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PREHISTORIC MAN AND HIS ENVIRONMENT IN
THE CATLINS, NEW ZEALAND.

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A Thesis submitted for the degree of
Doctor of Philosophy
at the University of Otago, Dunedin,
New Zealand

1977
ABSTRACT

This thesis is a regional study of the interactions between Polynesian man and his environment in the Catlins district, southern New Zealand. The prehistory of the Catlins differs from that of the rest of southern New Zealand (Murihiku) in its pattern of early and continuing settlement followed by abandonment at the end of the seventeenth century. The examination of such a marked change in settlement pattern is likely to yield useful insights into the interplay of cultural and environmental factors.

Three different approaches have been stressed: culture history, environmental characteristics and temporal changes in the environment. The relevant environmental factors were studied after consideration of the archaeological and ethnographic data. Methods of sampling and recording these factors were examined and the need to distinguish between man-induced and natural changes in the vegetation emphasised.

This thesis incorporates newly gathered data on local climates, forest associations, forest clearings, estuarine populations and site location in the Catlins region, as well as on stratigraphical associations at Papatowai Point.

Detailed analyses of the above disclosed that the initial economic pattern of Polynesian people in the Catlins was one of multi-resource zone exploitation of sea, estuary, soft and rocky shorelines, forests and inland plains. Early use of the Mataura and Waimea Plains may have been largely for exploiting silcrete and porcellanite sources, rather than for
food supplies. It is postulated that when the climate deteriorated, sites adjacent to fewer resource zones were occupied. The earlier sites may have been abandoned, or occupied at the same time. Two settlement models, incorporating these alternatives, are presented. Seasonal markers indicate a maximum occupation from spring to autumn, and there is no positive evidence of winter occupation. About 1700-1750 A.D., the Catlins coast was abandoned, despite the continued availability of most traditional food supplies. Moas had become extinct and, judging by the data from Papatowai, seals were less abundant than in the 11th to 14th centuries.

Ethnographic material indicates that the inland resources of eels, lampreys, forest birds and, presumably, bracken rhizomes were important in the 19th century to Maoris living immediately north and south-west of the Catlins. It is postulated that the local peoples ceased using the Catlins coast in the early 18th century because the dense forests made access to the inland regions difficult. With the moas extinct and seal colonies locally depleted, the Catlins coast lost much of its advantages. A new strategy was adopted of spending the summer months at the mouth of the Clutha River or west of Waikawa where the same resources could be exploited as on the Catlins coast but where inland access was easier. The Catlins coast may never have been occupied during winter, since the damp climate would militate against the storage of dried foods. Hence there is no need to assume a total shift of population in the 18th century to the north or west but rather a change in the pattern of seasonal movements.
The official change to metric units occurred during the course of this work, and some work was done with non-metric equipment. Metric values are used in most places in the text, but 'acres' and 'square feet' were retained for the quadrat work to allow easy comparison with previous research. Rounded measurements in feet and inches, used by Teviotdale and others, were generally converted to metrics and expressed to one decimal place, giving a spurious appearance of accuracy.

Radiocarbon dates are expressed in the format 1647 a.d. to imply simple subtraction of years B.P. from 1950 A.D.

'Porcellanite' is used to cover the terms 'jasper' and 'chert' as used by Lockerbie and Teviotdale before 1960. Lockerbie's 'jasper' and my 'porcellanite' are synonymous with 'vitrified mudstone' as used by Professor D. Coombs, Geology Department, University of Otago. 'Silcrete' is applied to the rock formed by cold accumulation throughout Otago and Southland (D. Coombs: pers. comm. 1973), and sometimes referred to by other archaeologists as 'quartzite' or 'orthoquartzite'.

Nomenclature of flora and fauna has been taken from the following authors: Mammals - Gaskin 1972 and others, Moas - Archey 1941, Small birds - Kinsky 1970, Fish - Graham 1953, Plants - Ferns and allies, Dicotyledons, Allan 1961; Monocotyledons except grasses, Moore and Edgar 1970; Grasses, Cheeseman 1925; Mollusca - Penniket and Moon 1970, Morton and Miller, 1968.

I gratefully acknowledge financial assistance from
the Skinner Foundation Fund for travel expenses to the Catlins in the course of three years field work. During this period I have received helpful advice from many people but I wish to particularly thank Mr. Alan Baker, National Museum; Dr. Alan Mark, Botany Department, Otago University; Dr. Ian Speden, N.Z. Geological Survey, D.S.I.R.; Dr. Peter Wardle, Botany Division, D.S.I.R.; my colleagues in the Anthropology Department, University of Otago and especially my supervisor, Professor C.F.W. Higham. The residents of the Catlins received me most hospitably and gave me much useful background information, particularly Mr. and Mrs. F. Bennett, Mr. and Mrs. J. Peterson and Mr. and Mrs. D. Stott; and finally I thank my husband and sons for regarding my work with patience and interest.

Typists: Mrs. Y. Benson and Mrs. B. Blok
Photographer: Mr. M. Fisher
Artist: Mr. M. Webb
# PREHISTORIC MAN AND HIS ENVIRONMENT IN THE CATLINS,
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<tr>
<td>BL</td>
<td>Black component of excavation TT1, Papatowai Point</td>
</tr>
<tr>
<td>°C</td>
<td>degree Celsius</td>
</tr>
<tr>
<td>Cab</td>
<td>Caberfeidh</td>
</tr>
<tr>
<td>cf.</td>
<td>compare, i.e. is close to</td>
</tr>
<tr>
<td>Chap</td>
<td>Chapter</td>
</tr>
<tr>
<td>cm</td>
<td>centimetre</td>
</tr>
<tr>
<td>d.b.h.</td>
<td>diameter at breast height as applied to trees</td>
</tr>
<tr>
<td>est.</td>
<td>estimated</td>
</tr>
<tr>
<td>°F</td>
<td>degrees Fahrenheit</td>
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<td>Fig.</td>
<td>Figure</td>
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<tr>
<td>ft</td>
<td>feet</td>
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<tr>
<td>FlH</td>
<td>Florence Hill</td>
</tr>
<tr>
<td>ibid</td>
<td>consecutive reference to the same work</td>
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<tr>
<td>ident.</td>
<td>identified</td>
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<td>in</td>
<td>inch</td>
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<td>k</td>
<td>kilometre</td>
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<tr>
<td>Kah</td>
<td>Kahuika</td>
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<tr>
<td>l</td>
<td>length</td>
</tr>
<tr>
<td>LS</td>
<td>Lower shell component of excavation TT1, Papatowai Point</td>
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<tr>
<td>m</td>
<td>metre</td>
</tr>
<tr>
<td>max</td>
<td>maximum</td>
</tr>
<tr>
<td>MHWN</td>
<td>Mean high water neap</td>
</tr>
<tr>
<td>min</td>
<td>minimum</td>
</tr>
<tr>
<td>ml</td>
<td>millilitres</td>
</tr>
<tr>
<td>MLW</td>
<td>Mean low water</td>
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MLWN  Mean low water neap
ms   manuscript
mt   metric tons
N    number in sample
NS   not statistically significant
N.Z.A.A. New Zealand Archaeological Association
O.S.N.Z. Ornithological Society of New Zealand
Pap  Papatowai
SB   Shell and bone component of excavation TT1, Papatowai Point.
sp   species (singular)
spp  species (plural)
Tah  Tahakopa
Tau  Tautuku
Taw  Tawanui
Temp temperature
US   Upper shell component of excavation TT1, Papatowai Point.
WF   Working floor component of excavation TT1, Papatowai Point.
Σ    Sigma, statistical symbol for 'sum of all'
<    less than
>    greater than
SECTION 1

THE CATLINS AND ITS PLACE IN NEW
ZEALAND PREHISTORY

Chapter 1:1

The Catlins as an archaeological entity

Between 1935 and 1955 archaeological research in Otago was directed towards the definition of a culture associated with the hunting of an extinct avifauna which included about seven species of moa. Most of the relevant excavations (Teviotdale 1937, 1938a, 1938b; Lockerbie 1953, 1959) took place in the Catlins district of south east Otago, though the material culture described was considered to be homogeneous throughout Skinner's culture area of Murihiku (Skinner 1921). This environmentally diverse area includes Stewart Island and all of the South Island south of a line drawn roughly east west at the latitude of the Rangitata River (Fig. 1:1).

Skinner had delimited the culture area of Murihiku using both archaeological and linguistic criteria (Skinner 1921). Teviotdale developed the description of the material culture in more detail (Teviotdale 1932) but neither he nor Skinner could apply a time scale to this material. Following their excavations in the Catlins, Teviotdale and Lockerbie (Lockerbie 1959) were able to develop a chronology demonstrating gradual economic and technological change, but in doing so raised some interesting problems. Teviotdale (1937, 1938a, 1938b) showed that whole moa bodies had been associated with a particular assemblage of adzes, fish hooks, ornaments and
flake material throughout the prehistoric sequence of the Catlins. Lockerbie (1953, 1959) confirmed Teviotdale's findings in the face of criticism from other archaeologists, established the value of stratigraphical excavation in New Zealand sites and, through pioneering work on radiocarbon dating, showed that the upper levels of the Catlins sequence were as late as the 17th century. Elsewhere in New Zealand and even in east coast Otago north of the Catlins, the indigenous material culture described by the first Europeans in the late 18th century was known to be quite different. How could the supposedly early moa-hunter culture have lasted so long in the Catlins?

To throw light on this problem Lockerbie (1959) presented a synthesis of prehistoric occupation in Otago set in the context of a single period of colder climate associated with a reduction in forest cover and with moa extinction. Though he realised that economic factors were relevant to an understanding of moa-hunter prehistory, Lockerbie tried to establish subsistence models which now seem too generalized. For the Catlins he set up a three stage sequence using evidence from the estuarine site of Pounawea where there was a change in dietary pattern from a predominance of moa to a broader spectrum of shellfish, fish and small birds (Lockerbie 1959: 82-84). This subsistence pattern could be correlated with a change over time in the relative proportions of the typical moa-hunter tool types though there was no great change in the types themselves. Though there were differences in the artefacts retrieved from the other estuarine site of Papatowai, no comparisons were drawn between the two sites, and there was
no clear exposition of the environments and available resources close to each site.

A second peculiarity of Catlins prehistory became evident as a result of Lockerbie's work. Radiocarbon dates and the dating of trees growing on the Catlins estuarine sites demonstrated that they had been abandoned by at least 1700 A.D. There was some evidence for later occupation of coastal fishing sites but the archaeological evidence combined with historical accounts supported a model of considerable prehistoric exploitation of a coastline rich in food resources which was utilized little if at all after about 1700 A.D.

Lockerbie (1959) assumed permanent occupation at Papatowai and Pounawea, followed by the movement of discrete groups to coastal sites such as False Island and Jacks Bay (Fig. 1:1). He integrated the 16th century inland moa-hunter site at Hawkesburn in Central Otago into this settlement pattern by assuming that some coastal peoples had moved earlier as the numbers of moas dwindled, to exploit inland moa populations. Lockerbie saw the movement from the estuarine to more coastal sites in the Catlins as part of a strategy for easier exploitation of marine resources. Other than this broad treatment there was little attempt to relate site function to the local environment.

The relationship between the settlement pattern and local environments in the Catlins must be first viewed in the wider context of the other environments available to the inhabitants of Murihiku. As Skinner, Teviotdale and Lockerbie perceived, it is valid to consider this southern part of New Zealand as a cultural entity on the basis of homogeneity of material culture. The geographical subregions are however so
distinctive that their topographical, climatic and biotic characteristics must have considerably influenced prehistoric economic strategies. Using data from Wards (1976), seven subregions of Murihiku can be distinguished - the Catlins, Fiordland-south Westland, the Foveaux Strait coastline of Southland and Stewart Island, the Upper Clutha and Waitaki Basins, Central Otago, South Canterbury and east coast Otago north of the Clutha River and finally inland Southland. The characteristics (Table 1:1) which separate the Catlins from the other subregions are its heavily forested but relatively low hills, a coastline of alternating cliffs and estuaries and a climate which was mild but cloudy and cool by comparison with inland areas.

Every environmental subregion of Murihiku has evidence of prehistoric occupation but the historically recorded Maori populations were mostly on the east coast north of the Clutha River and along the Foveaux Strait coastline of Southland and Stewart Island (Shortland 1844, Bathgate 1969). Though the inland subregions had harsher climates and more unevenly distributed food resources than the coastal areas, they possessed important sources of stone materials such as nephrite, silcrete and porcellanite. Of the coastal subregions, the southern coasts were obviously less attractive climatically than the more northern ones, but the abundant food resources of the south such as seals, penguins, muttonbirds (the young of Puffinus griseus), barracouta and, until the 16th century, moas could have been a major factor which ensured that there was no obvious disparity in exploitation evidence between north and south. Midden sites can be found in almost every sizable bay or beach of the eastern and
southern coasts of Murihiku as far west as Sandhill Point (Coutts 1972).

A consideration of the nature of occupation around the Catlins district at the time of European contact yields useful insights into the interplay of cultural and environmental factors. In the early 19th century Maori settlements were recorded at the mouths of the Clutha and Waikawa Rivers and inland at Tuturau (Roberts 1895, McNab 1907, McLintock 1949) (Fig. 1:1). The 65 kilometres of coastline from Nugget Point to Waikawa and about 800 square kilometres enclosed by the Waikawa River and the Slope down and Kaihiku Ranges were unoccupied.

The settlements at the mouth of the Clutha included a village at Murikauhaka in the 1830s and two other sites at Kaitangata and Karoro Stream in the 1840s (Fig. 1:1). Murikauhaka is a well documented site situated on a sheltered hillside sloping to the north. It was visited in January 1830 by a sealer, Captain Benjamin Morrel (McNab 1907:263), who described the village as consisting of 28 rectangular houses, some of them only half the size of the others. The larger houses were strongly constructed and painted with black and red pigments, suggesting a site of relatively permanent buildings. There was quite a large group of people in residence, even for January, in that Morrel mentions that 50 people, age and sex unspecified, came out to visit his ship. January was a time when the local inhabitants were likely to be on the coast (Beattie 1954: 59) for the beginning of the barracouta season (see p.100). Following measles and influenza epidemics in 1840, the
inhabitants of Murikauhaka moved three kilometres to Kararo Stream.

The Kaitangata site is more elusive. Roberts (1895) mentions that in 1856 there was a kainga on the site of the present township but Tuckett (1844) did not record it on his survey trip in 1840. Local tradition suggests that it might have been about a kilometre south of the present township on a terrace beside the river and sheltered from the south by a spur running down to the river edge.

When Thomson (1889) explored the Catlins and Owaka Rivers in 1863, the Maoris of Molyneux Bay told him that before the Europeans arrived in about 1835, they went occasionally to plant gardens on the sheltered terraces of the Owaka River. They also went on fishing expeditions to the vicinity of False Island and the Owaka Heads, but they had no recollection of Maoris ever having lived around the Catlins estuary. The passing reference to gardens, presumably for growing Irish potatoes, is of considerable interest. Stewart (1816) saw acres of Irish potatoes growing at Bluff in 1809, and so it is reasonable that Maoris living at Molyneux Bay in 1863 would remember growing them prior to 1835. Indeed it is possible that they had been growing potatoes effectively for nearly 30 years, an activity likely to have brought about increased sedentism and a new style of housing such as that seen at Murikauhaka by Morrel.

The site at Tuturau seems to have been a seasonal camp for the collecting of lampreys at the Mataura Falls. When Te Puoho, a chief from the North Island, raided Tuturau in 1836 (Ross 1933), there was only a small group of people
in occupation. They were associated with Tuhawaiki, a Ngaitahu chief of Foveaux Strait, who gathered together a war party and effectively repelled the invaders by killing Te Puoho and taking most of his warriors into captivity.

There is very little historical material on the exploitation of the Waikawa estuary to the south of the Catlins. In 1770 Cook saw a large fire on the land at about this point (Beaglehole 1961). The surveyor, Tuckett, saw evidence of fires in 1840, and was told that there was a favoured route inland up the Waikawa valley to the Mataura (Tuckett 1844).

The historic evidence shows that in the Contact Period there was little exploitation of the natural resources of the Catlins coast, and the Maoris with rights of exploitation were living on Molyneux Bay and, as will be seen below, to the west on the shores of Foveaux Strait.

If the Catlins is to be defined as an archaeological entity then it must be articulated in some way with the terrain exploited by a group of people who functioned as a community.

The critical features of a community in this context are considered to be those of "habitual social contact and economic cooperation within a particular area" (B.F.Leach 1976:22). For the hunters and gatherers of Murihiku this area is most conveniently defined as the annual territory, i.e. the area regularly covered during the yearly round of subsistence activities. Though the people of Murihiku shared technological skills sufficiently to generate a relatively homogeneous assemblage of artefacts, it is improbable that
they acted as a unified group in harvesting, preserving and distributing food resources. Economically it seems more likely that they were divided into partially discrete macroband-microband groups, between which some foods and artefacts were exchanged (Bathgate 1969:285). A macroband (McNeish 1964) consists of a group of people who live together for at least part of the year but more or less frequently divide into smaller groups for different economic activities. There is ethnographic evidence that this model is appropriate for the Contact period in Canterbury, Westland and Murihiku (H.M. Leach 1969, Bathgate 1969). These studies demonstrate a recurrent pattern of mobility, determined by the seasonal abundance of particular food species.

It can be shown that individuals commonly travelled more than 100 miles in pursuit of some economic objective (Bathgate 1969:276). Tuhawaiki, who killed Te Puoho at Tuturau, signed the treaty of Waitangi at his usual residence on Ruapuke, but was frequently seen at Otakou, and was seen by Shortland (1844) in January 1844, with 15 of his people gathering large quantities of flax at Moeraki to pay for a European boat. Though purchase of European boats had greatly increased Tuhawaiki's mobility, the important point is an economic one. He had rights to exploit resources far to the north and to the south of the Catlins coast, and was prepared to defend a site inland of the Catlins.

When Tuckett visited the Tautuku whaling station in 1840, he became concerned about two recently orphaned, half-caste children. He was told that they had land rights from their Maori mother at Otakou and that these were admitted
by the natives (Tuckett 1844:46). This suggests that the Maori people at the Tautuku whaling station were not residents of the Catlins coastline but had been drawn from a considerable distance by the presence of a whaling station. Barnicoat's (1844) description of the natives at Tautuku suggests that they were mostly Maori wives of the whalers or else impoverished people wholly dependent on the whalers.

