LATE PLEISTOCENE AND HOLOCENE SETTLEMENT PATTERNS AND ENVIRONMENT, KAKADU, NORTHERN TERRITORY, AUSTRALIA

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INTRODUCTION

Archaeological research in the Kakadu-Alligator Rivers area began forty one years ago (McCarthy and Setzler 1960). Major and systematic research, however, dates back only to 1964-5 (Schrire 1982). The pace of research has quickened over the past twelve years stimulated by the discovery of uranium and the opening of the Ranger Mine at Jabiru, and also by the proclamation of Kakadu National Park in 1979. A number of studies of the archaeology and of the landscape history of the Kakadu area are now available (Allen and Barton 1989; Jones 1985; Kamminga and Allen 1973; Schrire 1982; Woodroffe *et al.* 1986). These allow the region's prehistory to be synthesised in the manner presented below.

The emphasis, in Schrire's work, on the excavation of rockshelters located in the valleys, outliers or margins of the western Arnhem Land Plateau has been continued in some of these studies (Allen and Barton 1989; Jones and Johnson 1985a,1985b). Other studies, however, document sites located on the floodplains of the South Alligator River (Meehan *et al.* 1985; Woodroffe *et al.* 1988). This new information represents a considerable increase in our knowledge both of the chronology of Aboriginal occupation and also of landscape changes on the floodplains. To some extent, this fills in the archaeological picture for the region and allows comparisons to be made between the floodplain and plateau margin ecosystems.

To bring the results of these separate studies together into a single statement about Late Pleistocene and Recent settlement in the Kakadu area, it is necessary to create a common framework. The framework adopted here is multi-dimensional. It is one that makes use of chronology, environmental changes, midden contents, stratigraphy, site location and artefactual content. Combinations of these factors are used to place sites within the scheme and to allow comparisons between sites and between layers from different sites (Allen and Barton 1989:100-102). The usefulness of the framework set out below can be gauged by comparing it with existing syntheses of western Arnhem Land prehistory (Jones 1985:291-298; Schrire 1982:249-258; White and Peterson 1969).

Previous syntheses of the prehistory of the region have suffered from a number of deficiencies. These are, firstly, that sites were correlated in terms of grossly defined artefact

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assemblages or industries and inadequately dated stratigraphic units. Secondly, it was assumed that most of the sites excavated contained a complete and continuous record of Aboriginal activities over the time period in question (25000 to 200 BP). Finally, a major difficulty with these previous syntheses was not only that they were premature but also that the synthetic frameworks they utilised could not make use or sense of much of the information available at the time (cf., Golson 1986:4).

ROCKSHELTER OR PLATEAU MARGIN SITES

More than twenty rockshelters have been excavated in this region since 1948. The results of 12 rockshelter excavations are sufficiently detailed to allow them to be grouped in terms of their chronology, stratigraphy and artefact content. These are Jimeri I, Jimeri II, Paribari, Malangangerr and Nawamoyn excavated by Schrire (1982:45-226); Balawuru (Leichhardt); Nauwalabila I (Lindner), and Malakunanja II excavated by Kamminga (Kamminga and Allen 1973:45-52, 86-102); Burial Cave (Nawulandja) and Ngarradj Warde Djobkeng excavated by Allen (Allen and Barton 1989; Kamminga and Allen 1973:29-36, 64-66); and Nauwalabila I, Anbangbang I and Yiboiog excavated or re-excavated by Jones and others (Jones and Johnson 1985a:39-71, 1985b:165-224). The locations of these rockshelter sites are shown in Figure 1.

The layers from these sites have been grouped into six chronological divisions:

(1) 200 – 1000 BP
(2) 1000 – 3000 BP
(3) 3000 – 5000 BP
(4) 5000 – 7000 BP
(5) 7000 – 18000 BP
(6) 18000 – 25000 BP

The evidence supporting this organisation of the archaeological data is discussed in Allen and Barton (1989:73-95, 103-106).

Other rockshelter sites in western Arnhem Land, such as those near Oenpelli (Unbalanya or Inyaluk Hill, sites 1-12, Argaluk Hill – Pigment Cave and White Kangaroo Cave, see McCarthy and Setzler 1960:251-270, 274), Feather Dreaming, Nangalawurr, Spirit Cave, Anbangbang II, Blue Painting Site, and the open site of Nauwalabila II (Jones and Johnson 1985a:64-68, 71, 1985b:222-227; Kamminga and Allen 1973:38-39, 70-73) might also be placed within this scheme with some degree of certainty. The information from these sites generally confirms the picture obtained from the better known sites listed in Tables 1-6. However, until further information allows them to be adequately assessed it was decided to list these sites separately (Table 7) and to discuss them within the text where relevant. The location of these sites of uncertain age or content is shown in Jones 1985 (Figures 1.1, 4.1, and 9.1). The Oenpelli sites, Arguluk and Unbalanya/Inyaluk Hill, can be found in Schrire 1982 (Figure 1).

