Biases that may have been introduced into the archaeological record and data sets by both natural events and human behaviour were examined to help establish the degree of reliability that can be placed on the results of the analyses. Incidents — taphonomic processes — affecting the deposits may have occurred during the course of each habitation’s use and its abandonment. In addition, methodological procedures adopted for the research project may have affected the results, e.g., during the fieldwork (outside procedures relating to sample selection) and analysis of data.

Methodological factors — fieldwork

Methodological factors which may have affected the fieldwork results concern the way in which sites and archaeological traits were defined, the survey design, sample size, observer bias and whether excavation stopped before the base of an archaeological deposit was reached.

Definitions

It was thought that density figures (i.e., the number of sites per square kilometre) may have become biased due to the way sites and archaeological traits were defined (Chapter 3, Defining sites), in particular, criteria relating to the distance between sites. The following assessment, however, indicates that the site definitions have not significantly affected the results of the analyses relating to site densities.

There are three situations where two archaeological traits less than 50m apart were defined as separate sites:

- Delight Shelter and Delight Open Site;
- Kyola Road Images 1 and Kyola Road Open Site; and,
- Uprooted Tree Shelter and Uprooted Tree Grinding Area.
Each situation involves different types of archaeological traits and/or different types of locations (SH/AD and OD/AD; OR/IM and OD/AD; SH/AD and OR/GA respectively). If these traits are classified as three sites instead of six, the total number of sites in the random sampling units becomes 56 instead of 59, and the average site density becomes 5.5/sq km rather than 5.8/sq km. If, in addition, the original classification of Kyola Road Images as one site (as on the NPWS site card) is retained rather than classifying them as two, the number of sites is reduced to 55, but the site density remains 5.5/sq km; the density of images on open rock drops from 0.2 to 0.1/sq km (Attenbrow 1987: Table 5.11). All of the abovementioned sites are on periphery ridgetops. If the total number of sites on the periphery ridgetops is reduced by four (from 24 to 20), this zone still has the highest number of sites and the second-highest density of sites (Table 4.2A).

**Survey design**

Problems arose with two of the sampling units: RSU.101 in the northern part of the catchment and RSU.75 at the junction of Mangrove and Boomerang Creeks (Fig. 3.15).

**RSU.101**

A section of periphery ridgetop was inadvertently included in the subsidiary valley bottom zone when marking the map into topographic zones in the sampling design stage; the subsidiary valley bottom zone was extended too far upstream in this particular creek. This was realised only once in the field. This section of the periphery ridgetop is in the northern half of the RSU.101, a subsidiary valley bottom sampling unit. A grinding area, First of Day, recorded in RSU.101 is therefore just within the periphery ridgetop zone rather than subsidiary valley bottom. In this instance, that part of the sampling unit and the site were not deleted from the analyses. This boundary error does not affect the data and trends presented in this monograph.

**RSU.75**

This unit is in the main valley bottom at the junction of Mangrove and Boomerang Creeks — it extends along Mangrove Creek both above and below the junction. When surveying commenced in RSU.75, it was found that logging had begun in this section of the storage area, and fallen logs rendered the southern half of the unit below the junction with Boomerang Creek inaccessible. An on-the-spot decision was made to survey an equivalent section along Boomerang Creek which was part of RSU.74. The area actually surveyed has been called RSU.75/74.

The ‘abandoned’ southern section of RSU.75, which was surveyed during the salvage program, had four recorded sites. A comparison between the evidence recorded in RSU.75 and in RSU.75/74 was made to check whether the results would have been very different (Attenbrow 1987: Table 5.13). Some differences occur: a scarred tree and two open archaeological deposits were found in RSU.75-south, whereas no scarred trees and only one open archaeological deposit occur in the part of RSU.74 surveyed. One of the open archaeological deposits in RSU.75-south, Stockyards Open Deposit, has a much larger number of recorded artefacts (152) and a much larger area (7200m²) than Palmers Crossing in RSU.74 and all other open archaeological deposits in the random sampling units (Tables 4.5 and 4.6). As well as a surface collection, test excavations were undertaken at Stockyards, but there were no materials appropriate to date. The presence of a single Bondi point indicates occupation occurred most likely in Phase 2 or possibly Phase 3 — that is, sometime between ca 5000 and ca 1600 years BP, but it could have occurred up to ca 8000 years ago (Table 3.8; Hiscock and Attenbrow 1998). The limited and disturbed evidence at Palmers Crossing did not allow it to be included in the analyses. If Stockyards had been included, the numbers of sites established and/or used, and the artefact accumulation rates would have increased in the late-Holocene.
periods. However, the magnitude of the increase would not have been sufficient to substantially alter the trends presented in future chapters.

**Sample size**

The affect of sample size (Grayson 1984: 116–30; Hiscock and Allen 2000: 100; Hiscock 2001) in relation to the site survey was discussed in Attenbrow 1987 (Chapter 4). With regard to excavation, trends in the habitation and artefact indices may have become biased because of the small area excavated in some of the archaeological deposits (i.e., 0.25m²). For example, small sample sizes may mean that the evidence retrieved from the pit as a whole, or from particular levels, is not representative of the whole deposit. If so, then the number and type of artefacts and raw material retrieved, as well as the estimated total numbers of artefacts which were extrapolated from that sample may be inaccurate, or assignment to a particular phase or millennium may be incorrect. In addition, in shelters with sloping sandstone floors (see next section), it is possible that the earliest time periods are not represented by the excavated basal deposits. These questions can be tested only by further excavation in those archaeological deposits.

