Many cultural and natural processes have been proposed as explanations for the type of quantitative changes that have been documented in the habitation and artefact indices of the Upper Mangrove Creek catchment. In interpreting the catchment’s long-term trends, general broad-scale demographic changes that affected the whole continent since initial colonisation cannot be discounted as having played a role. However, the catchment’s population trends may not have followed continent-wide trends, which have long been debated (Birdsell 1953, 1957, 1977; Beaton 1983, 1985, 1990; Lourandos 1985b; Rowland 1989; Davidson 1990). An interesting aspect of the catchment data set is that trends in the habitation and artefact indices varied, with the dramatic changes in each index occurring in different millennia and the direction of the changes differing from each other in the last 1000 years (Fig. 9.1). In the first millennium BP, habitation indices continued to increase while the local artefact accumulation rate decreased substantially. Therefore, if it is accepted that increasing numbers of artefacts indicate increasing population size, then the decreased numbers of artefacts in the first millennium BP could mean there were fewer people inhabiting the catchment at that time.

Inter- or intra-regional shifts in population in different periods of time also cannot be discounted as having brought about changes in the catchment’s habitation and artefact indices. These movements entail people shifting the focus of their lives and daily activities from one environmental or geographic zone to another on a long-term basis. For example, they can take place through changes in seasonal subsistence patterns, changes in territorial/range/domain boundaries, or redistribution of populations in response to long-term global environmental changes. These regional-scale options cannot be investigated for the catchment yet, as appropriate levels of archaeological information are not available in adjacent areas and regions. The presence of estuarine shell (Anadara trapezia, Sydney cockle) in the upper levels of some of the catchment shelters indicates contact between the coast and/or estuary and the catchment, at least in the recent past, but not necessarily seasonal movements. Regional ethnohistorical descriptions refer to people travelling into the ‘mountains’ from Lake Macquarie ca 30km away on the adjacent coast for trading purposes (Threlkeld 1826 in Gunson 1974, Vol. 2: 206), but make no mention of seasonal movements. The ‘mountains’
referred to were probably the sandstone plateaux of the coastal hinterland and not the Great Dividing Range, but whether this would have included the catchment is not known. Similarly, in the Sydney region to the south, early colonial descriptions of Aboriginal life provide no evidence for seasonal movements (Attenbrow 2002: 53). However, that is not to say that seasonal movements between coast and hinterland could not have occurred in the past. In the terminal Pleistocene and early Holocene for instance, when the coastline was further to the east and more land was available, territories may have been larger and movements perhaps less restricted than in, say, the last 6000 years. However, no archaeological evidence for seasonal movements has been identified in the catchment or elsewhere on the NSW central coast.

Late-Holocene changes in habitation distribution patterns and the way subsistence activities were organised within the catchment, which may have included variations in mobility patterns, are also likely reasons for changes in both the numbers of habitations and the numbers of artefacts within individual habitations and the catchment as a whole. This proposition is examined below with some of the data available for the catchment.

Variations in the ‘intensity of site use’, which refers to changes in the number of person-days spent at a habitation, through either variation in the number of people, the number of visits or the length of each visit, may also have occurred. Nevertheless, there are other reasons which could account for increasing or decreasing artefact accumulation rates in individual habitations and these need to be addressed before change in ‘intensity of site/catchment use’ is accepted as an explanation. They cannot be fully addressed, however, until other analyses of the excavated assemblages (some of which are discussed below) are completed.

Dramatic changes in the artefact accumulation rates in the catchment, as in other regions in eastern Australia, were not correlated in time with either the introduction of new implement types or changes in technology or raw materials, all of which were part of geographically widespread, long-term changes in the stone artefact assemblages (Chapters 2, 6, 7 and 8). The reasons for such changes in the stone artefact assemblages are still subject to research and debate. Suggested explanations include changes in the availability of and access to stone materials because of variations in group boundaries and relationships due to social and territorial reorganisation, and/or changes in the nature and level of subsistence risk as a consequence of variations in plant and animal resource availability associated with climatic and environmental changes. Possible causes of subsistence risk, and risk minimisation strategies which may have produced increases and decreases in the artefact accumulation rates, are explored below.

Changing trends in both the habitation and artefact indices reflect the way people lived within only one part of their country: the Upper Mangrove Creek catchment. The catchment (which is only 12km by 10km) would have been only part of a clan territory and part of the range of a band or bands who, at contact, belonged to a language group now known as the Darginung. In 1788 (at the time of British colonisation), and for an unknown time beforehand, the Darginung (and their predecessors) would have belonged to a yet larger ‘culture-area’ (cf. Lampert 1971a: 70) which was east of the Great Dividing Range and extended from Port Macquarie in the north to the NSW/Victorian border in the south (Fraser 1892: ix, map, 1892 [1893]: 32, map, Appendix X: 92; Eades 1976; Attenbrow 2002: 33) (a smaller area than the south-eastern culture area of Peterson [1976: Fig. 8]). Trends in the catchment’s habitation and artefact indices thus cannot be interpreted without reference to what people may have been doing in other parts of their country or their neighbours’ country, which lay on each side of the catchment.

In south-eastern Australia, the appearance of new implement types and changes in technology and raw materials (Chapters 2, 7 and 8) were part of a sequence of stone artefact
assemblages which McCarthy (1964a, 1964b: 201–2, 1976: 96–8) called the Eastern Regional Sequence, and which is presently under review (Hiscock and Attenbrow in press). There are regional and sometimes local variations in the assemblages of each phase and the phases appear to have begun at slightly different times in different regions. Such regional differences were possibly due to variations in local environmental conditions and the way each region responded to climatic change as well as to regional variations in social organisation, territoriality and subsistence patterns due to historical precedents (Attenbrow 1987: 365–8). In addition, and for the same reasons, there would also have been variations in the habitation–subsistence organisation of each region or locality. These broad-scale behavioural changes, which are reflected in the stone artefact assemblages across the culture-area, would have been a ‘background’ to habitation and subsistence strategies used in the catchment. The catchment’s habitation and subsistence strategies would have been related to its specific environmental characteristics and the role they played in its inhabitants’ lives.

In earlier chapters, it has been shown that several explanations for dramatic changes in habitation and artefact indices do not apply to the catchment. For example, the impact of geomorphological processes (e.g., burial, erosion and deflation) on habitation distribution patterns in the catchment were found to be an unlikely source of bias in the observed trends in rockshelter sites, though they may have skewed the recording of open archaeological deposits (Chapter 5). Greater visibility of habitation sites due to an increase in the number of stone artefacts manufactured per person is also unlikely given the fact that the local artefact accumulation rate, as well as the rate in many individual habitations, decreased during the period when substantial increases occur in the habitation indices. Some explanations cannot be investigated without further fieldwork, for example, intra-site changes in the location of discard. Comparison of sequences in individual 50 × 50cm pits within the same rockshelter suggests this is an unlikely reason, particularly given the relatively small size of many catchment rockshelters.

The following discussions therefore focus on behavioural explanations and processes that are likely to have affected the catchment’s archaeological record. Interpretations of the dramatic increase in the habitation indices revolve around habitation patterns and subsistence organisation, while those for the artefact accumulation rates centre on subsistence methods and equipment. They include the concepts of mobility and risk, which were highlighted earlier as potentially fruitful avenues to explore the dramatic changes in the catchment’s habitation and artefact indices (Attenbrow 1982b: 76–7; 1987: 368–77, 384).

Habitation patterns and subsistence organisation

In earlier chapters, the habitations have all been treated as functionally equal, although it was foreshadowed in Chapter 3 (defining Archaeological Deposits) that they may not all have been used for the same activities. Their likely function is thus explored as a start to investigating the habitation and mobility patterns and subsistence organisation that operated within the catchment.

Base camps, transit camps and activity locations

Binford’s (1978, 1980, 1982, 1983) ethnographically based forager–collector model has been important in identifying past habitation, subsistence and land-use patterns from archaeological site distribution patterns. In Binford’s model, the principal contexts for discard or abandonment of artefactual remains, and thus places which can be identified archaeologically, were ‘residential (home) bases’ and ‘locations’. Binford (1980: 9) defined
residential bases as ‘the hub of subsistence activities, the locus out of which foraging parties originate and where most processing, manufacturing, and maintenance activities take place’. Locations, also referred to as ‘functionally specific sites’, were defined as

… a place where extractive tasks are exclusively carried out … only limited quantities [of food and raw materials] are procured there during any one episode, and therefore the site is occupied for only a very short period of time … abandonment of tools is at a very low rate. In fact, few if any tools may be expected to remain at such a site. A good example of a location generated by foragers, a wood-procurement site … (Binford 1980: 9–10)

Binford (1980: 10) defined three other places associated with the ‘collector end’ of the forager–collector continuum: ‘field camp’ (overnight camps while away from the residential base), ‘station’ (e.g., ambush locations or hunting stands) and ‘cache’. In his model, these latter places were associated with collectors who were characterised by storing food for at least part of the year and who logistically organised procurement parties. Such locations were used rarely by foragers, who typically did not store food but obtained it daily, ranging out on an ‘encounter’ basis before returning to their home base each afternoon or evening (p. 5); they stayed only occasionally in overnight camps when hunting (p. 7–8).

Binford’s model was based on ethnographic studies of the Nunamiut Eskimo of Alaska, the Gwi San and Dobe !Kung of the Kalahari Desert, as well as equatorial groups (Binford 1978). Other researchers, however, based on their own ethnographic observations in other countries, included a much wider range of places as ‘activity locations’ within forager subsistence strategies; for example: hunting hides, viewing/lookout points, artefact preparation locations, manufacturing localities, tree-felling areas, waterholes, ceremonial locales, burial areas, shade areas, as well as areas associated with food procurement (e.g., kill and butchery sites, and plant gathering areas), firewood and raw material sources (Foley 1981b: 164, 1981c: 11, 107, Table 2.1; Bettinger 1991: 66; Veth 1993: 83, 90). In northern Australia, in addition to base camps used by the present-day Anbarra, Meehan (1988: 179–80) described overnight (transit) camps, and places which she referred to as ‘dinner-time camps’. At some ‘dinner-time camps’, shellfish were processed and the meat was taken back to the base to eat.

Characteristics that have been said to identify base camps or distinguish them from activity locations in archaeological contexts include size (area in square metres) as well as the diversity, richness and nature of artefact types and faunal remains. Binford (1982: 15) proposed that base camps would have the most complex mix of archeological remains since they were commonly used logistically when residential camps were elsewhere. Meehan (1988: 179–80) observed that base camps have a much larger area and much wider range of food species, and, since parts of some animals would be eaten at dinner-time camps, home bases may not have the remains of whole animals. Nelson (1991: 79–81, 85) said locations identified archaeologically as base camps have a greater diversity and richness of artefacts representing a greater range of activities undertaken on site and in the immediate area, in contrast with activity locations that have low diversity of artefact types used for a few specific and focused activities. She cautioned, however, that the nature of the stone artefact assemblages and classes of artefacts representing reduction strategies at base camps would depend on the technological system operating at the time. Evidence of storage was another characteristic she said distinguished base camps from activity locations (Nelson 1991: 82).