It can be postulated that the rights of exploitation of the Maoris at Otakou, Molyneux and Ruapuke indicate the extent of annual territories in Murihiku during the Contact period. Thus there is no evidence in the distribution of the material culture nor in the articulation of 19th century Maori economy with local environments that the Catlins sub-region might have contained several small annual territories during the prehistoric period. This settlement pattern requires archaeological verification for the prehistoric period but in considering the interactions between prehistoric man and his environment in the Catlins it will be assumed that annual territories need not be confined to this subregion.
Chapter 1:2

**Archaeological Frameworks: Past and Present**

Among the related themes which have been important in the history of New Zealand archaeology have been the establishment of a national chronology, the origins of New Zealand Polynesian culture, the nature of developmental sequences and the relationship between the two entities designated as Moa-hunter and Classic Maori cultures. Catlins archaeology played an important role in initiating interest in the last of these themes. Duff (1956) saw the late survival of Moa-hunter culture in Murihiku as adequately explained "in terms of the usual hypothesis that culture changes more rapidly in the heart or central area which is in this case the major land mass of the North Island" (Duff 1956:7). The "usual" hypothesis was that of Age and Area, initially devised by the botanist J.C. Willis (1922) to explain the distribution of plant species in Ceylon. As a model of cultural prehistory it provided for regional variation but confined explanation to the historical trajectory of each culture. It fitted well with the diffusionist theories of anthropologists and achieved considerable popularity as a predictive, if not explanatory, model in the studies of trait dispersion in North America (Wissler 1923). Unfortunately typical 'Moa-hunter' assemblages survived also on Motutapu near Auckland into the mid-17th century (Golson 1959), and in any case the Age-area theory begged the question of why early assemblages should have had a longer history of use
in some places than in others.

Artefacts excavated by Teviotdale and Lockerbie were used by Golson (1959) in his efforts to reformulate Lockerbie's Moa-hunter culture into the Archaic phase of New Zealand Eastern Polynesian Culture and eventually to establish a nationally valid sequence. His concept of the Archaic has come into general use, but for the South Island it has remained essentially a term applicable to particular types of artefacts. Though Golson was well aware of the need to incorporate regional diversity into a national chronology the tools and models required to separate environmentally modulated variation from the more culturally controlled characteristics of assemblages were not available to him. Golson's 1959 paper can be viewed as an exercise in classification which presumes that although there are several possibilities there is one 'best' classification, akin to the natural phyletic classifications of the biologist.

Green (1963) recognized the importance of articulating a developmental sequence with a limited set of related environments and confined his synthesis to the geographical province of Iwitini in the northern part of the North Island. Though Green (1963) and Groube (1967, 1968, 1969) made useful forays into theoretical fields by defining the concept of phase for New Zealand, their efforts have added little to our understanding of Murihiku prehistory. If phases are defined as periods of relatively little change enclosed by short periods of rapid or strophic change, such a model is not suited to the slow steady changes in artefact proportions and economic activities seen in the Catlins sequence.
The concept of phase was considered appropriate to the North Island archaeology of the 1960s when most sites fell clearly into either an Archaic or a Classic Maori culture. It was postulated that "some of the changes crucial to our understanding of the Classic Maori took place very rapidly" (Groube 1969) and possibly only in a limited region. This model had some surprisingly old-fashioned diffusionist nuances and, until stratigraphic change can be demonstrated, may be misleading even in the North Island context. In his 1974 synthesis of economic adaptation and change, Green organised New Zealand prehistory into Archaic and Classic Maori phases in a very flexible way. He saw many of the differences between regions as having "historical rather than ecological processes as a major part of their explanation" (Green 1974:30), though he also documented some of the economic adaptations that show that both Maori and Archaic economies "exhibited an environmentally predictable regional diversity" (Green 1974:33).

With the development of interest in subsistence factors and economic prehistory (Clark 1954, Steward 1955), the proper integration of environmental factors into New Zealand prehistory began to receive attention. In the 1950s most of the archaeologists' ideas about the New Zealand palaeoenvironment had to be drawn from the work of soil scientists, botanists, palynologists and other non-archaeological workers (Taylor 1958, Holloway 1954, Harris 1959). This was an unsatisfactory situation, since archaeologists must view the natural environment rather as if it were a warehouse of resources to be manipulated by human communities,
an approach which is usually of little interest to the biologists. During the 1960s several archaeologists became involved in this general field. The themes that emerged included seasonality (H. Leach 1969, Coutts and Higham 1971, B.F. Leach 1976), the assessment of particular foods such as fern root (K. Shawcross 1967), dog (Allo 1970), kumara (K. Shawcross 1967, Yen 1975, H.M. Leach 1976) and snapper (W. Shawcross 1967), techniques of midden analysis (Davidson 1964a, 1964b; Coutts 1971), integrated analyses of changes in natural and midden populations (Terrell 1967, W. Shawcross 1967, Swadling 1972, Anderson 1973) and the location of sites in respect to natural resources (Green 1964, Hamel 1969, Cassels 1972). With these empirical themes, new conceptual approaches have been developed in New Zealand, drawn from theoreticians such as D. Clarke, Geertz and Taylor. Geertz's (1963) ecosystems approach, Clarke's use of systems theory (Clarke 1968) and the development of site catchment analysis by British archaeologists (Higgs 1975) have all stimulated the examination of palaeoenvironments within the context of regional studies.

Before considering the value of these new approaches to a re-examination of Catlins prehistory, it is worth assessing the results of work undertaken in the Wairarapa. In 1969 B.F. and H.M. Leach initiated the Wairarapa project in which a group of archaeologists excavated several different types of sites along the Palliser Bay coastline and integrated their results with environmental studies carried out by or with the help of archivists, geologists, biologists and climatologists. The models and strategies used owe much to
the conjunctive approach of Taylor (1948) which H.M. Leach interprets as involving "a description of prehistoric behaviour through time ... from as wide a variety of viewpoints as possible" (H.M. Leach 1976:8).

The Wairarapa chronology established by B.F. Leach (1976) was firmly directed towards establishing the history of the prehistoric communities of Palliser Bay against a background of changing climate and environment. Patterns of behaviour related to trading in stone materials, fishing in offshore and onshore waters (B.F. Leach 1976), establishment of gardens (H.M. Leach 1976), activities in and around houses (Prickett 1974) and strategies of shellfish collection (Anderson 1973) were each studied as a behavioural entity in its own right. B.F. Leach (1976) was also able by integrating cultural, faunal, climatic and geological data to establish a hypothesis that prehistoric man on the Palliser Bay coast transformed the local environment through the initiation of a cycle of deforestation and erosion to a point where it could no longer supply his needs (Leach 1976:319). In proposing that environmental degradation brought about the abandonment of the Palliser Bay coastline, Leach demonstrated unequivocally the importance of the ecological context to understanding culture history.

The application of similar approaches to the life of prehistoric communities in the Catlins presented numerous interesting possibilities. Initial efforts were directed towards reconstruction of aspects of the Catlins palaeo-environments which would have been relevant to the prehistoric communities. Relevance was established by closer analysis of faunal remains in middens than had previously been
attempted for the Catlins. Knowing which animal species were important, the productivity, spatial and seasonal availability of some of these were examined and aspects of moa ecology reconsidered. Since the available ethnographic material suggested that the annual territories of people exploiting the Catlins may have included nearby subregions of Murihiku, some comparative material on the resources of the Waimea and Mataura Plains was included. It was from an inductive study of the past distribution of forest and grassland and associated food resources in these adjacent areas that a hypothesis on the abandonment of the Catlins coast was initially developed.

In this thesis emphasis is given to the value of vegetation analysis. Reconstruction of prehistoric forests on the landscape may help explain the distribution of sites, as well as provide evidence for the presence of associated resources. This type of work is now standard procedure in archaeo-environmental studies and there is a need to determine the possibilities and limitations of the methods used for reconstructing past vegetation, and in particular of inferences made from present day distributions.

Even though setting Catlins prehistory in an environmental framework provides the most interesting insights, it has still been necessary to re-evaluate the chronology. Tevictdale's and Lockerbie's work on Papatowai Point from 1938 to 1956 produced in effect 13 different prehistories from 13 different excavations, and these have been integrated into a coherent sequence as possible. This could be done
only through the data recorded from each excavation, no matter how tempting it might be to speculate on the nature of unexcavated areas or on the placing of unprovenanced material. The lack of records on the provenancing of moa species to layers seemed so awkward however, that excavations on Papatowai Point were carried out to provide such evidence. Though very limited in scope, this excavation provided valuable data on exploitation strategies, a major concept used here in considering prehistoric behaviour.

In any consideration of prehistoric economies, an examination of the relationship of sites to resources is crucial. When looking at settlement pattern in the Catlins, a second factor had to be taken into account, that of changes in climate. Various indicators of palaeoclimates are available and these required integration with Catlins chronologies and settlement patterns to elucidate the effects of ecological factors on cultural processes. Though data for the Catlins are scant, the available material is brought together to support hypotheses about the abandonment of the Catlins coastline around 1700 A.D. Continuity of material culture suggests that major social disruptions through warfare and conquest were not critical factors. The heart of the problem lies in the changes in ecological relationships which made exploitation of the Catlins coast an uneconomic proposition.
SECTION 2

THE ENVIRONMENTAL BACKGROUND

Chapter 2:1

The Physical Environment

The Catlins hills and coastline form an equilateral triangle, lying between longitudes 169°15' and 169°50'E and latitudes 46°15' and 46°40'. The coastline, lying roughly north-east south-west (Fig.1:1), consists of headlands and peninsulas protecting estuaries and long sandy beaches from the full effects of the strong southerly and south-westerly winds which sweep this region.

Several long valleys run inland almost at right angles to the coast. The drainage pattern is closely related to the underlying geological structure of the folded beds of the south-east end of the Southland Syncline. The axial trace of the Syncline "separates two distinct physiographic regions. On the steeply dipping north limb (north of Owaka) the coarser beds form prominent strike ridges and the finer grained beds linear valleys and depressions" (Speden 1961, Sheet 5164). Faults at right angles to the synclinal axis have initiated a trellis pattern of tributaries and passes.

On the gently folded south limb the physiography consists of north-west striking homoclines separated by anticlinal and synclinal ridges and valleys which are transected by north-east striking wind and water gaps eroded along faults and joints ... only a poorly defined trellis pattern has developed. (ibid, Sheet 5164)
Though the ridges rise to only 300 metres close to the coast and to 600 metres inland, steep slopes have developed on the escarpment faces, and many valleys on the south limb of the Syncline have steep northern slopes and gentler southern slopes. Streams tend to have swampy headwaters on the dip slopes which form the tableland crests of the ridges, falling in rapids and waterfalls over the escarpments to the major valley floors. The swampy tablelands of the south limb contrast with the sharper ridges and conical hills developed on the more trellised drainage pattern of the northern limb of the Syncline.

The coastline cuts across the axial line of the Syncline and the headlands are formed by the more resistant beds. The long sandy beaches have been cut on the thicker of the siltstone-mudstone formations and are 'backed by extensive dune- and swamp-covered benches cut during the post-Glacial rise in sea-level' (ibid, Sheet S184). The major beaches of Waipati, Tautuku, Tahakopa and Seurat Bay are cut off from each other by the steep-sided ridges running back from the headlands. The three southern beaches are within easy reach of each other by sea but Seurat and Cannibal Bays are divided from the southern beaches by the major headland of Long Point and the strongly cliffed coastline from Pillans Head to Hayward Point. This cliffed section is however broken by several sheltered coves with short sandy beaches.

The lithology of the region is almost wholly controlled by the sediments of the Southland Syncline. Thick beds ranging in texture from mudstones and siltstones to very coarse
conglomerates laid down mostly within the Jurassic are followed by a strong discontinuity. Small pockets of Pleistocene gravels are found in some of the valleys. Petrographic evidence suggests that the Jurassic sediments were laid down in deltaic-shallow marine environments close to the shoreline of an ancient land mass extending in a curve from the west to the south of the Catlins region. This land mass seems to have had a surface which was blanketed by extensive, little or unconsolidated andesitic tuffs, through which projected areas of a diversity of basement rocks. These consisted mostly of past or contemporaneous lava flows, granitic and metamorphic rocks, and possibly areas of incipiently metamorphosed, previously deposited sedimentary rocks and gravels. The sequence was intruded by dikes of microgranitic and more basic compositions, as well as by active volcanoes, resulting in contact metamorphic aureoles of hornfelsic rocks... The unstable composition of the many constituents points to rapid erosion, and the angularity of the clastic material suggests short rapid transport and quick burial. (Speden 1961:44)

Within the finer sediments are some coarse conglomerates such as the McPhee Cove conglomerate with massive angular blocks suggesting rapid transport to the bottom of a cliff (Speden 1961:63). Among the pebbles in the conglomerate are granites, incipiently metamorphosed greywackes and argillaceous breccias, keratophyres, granophyres, hornfels and silicified sandstones (ibid:67). The variety of material available to prehistoric man is so great that it would be difficult to demonstrate that a particular type of basalt or argillite was not present. No volcanic flows or directly intruded materials such as obsidian however, are likely to occur.

The soils developed on these rocks under the cool, high
rainfall climate of the Catlins are typically lowland yellow-brown earths with well-developed podzols wherever drainage is impeded. The relevance of soil pattern to this regional study is limited since there is no evidence for agriculture in the area until the advent of the Irish potato in the Contact period. Soil of course affects vegetation pattern and this is discussed in the relevant sections on vegetation (Chapter 3:2).

Climate

Garnier (1946) described the South Island as a 'climatic jigsaw', where all the major types of Thornthwaite's climate classification are represented and where there can be a remarkable degree of climatic change over a short distance even in the lowlands. Garnier, in classifying New Zealand climates after Thornthwaite, placed the Catlins in the east coast Otago humid region where rainfall exceeds 30 in (750 mm). "The highland however stand out prominently as superhumid localities within the uniformity of the surrounding humid climatic province" (Garnier 1958:95). Garnier characterizes the climatic province of "Southern New Zealand" (east coast Otago and lowland Southland) as one in which westerly influences are dominant,

being expressed particularly in plentiful and reliable rainfall, and relatively small mean annual ranges of temperature... Antarctic influences are particularly noted in the area from time to time (and the area is) a generally homogeneous climatic unit. (ibid:51)

Garnier (1950), using Thornthwaite's criteria in different way, did delineate the area around Balclutha as falling in a different category (CC'r, Subhumid) from the Catlins (BC'r, Humid). Both areas are similar in their temperature
regimes and distribution of rainfall throughout the year, but Balclutha with 700mm of rainfall per annum is markedly drier than the Catlins (Tahakopa, 1500 mm).

Rainfall gradients within "Southern New Zealand" sharply differentiate the Catlins hills from the regions to the north and west (Table 2:1). Robertson (1959) emphasises the northern boundary in particular, using the criterion of 35-50 in (890 - 1270 mm) rainfall of the Catlins and Southland Coast to separate it from the area of 25 - 35 in (635 - 890 mm) rainfall to the north. Variability in rainfall from year to year is notably low for "Southern New Zealand", the mean variability for the district being less than 12% and for the Catlins as low as 8%, the lowest value for all New Zealand (Garnier 1958:87). Rainfall is evenly spread throughout the year with a modest peak in summer, for the Catlins in either October, November or December and often another peak in March or April (Fig. 2:2). The number of rain days is high, particularly compared to other parts of New Zealand with similar or higher rainfall. For Papatowai in 1970 and 1971, when rainfall tended to be low compared to the normal for Southern New Zealand (about -11% and -25% departure for 1970 and 1971 respectively), there were 214 and 148 rain days. Mean annual total of raindays for Owaka is 160 (ibid:83).

Heavy falls of more than 25 mm in 24 hours occur no more than once or twice a year on the Southland Plains but daily records for Tawanui (private station, Mills Bros.) show three to seven falls of over 25 mm for the years 1966 to 1970, the heaviest falls accompanying the 'Wahine' storm of 10-12 April,
1968 when 2.35, 3.87 and 2.37 in (60, 98, 60 mm) fell on consecutive days. Light flooding may occur in the Catlins from steady easterly drizzle or from southerly storms but even under high intensity rainfalls flooding is buffered by the short straight river systems and heavily forested hills.

Sunshine values are among the lowest for New Zealand, totals being mostly below 1750 hours and decreasing regularly from north to south. However long periods without sunshine are rare and intermittent sunshine and windy conditions quickly dry surfaces.

There are occasional brief snowfalls down to the valley floors during winter but these lie for only a day or two. The heaviest fall in the study period deposited nine centimetres at Papatowai on 24 Sept 1970 (F. Bennett: pers. comm.). Snow may lie on the tops of the ranges for several weeks.

Temperatures for Southern New Zealand tend to be "lower at all seasons than in other lowland areas of the country... no station... records a monthly average temperature above 60°F (15.5°C)" (Garnier 1958:90). Winter temperatures however are not particularly low and tend to be higher on the coast than inland, (Invercargill 49.9°F (4.9°C) and Gore 39.4°F (4.1°C), mean values for July.) Sunshine values for winter can be relatively high and weather calmer and more stable than in summer.

Research climate stations

To supplement the data from the New Zealand Meteorological Service publications, six small climate stations were installed and visited at two to three week intervals for two
years (August 1970 to August 1972). At each station three instruments were installed.

1. A standard metal rain gauge (galvanized iron with brass rim) with the aperture 30 cm above the ground.

2. A maximum-minimum zeal thermometer, set on a stake 0.9 m above the ground and shaded by sheet aluminium 'blinders'.

3. An evaporimeter (atmometer) of local design (Baylis 1957), using a Brownloe water filter candle as a porous pot, set on top of a bottle of 20% ethanol. A tube from the liquid up to the porous pot contained a mercury valve to prevent rain water absorbed by the filter candle passing in the opposite direction. Ethanol was added to the water to prevent freezing. The reservoir bottle (about 2 litres) was buried in the ground so that the evaporating surface was carried 8-20 cm above the ground. Jessep (1964) calculated the conversion values required to express porous pot evaporimeter values in terms of evaporation from a standard, open, raised pan evaporimeter, but Mark notes that these estimations may still be considerably in error as longer trials have shown greater seasonal variation than Jessep's six-month run at Lincoln, Canterbury (Mark 1965).

The climate stations were positioned in such a way as to provide data on variability of rainfall and temperature between the coast and inland, between hill slopes and valley floors and between slopes of different exposure (Table 2:2) over an area of about 40 square miles. The parameters of rainfall and temperature would give a rough indication of the nature of the 'human climate', and it was hoped would also
provide explanatory material on anomalous distributions of vegetation.

Four stations were placed on valley floors but only one was on a river flood plain, the others being on low river terraces. Two stations were on hill slopes, the one at Caberfeidh being immediately upslope from the valley floor station at Kahuika, and the one at Florence Hill in the headwaters of a small stream draining directly down to the coastal archaeological site at King's Rock (Fig. 2:1). A major consideration in the exact placement of each station was avoidance of human vandalism (which was in fact minimal) and disturbance by stock which was the major cause of disruption of the evaporimeter records. When each station was visited the data recorded were:—time; present, minimum and maximum temperatures and the rainfall. The amount of liquid lost from the evaporimeter was noted and replaced, and the grass was clipped as needed.