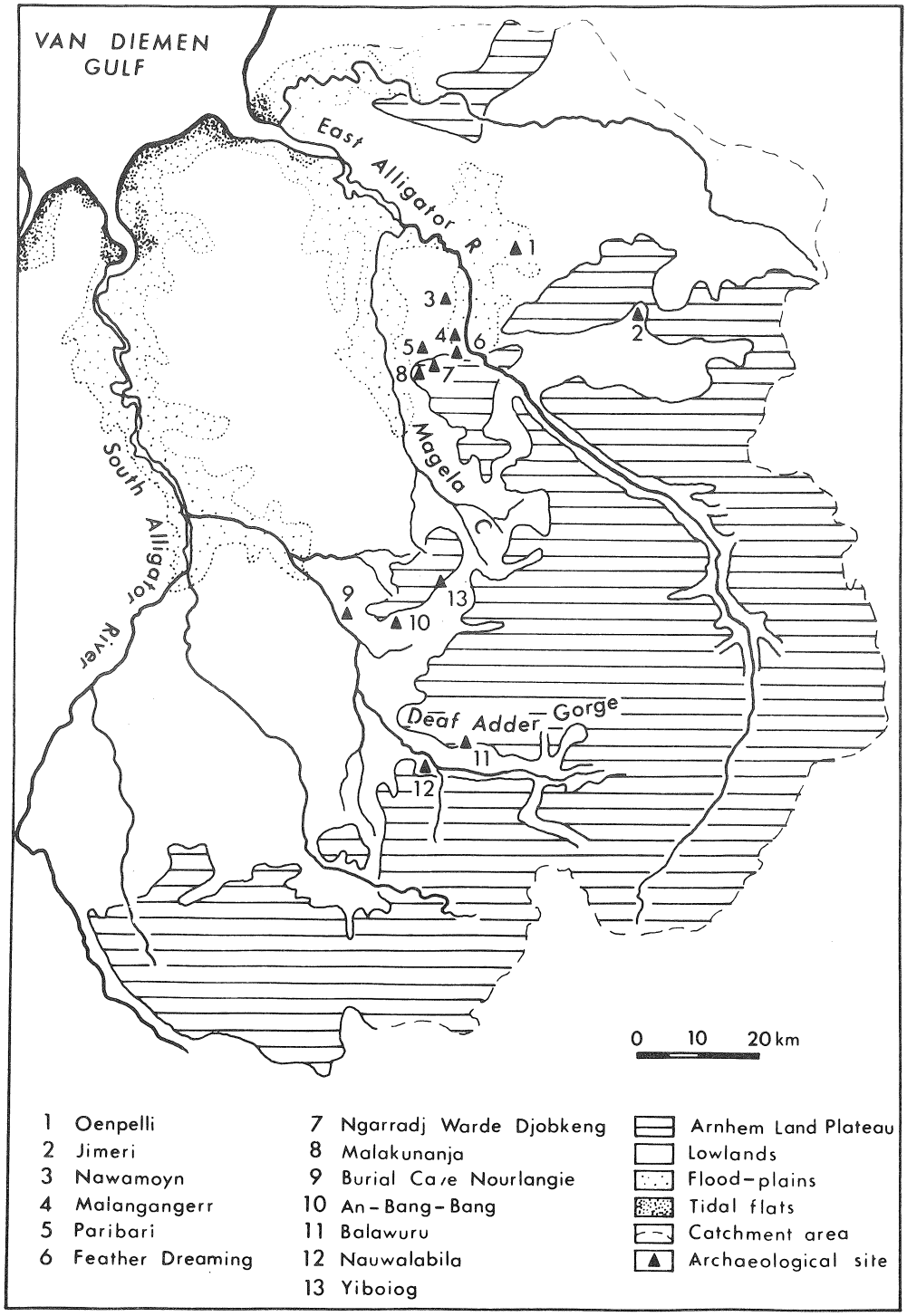


FIGURE 1: LOCATION OF ROCKSHELTER SITES, KAKADU REGION

Site	Layer	Stratigraphy	Contents
Paribari	non-midden zone	freshwater shells	points, polished flakes, flaked adzes
Jimeri I	level I	freshwater shells	endstruck blades, points, flaked adzes
Anbangbang I	level 1a	freshwater shells	endstruck blades, flaked adzes
Yiboiog		freshwater and mangrove shells	endstruck blades
Burial Cave (Nawulandja)	spits 1-3	freshwater shells	points, flaked adzes, endstruck blade
Nauwalabila I	units 1-8		points, flaked adzes, endstruck blades

TABLE 1: ROCKSHELTER SITES AND LAYERS, 200 – 1000 BP

Site	Layer	Contents
Jimeri I	level II	endstruck blade, points, flaked adzes, polished flake
Balawuru (Leichhardt)	upper levels	points, flaked adzes, endstruck blades
Nauwalabila I	units 9-17	points, flaked adzes
Anbangbang I	level 1b	blades, points

TABLE 2: ROCKSHELTER SITES AND LAYERS, 1000 – 3000 BP

Site	Layer	Stratigraphy	Contents
Paribari	midden zone	mangrove/mudflat shell midden	points, flaked adzes
Ngarradj	I-III	mangrove/mudflat shell midden	points, flaked adzes
Malangangerr	1a	mangrove/mudflat shell midden	points, flaked adzes
Nawamoyn	1a	mangrove/mudflat shell midden	points, edge ground axes
Malakunanja II	spits 1-2	mangrove/mudflat shell midden	points
Nauwalabila I	units 17-25/27	sand	points, flaked adzes
Balawuru (Leichhardt)	lower levels	sand	small cores, flakes
Jimeri I	level III	sand	blades, points, flaked adzes
Jimeri II	level I-II	sand	points, flaked adzes

TABLE 3: ROCKSHELTER SITES AND LAYERS, 3000 – 5000 BP

Site	Layer	Stratigraphy	Contents
Malangangerr	1b	mangrove/mudflat shell midden	quartz flakes
Nawamoyn	1b	mangrove/mudflat shell midden	edge ground axes
Malakunanja II	spits 3-7	mangrove/mudflat shell midden	quartz and fine quartzite flakes
Ngarradj	layer IV	sand	quartz flakes
Nauwalabila I	units 25/27-40	sand	quartz and chert flakes
Jimeri II	level III	sand	quartz, quartzite and chert flakes
Burial Cave (Nawulandja)	spits 4-6	sand	quartz flakes
Anbangbang I	level II	sand	edge ground axe, quartz flakes

5800 – 6800 BP – sea level reaches present height

TABLE 4: ROCKSHELTER SITES AND LAYERS, 5000 – 7000 BP

Site	Layer	Stratigraphy	Contents
Ngarradj	layer V-VI/VII	sand	quartz flakes, edge ground axes
Malakunanja II	spits 8-20	sand	quartz and fine quartzite flakes
Nauwalabila I	units 40-55	sand	quartz flakes
Burial Cave (Nawulandja)	spits 7-8	sand, gravel	quartz flakes

TABLE 5: ROCKSHELTER SITES AND LAYERS, 7000 – 18000 BP

Site	Layer	Stratigraphy	Contents
Malangangerr	level III	sand	quartzite flakes, cores, edge ground axes
Nawamoyn	level III	sand	quartzite flakes, cores, edge ground axes
Nauwalabila I	units 56-80	sand, gravels	quartzite flakes, cores
Ngarradj	layer VI/VII	gravels, sands	quartzite flakes

TABLE 6: ROCKSHELTER SITES AND LAYERS, 18000 – 25000 BP

FLOODPLAIN SITES

Archaeological surveying of the floodplain areas of the East and South Alligator Rivers has been less systematic than the investigation of sites near the Arnhem Land plateau. Much of our knowledge of the Aboriginal occupation of this region has come as a by-product of geomorphological or geographical studies of landscape and environmental changes (Clarke *et al.* 1979; Clark and Guppy 1988; Hope *et al.* 1985; Woodroffe *et al.* 1986). Exceptions to this are Baker's survey of beach ridge midden sites at Point Stuart to the west of the South Alligator River (Baker 1981), and Kamminga's (Kamminga and Allen 1973:10-15) and Meehan *et al.*'s (1985) surveys of middens associated with freshwater wetlands on the upper reaches of the South Alligator River. Sites on the hilly lowlands between the floodplains (see Figure 1) and on the floodplains of the East Alligator River and Magela Creek remain largely unrecorded.

Site	Dating BP	Stratigraphy	Contents
Unbalanya or Inyaluk sites 1-12	0-1000?	fine soil, freshwater mussels	endstruck blades, points, flaked adzes, use-polished flakes
Argaluk Pigment Cave	0-1000?	fine dust and ash	endstruck blades, points, use-polished flakes, quartz flakes
Argaluk White Kangaroo Cave	mixed 200?-5000	mangrove/mudflat shells	flaked adzes, use-polished flakes, 1 endstruck blade, 2 points, edge ground axes
Feather Dreaming			
layer A	?-5000	dark brown sand	quartzite and quartz flakes
layer B	5000-?	red brown sand	quartz flakes
Nangalawurr			
Layer A	SUA 161= 775±100	dark grey sand	quartz flakes
Layer B	1000+	red brown sand	quartz flakes
Spirit Cave			
Layer A	ANU 3211= 2490±200	coarse grey sand	edge ground axes, flaked adzes, quartz, chert and silcrete flakes
Layer B	2500-?		
Blue Paintings Site	?-8000 ANU 3210= 7900±200	greyish silts	edge ground axe, quartz flakes
Anbangbang II			
Layer A	200?-5000	compact grey silt	point, quartz and quartzite flakes
Layer B	5000-?12000	red cemented rubble	quartz flakes
Nauwalabila II (open site)	5000?-12000	sand	quartz flakes

TABLE 7: ROCKSHELTER AND OPEN SITES OF UNCERTAIN AGE OR CONTENTS

South Alligator River sites on the lower estuarine plain

An extensive geomorphological survey of the tidal reaches of the South Alligator River has been carried out by Woodroffe, Chappell, Thom and Wallensky (1986) as part of a larger tidal

rivers and mangroves study. They argue that the environment of the South Alligator River has passed through the following evolutionary stages:

(a)	Cuspate River Phase	200	–	2000	BP
(b)	Sinous River Phase	2500	–	4000	BP
(c)	Big Swamp Phase	5300	–	6800	BP
(d)	Transgressive Phase	7000	–	8000	BP

This succession of phases documents major environmental changes; first, the marine invasion of the South Alligator River valley between 7000 and 8000 years BP; second, the cessation of the sea level rise and the establishment of a widespread mangrove swamp at around 6500 BP; third, the demise of the mangroves and the transition to a freshwater floodplain dominated by grasses and sedges between 4000 and c.1800 BP; and finally, a shallow, widening-channel phase which continues into the present.

