surveys together with the increases in occupation shown in the excavated sites provide presumptive evidence for a resurgence of occupation in parts of the arid zone

during the last 1000 - 2000 years. The results of the series of excavations in Central Australia - reported in chapters 4-9 - allow a more detailed assessment of this change.

An increase in population in Central Australia.

The most striking features of archaeological sequences in Central Australia is the evidence for a significant increase in occupation of sites throughout the region beginning about 1400-600 yrs BP. This is shown in greatly increased densities of chipped stone artefacts, grindstones, charcoal, bone and other types of occupation debris after this date.

The change is registered in both rockshelters and open campsites; in sites associated with large ceremonial gatherings as well as in domestic occupation sites; in sites focussed on ephemeral water sources as well as in sites near permanent water. In addition, several of these sites are key points in the cultural landscape of Central Australia - as the summaries in chapters 4-9 will show. Apart from the excavated sites there is also some field evidence to suggest that other sites - not yet subject to controlled excavations - register the same general pattern of change.

As the evidence for an increase in occupation in the late holocene is widespread and is reflected in a range of different types of occupation debris as well as in different types of sites it is unlikely to be simply the product of inadequate sampling, or to result from changes in depositional behaviour. The evidence presented in the various site reports shows that changes in technology or rate of sediment accumulation do not account for

the increased density of occupation debris. Nor can it be shown to be an artefact of post-deposition preservation as it is reflected in the distribution of stone artefacts as well as in organic remains such as bone or charcoal.

The sample of excavated sites is also sufficiently broad to rule out the possibility that what is recorded is a simple redistribution of the existing population - as one might envisage in a change towards more nucleated settlement with a greater reliance on important watering points, or towards a settlement pattern tied to new resource configurations. If the former were the case one would not expect sites near ephemeral waters - for example at Intirtekwerle, Kweyunpe or Therreyererte - to show the same pattern of change. In the case of the latter, the ethnography for the region does not indicate that settlement was tightly mapped onto resources - other than water - in the recent past. Given the lack of sharply defined ecological zones in Central Australia it is also unlikely that any switch in resources would require a radically different pattern of settlement.

The most parsimonious interpretation of the change towards increased occupation of the various sites is that it records a corresponding increase in the population of the region. In the following sections I will summarise what I have been able to learn of the nature, timing and extent of this change.

Timing and geographic spread

Estimates of the basal age of the main late holocene occupation horizon at various sites are given in table 10.2. Four excavated sites are excluded. These are Ilarari 17, Kwerlpe, Urwemwerne and Krewurlpmurlpme kweke. The sparse occupation debris

at Ilarari 17 and Kwerlpe indicate that these sites have not been substantially occupied at any time throughout their period of use. Excavations at Urwemwerne rockshelter and at Rrewurlpmurlpme kweke yielded evidence of a recent increase in use but dates are unavailable.

For the remaining sites the pattern is one of a progressive increase, beginning about 1400 yrs BP, in the number of sites that show evidence of substantial occupation. By 600 yrs BP most sites have been affected although some - such as Kweyunpe 2 - register a similar change at a much later date.

In individual sites the archaeological deposits that post-date the change show further fluctuations in the density of occupation debris. In some sites, such as Intirtekwerle and Tjungkupu 2, use of the site appears to have continued to increase before stabilising after a few hundred years. In other sites, such as Tjungkupu 1, Urre and Keringke, the intensity of use peaked and then declined in the last few hundred years. Yet another pattern is shown by the sequence at Wanmara where use of the site began to increase at about 1320 yrs BP and continued to intensify into the ethnohistoric period. At present it is difficult to pick any regularities in these later fluctuations in site use. The most likely interpretation is that they reflect the ordinary adjustments of a hunter-gatherer settlement system, perhaps in response to individual factors such as changes in local resources, demographic imbalances, reassessment of totemic status etc. On present evidence there is little to suggest that use of the sites continued to intensify after 600 yrs BP.