Material from the climate stations will be discussed at various points in this thesis and only a general summary of intra-regional variation and one factor concerned with climatic change will be discussed here. Material from a seventh climate station at Tawanui (run by R. Mills, 1966-1971) will be included. Different instruments were used at this station, a plastic rain gauge and a different type of maximum-minimum thermometer, these being read daily at about 0700 hours. Comparison of data from Tahakopa and Kahuika with the Tawanui data shows that the Tawanui data can be validly compared with the six research stations for the type of analyses required here. Rainfall and temperature peaks coincide and as might be
expected minimum temperatures are consistently slightly higher on the Tawanui hillside 15 metres above the river, than at Kahuika only 2 metres above the river (Figs. 2:3 and 2:4).

At the end of the research period in August 1972, all the instruments were assembled at the Tahakopa site and run together for calibration: the thermometers for 27 hours (eleven readings taken) and the rain gauges and evaporimeters for up to nine months (up to 20 readings taken). For details of calibration see Appendix 2:1. During most of this nine month period a supplementary set of temperature observations was carried out in Stott's Clearing at Tahakopa to investigate the incidence of summer frosts on the river flood plains. Three maximum-minimum thermometers were installed along the length of the clearing over a distance of 1.5 miles and read every two to three weeks. These were to confirm that the summer frosts noted on the Tautuku flood plain site were a phenomenon common to the neighbouring valleys. A constant recording thermograph was also set up with a revolving drum which gave a week's record of temperature per revolution but this was relatively crude in its calibration and of only limited use.

Intra-regional variation in rainfall

There was a strong contrast in weather between the two years of recording. The summer of 1970-71 was unusually hot and dry and the winter of 1972 was unusually wet. In 1971 rainfalls were about 25% below normal at several stations around the Catlins whereas in 1972 rainfall was about 30-50% above normal according to New Zealand Meteorological Service
It should therefore be remembered that the research year of 1970-71 is an example of the pattern of rainfall in a drier-than-normal year and that 1971-72 shows a wetter-than-normal pattern. In 1970-71 the two driest stations were Papatowai and Florence Hill which are more sheltered from the south than the other stations (Fig. 2:7 and Table 4:7). The wettest were Caberfeidh and Tautuku which were more exposed to the south than the other stations (Fig. 2:6). In the very wet year of 1971-72 the driest stations were Florence Hill and Caberfeidh (Fig. 2:5) which share two characteristics, higher altitude and more shelter from the west than most of the other stations. Presumably the westerly shelter was the crucial factor. The wettest station was Tahakopa (220 mm more than any other station) with Tautuku and Kahuika close together as second wettest. Tahakopa from exposure and topographical position is the station most likely to receive rain from the westerly quarter, Tautuku and Kahuika being the next most exposed to the west (Fig. 2:7). The long straight valley of the Tahakopa with a low pass west into the Mokorotua tends to funnel westerly winds and is more open to westerly storms than the other valleys.

It would appear that in wet years there is an intensification of the westerly component in rain-bearing winds, which brings wetter conditions to sites exposed to the west such as Tahakopa, whereas stations exposed to the south are relatively sheltered. If the period of minimum temperatures from 1600 - 1800 A.D., the Little Ice Age (Bray 1971, Wardle 1973), was also a period of increased storminess from the westerly quarter for the Catlins, occupation sites which had previously
been comfortably sheltered from southerly and easterly rain may have become less comfortable with increased rain from the west. In a later chapter on settlement pattern, it will be shown that there is some evidence for a movement from sites sheltered from southerly winds to sites sheltered from westerly winds and open to the south.

It would be useful to know what factors of climatic change could increase the frequency of westerly storms in this latitude. Lamb (1967) discusses several parameters which suggest parallel northward and southward displacement of the main features of the northern and southern hemisphere circulation patterns in recent centuries. The local effects of such displacements are complex, and, though there is general agreement that the New Zealand climate was overall colder during the Little Ice Age, there is less agreement as to whether or not all or some parts of New Zealand were wetter and stormier. Lamb (1967: 434) can show that Santiago, Chile at 33°S was drier in the eighteenth century while at the same time Byrd Station at 80°S received an increased snowfall, both effects being attributed to the southward displacement of the South Pacific storm tracks. The effect of this displacement on the rainfall or the frequency of storms in the Catlins latitude of about 46°S is not obvious. Lamb also documents an increase in the vigour of general atmospheric circulation between 1840 and 1940 A.D., associated with a general rise in annual mean surface temperature and with changes in several other weather parameters such as fewer outbreaks of cold Antarctic air into temperate latitudes and increased snow accumulation at the South Pole.
An outbreak of cold Antarctic air seems to typically occur when there is an anticyclone stationary over south east Australia and a depression near the Chatham Islands with a strong disturbed south westerly airstream in between. (See de Lisle and Browne 1960:19, third illustration). This was the weather pattern which accompanied the disastrous Inch-clutha floods of June 1972, and then brought widespread snow-falls to Southland and Otago for about 14 days. This was the coldest June over New Zealand for many years and several thousand head of stock were lost by Otago farmers. Rainfall values were more than double from east of Invercargill to south west of Dunedin (114% above normal for Tiwai Point) (New Zealand Meteorological Service 1972). Rainfall at Tahakopa was unusually high, 310 mm between 1st and 20th June compared with 200 mm for the whole of June of the previous year. Tahakopa being the most exposed to the west of all the climate stations received markedly more rain in June 1972 than the others.

Stringer (1972:222) states (without documentation) that during the Little Ice Age southern hemisphere westerlies were weaker and further south than today and implies (ibid:261) that a weak zonal flow of westerlies in general allows more frequent outbreaks of cold Antarctic air into middle latitudes.

Meteorologists can suggest a circulation model for increased south-westerly storms during the Little Ice Age. The data from the Catlins climate stations give some indications of local weather patterns associated with such storms, and it should now be possible to carry the argument a step further to see if site distribution and chronology in the Catlins shows
any signs of having been influenced by a change in the frequency of westerly storms. This material will be discussed in the section on site distribution in the Catlins (Chap. 4:4).

Intra-regional variation in temperature

The observations of maximum and minimum temperatures, read at two to three weekly intervals, cannot be summarized in any standardized way. The Meteorological Service publishes mean maximum and minimum values derived from daily readings for each month and gives the mean of these two values as the mean temperature for the month. This will vary considerably from the mean of the extreme maximum and minimum of each month but the latter statistic is the only one available from the research stations for estimating the monthly mean. From limited comparison with published figures for Finegand, Balclutha, the research station means may be up to 2°C higher than means derived from daily readings. Mean values for each observation at the research stations are given in Table 2:4, and the annual means, annual extreme maxima and minima for each station in Table 2:5.

The coldest months of the year were July and August when mean temperatures fell to about 4°C on all except sheltered hill slopes. The warmest period was from mid-December to mid-February when mean temperatures rose to about 17°C (Table 2:4). Judging by mean annual temperatures from each station for the two research years, the very wet year of 1971-72 was markedly colder than the drier year of 1970-71 (Fig. 2:8).

From 1970 to 1972 there was a generally frost-free season from mid-October to the end of April (Fig. 2:9a), but
Frosts could occur at any time of the year on the river flats (Fig. 2:9b). Stations on the flats showed that screen frosts of \(-3.0^\circ C\) could occur in December and that temperatures regularly fell to at least \(0.0^\circ C\) every two to three weeks between October and April. There may be even more widespread frosts in some years, such as the one which occurred on 7 December, 1972, which frosted plants in gardens, pastures, along the forest edge and canopy up to 150 m above sea level. Seedlings of trees, shrubs and herbs in the open were killed. Summer frosts can have a very marked effect on plant growth as November is the main period of shoot extension in trees and the soft unripened growth is easily killed. Screen frosts on the valley floors during winter were usually about \(-4^\circ C\) to \(-6^\circ C\), but rarely more than \(-3^\circ C\) at the hill stations of Florence Hill (150 m) and Caberfeidh (90 m). The effect of summer frosts on the vegetation pattern will be discussed in Chap.2:2 (p.42).

Within the region, the lowest temperatures were recorded on the river flood plain at Tautuku. The stations on the river terraces at Kahuika, Papatowai and Tahakopa were intermediate in frost level between the flood plains and hill slopes. Maximum temperatures were highest in the sheltered valley floor sites of Kahuika, Tautuku and Tahakopa. Papatowai tends to be cooled by sea breezes which may funnel along the hillside and up the Tahakopa Valley during the hottest part of the day. These easterly sea breezes during daylight hours in spring and summer are a common phenomenon along the east coast of Otago (de Lisle and Brown 1968:13). There was otherwise no obvious gradation in temperature between sites close
or distant from the coast. In terms of mean temperatures the hill sites were warmest, the river valley sites intermediate and the coastal terrace site opposite to the Papatowai moa-hunter site coolest.

The temperature regime on the Papatowai archaeological site (500 m. across the river from the Papatowai climate station) is difficult to assess at the present day as it is covered with forest which dampens temperature fluctuations. Recordings taken over five days at the site, 9-13 April 1971, showed that the temperature could vary daily between 16°C and 4.4°C. By comparison with the Papatowai climate station maximum temperatures were similar (18° and 18.5°C respectively) but minimum temperatures in the forest were not so low (4.4° and -2.0°C).

In terms of human living comfort the river flats could be very cold and frosty at night even in summer, but warm and sheltered by day. On frosty nights the hill slopes were warmest but exposed to the wind. The river terraces in between the hill slope and the river flats or the coastal terraces back from the beach probably provided the greatest all round comfort on still frosty nights or in wet windy weather.

Evapotranspiration

Temperature and rainfall records give only a partial measure of the moisture conditions experienced by vegetation. Moisture conditions of the air also affect human tolerance of temperature changes and the storage of dried foods. During an observation period, rain may have fallen in short heavy showers with high temperatures and strong winds for the rest
of the period. The effect will be very different if the same amount of rain falls as light showers spread over several days, with light winds and only short periods of high temperatures. Evaporation from the porous pot surface of an evaporimeter gives a much better measure of overall moisture conditions of the air during the observation period. At mountain sites in Otago, Mark found that rates of evaporation were positively correlated with air and soil maxima but not with volume of precipitation, soil moisture or air and soil minima (Mark 1965); but shelter from wind seemed to "outweigh the importance of both temperature and fog in determining how evaporation changes with altitude" (Mark 1965: 63). The data obtained from the Catlins (Fig. 2: 11) shows a pattern of negative correlation of annual rainfall with annual evaporation for the six stations for both years. This high correlation of rainfall and evaporation \( r = -0.92 \), significant at the 0.001 level) in the sheltered Catlins valleys contrasts with the assumed correlation of wind and evaporation of mountain sites (Mark 1965).

The six research stations did not show any consistent relationship in annual evaporation between the two research years (Fig. 2: 10). Tahakopa with the lowest evaporation total, highest rainfall and intermediate mean temperature for 1971-72 had intermediate values for all three parameters in 1970-71. Papatowai did show relatively high values of evaporation (Fig. 2: 10) in combination with low temperatures and intermediate rainfall relative to the other sites (Figs. 2: 7 and 2: 8), which reinforces the supposition that the Tahakopa
River mouth is significantly affected by cool on-shore breezes. Otherwise there did not seem to be any correlation with southerly and westerly exposure in the two years. Caberfeidh and Tautuku had low evaporation totals for 1970-71 when they were the wettest stations and presumed to be most affected by southerly winds. In the following year Caberfeidh had a relatively high evaporation total and a low rainfall suggesting that rainfall, possibly in terms of length of rainfall events, affects evaporation at inland sites more than wind.

Where moisture is a limiting factor as at the inland edge of the Catlins forests, evaporimeter records may be particularly valuable in demonstrating gradients of potential evapotranspiration deficits, a matter of interest to the archaeologist when considering the effects of prehistoric fires. It was not expected that there would be any tendency to a soil moisture deficit within the main Catlins forest area, where the research stations were sited, and the water-storage capacity of the soil which is usually considered concomitantly with evapotranspiration rates was not investigated.

A comparison of accumulative values for evapotranspiration and rainfall at Tahakopa and Caberfeidh (Fig. 2:12) shows that there would seem to be a moisture surplus throughout the year, even during unusually dry months such as January, February and March of 1971. Evapotranspiration in the warm dry year of 1970-71 was greater at all stations than during the wet cool year of 1971-72 (Fig. 2:10). By comparison with published values from other New Zealand stations evaporation rates in the Catlins are markedly low e.g. Lincoln 1970,
1316 ml.; Taieri 1970, 963 ml.; Invercargill 1970, 902 ml.; mean for Catlins stations 1970-71, 691 ml. This is consistent with the evenly spread rainfall, moderate temperatures and shelter from strong winds of the Catlins valleys.
The strategies and daily life of prehistoric man were closely influenced by the type of vegetation within his reach, and by the pattern of that vegetation on the landscape. In the siting of living places, access to food, water, thatch, firewood and timber were obviously important, as well as the microclimate and defense characteristics of the local topography. The presence or absence of forest, the pattern of shrubland and grassland on the landscape and the actual species composition of the vegetation are worth investigation in developing explanations of settlement patterns.

No direct evidence has been obtained by excavation as to which plant species were exploited by the Catlins peoples. Plant utilization by North Island Maoris in the early nineteenth century was documented by Colenso (1868, 1880), and the edible plant resources of Canterbury and northern coastal Otago are discussed by H.M. Leach (1969). A general survey of the use of plant materials is given in Hamel (1974).

From this material it is argued that the important plant resources of the Catlins were:

- Podocarp timbers, especially totara for boat building,
- Forest foods - fruits, tree fern pith, young green leaves,
- Forest lianes, e.g. supplejack, and fibrous leaves, e.g. Astelia species, for stiff and supple cordage,
- Light timbers for construction of semi-permanent dwellings,
Cabbage trees and bracken rhizomes from forest clearings and margins for starchy food,
Reed from estuaries for thatch,
Flax from estuaries for cordage, textiles and thatch,
Firewood.

The availability of some of these resources in and around the Catlins forest will be considered in this chapter. Since the nature of land bird populations is affected by the richness and variability of the vegetation, attention will also be given to forest structure in terms of species numbers and distribution.

In 1851 Captain Stokes of HMS Acheron dispatched two men, Hamilton and Spencer, from Bluff to walk through the tussock grasslands and shrublands of the Mataura to Dunedin which they reached in 16 days, the first Europeans to accomplish the journey (Stokes 1852). In the same year Mantell made the reverse journey to buy Southland and the Catlins block of Otago from the Maoris (McClymont 1940). By 1856 runholders were taking up their properties in the grasslands of the Pomahaka, Waima Plain and Mataura Valley (Roberts 1895). In 1856 J.T. Thomson, the surveyor, had completed an extensive survey as far west as the Five Rivers Plain and Turingatura Hills (Fig. 1:1).

In contrast the first systematic exploration of the Catlins was not undertaken until 1885 when Thomas Mackenzie walked through the "Tautuku Bush" from northeast to southwest to find a suitable line for a road (Mackenzie 1889). The surveyor Strauchon who followed him produced the first useful map of the rivers and vegetation in the same year (Strauchon 1886), though a map showing the forest edge and the approximate courses of rivers had been issued by the Dunedin Survey Office in 1866. Between 1800 A.D. and these first descriptions of the
Catlins forests, introduced mammals and increased incidence of fires would have affected the vegetation in a variety of ways. These factors will require examination if we are to extrapolate from historic to prehistoric vegetation patterns.

The first European influence on the structure of the forest came from Palmer's whaling station on Tautuku Peninsula between 1839 and about 1845 (Shortland 1851). Introduced weeds and garden 'escapes' from the whalers' settlement probably had little effect on the undisturbed forest but the frequency of forest fires on the coastal margin presumably increased and the whalers seem to have cleared headlands and islets to use as look-out points. They also introduced rabbits to the Tahakopa-Tautuku part of the coastline (Tuckett 1844).

For the next twenty years marginal clearing and burning by runholders increased, particularly on the northern edges of the forest. In 1863 J.W. Thomson in describing an exploratory visit to the Catlins Lake and Owaka River, writes as if Begg of the Glenomaru sawmill was the first European to have explored more than the forest and coastal margins. Begg with two companions walked to the Owaka River, close to the present Owaka township site, some months previous to Thomson's visit (Thomson 1889). In the following year Hector the geologist spent two months examining the coastline between Kaka Point and Waikawa. He blazed "a circuitous track" along the coastline (Otago Witness, 4 Sept 1869), and some of his findings are included in a map of the Catlins River mouth (Fig.2:14). Though Hector does not seem to have published a report on the geology of the Catlins, gold miners began working the beaches south of Tautuku Peninsula. Very few men seem to have been involved, since a constable who walked along the coast in
1869 to investigate a wreck at Tautuku River saw only four
men and there was no formed track through the bush.

The forests which the first surveyors described had
been very little modified by European activities. Some
introduced mammals had appeared, as Strauchon found in 1885.

From Waikawato the west branch of the Chasland
river wild cattle are to be found... They thrive
exceedingly well on the gum and broadleaf. From
the west branch of the Chasland to Taukupu
(Tahakopa) River not a trace of cattle is to be
seen although the food is abundant. Wild pigs
are however to be found in all the valleys and
on lower spurs, but no trace of them on higher
ranges... Saw some traces of 'bunny' at Tautuku,
Chasland and Taukupu. (Strauchon 1886)

These introduced animals were already modifying the
species composition of the forests but probably had had little
effect on the gross structure.

Pigs were likely to have been brought in by the sealers
to Bluff along with the Irish potato between 1800 and 1810
(McNab 1907:138), so as to provide a source of 'vitalling'
for later sealing gangs (Wodzicki 1950). Though pigs were
abundant in many forested areas of New Zealand during the
nineteenth century, heaviest infestations tend to have been
on forest edges or in second growth, shrubland and bracken
country (Wodzicki 1950). Prior to European clearing in the
Catlins, habitats suitable for dense populations would have been
limited to the small natural clearings along valley floors and
the main forest margins. Wodzicki comments that even in 1946
the Catlins' pig population was smaller than expected, consid-
ering the amount of forest and second growth present at that
time (Wodzicki 1950:230). Pigs affect forest by stirring up
the ground for tubers and rhizomes such as those of bracken
Pteridium aquilinum, the orchid Gaertodia cunninghamii and by eating soft vegetation within their reach such as seedlings and the bush grass *Microlaena avenacea*. Their effect on the gross structure of the Catlins forest would be greatest in preventing regeneration in clearings and on forest margins.