Explanations for inter-site variability as well as intra-site temporal variability in the range of stone artefact types and animal species present in each archaeological deposit may also be prejudiced if sample size is not taken into account. In this regard, intra-site comparison of the stone artefact assemblage composition and density figures from individual 0.25m² pits in Mussel, Deep Creek and Confluence, three sites in the storage area, are relevant. In the deposit in each of these rockshelters, more than two adjoining pits were excavated. Temporal trends in the direction and magnitude of changes in density figures were similar in each pit, suggesting trends in artefact accumulation rates in deposits in small to medium shelters are unlikely to be biased. It is assumed, on the basis of this exercise, that numbers and densities of artefacts in a test pit reflect numbers and densities in the deposit as a whole and that the calculations of the estimated total numbers of artefacts (Tables 4.12, 6.11–6.16) based on extrapolations from the test pits are not widely divergent from reality.

In contrast with the density figures, the presence/absence of specific artefact types in particular levels does sometimes vary, and this was kept in mind where the ages of deposits are based on diagnostic artefact types in single 0.25m² pits.

**Excavation stopped prematurely**

In six sites, excavation stopped before reaching bedrock, or rock/rubble or colluvial sediment which could be assumed to be the original ground surface (Chapter 3, Table 3.4). At Black Hands Open Deposit, digging ceased when water from rising stored water in adjacent Mangrove Creek filled the pit. At two sites, Anadara (T2) and Mangrove Mansions (T2), excavation was not continued due to the clearly shallow and disturbed nature of their deposits. At three of the sites (Bird Tracks, Boronia, and Kangaroo and Echidna), excavation was stopped after about 20cm of sterile deposit was dug.

At a further three sites (Elongated Figure, Harris Gully, Uprooted Tree), the base of the excavation was sloping bedrock which suggests the adjacent deposit may be deeper. At each of these sites it is possible that earlier levels with stone artefacts are present.

The implications of these situations are discussed in the following chapter when changes in the habitation establishment rates are analysed.

**Observer bias**

This term covers non-detection of archaeological traits due to the inexperience of fieldworkers and/or ‘end-of-day’ tiredness. Both can affect survey and excavation results.
Survey results
Both inexperience and tiredness can cause evidence to go unnoticed during site survey. For example, one or two stone artefacts in a rockshelter dripline, or particularly faint remnant drawings or scratched outlines on a rockshelter wall/ceiling, could be missed.

During the excavation stage and/or during visits to rockshelters for other reasons, some pigment images were noticed in shelters that had been missed during the site survey (Chapter 4, Summary of fieldwork results). This suggests that some PH shelters which were not revisited may have images. An estimation of how many may have been missed can be gained from the following observations. At the end of the random sample survey, of the 27 rockshelter sites recorded, 11 were without images. After revisiting these 11 sites for test excavations, two were found to have pigment images (Dingo and One Tooth) and a third to have a possible image (Elngarrah); these represent 18% or possibly 27% of the rockshelter sites. By extrapolation, between one-fifth and one-quarter of the recorded PH shelters may contain images, which suggests there are another 30 to 45 rockshelters with images in the random sampling units. However, the 11 sites which were reinspected are a probably biased sample as they all had some other evidence of Aboriginal use (i.e., archaeological deposit). Thus, the number of images in rockshelters that are likely to have been missed is probably <27%.

Excavation results
Three factors may have affected the excavation results of some archaeological deposits.
1. The varying levels of experience and diligence of individual field assistants. Volunteers who assisted in the field varied in their experience, expertise and dedication. Care was taken to ensure people achieved the same level of retrieval, however, the same people were not present throughout each excavation period and some variation in the amounts recovered from the sieves at different sites may have resulted.
2. Field sorting versus laboratory sorting. The sieved residues from some archaeological deposits were sorted in the field and others were taken back to the laboratory for sorting. The level of recovery for sites where excavated materials were sorted in the laboratory may be higher than for those where sorting took place on site.
3. The presence of abundant organic matter and small rubble. The upper spits of some deposits contain a lot of leaf-litter and/or charcoal. Because of their bulk, these materials can hinder the visibility of other archaeological materials. In addition, charcoal tends to colour everything grey, making all the materials appear similar (e.g., this was the case in the upper levels of Loggers and White Figure). Archaeological materials are also less visible in deposits with large amounts of small rubble.

The above statements are based on the observations at two sites where it was possible to check results: White Figure and Deep Creek (the latter is in the storage area [Attenbrow 1982b]). Both have rich archaeological deposits with relatively large assemblages. A sample of the sieved residues from these two sites were returned to the laboratory — a check revealed that the 0–1cm stone artefact category and small bone fragments in some spits may be under-represented because of the factors listed above.

In the case of Deep Creek, the analysis indicated the ‘shortfall’ would have made no difference to the overall percentage of the artefact types and raw materials within individual excavation units or within analytical levels (combined spits) (horizontally and vertically). This suggests that where large numbers of stone artefacts are recovered, observer bias may not have substantially affected the results.