The geographical spread of the change shows that the earliest

dates for it are in the main body of the ranges - at Wanmara at 1320 yrs BP and at Kweyunpe 6 at 1400 yrs BP. Parts of the James range near the Hugh river also have sites with comparatively early dates for this event - at James Range NW rockshelter at 1700-1045 yrs BP and nearby at Urre at 980-1300 yrs BP. Sites isolated in sandhill country to the west or southeast of the main ranges register the change at a later date - at Puritjarra at 600 yrs BP, at Tjungkupu 1 and 2 at about 1000 yrs BP and at Therreyererte at 570 yrs BP. This pattern is particularly evident in the western part of the research area where a temporal gradient for the appearance of the change can be identified between Wanmara (1320 BP) in the ranges and sites progressively further out into the sandhill country - Tjungkupu 1 and 2 (1000 BP) and Puritjarra (600 BP). Although this pattern is intriguing it will require a larger sample of dated sites to substantiate.

The late date for the change at Therreyererte is complicated by the fact that this site was primarily used for large ceremonial gatherings. The change seems to have taken place later at such sites, irrespective of their location, than at ordinary occupation sites. For instance compare the timing of the change at Therreyererte (570 BP) and Keringke (800 BP) with other sites listed in table 10.2. In the category of ceremonial sites we should certainly also include Kweyunpe 2 a rockshelter where major use occurs sometime after 300 yrs BP and appears to be tied to the execution and maintenance of an important panel of rock paintings, rather than to domestic occupation per se.

Scale of the increase

To gain some appreciation of the scale of the increase in

occupation it is necessary to consider the archaeological record for the period preceding the change. For most of the sites the excavations have yielded a stratigraphic sequence spanning the last 3000-4000 years. This does not represent the base of the deposits but in most cases represents the limits of practical excavation. Except for Krewurlpmurlpme kweke - a site not relevant to the present discussion - Puritjarra is the only site to produce a sequence extending into the early Holocene.

During the period between 1400-600 yrs BP and 3000-4000 yrs BP use of the various sites appears to have been relatively light. In extreme examples, such as at Tjungkupu 1 and Intirtekwerle, the archaeological evidence for use before 1000 yrs BP is restricted respectively to a few flakes, and a small number of flakes, cores and scraps of bone. Other sites have produced larger assemblages for this period but the density of occupation debris is uniformly low. The general characteristics are as follows. The low proportion of fine debitage from knapping together with the low numbers of cores and retouched artefacts indicate that little manufacture of chipped stone artefacts or resharpening of blunted implements took place. Grindstones are rare and those that can be identified are amorphous implements, such as are common in any temporary camp and are often taken by Aboriginal men today to indicate that ngkwerlpe or bush tobacco has been prepared. Other types of occupation debris such as animal bone, charcoal, eggshell, and ochre are usually absent from these deposits or, if present, are in very small amounts. The similarity between the quantity and type of occupation debris in these levels and that from Ilarari 17, a site repeatedly used as a temporary bivouac during rainy weather but never heavily occupied, is instructive.

Table 10.2 : Summary statistics to show the timing and magnitude of the increase in occupation in the late holocene in Central Australia.

		timing of change			magnitude	
site	type	estimated date.	bracketing C14 dates.		artefact density no/m³/kyr	
Puritjarra	r	600 BP	Beta21273	570+/-50	a.	8025
			<Beta21274	3120+/-100	b.	228
Tjungkupu 1	r	1040 BP	>Beta16303	840+/-80	a.	3359
					b.	2
Tjungkupu 2	o	1000 BP	>Beta16305	940+/-70	a.	440
					b.	139
Wanmara	o	1320 BP	>Beta16307	970+/-70	a.	470
			<Beta16308	2550+/-110	b.	73
James Range NW	r	1045-1700 BP	>I-7597	1045+/-80		
			<I-7596	1700+/-80		
Urre	o	980-1300 BP	>Beta16306	980+/-80	a.	831
					b.	39
Intirtekwerle	r	850 BP	>SUA2247	670+/-100	a.	2595
			<SUA2125	1460+/-210	b.	406
Kweyunpe 1	r	600 BP	>Beta4895	265+/-75		
Kweyunpe 2	r	<300 BP	<Beta4896	320+/-55		
Kweyunpe 6	r	1400 BP	>SUA2096	590+/-80	a.	3986
					b.	1325
Keringke	o	800 BP				
Therreyererte	o	570 BP	>SUA2520	400+/-50	a.	24465
			<SUA2519	1830+/-110	b.	437

r: rockshelter o: open site a: main occupation horizon b: underlying levels

It suggests that the sites listed in table 10.2 were places subject to regular but rather fleeting visits prior to the change at 1400-600 yrs BP.