The dating and sampling of shells in prehistoric middens, located either on the floodplain surface or revealed through drilling, was a part of this study. In all, 14 shell middens were recorded. These are listed in Tables 8-11, and divided into four chronological groups:

(1)	200	–	1000	BP
(2)	1000	–	3000	BP
(3)	3000	–	5000	BP
(4)	Greater than 5000			BP

Because these middens were single or short occupation sites, their dates allow finer chronological resolution than do dates from the rockshelters. However, detailed information about their shellfish and artefactual contents is not yet available. Woodroffe *et al.* (1988:101) commented that the majority of middens on the coastal and estuarine plains of the South Alligator River were deposited in the last 1000 years. The location of these sites is shown in Figure 2, and the code for the shellfish species recorded on them is provided in Table 12.

The most recent middens occur either near the coast or on palaeochannel levees. The coastal middens (A, B, C; dating between 400-800 BP) are located on the crests of chenier ridges on the coastal plain close to the mouth of the river.

Shellfish are mostly comprised of intertidal and shallow marine species such as the bivalve *Anadara granosa* (Woodroffe *et al.* 1988:96). These sites are similar in age and shellfish content to the 43 sites on beach ridges recorded by Baker at Point Stuart and Chamber's Bay, immediately to the west of the South Alligator River (Baker 1981, Table 14, pp.62-82). Baker regards these sites, on locational evidence, as wet season sites. They generally have few stone artifacts (Baker 1981:67, 77). Other recent shellmiddens (sites E, L, and M) consist either of surface scatters or are sites on palaeochannel levees raised slightly above the level of the floodplain. Shellfish consist of species characteristic of mangrove environments which today occur as a narrow to sparse fringe along the banks of the main tidal channel.

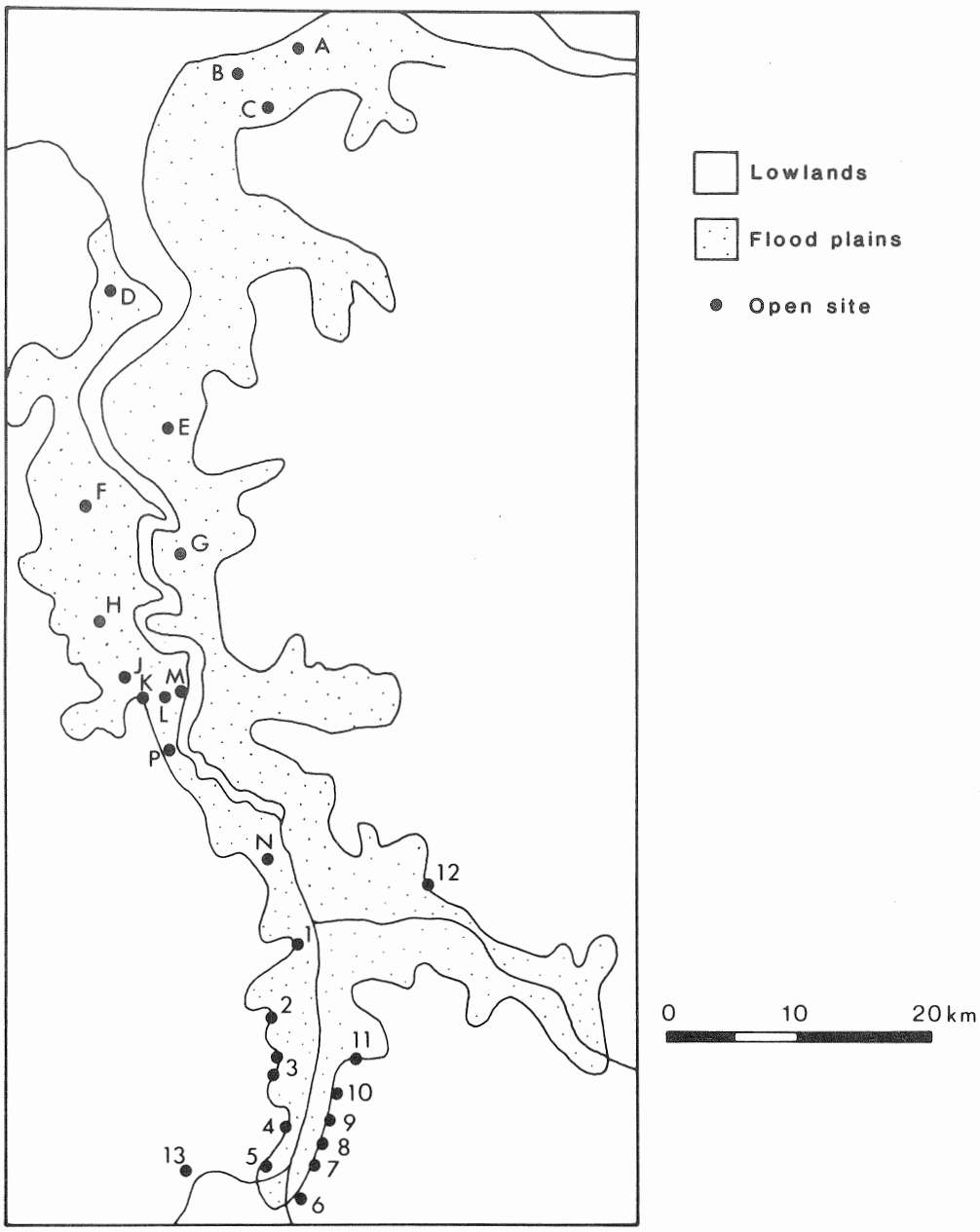


FIGURE 2: LOCATION OF OPEN SITES ON THE SOUTH ALLIGATOR RIVER FLOODPLAIN

Midden	Type	Shellfish (Table 12)	Date BP
A	Coastal shell mound	1, 2, 4, 6, 7, 10, 11, 14, 15	ANU 4043 = 430±70
B	Coastal shell mound	1, 2, 4, 6, 7, 10, 11, 14, 15	ANU 4048 = 690±70
C	Scattered shell	4, 6, 11	ANU 4042 = 800±70
E	Scattered shell	3, 6	ANU 3987 = 280±60
L	Palaeochannel (mound)	3	ANU 3914 = 570±60
M	Palaeochannel (mound)	3, 4, 6, 8, 16	ANU 4046 = 650±70 ANU 4044 = 520±60

TABLE 8: SOUTH ALLIGATOR RIVER SHELLMIDDEN SITES, 200 - 1000 BP

Midden	Type	Shellfish (Table 12)	Date BP
D	Scattered shell	4, 6	ANU 4041 = 2480±70
G	Surface mound	-	ANU 3994 = 2080±70
J	Surface mound	1, 3, 16	ANU 4047 = 1950±100
K	Palaeochannel (scattered shell)	3, 15	ANU 4067 = 2680±70
N	Surface mound	3, 16	ANU 4045 = 3050±70

TABLE 9: SOUTH ALLIGATOR RIVER SHELLMIDDEN SITES, 1000 – 3000 BP

Midden	Type	Shellfish	Date BP
F	Palaeochannel (scattered shell)	-	ANU 3993 = 3790±70
H	Surface mounds (two)	-	ANU 3992 = 4600±80 ANU 3991 = 4170±100