At White Figure, all three of the above factors were involved. Large amounts of organic matter (leaf-litter and charcoal) in the upper spits made thorough checking of the
sieved materials a difficult and lengthy process. When work started on site, the person initially sieving the excavated deposit did not realise that residues should be bagged for later sorting if it was not possible to check the sieved residues thoroughly without holding up the excavation process. The field-sorted residues from the surface and upper two spits were thrown out before I realised they had not been thoroughly checked. From spit 3 onwards, sieve residues were kept and a final sort undertaken in the laboratory. Results gained from excavation units sorted in both the field and laboratory suggest that about 50% of the stone artefacts in the upper two spits may have been missed. The figures used in the analyses were adjusted where necessary to compensate for this (e.g., when estimating the total numbers of artefacts in the archaeological deposits in White Figure — Tables 4.12, 6.11 to 6.13, and A2/16).

Methodological factors — analyses

Calculating artefact accumulation rates
Artefact accumulation rates were calculated for each of the excavated deposits in the catchment (Chapter 6) as well as for sites in the comparative regions in eastern Australia (Chapter 7). The method adopted, using depth/age curves, is described in Chapter 6. Rates derived by this method are very much dependent on (a) the position of dated levels, and (b) the assumptions that deposition rates for sediments remained relatively constant between the dated levels or dated materials, and that gross sediment deposition and erosion patterns are well approximated by the net rate (Morwood 1981: 32; Davidson 1997: 217). Since we often do not know whether these assumptions are true, there are, as Morwood states, limits to the precision of the method. In addition, the small number or lack of radiocarbon ages for some of the catchment deposits may have led to inaccuracies in the trends in the artefact accumulation rates. Various alternatives, involving the way spits were combined into phases of millennial units, were examined for some sites before accepting those presented (Chapter 6). The existence of uneven stratigraphy, sterile layers, disconformities and the integrity of the deposits were taken into account (cf. Rosenfeld et al. 1981: 11–13).

Any biases in the artefact accumulation rates of individual deposits would have been extrapolated across to the local artefact accumulation rates. Again, however, various alternatives were examined before adopting those presented. In calculating the artefact accumulation rates for the eastern Australian sites (Chapter 7), if any of my assumptions about the published information are in error, there may be inaccuracies in the trends presented for these regions.

Natural processes

Natural processes which can affect archaeological evidence include chemical, geomorphological and biological (animal and vegetation) processes. The effect of weather conditions at the time of site survey and recording has also been included under this section, although it could be seen as ‘methodological’. These processes can cause the archaeological record to become biased in several ways.

1. Materials in an archaeological deposit can be disturbed or redistributed by faunal activity and vegetation growth. Fauna which can affect archaeological traits include beetles, ants, termites, wasps, cicadas, as well as larger animals such as wallabies, small rodents, rabbits, wombats, bower birds, lyrebirds and emus. People also dug holes in archaeological deposits for various purposes (including burials), cleared areas and caused general treadage and scuffage during habitation of a site.
2. Organic materials decay; groundwater causes decomposition of materials.
3. Deposits and sandstone in or on which archaeological materials were present can become totally or partially removed or destroyed by erosion and/or weathering.
4. Subsequent sediment deposition or vegetation growth can restrict visibility and thus hinder visual observation of materials and sites in open as well as shelter contexts.
5. Poor lighting conditions during overcast weather or at the end of the day can affect visibility of archaeological traits during fieldwork.
6. Charcoal from past bushfires (either natural or humanly-initiated) which has existed in/on the ground for long periods of time (environmental charcoal) can become incorporated into more recent archaeological deposits through fluvial and slope processes (cf. Blong and Gillespie 1978).

Ironically, the erosion and/or disturbance of sediments (1 and 3 above) probably does as much ‘good’ as ‘harm’, in that it is these processes which are instrumental in exposing materials which are obscured by deposition of sediment and vegetation (4).

Points 3 and 4 have been put forward as explanations for the lower numbers of archaeological sites dating to the late-Pleistocene and early-Holocene periods (refer to Chapter 2; Worrall 1980: 81–3; Bonhomme 1985: 33; cf. Mellars 1973: 269–70 for similar discussion for Palaeolithic Europe). These points bear on the questions:

1. were all sites that existed at the time of fieldwork found in the random sampling units during the site surveys and excavations?
2. of the sites that were formed in the past, what type and number are no longer likely to exist?

Question 1 relates to questions of visibility and question 2 to processes of destruction. Each of these circumstances is discussed below, as well as the problem of older ‘environmental’ charcoal being incorporated into more recent archaeological deposits.

Visibility
The visibility of archaeological traits that occur in the catchment can be impaired partially or restricted totally by vegetation growth and sediment cover (Sullivan 1983: 6). In addition, bad light at the end of the day or in overcast weather can also affect visibility. These in turn can be accentuated by the factors discussed above under observer bias (inexperience and end-of-day tiredness).

Archaeological deposits in rockshelters
In rockshelters, archaeological materials can be totally covered by sediment and the mouths of small rockshelters can be obscured by dense vegetation. Recording and test excavating potential archaeological deposits in PH shelters has overcome (to a certain extent) some of the difficulties which result from archaeological materials in rockshelters being totally buried. As discussed in the previous chapter, the results of test excavations of potential archaeological deposits provide an estimate of the number of archaeological deposits in rockshelters which may have been missed.