The deposits that post-date the change at each site contain not only a higher density of artefacts but also a wider range of implements and types of occupation debris. Usually these deposits contain large amounts of fine flaking debitage as well as large quantities of charcoal and bone and small quantities of emu eggshell and ochre. The stone artefact assemblages are larger and contain more retouched implements. Grindstones are numerous. Specialised implement forms such as backed blades, tula adzes, endscrapers, seedgrinders and flakes off ground-edge implements are most common in these deposits. The overwhelming impression is that the deposits that post-date the change represent the residue of substantial occupation, and that by this period these points in the landscape had become major residential sites of the type that Aboriginal people today refer to by terms such as "main camp" or "homestead".

To give a better idea of the magnitude of the change I have listed figures in table 10.2 for the density of chipped stone artefacts, expressed as no/m^3/kyr, in (a) the main occupation horizon compared with (b) the underlying levels dating back to about 3000-4000 yrs BP. It should be remembered at this point that because of the various factors that affect artefact density in a site - primarily floor area and ease of access to stone suitable for knapping - that these figures should not be used for comparisons between sites, except perhaps in terms of a very broad rank ordering. However, it is valid to examine the relative change in the density of artefacts within the sequence at any particular

site as there is evidence that the accessibility of raw material from each of the sites has been effectively constant throughout the occupation. Similarly, I can detect no change in manufacturing techniques throughout this time period.

Turning to table 10.2, the increase in artefact density ranges from threefold to more than 50 times. As one would expect the change is less marked in open sites, than in rockshelters, but even for some open sites there is an increase of more than 20 times in the density of artefacts after 1400-600 BP.

Most open sites would in fact under-represent the scale of the change because of the degree of latitude in siting new camps. At the higher end of the range at least two of the estimates can be set aside. For instance, the change at Therreyererte records the beginning of large ceremonial gatherings rather than changes in domestic occupation. At Tjungkupu 1 the negligible use of the rockshelter before 1000 yrs BP over emphasises the extent of the subsequent change. This leaves a series of estimates for the magnitude of the change, ranging from a factor of 3 to 35. There is no way of calibrating this change in occupation to real changes in population density. However, one would presume that for any increase in population, particularly if associated with demographic packing and some reduction in group mobility, that the amount of refuse accumulating in sites would increase at an exponential rather than a simple geometric rate. On this basis the real change in population may be at the lower end of the above range of estimates. A fivefold increase in population after 1400-600 yrs BP is a useful working estimate for the time being.

Lack of correlation with changes in stone industries

In temperate parts of southeastern Australia a similar increase in occupation occurs at about 4000 yrs BP and is thought to have been associated in some way with the appearance of the small-tool tradition (Bowdler 1981; Hughes and Lampert 1982). What then is the relationship between the new types of stone artefact and the change in Central Australia ?

Firstly, it is clear that the first appearance of backed blades and tula adzes occurs several millennia earlier than the increase in occupation. For instance, there is evidence from Ilarari 17 that backed blades were present in Central Australia by 3210+/-90 yrs BP (Beta-5349). This is confirmed by the presence of backed blades and tula adzes in levels estimated to date to between 2700 and 3600 yrs BP at Kwerlpe. These are comparable to dates for backed blades in other parts of the arid zone such as the Pilbara (Brown 1987) and Murchison basin (Bordes et al 1983). From Intirtekwerle there is also firm evidence that tula adzes and endscrapers significantly predate the changes in site use, although in this case the specimens are not older than about 1500 yrs BP. At Puritjarra, Wanmara and Therreyererte there are stray examples of either backed blades or tula adze slugs from the levels predating the change. At Puritjarra these would date to between 2000-4000 yrs BP while at the remaining two sites ages of less than 1500 yrs BP are indicated. To the extent that Puritjarra and other sites provide some record of events before 3000 yrs BP it seems that the introduction of this technology had little impact upon site use.