TABLE 10: SOUTH ALLIGATOR RIVER SHELLMIDDEN SITES, 3000 – 5000 BP

Midden	Type	Shellfish	Date BP
P	Buried	6,	ANU 4915 = 6240±100

TABLE 11: SOUTH ALLIGATOR RIVER SHELLMIDDEN SITES OLDER THAN 5000 BP

Family	Species	Code
Gastropoda		
Neritidae	*Nerita lineata*	1
Turritellidae	*Turritella terebra*	2
Potamididae	*Cerithidea anticipata*	3
	Terebralia palustris	4
	Terebralia sulcatus	5
	Telescopium telescopium	6
Muricidae	*Naguetia capucina*	7
	Chicoreus capucinus	
Melongenidae	*Volegalea wardiana*	8
Ellobiidae	*Cassidula angulifera*	9
	Ellobium aurisjudae	10
Bivalvia		
Arcidae	*Anadara granosa*	11
Hyriidae	*Velesunio angasi*	12
	Alathyria sp.	13
Mactridae	*Mactra alta*	14
Corbiculidae	*Geloina coaxans*	15
Veneridae	*Meretrix meretrix*	16

TABLE 12: SHELLFISH SPECIES FROM KAKADU REGION SITES

Slightly older middens dating to the period 1000-3000 BP (sites D, G, J, K, N – Table 9) occur either as surface mounds, 15-20 m in diameter and less than 50 cms elevation above the plains, or in the form of scattered shell. Again mangrove species predominate. These sites were occupied during the sinuous river phase when the river channel is likely to have been forested with mangroves particularly on the inside of meanders. Sedges such as *Eleocharis* and grasses would have covered much of the plains away from the active river channel (Woodroffe *et al.* 1986:133).

Sites F and H (Table 10), with C^{14} dates between 3800 and 4600 BP, relate to the terminal period of the big swamp phase. Woodroffe *et al.* comment that the dates for the mounds at site H suggest recurrent use. The mounds overlie freshwater clay which in turn overlies mangrove mud

> confirming that by 4000 years BP mangroves had disappeared at this site and an open freshwater plain existed. The shells were presumably collected from nearby creek or riparian mangrove forests. (Woodroffe *et al.* 1988:99.)

The oldest shellmidden recorded by Woodroffe *et al.* (site P – Table 11), was buried 3 metres deep in mangrove muds near *Avicennia* sub-fossil mangrove stumps. Woodroffe *et al.* comment

> The shells were probably collected from adjacent *Rhizophora* forest and brought to the site. The chance discovery of this site implies that other middens are likely to be buried within the plains (1988:99).

The existence of this site dating back to 6200 BP has a number of implications regarding the continuity of use of the South Alligator flood plain over the past 6000 years. These aspects of continuity concern the use of the floodplain as a location for open camp sites, the use of mangrove forests for the collection of shellfish and other foods, and the probable existence of local sources of freshwater from springs and lagoons on the plains, even during the big swamp phase.

South Alligator River sites on the upper estuarine plain

Landscape and geomorphological studies of the upper estuarine plain of the South Alligator River, in addition to those of Woodroffe *et al.* (1988) mentioned previously, were undertaken by Hope, Hughes and Russell-Smith (1985) as part of an archaeological consultancy for Kakadu National Park (Jones 1985). A survey of archaeological sites in this portion of the floodplain was carried out by Meehan, Brockwell, Allen and Jones (1985).

The upper reaches of the South Alligator estuarine plain are close to the tidal limit. While the main channel of the river remains tidal, the presence of levees has allowed freshwater wetlands to form on the lower, surrounding plains.

The formation of these wetlands is documented by Hope *et al.* (1985:236-237). They note that stratigraphy and pollen data demonstrate a change from open water to a dense mangrove stand of *Rhizophora* and *Ceriops* at about 6000 BP. As siltation continued, mangroves became restricted to a riparian fringe surrounded by hypersaline flats. Following the building up of levees along the river channel, the plains were invaded by grasses. Hope *et al.* (1985:237) comment,

> The ponding of freshwater against the floodplain and backing up of sediment in the lower river sections created freshwater wetlands, with about 600 square kilometres of seasonally flooded wetlands appearing, ... within the last 2000 years.

Jones (1985:292) believes that formation of these wetlands greatly increased the productivity of the plains and allowed a higher intensity of human utilisation. Thirteen open sites associated with these freshwater wetlands are described by Meehan *et al.* (1985:103-164).

These are listed in Table 13 below and shown in Figure 2. Some of these sites are the same as those described by Kamminga (Kamminga and Allen 1973:10-13).

Although only Ki'na was excavated and dated (ANU 3212, 280±140 BP, depth 45-60 cms below surface; Meehan *et al.* 1985:152), geomorphological considerations suggest that all the freshwater wetlands sites surveyed by Meehan *et al.* date from quite recent times 'probably from within the past 400-1000 years' (Meehan *et al.* 1985:142).

The sites generally consist of areas with artefact scatters, 200-500 m long by 50-150 m wide, located on the margin of open woodland (mixed with monsoon rainforest in the cases of Bulkin, Malakanbalk and Kun-kundurnku) adjacent to freshwater lagoons and surrounding swamps. Mounds occur at some of these sites. Stone (1989:59-64) argues that similar mounds are usually the work of scrub-fowl (*Megapodius reinwardt*) rather than being of human agency.

Site no.	Name	Comments
1	Malakanbalk	mounds, mortars, stone points, flaked adzes, use-polished flakes
2	Malakarnba	edge ground axes, blades, pestles, stone points
3	Lurrukuku	6 areas, mortars, quartz, silcrete and chert artefacts
4	Bulkin	mounds, mortars, edge ground axes, quartz and silcrete artefacts
5	Indarru	freshwater mussels, mortars and pestles, small points
6	Nurrungurrudjpa	flaked boulders and scatters of volcanic rock suitable for axes and mortars
7	Ki'na	fresh and brackish water bivalves, small points
8	Amakada	
9	Kumunkuwi	quartz lumps
10	Kun-kundurnku	small unifacial points, use-polished flakes
11	Mamutjirra	edge ground axes, mortars and pestles, use-polished flakes
12	Mularnani	mounds
13	Biliringba	freshwater mussels

TABLE 13: SOUTH ALLIGATOR RIVER - WETLAND SITES

Artefact collections from these sites, and detailed analysis of those from Kun-kundurnku (10), Kumunkuwi (9) and Ki'na (7) (Meehan *et al.* 1985:136-154), indicate that very large numbers of artefacts were present (0.5 to 1.5 million artefacts/site). Raw materials consisted

of quartz (50-65 per cent), quartzite (15-30 per cent), chert (3-15 per cent) and dolerite (6 per cent). Few quartz pieces were retouched. Flaked tools varied in proportion from site to site, a factor probably indicative of site function. Use-polished flakes made up 20 per cent of all tools at Kun-kundurnku, adze/chisels were 36 per cent of the combined surface and excavated collections from Ki'na, whereas small points were relatively rare making up only 3-5 per cent at all sites. Large blades occurred in small numbers at Kun-kundurnku and Kumunkuwi. Ground axes or flakes off axes, and fragments of mortars, pestles and grinding slabs occurred at most of these sites. Axes, pounders and grindstones and mortars occurred at midden sites on the Chambers Bay coastal plains (Baker 1981:66-67) and also on the surface mounds of the lower South Alligator plains (Woodroffe *et al.* 1988:96).

Meehan *et al.* interpret these sites as dry season camps from which the freshwater animal resources – turtles, mussels, fish, swamp birds and snakes – and plants: such as yams, waterlilies (*Nymphaea* sp), spike-rush corms (*Eleocharis* sp) and pandanus could be harvested. Aboriginal informants described using large pebbles to crush/grind lily seeds with flat stones being used as plates (mortars) (Meehan *et al.* 1985:131). The polished flakes may have been used to trim *Phragmites* spear shafts.