Open archaeological deposits
Five open archaeological deposits were found during the random sample survey. Two are on periphery ridgetops (Delight and Kyola Road) and three in the main valley bottom (Black Hands OD, Palmers Crossing and Willow Tree Gully). The two on the ridgetops were found in areas with sparse leaf-litter and skeletal soils. Those on the valley bottom were all found in disturbed locations on deep deposits forming the creek banks (Attenbrow 1997 [1998]).
archaeological deposits probably exist within the random sampling units but are buried under fill in the valley bottoms, and under slopewashed sediments and leaf-litter on the ridgetops and structural benches on ridgesides (see also Vinnicombe 1984: 110). A recording and testing program similar to that for the PH shelters would be required to investigate locations with potential open archaeological deposit in order to assess how many open archaeological deposits are unrecorded. Unfortunately, as previously stated, this is not possible now in the main valley bottom zones of the catchment, but such a program could be carried out above the storage area.

Isolated finds may provide clues to the occurrence of open archaeological deposits in places other than those at which they have been recorded. In addition, site records in many other regions (e.g., the Hunter Valley and Cumberland Plain to the north and south of the catchment) indicate that open archaeological deposits are commonly found on river banks and terraces. However, for both ridgetops and structural benches on ridgesides there are no definite clues as yet to the specific places where open archaeological deposits may occur in the catchment. Although studies such as those by Byrne (1983, 1984), Egloff (1984), Packard (1992) and Hall and Lomax (1996) describe site distribution patterns with open artefact scatters predominantly along ridgetops for many of the NSW east coast forests, a similar pattern has not been documented in the Upper Mangrove Creek catchment or other parts of the sandstone country of the greater Sydney region (e.g., Vinnicombe 1980; Setton 1988; Illawarra Prehistory Group 1990, 1995, 1996; McDonald 1994; Kinhill Engineers 1995). The reasons for this variance can be seen in the differences in the geology and terrain whereby different types of potential site locations are available in the catchment than in the other NSW east coast forests. The most significant difference is the lack of rockshelters (or the much smaller number of rockshelters) in forests in non-sandstone environments.

Grinding areas and engraved images
Dense understorey shrubs along the creek banks and around rock platforms may obscure the existence of exposed sandstone surfaces where grinding grooves and engraved images typically occur. Grooves and engraved images can also be covered by silt and soil mobilised by slopewash processes.

Destruction
Destruction refers to the removal of archaeological materials, engraved or pigment images, or grinding areas from their original place of deposition or creation. It can be total or partial.

Worrall, in discussing geoarchaeological issues relevant to the catchment, stated:

... that the likelihood of survival of an occupational deposit of a given age decreases with time. The relatively small number of early sites located in the catchment may thus be explained solely in terms of contemporary geomorphic process without recourse to speculation concerning prehistoric population size. (Worrall 1980: 82-3)

It is suggested that the operation of a process of discontinuous aggradation and denudation of deposits in the majority of archaeological sites in the catchment may be sufficient in itself to explain the trend towards fewer sites from progressively earlier periods (Worrall 1980: 89).

In contrast, other researchers state that it is unlikely that archaeological deposits within rockshelters, once formed, would have suffered severely from erosion (Hughes and Lampert 1982: 19). In the random sampling units, the majority of the archaeological deposits (30 out of 35) were located in rockshelters. Processes affecting archaeological deposits in the open differ to some extent from those affecting rockshelter deposits.
Archaeological deposits in rockshelters

Worrall (1980: 81–2) made three points about archaeological deposits in rockshelters:

1. Rockshelters in valley floor situations that were filled during deposition of Unit A (late-Pleistocene in age) may have been repeatedly filled or flushed or the deposit cliffed during events of Unit B deposition (Holocene events). Worrall refers to Bracken and Deep Creek as examples where this could have occurred; both sites are in the storage area and outside the random sampling units.

2. Archaeological deposits in rockshelters which are on slopes may be subject to intermittent episodes of scour and fill of varying intensity. Worrall places Black Hands Shelter in this category. Worrall adds that the probability of a major scour event severely truncating or flushing the deposit from a rockshelter is obviously a function of time.

3. The activation or cessation of deposition in rockshelters which are located in talus zones or cliff faces (on slopes) may be closely related to the operation of structural controls and thus may be relatively stable.

The situation, however, is more complex than Worrall’s tripartite breakdown suggests. The stratigraphy at Deep Creek does not indicate that its deposits have been affected by filling, flushing or cliffing. The base of the deposits is 3m above present creek level and above flood level. In addition, it is a relatively large shelter (12.4m × 5m) and inside the dripline the shelter is dry and not open to slopewash processes. The deposits at Bracken comprise alluvium derived principally from slopewash (Hughes and Sullivan 1979: 10). Though subject to inundation and deposition of sediments by low-energy floodwaters, there was no evidence of cliffing in the stratigraphy (contrary to Worrall’s statement, 1980: 64), scours or erosional lags of gravel and artefacts.

The degree to which the catchment rockshelters are exposed to slope processes also depends on the direction in which their mouth faces (i.e., downslope or across slope) and whether the rockshelter has closed or open sides. Rockshelters facing downslope and those which have closed sides are less prone to slopewash processes than those facing other directions and with open sides.

To assess the processes operating in the rockshelters in the random sampling units, it was recorded whether or not each rockshelter was:

1. on the valley floor and liable to inundation during floods; or,
2. on a ridgeside and its morphology was such that it was vulnerable to slope processes which could scour its deposits.