For the Upper Mangrove Creek catchment, there are no historical or ethnographic descriptions of subsistence strategies or land-use practices for the early colonial period. Historical sources for adjacent areas suggest that groups moved frequently and those inhabiting the hinterland of the NSW central coast would have employed strategies closer
to those of foragers rather than collectors (e.g., Threlkeld 1825–26, 1826; see also Brayshaw 1986; Vinnicombe 1980; Attenbrow 2002). On this basis, it is proposed that the catchment’s inhabitants were relatively mobile hunter-gatherers who moved between many short-term base camps within their country, with group size varying according to weather, season and locality. While in the catchment, family groups stayed at base camps for several nights undertaking a range of domestic tasks, members going out daily to obtain food and raw materials. Tasks undertaken at activity locations away from base camps may have included: (a) hunting, butchering, fishing (including eels) and shellfishing (freshwater mussel), plant and honey collecting; (b) procuring raw materials, such as stone, wood, plant fibre and resin; and, (c) religious or ritual responsibilities. During these daily forays, to places inside or outside the catchment, damaged tools and implements would have been mended, and food prepared and/or eaten at locations away from the base camp. People also may have sought protection in rockshelters during the day from the extreme heat of summer, the frosts and cold winds of winter, and the rain at any time of the year. Individuals or small groups would have made occasional longer trips for subsistence, trade or social purposes to places which necessitated the use of overnight/transit camps away from their base camps. Large gatherings for ceremonial purposes probably occurred at locations outside the catchment.

Within the catchment, in addition to the numerous archaeological deposits (habitations), there are also many sites with images (mostly pigment drawings in shelters) and grinding grooves (and a scarred tree outside the random sampling units). Together, this suite of archaeological sites demonstrates that many of the activities described above were carried out. Overnight camping and a range of domestic tasks were undertaken at habitations. The grinding grooves indicate that the shaping and sharpening of ground-edged implements occurred, and the pigment and engraved images were likely created in association with both religious and secular activities. Although there is no outcropping bedrock in the catchment from which stone artefacts can be made, pebbles and cobbles eroded from the Hawkesbury sandstone and conglomerate beds in the Narrabeen sandstones are available on the ridgesides and in creek beds (Chapter 3). Some catchment habitations may have been used as transit camps by people travelling from one locality to another on ceremonial business or to procure raw materials by direct access or trade — for example, along the historically documented route between the Hunter Valley and Brisbane Waters via the Wollombi Valley and the ridge forming the catchment’s eastern boundary, which also linked with other routes extending west as far as Mudgee–Rylstone (McCarthy 1936: 2–3, 1939a: 1, 1939b: 407, 1939c: 100).

Identifying base camps, activity locations/transit camps

Although I address only the habitation indices in this section, it is not realistically possible to address the habitation indices by themselves. As mentioned above, the number of artefacts in each habitation varied widely, and the small size of the assemblages in some (even when extrapolated to estimated total numbers) suggests all were not base camps. Even the six long-term habitations (i.e., those used for more than 3000 years) with the most abundant and richest assemblages were unlikely to have been only base camps throughout their history of use. Their earliest use may have been as activity locations or transit camps (cf. Morwood and L’Oste-Brown 1995: 161).

Stone artefact analyses appropriate to investigating whether ‘habitations’ are base camps, transit camps or activity locations, and whether their function varied over time, have not been undertaken (see below). Therefore, to explore this idea further, I used the breakdown into ‘millennia assemblages’ for individual habitations, which was used in calculating the local artefact accumulation rates (Table 6.13, Appendix 2). These figures
represent the estimated total number of artefacts that accumulated in a habitation site in each millennium. To devise a model based on assemblage size which can be tested later through the archaeological assemblages, a K-means cluster analysis was employed as it provides a good approximation of the number of divisions into which a population can be split (Orton 1980: 52–3; Wright 1992). This analysis indicated that the millennial assemblages could be grouped into either four or seven clusters (Table 10.1). In both series, there are large gaps between the clusters at the higher end of the figures, but at the lower end, there is no obvious break between ‘small’ and ‘large’ assemblages. There is thus no clear indication of what can be assigned as activity locations/transit camps or base camps, assuming the former would have a small number of artefacts discarded at them whereas the latter would have had much larger assemblages incorporating debitage from stone implement manufacture. So, for the purpose of model-building, the lowest group in the cluster of seven (0–2350) was taken as activity locations/transit camps, and the other groups as base camps. This assignment on the basis of estimated artefact numbers is still somewhat arbitrary and speculative. However, when the grouping into four clusters was chosen and assemblages in the 0–7000 cluster were assigned as activity locations/transit camps, there were no base camps in the catchment until the third millennium BP, except in Loggers in the 10th and ninth millennia BP. While that is a possibility, it seems a less reasonable basis on which to develop a hypothesis than the one adopted.

Clearly, in testing the proposed habitation and land-use model, one avenue to investigate will be whether the ‘habitations’ and/or the millennial assemblages in long-term ‘habitations’ in ‘Group 0–2350’ are activity locations or transit camps and whether the others are base camps. Assemblages resulting from very short-term or infrequently used base camps could overlap in size with frequently used activity locations. Assemblage/artefact attributes chosen for analysis need to be those that will identify whether assemblages were derived from domestic activities at base camps (e.g., cooking and eating of meals by family groups, and implement manufacture), hunting and gathering tasks that would happen in activity locations (e.g., minor maintenance of hunting equipment and butchery of large animals), or preparation and consumption of food by small groups as would occur in transit camps. Questions to address include: what level of diversity exists in tool types and faunal species (bearing in mind the effect of sample size; Attenbrow 1981: 170, 1987: 134–5, 147; Grayson 1984: 116–30; Thomas 1989: 86; Hiscock 2001)? What activities are represented by the assemblages? What do use-wear and residue analyses tell us about tool functions? What reduction stages are

<table>
<thead>
<tr>
<th>NO. AND SIZE OF CLUSTER</th>
<th>MILLENNAL ASSEMBLAGES</th>
<th>SITES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grouped into 4 clusters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–7000</td>
<td>63 [3]</td>
<td>30</td>
</tr>
<tr>
<td>11,550–25,250</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>36,450–66,350</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>165,200</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Grouped into 7 clusters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–2350</td>
<td>52 [3]</td>
<td>28</td>
</tr>
<tr>
<td>2650–7000</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>11,550–17,200</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>23,200–25,250</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>36,450–46,300</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>66,350</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>165,200</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
represented in the stone artefacts — stone implement manufacture or only tool maintenance? What particular skeletal parts of animals are present? What other cultural features are present, e.g., hearths or heat-treatment pits? Issues relating to measuring ‘intensity of site use’ could be addressed by analysing deposition rates for more than one set of evidence; for example, faunal as well as stone artefact assemblages, charcoal and sediments (cf. Smith 1982; Hiscock 1984: 134; Morwood 1986). Site location analysis may also identify whether any category is associated with specific environmental or topographic contexts and habitat/resource zones (Foley 1981a: 4–7).

Using the above basis for assigning assemblages as base camps or activity locations/transit camps, only one of the seven long-term ‘habitations’ appears to have been a base camp throughout its history of use — Emu Tracks 2, first established in the fourth millennium BP. The function (or principal function) of the other long-term ‘habitations’ changed over time from activity location to base camp. Loggers was used initially as an activity location in the 12th millennium BP (i.e., <2350 artefacts accumulated in that millennium, see Table 6.13), and it was not until the next millennium that a base camp was established there, which was then used for such purposes throughout its history. Three long-term ‘habitations’ were not used as base camps until the third and another until the second millennium BP. In the first millennium BP, only one ‘habitation’ was first used and established as a base camp (Mangrove Mansions, though it is its large area that results in a high estimate for the total number of artefacts and places it in this category, rather than the excavated assemblage size), and another used as a base camp in the second millennium BP reverted back to use as an activity location. Of the 22 ‘habitations’ used solely as activity locations, only one was initially used before 3000 BP — Kangaroo and Echidna. This was established by at least 6700 BP, based on a radiocarbon age for a level 28cm deep. Extrapolation of this date to the base of the cultural deposit at 43cm using a depth/age curve would place initial establishment about 9800 BP (Table A2/12), but this seems improbable and here a maximum age of 7000 BP is assumed.

Most activity locations were first used in the last 2000 years — seven in the second millennium BP and 13 in the first millennium BP. Some may have been used only once, whereas others were used on numerous occasions over centuries or millennia. Even once established as a base camp, ‘habitations’ would have been used occasionally or frequently as an activity location on daily forays, or as a transit camp on long-distance trips for trade, ceremonial or other social purposes (cf. Binford 1982: 15; Ebert 1992: 30–1).

Variations in the number of base camps and activity locations in different millennia (Table 10.2, Fig. 10.1) support the proposition that habitation patterns and subsistence organisation in the catchment changed over the last 11,000 years, and that change of an unprecedented scale and nature began in the third millennium BP. In this period, a substantial increase in base camps occurred which contrasts with the lower number of locations used solely as activity locations/transit camps. The timing of this change, based on the size of assemblages within ‘habitations’ was earlier than the dramatic increase in the habitation indices, which was in the second millennium BP (Fig. 9.1). As well as an increase in the number of activity locations in the second and first millennia BP, there was also the use of topographic zones which had not been used (or not often used) before (Table 10.2), though given the small size of the catchment this should not be interpreted as movement into marginal environments (Lourandos 1983a: 82; 1985a: 391, 400) or into unfamiliar territory (Hiscock 1994: 277–8, 282).

During the last 4000 years, and perhaps more commonly in the last 2000 years, in addition to activities that occurred within ‘habitations’, the manufacture and maintenance of ground-edged implements occurred on sandstone where water was available, e.g., in creek-
What’s changing: population size or land-use patterns? The archaeology of Upper Mangrove Creek, Sydney Basin

lines, adjacent to rock pools and seepage areas on rock platforms, and beneath rockshelter driplines. Chronological assignment of these activities is based on the presence of ground implements and ground fragments in stone artefact assemblages dated to the last 4000 years, and increasingly in the last 2000 years, when there is also a greater amount of igneous material in the assemblages (Table 10.3, Figs 10.2 and 10.3). Most sites with grinding grooves (74%) occur in the upper elevations of the catchment — on Hawkesbury sandstone exposed in creek-lines and on rock platforms principally in the periphery ridgetop zones (Table 4.2, Figs 4.1 and 4.2). This grinding groove distribution pattern reinforces the view that activities were increasingly dispersed across the catchment in the last few thousand years.

Half the locations with images (principally pigment in rockshelters) are on ridgesides above subsidiary creeks; the rest are relatively evenly distributed in each of the other zones.

![Table 10.2](image)

**Table 10.2** Upper Mangrove Creek catchment: distribution of base camps (BC) and activity locations/transit camps (AL/TC) in each topographic zone in each millennium. Numbers in square brackets indicate a location possibly used in that millennium.