Cattle had been in the Catlins forests for about 40 years before Strauchon reported them. Roberts reported that wild cattle in the Mataura originated from stock strayed from the Bluff Maoris about 1844-46 which would be close to the time of their introduction (Roberts 1895). McLennan grazed cattle in the upper basin of the Tahakopa River from 1859 (Jowett 1965), and cattle had been run at the mouth of the Clutha and on the Kaka Point coast since about 1840 (Tuckett 1844), probably working their way south into the forest from there. Obviously penetration was slow since the Tahakopa Valley was still free of cattle in 1885. There is no evidence that cattle would have had any marked effect on the Catlins forest by 1885. Certainly there is no replacement of forests on dry ridges by a sward of the bush grass *Microlaena avenacea* as has been reported for the Coromandel forests which are infested with wild cattle, pigs and goats (Moore and Cranwell 1934).

The other introduced mammal mentioned by Strauchon, the rabbit, does not extend far into dense forest, and in the nineteenth century would have affected mostly the regeneration of coastal dune vegetation. It is possible that rabbits were a factor in increasing the area of moving sand dunes on Tautuku Point, where a historic Maori cemetery and a prehistoric site have been destroyed by wind erosion. Opposums are
unlikely to have been in the Catlins forests in 1835 since they are reported as being liberated in 1890 at Fortrose and 1892 at the Catlins River (Pracy 1962).

The effect of introduced rats on the forests of the nineteenth century is difficult to assess, since the Polynesian rat *Rattus exulans* has been present since at least the eleventh century (Table 4:8 and Fig. 4:13). Brown rats *R. norvegicus* can be presumed to have been introduced at an early date, but Atkinson (1973) considers that ship rats *R. rattus* did not enter the South Island until about 1890. The whalers at Tautuku in 1840, who cultivated wheat, barley and potatoes and kept ducks, fowls and goats (Tuckett 1844), are likely to have been the first introduction point for European rats. Roberts (1895) found rats very numerous in the lower Mataura Valley in 1856, seeing them well away from human habitation and noting that they ate the roots of speargrass *Aciphylla* spp.

Rats affect forest structure mostly by eating tree seeds. At Pureora forest west of Lake Taupo, Beveridge (1964) found that ship rats took seeds of rimu, matai *Podocarpus spicatus* and Kahikatea *Dacrycarpus dacrydioides*, consuming almost the whole seed crop but were less interested in totara seeds. They also ate hinau *Elaeocarpus dentatus* seeds in large numbers and presumably would also take the seeds of pokaka *E. hookerianus* which is the species of this genus present in the Catlins. Brown rats on Mokoia Island, Rotorua, also took tree seeds, fruits and bark. Daniel (1973) in the Orongorongo Valley, Wellington, and Best (1969) working at Banks Peninsula and in Westland confirmed that ship rats took podocarp seeds, especially during winter.
The effects of rats on forest composition is complex. They destroy seed crops but also kill large insects which eat leaves and sap of trees. They compete with birds, who mostly pass seed through the gut without destroying it and are thus more helpful than harmful in seed dispersal. The Polynesian rat is known to eat many of the same seeds and forest fruits as ship rats (Daniel 1973), so that rat damage to forest regeneration may have been present to some degree throughout the prehistoric period, possibly increasing in scale with the introduction of European rats.

The species of trees likely to have been affected in the Catlins are the podocarps, pokaka, mahoe *Melicytus ramiflorus*, supplejack *Ripogonum scandens*, *Solanum* spp., *Pseudopanax* spp. and *Schefflera digitata*. It is unlikely that rats could have affected the extent of the forest but they could have been a factor in changing forest structure and species frequencies.

The Catlins forests which the first Polynesian occupants found were likely to have been more extensive than the early European records show and may have been richer in podocarps and in the other species whose seeds are eaten by rats.

The Pre-European Forests

In this section particular attention will be paid to the origins of clearings on the floors of otherwise heavily forested valleys. It has been suggested by soil scientists and botanists that such clearings in the Catlins could have been caused by prehistoric fires. Palynological evidence, however, suggests that fire was of limited importance.
McGlone (Botany Division, D.S.I.R.) interpreted a six metre pollen core, which he took from the centre of Stott's Bog, as showing a standard pollen sequence, including near the base a fall in herb and miro-matai pollens and a rise in rimu (Fig. 4:19), an event dated to about 5000-6000 B.P. (McGlone: pers. comm. 1976). At the same time large amounts of the insect-pollinated species Rubus, Pennantia and Muehlenbeckia appear. These were almost certainly growing on the bog itself, suggesting that a low, relatively open shrubland with large patches of the wire rush Calorophus (Fig. 4:19) was present throughout the prehistoric period (McGlone: pers. comm. 1974).

The fall in shrubs at 2.4 m (Fig. 4:19) could mark a natural stage in the growth of this type of bog, being the point at which the raised part began to form. Expansion of the bog at the same time would effectively move the insect-pollinated species out of range. The absence of charcoal at this level precludes Polynesian fires and McGlone gives an estimated date of 2500-4000 B.P. for this event (McGlone: pers. comm. 1974). It is more likely that the beginning of Polynesian occupation is marked by the rise in bracken, manuka and grassy species and the appearance of charcoal at the 1.00 m level. The lack of exotic pollens in the upper 0.5 m makes it unlikely that the charcoal at 1.00 m is due to European fires.

Evidence was also collected that valley floor clearings could have been partly temperature-induced. In the section on temperature patterns (Chap. 2:1, p. 30), the occurrence of summer frosts on the river flats was noted and,
this factor combined with poorly drained soils, could create considerable physiological stress for tree seedlings in the course of forest establishment. Wardle (1971b) discusses some of the possible processes involved in the creation of inverted timberlines against valley floors. Not only do the low summer temperatures tend to freeze unripened shoots, there is also a tendency for the upper few centimetres of the soil to remain frozen after air temperatures have risen. The roots are unable to compensate for evapotranspiration from the leaves and death from dessication can occur.

From the pollen core and the temperature data it can be postulated that the first Polynesian occupants of the valley found areas of open bog carrying Sphagnum, wire-rush, umbrella fern Gleichenia circinnata and about 20 other species. These bogs were set in an open shrubland of manuka, bracken, flax Phormium tenax, reeds and lowland red tussock Chionochloa rubra with a forest of kamahi and podocarps on the adjacent terraces. During the prehistoric period, fires either deliberate or accidental, may have increased the area of the clearings and would have helped to maintain such seral species as bracken and manuka.

The description given by the surveyor, Strauchon, of the forest between Waikawa and Tahakopa in 1885 is one of the most detailed early accounts available (Fig. 2:13). On the main ranges Strauchon found large silver beeches, kamahi, rimu, rata and broadleaf, with a few matais and totaras. On the flats and lower spurs, "scrub, ribbonwood, manuka and small straight birch (silver beech) abound." Of the useful timber
trees he considered rimu to be the only abundant species. In the clearings of Long Beach, Deborah and Chaslands Valleys he found "a very luxuriant and dense growth of snowgrass and scrub" (probably mostly manuka) and along the coast considerable areas of *Hebe salicifolia*, *Anium australie* and "gum scrub" (possibly *Pseudowintera colorata*) (Strauchon 1885). Tuckett's only useful comments were on the forests between Tautuku and Tahakopa in which rimu, totara and rata were the prevailing species. He also commented on the signs of recent fires along the course of the Waikawa which was known as a good river for lampreys (Tuckett 1844).

Mackenzie (1889) noted an abundance of supplejack between Tautuku and Tahakopa, an indicator of relatively fertile soil. In the Tahakopa he found two miles of rimu forest immediately above the estuary, "trees standing close with tall trunks running fully 100 ft high before branching" and mixed with matai, silver beech and miro. The next few miles of the valley terraces carried more totara and matai with a mixture of broadleaf, pepper-tree *Pseudowintera colorata* and small-leaved coprosmas, this being a better drained part of the valley. Close to the river were patches of mossy peat bog (*Sphagnum*) and manuka *Leptospermum scoparium* with ribbonwood and kowhai *Sophora microphylla* along the river. About six miles up river he found a clearing (Stott's Clear) which he simply recorded as three miles long, the extent of the present day evidence of relict vegetation marking this clearing. The lower end of the next clearing up-river (the Run Clear) was covered with manuka and fern,
presumably bracken, the rest of the clearing probably being in red tussock.

In 1892 Hocken found, lower down the Tahakopa Valley, the Cemetery Clear, which Mackenzie had missed because of the topography of the terraces at this point. Hocken found the clearing by rowing upstream two miles from the Tahakopa-Maclennan confluence and, having pulled up a small creek, landed on a grassy terrace which still carries relatively dense clumps of snowgrass (Hocken 1892). These clearings have an important relationship to the pattern of Polynesian occupation in the Tahakopa Valley (see p.174 ff). Strauchon's, Tuckett's and Mackenzie's descriptions of forest composition still coincide effectively with descriptions of the present forests.

In the Catlins and Owaka Valley there is a similar pattern of early explorers and surveyors describing vegetation of which traces are still visible. The sawmiller Thomson (1889) in 1863 sailed into the Catlins Lake and found that the Owaka River formed a tunnel through dense forest but the river bank and ridge immediately east of the present township of Owaka was covered with manuka suggesting burning within the previous 100 years. This manuka lies at the south eastern end of a chain of clearings up the Owaka Valley which, after a short canoe trip up the Owaka River, would have given the easiest access from the Pounawea moa-hunter site to the grasslands of the Southland Plains (Fig. 2:13a).
In Capt. J.L. Stokes' map (Stokes 1866), the Catlins Valley is shown as fully forested and there is no evidence for natural clearings on the valley floor until it reaches the inland margin of the forest near Wisp Hill. Present day relict vegetation indicates that here it entered the forest through two small boggy red tussock clearings in the lowest of which there are traces of Polynesian occupation (see Chap. 4:1).

In the Owaka Valley the 1866 map shows a clearing extending as a long finger from the continuous tussock grasslands of the Waipahi and Waiwera, down the Owaka Valley as far as the present Owaka Township. On the early survey maps, there are some bands of forest across the valley floor near the Bonnet (Fig. 2:13a). The flats beside Owaka were in manuka and flax, possibly from a combination of Polynesian fires, cold-air drainage and water-logged soil. The clearings further up were boggy flats in heavy tussock and flax (Keene 1966) running into drier hilly tussock country near Wisp Hill.

Above the Bonnet the terrace and hillside forests were predominantly broadleaf and matai with patches of kowhai on warm faces, but lower down the valley totara and rimu, which tolerate wetter and more leached soils, predominated (Keene 1966). This is an indication of increasing rainfall and decreasing fertility from the inland forest margin out to the coast. Relict vegetation still marks the sites of these clearings and forests. Even the narrow band of forest marked by
Strauchon a mile up river from the Bonnet is visible as a line of *Plagianthus* and kowhai running up a side stream from the river. Wherever the steep hillsides have not been ploughed the previous forest is indicated by dimpling and rough ground. Terrace forests are almost totally obliterated by ploughing and are only indicated by relict matais left standing for shade in a few places. Since matai seedlings can establish only under a closed forest canopy the adult matais mark the site of previous forest.

North of the Owaka Valley, the Catlins forest block is broken into strips of forest on the ranges with long fingers of tussock grassland on the valley floors, easily accessible from the Southland and lower Clutha grasslands. The Ahuriri Flat was the least accessible of these valleys, the best route being through the shrublands of the Omāru gorge, which like Ahuriri Flat carried a mosaic of red tussock, manuka and other shrubland species. There may have been a second access route from Kaka Point through the more densely forested gorge of the Karoro Stream (Fig. 1:1), since indications of occupation have been reported all along the gorge (Lockerbie:pers.comm.) and in the headwaters on Ahuriri Flat (P.Boyce:pers.comm.).

For the purposes of extrapolating from the structure and composition of the modern forests to the forests available for exploitation by pre-European
populations, the effects of introduced animals were considered in the first part of this chapter. Early maps and descriptions prior to logging and clearing demonstrated the extent and gross structure of the forest in the mid-nineteenth century. Descriptions of present day vegetation can only be used if the history and effects of logging, clearing and European fires are also added to the pattern.

In the Catlins, logging of the lowland forests has been primarily for the podocarps rimu, miro, kahikatea and the two totara species. Kamahi, which is widespread and abundant, is commercially useless and is not touched unless the ground is being clear-felled for farming. A terrace or lower hillside forest after heavy logging has an irregular canopy of kamahi, with occasional trees of southern rata and also emergent podocarps which were unsuitable for logging. The scars left by hauling out logs regenerate in Fuchsia, wineberry, mahoe and other second-growth species wherever the ground is reasonably fertile, moderately well-drained and not subject to cold-air drainage. Cold boggy flats or strongly-leached and podzolised terraces with perched water tables, especially those in the heads of valleys, regenerate in manuka.

Where historical records are lacking, regenerated logged forest can be readily distinguished from intact forests by the presence of the durable podocarp stumps, second growth on logging trails, to some extent by species composition in relation to site and by the presence of
long scars on standing podocarps, produced by the felling of adjacent trees. If relevant the annual rings of the scarred trunks can be examined to ascertain the time elapsed since logging. Since forests adjacent to occupation sites have more usually been logged than not, sometimes as much as 100 years previously, the archaeologist must be alert to the effects of logging when considering available forest resources.

In the Catlins the two second-growth communities (mixed hardwoods and manuka) appear after a hot fire in standing forest or an unsuccessful burning of clear-felled forest. Fires in standing forest usually leave some large and durable podocarp trunks upright and the presence of numerous emergent dead trees above even-age stands of second growth hardwoods, generally indicates the firing of standing forest, in either the European or pre-European period. An even canopy of second-growth hardwoods, particularly of Fuchsia and wineberry which are light demanding, indicates European clear-felling followed by an unsuccessful burn. These patches of second growth forest up to 70 years old are prominent on some of the shaded hill slopes in the Catlins where early European attempts at forest clearance have failed, and should not be confused with the effects of Polynesian fires. Catlins forests are not easy to burn since there is no dry season and soil moisture is generally high.

A stand of manuka enclosed by forest is not always good evidence of previous fires or forest clearance. Manuka may
form long-lived communities of slow-growing trees on cold water-logged terraces and flats. Water-logging may be due to topography or to pan-formation in the soil with peat build-up as on the Tahakopa sand-dunes (see chapter 3:2). The surveyors of 1890 found large areas of manuka (Jowett 1965), of which only a few dead stands remain, on the upper terraces of the Tahakopa Valley, particularly on the warm dip slopes facing north. The genesis of these stands has not been examined but the warm site and the high frequency of small poles in the relict stands (killed by 'manuka blight', an Australian scale insect Eriococcus orariensis, in the last 15 years) suggest regeneration after fire rather than an edaphic-climatically induced vegetation. Macleanan was active in this area in 1860 (Jowett 1965) and it cannot be discounted that he was able to start a hot fire on these slopes 30 years before the surveyors entered the valley. The manuka stands give no indication of being more than 100 years old, an average span of life for such stands (Burrell, 1965). Since all the larger poles have been dead for some years estimation of ages from annual rings was not undertaken.

Other anomalous forest clearances are found along the coastline at the mouth of the Catlins River and in the vicinity of the sites of the Tautuku and Waikawa whaling stations. Tuckett (1844) suggested clearance of the headlands by whalers for lookouts. During the eighteenth and early nineteenth century Maoris travelling by canoe between Foveaux Strait and the Otago-Southland settlements for purposes of trade (Leach 1969:57) may have constantly fired useful camping sites along the coast, such as that at Jack's Bay and on Tuhawaiki Island. Hector
(Smith 1864) shows two areas at Jack's Bay labelled 'Native clearing', one of which he says was overgrown with veronica *Hebe salicifolia*? and toetoe *Cortaderia richardii*. Both areas slope gently to the north and are unlikely to be affected by cold air drainage or summer frosts. Tuhawaiki Island was also cleared (Fig. 2:14). Coastal scrub on islets and on the light sandy soil of the shoreline is more vulnerable to fire than the more inland forest and the activity of whalers between 1839 and 1845 may well account for the clearance of islets and parts of headlands. Where the forest was heavier as at Jack's Bay it seems less probable that whalers could have converted about six square miles of rata-podocarp forest to "veronica and toetoe" in four to five years. The historical account, of the Maoris of Molyneux (Thomson 1889) visiting the Owaka-Catlins river mouth for fishing, also suggests that the clearing at Jack's Bay is more likely due to prolonged burning by pre-European people. Only archaeological excavation could confirm this satisfactorily.

The position of the inland forest edge depends strongly on the period under consideration. Where active clearance by farmers is not being carried out, the present edge is relatively stable. This is well shown in the Mokoreta Valley against the slopes of Mouse Back, The Chimney and Catlins Cone and up the Caddon Burn.

The agreement between the bush-line shown on Strauchon's 1886 map and a modern topographical map (N.Z.M.S. 1, Sheet S178, Dept. of Lands and Survey 1965) is very close. The forest edge in this region is bordered by fire-hardy and fire-resistant shrublands of *Cassinia fulvida* and flax. Judging by Strauchon's map this edge is close to the forest line of the Contact period but it is certainly not very ancient. Local farmers (J. Begg,
Wyndham Station:pers.comm.) found numerous logs on the tussock grasslands of the Mokoreta river terraces. Thomson (1858) reported evidence of recently burnt forest from several areas of the Waimea Plains which could have been expected to be in tussock grassland. On the plains immediately north and east of Invercargill "clumps of forest and grassy plains alternate... on many parts of the plain I observed prostrate trees, proving very recent occupation by forest" (Thomson 1858:326-331). At the north end of the Turingatura Downs, 60 miles to the north west of the Catlins "we observed thousands of acres of dead forest apparently destroyed at one burning" (Thomson 1857:336).

It would seem likely that Polynesian populations found large areas of the ranges and downlands from the Mokoreta and the headwaters of the Owaka and Catlina Rivers to the Takitimus and Longwoods in forests similar to those of the Catlins block, and that throughout the whole or part of the prehistoric period the Southland forests steadily decreased in area. There is little information available to assess likely Maori and moa-hunter strategy on forest burning in non-horticultural areas. On the one hand the forests were a source of a preferred food, forest birds such as pigeons, tuis and kakas (Beattie 1954); but the more open country of mixed wetland, tussock and shrub-land left after burning provided suitable habitat for wekas, paradise ducks, native quail, pukako, grey duck, cabbage trees, bracken and sowthistle Sonchus littoralis, all mentioned by Roberts (1895) as readily available on the Mataura Plains in 1856. A mosaic of habitats provides a more varied food supply, and an increase in ecotones (interfaces between major types of
vegetation could increase the volume of food resources as well, since ecotones commonly carry denser populations than the adjacent habitats (Odum 1959:278); but the best proportion of each element of the mosaic would be both difficult to determine and to achieve. Polynesian strategy on firing of the forest may well have varied over time and space and with changing conceptions about the best type of vegetation mosaic. Accidental fires and the possibility of fires started by feuding groups complicate the pattern. Whatever their genesis, the actual frequency of fires in the Catlins and Southland areas must have increased with the arrival of Polynesian man. Was this increased frequency the major factor in the destruction of the Southland forests?