The second point that needs to be made about these types of implements is that in the excavations their occurrence is strongly correlated with the overall density of occupation debris. Thus they are most commonly found in levels post-dating 1400-600 yrs BP. Even within the major occupation horizon the frequency of backed blades and tula adze slugs is correlated with peak densities of other types of occupation debris - as the information in chapters 4-9 will show. This implies that changes in the intensity of site use can effectively mask the presence or absence of these artefacts.

The chronological distribution of seedgrinders.

The Central Australian ranges

Seedgrinding implements are one component of the technology that is clearly linked in some fashion with the changes in occupation in Central Australia. More than 60 specimens of seedgrinding implements - mostly fragments - have been recovered from archaeological excavations in the region. Although one specimen is from a level pre-dating the changes in site use - a rim fragment of a millstone from Intirtekwerle - none of the seedgrinding implements are from stratigraphic contexts earlier than 1400 yrs BP. At Puntutjarpa there are five seedgrinders from levels above the rockfall (Smith 1986a). In view of my reassessment of the chronology of the Puntutjarpa sequence, none of these are likely to be older than 500 - 1000 yrs BP.

At present I consider the lack of seedgrinders from earlier levels as a product of their low archaeological visibility combined with the small size of the assemblages recovered from these levels. For instance, even in the main occupation horizon at

the various sites, identifiable fragments of seedgrinding implements comprise only a small proportion of the total number of grindstone fragments. If one also considers that the vertical distribution of such fragments within the excavated sites is correlated with the overall density of occupation debris - as already suggested for backed blades and tula adzes - then the lack of seedgrinding implements below the main occupation horizon at the respective sites is not surprising. However, if further work consistently fails to produce any evidence for seedgrinding in the period 4000 - 1400 yrs BP this interpretation will have to be revised.

Other parts of the arid zone

Other sites in the arid zone reveal a similar picture. Seedgrinding implements were not recovered in excavations at Walga rock (Bordes et al 1983), Newman rockshelter (Maynard 1980), Ethel Gorge rockshelter (Brown 1987), or Hawker lagoon (Lampert and Hughes in prep; Lampert pers. comm.). At Burkes cave there are no grindstones - including any possible seedgrinders - in levels older than 1850+/240 yrs BP (Allen 1972:138-218).

Evidence from the eastern part of the semi-arid zone

For earlier evidence of seedgrinding implements we need to look at several sites located on the eastern margin of the semi-arid zone. From Native Well 1 (Morwood 1979, 1981; Smith 1986a:35) there is part of a millstone from levels estimated to date to about 3000 yrs BP. This specimen is bracketed by radiocarbon dates of 1270+/-70 (ANU 2002) and 4320+/-90 yrs BP (ANU 2003). From the Graman sites B1 and B4 (McBryde 1974, 1977) there is a millstone

and a muller, both with an estimated age somewhere between 2000 - 4000 yrs BP. Finally, Morwood (pers. comm.) reports millstones dated to 3280+/-100 yrs BP at the base of excavations at Quippenburra cave, in the northeastern section of the semi-arid zone.

Unresolved problems

The evidence as it stands confirms the presence of seedgrinding implements in sites along the inland slopes of the Great Dividing range by about 3000 yrs BP but not in the arid zone until after 1000 - 2000 yrs BP. This raises the question of whether this discrepancy in timing is simply a product of inadequate data or whether there is a genuine time difference between these areas in the appearance of seedgrinding implements.

I consider the former explanation the most likely for two reasons. Firstly, the low number of dated specimens from the semi-arid zone emphasises the inadequacy of the present sample. For instance, there are only three seedgrinding implements dated before about 2000 yrs BP from sites in the semi-arid zone. This includes parts of western New South Wales where Allen (1986:36) reviewed the evidence and concluded that,

> The cumulation of a lot of poor evidence cannot, in this case make up for the absence of a single securely dated seed grindstone of any antiquity in western New South Wales.

The new information from Quippenburra cave may add several specimens to the total figure but will not substantially alter the fact that the available information on the chronology of seedgrinding implements is inadequate for plotting regional differences in chronology.

Secondly, the probability of discovering seedgrinding implements dating to about 3000 - 4000 yrs BP in sites in eastern Australia is enhanced by the fact that there is a widespread increase in the occupation of sites in this part of the continent at about 4000 yrs BP (for reviews see Rowland 1983; Lourandos 1985).