<table>
<thead>
<tr>
<th>MILL. BP</th>
<th>MAIN VALLEY</th>
<th>PERIPHERY</th>
<th>SUBSIDIARY</th>
<th>MAIN VALLEY</th>
<th>SUBSIDIARY</th>
<th>PENINSULA</th>
<th>RATIO</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BOTTOMS BC</td>
<td>Ridgetops BC</td>
<td>Ridgesides BC</td>
<td>Bottoms BC</td>
<td>Ridgetops BC</td>
<td>Ridgetops BC</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AL/TC</td>
<td>AL/TC</td>
<td>AL/TC</td>
<td>AL/TC</td>
<td>AL/TC</td>
<td>AL/TC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12th</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0:1</td>
<td>1</td>
</tr>
<tr>
<td>11th</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1:0</td>
<td>1</td>
</tr>
<tr>
<td>10th</td>
<td>1</td>
<td>[1]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1:1</td>
<td>1 +[1]</td>
</tr>
<tr>
<td>8th</td>
<td>1</td>
<td>[1]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1:1</td>
<td>2 +[1]</td>
</tr>
<tr>
<td>7th</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1:2</td>
<td>3</td>
</tr>
<tr>
<td>6th</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1:3</td>
<td>4</td>
</tr>
<tr>
<td>5th</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1:4</td>
<td>5</td>
</tr>
<tr>
<td>4th</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2:5</td>
<td>7</td>
</tr>
<tr>
<td>3rd</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>2:5</td>
<td>7</td>
</tr>
<tr>
<td>2nd</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td></td>
<td></td>
<td>5:4</td>
<td>9</td>
</tr>
<tr>
<td>1st</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>2:1</td>
<td>6</td>
</tr>
</tbody>
</table>

*Figure 10.1* Upper Mangrove Creek catchment: number of base camps and activity locations/transit camps used in each millennium.
except peninsula ridgetops. Unfortunately, the creation of pigment and engraved images cannot be incorporated into the chronology. McDonald (1994: 152) assumes pigment images are more likely to ‘correspond in age with more intensive occupation’ (i.e., the period during which high artefact accumulation rates are documented) in the shelter in which the images occur. However, I have not assumed such a correlation since (as suggested above) the function of many shelters may have changed over time (see also Rosenfeld 2002: 76). The only evidence that indicates an age for pigment images in the catchment is outside the random sampling units, in a shelter called Dingo and Horned Anthropomorph. In this shelter, red ochre of similar colour to images on the shelter walls was found in excavated contexts dated to ca 580 BP and younger (Macintosh 1965: 85, 96–7).

### Table 10.3 Upper Mangrove Creek catchment: number and percentage frequency of backed, ground, igneous, bipolar and quartz artefacts in each millennium.

<table>
<thead>
<tr>
<th>MILLENNIUM BP</th>
<th>TOTAL NO. OF ARTEFACTS</th>
<th>BACKED ARTEFACTS NO. %</th>
<th>GROUND ARTEFACTS NO. %</th>
<th>IGNEOUS ARTEFACTS NO. %</th>
<th>BIPOLAR ARTEFACTS NO. %</th>
<th>QUARTZ ARTEFACTS NO. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11th</td>
<td>145</td>
<td>1</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10th</td>
<td>906</td>
<td>2</td>
<td>0.22</td>
<td>1</td>
<td>0.11</td>
<td>309</td>
</tr>
<tr>
<td>9th</td>
<td>873</td>
<td>3</td>
<td>0.34</td>
<td>1</td>
<td>0.11</td>
<td>332</td>
</tr>
<tr>
<td>8th</td>
<td>167</td>
<td>1</td>
<td>0.60</td>
<td>1</td>
<td>0.60</td>
<td>53</td>
</tr>
<tr>
<td>7th</td>
<td>146</td>
<td>1</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6th</td>
<td>167</td>
<td>2</td>
<td>1.20</td>
<td>3</td>
<td>1.80</td>
<td>53</td>
</tr>
<tr>
<td>5th</td>
<td>219</td>
<td>1</td>
<td>0.46</td>
<td>2</td>
<td>1.83</td>
<td>81</td>
</tr>
<tr>
<td>4th</td>
<td>444</td>
<td>5</td>
<td>1.13</td>
<td>1</td>
<td>0.23</td>
<td>11</td>
</tr>
<tr>
<td>3rd</td>
<td>5936</td>
<td>67</td>
<td>1.13</td>
<td>9</td>
<td>0.15</td>
<td>58</td>
</tr>
<tr>
<td>2nd</td>
<td>6694</td>
<td>30</td>
<td>0.45</td>
<td>16</td>
<td>0.24</td>
<td>222</td>
</tr>
<tr>
<td>1st</td>
<td>3455</td>
<td>8</td>
<td>0.23</td>
<td>24</td>
<td>0.69</td>
<td>144</td>
</tr>
</tbody>
</table>

![Figure 10.2](image_url)  
**Figure 10.2** Upper Mangrove Creek catchment: number and percentage frequency of ground implements and ground fragments in each millennium.
It is therefore proposed that the number of activity locations/transit camps used in the catchment gradually increased until 3000 BP. Then, particularly after 2000 BP, there was a dramatic increase in their number associated with the use of topographic zones not previously used or only infrequently used (Table 10.2). Base camps were first established in the 11th millennium BP, but the number did not increase until the fourth millennium BP, with the greatest increase in establishment occurring in the third millennium BP.

**Mobility — residential or logistical?**
In his collector–forager model, Binford (1980, 1982) described residential mobility and logistical mobility as organisational alternatives that could be employed in varying mixes in different settings. Logistical mobility was a strategy adopted by collectors in which base camps were inhabited for relatively long periods, and task groups went out overnight or longer using field camps, stations and caches, and then brought resources back to base camps. Residential mobility related to the movement of people between base camps. It was a strategy used by foragers, who had high residential mobility, in which people moved so that they camped near the resources they were exploiting.

Residentially mobile groups operated within a foraging range around each base camp within which they used a number of activity locations, which included hunting blinds and other special-use locations (Binford 1982: 7, 11, Fig. 2). The field camps, stations and caches used by the logistically mobile groups were beyond their foraging range, but within a logistical range. Highly mobile foragers did not develop a logistical range, although occasional logistical trips were undertaken. Binford states that ‘with any condition that restricts residential mobility of either foragers or collectors, we can expect (among other things) a responsive increase in the degree of logistically organised production’ (1980: 17; see also Nelson 1991: 85). The several residential bases with their associated foraging ranges and logistical ranges, which were used over the course of a year, were within an ‘annual range’ (Binford 1982: 7). ‘Long-term mobility’ involved circulation through a series of annual ranges, perhaps every decade, and the
country which encompassed several annual ranges of a community formed an ‘extended range’ (Binford 1983: 382–3).

The concept of a series of ‘ranges’ to describe Aboriginal subsistence patterns is well accepted in Australian ethnographic studies (e.g., Stanner 1965; Maddock 1982: 42–7), but Binford’s forager–collector model is not without problems and it has often been applied too simplistically (Bamforth 1991; Bettinger 1991: 71–3; Odell 1996: 52–3; Lourandos 1997: 19–20). Kelly (1992: 44–5, 50, 60) pointed out that there are many different dimensions to mobility — individual mobility, group residential, territorial shifts and migrations, each of which can vary independently of the others. He considered it is not useful to speak of a continuum between mobile and sedentary systems, since mobility is not merely variable but multidimensional. The concept of residential mobility involves not just the movement between base camps but also the frequency of movements and distance (km) between them, as well as the duration of visits at base camps (or duration of time between each move). It also involves the total distance covered in residential moves each year (Kelly 1983: 278–9; Shott 1986: 26; Andrefsky 1998: 212), as well as distance covered from the base camps in daily forays, which can vary in length according to circumstances. For example, the longer people stayed at a base camp, the further they had to go each day to gain resources; that is, the distances covered on trips out from the base camp became greater (Kelly 1992: 46–7). Bettinger (1991: 72) questioned Binford’s claim that increasing population pressure should lead to an increase in logistical mobility (and a decrease in residential mobility), as surrounding populations would have restricted group movements. However, Australian ethnographic studies (e.g., Gould 1975: 149–50; Maddock 1982: 42–7) show that controlled territorial boundaries are often counterbalanced by social mechanisms based on kinship and exogamous marriage rules, which facilitate subsistence movements across boundaries in times of need — though when such systems came into being is not yet known. Binford’s model also does not include a term for groups part-way along the continuum, e.g., those who are residentially mobile but who undertake occasional logistical forays. The terminology in effect imposes a binary view of hunter-gatherer strategies: they are either foragers or collectors. As well, mobility models by Binford and others are based on ethnographic studies of communities who inhabited different environments to that of the catchment (which is forested plateau country with a temperate climate) and who were removed in time for most of the period over which the catchment was used. The mobility patterns and subsistence organisation of groups using the catchment (particularly those of the distant past) were probably quite different to those of the communities on which the models were based.

Although the catchment habitats have been assigned provisionally as either base camps or activity locations / transit camps on the basis of assemblage size, it is more difficult to identify the degree of mobility or the mobility strategy / strategies under which they were formed. Part of the difficulty arises because the catchment is of a size (12km by 10km) that it would have been only part of the daily, annual or extended range over which groups operated (Higgs and Vita Finzi 1982: 30–3; Foley 1981a: 4–9; Binford 1982: 7). However, intensive archaeological fieldwork programs equivalent to that of the catchment have not been carried out in adjacent catchments or regions. The location of base camps in adjacent regions throughout the Holocene is not known. The closest excavated shelters to the catchment are Mogo Creek, ca 7km to the west in the adjacent Macdonald River catchment (Kohen 1995), and Upside-Down Man, ca 18km to the south on Ironbark Creek, a tributary of lower Mangrove Creek (McDonald 1994: Appendix 3). Both may have been within the daily or at least annual range of groups using the catchment. Mogo Creek Shelter, first used at least 2340 years ago (Kohen 1995: 15), has an upper layer which has a very rich and diverse faunal assemblage but very few stone artefacts; unfortunately, this layer is highly disturbed. Upside-
Down Man was first used about 4000 years ago, but it is only in levels post-dating 1500 BP that total estimated numbers of artefacts (based on McDonald 1994: Appendix 3: 264–6, Tables A3.13 and A3.24, Fig. A3.14) are high enough to suggest it was a base camp (according to my methods of categorising catchment habitations).

As stated above, people using the catchment would have been relatively mobile hunter-gatherers — certainly in the recent past, based on early colonial descriptions for the NSW central coast, but probably also throughout the Holocene. Any variation in mobility patterns would have been within the ‘forager’ end of the spectrum rather than ‘collector’. However, many details are not known for any period of time, even the historical period; for example: (a) how long groups stayed at particular base camps or activity locations; (b) how many base camps people used each year; (c) how often groups returned to particular camps or activity locations; (d) how often people moved throughout a year from base camp to base camp; (e) what distance they moved between base camps or, (f) the size of the group/s (band/s) that visited the catchment. Groups may have varied in size and composition when they were in different parts of their annual range according to resource abundance and social/ceremonial occasions. It is also not known how far they ventured out from base camps on daily foraging trips (their daily range); how often they undertook subsistence trips requiring overnight camps away from their base camps (logistical trips); the size of their annual subsistence range; or where clan and language group boundaries were. Oral histories indicate movements from Singleton in the Hunter Valley (ca 60km distant to the north) via the catchment’s eastern periphery ridgetop to Brisbane Waters (28km away to the south-east). These trips entailed movement into territories of other clans and language groups, but we do not know the frequency of such special-purpose trips (e.g., to obtain raw materials or attend rituals/ceremonial functions), or whether people travelled yet greater distances. Each variable listed above would not have been constant, but may have varied over the course of a year, seasonally, in different environmental zones, and over the 11,000 years of the catchment’s use.