Thomson's prostrate trees, a comment by Roberts (1895) and evidence of windthrown forest on Tiwai Peninsula (Hamel 1969:153) suggest that windthrow of insecurely rooted trees as well as fire, was a factor in forest destruction. Forest growing under suitable edaphic and climatic conditions is not easily destroyed by windthrow or fire to the point of replacement by shrubland/grassland, and the assumption can be made that conditions on the plains were only marginally suitable for forest in the immediate pre-European period, but that conditions in the Catlins were much more suitable. The present day patterns of rainfall, temperature and shelter from gale force winds confirm this assumption. It seems more profitable to inquire into the details of the combinations of factors which caused forest destruction rather than to search for the critical factor, a botanical rather than archaeological exercise.
There was a marked contrast in the vegetation-dependent resources which could be obtained from the Catlins forest block and from the Southland Plains at the time of European contact, but this contrast may have been far less apparent when Polynesian man first arrived in southern New Zealand and found the Southland Plains more widely forested. An improvement in variety and amount of these resources after the destruction of some of the forest could have been a stimulus to greater exploitation of inland resources in the later as compared to the earlier period. A similar type of change, triggered by the pattern of moa extinction, has been suggested previously (Lockerbie 1959:85) but a search for indications of greater exploitation of inland resources may reveal that moa exploitation was only one factor of many in a change from heavy dependence on seal, fish, shellfish and coastal moa populations to a more nomadic yearly pattern of exploitation of both coastal fish/shellfish populations and inland lamprey, eel and bird populations (of wetlands, grasslands and forests) including the remaining inland moa populations. Access to the Southland Plains is much more difficult from the Catlins coast than from Foveaux Strait and the Molyneux Bay coast. This may be a worthwhile hypothesis to test in 'explaining' the decrease in exploitation of the Catlins coast over the prehistoric period to a point where, by the time of European contact, there were no known settlements of Maoris on the Catlins coast. Access to the varied inland habitats and resources could have become a critical factor in settlement pattern, possibly not so much to avoid starvation as to obtain
as easily as possible a varied and preferred diet.

It should be strongly emphasised that the vegetation pattern cannot usually provide evidence to support hypotheses about the behaviour of human populations. The presence of a forest suitable for native pigeons does not imply, let alone demonstrate, pigeon exploitation. The demonstration of if and how a vegetation-dependent resource or benefit was exploited, and how that exploitation changed over time, is best carried out from an archaeological viewpoint.
Chapter 2:3

The Exploitable Avifauna of the Catlins

The present land bird populations of the Catlins have been strongly modified by European changes in habitat and the introduction of new species, but the marine birdlife is still wholly 'native'. Deductions from present to past available sea bird resources must be based on wholly different assumptions compared to land bird populations. It must be assumed that sea bird populations have changed with the modification of fish populations by European fishing and interference with nesting sites, but these changes will be subtle and difficult to deduce from the relatively inadequate and patchy evidence we have for sea birds as compared to land birds. In this chapter a brief summary is given of the present status of the species found in sites from Pounawea to Tautuku, along with other apparently available and exploitable species. Material relevant to exploitation and factors grossly affecting population sizes will be considered, with some general discussion on the relative "richness" of different habitats in the Catlins.

Ratites

The numerous moa bones of the Catlins middens, and kiwi bones at Pounawea and King's Rock (Lockerbie: unpubl.) are no longer represented by live populations in the Catlins. Biological aspects of moa populations will be considered at the end of this chapter. Considering the strong similarities of
habitat between the Catlins and Stewart Island where kiwis are relatively abundant, the present day absence of kiwis must be attributed to hunting by men and dogs, Polynesian and possibly European. The dense wet forests of the Catlins with deep soft soils would appear to be ideal kiwi habitat and the basic soil types of the Catlins are well represented on Stewart Island; there should be strong similarities in soil fauna and particularly worm populations, an important item in kiwi diet.

Penguins

With the arrival of human predators, there seems to have been a change from penguin species which nest in exposed colonies to those which nest cryptically in pairs and small scattered groups, an obviously adaptive change. The present breeding species are the Yellow-eyed penguins *Megadyptes antipodes*, and Blue penguins *Eudyptula minor*, with frequent reports of single birds of Fiordland crested *Eudyptes pachyrhynchos* and Erect-crested penguins *S. sclateri* coming ashore to moult. The midden species however are Blue penguins, Fiordland crested, Erect-crested and Rockhopper penguins. Yellow-eyed penguins have not been reported from Catlins middens (see Tables 4:8 - 4:12). Penguins reach their maximum weight after finishing breeding and before moultting, some time between March and May. Once the moult begins they lose weight very rapidly. The minimum weights shown below in kilograms (extracted from Stonehouse, 1967) will mostly represent weights at the end of moult.
<table>
<thead>
<tr>
<th>Species</th>
<th>Min</th>
<th>Mean</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow-eyed</td>
<td>3.2</td>
<td>5.2</td>
<td>8.7</td>
</tr>
<tr>
<td>Erect-crested</td>
<td>2.5</td>
<td>3.6</td>
<td>5.4</td>
</tr>
<tr>
<td>Fiordland</td>
<td>1.7</td>
<td>3.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Rockhopper</td>
<td>1.9</td>
<td>2.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Southern blue</td>
<td>0.8</td>
<td>1.1</td>
<td>2.1</td>
</tr>
</tbody>
</table>

These species tend to moult singly, concealed under rocks and shrubby vegetation along the coastline. It would be more profitable to visit breeding colonies early in the breeding season when the birds are still in relatively good condition and grouped together.

Considering present breeding distribution (Fig. 2:15) there is a reasonable probability that Fiordland and Erect-crested penguins once nested on the Catlins coast, but mainland breeding of the Rockhopper is more problematical. Yellow-eyed penguins on nests are no more difficult to find than Blue penguins and the absence from the middens of Yellow-eyes, the largest of the local species, is difficult to account for unless the species was absent from East Otago. Local informants remember much larger penguin colonies at Jack's Bay and Wallace Head than there are at present, and were also positive that there were three different sorts of crested penguins of different sizes present in large numbers. Allowing for immatures and Yellow-eyed penguins, this still leaves evidence of a crested penguin species present and perhaps breeding, the most likely one being the Fiordland created. This historical evidence gives some support to the midden evidence.

The relative differences in vulnerability of the different species is quite marked. Erect-crested penguins on the Antipodes and the Bounties form dense breeding colonies on rock ledges and slopes; the closely related Snares created penguin also forms colonies in trampled open spaces in the
Olearia forest of the Snares. The Fiordland crested penguin (which is sometimes placed in one species with the above two crested forms) at present nests cryptically around the Fiordland coast in caves or in deep holes beneath tree roots, but on Big Solander away from mainland predators and human disturbance they nest in the open, suggesting that originally they tended to nest in open colonies on the mainland. Colonies of these species would be relatively easy to exploit.

Blue penguins nest in caves, under rocks and logs and the only vulnerable birds would be those nesting in caves accessible by climbing down the cliffs or which could be safely reached by canoe. Blue penguins are less commonly seen than Yellow-eyed penguins along the Catlins coast but are much more cryptic in their habits. A large number were found on Tuhawaiki Island, March 1961 (B.D. Bell, report 46/248 filed with Conservator of Wildlife, Wellington) scattered among the shrubs on this mostly grassy island. Twenty birds have been seen on one day swimming off the cliffs of False Island and White Head (OSNZ:1970).

Yellow-eyed penguins show strong preferences for nesting under dense vegetation such as flax and tangles of coastal shrubs on steep soft ground or under clumps of tree nettle Urtica ferox. Colonies are widely scattered through the vegetation, so

1 OSNZ: Ornithological Society of New Zealand. A field camp of 27 ornithologists held 24-26 October 1970, leader G. Hamel, assembled lists and numbers of birds seen in representative habitats between Nugget Point and Waipati Beach and inland for about five miles. Since this was a voluntary group, effort was concentrated where birds were likely to be seen in largest numbers, and forest interiors were hardly examined. A summary of these notes is deposited in the Society's Central Recording Scheme.
that individuals are hard to find, and the adult birds are large enough to defend themselves very capably against dogs and humans so long as they are backed up against a rock or dense vegetation. In the Catlins nests were found amongst dense tree ferns Dicksonia squarrosa, under fallen broadleaf logs and among flax and Hebe scrub (OSNZ:1970). Seven small nesting colonies were found in October, 1970 between Sandy Bay and Rainbow Island, and a total of 47 adults counted with evidence of at least 20 more birds being present. At least one large colony, reported to be at Wallace Head was not found, so that there could be more than 100 adults nesting at the present day along a coastline much frequented by dogs, cattle and human beings. Yellow-eyed penguins would be a relatively expensive resource to exploit in terms of searching time, but because of their size more profitable than Blue penguins.

Albatrosses and Petrels

Petrels are not an important component of the Catlins middens. Single specimens of Sooty shearwater and Diving petrel were found at Tautuku. Sooty shearwater and Diomedea spp. are recorded for Pounawea and Papatowai.

The only petrels known to nest on the Catlins coast are Sooty shearwaters or muttonbirds Puffinus griseus, but it is suspected that Fairy prions Pachyptila turtur nest on the offshore islands. The members of the petrel family commonly seen at sea and which can be captured from a fishing boat are Giant petrels Macronectes giganteus, Shy and Buller's
mollymawks *Diomedea cauta* and *D. bulleri*, the occasional albatross *D. exulans* or *D. epomophora* and Cape pigeons *Daption capensis*. These species will take carrion attached by a gorge or hook to the end of a line or can be lassoed and pulled aboard, particularly the mollymawks. Other petrels such as the Storm petrels, Diving petrels and large prions are not easily captured from a boat. From ornithological evidence the nesting grounds of these pelagic birds seem to have been always on offshore islands, protected from predation, and any changes in population will be linked with changes in pelagic marine foods. There is no useful historical evidence of population trends in the pelagic species. It is difficult to use the archaeological evidence of the presence in mainland middens of Broad-billed prions *Pachyptila vittata* and Diving petrels *Pelecanoides urinatrix* to demonstrate mainland breeding colonies, but the possibility cannot be ruled out.

Undoubtedly the most abundant and available petrel species was the Sooty shearwater, which nests in millions on the islands of Foveaux Strait and around Stewart Island. A conservative 'best estimate' of the total population of Sooty shearwaters, according to the Wildlife Service, is about 40 to 50 millions, extrapolated from a rough census for the Snares Islands of five million pairs and on an estimated steady harvest of a quarter of a million chicks from the "mutton-bird islands" each year since at least 1920 (R. Nilsson, pers. comm.).

The fat nestlings, almost ready to fly, are easily extracted from their burrows in April and early May. Adults
can also be readily obtained at night from the burrows from December to February. There are numerous records of small mainland colonies on headlands and offshore islets around the southern coasts of the South Island. For the sake of protection the location of these is not published, but at least one sizeable colony is known on the Catlins offshore islets, and small clusters of burrows occur on several headlands. During the breeding season and particularly in windy weather, skeins of feeding birds may be seen off the coast stretching as far as the eye can see in all directions.

Shags

Though not commonly thought of as edible, shags were an important item of diet at Tiwai Point. Spotted shags, *Stictocarbo punctatus* and Stewart Island shags *Leucocarbo carunculatus chalconotus* making up 14% of the minimum number of individuals of the birds found (Hamel 1969:163). In the Catlins, shags are reported from the Pounawea Midden (Lockier-bie:pers.comm.) but were not found at Papatowai. Spotted shags nest in very large colonies on Nugget Point and the cliffs immediately to the south. A count made from Nugget Point of the morning movement of birds into Molyneux Bay to fish, 20 March 1966, gave a total of about 4000 birds (Field notes, G. Hamel and R. Gray). Spotted shags form smaller colonies on the cliffs between False Island and Waipati Beach, a count on 24-26 October 1970 (USNZ:1970) giving a total of 240 birds, with nesting colonies at Hinahina Cove and Jack's Bay. Many cliffs were not visited and there could be much larger colonies present.
Stewart Island shags are almost wholly absent from the Catlins coast for no reason obvious to local ornithologists. There is a small colony at Nugget Point (6 birds, 3.3.73) but no reports of the species until the Fortrose-Bluff area is reached.

The only other shag species of the Catlins, the Black shag *Phalacrocorax carbo* and the Little shag *P. melanoleucos* are species which tend to frequent inland waters rather than the coastline, and are not known from midden collections. Both species tend to conceal their breeding colonies and never form such large aggregations as Spotted and Stewart Island shags. During the 1970 survey only four Black shags and 30 Little shags were seen (OSNZ:1970).

**Herons**

A single specimen of the heron family, apparently a bittern (R.Scarlett:pers.comm.), was found in the lowest layer at Papatowai. Bitterns *Botaurus stellaris* are relatively common in the wetlands of the Catlins. The only other herons likely to have occurred in the prehistoric period are the large White heron *Egretta sacra*, which has probably always been represented by small scattered populations of low exploitation value. Other present day heron populations are of Australian species which have colonised New Zealand in the last century or which occur only as stragglers. Herons always occur in low numbers in New Zealand and except for the plumage as a status symbol are unlikely to have been significant in prehistoric economies.
Ducks and swans

There is a marked absence of wetland birds in Catlins middens, being represented by a single bittern at Papatowai, a small duck at Tautuku, the occurrence of the extinct swan *Cygnus sumnerensis* and the extinct goose *Cnemiornis calcitrans* at Pounawea (Lockerbie: pers.comm.). No well-provenanced duck species have been listed from middens and it is quite possible that the closely forested lake edges and dense reed beds of the local wetlands kept duck populations small and scattered. The Brown teal *Anas aucklandica chlorotis*, still found on Stewart Island, is the only duck likely to have found these habitats congenial, and the small duck found at Tautuku could well have been Brown teal. The small duck species all tend to be shy and are unlikely to have been an easily exploited resource. Even at present Catlins duck populations are relatively small and almost limited to the commonest native, the Grey duck *Anas superciliosa*, interbred with the introduced Mallard *A. platyrhynchos*. Paradise ducks *Tadorna variegata* are reported to be present in the Waikawa Valley but in low numbers. For the nineteenth century, Strauchon (1885) recorded that in the Tautuku-Tahakopa Valleys 'Teal' and Grey ducks were the most plentiful species although on the Tahakopa there were also a good many Blue duck *Hymenolaimus malacorhynchos*, which are now found only in mountainous areas of New Zealand. Strauchon also found Paradise ducks to be rare.

Hawks and related birds

Bones of a Falcon *Falcro novaeeelandiae* have been re-
ported from King's Rock and there is still a small population of Falcons in the heavily forested areas, especially in the Maclennan Valley. They take Native pigeons by flushing the pigeons out of the tree tops and then stooping on them. The inhabitants of King's Rock may have caught the Falcon(s) for plumage or in the hope of preserving the pigeon population for their own use.

The extinct Eagle Harpagornis moorei is reported from Pounawea (Lockerbie: pers.comm.). This close relative of the Australian Wedge-tailed eagle is thought to have preyed on the populations of large flightless birds such as the moas and the Takahe, and it does seem probable that in the period between the extinction of the moas and the advent of European farm stock there is unlikely to have been a suitable niche for an eagle in New Zealand, hence its extinction.

Rails, Pukekos and related birds

The commonest large member of this family, the Pukeko Porphyrio porphyrio melanotus, is widespread in the Catlins in suitable habitats, 21 birds being seen in eight different areas during the three day OSNZ survey (OSNZ:1970), but as usual there are no pukeko bones in the middens. This bird is placed in the same subspecies as the Australian population, and increased its numbers and range markedly in the last half of the nineteenth century (Buller 1888). Either it colonized New Zealand only a century or two before Europeans arrived or some cause such as unsuitable habitats kept the population at a low level until about 1850. This problem, the paucity of
pukèko bones in middens, which is of considerable ornithological interest, will best be solved by properly identified material from securely dated levels of early middens.

The related Takahe *Notornis mantelli* has been reported from Pounawea and from other east Otago middens (Lockerbie: pers.comm.) but is now found in only a limited area of Fiordland. Since large tussocks of *Chionchloa* are important feeding and nesting sites for the modern Takahe populations, it is unlikely that the Catlins ever harboured large numbers, though the valley floor clearings in the wetter zone of the Owaka, upper Catlins and Tahakopa Valleys would have provided habitat similar in many respects to the valleys that the species now occupies in the Murchison and Kepler Ranges.

The only reference to living Wekas in the Catlins is a mention by Strauchon. "Pigeons, kakas, tuis, wekas and other small birds common to our bushes are to be found in plenty, also a few native crows (Kokako) and saddlebacks" (Strauchon 1885-28). Local bushmen who have worked in the Catlins forests since 1920 have never heard of Wekas being seen. The modern species *Gallirallus australis* has not been reported from the Catlins middens but the bones of the small extinct Weka *Gallirallus minor* have been found at Pounawea (Lockerbie: pers.comm.) and at Tautuku (Hamel: unpubl.). There seems to be no way at the moment to test whether Strauchon was right or wrong, or what the status of the Catlins Weka populations were during the prehistoric period.

The extinct Coot *Nesophalaria chathamensis* is reported from King's Rock but at present there are no coot populations in the Catlins, though Catlins Lake and Tahakopa and Tautuku
estuaries carry good coot habitat. The recently arrived Australian coot *Fulica atra* is still extending its range and may well establish in the Catlins.

**Waders, Oystercatchers, Godwits and related birds**

Few bones of waders have been reported from Catlins middens. Some species such as the South Island Pied Oystercatcher *Haematopus ostralegus* and Pied stilts *Himantopus himantopus* have built up their large populations throughout New Zealand only in the last century. For other species there is only limited habitat, the largest tidal mudflat being the Catlins Lake, which is too limited in area and water flow to feed more than a small population of Eastern Bar-tailed godwits *Limosa lapponica*, the most adaptable of the Northern Hemisphere visitors. Godwit flocks are usually small e.g. 47 on 24 October 1970 (OSNZ:1970) rising to larger numbers occasionally e.g. 105 on 12 November 1970 (G.Hamel:unpubl.). The present high tide roost on Cabbage Point, Catlins Lake, does provide a small exploitable population of godwits within half an hour's travelling of the Pounawea and Hinahina moa-hunter sites. Though Maori techniques for capturing Godwits at high tide roosts are recorded for the nineteenth century (Buller 1888), Godwit bones are rarely found in middens (reported for Marfell's Beach, Lake Grassmere, R. Scarlett: unpubl.). The only other Northern Hemisphere waders seen at Cabbage Point have been single stragglers of Turnstone *Arenaria interpres* and Siberian tattler *Tringa brevipes*.

**Gulls and terns**

Gull flocks in the Catlins are not large, even with the
extension of habitat produced by European farming and there are no reports of this group from Catlins middens. Gulls occur relatively often in middens elsewhere (Scarlett: unpubl.), especially Black-backed gulls *Larus dominicanus*, and their absence from the Catlins middens seems likely to be because their numbers were too low and their coastal nesting sites on cliffs too difficult to reach to be worth exploiting.