In many rockshelters, the deposit is partially affected by erosional/slope processes, for example, along the dripline from water coming over the overhang, or by water coming downslope and entering the rockshelter from an ‘open’ side (Table 5.1). In these instances, only a small part of the deposit is affected, not the entire shelter floor.

Worrall (1980: 40, 73) said, on the basis of a stratigraphic section in a road cutting downslope of Black Hands, that the ‘shelter deposits … comprise the infill sediments of a prior scour channel directed along the back wall of the shelter’. Worrall’s interpretation suggests the archaeological deposits built up (i.e., habitation took place) in a scour channel within the rockshelter. The stratigraphic sections of the deposit excavated within Black Hands Shelter (squares A and B) and just outside the dripline (square F) do not support an interpretation that earlier materials were scoured out and the later archaeological deposit built up within a scour channel. Unless the hypothesised torrent swept through the rockshelter with such force that it removed all artefacts and small rubble which was deposited within the shelter before the scouring event, a layer of lagged rubble with an artefact density higher than other levels would be expected. No lag of artefacts or rubble was found within or at the base of the excavations to suggest large amounts of sediment had been removed. Worrall may have
misinterpreted the sides of the unknown excavator’s trench in Black Hands Shelter (see Chapter 3, Excavation strategy and methods) as a scour channel.

Stone artefacts occur outside the rockshelter for a distance of at least 2m across the slope and 2m downslope (i.e., in square F outside the shelter and in the 70m contour road cutting below the shelter). These artefacts are just as or more likely to be from activities carried out within and in close proximity to the rockshelter as from geomorphological movement of artefacts downslope. Several artefacts were recovered from the slightly steeper slopes further

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**Table 5.1** Upper Mangrove Creek catchment: random sampling units. Archaeological deposits in rockshelters and geomorphological processes. [1] Other details about radiocarbon ages are provided in Table 6.1.

<table>
<thead>
<tr>
<th>SITE NAME</th>
<th>RADIOCARBON DEPOSIT LIABLE</th>
<th>DEPOSIT LIABLE TO INUNDATION</th>
<th>SHELTER OPEN TO SLOPE PROCESSES — DEPOSITS EXPOSED TO SCOURING</th>
<th>SHELTER MOUTH FACES DOWNSLOPE — FLOOR DEPOSITS NOT SUSCEPTIBLE TO SCOURING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AGE (BP) [1]</td>
<td></td>
<td>SUBSTANTIAL</td>
<td>LIMITED</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Anadara</td>
<td>3040±85</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Axehead</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Black Hands</td>
<td>11,050±135</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Button</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Geebung</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Harris Gully</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Loggers</td>
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<td>Mangrove Mansions</td>
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<tr>
<td>Ti-Tree</td>
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<tr>
<td><strong>RIDGETOP</strong></td>
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<tr>
<td>Caramel Wave</td>
<td>1430±60</td>
<td></td>
<td>x</td>
<td></td>
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<tr>
<td>Dingo</td>
<td>1840±60</td>
<td></td>
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</tr>
<tr>
<td>Elongated Figure</td>
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<td></td>
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</tr>
<tr>
<td>Firestick</td>
<td></td>
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</tr>
<tr>
<td>Kangaroo and Echidna</td>
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<tr>
<td>Low Frontage</td>
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<td></td>
<td>x</td>
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<tr>
<td>McPherson</td>
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<tr>
<td>One Tooth</td>
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<td>Two Moths</td>
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</tr>
<tr>
<td>Venus</td>
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<td>White Figure</td>
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<td></td>
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<tr>
<td>Sunny</td>
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<tr>
<td>Token Male</td>
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<tr>
<td>Uprooted Tree</td>
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</table>

| Totals — No.        | 1                          | 2                          | 11            | 16            |                             |                             |                             |                             |                             |
| %                   | 3                          | 7                          | 37            | 53            |                             |                             |                             |                             |                             |
below the rockshelter (through either slopewash movement or perhaps being thrown out from the shelter), but their morphology, size and raw material suggests they are of similar age to those in the rockshelter deposits.

Only one other rockshelter in the random sampling units (Harris Gully) is open substantially to slope processes in the same way as Black Hands Shelter (Table 5.1), though there the slope gradient is much lower. Only one rockshelter occurs within the valley floor zone in a position liable to creek overbanking (Mangrove Mansions). Most rockshelters in the catchment are formed in cliffs or low bands of sandstone on the ridgesides. These rockshelters, unless at the end of the cliff or band of sandstone, invariably face downslope and slope materials cannot enter (16, 53%).

At rockshelters such as Bird Tracks, Low Frontage, Sunny and Uprooted Tree, water passes over the overhang and affects a limited part of the deposit along the dripline. Other rockshelters, such as Anadara, have an open side, which allows slope processes to affect a small part of the deposit at one end. In all of these rockshelters, the affected areas were a small portion of the total deposit. If, in the past, the water ‘course’ was different and affected different and/or greater areas before the deposit built up to its present depth, then it was not apparent in the stratigraphy of the test excavated area.

Of the 30 rockshelters classified as having archaeological deposit, three do not have deposit within the rockshelter but archaeological materials were recovered in the deposit immediately outside the dripline area (Button, Delight, McPherson). At another two, the archaeological materials were present on very shallow sandy sediment overlying bedrock (Axehead and Firestick). A further rockshelter has only images (both pigment and engraved) and no archaeological deposit (Emu Tracks 1). In those sites where there is no deposit within the rockshelter, the floor is steeply sloping bedrock on which sediment could not be retained and/or no rocks are present to help retain the deposit within the rockshelter (Button, Emu Tracks 1, Delight and McPherson). Except for Axehead and Button, they are semicircular, cavernously weathered rockshelters in clifflines facing downslope.