Rowland (1983: 73) proposed that more short-term, briefly occupied sites may result after a change from reasonably stable and semi-sedentary activities to those based on greater mobility and more geographically or seasonally separated resources. Whether changes in the distribution patterns of base camps and activity locations/transit camps in the catchment involved variations in residential mobility patterns and the length of subsistence trips, is not clear from the archaeological evidence. However, since the location and nature of base camps outside the catchment for most of the Holocene is unknown, the nature of any logistical trips undertaken is uncertain. Nevertheless, the archaeological evidence does indicate that land-use patterns changed many times throughout the Holocene, as people reorganised their habitation, subsistence and manufacturing activities within the catchment — a suggested model is presented in Table 10.4.

**Other measures of mobility patterns**

Habitation patterns by themselves cannot be taken as the only indication of mobility, irrespective of the area over which habitation patterns have been recorded. Modifications to subsistence tools and equipment may also have been associated with or made in response to changes in mobility strategies (Odell 1996: 53). Other proposed measures of residential mobility involve certain characteristics of stone artefact assemblages from habitation sites, as well as the nature of site structure and the presence of specific features or facilities such as heat-treatment pits (Kelly 1992: 56–7) or storage places (Nelson 1991: 82). None are absolute measures that distinguish different levels of mobility in hunter-gatherer communities — most are relative measures between what went before and what came after, and many are
interrelated. Advocated measures of mobility involving stone artefact assemblages include variations in tool-kit/assemblage diversity and richness, and multifunctionalism (versatility and flexibility) of tools; curated versus expedient artefacts/technology and longevity; the production/use of blades; the use of bipolar technology; the portability (transportability) of implements; tool/artefact size and weight; and selectivity in raw material use. These issues have been discussed by many authors (e.g., Binford 1977: 34; Ebert 1979; Torrence 1983, 2001: 86; Binford and O’Connell 1984; Bamforth 1986; Shott 1986; Parry and Kelly 1987; Kelly and Todd 1988: 237; Baker 1992: 16; Nelson 1991: 70–1, 74, 76; Kelly 1992: 55; Hiscock 1993, 1994, 1996; McNiven 1994; Morwood and L’Oste Brown 1995: 161; Hayden et al. 1996; O’Dell 1996; Andrefsky 1998: Chapter 9; Jochim 1998: 201–4; Clarkson 2002).

A number of these measures involve the concept of raw material conservatism or stone rationing (Bamforth 1986: 39–40; Nelson 1991: 74–7; Morwood and L’Oste Brown 1995: 161; Hiscock 1996; Bamforth and Bleed 1997, Table 7.3; White 2001: 10–15, Table 3), which is also said to incorporate increasing core reduction, including the use of bipolar technology; selection and procurement of better quality stone material; rotating cores, and re-using/recycling previously discarded cores and flakes; more careful knapping strategies such as platform preparation and overhang removal; reducing tool size, producing blades, and development of hafted tools; and extending the use-life of tools by additional retouch. The adoption of stone rationing strategies such as the use of bipolar technology has been said to be important under conditions of low residential mobility (i.e., increased sedentism), though it depends on the availability and abundance of stone (Parry and Kelly 1987: 300–1; Hiscock 1996).

Many of the above strategies are reflected not only in the catchment’s assemblages but also in the stone artefact assemblages in other parts of the south-eastern coastal NSW culture-area, though expressed to varying degrees according to the specific environment and/or availability of resources. As such, these strategies may be indicators of what were general, prevailing regional or culture-area customs and practices and they are not necessarily predictors of the mobility patterns in one small area of a group’s range. In addition, the usefulness of some proposed measures has been questioned. Some systems or terms used in the above propositions (e.g., curated/expedient/opportunistic, reliable/maintainable, and flexibility/versatility) are not mutually exclusive and are often interdependent, and some indicators are over-simplifications and sometimes contradictory (e.g., Bamforth 1986, 1991; Jochim 1989; Myers 1989: 86–8; Torrence 1989a: 62–4; Nelson 1991; Kelly 1992: 55–6; Hayden et al. 1996; Nash 1996; Odell 1996; Odell et al. 1996: 378–9, 381–2; Bamforth and Bleed 1997: 134; Andrefsky 1998: 214, 221–9; Mulvaney and Kamminga 1999: 266; Daniel 2001: 239, 250–2). In addition, some terms are not self-explanatory and unless defined in each study are open to ambiguous use and interpretation.

In the case of the catchment, it will ultimately be best to look at the assemblages as a whole to identify relationships between different technological strategies (e.g., within manufacturing as well as subsistence practices) and their place in the total technological system, and then to study how the system changed over time. However, as an initial stage in this process, the use of bipolar technology as an indicator of mobility levels is examined below with presently available catchment data.

Bipolar technology
Expedient technologies, such as the bipolar reduction of cores, are argued to be associated with low residential mobility — in particular, with a shift from high mobility to increased sedentism (Parry and Kelly 1987: 300; Hiscock 1996; Morwood and L’Oste-Brown 1995: 161). However, based on ethnographic analogies from New Guinea, Brazil, Western Australia and
What’s changing: population size or land-use patterns? The archaeology of Upper Mangrove Creek, Sydney Basin

Table 10.4 A habitation, subsistence and land-use model for the Upper Mangrove Creek catchment.

<table>
<thead>
<tr>
<th>MILLION YEARS BP</th>
<th>HABITATION DISTRIBUTION PATTERN (CATCHMENT)</th>
<th>MOVEMENTS AND MOBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th millennium BP (11,500–11,000 BP)</td>
<td>An activity location/transit camp was used in the main valley bottoms. (1 AL/TC)</td>
<td>The earliest group/s to visit the catchment had their base camp outside the catchment. Members of the group/s visited the catchment occasionally to get food and raw materials or were simply passing through the catchment staying overnight on their way elsewhere for trade or ceremonial purposes.</td>
</tr>
<tr>
<td>11th millennium BP (11,000–10,000 BP)</td>
<td>A base camp was established in the main valley bottom in the shelter previously used as an activity location/transit camp. (1 BC)</td>
<td>The shelter on the north-eastern periphery ridge continued to be used as an activity location or as a transit camp during use of the ridge as an access route for trade or ceremonial activities between the Hunter Valley and Brisbane Waters, as historically documented.</td>
</tr>
<tr>
<td>10th millennium BP (10,000–9000 BP)</td>
<td>A base camp was established in the main valley bottom in the shelter previously used as an activity location/transit camp. (1 BC)</td>
<td>Members of the group/s visited the catchment occasionally to get food and raw materials or were simply passing through the catchment staying overnight on their way elsewhere for trade or ceremonial purposes.</td>
</tr>
<tr>
<td>9th and 8th millennia BP (9000–7000 BP)</td>
<td>The base camp in the main valley bottom continued to be used. An activity location/transit camp was used on a subsidiary ridge on a subsidiary ridge. (1 BC and 1+1 AL/TC)</td>
<td>The northern and eastern periphery ridges continued to be used and activity locations/transit camps were used increasingly on subsidiary ridges. (1 BC and 2–3 AL/TC)</td>
</tr>
<tr>
<td>7th and 6th millennia BP (7000–5000 BP)</td>
<td>The base camp continued to be used in main valley bottoms. The number of activity locations/transit camps increased gradually with another being used by the end of this period.</td>
<td>The northern and eastern periphery ridges continued to be used and activity locations/transit camps were used increasingly on subsidiary ridges. (1 BC and 2–3 AL/TC)</td>
</tr>
<tr>
<td>5th millennium BP (5000–4000 BP)</td>
<td>The base camp continued to be used in main valley bottoms. The number of activity locations/transit camps increased gradually with another being used by the end of this period.</td>
<td>The northern and eastern periphery ridges continued to be used and activity locations/transit camps were used increasingly on subsidiary ridges. (1 BC and 2–3 AL/TC)</td>
</tr>
<tr>
<td>4th millennium BP (4000–3000 BP)</td>
<td>The base camp continued to be used in main valley bottoms. The number of activity locations/transit camps increased gradually with another being used by the end of this period.</td>
<td>The northern and eastern periphery ridges continued to be used and activity locations/transit camps were used increasingly on subsidiary ridges. (1 BC and 2–3 AL/TC)</td>
</tr>
<tr>
<td>3rd millennium BP (3000–2000 BP)</td>
<td>The base camp continued to be used in main valley bottoms. The number of activity locations/transit camps increased gradually with another being used by the end of this period.</td>
<td>The northern and eastern periphery ridges continued to be used and activity locations/transit camps were used increasingly on subsidiary ridges. (1 BC and 2–3 AL/TC)</td>
</tr>
</tbody>
</table>

An activity location/transit camp was used in the main valley bottoms. (1 AL/TC) Regional subsistence patterns were reorganised in this period. Groups now spent more time in the catchment, camping for several days in at least one base camp around which they hunted, gathered food plants, and obtained raw materials. This is evidence of increased use of the catchment, and increasing use of the access route along the northern and eastern catchment boundary.

The base camp in the main valley bottom continued to be used and an activity location/transit camp on a subsidiary ridge may have been used (1 BC and 1 AL/TC). Subsistence patterns remained the same. The shelter on the north-eastern periphery ridge was used as an activity location or as a transit camp during use of the ridge as an access route for trade or ceremonial activities between the Hunter Valley and Brisbane Waters, as historically documented. The northern and eastern periphery ridges continued to be used and activity locations/transit camps were used increasingly on subsidiary ridges. (1 BC and 2–3 AL/TC)

The base camp was established in the main valley bottom in the shelter previously used as an activity location/transit camp. (1 BC) Regional subsistence patterns began changing. The larger number of activity locations/transit camps suggests an increasing use of the catchment, and increasing use of the access route along the northern and eastern catchment boundary. The northern and eastern periphery ridges continued to be used and activity locations/transit camps were used increasingly on subsidiary ridges. (1 BC and 2–3 AL/TC)