**Pigeons**

Native pigeons *Hemiphaga novaeseelandiae* were an easily exploited and relatively abundant resource in the Catlins. The bird's habit of freezing when discovered feeding on low-level branches would make it easy to spear, and devices such as snares set in trees, at drinking places or round water troughs (Best 1924: 196), set in the heavily fruiting miro trees typical of Catlins podocarp forest, should have been as effective as in other New Zealand forests. In October 1970 about 160 pigeons were counted in 14 different areas, 50-60 being seen in the vicinity of the Tautuku Lodge (DSNZ: 1970). Many birds would have been missed because of their cryptic behaviour. Though population densities in suitable forest may not be as high as in pre-European days, protective measures over the past forty years are allowing pigeon populations throughout the country to increase, and densities may well be approaching those of the prehistoric period. Pigeon bones are moderately common in the Pounawea and Papatowai middens but are not reported for the more coastally oriented middens at Tautuku and King's Rock.
Parrots

Kakas *Nestor meridionalis* are still present in small numbers in the Tautuku-Maclennan forests (one bird seen mid-August at Papatowai Township, one bird in the Fleming River catchment, 20.10.70; OSNZ survey, 1970). In the early twentieth century kakas were present in quite large numbers but the population 'crashed' about 1920. Small flocks used to be seen flying across the Tahakopa Valley in the evening (J. Peterson: pers.comm.). This is a relatively easy species to catch, particularly when apparently drunk and agressive from taking rata nectar. Southern rata is abundant in the midslope and higher hill forests of all the major Catlins valleys and on a good flowering year a flush of red can be seen moving slowly up the hillsides between December and February as trees at successively higher altitudes come into flower. Other kaka foods such as berries and larvae of wood boring beetles are abundant. It is not surprising that kaka bones appear in the Pounawea, King's Rock and Tautuku middens. It is likely that a larger sample of bones from Papatowai would contain kaka bones.

The other important parrots of the Catlins are Yellow-crowned parakeets *Cyanoramphus auricapa* and the now almost extinct Kakapo *Strigops habroptila*. A family of four Yellow-crowned parakeets, frequented the forest on Papatowai Point for about a month in October 1970 and the species is seen frequently enough, flying over forest, both inland and coastal, to suggest that quite a healthy population is present. There seems to have been an increase in sightings in the last three
years in the coastal forests, suggesting an expansion from the inner ranges with population increase. Red-crowned parakeets *Cyanoramphus novaeseelandiae* were also once present (Keane 1966). Though parakeet bones have been reported from King's Rock midden only, the increase in the modern protected populations is an indication of the suitability of the Catlins forests for carrying a species-rich avifauna.

Kakapos are now confined to a very few areas in Fiordland and Stewart Island, but historical and midden evidence shows that they were widespread throughout New Zealand up to the nineteenth century. In the Catlins they occur in the Tautuku midden material. Their preferred habitat seems to be open forest and shrubland, particularly where it abuts on tussock grassland. They are known to take the fruits of *Fuchsia, Flacouria*, tutu and tawa (Oliver 1955: 553) and to thrive in podocarp-hardwood forests. The ecotones between the red tussock of the Catlins valley floors and the hillside podocarp forests with gully and river edge beech forest should have provided useful Kakapo habitat.

**Passerines**

The only passerines reported from the Catlins middens are the extinct Crow *Palaenocorax moriorum* and Tui *Prosthemadera novaeseelandiae*. Since there are no corvids in New Zealand except the introduced Rook *Corvus frugilegus*, a bird of open pastures with clumps of trees, it is difficult to assess habitat available for the New Zealand Crow. The Australian Crows, which are likely to be its nearest relatives, are birds of open forest and savannah country. The only compar-
able habitat in the Catlins would have been the small red
tussock clearings of the Tahakopa Valley and the larger ones
of the Owaka Valley. The mosaic vegetation of the Mataura
and Mokoreta Valleys are much more likely Crow habitat than
the main Catlins forest.

The occurrence of the extinct Crow at Pounawea on the
Owaka River is not as puzzling as its occurrence at King's
Rock and Tautuku, unless the species frequented cliffs and
shorelines as do the European Crows. Biological reasoning
cannot aid the archaeologist here; the archaeologist must
supply the basic data on the distribution of this species to
the biologists.

Tuis have been found only at Tautuku (Table 2:6), though
a much eroded small pelvis from Papatowai was probably Tui.
Since these are some of the smallest bones from the midden,
the paucity of Tuis may be due to differential preservation.
Certainly Tuis are relatively common in the lowland Catlins
forest and are prominent when they congregate on flowering
kowhais along the river banks and estuaries of the Tautuku,
Tahakopa and Catlins Rivers.

Native passerines known to be in the present day forests,
swamps and grasslands are Rifleman Acanthisitta chloris, Pipit
Anthus novaeseelandiae, Fernbird Bowerlia punctata, Brown
creeper Finschia novaeseelandiae, Fantail Rhipidura fuliginosa,
Yellow-breasted tit Petroica macrocephala, Silvereye Zosterops
lateralis, Grey warbler Gerygone ignata, Bellbird Anthornia
melanura, Tui Prosthemadera novaeseelandiae, Yellowhead Mohoua
ochrocephala, and possibly Kokako Callaeas cinerea. Species
now absent or rare but recorded as present in the nineteenth century are Robin Petroica australis, Saddleback Philasturinae carunculatus and Kokako (Hocken 1892, Keene 1966, Strauchon 1885).

As noted in Chapter 2:1 the biota of the Southland and Waimea Plains at the time of European contact was very different from that of the Catlins hill block. Roberts' notes (1895) on the bird life of the Mataura Valley nicely demonstrate this difference.

After riding on horseback down the Mataura to the Seaward Forest immediately east of Invercargill, Roberts stated that in this forest Kakas were not relatively numerous but that occasionally large flocks would appear and the birds were very unsettled and migratory. "They have not been seen in large numbers since 1861", five years after his initial visit. This comment suggests that the Kaka decline began in the mid-nineteenth century and reached a critical point about 1920 (see above). He also noted that the Seaward Forest had plenty of Robins (scarce by 1895), numbers of Yellowheads, and that Tuis, Riflemen and Fantails were present. The Seaward Forest was separated from the Catlins block by only the tussock-covered flats of the Mataura, and this is useful confirmation of the presence of Robins in this corner of the South Island. Parakeets were few. Out on the grasslands and swamps there were numerous Native quail Coturnix novanzaalandiae (now extinct), also Fernbirds Dowdleria punctata, Pukekos, Paradise ducks, Grey duck and a teal which he describes as a small brown duck with a white bar on the wing and green
speculum, difficult to shoot, which is an adequate description of the Brown teal *Anas aucklandica chlorotis*. This confirms that Strauchon's (1885) teal in the Tahakopa Valley were more likely to have been Brown teal than New Zealand scaup. Seagulls, which species is not stated, fed in the Mataura on the fresh water mussels, *Hyridella* sp., "a favourite food of the Maoris and seagulls" (Roberts 1895:41ff.). To this list Thomson (1857) added wekas which he says frequented the shrublands surrounding the clumps of forest on the plains to the north and east of Invercargill.

The bird bones identified from the Castle Rock cleft on the Five Rivers Plain to the west of the Waimca Plains give an interesting insight into the avifauna of an undated part of the Post-glacial (Hamilton 1893). There were very large numbers of bones of duck, Kiwi and Kakapo. The only duck species identified was *Euryanas finchii*, a relatively large duck falling between the Grey and Paradise ducks in size. Of useful exploit-able species there were Kokako, Native Quail, Native pigeon, Takahe, modern Weka, small extinct Weka, the extinct Coot, the extinct Giant rail *Antornis otidiformis* and the moas *Dinornis robustus*, *D. tesorosus*, *Pachyornis elephantopus*, *Emeus buttonii* and, the commonest species in the site, *Anomalopteryx didiformis*. Other species help to indicate that forest, grassland and wet-land habitats existed in the close vicinity of the cleft, probably not contemporaneously. Since the area has a history of forest decline and increasing tussock grassland approximat-ely during the period of Polynesian occupation, the mixture of forest and grassland species can be expected.

These accounts give an impression of abundant forest,
wetland and grassland bird populations. There is a considerable contrast with the Catlins where only forest birds seem to have been an abundant and exploitable resource; and where the ecotonal abundance of forest edges would have been reduced by the more massive forest blocks. The historical accounts of the bird populations help confirm the hypothesis presented in Chapter 2:2, that as Polynesian fires increased the mosaic pattern of the vegetation on the Southland and Waimea Plains, the bird life of the Catlins coast became progressively a less useful resource relative to that of the Southland plains, particularly when set within the annual round of gathering food surpluses for storage.

The articulation between the expected bird populations of the pre-European habitats and the bird bones in the middens is reasonably close. There are 'predictable anomalies' such as the midden occurrence of Kiwi, Takahe and Kakapo in an area with no historical records of these species. The reduction in range of these species during the period of Maori occupation has already been documented (Williams 1962). The presence of three extinct wetland birds (swan, goose and coot) is unexpected in view of the paucity of ducks in both midden and present day populations. The most surprising anomaly however is in the penguin species. The presence in the middens of three crested species and the absence of the largest and commonest species, the Yellow-eyed penguin, is ornithologically unexpected. Penguin colonies are highly vulnerable to human disturbance and it is valid to reason that the presence of the crested species in the middens does indicate larger populations at an earlier period. The absence of the Yellow-eyed
penguin requires more data, archaeological and ornithological for a satisfactory explanation. Three possible explanations are that (a) the species was absent from the Catlins coast before the nineteenth century, (b) it was not an acceptable food, (c) it was not worth exploiting at any of the sites so far examined. Recent evidence for extension of the range of Yellow-eyed penguins north to Banks Peninsula (Harrow 1971) suggests that the first explanation may be the best one to pursue.

Moa ecology

The major unknown factor in this range of available resources is the part played by the moa populations and the effect of their extinction on the exploitation strategy of the Polynesian populations on the Catlins. The only empirical evidence available on the nature of moa populations in the Catlins has to be derived from the bones found in natural deposits and in local middens (Tables 2:6, 4:8, 4:9, 4:12). Time control for all deposits is poor. About eight bones from Lockerbie's excavations have been radiocarbon dated and the rest of his information can be constrained only to about 500 year periods. Most large natural deposits of moa bones are considered by Fleming to be less than 5000 years old. The late post-glacial was a period of mostly prograding coastlines, "advance of dunes, ponding of streams... and moderate alluviation of many inland valley bottoms... the deposits formed in this late Holocene phase are the main sources (of moa bones)" (Fleming 1962). Dates of material from Pyramid Valley confirm this. The matrix in which most of the moa skeletons
were found gave a satisfactory date of $3720 \pm 60$ B.P.; three sets of gizzard contents were dated:

- *Dinornis maximus* $3640 \pm 72$ B.P.
- *Emeus crassus* $3740 \pm 72$ B.P.
- *Euryapteryx gravis* $3450 \pm 71$ B.P.

Bones from the *Emeus crassus* skeleton gave a date of $3600 \pm 45$ B.P. (Gregg 1966:157-158).

Since the midden material is the most extensive information available on the natural pattern of moa populations of the Catlins it will be briefly summarised in this chapter. A major difficulty in using midden material, of course, is in assessing how far the bones have been transported by man. Evidence will be presented later that the species of smaller birds and coastal animals found at Pounawea, Papatowai, King's Rock and Tautuku could all have been harvested within ten miles of each site, and that conversely some resources such as ducks, large wekas, quails and fresh-water mussels, which were likely to have been abundant in the Mataura, 40 miles easy walking inland, are not present in the coastal middens. In terms of energy output-input it seems highly improbable that whole moa carcasses would be transported more than 10 miles, even by canoe, if smaller birds were not transported such distances as whole bodies. Assuming then that the species represented in the four middens were hunted in the Catlins' forests and wetlands, what evidence is there about the natural patterns of the moa populations?

All nine species of moas that could be expected to be found in a naturally deposited, southern moa deposit, rare
forms excepted, have been found in the Papatowai middens from the largest moa, *Dinornis maximus*, to the smallest, *Megalapteryx didinus*. At Pounawea, only two species (of *Dinornis*) are missing; in the poor sample from the Tautuku site there are only three species known to be present and from King's Rock two or three species (Table 4:12). Throughout Otago proportions of each species in any one deposit vary greatly, and are further obscured by the uncertainties of the delimitations of each species from the next in size. The two species pairs, *Dinornis maximus*/*D. robustus* and *Emeus crassus*/*E. huttoni* show particularly clear intergradation. Each pair may have been a single breeding population. There is however a clear division between the *Dinornis* species (Family *Dinornithidae*: the Greater moas) and all the other species of moas (Family *Anomalopterygidae*: the Lesser moas), on the basis of proportions between the width and length of leg bones. Almost every species is widely distributed through Otago, though some species tend to be more numerous in certain areas e.g. *Emeus crassus* close to the coast (Table 2:0); also in areas where moa finds are few some species are missing. There is no strong pattern of geographical or habitat separation of species within the South Island. There is no species that seems to have been exclusively a forest moa or exclusively a grassland moa.

We must assume that as elsewhere in New Zealand, a wide range of moa types inhabited the Catlins, from animals with the bulk of a horse to those a little bigger than a large turkey. This pattern of species distribution can be seen in many natural deposits from the large coastal site at Enfield,
near Oamaru (Hutton, 1895) to a small collection from above 550 m on the northern end of the Remarkables, Lake Wakatipu (Kennedy Collection, Arrowtown Museum: identified G. Hamel, unpublished). This latter collection from a small alluvial pocket on a bleak tussock-covered hillside contained among 20 identifiable bones, portions of one individual of a very large *Dinornis robustus*, two of *D. torosus*, one of *Pachyornis elephantopus*, two of *Euryapteryx gravis* (including one juvenile), one each of *Emeus huttoni*, *Anomalopteryx didinus* and *Megalapteryx didiformis*. There were no other species of birds in the deposit which was obviously sorted by being water-borne. The only common moa species missing were *Dinornis maximus* and *Emeus crassus*. *Dinornis maximus* has been found about seven miles east of the Remarkable site on the Crown Terrace where among a collection of bones from Jeffrey's farm, a metatarsus and femur could be assigned to a very large *D. maximus* (Hamel: unpubl.).

The only natural deposits satisfactorily documented from the Catlins area are at Owaka and in the rolling tussock valley system between the headwaters of the Kuriwao and Waiwera streams (See "Clinton", Table 2:6). Odd bones have been picked up from the edges of the Catlins Lake. The Owaka deposit, found in a trench being dug for a sewer west of Owaka Township Jan 1971, consisted of about 20 bones which were taken from a stiff blue 'pug' below the water table, between 0.9 and 1.2 metres below the surface of a woody swamp layer. The bones were found along only two metres of the one metre-wide trench. Species identified were *Pachyornis elephantopus* (4-5 individuals), *Euryapteryx gravis* (1) and *Emeus crassus* (1). Two of the
P. elephantopus individuals fell within the range of measurements given by Archey (1941) and common to the Otago Museum collection of this species, much of which comes from the Papa-towai midden. The other two (possibly three) individuals were represented by unusually thick bones, the femora and tibiae being 1.0 - 1.5 cm wider proximally and 0.5 cm wider at mid shaft than any given by Archey (1941). The Clinton site is in a small bog against a steep hillside south of the Kuriwao Gorge. When a ditch was put through the bog about seven skeletons of moas were found in a stiff clay about 1.2 m below the surface. Leg bones and a pelvis deposited in the Otago Museum (Adam Harris collection, 1932 and 1937) have been identified as belonging to two individuals of Euryapteryx gravis, four of Emeus crassus and two of E. Huttoni. In contrast to the Owaka site where the bones seem to have been water-borne the Clinton bones were of birds in situ where they died.

The Remarkables, Owaka and Clinton sites have been described in detail here from personal experience of the sites and bones, because they show the tendency for several species of moas to occur together even in small samples from three very different areas i.e. a swamp in a densely forested area (Owaka), a bog in recently forested country (Clinton) and a mountain hillside possibly forested at some period in the Post-glacial (Remarkables). This supports to some extent the above hypothesis that the Catlins moas available for exploitation by the first Polynesians consisted of a number of sympatric species varying greatly in body size. According to orthodox ecological theory they would occupy different niches and probably show different behaviour patterns of breeding, feeding and
social interaction.

From a group of 73 sites in Murihiku where moa bones have been found, 31.5% are midden sites and 68.5% are natural deposits (Table 2:9). Theoretically the distribution of each species between midden and natural sites should also be about 3:7. Chi-square testing showed that all species, except *Euryapteryx gravis*, were distributed as expected. This latter species is common in Murihiku middens and is often the only moa species present, especially on the east coast of Otago north of the Clutha River, where conditions for forests are marginal. The high frequency of *E. gravis* in middens could be accounted for by selective hunting or by it having survived for longer than the other moa species.

There are a few interesting constraining statements which can be made about moa populations on biological grounds which must have affected their exploitation by hunters and gatherers. The probability of differing behaviour patterns of different species is noted above. The best hunting strategy for one species may not have been suitable for another species.

Moaas were heavily built, cursorial (locomotion by walking), herbivorous birds with strong feet and bills. As pointed out by the nineteenth century anatomist, Owen, the metatarsal is shortened and strengthened to almost the proportions typical of the turkey, grouse and pheasant Suborder, presumably for effectively scratching up soil rather than just for weight bearing (Owen 1879:107). The herbivorous habit is borne out by the heavy crushing and nipping bills of various shapes, the long neck and legs, overall pachydermal body proportions and
by the few gizzard contents competently analysed. Preserved
gizzard contents have been found only in suitable swamps and
most have contained fruits of forest and shrubland species.
The other high calorie plant foods are young shoots, starchy
stems and rhizomes, small roots and bark. White (1875) recog-
nized fragments of fern (probably bracken) stalks in what
he considered to be moa droppings accompanying moa bones in
the Wakatipu caves at the Von River and Gorge Road, Queenstown.
Gizzards at Pyramid Valley were reported as containing leaves,
twigs and seeds (Duff 1955). Mason (Falla 1941:341) found that
a gizzard of *Emeus crassus* (14B) contained:

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Podocarpus spicatus</em> (matai)</td>
<td>50 seeds</td>
</tr>
<tr>
<td><em>Myoporum laetum</em> (ngaio)</td>
<td></td>
</tr>
<tr>
<td><em>Nertera</em> sp. (tree nettle?)</td>
<td>1 seed</td>
</tr>
<tr>
<td>?<em>Carmichaelia</em> (native broom)</td>
<td>Present</td>
</tr>
<tr>
<td>?<em>Gaimardia</em> (cushion reed)</td>
<td></td>
</tr>
</tbody>
</table>

A gizzard of *Dinornis maximus* (22K) contained:

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Coprosma rhamnoides</em></td>
<td>200 seeds</td>
</tr>
</tbody>
</table>

Twigs of a dicotyledon, possibly *C. rhamnoides*.