On the other hand a real time-difference in the appearance of seedgrinding implements would be consistent with Bowler's view of the semi-arid zone, in the eastern part of the continent, as a climatically sensitive region where human populations are likely to have experienced greater environmental fluctuations than in the arid core (1976:74-75). Although this vulnerability would have been offset to some extent during the holocene by the extensive riverine tracts in the region we might expect that pressures and incentives towards some form of economic intensification around 4000 yrs BP were greater than in the arid zone. On this basis one could argue that the technology for processing seeds was first developed in the semi-arid parts of eastern Australia and either (a) spread into the arid zone between 1000 - 2000 yrs BP or (b) was independently developed in the arid zone as conditions led populations to adopt a similar solution to a diminishing resource base - whether this be due to a deteriorating environment or a growing population. However, neither of these scenarios are very satisfactory.

If diffusion is seen as the mechanism it begs the question of why the technology did not spread into Central Australia before about 1400 yrs BP, whereas other types of artefacts - such as backed blades - appear as early as 3000 yrs BP. This discrepancy is emphasised when one notes that in the semi-arid zone there is

evidence to suggest that the first appearance of seedgrinding implements is linked in some fashion with the appearance of small-tool tradition assemblages - as for example at Native Well 1 (Smith 1986a:36). The archaeological evidence from Central Australia also suggests that the changes in site use began in the central ranges and spread outwards to affect the surrounding sandplains and dunefields. This is not consistent with the argument that these changes are the result of a diffusion of seedgrinding techniques into the region from an external source.

This suggests that if the discrepancy in timing is real it must indicate independent development of seedgrinding implements in Central Australia - albeit at a later date than in the semiarid zone. There is no technological reason to rule out this possibility. Expedient grindstones were already part of assemblages and specialised seedgrinding implements can be considered more of a byproduct of a shift towards the intensive use of seed foods than a major technical innovation. However, this scenario begs the question of why there would be a switch at 1400 yrs BP towards using seeds - which are costly in terms of time and labour to collect and process. This is not a period when palaeoenvironmental data suggests a deteriorating human environment in Central Australia, nor does population pressure as an alternative explanation for the appearance of seedgrinding implements fit the available archaeological evidence very well.

Summary of the late holocene changes.

There is widespread palaeoenvironmental data, from different parts of the continent, to indicate an improvement in rainfall after about 1500 yrs BP. Taken at face value this correlates well

with archaeological evidence for a resurgence of occupation in the arid zone. However, both the palaeoenvironmental and archaeological sequences for this period are only poorly known. In this context the archaeological sequence for the Central Australian ranges allows a more detailed assessment of events in the late holocene.

Information for the central part of the arid zone is sketchy but indicates that the palaeoenvironmental changes involved an increase in the frequency of high rainfall events - reflected in large palaeofloods in the Lake Eyre basin - rather than simply an increase in annual rainfall. The likely linkage with the El Nino Southern Oscillation phenomenon (see Allan 1985) offers a possible mechanism for these changes, which also affected other parts of the continent. It is interesting to note that archaeological evidence from the latter also shows a range of adjustments in site use, technology and subsistence around 1000 yrs BP, indicating that human populations in other environments may have also been responding to these environmental changes in some fashion - see for example Jones (1985) for western Arnhemland, Hiscock (1986) and Sullivan (1987) for coastal New South Wales, Luebbers (1978) for the coastal swamplands of southeastern South Australia. However, the links between the environmental changes at this time and the various human responses have not been systematically studied.

In Central Australia the principle effect of the high rainfall events may have been to substantially recharge local supplies of groundwater (cf. Calf 1978). This would had the effect of increasing the reliability and number of springs and soakages

throughout the region and would thereby allow greater access to marginal areas. The nature of the high rainfall events suggests that any impact upon the long-term productivity of the land would be negligible. Given that they were at least several decades apart any beneficial long term effects upon the vegetation were probably limited to the recruitment of long-lived perennial plant species, especially trees such as desert oak (Casuarina decaisneana) and red gum (Eucalyptus camaldulensis). Although the environmental changes would create conditions favouring closer settlement in the ranges it is unlikely that the productivity of the country would have been increased sufficiently to sustain the more intensive foraging that a closer pattern of settlement would entail.

