Following the initial work of Ralph and Susan Bulmer in the early 1960s, research into the early prehistory of the Highlands of Papua New Guinea has produced a considerable body of evidence, both archaeological and environmental. Although the picture is far from clear, it is possible to present a scenario of human interaction with the changing environment from 40,000 years ago on the northern coast of Papua New Guinea to the first record of agricultural development in the Highlands between 9-6,000 years ago. A plausible hypothesis can be made that these Late Pleistocene hunter-gatherers were manipulating their environment, targeting the forest edges and disturbance zones to increase desirable plant and animal resources. Data from the site of Nombe rockshelter shows development through the end of the Pleistocene period towards more permanent and intense activity with marked increases in artefact and bone density at the beginning of the Holocene period.

INTRODUCTION

In 1969, when the prospect of working in the Highlands of Papua New Guinea became a possibility, I read the 1964 American Anthropologist’s Special Publication on The Central Highlands of New Guinea. The article by Ralph and Susan Bulmer, ‘The Prehistory of the Australian New Guinea Highlands’, formed the beginning of my understanding of the development of the region throughout its prehistory. Ralph Bulmer was Professor of Anthropology when I arrived in his Department at the University of Papua New Guinea in October 1971. His work in the Highlands provided me with many ideas for the integration of various disciplinary approaches to research. In particular his insight into the multifaceted but always interdependent relationship between Highland people and the fauna and flora of their environment was always in my mind whilst I battled through the sorting, identification and computerisation of over 50kg of archaeological bone from Nombe rockshelter. Bulmer was one of a handful of researchers working within Papua New Guinea who incorporated local knowledge of plants and animals into western theory and I pay tribute to his unique efforts, especially to his vision of the production of the series of publications begun with Majnep and Bulmer 1977. I wish every success to Majnep and Pawley, now working to finalise those publications.
The Bulmers postulated three main chronological phases during the development of New Guinean Highland prehistory (S. and R. Bulmer 1964). I deal here with Phase 1 and Jack Golson deals with Phase 2 (this volume). In this paper I present some of the early archaeological and environmental evidence that has been accumulating since 1964 and a brief summary of the complex interaction between people and environment during the Late Pleistocene to Early Holocene period. Although Geoff Hope has published some environmental evidence from Irian Jaya there has as yet been little archaeological evidence from west of the Indonesia/Papua New Guinea border but there is no doubt that conditions would have been very similar throughout the entire New Guinea Highlands.

BULMER PHASE 1

The Bulmers saw their Phase 1 as a period of time when people were "pre-neolithic, lacking edge-ground implements, who are unlikely to have made much progress with clearing the original forest" (S. and R. Bulmer 1964:72-3). Since there were no radiocarbon dates available for this publication, the authors had no framework of absolute dating. They judiciously suggested that, should the arrival into the Highlands of the Phase 1 hunting-gathering people have been relatively recent, limited agriculture might have been practised, although there was no archaeological evidence to suggest this from the two excavations discussed. They also hinted that the exploitation of indigenous plants, such as sago, may have played an important part in early prehistory of New Guinea. They posited three theories for the arrival of people in the Highland region: (1) by the normal process of population expansion from the Lowlands to the Highlands, possibly at a very early date; (2) through the positive attractions in the environment of the lower montane forest in contrast to the disadvantages of the unhealthy lower altitudes; or (3) as a late refugee displacement from more technologically advanced people arriving in the coastal regions.

We now know that human occupation of Sahuland probably began between 60-45,000 years ago (Roberts, Jones, and Smith 1990), with the earliest known occupation in the Melanesian coastal regions of that continent before 40,000 b.p. (Groube 1989) and twelfth settlement in the adjacent northern islands recorded by 31,000 b.p. (Allen, Gosden, and White 1989). The earliest dates for human activity in the Highlands region of New Guinea follow not long after by about 30-27,000 b.p. at Kosipe, Nombe and Kuk through what appears to have been a natural exploratory progression into the higher inland regions. There is certainly no evidence to suggest that the first Highlanders were refugees from more advanced immigrants although it is possible that the higher altitudes were favoured over the mangrove swamps found in some coastal regions. During these early periods of settlement, for the remainder of the Pleistocene and the early years of the ensuing Holocene period, it is not easy to disentangle the results of human activity from those caused by natural environmental change. Nevertheless hints of a wide range of human activities including forest exploitation, management and clearance do seem to be emerging for the time period of about 30-9,000 b.p.