Further analysis of gizzards excavated in 1965 (Gregg 1972)
gave the following results.

**Dinornis maximus** (AV 20,118)

- Matai fruits, seeds, leaves and male cones
- *Rubus* (lawyer) seeds
- *Muehlenbeckia australis* fruit
- *Coprosma* sp. fruit
- *Carmichaelia* (native broom) stem
- Unidentified leaves.

**Euryapteryx gravis** (AV 20,113)

- Matai fruit and leaves
- *Rubus* (lawyer) seeds
- *Muehlenbeckia australis* fruit
- *Cladium* (reed-like sedge) fruit
- Some unidentified material.
Emeus crassus (AV 20,119)

Matai few fruit, leaves
Rubus (lawyer) few seeds, thorns
Coprosma rotundifolia fruit
Coprosma sp. fruit
Pittosporum sp. capsule
Scirpus sp. (sedge) one fruit
Unidentified leaves similar to those in the Dinosaur gizzard.

Oliver (1949) reported that Mason had also found fruits of kamahi, Epilobium and Carex as well as the leaves of Myrsine divaricata and the sundew Drosera auriculata.

The wetland species of Epilobium, Drosera, Gaimardia, Gladiolus, Carex and Scirpus suggest grazing of the swamp edge vegetation prior to the birds becoming mired. Rubus, Muehlenbeckia, Carmichaelia and Myrropora indicate an open shrubland and/or forest edge habitat; Pittosporum, Myrsine divaricata and the Coprosma species identified also fruit well on the forest edge. Only the matai indicates dense forest and since massive logs of matai have been found in the Pyramid Valley gyttja, the birds could have fed on matai very close to the swamp edge. The presence of leaves and male cones of matai suggests that the birds were browsing directly from the trees. Matai however rarely fruits within five metres of the ground but does drop whole twigs very readily. After strong winds during summer and autumn the ground under a matai is littered with fruiting twigs. A large herbivorous bird scratching beneath matais would also find a litter of half-rotted leaves (equivalent to a poor silage) and a dense mat of noduliferous young roots of the matai. Such a site presents a relatively high calorie focus for a herbivore. The only suggestion that moas ate grasses (perhaps the succulent bases of tussock leaves
as Kakapo and Takahe do) was made by Forbes (1892), who reported that in the large deposit of 800-900 moas at Enfield, near Oamaru, he found gizzard contents beneath some of the aterna consisting of "triturated grass mingled with crop stones".

The analysed gizzard contents support the general ecological premise that one of the most suitable habitats for herbivores as large as moas would be the ecotones of forest-shrubland and shrubland-wetland. Fertile wetlands are the most productive communities of the temperate zone, producing 30-45 metric tons dry weight per hectare per year, compared to a New Zealand ryegrass pasture yielding 29 mt/hectare (Phillipson 1966:36). The empirical evidence for moa utilization of wetlands is somewhat equivocal. The birds most likely to be preserved in the Pyramid Valley swamp would have been the ones feeding on swamp vegetation. Three of the five gizzards analysed contained wetland plants but not in great quantity. The evidence so far is for moderate utilization of wetland vegetation, presumably as part of an ecotonal zone. All the plant species and genera identified in the Pyramid Valley gizzards, with the exception of *Myosorum*, are present and abundant in the Catlins. Birds feeding along the margins of valley floor swamps of the Owaka, Catlins, Macclennan, Tahakopa or Tautuku Valleys could readily have obtained assemblages of food materials similar to those at Pyramid Valley. The boggy clearings of the Tahakopa Valley would provide particularly suitable forest-wetland ecotones with *metri* and other podocarps, understoried by *Coprosma* and *Pittosporum* and edged with vines of lawyer and *Muehlenbeckia*. Shrubs of
Carmichaelia are common in the small gullies of all the clearings and the boggy edges include species of *Scirpus*, *Carex*, *Gaimardia*, *Drosera* and *Epilobium*.

Some useful deductions can be made from the cursorial habit of moas. Lack (1968) has compiled data for most of the bird families of the world, looking for regularities between types of feeding habits and breeding patterns, and seeking the apparent functional value of these regularities. He found that most cursorial land birds are solitary nesters, only a few rather peculiar groups forming loose colonies. Also they are generally nidifugous, the chicks leaving the nest after hatching and often picking up food for themselves from their first days. Lack sees these habits as the best strategy for raising the maximum number of young given a cursorial habit, ground nesting, a plant diet and the presence of egg and chick predators. The solitary nests and dispersed chicks are more difficult for a predator to find. For many herbivorous passerines, e.g. tuiks, bellbirds, the problem of supplying bulky plant food to chicks is overcome by a change of diet to insects for the breeding season, but this does not seem a feasible strategy for such a large animal as a moa in a country lacking small mammals and not particularly rich in other suitably sized animals. Hector (1871) compared the dried embryo of a moa chick in a whole egg found at Cromwell, to an Emu chick at the same stage of development. The pattern of ossification of the bones was very similar and Emu chicks leave the nest soon after the clutch has hatched (Eastman 1969). The proportion of incubation completed for the two eggs, and muscle development and feather
growth at hatching could of course have been very different in the two groups.

All the living ratites are solitary nesters. The forest dwellers (Cassowaries, Kiwis and some Tinamous) have relatively small clutches of one to eight eggs and tend to be monogamous; the plains and open country species lay large clutches of eight to 30 eggs and tend to be polygamous with several females laying in a nest guarded and incubated by one male. Evidence for solitary nesting in moas can be derived from Ambrose's (1970) descriptions of natural deposits of moa bone (mostly Megalapteryx), eggshell, droppings and nesting material in small rock shelters at Danmore, Waitaki Valley. Each rock shelter could have held at most only a few nesting birds at one time. Hartree (Falla 1962) examined the remains of moa nests on ledges and in sheltered cavities in limestone country in Hawkes Bay. In most nests (which were generally assigned to Anomalopteryx) there were the remains of one egg or one chick. An entire skeleton of Dinornis robustus found in a cave at Tiger Hill, near Alexandra, had the bones of four chicks beneath it (Ewen 1895). There is no evidence for large clutches or large nesting colonies among moa species and evidence that at least some species of moas were solitary nesters laying small clutches. Predator pressure may have been linked with a need to maintain an exclusive feeding territory for the young chicks as in the case of the Emu, both factors making solitary nesting an essential strategy. Possible predators of chicks were the extinct eagle, the New Zealand falcon, Black-backed gulls and wekas. The last two are also capable egg predators.
There is no biological evidence that during the breeding season moa adults, chicks or eggs would be an easy or predictable harvest for Polynesian man to gather as would have been the case if moas could have been shown to be colonial nesters and to have large clutches. Also it is much easier to conserve a species which nests in colonies. Changes in the size of a given colony over several years can be assessed by eye and, if the hunter-gatherer group wishes to do so, the harvest can be increased or reduced; but with solitary nesters even modern conservators find estimations of population change difficult to make with any accuracy.

Was a particular habitat a reliable source of moas for the human hunters? Birds of different sizes and with differently shaped bills take different ranges of food though there may be a great deal of overlap between similar species. The range of resources utilized by a species is part of a multidimensional abstraction, its ecological niche, made up of all the aspects, morphological, physiological or behavioural, which the investigator considers limiting in some way to the species, along with an undefinable number of other characteristics which could be used to delimit the status of the species in the community and in the habitat in which it lives (Odum 1959). The niche of a species is usually defined in relation to the niches of competitors or in relation to change over time. Some aspect of niche overlap between species can be measured or a niche can be said to have expanded or contracted. The habitat of a species is a much more concrete phenomenon and can be defined in terms of geography and vegetation. Thus generalizations from niche theory may enable us to make
statements about concrete habitats which may have been occupied by moas. Hutchinson (1959) presented evidence that "species that differ only in size seem to require that the larger be about twice as heavy as the smaller in order to co-exist" in the same habitat. It seems improbable therefore that the three Dinornis species of the Catlins (D. maximums, D. robustus, D. toroicus) with the same bill shape and an almost continuous range of body measurements lived in the same habitat. Since they do occur together in natural deposits they may well have overlapped in their resource requirements, but a hunter might have had to search swampy ground, neighbouring shrubland and the interior of a forest edge to find members of all three species. The members of the Family Anomalopterygidae (Lesser moas) differed in characteristics other than size. Eurypteryx species had relatively shovel-ended bills, Pachyornis species have more sharply pointed bills, and Emus had a bill shape intermediate between these two. Emus and Eurypteryx have only four phalanges instead of the usual five on the outer toe (an adaptation to stronger digging feet?). Anomalopteryx, a variable species, could be close in size to Emus huttoni but the bill of the former was narrower, shorter and yet blunt ended. Megalapteryx was closest in size to Anomalopteryx but had a more fragile, pointed and hooked bill rather similar to that of the Dinornis species but very much smaller. This is positive skeletal evidence that all members of the Anomalopterygidae along with one Dinornis species could have shared a single reasonably diverse valley, with a string of grassland-shrubland-forest ecotones along the length of the river and its estuary. A catchment such as the Tahakopa Valley
could have provided a sufficient diversity of habitats within ten miles of Papatowai to provide niches for all the moa species found in the midden.

The diversity of bill shapes among the Lesser moas suggests a diversity of feeding habits but cannot convey evidence as to whether or not these feeding habits were pursued in a limited or diverse set of habitats. However the conjunction of several species in almost every sizable natural deposit throughout Otago, e.g. the Kennedy collection, supports the hypothesis suggested by the diversity of bill shape, i.e. that any given habitat suitable for one species of the Lesser moas was likely to contain some or all the other species of this family and possibly a Dinornis species. Macarthur (1972) has shown that the richer the habitat in terms of equally common characteristics such as tree species or foliage density at different heights the greater the diversity of animals it can support. Thus in an area of relatively homogeneous climate and topography, a forest rich in common species i.e. with a high Diversity Index, would theoretically be able to carry more moa species than a forest with only one or two common species.

Following these arguments from niche theory to a logical conclusion there should be a scarcity of natural sites in which two or more Dinornis species occur together. Unfortunately many circumstances are likely to prevent gyttja and cave collections from representing the species of one habitat. Birds from different habitats could become mixed when drinking from the same pond and subsequently becoming mired in the gyttja or when taking refuge in the same cave in the terminal stages of dying from disease. It is not feasible to use the data of
Table 2:6 to determine whether or not deposits of one or two or three species of Dinornis occur more commonly than expected, since the deposits have been so variably sampled.

An ecologically more useful type of site is that in sand dune country even though bone preservation is often poor. Occasionally whole articulated skeletons of moas, apparently lying in situ where they died, have been found in eroding dunes along many New Zealand coasts as well as at inland sites such as in the Mackenzie Country (Chapman 1885). One of the most productive areas for this type of deposit in Otago and Southland lies along the Foveaux Strait coastline from Wakapata (Kawakaputa) to Riverton Beach. Chapman (1885) reported finding four moas at Wakapata, two small ones 20 yards apart and half a mile from two other larger ones. One of the small ones had died crouching. Ewen (1895) found two skeletons half a mile apart, of Dinornis maximus in the sandhills of Riverton Beach. One bird had a few fragments of eggshell with the sternum and about 300 yards from it there was about a pint of broken egg shell. Of the identified bones from these beaches most belong to Dinornis maximus, and Emeus crassus/huttoni, the latter species pair being medium to small moas. (Scarlett (1974) considers that E.crassus and E.huttoni should be placed in a single variable species.) The other six species common in the region have also been found along the beaches, but due to incomplete reporting some such as Henalcontrix may be confined to middens and so not securely provenanced to habitat.

Several skeletons of small moas were uncovered after a storm at the south end of Tautuku Bay (Lockerbie: pers.comm.), and Teviotdale (Ms. Hocken, Diary for 4 Feb, 1939) found a small
juvenile moa in the dunes at the north east end of Tahakopa Beach. Benham (1910) reported the finding of two skeletons in the sand dunes at the southern end of Masons Bay, lying stretched out in the sand a few yards apart. The bones from the larger skeleton fits Archey's (1541) measurements for *Emeus crassus* but the bones of the smaller one do not seem to have been reported on. At Lake Tekapo, Chapman (1885) reported nine moa skeletons all about the same size lying quite isolated from each other on hard ground blown clear of loose sand and loessic material. He made no useful comment on possible species. Chapman walked many beaches and had seen more moa skeletons than he reported. He commented

> What I have noticed here (Wakapatu) and in many other localities, including the sandy district near Otago Heads (Harrington Point?), satisfies me that a small Moa was a regular denizen of the sea beaches, and that a large one, if not similarly disposed, often frequented similar country. The small one must have been plentiful at one time upon narrow pieces of country which could not be reached or quitted without passing through miles of bush." (Chapman 1885)

It has been suggested that sand dune country may have been favoured nesting grounds for moas. The shrubby and grassy vegetation of sand dunes bordering on species-rich forest would have presented a diverse ecotonal habitat with areas of reasonably open ground where the very young chicks could be led about to find food. Eastman (1969) comments that Emus establish small territories during the breeding season with plenty of open ground in which the male tends the young chicks. Dense undergrowth is too difficult for the young Emu chicks to scramble through.

In summary there is some evidence that a given habitat
such as sand dune country carried only a small number of moa species and, as Hutchinson (1959) would have predicted, the overlap tended to be between a small species of the Anomalopterigidae and a Dinornis species.
Chapter 2:4

MARINE AND FRESHWATER FAUNA

Mammals

Reading Teviotdale's diaries on the excavations at Papatowai, it becomes quite apparent that seal bones, in terms of individuals, were about as common as moa bones. If moas were still common and seals interestingly extinct, the early occupants of New Zealand might have been referred to as Seal-hunters instead of Moa-hunters.

The four seals found around the Otago coasts, in descending order of abundance, are the Southern Fur seal Arctocephalus forsteri, Hooker's sea lion Phocarctos hookeri, the Southern Sea elephant Mirounga leonina, and the Sea leopard Hydrurga leptonyx. The first two are eared seals of the family Otariidae and the others are earless seals of the family Phocidae.

The only species of seal which breeds regularly on the New Zealand mainland is the Fur seal. At present there are no breeding colonies where pups are born regularly in large numbers north of Open Bay Islands at 44°S. Occasional pups are born at Kaikoura 42°S, and non-breeding colonies are established on all coasts during winter. Crawley (pers.comm. 1975) considers that it is unlikely that there were breeding colonies any further north than 44°S during the prehistoric period. The males at Open Bay Islands have to abandon their territories on hot days to lower their body temperatures in tidal pools, and heat stress is likely to be even more of a limiting factor to breeding in the North Island. Breeding colonies are sited on shorelines where the rock is so broken or the boulders so large that there are numerous sheltered places for the pups.
to lie in the shade and out of the way of the large bulls and
of storm waves. The animals at Open Bay Islands also shelter
in the shrubs at the back of the colony rocks.

There have been reports of seal pup bones in northern
archaeological sites, e.g. at Mt. Camel, Houhora, 34°50'S. "The
majority of the seals (43 individuals) are of the smaller species
of native fur seal, and include some pups ..." (Shawcross 1972:
608). Unfortunately it is not known how many pups there are in
the Houhora material, nor of what ages. Research is now being
carried out to discover the size ranges of bones in fur seal
pups ready to disperse from their place of birth (I. Smith: pers.
comm. 1976). It is known that they generally do not leave until
they are nearly one year old and about one third to one fifth
the size of the adult (Crawley: pers. comm. 1975). Epiphysial
fusion of the long bones is of little value for determining
this event since fusion can be delayed until the females are
three to four years old and the males eight to nine years old
(I. Smith: pers. comm.).

The Catlins coast is well within the present known breed-
ing range of Fur seals, and occasional animals are seen all along
the coastline but there are no reports of pups being seen. How-
ever at Nugget Point, 3 March 1973, I counted 150 fur seals of
all sizes, from pups about 0.75 m long to adult males. The pups
were in broken terrain where there were boulder cavities and caves
for shelter. The presence in the Papatowai midden of very small
seal pup bones, some estimated to be about 7 weeks old at death,
shows that there was some breeding occurring in the colonies
being exploited. Though it is virtually impossible to separate
the post-cranial bones of Fur Seal and Sea lion pups, present
breeding distribution (see below) does suggest that the midden
bones are most likely to be those of Fur seal pups.

The pups are generally born during December, with a sharp peak in mid-December. The pups swim competently at two months in still water but cannot cope with waves until three months old (Stirling 1970). Their mothers return to feed them at the birth place until the pups are nine to eleven months old (Crawley and Mattlin: pers. comm. 1975).

Fur seal pups are likely to be an easy harvest while they are land bound from December to March. Adult seals will be most readily available at breeding colonies at the end of January when the large territorial males leave. The juvenile males rest around the edges of the colony and when the territorial males leave they move in among the females and 'practice' holding territory. Numbers fall off in late autumn as animals without pups move north to non-breeding colonies. In winter and spring there are likely to be only lactating females and pups at the breeding colonies.

With the great depletion of the Fur seal colonies during the nineteenth century, it is not possible to plot the distribution of prehistoric breeding colonies. Sealers working from Australian ports were secretive about the location of the colonies that they were exploiting, and there are only occasional indications in the early records as to where they were working. Activity seems to have centred around Fiordland, Stewart Island and the southern off-shore islands, and at the present day most of the breeding colonies are along the Fiordland coast. The Catlins coast has short stretches of suitable rough, rocky terrain which could have carried sizable colonies. The nearest suitable beaches to Papatowai are about two
kilometres to the south towards King's Rock.

Sea lions (adult males, females and middle to large-sized juveniles) are also common in the Papatowai midden (see Chapter 4:2). Present day breeding colonies are limited to the coasts of Auckland Islands, and concentrated on Enderby Island. Now that they are protected, adult and juvenile Sea lions wander extensively in the non-breeding season and are commonly reported from the New Zealand mainland. On 5 March 1973 an immature male or adult female Sea lion about 1.5 metres long was found fishing in the Tahakopa Estuary immediately beside the Papatowai middens. It played in the shallows of the river with a large flounder until it sighted me 20 metres away, and then slowly worked its way down over the ford, surfacing and returning to observe and be observed every few minutes. Considering how oblivious it had been at first to me working in the river 100 metres from it and its subsequent curiosity and lack of apprehension, it could have been easily captured by two or three determined adults. Without suggesting that every Sea lion in the Papatowai midden swam of its own volition to the edge of the midden for slaughter, this behaviour indicates how easily Sea lions could be obtained in the vicinity of the site. The wide shallow waters of the estuary, cut off by a narrow exit from the sea, constitute a baited trap for seals.