The base camp was established in the main valley bottom in the shelter previously used as an activity location/transit camp. (1 BC) Regional subsistence patterns were reorganised with greater catchment use and/or the long-distance access route along the north-eastern boundary was more frequently used. Ground-edge hatchets/implements began to be made and used within the catchment. The northern and eastern periphery ridges continued to be used and activity locations/transit camps were used increasingly on subsidiary ridges. (1 BC and 2–3 AL/TC)
South Africa, as well as North American archaeological examples, Parry and Kelly (1987) outline how expedient core technologies can be associated with both high and low residential mobility depending on factors such as the abundance and distribution of raw materials. In regions where stone material is abundant and widely distributed, highly mobile groups can practice an expedient technology. In contrast, in areas where raw stone sources are scarce and localised, highly mobile groups will design tools to overcome a potential lack of raw material availability and use a formal core technology. Parry and Kelly maintain that, although it is a technology wasteful of stone, more frequent bipolar core reduction was associated with low residential mobility/sedentary groups for whom the main consideration in stone-working was to have an adequate supply of useable stone at locations where it was needed. Such a supply could be maintained at residential locations by stockpiling material obtained through trips to quarries. Hiscock (1982b: 39–41; 1996: 152) explained that bipolar knapping is not necessarily wasteful, in the sense that it can be used to extend the life span of rocks by enabling flakes to be removed from a core that is too small to be worked by other percussion techniques (see also Parry and Kelly 1987: 301–2; Odell 1996: 70–1, 76; Andrefsky 1998: 227). Hiscock (1996: 152) considered that bipolar techniques conferred advantages on groups with low residential mobility if they were not camped adjacent to a large quarry, as it reduced the frequency at which stone needed to be transported to a base camp, in that more flakes could be gained from a single core. In a study of sites on the Kakadu flood plain in Arnhem Land, he demonstrated that in assemblages of the same age, the percentage of flakes removed from a core that is too small to be worked by other percussion techniques varied in frequency, as each site increased in distance from the raw material sources. Hiscock considered that the increased use of bipolar technology during the late-Holocene demonstrates an increased use of this technology in areas where raw materials are abundant and widely distributed,高地移动群体可以实践便捷的技术。相反，在石材来源稀缺且集中的地区，高移动群体将设计工具来克服潜在的石材供应不足，并使用正式的核技术。Parry和Kelly认为，虽然这是一种石材浪费的技术，但更频繁的单极核减法与低住宅移动/定居群体相关联，因为后者的首要考虑是确保住宅选点处有充足的可使用的石材。在这种情况下，石材可以通过在住宅地点存储材料来保持，通过前往采石场的旅行来获得。Hiscock(1982b:39–41;1996:152)解释说，单极核剥片技术并不一定浪费，因为这种方法可以使较小的核块更有效地被利用，以延长石头使用的寿命。例如，它可以去除由于核过小而不能被其他敲击技术加工的石头。Hiscock在其研究中证实了这一点。他在阿纳姆兰卡卡杜平原的一个遗址中进行了研究，该遗址中包含的相同年龄的石器，单极核剥片技术在不同距离的石材来源处的频率各不相同。Hiscock认为，在离石材大坑较远的地区，单极核剥片技术可以降低石材运输的频率，因为这可以减少对单一核块进行加工的石材数量。
expedient technology associated with increased sedentism, or at least decreased mobility during this period. Variations may also occur in assemblages of the same age however, because of the different function of sites in the subsistence system. For example, base camps may contain greater evidence of bipolar core reduction than activity locations at which only a short time (i.e., no more than one night) is spent.

In the catchment, the number of bipolar pieces (cores and flakes) in Loggers and Black Hands increased during the late-Holocene (Tables A1/33 and A1/7 respectively). In Emu Tracks 2, Uprooted Tree and White Figure, in addition to an increase in bipolar cores and flakes, the ratio of hand-held cores to bipolar cores decreased (Tables A1/25, A1/47 and A1/51). Quartz as well as FGS, silcrete and chert were all reduced by bipolar techniques though quartz bipolar cores and flakes are much more abundant in the assemblages. In the catchment as a whole, there was a greater and increasing use of bipolar technology at the expense of hand-held core reduction starting ca 6000 years ago, but more dominantly in the last 3000 years (Table 10.3, Fig. 10.4). The amount of quartz in the assemblages was similar over the last 3000 years (Fig. 10.5), suggesting other stone materials were increasingly reduced by bipolar techniques. If the use of bipolar technology in core reduction was associated with low residential mobility, then this component of the stone artefact assemblages suggests people using the catchment gradually became less residentially mobile from ca 6000 years ago, but especially after 4000 BP.

In many parts of the central and south coast of NSW, the increasing use of bipolar core reduction in the late-Holocene has been documented in numerous stratified rockshelter deposits and is thus associated with broad-scale culture-area changes (e.g., Burrill Lake and Curraong, Lampert 1971a: 38, 46–7, 65–8, Tables 3 and 15; Curraurrang 1, Megaw 1974: 35–7; Curraurrang 2, Glover 1974: 15, Table 2; Lapstone Creek, McCarthy 1948: 22; Macdonald River, Moore 1981, Table 6; Mill Creek 11, Koettig 1985b: 45–9, Table 12, 1990: 1; Mt Yengo, McDonald 1994, Appendix 1: 61, 73–4; Sassafras 1 and 2, Flood 1980: 229, 233, Figs 40, 43; Shaws Creek K2, Kohen et al. 1984: 66, Table 5; Upside-Down Man, McDonald 1994, Appendix 3: 245–6). While bipolar core reduction is well documented in excavated rockshelter deposits in sandstone regions of south-eastern NSW, it is much less common in non-sandstone areas

Figure 10.4 Upper Mangrove Creek catchment: number and percentage frequency of bipolar artefacts in each millennium.
where silcrete, chert/tuff and other fine-grained siliceous materials are locally available and predominantly used, but quartz is much less readily available and much less commonly used; for example, the Cumberland Plain (AMBS 2002b: 9–11, 32–5, Table 14), Hunter Valley central lowlands (Baker 1992: 7, 20) and upper Shoalhaven River Valley (Attenbrow and Hughes 1983; Attenbrow 1984). Thus, inter-regional variations, which appear to correlate with the availability of certain raw materials, are evident in the use of bipolar technology.

Use of bipolar technology may have been the most efficient way to exploit the stone materials available in the sandstone country. For example, in the catchment, raw material sources suitable for making flaked tools are pebbles and cobbles from the conglomerate beds in the Narrabeen Group sandstones and quartz pebbles from the Hawkesbury sandstone. The largest cobbles I observed in the catchment was of FGS and was 160 × 110 × 70mm in size, but the majority were much smaller, particularly the quartz pebbles (generally < = 25mm). Silcrete and chert/tuff materials are not available within the catchment, with the nearest sources of the former being in the Hunter Valley lowlands (ca 60km to the north) and the south of the Hawkesbury River (e.g., Cumberland Plain, ca 55km to the south). Sources of chert/tuff are also available in the Hunter Valley lowlands as well as the Colo and Grose River valleys of the Blue Mountains and the Hawkesbury River gravels (35–60km to the south — all distances as the crow flies, but ground travel distances would be longer). Thus, changes in access to and availability of stone material sources which were not available within the catchment may have influenced the degree to which bipolar working was used in core reduction. It may have been used to exploit the imported silcrete and chert/tuff materials to the maximum and, at the same time, would have been the most suitable method to gain useful flakes from the local, small-sized quartz pebbles (Lampert 1971a: 47; Hiscock 1982b). The need to reduce cores of imported materials by the bipolar technique in order to maximise their use may have led to its greater use with other local materials when there was a demand for greater numbers of stone implements (see below). Groups in regions such as the Hunter Valley and Cumberland Plain had no need to adopt bipolar core reduction techniques on a large scale since they had continuing access to quality materials such as silcrete and chert/tuff.

Figure 10.5 Upper Mangrove Creek catchment: number and percentage frequency of quartz artefacts in each millennium.
Taçon (1991: 198-9, 203-4) suggested quartz and quartzite were especially valued as raw materials in western Arnhem Land because they were shiny and iridescent, properties associated with Ancestral Beings. In south-eastern Australia, this could be the case with quartz crystals, which are reported as being associated with rituals and ceremonies (Mathews 1897: 2–3; Howitt 1904 [1996]: 357–8). However, quartz in reef and pebble/cobble forms is so ubiquitous in so many areas it is hard to accept that such forms of quartz had symbolic significance or special powers in this part of Australia. Its easy accessibility combined with the absence of preferred raw materials may be the reason for its increased use in sandstone country of the culture-area. Why it increased in the catchment at the expense of FGS where both materials are readily available is presently inexplicable.

It is possible that the increasing use of bipolar core reduction in the catchment in the late-Holocene was initially a response to restrictions in access to preferred raw materials unavailable in the catchment (i.e., silcrete and chert/tuff). Such restrictions may have been a result of reorganisation of social relationships in the culture-area, which led to greater territoriality and/or more tightly controlled territorial boundaries. Newly established boundaries, or more tightly controlled boundaries, may have meant groups inhabiting the sandstone country could no longer make long-distance trips to stone sources in the non-sandstone country without prior permission or outside the context of trading partnerships and marital relationships. Such a scenario suggests long-distance mobility patterns may have changed, but whether reduced residential mobility was also involved is not yet clear.

Subsistence methods and equipment

The proposed habitation, subsistence and land-use model (Table 10.4) based on the tentative assignment of habitations as either base camps or activity locations provides an explanation for late-Holocene trends in the habitation indices. While artefact numbers were used to produce the model, the model does not explain either the dramatic increase in the local artefact accumulation rate in the third millennium BP or the subsequent substantial decrease in the last 1000 years. Changes in the local artefact accumulation rate do not coincide in time, direction or magnitude with changes in the habitation indices. However, the major increase in base camps in the third millennium BP does coincide in time with the dramatic increase in the local artefact accumulation rate (compare Figs 9.1 and 10.1). The question now has to be asked: are the major increases in both numbers of base camps and the local artefact accumulation rates linked and simply due to a greater number of people inhabiting each base camp and the catchment as a whole, or are they due to some other events or circumstances? The following discussion addresses only changes in the local artefact accumulation rates. Variations in the artefact accumulation rates of individual habitations will be addressed elsewhere.

One explanation for changing local artefact accumulation rates that is explored below is that they reflect a change in the number of implements that were made/used by each person in response to changing levels of subsistence risk rather than local, regional or continental population increase. That is, were risk minimisation strategies adopted in the third and first millennia BP that could have led to changes in the tool-kit, which in turn resulted in the dramatic increase in the local artefact accumulation rate in the third millennium BP as well as the substantial decrease in the last 1000 years BP? In fact, advocating population increase at a time when the climate was colder and drier would be incongruous — such conditions are usually described as ‘deteriorating’ and as being associated with low levels of subsistence resources (e.g., David and Lourandos 1998: 212), although whether resource levels were lower at this time in temperate coastal south-eastern Australia is not certain.
No new flaked implement types appeared in the late-Holocene assemblages; that is, tool-kit diversity remained the same. It appears that an increase occurred in the average number of implements used by each person in the third millennium BP that did not involve an increase in the number of implement types. Flaked implements that did increase in abundance in the catchment in the third millennium BP (both in number and as a percentage of the catchment assemblage) are the backed artefacts (Bondi points, geometric microliths and elouera). Most backed artefacts (85%) were in levels dated to between ca 3000 BP and ca 1000 BP (Table 10.3, Fig. 10.6). The possible use of backed artefacts in risk minimisation strategies is explored below.

The similarity in percentage frequencies for backed artefacts as a proportion of the total catchment assemblage in both the fourth and third millennia BP (despite the large difference in size between the assemblage for each millennium) suggests that there may have been a relationship between the proliferation of backed artefacts and the dramatic increase in the local artefact accumulation rate in the third millennium BP. However, it seems unlikely that backed artefact production was the sole reason for the similarly high local artefact accumulation rate in the second millennium BP as backed artefacts decreased in the number and percentage in this period despite a slight increase in the total number of artefacts. In assemblages of the first millennium BP, backed artefacts are represented only by eloueras and geometric microliths — no Bondi points have been identified in catchment assemblages dating to this period.