Layers of lagged rubble and/or lagged artefacts were not found in any of the archaeological deposits excavated in the random sampling units. This suggests that there were no putative earlier sediments which might have been washed out. Of the sites excavated in the catchment, only one, Wattle Creek, has evidence of water scouring or channelling and subsequent refilling — this site was dug during the salvage program. No radiocarbon dates were obtained from Wattle Creek, but on the basis of the artefact types retrieved, the earliest assemblages were estimated at less than ca 3000 BP.

The fact that the two rockshelters with the earliest dates are in positions that are vulnerable (Loggers) and partially open (Uprooted Tree) to slopewash processes, and that the majority of the recent archaeological deposits are in rockshelters not subject to slopewash processes, suggests that the larger number of recent archaeological deposits is not the result of the early deposits being scoured out. At Loggers, only a small proportion of the archaeological deposit is sheltered beneath the overhang. This supports the conclusion reached by Hughes and Lampert for the NSW south coast:

... that it is unlikely that the archaeological deposits within them [i.e., rockshelters], once formed, would have suffered severely from erosion. (Hughes and Lampert 1982: 19)

Open archaeological deposits
In the catchment, situations where open archaeological deposits are susceptible to destruction are creek banks (valley fill) where flooding can remove and redeposit sediments in which
archaeological materials may have accumulated, and ridgesides where slope processes operate. Relatively flat ridgetops are less prone to these processes.

Valley fill. Worrall (1980: 56) divided the valley fill in the catchment into two major units, A and B. The oldest, Unit A, she said (1980: 58) is of late-Pleistocene age, and Unit B is Holocene in age (1980: 74). Worrall (1980: 81) suggested that prehistoric vegetation cover on the Holocene Unit B deposits was probably shrub thickets and thus the likelihood of sites being formed on these deposits was small.

After completion of the salvage program, bulldozing operations took place on the valley floor. Inspections at disturbed locations resulted in the detection of several open archaeological deposits (see previous chapter and Attenbrow 1997 [1998]). They did not appear to be as rich in artefacts as sites such as Loggers and Black Hands, but insufficient work was undertaken on these sites prior to inundation to place any credence on such observations. The majority, if not all, of the more recently recorded open archaeological deposits on the valley bottom are on what I believe Worrall calls Unit B deposits. (No map of the areal extent of Unit A and Unit B deposits was presented by Worrall.)

The geomorphological processes involved in the accumulation and scouring of valley fills was probably of sufficient magnitude to have caused the loss of many sites of all ages. Radiocarbon dates for valley fill in the catchment indicate that fill dating back to at least 7000 BP is present (Sullivan and Hughes 1983: 123, Table 2). It is possible that in situ areas of fill of an older age have survived and that such deposits contain archaeological materials.

Ridgesides. Open archaeological deposits on the slopes of ridgesides would be subject to natural geomorphological processes and occasionally to periods of accelerated erosion (Bonhomme 1985). Bonhomme (1985: 14) reasoned that ‘as a result, the material evidence of open sites is continually being reworked and probably lost from the slopes altogether’. Although Bonhomme’s first observation may be true, the present archaeological record indicates that all materials have not been lost.

It is clear that the surviving open archaeological deposits in the catchment are unlikely to comprise a comprehensive record of such sites that have existed over time — much less so than the rockshelter deposits, which have greater protection from destruction. The question as to whether the rockshelter deposits by themselves can be accepted as representing the changing trends in catchment habitation patterns over time is raised again when interpretations and explanations for the documented archaeological trends in the catchment are discussed.

Further comments on visibility

The foregoing discussion highlights the fact that, irrespective of whether some sites have been destroyed in the past, all of the archaeological sites that presently exist in the random sampling units are unlikely to have been recorded during the fieldwork undertaken. This is a situation which no doubt exists for all archaeological programs. For some sets of data — in particular, the archaeological deposits and images in rockshelters — estimates of the numbers unrecorded can be made. It can be assumed that the images which were overlooked do not contain numerous figures, but it cannot be assumed that unexcavated potential archaeological deposits do not have abundant archaeological materials (e.g., as found in Bracken and Sunny). For traits on open deposit and open rock, there is, as yet, no data on which to estimate the number of unrecorded sites.

With respect to rockshelters, it would be fruitful to undertake an intensive testing program of the PH shelters to assess more accurately the numbers of unrecorded archaeological deposits and images in rockshelters, and to test Szpak’s conclusion ‘that it must be assumed that all these rockshelters have been used’ (1997: 112). A random sample of PH shelters could be selected, their deposits test excavated and the walls re-inspected for images.
To investigate more rigorously the lack of recorded open archaeological deposits due to visibility problems, a program of site survey followed by shovel and/or backhoe testing in open locations with potential archaeological deposits could be undertaken. Fieldwork could perhaps specifically target flat areas along creek banks, structural benches on ridgetop sides, and ridgetops. Since most of the alluvial flats in the catchment valley bottom zones have been inundated, a testing program in such locations would have to be undertaken above the storage area in the catchment, downstream of the dam wall, or perhaps in an adjacent river valley.