The Magela Floodplain

The transition from mangrove forest to freshwater wetlands has also been documented for the Magela floodplain, a prior-tributary of the East Alligator River, by Clark and Guppy (1988:665-684). This work confirms the claim by Woodroffe *et al.* (1986:160) that

> the South Alligator River is one of many tidal rivers along the north coast of Australia that have experienced similar broad controls on river morphology and plains development during the Holocene.

Today, Magela Creek and its floodplain is a backwater swamp of the East Alligator River. However, before about 8000 BP sea level was 6-10 m lower than it is today and the Magela Creek flowed across a terraced, sandy alluvial plain. Clark and Guppy (1988:670) add that

> As the sea rose, it flooded the Magela embayment almost to Mudginberri. ... From about 8000 BP to 5000 BP mangroves encroached up the floodplain at a decreasing rate that averaged about 10 m per year. From about 6500 BP to 4000 BP, the rate of encroachment was slower ... mud was deposited in the basin behind the delta, forming an extensive mangrove forest.

The changeover to freshwater conditions occurred upstream before 2500 BP, and had affected downstream billabongs by about 1300 BP. Clark and Guppy (1988:680) divide the evolution of the Magela floodplain into the following stages

(a)	Freshwater wetland	0 – 1300 BP
(b)	Transition	1300 – 3000 BP
(c)	*Rhizophora* forest	3000 – 8000 BP

The existence of the *Rhizophora* mangrove forest down to 3000 BP, (2300 years longer than Woodroffe *et al.* 1986:127 claim for their 'big swamp phase') is independently confirmed

by dates from shellmiddens in rockshelters adjacent to the Magela floodplain. Radiocarbon dates on mangrove/mudflat shells in these middens from 6 rockshelters all fall between 3000 and 7000 BP (Allen 1987a:6). Clark and Guppy (1988:673) also note that charcoal, indicative of Aboriginal burning, is common only in freshwater sediments suggesting that fires on the floodplain are a recent phenomenon, one that has not affected the vegetation significantly.

Open archaeological sites, away from the plateau margins on the Magela floodplains, have not yet been surveyed in detail. It is known, however, that three open sites are located next to the Jabiluku billabong (Allen 1978:1; Kamminga and Allen 1973:14, Figure 6). Artefact collections from an open site adjacent to the southern end of this billabong revealed artefacts comparable with those collected by Meehan *et al.* 1985 from the South Alligator wetland sites, namely, many quartz cores and flakes, axe fragments, some quartzite flakes with use-polish and grindstone pieces, but few small points, adze/chisels or other retouched pieces. It is likely that similar recent sites occur at other lagoons on the Magela floodplain.

DISCUSSION

The number of sites and layers placed within the chronological divisions discussed previously is shown on Table 14. From that table, it can be seen that there is a gradual, but fluctuating, increase in site frequency in the Kakadu area over time. Furthermore, there is a marked increase in the number and proportion of open sites in the final 1000 years of the region's prehistory. Some caution with these figures is obviously called for. There is a degree of overlap between the time periods and also between the dated layers at these sites. On the other hand, the inclusion of the data from the less securely dated and described sites (Table 7) adds to, but does not alter, the picture obtained from the better known sites.

Period (BP)	Site type			Total
	Shelters	Open	Table 7	
200 – 1000	6	19	3	28
1000 – 3000	4	5	1	10
3000 – 5000	9	2	4	15
5000 – 7000	8	1	1(+3?)	10
7000 – 18000	4	-	3	7
18000 – 25000	4	-	-	4

TABLE 14: NUMBER OF SITES/LAYERS FOR EACH TIME PERIOD

Late Pleistocene landscapes, sites and sediments

Before 7000 BP, i.e. prior to the Holocene peak in sea level, the archaeological evidence for the Kakadu region is restricted to rockshelter sites located either in plateau valleys or on the margin of the plateau and its outliers. This pattern is almost certainly an artefact of site survival and visibility. Open sites on the lowlands have been subjected to tens of thousands of years of erosion while those in the valleys and plains have been covered either by Pleistocene sandsheets (Hope *et al.* 1985:239) or else by sea and mud during the Holocene marine transgression. In the case of the South Alligator floodplain, more than 18 m of estuarine sediments separates the Pleistocene land surface from the grassy plains of today (Woodroffe *et al.* 1986:97).

Even in the rockshelters, faunal remains are not preserved in their lower layers. Consequently virtually nothing is known about Aboriginal subsistence activities before 7000 BP. Notwithstanding these difficulties, it is possible to discern two phases of prehistoric activity prior to the sea level peak – first, 18000 – 25000 BP, and second, 7000 – 18000 BP.