Tasks for which Bondi points and geometric microliths were used are still debated. The original view was that Bondi points were ‘surgical knives’ (Etheridge and Whitelegge 1907: 238), but the most common view now is that they were barbs for hunting spears (McCarthy 1958: 186; Lampert 1971a: 69; McBryde 1974: 264–5, 326, 1977: 234, 1985; Mulvaney 1975: 229; Kamminga 1980: 5, 9, 11; Kohen 1986: 313, 323, 1995: 77, 82; Flood 1999: 224–5; Mulvaney and Kamminga 1999: 236; Moore 2000: 35–6). It has also been suggested that Bondi points were points or barbs for multi-pronged fishing spears (McCarthy 1958: 186, 1965: 79; Branagan and Megaw 1969: 8). Others say they could also be small cutting tools/knives — hafted or even hand-held (Stockton 1970b: 227–9, 1979: 54; Moore 2000: 36–7); awls (needles or...
points) for skin-working (Tindale 1957: 27; Stockton 1970b: 227–9, 1979: 54; Kamminga 1980: 5), or ceremonial objects (White and O’Connell 1982: 123). As with other parts of Australian Aboriginal tool-kits, they may have been multifunctional components used in a range of different tools for a range of different tasks (Dickson 1973: 7); though Mulvaney and Kamminga (1999: 266) question this. Examination of use-wear patterns and residues adhering to backed artefacts from eastern NSW assemblages suggests various uses: spear barbs and plant processing (Boot 1993a: Tables 8–11), and hafting as a knife rather than a spear (Therin 2000; Haglund 2001b: 35–6). Robertson’s (2002) examination of backed artefacts from the catchment sites Deep Creek and Emu Tracks 2 has revealed traces of bird feathers. For the following discussion, I assume backed artefacts were multi-functional components and their functions included being points and barbs in hunting spears.

**Risk minimisation strategies**

Risk can be defined as the probability of loss, or, more specifically when related to food resources, it can be seen as the probability of failing to meet dietary requirements and the costs of such failure, for example hunger and malnutrition (Wiessner 1982a: 172–3; Torrence 1989a: 59; Bamforth and Bleed 1997: 117, 133–4). There are thus two components to the concept of risk: the first, the likelihood of an event’s occurrence, and the second, the magnitude of that event (Kelly 1992: 47) or the cost or consequence of losing the sought-after resource (Cashdan 1985; Bamforth and Bleed 1997: 112, 117).

In ethnographic studies, mobility is seen as the simplest response to subsistence risk, which works by taking advantage of the spatial and temporal variations in resource abundance and moving away from areas with scarce food resources (Gould 1980: 84–7; Halstead and O’Shea 1989: 3–4; O’Shea and Halstead 1989: 124; Veth et al. 2000). Risk and mobility are thus interconnected (Parry and Kelly 1987; Torrence 1989a, 1989c, 2001: 88; Odell 1996: 53). However, many other strategies aimed at reducing or avoiding subsistence risks have been documented ethnographically (e.g., Colson 1979; Wiessner 1982a: 172–3, 1982b: 65; Cashdan 1983, 1985; Whitelaw 1983: 58–62; Boydston 1989: 75–6; Myers 1989: 84–5; Thorley 2001: 10; Torrence 2001: 80). These include food storage; transmission of information about famine foods; conversion of surplus food into durable valuables which could be stored and traded for food in an emergency; transfer of risk or loss from one party to another; diversification of activities and/or resources rather than specialisation; and, switching to different resources or switching territories (Colson 1979: 21; Wiessner 1982b: 172–3; Kelly and Todd 1988: 233). Other ethnographic examples include pooling or sharing of risk, which combines principles of risk transfer with principles of storage, and storage of obligations (i.e., generalised reciprocity) (Wiessner 1982b: 172–3). This strategy operates at varying levels and involves the establishment of social relationships as well as kinship and exchange networks and political alliances (at inter- and intra-group levels), which enables the use of food resources in the territories of other clans or language groups in times of hardship (i.e., group mobility) (Colson 1979: 21; Gould 1980: 84–7; Maddock 1982: 42–7; Halstead and O’Shea 1989: 3–4; Myers 1989: 85; O’Shea and Halstead 1989: 124). Prevention of loss through measures such as rituals, control of resources through burning, land rights (territoriality) and defence of territory, so that a group can plan a yearly round without the risk that others will come into the area unexpectedly and exhaust critical resources, have also been reported as methods of reducing risk (Wiessner 1982b: 172–3).

Most hunter-gatherer communities have a variety of strategies and have different strategies for use in different contexts, though some categories are mutually incompatible (e.g., food storage and mobility) and others mutually reinforcing (mobility and diversification) (Halstead and O’Shea 1989: 4; O’Shea and Halstead 1989: 124). The two most common
strategies mentioned in ethnographic literature are risk pooling (reciprocity) and risk avoidance in the form of local mobility, but Torrence (1989a: 58–9) pointed out that the role of tools and technology was often left out of anthropological and archaeological discussions about risk minimisation. The term technology in this context is used more broadly than I have done in previous chapters and includes the use, transport and discard, as well as all stages in making and maintaining the components of a tool-kit (Nelson 1991: 57).

**Technological options**

Technological options that have been proposed as subsistence risk minimisation strategies include a reduction in expedient tools and/or opportunistic technological behaviour (Nelson 1991: 64–5; Torrence 2001: 84–5), as well as the introduction or increased use of highly structured tools and techniques (Wiessner 1982a and 1982b). Other suggested options comprise tended and untended facilities (Torrence 2001: 80); tools designed for curation/longevity and portability (transportability) (Nelson 1991: 62–4, 73–6; Torrence 2001: 84, 86–8); diversified assemblages (tool-kit diversity), including special-purpose tools, as well as increased complexity of tools (number of component parts) (Bleed 1986: 743; Myers 1989: 86; Torrence 1989a: 60–2); efficient and specialised tools that require high investment in production time — specialising in a small set of reliable resources (Bamforth and Bleed 1997: 115); reliable, versatile and portable tools that require low investment in production time, used in association with resource diversification (Bamforth and Bleed 1997: 115); multifunctional, readily modifiable, easily portable tools — that is, formal tools (Andrefsky 1998: 214); reliable and maintainable technological systems which, separately or together, ensure tools are available and work when they are needed (Bleed 1986; Torrence 1989a: 60, 62–3, 2001: 82–9; Myers 1989: 87; Nelson 1991: 66–73; Odell 1996: 53; Jochim 1998: 205–6).

As with proposed measures of mobility based on stone artefact assemblage variables, not all of the above propositions have proved useful when applied in archaeological studies (e.g., Hayden et al. 1996). The central problem that technological strategies have to solve is to ensure that the tools are available and are in a useful condition when needed; that is, technology reduces risk by preventing or at least reducing the probability that loss will occur (Torrence 1989a: 59; Bamforth and Bleed 1997: 116). Efforts to devise loss-reducing technology will be greatest where the consequences of resource loss or the frequency with which risk will occur is greatest (Torrence 1989a: 59–60). However, the context in which the risk occurs also needs to be considered; similar events with similar probabilities of occurrence may result in very different costs in different environments/regions and different communities and thus responses will vary (e.g., Jochim 1989: 110–11); choosing one technological option over another, or a technological rather than a social solution, may also impose costs. Alternative technological solutions have to be acceptable within constraints imposed by other demands on time and the resources of the community, and options must be effective as well as feasible; thus some options may not be acceptable in certain circumstances or contexts (Bamforth and Bleed 1997: 125, 133–4). Torrence (1989a: 61–2) considered technological strategies would be used for coping with short-term risk associated with potentially serious consequences but, as the severity and/or frequency of the risk encountered diminished, different forms of social behaviour would be introduced; for example, mobility and information sharing would be adopted for spatial variations in resource availability. Another technological cost, in addition to application failure (i.e., breakage during use or because of poor tool design), is the cost of production. Such costs include the failure to produce sufficient numbers of tools due to, say, breakages during manufacture, the inability to obtain sufficient raw materials because of time, or social constraints (Bamforth and Bleed 1997: 112, 127–8). The necessity to prepare some
stone materials by heat treatment also may have incurred considerable wastage (Mulvaney and Kamminga 1999: 266). Thus, high technological costs may constrain some choices, and opportunities and constraints would have been balanced against or perhaps integrated with each other in some circumstances.

**Backed artefacts**

Several European studies have linked changes in the availability of game with an emphasis on backed artefacts (microlithic tools) in stone artefact assemblages (e.g., Myers 1989: 90–1; Jochim 1989, 1998: 201–14; Torrence 2001: 88–9). These studies interpret the trend as an increase in the number of stone points/barbs on spears, whereby they could easily be replaced and/or the spear could continue in use even if one was broken. Myers (1989: 82, 87–8, 90–1) proposed that the alteration in microliths from large forms in early Mesolithic British assemblages to smaller more abundant late Mesolithic forms represented a change in tool-kit, in which the microliths were standardised components in multi-pronged tools, which were part of a more diverse, reliable and maintainable tool-kit. This change was a response to a climatically associated faunal change — from migratory species that inhabited open vegetation and could be intercepted along known routes, to non-migratory species that inhabited a denser understorey, were dispersed and unpredictable in location. The late Mesolithic microliths were part of a strategy to enable animal resources to be procured quickly and effectively once they were encountered.

The introduction of new tool-kits (including backed artefacts, unifacial/bifacial points and tulas) and stone-working strategies in Australia in the mid-Holocene (between 6000 BP and 3000 BP) has been explained by Hiscock (1994: 268; 2002) as the introduction of technological solutions to risks created by scheduling uncertainties. At that time, he said, organisational difficulties were imposed by particular systems of settlement and mobility (p. 273) during the use and/or colonisation of previously unoccupied or unfamiliar country, the latter including rapidly changing environments, such as areas in Arnhem Land impacted by the final stages of the rising sea-levels (Hiscock 1994: 277–8, 282). Hiscock described these tools as standardised, multifunctional, reliable, maintainable and portable, with their production geared to raw material conservatism (Hiscock 1994: 278, 287). The subsequent decline in backed artefacts and points, he maintained, was ‘primarily a response to the economics of raw material usage associated with low residential mobility together with a reduction of uncertainty in landscape use’ (Hiscock 1994: 286). In a recent article building on earlier ideas but focusing on backed artefacts, Hiscock (2002: 171, 174) considered that broad chronological trends in the proliferation of their production in many different contexts in southern Australia may well reflect one cultural response to risk incurred by increased environmental variability — a drier and more variable ENSO-controlled late-Holocene climate beginning 5000–4000 BP. This response, he pointed out, was increased production of a pre-existing implement form. He (2002: 172–3) said that other shifts in food resource use in the mid-Holocene in several parts of the continent would have been risk-reduction mechanisms in the face of environmental variation, increased pressure through population increase, and/or reduction of territory size. The subsequent late-Holocene decline in backed artefacts, he said, was, however, not a response to reduction of foraging risk, but to ‘the onset of new environmental and social contexts involving factors such as sedentism, territoriality and population increase, that has a more potent effect on the selection of appropriate technology’ (Hiscock 2002: 172).