ENVIRONMENTAL CHANGE

The broad patterns of environmental change through the Pleistocene have been well summarised by Hope (Hope, Golson, and Allen 1983). He interprets the environmental evidence in terms of an interaction between natural climatic changes which caused vegetational and faunal adaptations and the increasing imposition of human activity and exploitation. The major climatic factors involved in the Highlands during the Late Pleistocene to Early Holocene are in general those that caused world-wide changes at the time. In New Guinea there were seen significant changes in sea levels, glaciation, snow and cloud coverage and in altitude variation between the major vegetation zones all accompanied by tectonic/volcanic activity (Van Andel 1990). Hope (Hope, Golson, and Allen 1983:39) points out that the higher altitudes demonstrate the greatest ecological differences in the Pleistocene from the climatic patterns of the present. Towards a climatic maximum of about 35-30,000 b.p. the region experienced a marked increase in the areas of alpine shrub/grassland vegetation below the snow-line. This vegetation zone, linking the upper reaches of the extensive mountain spine of the island, was to survive for over twenty thousand years before declining in area after the Last Glacial maximum (from about 20-15,000 b.p.), in many areas disappearing altogether with the inexorable rise of the treeline as temperatures rose at the very end of the Pleistocene. During at least the first thousand years after the rise of the forest edge, species (both plant and animal) would be variable as regional adaptation to the new conditions took place (Walker and Flenley 1979). There is no doubt that conditions throughout much of the period would have varied a great deal from one area to another depending on altitude and local factors within each valley but the higher altitudes open to human occupation were considerably colder than at present whereas forest zones would afford more shelter.

Hunting, subsistence and residence patterns of the human population could not remain static in situations where the plant life and animal population were responding to such climatic changes; constant adaptation and cultural innovation must have been occurring throughout the Late Pleistocene period although this is not to suggest that environmental factors were the sole determinants. There are signs of deliberate burning (increased
charcoal particles) and slope degradation from the floor (1420m asl) of the Baliem Valley in West Irian as early as 26,000 b.p. (Haberle, Hope, and DeFretes 1990). The cool climate favoured *Nothofagus* growth in the upper levels of the forest where persistent cloud and mist would have decreased the chance of natural burning. In such cool climates some adaptations for clothing, shelter and the manipulation of fire would have been necessary (Haberle et al 1990:13). Corlett points out that forest near the treeline of high mountains is particularly sensitive to disturbance and even infrequent disturbance may have a lasting impact (Corlett 1984:841). At Telefomin (1300-1550m asl) relatively high frequency of charcoal particles between 18-15,000 b.p. coincides with a rise in grass pollen and the beginning in a gradual decline in *Nothofagus* (Hope 1983). Hope emphasises that the natural open swampy areas of this high valley would have been accessible from higher altitudes of the subalpine grasslands up until about 13-12,000 b.p. (Hope 1983:32). Hope has also suggested that deliberate burning may have prevented forest regeneration in some mountainous areas during the last 12,000 years (Hope, Golson, and Allen 1983:41). There is also environmental evidence suggesting deliberate burning from Kosipe, both from the archaeological site on the hillside at 1940m asl and from the swamp in the valley below, where there are indications of deliberate burning of the reed swamp as early as 30,000 b.p. (Hope 1982:217). The archaeological artefacts seem to have been deposited in a forest clearing occupied by grasses and tree-ferns, such as exist today where subalpine forest has been cleared, often during hunting.

Such clearance must have been on a minor and purely local scale and did not cause major or lasting effects and evidence will therefore be scant and, by its nature, difficult to interpret and open to argument. There is a considerable amount of discussion in the literature as to the role of humans in comparison with nature in causing clearance by fire, particularly within recent times (for example Hope 1983:32, Smith 1985:332-7, Brookfield 1989:314-15). Although natural occurrences have occasionally been documented, the general opinion seems to suggest that deliberate human intervention (even at times of drought) was usually present, for a number of purposes which include hunting strategies, improved communications, signalling and increased growth and production in specific plants.

PLEISTOCENE FOREST CLEARANCE

Groube (1989) has suggested that people arriving in northern Sahul found a range of plant resources which included many familiar foods to those from their tropical humid-forest homelands in Southeast Asia. Experiments must soon have targeted a range of other desirable plant products particularly within easy range of the forest edges and other disturbed areas of the forest, where light was stronger and the biological diversity is greater than in closed forest zones. As the newcomers proceeded to explore the higher altitudes, the flora would present an increasing number of unfamiliar plants which, as Groube (1989:293) points out, were remains from the ancient flora of Gondwanaland. Groube argues cogently for the thesis that, throughout the Late Pleistocene settlement of northern Sahuland, there was an intensification in the human management and manipulation of forest environments.