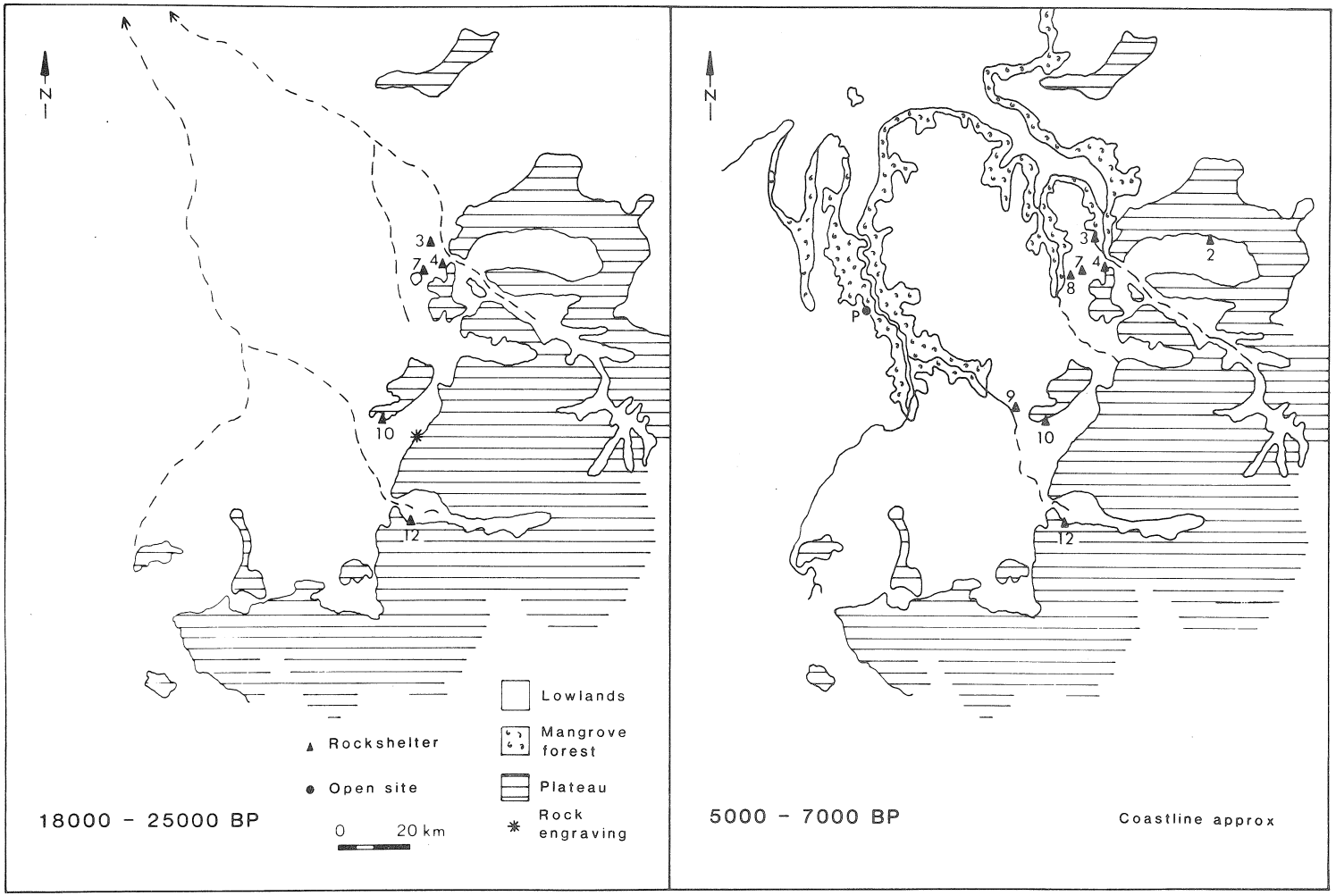
18000 – 25000 BP

The evidence for this period consists of stone artefacts in the lowest levels of four sites; Malangangerr, Nawamoyn, Nauwalabila 1 and Ngarradj (Table 6, Figure 3). Stone tool assemblages of this age are composed of grindstones, ground edge axes and medium to large quartzite flakes and cores. Some of the cores may have been used as implements (cf. cores/core scrapers, Schrire 1982; horsehoof cores, steep-edged scrapers, Jones and Johnson 1985b:215). The excavators of the Anbangbang 1 site attribute level III, which contained a single horsehoof core/scraper and step-flaked rejuvenation flakes in brick-red gravel deposits, to at least the same order of antiquity as the sites listed above (Jones and Johnson 1985a:57, 58).

A site type rare in this region, highly eroded rock engravings of kangaroo tracks at Lightning Dreaming (Edwards 1979:116), may relate to this period. Dating of similar engravings in southern Australia may have extended their known age back to 30000 BP (Dorn *et al.* 1988:686-688).

Local environmental conditions were approaching the coolest, driest and most continental phase reached during the Pleistocene period of lower sea levels (Woodroffe *et al.* 1986:19; Chappell and Shackleton 1986:140). The presence of gravels in the lower levels at Nauwalabila 1 and Ngarradj (Allen and Barton 1989:23, 30; Jones and Johnson 1985b:182) and of sandsheets at Malangangerr, Nawamoyn and Malakunanja II (Hope *et al.* 1985:236) indicate large scale movement of sediments at this time.

Lack of water on the plains may have restricted occupation during drier parts of the year to the plateau valleys where permanent waterholes would have occurred. This is the reverse of seasonal patterning under today's climatic circumstances. The presence of springs (Hope *et al.* 1985:238) might have lessened the impact of the dry conditions, however. The oldest habitable sites in the region are likely to be rockshelters close to the plateau margins and permanent waterholes. Certainly the Nauwalabila 1 site with a metre of sand and rubble beneath the lowest dated horizon (20000 BP) is a likely candidate.



FIGURES 3 AND 4: SITES 18000 - 25000 BP AND 5000 - 7000 BP

Schrire (1982:242) has aptly summed up our information for this remote period

> the identity and behaviour of the people who made the early industry remains elusive. They seem to have used shelters briefly in [this] area.

7000 – 18000 BP

A stone flake assemblage of quartz and sometimes chert flakes, cores and lumps dating to the period 7000 – 18000 BP has been excavated from four sites – Ngarradj, Malakunanja II, Nauwalabila I and Burial Cave (Nawulandja). The artefacts from these sites have been described as an 'amorphous quartz and chert flake assemblage' by Allen and Barton (1989:77-87). Compared to the quartzite flakes and cores found in the very lowest levels of these sites, this assemblage consists of smaller flakes, lumpy irregular cores and an absence of any definable tool types (Jones and Johnson 1985b:215). The uses and possible meaning of this assemblage are discussed in Allen and Barton (1989:113-116). Sediments dating between 8000 and 18000 BP and the associated quartz and chert flake assemblage are absent from level III at Nawamoyn and Malangangerr. This could be the result of post-depositional scouring of deposits or an absence of habitation at this time.

The change in artefacts at about 18000 BP (from a medium-sized quartzite flake and core assemblage to an amorphous quartz and chert flake assemblage) does not appear to correlate with any abrupt change in local environmental circumstances. Conditions between 7000 and 18000 BP show a gradual amelioration of the Pleistocene conditions as sea levels, temperatures and rainfall made their approach towards today's values. Western Arnhem Land, however, would have remained an area of plateau valleys, wooded lowlands and sandy alluvial plains at least to 8000 BP (Woodroffe *et al* 1986:21, Figure 3).

It is difficult to determine, on the information available, whether there was an increase in population during this period as judged by the number of sites occupied. If we add those sites likely to belong to this period from Table 7, namely Feather Dreaming (layer B), Anbangbang II (layer B) and Nauwalabila II, to the four sites listed above (Table 5), then there are some indications of an increase in site frequency (Table 14). Compared to the earlier period, there are also indications of an increase in the intensity of site usage in terms of the density of artefacts per cubic metre of deposit at Ngarradj (Allen and Barton 1989:27) and Nauwalabila 1 (Jones and Johnson 1985b:183-187).

Mangrove swamps and riparian forests, 3000 – 7000 BP

The sea level rise and the establishment of the mangrove swamps after 7000 BP created entirely new environmental circumstances in western Arnhem Land. Aboriginal site location and subsistence patterns were altered to take advantage of them. Between 7000 and c.3000 BP, Aboriginal people basing themselves at sites situated in the narrow zone between the mangrove swamps and the Arnhem Land plateau exploited the landward fringe of the mangroves and the woodland areas on the adjacent lowlands.

A high proportion of the food collected from the mangroves came from the small climbing snail *Cerithidea anticipata*. In this regard the Aboriginal economy at this time, as shown in

the midden layers at Malakunanja II, Ngarradj Warde Djobkeng, Nawamoyn and Malangangerr, is unique. The faunal remains in the western Arnhem Land mangrove/mudflat midden sites suggests that freshwater lagoons have existed alongside the mangrove swamps in the Magela and East Alligator areas since 7000 BP. In addition to the mangrove/mudflat shellfish and crabs in these middens, freshwater fish, shellfish and turtles occur throughout. The faunal materials from Malangangerr, Nawamoyn and Paribari (Schrire 1982:232-235) indicate a complicated mosaic of mangrove, freshwater, and terrestrial habitats nearby, and a diverse pattern of Aboriginal collecting activities. The size of the area covered by mangroves plus the complexity of the mosaic of habitats, as revealed by the midden contents, suggest that we are dealing with environmental circumstances for which no comparable modern analogue exists in northern Australia. Middens and rockshelters from the period 3000 – 7000 BP can be divided into two series on the basis of stone artefact content. These are, firstly, 5000 – 7000 BP, and secondly, 3000 – 5000 BP.

5000 – 7000 BP

Despite the scale of mid-holocene environmental changes and their obvious effects on Aboriginal site locations and subsistence patterns, these changes initially do not seem to have had any marked impact on Aboriginal flaked stone technology. Aboriginal people produced large numbers of quartz, quartzite and chert flakes at Ngarradj Warde Djobkeng, Malakunanja II, and Nauwalabila I before sea levels began to rise, and continued to manufacture them well after sea levels reached their present height and the patterns of Aboriginal exploitation of the mangrove/mudflat area were established.

The mangrove/mudflat middens dating between 5000 BP and 7000 BP also contain large numbers of shell scrapers (*Geloina* sp.) and bone points in a variety of shapes – spatulates, unipoints and small bipointed bones. Shell scrapers and bone points occur at every rockshelter midden throughout this time period.