**Sources of risk and risk minimisation in the Upper Mangrove Creek catchment**

Environmental changes associated with late-Holocene climatic shifts may have altered the levels of subsistence risk experienced by the catchment’s inhabitants. The general correlation
in timing of late-Holocene climatic changes with the dramatic changes in the local artefact accumulation rates, and the proliferation and decline of backed artefacts, all of which occur within the last 4000 years, suggest an association. Late-Holocene climatic changes (as discussed in the previous chapter) are likely to have affected the catchment’s vegetation communities and animal populations, though it would have been the areal extent and/or abundance of certain plants that altered rather than a loss of communities.

Archaeological faunal evidence
Archaeological evidence from Deep Creek and Mussel Shelters indicates that there may have been a change in the macropod populations in the catchment in the late-Holocene. Several macropod species were identified (Aplin 1981: Tables 4 and 7; Aplin and Gollan 1982: Tables 7 and 8). Faunal assemblages dating from ca 3000 BP to ca 1200–1000 BP were characterised by the presence of the eastern grey kangaroo (*Macropus giganteus*) and the relative importance of the red-necked wallaby (*M. rufogriseus*) and later assemblages (less than ca 1200–1000 BP old) by pademelons (either *Thylogale stigmatica*, red-legged pademelon, or *Thylogale thetis*, red-necked pademelon). The later assemblages also have a greater abundance of swamp wallabies (*Wallabia bicolor*) than the early assemblages. The two macropod species distinguishing the earlier assemblages are much larger in size than the macropod species characterising the later faunal assemblages (Table 10.5).

The habitats of these macropod species suggest that the forest understorey in the catchment was generally more open in the early period from ca 3000 BP to 1200–1000 BP than during the last 1000 years or so. Such vegetation changes are in general agreement with regional pollen records, which indicate forests were more open between ca 2800 BP and ca 1800 BP and the climate was colder and drier than in the preceding five or six millennia. In the warmer–wetter millennia of the early to mid-Holocene, the forest understorey may have been as dense as or denser than it was in the last 1000 years. Consequently, both the eastern grey kangaroo and the red-necked wallaby may have been less numerous in the catchment in the early to mid-Holocene than between 3000 to 1200-1000 BP. If so, the transition to a more open forest environment in the late-Holocene may have provided a situation in which the use of stone-barbed spears and/or multi-barbed spears (incorporating Bondi points) became a preferred method of hunting macropods, including the then more common large eastern grey kangaroo and red-necked wallaby.

**Backed artefacts**
The onset of increasingly colder and drier conditions following the early Holocene ‘optimum’ began ca 5000 or 4000 BP, and at this time backed artefacts began to increase as a proportion of the catchment’s artefact assemblages (Fig. 10.6). However, after ca 3000 BP, when conditions became very much colder and drier than at any other time during the Holocene, the numbers

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>MACROPOD SPECIES</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td><em>Macropus giganteus</em>, eastern grey kangaroo</td>
<td>up to 66kg for males/32kg for females</td>
</tr>
<tr>
<td>Early</td>
<td><em>Macropus rufogriseus</em>, red-necked wallaby</td>
<td>up to 26.8kg males/15.5kg females</td>
</tr>
<tr>
<td>Early-Late</td>
<td><em>Macropus robustus</em>, wallaroo, euro</td>
<td>up to 46.5kg males/25kg females</td>
</tr>
<tr>
<td>Early-Late</td>
<td><em>Wallabia bicolor</em>, swamp wallaby</td>
<td>up to 20.5kg males/15.4kg females</td>
</tr>
<tr>
<td>Early-Late</td>
<td><em>Petrogale penicillata</em>, brush-tailed rock wallaby</td>
<td>up to 10.9kg males/8.2kg females</td>
</tr>
<tr>
<td>Late</td>
<td><em>Thylogale thetis</em>, red-necked pademelon</td>
<td>up to 9.1kg males/4.3kg females</td>
</tr>
<tr>
<td>Late</td>
<td><em>Thylogale stigmatica</em>, red-legged pademelon</td>
<td>up to 6.8kg males/4.2kg females</td>
</tr>
</tbody>
</table>
of backed artefacts produced in the catchment increased dramatically — that is, the
technological response to climatic change was far greater than earlier on. Weather conditions
became more variable with the onset of current ENSO phenomena ca 3000 BP. Increasing
seasonality and variability in precipitation, combined with the colder–drier conditions, may
have increased the magnitude of resource fluctuations and thus increased the levels of
subsistence risk (cf. Bamforth and Bleed 1997: 113). By ca 3000 BP, the probability of failure in
the hunt may have become too great to ignore. Macropod populations inhabiting the
catchment had changed to the extent that there was a greater level of risk associated with
hunting them — the probability of failing to spear (kill) a kangaroo or wallaby had increased.
Part of the response was increased production of backed artefacts to act as points and barbs in
hunting spears so that each hunter had more stone-barbed spears and/or each spear had more
barbs than previously to increase their chance of hunting success. Hunters may have made
more stone-barbed spears to ensure against loss or breakage of a spear shaft during the chase.
Alternatively, more barbs were inserted in their spears because of the larger size of the animals
and/or such a method of manufacture would have enabled the hunter to continue the chase
even if one barb had broken or been lost.

The evidence for the end of the colder–drier period is not as easily interpreted. The
pollen evidence indicates drier conditions lasted only to ca 1800 BP. The number and
percentage of backed artefacts decreased during the second millennium BP, with Bondi points
absent after ca 1600 BP. However, the change in the macropod populations, according to the
archaeological evidence, did not occur until ca 1200–1000 BP. Macropod species were possibly
able to maintain their population levels well after the late-Holocene driest–coldest conditions
prevailed. Alternatively, perhaps the hunters continued for as long as they could to catch the
species to which they had become accustomed, despite variations in their abundance, but
used different equipment and/or moved to strategies that involved the production of fewer
backed artefacts.

By ca 1000 BP, climatic conditions had returned to a warmer-wetter regime and
vegetation patterns that were similar to those at the time of British colonisation. The macropod
species commonly represented in the faunal assemblages of this period — swamp wallaby,
pademelon and brush-tailed rock wallaby — are smaller than the eastern grey kangaroo and red-
neck wallaby, which are present only in the early assemblage (Table 10.5). The continued decline in
backed artefact production (including the abandonment or much reduced use of Bondi points)
may have occurred because stone-barbed spears were not as useful or efficient as other methods to
catch the smaller macropods, and even the larger species such as the euro, which is present
throughout the deposits, in the denser understorey of this period. Other ways of minimising risk,
such as the use of traps or communal hunting, may have been more common. The latter were
observed in early colonial times in adjacent areas: Macdonald River (Mathew 1833 in Havard 1943:
237); Lake Macquarie (Threlkeld 1825 in Gunson 1974, Vol. 2: 191), and near Maitland in the
Hunter Valley central lowlands (Dawson 1830: 8 in Brayshaw 1986: 79, Table B). In some instances,
nets were fixed among the trees (Fawcett 1898: 153 in Brayshaw 1986: 79). The use of wooden
barbed and/or wooden pointed spears may have increased, or the quartz pieces produced by
bipolar core reduction may have begun to replace backed artefacts in stone-barbed hunting spears.
Both wooden pointed and quartz barbed hunting spears were used locally on the coast at Lake

If the catchment’s archaeological record is representative of changes that happened in
the forested sandstone plateau of the NSW central hinterland, then similar faunal sequences
should be identified in future excavations where conditions are suitable for the preservation of
organic remains. Outside the sandstone plateau country, in areas where vegetation and faunal
communities were different and responses to climatic changes may have differed, human
responses may have varied as well, especially in the adjacent coastal zones where ocean and estuarine resources were available. However, the widespread distribution of backed artefacts and their ubiquitous proliferation ca 3000 BP across the wider culture-area and south-eastern Australia generally, indicates that, if their increased production was due to their adoption in risk minimisation strategies at this time of marked climatic and environmental changes, their pre-existence and multifunctional nature meant they were accepted as ‘a universal panacea’ ready for a variety of contexts (Hiscock 2002).

So, in seeking explanations for the dramatic increase in the local artefact accumulation rate in the third millennium BP, I propose that it may partially reflect the greatly increased production of backed artefacts as a technological response to variations in subsistence risk. In the catchment, the increased risk may have arisen because of a change in the abundance of specific macropod species, which was brought about by changing climate and vegetation patterns.

It seems likely, however, that variations in the rate of backed artefact production were not the only technological or behavioural change involved in the dramatic changes in the local artefact accumulation rates, particularly in the second and first millennia BP. For example, backed artefacts began to decline in the second millennium BP, whereas the faunal assemblage and local rate of artefact accumulation remained unchanged until the first millennium BP.

Ground-edged implements

Although no new flaked implements appeared in the catchment’s late-Holocene assemblages, new stone implements did occur earlier than the third millennium BP proliferation of backed artefacts. In the fourth millennium BP, ground-edged implements appear. They are evidenced as whole implements as well as fragments which increase over time, both in abundance and as a proportion of the catchment assemblages (Table 10.3, Fig. 10.2). Ground-edged implements may have been used in manufacturing wooden food-procurement equipment, such as spears, spear-throwers, clubs, traps or containers, or in gaining possums from tree trunks. Climatic conditions were beginning to get colder and drier in the fourth millennium BP. In these conditions, ground-edged implements may have been adopted as part of risk minimisation strategies to cope with associated environmental changes to vegetation or faunal communities, before strategies and equipment using greater numbers of backed artefacts were devised.

Later again, in the second and first millennia BP, with lesser use of strategies incorporating backed artefacts, there was an increase in subsistence methods using ground-edged implements, or wooden implements or equipment. By the historical period, ground-edged implements were commonly used by both men and women for a wide range of subsistence and manufacturing purposes (Collins 1798 [1975]: 456; Hunter 1793 [1968]: 61; Tench 1793: 191 [1979]: 284).

Unanswered questions and further research

The above model provides plausible reasons why each hunter required more backed artefacts with the onset of the coldest–driest conditions, and why they subsequently declined in use. There are, however, still some areas of uncertainty. For example, the function of the backed artefacts as spear points and barbs still needs to be demonstrated. Although bird feathers have been identified on some backed artefacts from the catchment (Robertson 2002), no evidence for their being hafted as spear points or barbs has been observed. If backed artefacts were not spear points/barbs or were not associated with hunting land animals solely for food as discussed above, what was their function and what promoted their proliferation ca 3000 years ago? Was that function associated with risk of another nature, such as personal health and comfort and the manufacture of skin cloaks for warmth?
In addition, the cost of failure — not killing an animal — is not known because there is insufficient knowledge about alternative reliable food sources (plant and animal) in the catchment. If such technological steps were taken to minimise the risk of failure/loss, it suggests there were possibly fewer alternative reliable food sources than in the preceding period. The effect of the proposed vegetation changes on plant food sources needs to be explored. Did some resources become more restricted or limited in availability and abundance, while others became more widespread and plentiful? Failure in the hunt may also have had a social cost to the hunters — their status as a hunter and food provider was at risk (e.g., Gould 1969: 17).