Incorporation of older charcoal

The mouth of Black Hands Shelter faces across-slope, which means the shelter deposit may have been prone to slopewash processes at some stages of their accumulation, and to incorporation of ‘environmental charcoal’ from the surrounding slopes. If charcoal in the shelter deposit includes material that had been accumulating on the surrounding slopes for centuries, radiocarbon determinations received for the submitted charcoal samples may indicate an age that is older than the real age of the excavated level from which they were collected (cf. Blong and Gillespie 1978). Consequently, any cultural materials associated with that dated sample may be placed incorrectly into a period earlier than that to which they belong. However, it is possible that the submitted sample from near the base of Black Hands was not contaminated by environmental charcoal because, for example, the surface of the shelter deposit at that time was higher than the surrounding land surface. Alternatively, if it was, any charcoal washed in from the surrounding slopes may have been very much less than that from Aboriginal fires built within the rockshelter, and its influence on the age of the ‘combined’ sample was not critical. What can be said is that the age obtained for the charcoal sample submitted from near the base of Black Hands (3040±85 BP [SUA–932] from a depth of 90–100cm) is consistent with the type of artefacts present at that depth and the sequence of assemblages above it.

It is unlikely that slopewashed charcoal has contaminated many of the other rockshelter deposits except areas around and outside the dripline areas. Excavated pits were placed well inside the rockshelters except at Loggers and in the three cases where no deposit, or no substantial depth of deposit, existed inside the rockshelter. At Delight and Boat Cave, the only feasible place to excavate was in the dripline zone, and at McPherson the test pit had to be placed in front of the shelter. Of these sites, charcoal from only Boat Cave was used for dating purposes. The charcoal submitted for dating other archaeological deposits came from pits well inside the rockshelters and most probably derives from fires built within the rockshelters. In addition, in all samples, the largest pieces of charcoal available were submitted for dating.

A radiocarbon age of 2370±60 BP (Beta-81625) was obtained for a charcoal sample from near the base of the excavated pit at Boat Cave. This is earlier than my estimate of <1000 BP, based on the artefact types present and the nature and depth of deposit (Attenbrow 1987: Table 7.2). It may be that the earlier than estimated age is due to the inclusion of older charcoal from the ridgeside above (cf. Blong and Gillespie 1978) or simply that the deposits accumulated more slowly than my extrapolations and calculations predicted.

Ages were not obtained from either of the excavated open archaeological deposits on the valley bottom (Black Hands and Stockyards Open Archaeological Deposits). At Stockyards OAD, which was outside the random sampling units, a Bondi point was found which suggests the valley fill and habitation in that location pre-dates ca 1600 BP (see above). Charcoal in these two locations was scattered throughout the deposit — no hearths or hearth-
like features were recorded. Using charcoal from these open archaeological deposits to estimate their age was not considered warranted.

**Focus on rockshelters**

Because of the few open archaeological deposits initially found, and the little if any datable material in those recorded, the analyses of changes over time in habitations has focused on the archaeological deposits in rockshelters. However, many aspects about the use of the catchment rockshelters are not known: for example, the extent to which rockshelters rather than open locations were used for habitation purposes; what other functions besides being habitations/campsites did the rockshelters serve; what size groups visited the catchment and used the rockshelters; and was the use of rockshelters related to seasonal or climatic conditions, or other events. Even for the early colonial period, there are no direct observations about life and activities undertaken in the catchment that can be used as a ‘benchmark’ from which to work backwards to assess changes over time.

Historical observations indicate that Aboriginal people in many parts of Australia preferred living in the open rather than in enclosed structures (Koettig 1976: 142–60). Even so, where they were available, rockshelters were commonly used, in particular, as refuges from rain, sun or wind, though not specifically from cold (e.g., Mulvaney 1960: 53; White and Peterson 1969: 59; Koettig 1976: 142–60; Jones and Johnson 1985a: 167; Flood 1997: 194–5). In northern Australia, rockshelters were used particularly in the wet season when travel was difficult and relatively permanent camps were established (Tresize 1971: 7, and Haviland and Haviland 1979 in Morwood and Hobbs 1995a: 179; Veth 1993: 77; Flood 1997: 194).

In the Sydney region, McDonald (1994: 348–9) suggested that open locations would have been preferred campsites at the time of British colonisation as the historical records for this region indicate there were large territorial groupings. However, the early historical sources for the coastal zone between Broken Bay and Botany Bay indicate that in terrain where rockshelters are prolific, they were frequently used as campsites (e.g., Bradley 1786–92 [1969: 74,140]; Extract … 1788 in HR.NSW 1892 [1978: 222]; Worgan 1788 [1978: 15–17]; Tench 1789: 80 [1961: 47–8]; White 1790 [1962: 157]; Hunter 1793 [1968: 59–60, 80]; Collins 1798 [1975: 460]). In addition, although large groups were occasionally observed in this area — up to 300 people were seen on some occasions (Collins 1798 [1975: 25]; Tench 1789: 90–1 [1979: 52]) — they were ‘seldom seen more than 20 or 30 & frequently two & three together’ (Bradley 1786–92 [1969]: 141–2). Resource abundance in the catchment would have been much less than in the coastal zone, where marine/estuarine resources are available in addition to terrestrial plants and animals. The size of groups visiting the catchment would have been at the smaller end of the scale.