Waisted artefacts dated to this early period of Highlands prehistory have been documented from Kosipe and Nombe, all much smaller than the earlier examples from the Huon terraces, but capable of dealing effectively with ring barking or other tasks that would increase the light and encourage specific plants (such as the montane *Pandanus*) in disturbed areas of Highland forest. An edge-ground axe was also recovered from the Pleistocene deposits at Nombe (Mountain 1983:94). These two artefacts and other less well defined primary flakes could have constituted an efficient stonetool kit for both direct activity and for the production of other organic artefacts. Together with skilled fire control, they could have been sufficient to tackle some effective forest manipulation although not major or sustained clearance. Such forest management assumes a deliberate strategy of forward planning that must have involved either lengthy periods of settlement within one region or regular return visits to targeted zones within a well defined territory.

In a stimulating paper Bailey et al (1989) have explored the question of whether pre-agricultural hunters and gatherers were ever able to support themselves in tropical rain forest. Their review of current evidence suggests the hypothesis (already expressed by others including Headland 1987, and Hart and Hart 1986) that permanent exploitation of these vegetation ecosystems only became practical once plant domestication allowed exchange of forest products for staple carbohydrate food grown on forest edges or in areas cleared of primary growth. The authors argue that although tropical rain forests are the most productive ecosystems on earth, there are real problems in the production of adequate quantities of food suitable for human consumption from primary closed rain forest, including lack of carbohydrates and general inaccessibility of vegetable foods. This lack of plant carbohydrate does not appear to be replaced by animal sources, due to the lack of fat in meat from tropical rainforest fauna (Bailey et al 1989:61). I also believe that many of the small to medium sized animals present in the rain forest of Highland Papua New Guinea would have been difficult to catch in large numbers before the introduction of the dog as a partner in forest hunting, although certain species (such as fruit bats) could have been caught in large numbers in occasional raids on their communal breeding grounds, such as
large caves (Mountain 1979:68-70). All these factors could have encouraged the transitory groups to target the forest edges (either high or low altitudes) and accessible disturbed regions of the primary forest cover, such as swamps and natural clearings, where the quality and quantity of light was increased. Hope foreshadowed much of this speculation when in 1980 he wrote

I suspect that even pre-agricultural societies widened natural clearings with fire and perhaps by felling without a clear economic incentive. Such clearances would resemble the effects of landslides and would be reversed in due course, except where the forest was at a limit to growth, in a ‘climatic tension zone’ as at an altitudinal or soil boundary (Hope 1980:161)

We cannot yet prove whether, if humans were responsible for Pleistocene forest clearance, they were using it as a specific hunting technique or to promote the growth and production of specific plants. Both purposes were probably achieved (Corlett 1984, Hope and Hope 1976a, Groube 1989). The people who were occupying the Highlands of Papua New Guinea during the end of the Pleistocene survived by direct exploitation of forest resources: collecting, gathering and maintaining plant resources, hunting, trapping, collecting and manipulating faunal products. Current indications show that these activities may have caused environmental change, that can be monitored from the earliest years of occupation, rather than, as often has been supposed, only becoming apparent in the mid Holocene period. Pleistocene Highlanders were as adaptable and canny in their knowledge and understanding of the environment as are their descendants.

EXTINCTION OF LOCAL MEGAFANUA

One of the resources present in the Highlands for at least the earliest period of human exploitation were a number of large animals that were to become extinct before the end of the Pleistocene. These megafauna, I believe, were of major importance to the establishment of human settlement in the Highlands. The question of human association with the megafauna of Papua New Guinea has to be examined. The evidence is extremely slim but interesting.

Three sites have established the existence of extinct species with broad similarities to those found in Australia but strong indications that the New Guinean species were highly endemic and probably had been isolated from Australia since the late Miocene period.

a) Pliocene fauna was found near Wau, in Morobe Province in the Otibanda formation (this collection included 3 species of diprotodontids, 3 large extinct macropodids (2 Protemnodon species and a newly named macropodid Watutia novaeguineae (Flannery, Hoch and Aplin 1989)), a dasyurid, a murid and a Thylacinus) (Plane 1967a,b, Flannery 1990).

b) Pleistocene fauna has been found at Pureni Swamp, in the Southern Highlands. The evidence included a murid, Phalanger carmelitae, a cassowary and an extinct zygomaturine diprotodontid species but no human associations were found. Ballard is at present undertaking work in the Tari Basin that may extend this evidence (Chris Ballard pers.comm). Flannery and Plane have published a description of the Pureni diprotodontid remains, now allocated the species name Hulitherium thomasetti (Flannery and Plane 1986).

c) In West Irian evidence of other diprotodontid finds are attributed by Flannery to Zygomaturus nimborensia (Hardjasasmita 1985, Flannery 1990).

None of these sites has produced any evidence of human activity.