In addition to the eight rockshelters listed on Table 4 and shown on Figure 4, the Blue Paintings site (Table 7, Jones and Johnson 1985a:71) was probably first occupied during this period. It is not known whether the quartz flake layers at Feather Dreaming (layer B), Anbangbang II (layer B), and Nauwalabila II were used at this time. Lack of dating here effects our ability to discern the degree of change in site numbers.

The rise in sea level and the creation of the big mangrove swamps would have markedly increased the biological productivity of the region. Comparison of the number of sites from the period of lower sea levels (pre 7000 BP) with those known to have been used between 5000 and 7000 BP (Table 14) shows an increase in the number of sites occupied.

As the area covered by mangroves reached almost to the Arnhem Land Plateau, Aborigines would have been denied easy access to the river channels and the coastal plain. Seasonal movements and sites would have been restricted to the plateau valleys, the plateau margins, and the lowland corridors between the tidal floodplains. However, even at the height of the big swamp phase, Aborigines were making some use of the river floodplains, as the existence of midden P (6240 BP – Table 11) demonstrates. It is significant that site P occurs at a spot where the South Alligator river was flowing close to a lowland edge (Figure 4). The pattern of

site usage involving open midden sites and rockshelters may have occurred in concert with seasonal climatic changes similar to those to today.

3000 – 5000 BP (Figure 5)

A major change in Aboriginal stone technology occurred halfway through the time period that the mangrove/mudflat middens were being accumulated. After c.5000 BP, small projectile points and adzes began to occur in these middens and also in the plateau valley sites.

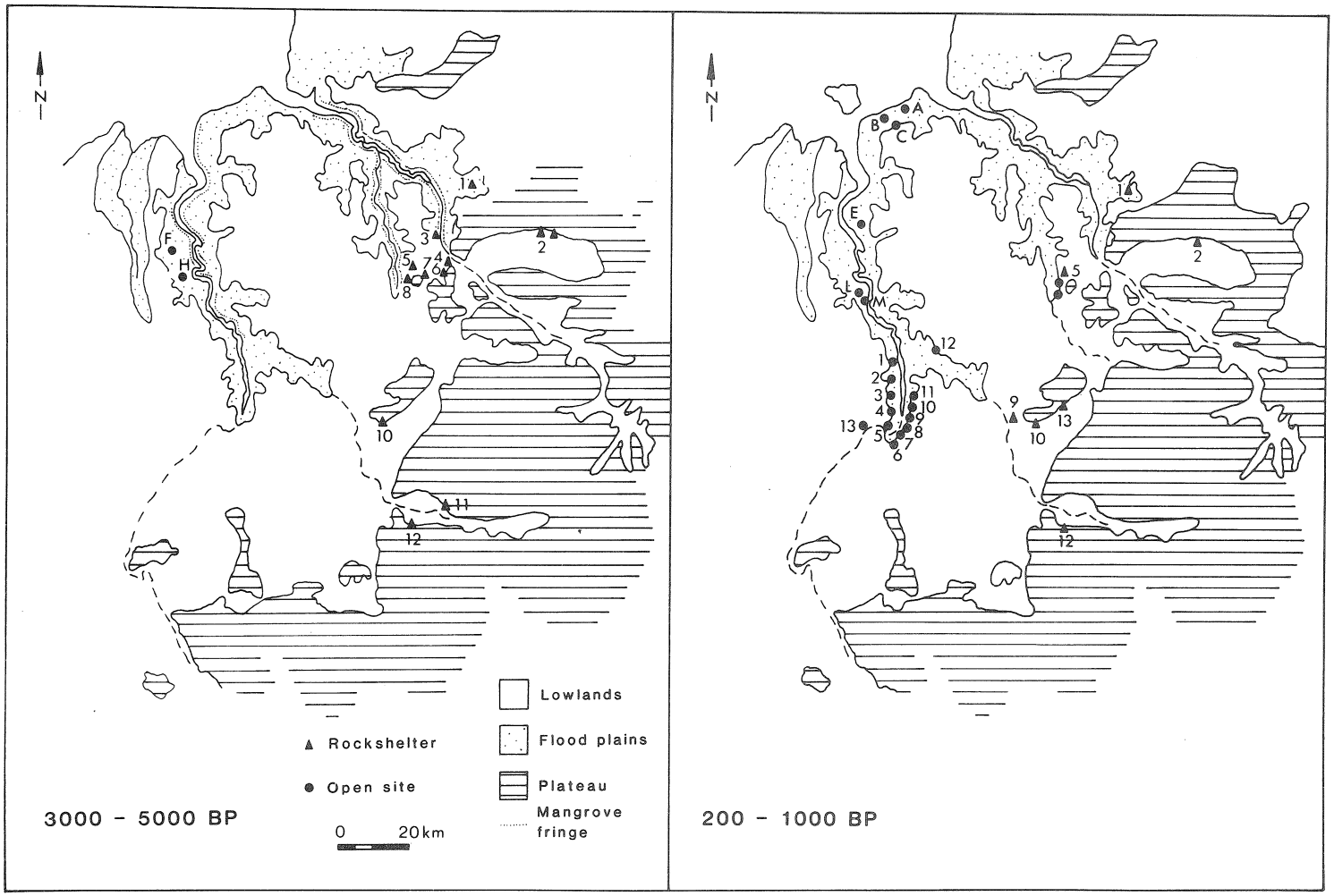
If we compare the midden layers at Ngarradj Warde Djobkeng (3500 – 4000 BP) with the arguably older midden layers at Malakunanja II, Malangangerr and Nawamoyn (levels 1b), then the introduction and manufacture of small points and adzes at these sites does not appear to have had any marked effect on the shellfish, fish or mammal species being collected, the use of *Geloina* shells for scrapers, or the production of bone points.

The archaeological changes that can be associated with the production of stone points are firstly, a reduction in the proportion of quartz flakes, secondly, an increase in the number of tiny quartzite flakes, thirdly, some increase in the number of sites occupied, and finally, an increase in the intensity of site usage as measured by the number and density of stone artefacts per unit of deposit.

While there are arguments about the dating of the oldest small projectile points in this area (Allen 1987b:97; Jones and Johnson 1985b), their absence from the lower mangrove/mudflat middens at Malakunanja II, Malangangerr and Nawamoyn supports the chronology adopted here. On the information presently available, it is clear that manufacturing of these points in any number did not begin until after 5000 BP and that furthermore the date of proven point manufacture varies from site to site (4770 BP at Jimeri II; 3820 BP at Jimeri I; 3990 at Ngarradj and 3070 at Nauwalabila 1 – Allen and Barton 1989:29, 93; Jones and Johnson 1985b:181, 194, 195; Kamminga and Allen 1973:96; Schrire 1982:239). This can be interpreted either as increasing intensity of point manufacturing in the region or else as shifts in activity centres. Implement manufacturing sites such as Ngarradj or Jimeri II appear to be multi-purpose base camps with no marked segregation of implement making from general debris and cooking areas.

The exact date of introduction of stone points and adzes is less significant that the fact that the midden evidence demonstrates that they only appear in any number between 1000 and 2000 years after sea levels rose to their present height and the patterns of Aboriginal exploitation of the mangrove forests on the coastal plains were well established. The later reduction in mangroves from the big swamp phase to a riparian forest, and the creation of grasslands on the floodplain behind this forest fringe, are likely to have created a diversity of productive mangrove and freshwater ecosystems on the floodplains. On the information available, it is difficult to know whether this ecosystem diversity enabled a larger human population to live in the area.

There is some increase in site usage at this time. To the 9 rockshelter sites listed on Table 3, and the 3 open midden sites (Table 10), four additional rockshelters can be added (Table 7); Anbangbang II (layer A), Spirit Cave (layer B), Feather Dreaming (layer A) and Argaluk – White Kangaroo Cave.