The archaeological evidence from Central Australia shows that there was not only an increase in the use of marginal areas at this time - as might reasonably be expected - but also a substantial increase in the occupation of sites near major waters in the central ranges, such as at Wanmara. This suggests that although the changes in occupation and the environmental changes are contemporaneous the latter alone are not sufficient to account for the increase in occupation that is evident in the archaeological sites.

The changes in occupation must therefore reflect the operation of an additional factor - one likely to have increased the carrying capacity of the country accessible from the various waters thereby allowing closer settlement. I have argued elsewhere (Smith 1986a) that this is precisely the role that the use of acacia and grass seeds have in subsistence in the arid zone. As seedgrinding implements do appear to be linked with the changes in

site use in Central Australia it is likely that it was the combination of more closely spaced waters and the ability to use seed foods that led to such a dramatic increase in occupation at this time - compared to events in the early holocene.

In chapter 2 I suggested that adjustments made to cope with a diminishing resource base at about 4000 yrs BP would have changed the nature of subsequent responses later in the prehistory of the region - particularly where they involved the accrual of new abilities to exploit the limited resources of the region. More specifically I cited a switch towards intensive use of wild seeds as an example of such an adjustment. Empirical support for this proposition is at present equivocal as I have been unable to demonstrate that seedgrinding implements occur in the region prior to about 1400 yrs BP. This must remain as a challenge for future fieldwork.

Some historical implications.

The research presented in this thesis shows that the Central Australian ranges were occupied during the late pleistocene. Other evidence from the study of genetic markers (Kirk 1971; Balakrishnan et al 1975) suggests that the Arrernte and other Central Australian groups may well be the direct descendants of this ancient population. However, the changes that are evident within the last few thousand years suggest that classic Arrernte society, as documented by Spencer and Gillen in The Native Tribes of Central Australia (1899) and The Arunta (1927) is a recent efflorescence of an otherwise ancient cultural tradition.

For Central Australia the evidence suggests that the regional

population prior to about 1000 yrs BP was much lower than that recorded historically - perhaps as low as twenty percent of the figure estimated for the ethnohistoric period (Strehlow 1965, 1970; Layton 1983; Yengoyan 1968). If this is a reasonable approximation of the scale of the change, and if we take the figure of 1 person per 30 km^2 as an average figure for population density in the central ranges in the ethnohistoric period, then the population density prior to about 1000 yrs would have been about 1 person to 150 km^2 - a figure close to that for the Pintupi (Long 1971) in more recent times.

With such a low population it is arguable that the Arrernte would not have been able to sustain the pattern of land ownership - based upon a well developed clan and a small tightly bounded estate (Strehlow 1965; Peterson 1979) - that later came to distinguish them from Western Desert groups. We can speculate that at this time the Arrernte would have found it necessary to operate with a more flexible system perhaps along the lines of recent Western Desert groups - without tightly defined land owning groups or bounded estates (Peterson 1979; Layton 1983; Hamilton and Vachon 1985).

Another aspect of Arrernte society likely to have been somewhat different prior to 1000 yrs BP is the scale of ceremonial gatherings. For instance, Strehlow (1965) took the view that the favourable environment and higher population in the central ranges allowed the Arrernte to develop larger and more elaborate ceremonies than those able to be staged by Western Desert groups occupying poorer country. Opportunities to stage ceremonies on such a grand scale may have been rare until the changes in environment and population of the last thousand years. Ages of 800

yrs BP and 570 yrs BP for the beginning of major activity at the ceremonial centres of Keringke and Therreyererte offer some support for this proposition.

In the Western Desert we can also infer that population levels are likely to have been lower, and environmental uncertainty higher prior to 1000 yrs BP. Possibly the region was either depopulated or only very sparsely occupied during much of the late holocene. A rapid recolonisation of the region within the last thousand years - by a small founding population drawn from a long established desert population - is consistent with the remarkable cultural and linguistic uniformity noted for the region (Berndt 1976; Gould 1977; Tonkinson 1978) and with the distinctive genetic structure of its population (Kirk 1971; Balakrishnan et al 1975).

The notion of a stable desert culture now seems obsolete.