Some further evidence comes from archaeological sites:

d) At Kafiavana a large macropodid tooth (Protemnodon or Sthenurus) was recovered together with rodent bone and a small phalangerid mandible from clay levels below those containing the oldest human artefacts (Plane 1972)

e) At Kiowa there is evidence that Thylacinus cynocephalus existed in the early Holocene levels.

f) At Nombe three new species of extinct macropod were found: Protemnodon nombe, Protemnodon tumbuna and Dendrolagus noibano as well as an unallocated diprotodontid species (Flannery, Mountain, and Aplin 1983). Thylacinus cynocephalus also occurs throughout the site from about 33,000 b.p. into the last 5,000 years (Mountain 1990).

There is little doubt that New Guinea in the Pleistocene was home to a range of large megafauna. Some progress has been made in dating these faunal occurrences. A date of 38,600 ± 2500 b.p. ANU sample-231 (Williams et al 1972) was obtained from a radiocarbon determination of a log in the bed containing the Pureni bones but no date is provided in connection with the West Irian specimen. The Kafiavana tooth must be older than the radiocarbon determination of 10,730 ± 3700 b.p. obtained from the lowest level at the site to contain evidence of human activity but there is no indication of how much earlier the creature lived and died. The megafaunal material at Nombe was recovered from Pleistocene clay levels dated from approximately 26-24,000 b.p. to about 16-14,000 b.p. and the large extinct macropods do not appear in the succeeding strata. Extinct macropod bone was recovered from the basal layers of a more recent strata but is thought to have been
dug up from earlier levels during human activity at the end of the Pleistocene and redeposited. So far none of the macropod or diprotodon bone can be proved to have resulted from direct human predation although there are artefacts and other indicators of human activity in the levels that have produced megafaunal remains. It still remains to prove the nature of the association between the coexisting humans and megafauna at the site.

Flannery has suggested that most of the New Guinean marsupial megafauna were montane forest browsers (Flannery 1990) with *Hulitherium thomasettii* inhabiting the cool mossy upper montane forest (Flannery and Plane 1986:74). Peterson (1981:4) discusses the "edge effect" whereby certain animal species are attracted to boundaries between two environmental types, using the resources of both communities. Such ecotones support higher densities of game species than do those on either side and human clearance obviously increases such ecotones or edge effects. It seems possible that the presence of a number of large animal species towards the upper edge of the forest areas would be an incentive to human activity there from an early period.

The dating suggests that the megafauna in Papua New Guinea had died out well before the end of the Pleistocene and there is no evidence to suggest that human predation was the only, or indeed the major, cause of their extinction throughout the entire mainland of New Guinea. I agree with many of the observations and ideas raised by Webster and Webster (1984) in their discussion of optimal hunting strategies and Pleistocene extinctions, such as the introduction of new strategies switching to other prey when targeted species become more difficult and time consuming to catch. It seems unlikely that in such heavily forested mountainous areas, as the New Guinean Highlands, that at least six species of large animals would decline to extinction merely from human predation unless there were also powerful environmental changes causing major stress.

The demise of the megafauna as the treeline rose and the subalpine shrubs and grasses were replaced by thicker forest suggests that these animals flourished at the upper forest edge and that they were disadvantaged by the climatic and vegetational changes of the Late Pleistocene. Their decline could have led to a prey-switch towards greater exploitation of the surviving medium and smaller fauna and to increased targeting of plant resources already known and widely used. The shrinking of the open alpine vegetation, the steady rise in altitude of the upper tree limit and the concomitant extension of the forest cover to regions that had earlier had a more open (and colder) environment must have caused significant human cultural adaptation and technological innovation. This is not apparent in changes in surviving stone artefacts but could have been manifest in specific non-surviving organic materials such as bamboo and wood, indicating changes in hunting and trapping methods.

The loss of open areas and increased difficulty of access to areas of upper montane forest covered with cloud (Hope 1983) may have caused humans to concentrate their attention increasingly on the resources of the lower rain forest zones during the last years of the Pleistocene, perhaps involving an intensification in the clearance strategies. The gradual drowning of land around Lake Carpentaria a little later must have deprived any lowland peoples of rich resources possibly causing an upward expansion of human settlement into the Highlands. Environmental changes appear to have contracted some of the areas most attractive in earlier years for human activity and new adaptations and intensification of food production strategies were inevitable.

ARCHAEOLOGICAL EVIDENCE

The archaeological evidence is limited at present to a small number of sites within Papua New Guinea excavated since the late 1950s from which the quality and range of evidence is very variable. Several authors, following the Bulmers' initial article (S. and R. Bulmer 1964), have summarised the available evidence (e.g. Allen 1972, J. and G. Hope 1976a, Bulmer 1982, Hope, Golson, and Allen 1983, Gorecki 1986) to which little new evidence can yet be added. A few sites are currently under excavation and further field research will produce new evidence of the early human activities in the Highlands area. I include here a summary of sites, showing details of altitude, type of site and periods of occupation. Three purely chronological phases have been devised (A, B, C) in order to provide a visual summary of the chronology and continuity of human activity at each site over a period of more than twenty thousand years (Table 1). Unfortunately the diverse nature of the data preclude comparison on cultural grounds.