FIGURES 5 and 6: SITES 3000 - 5000 BP AND 200 - 1000 BP

A site that goes against the trend of increased usage is Malakunanja II. There, collection of mangrove/mudflat shellfish ceased at c.4000 BP (corrected shell date, 4050 minus 450 years correction = 3600 BP). The virtual abandonment of this site at this time may indicate that mangrove forests had retreated from its vicinity by 3600 BP. With this exception, the use of rockshelters and of open midden sites on the floodplains, established by 7000 BP, continued through this period (Table 14).

The change to the manufacturing of small projectile points, adzes, and presumably composite reed spears, also had a social dimension. There was an increase in the intensity of site usage (as measured by stone flake indices), the successive or cumulative increase in the number of implement manufacturing centres, and finally, the existence of regional trade networks. These indicate more intensive social interactions including conflicts (Allen and Barton 1989:125-127). Consequently it is not possible yet to disentangle environmental from social causes of the archaeological changes discussed above (cf., Jones 1985:293-294 and Lourandos 1985:391).

1000 – 3000 BP – the transition to wetlands

The period 1500 – 3000 BP was one of increased sediment movement in these river systems causing rapid progradation of the coastal plain, the formation of cheniers, and the migration of mangroves towards the river mouth. At the same time, on the central and upper portion of these floodplains, permanent freshwater paperbark swamps began to form on their margins and freshwater lagoons filled old river channels. In addition, seasonally inundated grasslands protected by river levees from the intrusion of saline tidal waters developed on black soil plains.

The Aboriginal response to these changes was to abandon the use of rockshelters such as Nawamoyn, Malangangerr, Ngarradj, Malakunanja II and possibly Paribari. With the shrinkage of the riparian mangrove forests, these sites lost their usefulness as base camps for the collection of mangrove shellfish.

Some shelters do show continuous occupation through this period. These are Jimeri I, Balawuru, Nauwalabila 1 and Anbangbang 1, sites located in plateau valleys or near freshwater lagoons and creeks, where major ecosystems changes did not take place. Mangrove shellfish continued to be collected and dumped, not in rockshelters, but on open middens (sites D, G, J, K, N – Table 9, Figure 2) located on the alluvial floodplains, presumably used during the dry season.

The period 1000 – 3000 BP is marked by a drop in the number of rockshelter sites utilised and a shift to open sites on the floodplains and their margins (Tables 9 and 14). If allowance is made for a correction of minus 450 years BP to the shell dates on Table 9, then midden sites were occupied throughout this period.

Between 1000 – 3000 BP there was a reorganisation of Aboriginal site location and subsistence strategies. This change correlates with the final phase of transition from fringing mangrove forests to grasslands on the floodplains.

200 – 1000 BP – freshwater wetlands

The freshwater lagoons and wetlands of the South and East Alligator Rivers, Magela and Nourlangie Creeks have long been regarded as exceptionally rich habitats for Aboriginal hunter gatherers. Clark and Guppy (1988:682) and Hope *et al.* (1985:236), however, present evidence that the mosaic of freshwater wetlands, so characteristic of today's Kakadu landscape, has only been in existence for the past 1000 – 1500 years.

This final 1000 years of Kakadu prehistory has seen a great increase in site occupancy, especially of open sites on the floodplains (Table 14, Figure 6). Jones (1985:291-2) notes

> This sudden expansion of occupation is also reflected in sites on the edges of the wetlands ... On a traverse of 16 km on the east bank of the South Alligator River, we have studied six extensive open sites, ... with areas approximating to between 10,000 m^2 and 25,000 m^2. ... millions of stone flakes and other artefacts are present on their surfaces ... The sites were probably used at different phases of the dry season, and they indicate in the recent prehistoric past a dense occupation of this area, at this season, directly related to the exploitation of wetland resources in particular *Eleocharis* spike rush corms, together with geese and other water birds.

Midden site usage was not restricted to the wetlands. A large number of open sites with tidal/mangrove shellfish, dating to this period, occur on beach ridges near the mouth of the South Alligator River (Table 8) and also at Point Stuart (Baker 1981:62-63).

Major use of rockshelters occurs only at those sites close to freshwater wetlands, Paribari, Unbalanya and Argaluk, and the Nourlangie sites; Anbangbang 1, Burial and Blue Paintings sites (Nawulandja), and Spirit Cave. Other rockshelters utilised are those located in plateau valleys near lagoons or creeks (Figure 6).

Not shown on Tables 1 and 14 is the evidence, in the form of radiocarbon dates of less than 1000 BP, for the transitory reoccupation of rockshelters such as Malangangerr, Nawamoyn and Ngarradj which had previously been abandoned (Allen and Barton 1989:90). Addition of these sites to Table 14 would heighten the impression of an increase in the number of sites during the last 1000 years.

The occurrence of a large number of recent sites within this small area suggests restricted seasonal movement between sites and intensive utilisation of local ecosystem variation. One imagines the South Alligator plains supporting a number of local groups each pursuing a relatively specialised lifestyle in a different environmental zone (beach ridge and river mouth, lowland hills and floodplain backswamps, plateau valley and local creeks etc.,). Seasonal movements and changes in subsistence activities could be of the type made by the Anbarra people on the lower floodplain of the Blyth River, documented by Meehan and Jones (Jones 1980).

The changes in site location and frequency were accompanied by changes in the nature and number of stone artefacts. Jones, in a comment on the location of implement manufacturing sites, noted that immense numbers of artefacts occur on the open sites (Jones 1985:294). However, the bulk of these artefacts consist of quartz lumps and unretouched flakes. Such quartz artefacts occur at Kun-kundurnku, Kumunkuwi and Ki'na (Meehan *et al.* 1985:137). Quartz flakes are also common at the recent Nangalawurr rockshelter (Table 7). Apart from

miscellaneously retouched and utilised flakes, few retouched implements occur at these sites (Meehan *et al.* 1985:139). The commonest implements are scraper/adzes (adze chisels) and use polished flakes (Meehan *et al.* 1985:139; see also McCarthy and Setzler 1960:266).

There appears to have been a fall-off in the number of small projectile points manufactured or used compared to earlier periods. This is documented in the low number of points at the open floodplain sites, at rockshelters such as Paribari (Schrire 1982:72, 187), Anbangbang 1 (level 1), Nauwalabila 1 (units 1-8), and also at the Oenpelli sites (with the exception of the undated sites 1 and 3 on Unbalanya Hill – McCarthy and Setzler 1960:274). The presence of large endstruck blades, *leilira*, does not compensate for the drop off in the number of small projectile points. Large blades are relatively rare at all sites except the remote Yiboiog on the top of Mount Brockman (Jones and Johnson 1985a:71; Schrire 1982:187). Blade quarries/workshops have been reported at Unbalanya (McCarthy and Setzler 1960:258) and Deaf Adder Gorge (kamminga and Allen 1973:103-104, 106). The specialised nature of these sites, and Yiboiog, suggest that large blades were produced under different social circumstances to the small projectile points (see Jones and White 1988 for a discussion of a specialised eastern Arnhem Land Quarry where blade production was surrounded in ritual). Small points, in the Kakadu region, appear to have been produced or completed at ordinary habitation sites.

ENVOI

The final phase of the *prehistory* of western Arnhem Land appears to dove-tail with our understanding of Aboriginal life during the recent past. The ethnographic present was, however, only the last of numerous changes in site location and settlement, of the type of implements manufactured, and of economic, and possibly social, orientation, which are documented here. Such changes in habitat and lifestyle stretch back into the late Pleistocene. It would be a mistake, therefore, to continue to project our vision of the ethnographic present back onto the past of the Kakadu region. On the other hand, further documentation and testing of the phases discussed here is clearly required. Archaeologically, Kakadu is the most fully researched area in Australia. It is also one of the most interesting.

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