In the catchment, it is likely that opportunities would have been taken to use a nearby rockshelter rather than constructing a hut of bark or other materials, especially in periods of bad weather (e.g., extremely wet, rainy, cold, windy or very hot weather). Along the NSW central coast and its hinterland, such conditions are not restricted to any particular season. Frosts and fog can be relatively thick on the catchment’s river flats in winter (pers. obs.) and so those areas would most probably have been avoided at that time of the year. Catchment rockshelters were probably used in all seasons, by groups of varying but relatively small size.

Climatic changes that occurred throughout the Holocene (Chapter 9) may have affected the degree to which each type of location was inhabited in different periods of time (cf. Stockton and Holland 1974: 56, 60; cf. Hiscock 1988b: 228). McDonald (1994: 75) said that
the decreased artefact accumulation rates in the catchment in the first millennium BP is ‘suggestive of a change in preference to outdoor camping, or more specifically outdoor knapping’ and ‘could be interpreted as indicating that there was a shift in settlement patterns, from shelter locations to open locations during the last millennium’.

However, it is not possible to say from the historical and (as will be seen later) the archaeological evidence whether rockshelters were used more frequently than open locations, and/or whether the use of rockshelters versus open locations remained constant throughout the Holocene. It is thus not possible to say whether rockshelters by themselves provide an accurate or biased record of the changing use of the catchment over time. In general, however, rockshelter deposits are less prone to destruction than open deposits. The catchment rockshelter deposits therefore provide reliable evidence on which to make statements about changes in the rate at which habitations were established in rockshelters, the number of habitations in rockshelters in each time period, and the rate at which artefacts accumulated in rockshelters. Moreover, as will be seen in the final chapters, other behaviours, besides preference for either open or rockshelter camping locations depending on climatic conditions, can be shown to account for increases and decreases in the habitation and artefact indices.

Discussion

This study of factors that are likely to have influenced the results of analyses suggests that it is highly likely there are unrecorded sites in the random sampling units due to observer bias and visibility problems and that some sites (particularly open archaeological deposits) will have been destroyed in the past or remain buried. The exact way in which this knowledge effects the results presented in later chapters is not entirely clear. However, the number and density of locations and/or archaeological traits from all time periods is likely to have been higher in the past than presently exists, and to be higher than currently documented.

The incorporation of older ‘environmental’ charcoal into archaeological deposits may have occurred at some rockshelters, but excavated pits were usually placed away from the dripline zone and outside scoured and other zones where such contamination could occur. Radiocarbon determinations from such charcoal samples would give an age older than the ‘real’ age of the associated stone artefact assemblage. Thus, if such situations do occur, the bias introduced by the incorporation of older ‘environmental’ charcoal will not produce a trend towards a greater number of more recent habitations.

Comparison between results from random sampling units, storage area and the total catchment

Comparing the results from the random sampling units, the storage area and the total catchment enables a number of comments to be made about the results of the random sample survey (Fig. 5.1). The ‘total catchment’ consists of all sites in the catchment; that is, those in the random sampling units, in the storage area, as well as all other recorded sites outside those intensively surveyed areas.

Archaeological traits

In all three data sets (random sampling units, storage area and the total catchment), archaeological deposits are the most common trait. However, they represent a greater percentage of the traits in the storage area (73%) than in the other two data sets (44% and 48% respectively — Fig. 5.1A).
In the total catchment and random sampling units, images and grinding areas occur in similar proportions, whereas in the storage area they occur in much lower percentages. In addition, grinding areas are less common than images in the storage area, and form a much smaller component in the total catchment sample.

Figure 5.1 Upper Mangrove Creek catchment: percentage frequency of each type of (A) archaeological trait and (B) location in the random sampling units (RSUs) compared with the storage area (SA) and the total catchment (UMCC).
Locations
In all three data sets, rockshelters are the most commonly recorded location (random sampling units 54%, storage area 55%, total catchment 54%). The percentage of open deposit and open rock in each sample varies; for example, the storage area has a higher percentage of open deposit sites and a lower percentage of open rock sites than the random sampling units (Fig. 5.1B). This is probably due to the fact that the storage area:
1. has many large alluvial flats (where open archaeological deposits are more likely to occur);
2. has a greater degree of ground disturbance (and hence greater visibility of open archaeological deposits) than ridgesides and the periphery ridgetops; and,
3. is principally within the Narrabeen Group of sandstones and has less area of Hawkesbury sandstone than the random sampling units. Hawkesbury sandstone overlies the Narrabeen Group and occurs only on the ridgetops and upper ridgesides in the catchment. In the Sydney/Hawkesbury region, most grinding areas and open images (engravings) are recorded on Hawkesbury sandstone (Vinnicombe 1980 XI: 5–6; pers. obs.).

The selected sampling strategy was adopted so that an unbiased, and hopefully representative, sample of not only the valley bottoms (the alluvial flats and lower ridgesides) but also the middle and upper ridgesides and ridgetops was included in the survey program. The above comparison between the data sets from the storage area, the random sampling units and the total catchment indicates that the valley bottoms by themselves are unlikely to contain an unbiased or representative sample of the archaeological evidence within the total catchment.

Problems brought about by restricted visibility and destruction of archaeological traits are common to all three data sets. Thus, the comparison does not help in determining the effect of these factors on the ability to detect sites in the random sampling units. However, the comparison does validate the need for the fieldwork to have been undertaken outside the storage area and for the catchment to be the area of study for this project.