*The position and location of sites*

The nine sites occupy an altitudinal range of 1,280-1,940m asl. Only one site (Kosipe) (White et al 1970) is high enough ever to have been on the edge of the alpine grass and shrublands but two others (Nombe (Gillieson and Mountain 1983) and Wañekele (Bulmer 1977)) must have been within the upper montane forest in the earliest part of the period. The rest were all situated within the lower montane rainforest zone.

**Phase A (c.30 - c.15,000 b.p.) (Table 1)**

Within the Highlands of Papua New Guinea there are four sites which show evidence of human occupation during this period. Another site (Yuku) (Bulmer 1966) has no date from its earliest levels below levels dated during the B Phase so is a potential site only during this Phase. The early date from the basal levels of Batari
Environmental Change and Human Activity

TABLE 1
Archaeological Sites during Late Pleistocene/Early Holocene in Highlands of Papua New Guinea

<table>
<thead>
<tr>
<th>Site name</th>
<th>Province</th>
<th>Alt(m)</th>
<th>Type</th>
<th>Phase</th>
<th>Earliest C14 date</th>
</tr>
</thead>
<tbody>
<tr>
<td>KOSIPE</td>
<td>Central</td>
<td>1940</td>
<td>Open</td>
<td>ABC</td>
<td>27,460-26,280 b.p.</td>
</tr>
<tr>
<td>NFX</td>
<td>E.High</td>
<td>1550</td>
<td>Open</td>
<td>AB</td>
<td>18,800-17,300 b.p.</td>
</tr>
<tr>
<td>BATARI</td>
<td>E.High</td>
<td>1300</td>
<td>Cave</td>
<td>ABC</td>
<td>17,550-16,150 b.p.</td>
</tr>
<tr>
<td>WANLEK</td>
<td>Madang</td>
<td>1675</td>
<td>Open</td>
<td>B</td>
<td>15,500-14,650 b.p.</td>
</tr>
<tr>
<td>KAFIAVANA</td>
<td>E.High</td>
<td>1350</td>
<td>RS</td>
<td>BC</td>
<td>11,100-10,360 b.p.</td>
</tr>
<tr>
<td>MANIM</td>
<td>W.High</td>
<td>1770</td>
<td>RS</td>
<td>C</td>
<td>10,480-9,360 b.p.</td>
</tr>
<tr>
<td>KUK</td>
<td>W.High</td>
<td>1650</td>
<td>Open</td>
<td>C</td>
<td>c9,000 b.p.</td>
</tr>
</tbody>
</table>

PHASE A - occupied during period c.30,000-15,000 b.p.
PHASE B - occupied during period c.15-10,000 b.p.
PHASE C - occupied during period c 10-7,000 b.p.
E.High - Eastern Highlands
W.High - Western Highlands
RS - Rockshelter

Notes:
As discussed in Note 2 Kuk also has an isolated early date c 30,000 b.p.
Yuku has undated deposits below the earliest radiocarbon dates
Kafiavana has megafauna in deposits below the lowest levels containing artifactual evidence.

comes from charcoal from a matrix containing cultural material (White 1972:16) but White did not rule out the possibility that it could be from natural burning in non-human sediments. In view of the other well documented early sites I have accepted this date as indicating human activity. Kosipe (White 1970), situated at the upper margins of the forest and grasslands, has been suggested as a seasonal site for the exploitation of mountain pandanus nuts and perhaps hunting of some of the upper forest megafaunal browsers such as Dendrolagus noibano, Protemnodon tumbuna, Protemnodon nombe (Flannery, Mountain, and Aplin 1983) and Hulitherium thomasetti (Flannery and Plane 1986) as well as potential for activity round the swamp area of disturbance (Hope 1982). Nombe rockshelter was in the upper forest zone with access to small areas of more open grasslands. The open site of NFX (Watson and Cole 1977) and the cave at Batari were situated at lower altitudes of the montane forest. Three of these sites occur in the Eastern Highlands or neighbouring eastern Simbu with Kosipe situated about 250km further east in the mountains of the Central Province suggesting a widespread, if probably seasonal, nomadic and sporadic use of many areas of the Highlands prior to 15,000 b.p.