The series of archaeological changes that occurred at the beginning of the coldest-driest period (ca 3000 BP) differed from those at the end of the period. The decrease in the local artefact accumulation rate in the last 1000 years was not as great as the initial increase in the third millennium BP. Although the decrease in the local artefact accumulation rate correlates relatively well in time with the change in the archaeological faunal assemblages, the decline in backed artefacts began earlier — in the previous millennium, when ground-edged implements increased (Table 10.3, Figs 9.1, 10.2 and 10.6). The nature of these changes suggests that subsistence activities and their associated technologies did not return to those of previous times — a conclusion supported by other long-term changes in the stone artefact assemblages (e.g., the increasing use of bipolar technology) and the habitation distribution patterns. By ca 1000 BP, social behaviour, including the nature of social interactions within and beyond the culture-area, was substantially different from that of the period preceding ca 3000 BP.

Social and territorial organisation
During the first millennium BP, at the same time as technological solutions were being adopted to minimise newly encountered subsistence risk, social and territorial organisation within the region and wider culture-area may have changed too. For example, the effects of modifications to the nature and position of territorial boundaries of clans and language groups, as suggested above in relation to the increased use of bipolar core reduction, might have been offset by developing and extending trading and political alliance networks (cf. Wiessner 1982a: 172–3; David and Lourandos 1998: 198, 212). The alliances, which may have begun initially many millennia before as trading partnerships and networks based initially on relationships between individuals (cf. Gamble 1998), eventually evolved together with the systems of kinship, exogamous marriage and ceremonial life into the social and territorial organisations that existed at the time of European contact. These networks and alliances, therefore, facilitated not only the procurement of raw materials and the performance of ceremonies associated with religious beliefs, but also the sharing of subsistence risk by enabling people to move into the country of other clans and language groups in times of hardship.

The late-Holocene archaeological record of the catchment could be interpreted as a series of diverse measures implemented to minimise subsistence risk in a period of increasing climatic variability — such measures incorporating both technological and social solutions. The dramatic increase in the local artefact accumulation rate ca 3000 BP and the substantial decrease ca 1000 BP may be the consequence not only of an increase and subsequent decrease in the production of backed artefacts, but also of the increasing production and use of ground-edged implements and the increasing number of quartz pieces produced by bipolar core-reduction techniques. Such measures were only some of the actions taken to ameliorate subsistence risk at various points in time. Further research as outlined above is needed to support these claims, particularly those relating to the nature and timing of social and territorial reorganisation, for which there is presently little unambiguous physical evidence.
Conclusions and future research

In the course of investigating interpretations and explanations for the quantitative changes in the catchment’s archaeological record — that is, the habitation and artefact indices — several themes have been explored. This has led to the production of explanatory models which will require evaluation and testing by future research.

The provisional assignment of individual ‘habitations’ as either home bases or activity locations/transit camps, and their spatial distribution within the catchment in different periods of time, suggests that changing habitation and land-use patterns, involving shifts in subsistence and mobility patterns, may explain the dramatic late-Holocene increases in the habitation indices. Very few base camps were established during the early Holocene and it appears that it was not until the fourth millennium BP that increasing numbers of base camps began to be established in the catchment — at a time when ground-edged implements first appeared. Nevertheless, the third millennium BP stands out as a period when something different occurred, with a substantial increase in base camps and a reversal in the ratio of base camps to locations used only as activity locations or transit camps. The dramatic increases in the habitation indices in the last 2000 years appear to be almost totally due to increases in activity locations/transit camps and not in the numbers of base camps. However, activity locations/transit camps are not assumed to be associated only with logistical movements, and consequently are not taken as indicators of frequent logistical mobility and the transformation of foragers into collectors. The inhabitants of the Upper Mangrove Creek catchment continued to be relatively mobile hunter-gatherers throughout the Holocene. Even so, the continually changing ‘habitation’ distribution pattern indicates that a reorganisation of mobility patterns (in the broadest meanings of the term) relating to camp life and subsistence activities took place in the catchment at frequent intervals and even more frequently and dynamically within the last 4000 years.

If the increasing use of bipolar core reduction in the catchment from ca 4000 BP was related to a reduction in residential mobility, then to some extent this is paralleled in the hypothesised initial increase in the establishment of catchment base camps. The continuing increase in the proportion of bipolar artefacts in the assemblages of the last 1000 years, however, is not paralleled by an increase in the number of catchment base camps. In addition, with present data, it cannot yet be established whether the dramatic increase in activity locations/transit camps in the first millennium BP was associated with greater logistical mobility from within or outside the catchment, or due to some other subsistence strategy. Changes in the abundance of quartz, FGS, silcrete and tuff-type chert in the catchment assemblages suggest that access to and/or availability of non-local stone resources altered over time. Such restrictions may also account for the increased use of bipolar reduction techniques. The stone material changes may have been associated with variations in long-distance movements and/or trade, which were influenced by changing territorial boundaries/trading networks and alliances, as well as culturally determined preferences in raw material use.

In summary, the long-term trends in the habitation indices and in the changing numbers of base camps and activity locations, as well as the increasing use of bipolar core reduction, suggest there was a reorganisation of subsistence strategies and land-use patterns involving changes in habitation and possibly long-distance and local mobility patterns. The changes in habitation patterns and mobility may have been associated with climatically associated environmental changes. Even the initial establishment of a base camp in Loggers in the 12th millennium BP may have been part of a redistribution of populations as they responded to the rising sea-level, which by this time had reached the base of the present coastal clifflines and was extending further up the palaeo-Hawkesbury River Valley.
Comparison of the timing of late-Holocene climatic changes with trends in the habitation indices (Fig. 9.1) shows that dramatic changes in the latter did not correlate with the onset of the increasingly colder and drier conditions (which began ca 4000–3500 years ago), the period that was much colder and drier than the present (ca 3000 BP to ca 1800 BP), or the onset of the current El Niño mode of operation (ca 3000 BP). However, the initial increase in the establishment of base camps in the fourth millennium BP does coincide with the onset of colder–drier conditions. In addition, the major increase in base camp numbers and the local artefact accumulation rate correlate with the beginning of the coldest-driest Holocene period in the third millennium BP. The warmer-wetter conditions of the last 1000 years were not matched by a return to a smaller number of base camps, though artefact numbers decreased in some. More detailed studies of the stone artefact assemblages and ‘intensity of site use’ are required before concluding that these correlations reflect greater rockshelter use — whether in response to demographic pressures or the need for greater protection from the weather which they would have provided.

The changing Holocene climatic conditions, particularly the period of coldest-driest conditions in the late-Holocene, which brought about changes in the catchment’s vegetation patterns and in the catchment’s macropod population, is also seen as the impetus for the adoption of a series of risk minimisation strategies (cf. Torrence 2001: 94). These strategies, which were designed to minimise or avoid subsistence risk, initially involved the introduction of ground-edged implements and greatly increased production of backed artefacts possibly used as spear points and barbs, as well as changes in local and long-distance mobility patterns which are reflected in the increasing use of bipolar core reduction. These changes to the tool-kit and stone reduction techniques probably only partially explain the dramatic increase in the local artefact accumulation rate in the third millennium BP and the continuing high rate in the second millennium BP.

The substantial decrease in the local artefact accumulation rate in the first millennium BP can, again, be explained only partially by changes in the tool-kit and technology, such as the reduced production of backed artefacts, the effects of which may have been offset partially by the increasing manufacture and use of ground-edged tools and bipolar pieces. It is likely that subsistence risk was also minimised by the adoption of social solutions which enabled greater mobility (residential, logistical and long-distance) and reciprocity of subsistence resources at the inter- and intra-group level. During this period, network systems based on kinship, trade, ceremonial responsibilities and obligations, and political alliances may have attained the level of organisation and complexity similar to that observed at the time of British colonisation, even though these systems and alliances had their origins many millennia in the past.

The decreased local artefact accumulation rate may also represent decreased catchment use. Decreasing population seems an unlikely correlate of increasingly warmer-wetter conditions if these ‘ameliorating’ conditions were associated with an increasing abundance of food sources. However, if this was the case, a decline in the catchment population could represent a redistribution of the regional population which led to higher densities in the coastal zone where fish-hooks were introduced some 900 years ago (Attenbrow et al. 1998). Adoption of this small implement may have enabled the resources of the ocean shoreline, estuaries and lagoons to be more efficiently harvested. Such a scenario could accommodate a reduction in catchment use in the last 1000 years, however, demographic change does not have to be invoked to explain or interpret the quantitative changes in the catchment’s archaeological record.

The foregoing models go part way to understanding and interpreting the catchment’s archaeological record, in terms of the use of habitations, the land and its resources. Only selected data sets were incorporated: the habitations as places where a variety of activities or
functions were undertaken and between which people moved in their daily lives; bipolar core reduction as a measure of mobility; and backed artefacts and ground-edged implements as a response to subsistence risk. Each of the studies presented here has looked at different aspects of life and material culture.

Further research using other data sets and with other theoretical contexts is required to establish the strength of the models. Such studies could begin by testing the proposed habitation and land-use model by reanalysing the excavated assemblages to identify the functions of each habitation in each millennium and the activities which took place inside them. Secondly, they would investigate the artefact accumulation rates in individual habitations to explore ‘intensity of site use’, and, thirdly, they would involve spatial analyses incorporating all archaeological traits in the catchment. Additional studies are also needed to investigate the use, availability and accessibility of the various stone materials to test whether reasons for the increasing use of bipolar core reduction techniques are solely reduced residential mobility, or involve restricted access to distant raw materials. In the context of risk minimisation, it is essential to have more detailed palaeo-ecological data about past vegetation and faunal changes and the availability and abundance of food resources, which will allow identification of options and constraints in different periods of time (cf. Jochim 1989: 108; Veth et al. 2000: 60, 62). Such data would assist in assessing the level of subsistence risk that may have existed. Similarly, the nature of Aboriginal burning regimes in the past and the effect that the people themselves may have had on the vegetation and faunal populations of the catchment also requires further research.

Ideally, and eventually, it will be fruitful to look at the various strands of the catchment’s archaeological record as an integrated body of data (cf. Nelson 1991: 57–8, 89–90): all archaeological traits and their assemblages, all materials and manufacturing processes and the tool-kit. Ultimately, they are all related — just as the behaviours and processes that created them were interrelated. For example, with mobility and risk, the degree of risk involved in acquiring a certain resource may influence adoption of particular mobility patterns (Myers 1989: 84, 90–1; Odell 1996: 53; Torrence 1989a: 61–2, 2001: 88). However, before that can be done, studies of individual aspects of the various archaeological traits and excavated materials (faunal remains as well as stone assemblages, sediments and charcoal) are needed. In addition, the catchment has to be set in a wider regional context taking into account changes along the coast and other parts of the region.

While many questions remain to be addressed, this study reaffirms that a region’s prehistory cannot be portrayed on the evidence from a single site or a few selected sites. It is not sufficient to look at only habitation indices or only artefact accumulation rates in isolation, particularly when investigating long-term regional habitation, land- and resource-use patterns. I agree with Lourandos (1996: 17–18) that general trends in the use and establishment of habitations must be differentiated from those of stone artefacts, but stone artefacts are not a ‘subsidiary indicator’ to sites in regional studies seeking to identify long-term trends in habitation and land-use patterns. Both habitation and artefact indices, as well as the nature and diversity of artefact assemblages, and habitation function and distribution patterns, need to be taken into account whether demographic-change or behavioural-change explanations are proposed as part of a region’s prehistory.