Phase B (c.15,000 - 10,000 b.p.) (Table 1)
Seven sites are known to have been used during this period, four continuing from Phase 1, with Yuku producing definite dates and two new sites in the forest of both the Eastern and Western Highlands (Kafiavana (White 1972) and Wafeekele (Bulmer 1977)). Wafeekele, an open site at 1,675m asl, could have provided some access to higher vegetational zones but Yuku rockshelter at 1,280m was situated just above river level in a gorge of the River Yuem.

Phase C (c.10,000 - 7,000 b.p.) (Table 1)
There is evidence for activity at seven sites ranging from 1,750m and above to 1,300m. The two new sites are Manim (Christensen 1975), a small rockshelter towards the top of a mountain ridge and an open site, Kuk (Golson 1989), on the swampy valley floor, which in the early Holocene shows signs of the most significant manipulations of local environment leading to the development of forest clearance on a large scale and the beginnings of true agriculture.

Obviously we do not yet have a large enough sample of archaeological sites to present clear patterns of change within human settlement over this period of time and perhaps we should not expect such sites to produce this evidence as a matter of course given the exigencies of preservation and discovery. The Highlands of New Guinea were used for human exploitation and settlement from about 30,000 b.p. and the early sites are widely distributed both in geographical position and altitude. During the period of change from the Pleistocene to the Holocene periods, the Highlands were certainly an area for human activity utilising both higher and mid montane ecotones.
There is little archaeological evidence so far that can be used to support the model of gradual and increasing plant and animal exploitation. There are slow changes in the stone artefact assemblages (such as increase in the number of smaller tools) but the quantity of Pleistocene tools available is not sufficient to see regional or chronological change. Techniques such as residue analysis or plant data may provide more information in the future. Faunal analysis from sites such as Nombe should present hypotheses that can be tested on other environmental or archaeological data.

ENVIRONMENTAL AND ARCHAEOLOGICAL EVIDENCE FROM NOMBE ROCKSHELTER

This small cave and rockshelter (White used the name of Niobe (White 1972)) on the borders of Simbu and Eastern Highlands Provinces provides a well documented series of archaeological strata surviving the last 30,000 years (Table 2) (Gillieson and Mountain 1983, Mountain 1983).

<table>
<thead>
<tr>
<th>Strata</th>
<th>Approx. age range</th>
<th>Range kyr</th>
<th>Sediments present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stratum A</td>
<td>Present - 4,500</td>
<td>4.5</td>
<td>Fine dusty sediment</td>
</tr>
<tr>
<td>Stratum B</td>
<td>4,500 - 10,000</td>
<td>5.5</td>
<td>Loam, redbrown clay</td>
</tr>
<tr>
<td>Stratum C</td>
<td>10,000 - 15,000</td>
<td>5.0</td>
<td>Flowstones, tephra, clay</td>
</tr>
<tr>
<td>Stratum D</td>
<td>15,000 - 33,000++</td>
<td>18.0+</td>
<td>Various clays</td>
</tr>
</tbody>
</table>

Analysis of data from Nombe so far suggests the following scenario during the late Pleistocene period. The earliest dates for artefactual evidence in the clay deposits of Stratum D are no earlier than 27,000 b.p. when stone tools (already mentioned on p.512) occur together with megafauna and other small and medium sized animals in heavy clays. These are water laid by a small stream and are not closely stratified. Sedimentation rates are low for this period and human activity is likely to have been sporadic and intermittent with occupation of the site by various other species, including thylacine and various raptors on the cliff above the site. These clays are sealed at about 16-14,000 b.p. by deposits indicating a wide range of geomorphological activity. Pools of standing water (gour pools) occupied the site for sufficient time for over a metre of tephra to be formed in them and thick flowstone formation indicates periods of running water both before and after the tephra episode. However, towards 10,000 b.p., environmental and cultural changes took place producing a thick loam in the centre and back of the site with redbrown clay towards the front, both showing distinct evidence for increased human activity. Flowstone formation continued at a reduced rate. There is tremendous contrast between the paucity of human artefacts in Stratum C and the wealth of artefactual material in Stratum B (c.10,000 - c.5,000 b.p.) although it is possible that erosion of sediments has caused the removal of human artefactual evidence from the earlier period. Although the overall density of artefacts is low in Stratum C there are sufficient signs of human activity (for example small quantities of charcoal, egg and other shell and a mean of over 30% burnt bone) to indicate that sporadic human visits continued. One obvious activity that was undertaken during the period of Stratum C was the digging of a man-made trench into earlier Pleistocene clays. From about 10,000 b.p. onwards there is evidence for a sudden increased activity at the site with increased quantities of stone artefacts and heavily burnt and fragmented animal bone in large quantities throughout the site. People were using the site more regularly and extensive hunting was being undertaken in a number of different vegetation zones, both higher and lower than the site.

FAUNAL EVIDENCE FROM NOMBE

The faunal material included in this analysis comes only from archaeological units in Stratum C and B (Stratum D is not available at present) clearly identified as belonging to only one period of stratified deposits (i.e. units which may contain mixed material from two or more levels are excluded). All bone (both cranial and postcranial) from the units used has been identified and weighed and minimum numbers of animals (MNI) have been used with caution.

Analysis of this data suggests the following points:

a) that there are distinct changes in the density of bone (grams per litre of deposit) from Stratum C to Stratum B.

b) total species numbers rise at the end of the Pleistocene: in Stratum C there are 29 species, up to 35 in the basal levels of Stratum B and peaking at 42 in the middle levels of Stratum B. Many of the new species appearing after 10,000 b.p. are bird species probably reflecting hunting increase in the medium and small sized prey but it may also reflect improved preservation of bone in the Holocene levels.4

c) there is a marked decline in the number of very small animal bones present (especially frogs) from Stratum C to Stratum B. I see this as a reflection of increased human activity on the site causing a decline in those
species which naturally inhabit such sites or are predated by other larger predators driven away by increased 
human activity. Stratum C contains about 42% of the total minimum number of animals present in the range 
of very small animals (average body weight of less than 300g, including small ringtails, rodents, dasyurids, 
birds and frogs) although only five species were present in the sample. In Stratum B (basal levels) this 
dropped to about 3% (with eight species present) and in Stratum B (middle levels) it was about 4% (five 
species present).

d) the numbers of fruit bats increase throughout the first half of the Holocene period (Stratum C 11%, Stratum 
B basal levels 14% and Stratum B middle levels 33% by minimum numbers of animals). This dramatic rise 
seems to me to indicate an increase in bat numbers in the surrounding hunting areas, although I am aware 
that the opposite view of increased exploitation of an already existing resource is viable. Bulmer found an 
increase in bat remains at the nearby site of Kiowa although since that site has few surviving remains from 
the Late Pleistocene the effect is far less noticeable (Bulmer 1979). A large extinct form of fruit bat 
Aproteles bulmerae was present there in the Late Pleistocene and was replaced about 10,000 b.p. by the 
now common species Dobsonia moluccensis (Menzies 1977). Menzies suggests that incoming Dobsonia 
may have competed with the established species for cave roosting sites or even that increased human activity 
may have reduced suitable ecotopes or the specialised diet of the extinct form and that extinction may have 
followed quite rapidly. Menzies has examined the bat material from Nombe and has found both species 
present but it is not yet clear whether the same pattern of exchange between the two species can be seen in 
the Nombe data.

e) The percentage of animals (by minimum numbers) that is represented by the medium and small animals 
(average body weight between 5kg-300g) that are commonly caught in the Highlands today (medium and 
small macropods, possums, ringtails, bandicoots, large and medium rodents, bats and brush turkeys) 
increased from 49% in Stratum C to 88% in Stratum B (basal levels) to 96% Stratum B (middle levels). A 
similar rise can be seen in the Kiowa fauna. At Nombe the proportion of possums and ringtails rose from 
15% Stratum C to 43% Stratum B (basal levels). These figures confirm the rise in hunting activity as does 
the rapid rise in the density of burnt bone about 10,000 b.p.

CONCLUSION

Today there are significant differences in the existing cultural systems of the Western and Eastern 
Highlands, as pointed out by Feil (1987). He has suggested that prehistorians have generally considered the 
Highlands of Papua New Guinea to have been an homogeneous area, whereas he sees the present cultural 
variations as an ultimate reflection of basic environmental differences. These are higher rainfall in the Western 
regions, and less seasonality in that rainfall. Consequence of more seasonal rain in the Eastern Highlands can 
be a higher evaporation rate and more frequent seasonal drought. Feil suggests that these environmental 
conditions were fundamental to the process of agricultural development and intensification during the 
Holocene period, allowing the Western Highlanders to develop the large, complex, language communities held 
together by powerful exchange systems documented within living times. An increase in pig raising (made 
possible by intensified taro production) allowed an increase in community size with concomitant effects in 
social complexity. He posits that the less advantageous natural conditions in the Eastern Highlands provided 
no stimulus to agricultural intensification or increase in pig production, leaving communities there to remain 
small and more isolated with hunting/gathering retaining its major role in food production far longer than in the 
west. He suggests that prehistoric evidence (yet to come) may provide a series of development stages from 
esto west across the Highlands showing increased intensification in agriculture.

Feil's theories basically relate to Holocene developments but already there are suggestions that the 
prehistoric situation was not following the path he suggests. Terraces, almost certainly used in connection 
with agricultural production, are documented but not yet firmly dated in the Eastern Highlands (Hughes, 
Sullivan, and Yok in press). Although there are some basic environmental differences between the two areas, 
communities in the Eastern Highlands, well established in the Late Pleistocene period, may have experimented 
with methods of food production that leave different archaeological traces to those in the ditches of Kuk. I feel 
that there is a possibility that the dramatic increase in bat bones at Nombe may be due to a local intensification 
in their favourite food, fruit trees, and that this could be a response of one local community to developing their 
food resources towards 10,000 b.p. The suggestion is little more than a hunch at present and can be easily 
refuted. Feil may well be correct in assuming that there were different responses by people in various parts of 
the Highlands to local climatic conditions but I do not feel that the lack of similar evidence to that from Kuk 
has to suggest that other Highland regions were necessarily more backward in the origins or intensification of food 
production. Instead, I am suggesting that we are more sensitive to the available evidence and its possible implications. He could be also be correct in assuming that, once disturbed, the forest in the more fragile environment of the Eastern Highlands may not be capable of regeneration as easily as that in
the Western Highlands (Feil 1987:15) and that, once agriculture was established, taro grew better and could support larger populations in the regions of higher rainfall than in the drier Eastern Highlands.

It has to be emphasised that the evidence available at present is extremely limited and often inadequate to answer many pertinent questions. Nevertheless I feel optimistic that the Pleistocene scenario of New Guinea Highland forest manipulation and management suggested here has validity. The first human groups to occupy the region produced a technology (including fire control) that established their understanding of and partnership with the natural environment. The evidence for human activity during the period from 30-10,000 b.p. indicates widespread occupation, both in the geographical and altitudinal sense, although sporadic at any individual site. After 10,000 b.p. human activity appears to increase at a number of sites, especially at Nombe, but other sites show a peak in artefact density between 9,500 b.p. and 4,500 b.p. Human control of the Highland environment had increased to the level where major changes were effected and landscapes began to be changed under the domination of human behaviour. Brookfield wrote (1989:307) that there is little evidence of human impact on the vegetation until the mid Holocene period, but such minor clearance as is suggested by the evidence presented in this paper would leave little trace, except in the occasional pollen and sediment record. I believe such evidence is beginning to appear and, together with other forms of evidence such as technological, does indeed suggest that human interference and management of the Pleistocene forest is significant, at least as an indication of consistent human activity, if not for major observable effects on the forest cover. I have suggested that human cultural adaptation worked alongside environmental change, to allow the successful human penetration and manipulation of the Highland areas of New Guinea during the Pleistocene period, setting in train subtle changes that were to lead to widescale forest clearance, village settlement and horticulture that marked the area for the next 10,000 years of development.

Martin Wobst has cautioned against the trap of environmental determinism. When discussing the environmental and cultural changes of the Late Pleistocene it may be that “nature is easier to measure and observe than human behaviour” (Wobst 1990:326) and therefore it is easy to see human adaptation as a response to environmental change, but it is clear that in New Guinea, as in many other areas of the world, Late Pleistocene human society was clearly making its own regional impact, adapting certainly to environmental change, but imposing their own social and cultural changes outside those constraints. Yen (1989) in a recent paper discusses an idea that he calls ‘the domestication of the environment’. I believe this is an appropriate term to describe the human activities in the Highlands of New Guinea during the Late Pleistocene.

The Bulmers in 1964 suggested that the lack of edge-ground axes indicated little environmental impact during Phase 1. The presence of such artefacts, along with subtle environmental evidence and a belief that Late Pleistocene hunter-gatherers were not at the mercy of their world but capable of managing their environment, has allowed a new reconstruction to be made of this first stage of human development within the Highlands of Papua New Guinea. The Bulmers, with their hints at the possibility of early dates and of the importance of the use and understanding of native food plants, showed remarkable insight into the subtle but dynamic picture of prehistoric cultural and climatic change over the first 30,000 years that is now emerging from the data in the New Guinea Highlands prehistory.

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NOTES

1. New Guinea in this context refers to the entire palimpsest of islands now incorporated into Irian Jaya and Papua New Guinea.
2. Along with Groube (1989) I prefer this neutral term to the rather colonial Greater Australia favoured by Allen, Gosden, and White (1989)
3. The date from Kuk is from imported rocks associated with a hearth without artefacts or other evidence (Golson and Hughes 1977:16)
4. The taphonomic aspects of the Nombe material are discussed in further detail in Mountain 1990.

REFERENCES

Edai Siabo was an insignificant, if not deformed, resident of the Papuan village of Boera. One night when fishing on the reef, he was taken by a spirit to a cave under the sea. The spirit taught him to make big trading canoes called *[lagatoi]* and to undertake *[hiri]* trading expeditions to the Gulf of Papua. When he made a model trading canoe and explained his intentions, his fellow villagers mocked him. At last, however, he sailed with his crew to the west.