Sea lion populations were greatly reduced in the nineteenth century and the restriction of the present breeding grounds of Hooker's Sea lion to the Auckland Islands at 51°5 is anomalous when compared to its closest relatives. The Australian Sea lion at present breeds along the southern coasts
of Australia and up the western coast to about 33°S. The South American Sea lion breeds round the southern coasts from Ecuador at about 3°S and up the Atlantic coast to about 27°S. The northern hemisphere Sea lions have equally extensive breeding ranges extending south down the Pacific coast of North America to the Galapagos Islands (Gaskin 1972). It is not possible to rule out Sea lion breeding colonies on the mainland of New Zealand in the prehistoric and even early European periods. The young bones at Papatowai could be those of Sea lion pups, and pups and immatures could have come from nearby colonies. The juvenile humeri are relatively easily assigned to Fur seal or Sea lion and it would be worthwhile looking at large midden collections of both species in the hope of finding that there are juvenile Sea lion humeri on the mainland below the general size of the immatures when they leave the Auckland Island breeding colonies. This would indicate mainland breeding.

The Southern Sea elephant breeds in the circumpolar subantarctic region but has been known to breed well into the southern temperate region, over-exploitation exterminating it in the more northern colonies. Even at present the occasional pupping of a lone female is recorded from the New Zealand mainland. There is a skull of a very young pup from the Shag Point middens in the Otago Museum (No acc. no.) and parts of skulls of six young individuals in the middens of the Archaic sites at Pleasant Point (Teal 1975). If born at the normal season they could be assigned to late September. The nearest sizeable breeding colonies to New Zealand are on Macquarie, Campbell, Auckland and Antipodes Islands (Gaskin 1972). There
is a small amount of adult Sea elephant bone in the bottom layer at Papatowai Point.

Leopard seals are generally solitary and wide-ranging animals whose breeding habits are little known. They occur quite regularly around New Zealand shores particularly the younger animals, who are often in a moribund state, but have not been known to breed in New Zealand. There is only minor evidence of Sea leopard at Papatowai - part of a cranium from 'the most northerly midden, collected 29.12.53' (Otago Museum, labelled material), and a basioccipital from the lowest layer at Papatowai. It is improbable that this aggressive predator was ever an important element of the local economy.

The use of seals for seasonal dating.

The most hopeful means of establishing seasonality from seal bones is by correlating bone measurements with age in months of juvenile seals, and possibly by growth rings in the canine teeth. There are no adequate studies of increase in bone size with age for Fur seals or Sea lions but Bryden (1972) has produced a model study for Sea elephants of the type of information required by archaeologists. He was able to construct predictive graphs from the close correlation of the major bones with each other and with weight, length and age.

Rings on canine teeth can be used with some precision for dating the stage of the annual cycle for Sea elephants. The Sea elephant starves twice a year - during breeding and during moulting. The period at sea between breeding and moulting produces a narrow dark line in the dentine of the canine, and the period at sea after moulting produces a wide
dark line. The rings can also be used to work out age (Laws 1953). It is not yet known if Sea lions and Fur seals undergo periods of starvation sufficient to produce regular stress lines in their teeth. Crawley and Mattlin (pers. comm. 1975) found that territorial male Fur seals remain ashore from November to mid-January, but the immatures and females appeared to feed regularly. Sea lions are reported to feed during both breeding and moulting periods (Mungrave 1966). Scheffer (1950) examined teeth of several species of fur seals and found that annual rings were obscure.

Fish

Fish bones and fish hooks are found in all the sites along the Catlins shoreline (Lockerbie 1959, Teviotdale 1937, 1938a, 1938b). The coastally oriented sites of False Island and King's Rock in particular are described as fishing camps (Lockerbie 1940, 1959). The traditional view is that as moa-hunting ceased to be profitable greater use was made of fish and shellfish populations.

A local second-generation fisherman at Papatowai (N. McCulloch) stated that the easiest fish to catch by line from the rocks in the vicinity of Papatowai are Red cod Physiculus baccus, Blue cod Parapercis colias and Groper Polyprion oxygeneios. In the Tahakopa estuary yellow-eyed mullet Aldrichetta forsteri and flounders Rhombosolea sp. are easily obtained. Species commonly taken offshore are Kingfish Jordanidia escondri, Barracouta Thysites atun, Sea perch Helicolenus percoidea, Spotted stargazer Leniagnus monopterygius, Sole Peltorhamphus novaeezelandiae, skate Raja sp.,
small dogfish *Squalus* sp., Elephant fish *Callorhynchus milii*, some Kahawai *Arripis trutta*, Terakihi *Cheilodactylus macropterus*, Moki *Latridopsis ciliaris* and very occasionally Snapper *Chrysophrys auratus*. The fishing season for small boats begins in October and continues till June. Between June and October the seas are too rough and there are too few fish.

The only fish species identified from the Papatowai site were barracouta and groper (Table 4:8), and at King's Rock, Lockerbie recognised Groper, Barracouta and 'cod' among the fish bones (Lockerbie 1940).

It is difficult to assess the nature and magnitude of the fish population available to prehistoric man on the Catlins coast. Modern, recorded, commercial fish catches are influenced by European preferences, European technology and depletion of fish stocks by selective fishing. Also fish catches along the Catlins coast are divided between boats working from Nugget Point (mostly into Molyneux Bay), from Waikawa (mostly off the Catlins coast) and from Bluff and Stewart Island (widely scattered). Using the Waikawa figures (about 15 boats) the commonest species taken over the past twenty years are Sole (by trawling) and Blue cod and Groper (by line). Representative catches for the small group of Waikawa boats are: - Sole 371 cwt, Blue cod 374 cwt and Groper 161 cwt for 1971 (Ministry of Agriculture and Fisheries Report 1971).

The east coast of Otago is the most important Sole fishery in New Zealand but this species is not known to have been important in the prehistoric period. It is absent from the few sites for which fish bones have been identified to
species. It is possible that Maori trawl nets were not effective in the depths of water where Sole most commonly occur, but Sole can be taken in seine nets worked from a beach (Moreland 1967), and Graham (1953) reported that they can even be taken by hook. Long mullet lines, each line baited with worms, set in the mouth of Tomahawk estuary might take up to eight Sole during a tidal cycle. Possibly hangi cooking so softened the bones that the whole fish was eaten or the largest bones chewed into a quid and spat out.

Barracouta is rarely taken at the present day (3 cwt at Waikawa in 1950) and is locally reported to have decreased greatly in numbers. It is a very easy fish to catch from an open boat, requiring no bait and only a simple catching device called a kaihau manga (Best 1929). This was a short stout rod about 1.2 m in length with a line about one metre long and a simple hook with a wooden shank and one inclined spike. The hook was violently swirled in and out of the water to imitate jumping sprats. Barracouta shoals could be immensely large but the time of their appearance off the Otago coast was erratic (Graham 1953). However barracouta do disappear in July, presumably to spawn in deep water, and reappear in October in a spent condition. They would be in best condition and easiest to catch between January and May.

The Catlins rivers contain large eel populations Anguilla dieffenbachii. Commercial eelers trapping a new stretch of the Tahakopa River with small fyke nets were able to take 50 to 150 pounds of eels in each net in a night, the nets being laid about 200 yards apart along the river bank (B. Gorton: pers.comm.). This weight of catch is possible
for only one night. The number of eels trapped falls off sharply to almost nil after about five nights and replenishment of stocks will depend on the age structure of the population and the rate of growth of young eels. Burnett (1952) trapped the tributaries of the Waiau River in western Southland and related age to length. He obtained a frequency curve which showed that after removal of all trappable eels the population would recover to 80% of its former total in three years. Eels under 30 - 35 cm are not easily trapped as they spend most of their time in the mud and under stones. At about 30 - 35 cm they change to feeding in open water.

In terms of productivity per acre of water, Burnett (1952) estimated for Kakapo Stream, Manapouri 1350 pounds; Upper Flaxy Creek, Waiau 1120 pounds and Lower Flaxy Creek 106 pounds. The variability in productivity is related to depth and stability of the river and especially to the amount of cover in the form of overhanging banks, vegetation and fallen timber. The main rivers of the Catlins provide very good eel habitat where they flow through the wide, gently-graded, main valleys with densely forested banks.

The other major freshwater resource known historically was the lamprey *Geotria australis*. The Waikawa and Mataura were traditionally important lamprey rivers, the adult fish being taken on migration as they climbed the falls at Mataura and on the lower Waikawa. Less is known about lamprey runs in the Tautuku, Tahakopa, Catlins and Owaka rivers but lampreys have been reported from the first three. The timing of lamprey runs does not seem to be well understood. Best (1929) describes the run as taking place during autumn and winter
freshes between May and August in the North Island rivers.
In the southern South Island the rainfall maximum tends to be
in summer and flooding shows no seasonal regularity. Beattie
(1954) states that Southland Maoris went to the Mataura Falls
for the lamprey run in September and October, and statistically
there is a greater probability of floods in September than in
July and August.

Whitebait (the young of *Galaxias attenuatus*) are likely
to have been utilised in the prehistoric economies of the
Catlins, though there are no specific records of their use.
Whitebait runs occur at present in most of the rivers particu-
larly in the Tahakopa, Owaka and Catlins rivers during August,
September and October. Graham (1953) records that the adults,
descending the rivers to spawn in February, March and April
were taken in large numbers by the Maoris. These adults as
well as the larval whitebait in spring were preserved by
drying them on flax mats in the sun.

Again there seems to be uncertainty as to the timing
of the main harvesting of these fish. Best (1929) states that
a South Island Maori claimed there were three distinct runs
in April, May and June, the May run being larger than the April
run. In the North Island substantial weirs were built out
into the rivers to direct lampreys and whitebait into traps
but these more intensive harvesting methods do not seem to have
been used in Southland and Otago.

The occurrence of fish bones in the Catlins middens will
be discussed in detail in later chapters, but it is worth not-
ing here that the Catlins is characterized by large natural
populations of freshwater and marine fish species but by a
paucity of archaeological evidence on how these populations were exploited.

Shellfish

There are only four species of shellfish which could be said to be abundant in the Catlins coastal sites - *pipi Paphies australis*, cockle *Chione stutchburyi*, blue mussel *Mytilus edulis* and paua *Haliotis iris*. Other species which occur less frequently are the mud snail *Amphibola crenata*, the large limpet *Cellana striqilis redimicum*, catseye *Lunella amaragda* and green mussel *Perna canalicula* (Table 2:10). About 10 other species of molluscs also appear in middens but they are either very uncommon or the shells on the beaches are placed and weathered in such a way as to suggest sub-fossil origin. These latter species are discounted in this discussion of available natural resources.

Distribution down the shore affects the availability of shellfish at different states of the tide. At Papatowai cockles occur from about the mid-tide area of the inter-tidal flats down to three metres below mean low water in the estuary (Fig. 2:16). This downshore distribution is similar to that found at Aramoana, Otago Harbour (Hamel and Barr 1974) and at sites in the North Island (Morton and Miller 1968, Larcombe 1971).

Adult pipis occur only below low tide at Papatowai, i.e. in the sublittoral zone. It is worth emphasising this point, as it seems to be true for South Island sandy shores in general and for the Wellington West beaches in the North Island. In the north of the North Island the major pipi beds are in the
midtide zone of the intertidal area though Larcombe (pers. comm. 1975) reports sublittoral beds. General ecology books on the seashore e.g. Morton and Miller 1968, which are mostly written on the Auckland region, give an erroneous impression for New Zealand as a whole. Some spat fall of pipis may occur above low water in the South Island as a small area of young pipis was found at Papatowai about 40 metres upshore from Mean Low Water (MLW).

Mud snails are found in the upper intertidal zone grazing on diatom films in slightly silty sand. At Papatowai this sort of habitat is found further up the estuary than the main pipi and cockle beds, and mud snails are relatively abundant about half a mile from Papatowai Point. At Hinahina and Tautuku South (Table 2:10) mud snails are abundant on the intertidal flats immediately adjacent to the sites.

The rest of the midden species require a rocky substrate. Of these, blue mussels can be abundant on rocks between MLW and midtide levels, and pāua may be numerous in rock pools just below MLW. Commercial collecting of these two species has been heavy in recent years, but reports of local informants along with remnant populations and the distribution of suitable habitat indicate that the densities of natural populations and their distance from a midden site correlate well with the frequencies indicated in Table 2:10. At Papatowai, for instance, pāua are abundant on rock shelves about 20 minutes walk across the Tahakopa River ford and west along the shore. Mussels tend to be small and occur mostly just above MLW. In terms of meat to total weight mussels would be less profitable to carry back to Papatowai Point compared to pāua. It seems significant that
the Picnic Point middens adjacent to the mussel beds contain a far greater proportion of mussel shell than any of the midden material examined quantitatively and visually at Papatowai Point. Catseye and limpet occur in the lower intertidal zone and the green mussel from about MLW down into the sublittoral. At mean low tide at Papatowai medium sized cockles, blue mussels, the large limpet and the catseye could be collected without subjecting the body to the stresses of immersion in cold seawater. By wading in the estuary and rock pools at low tide, to depths of about 60 cm pipis, large cockles, paua and green mussels could also be collected. Table 2:7 lists drift shells found in October 1969 on the sandy beach enclosed by a low reef immediately south of Tahakopa River mouth; i.e., beyond Picnic Point. This list indicates the relative richness of the local molluscan biota.

Pipis and cockles

Since pipis and cockles are by far the most abundant species in the Papatowai midden, they warrant closer examination than the other shellfish species. Midden shells can be measured for various shell dimensions, as well as for the growth rate of individuals and these parameters used to examine the problems of population structures. To relate the economically useful parameter of flesh weight to the shell measurements available from midden materials, it is necessary to make intra- and inter-estuarine comparisons of densities, dried flesh weights, shell/flesh weight ratios, length frequencies and annual shell increments in natural populations.
Sampling methods and analyses

A preliminary sampling of a minor shellfish bed at Papatowai was made in both February 1972 and February 1973, to obtain some data on change over time. In March 1973 a general reconnaissance was made to obtain samples close to the Papatowai Point site and across the ford of the Tahakopa River (Fig.2:16). In April 1973 a transect of quadrats was laid across the river where the main sublittoral bed was about 70 m wide. The transect ran across the intertidal flat for 60 m, across the river for 70 m, ending 9 m from the sharply defined inside bank of the meander. Quadrats one metre square were laid down at 10 m intervals and two people excavated each quadrat by hand into 6.35 m (½ in) mesh sieves. All live animals were counted and the nature of the substrate, the depth of the water and the time required to clean out the quadrant were recorded. Live shellfish were retained from alternate quadrats and returned to the laboratory for cleaning, counting and measuring. For both pipis and cockles a maximum posterior-anterior measurement was taken with vernier calipers accurate to one tenth of a millimetre. Measurements were also made of growth increments (for method see Larcombe, 1971) on a sample of 12 fast growing cockles.

Analysis of the data from the quadrats was carried out by:

(1) comparison of their length-frequency histograms, and by
(2) performing t-tests of the differences between each pair of sample means. An analysis for fine and coarse grained selection was considered but Macarthur's (1968) D method is not pragmatically suited to sandy shore shellfish. Individuals of pipis and cockles are collected by feel and not by eye.
There is not the same sort of possibilities for selection among animals buried in sand as there would have been, for instance, with rocky shore shellfish at Black Rocks (Anderson 1973). Also Macarthur's $D$ does not seem to be mathematically suited to considering selection between only two species.

Cockle beds at Aramoana and Te Rauone were also sampled, using one tenth square metre quadrats, laid out in transects across and parallel to the low tide mark. These samples were used to investigate the relationships between density, length and dried flesh weights.

**Distribution of cockles and pipis**

At Papatowai (Fig. 2:16) a rock bar across the estuary mouth has encouraged the formation, immediately upstream of the bar, of a firm bed of small cobble stones lying on top of fine sand. The pipis and cockles under these cobbles are protected from the turbulence of the tide and from scouring by river flooding but can extend their feeding siphons between the stones into fast-flowing, plankton-rich water. The main sublittoral bed of pipis and large cockles extends upstream from the rock bar, across a little-used ford and up the river channel into water over three metres deep at low tide. The upper boundary of the bed could not be found by a diver with snorkel, but certainly the bed extended into water so deep as to be difficult to utilise. The deep water area would provide an unutilized stock for regenerating the exploitable bed downstream. This bed is about 57 m across at the widest part and tapers downstream. The utilisable
length is approximately 137 m and the approximate area is 4600 square metres. Cockles do not extend evenly upshore on both sides of the sublittoral bed. The sediments of the intertidal area are suitable for cockles only on the inside of the main meander and in a small area close to the Papatowai bridge (Fig. 4:5a). In both areas the intertidal zone has an even gentle slope.

There is a marked decrease in densities of cockles at the edge of the river channel (Fig.2:17), where there is a stand still of an hour or more at low tide. Two factors may be involved. The stand still of the tide allows wave action to disturb the sediments for a longer period than elsewhere. Also fresh water floats on top of salt water in estuarine systems, and the stand still allows a relatively unmixed layer of fresh water to impinge on the mean low water edge for an hour or more during each tidal cycle. Such a reduction in salinity could kill shellfish in this zone.

There is some indication that pipis have competitive advantage over cockles in the sublittoral zone. Cockle densities are high on the intertidal flats where pipis are absent, decline towards mean low water and then rise in the sublittoral; but they never reach as high a value in the sublittoral as on the intertidal flats. The highest pipi densities coincide with a drop in cockle densities even where water depth is even as in the middle of the river channel (Fig.2:17). Competition from pipis seems to be excluding cockles from the densest parts of the pipi bed at least.
Growth rates and length frequencies

The growth rates of pipis and cockles, which are both filter feeders, seem to be basically controlled by the supply of plankton brought in from the open sea (Larcombe 1971). To provide good habitat the tidal flow into an inlet must not be so strong or turbulent as to wash the sand away from the shellfish but sufficiently strong to carry a large supply of plankton. There is an optimum zone usually close inside the mouth of an inlet where the current flow is slowed by channel meanders and begins to drop its plankton load. Further up an inlet the plankton load will have been depleted by the beds of filter feeders closer to the mouth. This is well demonstrated for several New Zealand harbours and estuaries. In Otago Harbour and the Heathcote-Avon estuary the largest and fastest growing cockles for New Zealand are found immediately inside the inlet mouths (Larcombe 1971, Hamel and Barr 1974). There is a decline in growth rate and therefore in size of cockles with distance from the inlet mouth. There is also a rapid decline in size from MLW upshore to the upper edge of the cockle bed (Larcombe 1971). Comparisons between different regions must therefore be made between comparable habitats. Larcombe (1971) used samples from MLW immediately inside the inlet mouth for between-inlet comparisons.

There is very little human exploitation of the modern
pipi and cockle beds at Papatowai. Length frequency distributions can be assumed to be a function of natural parameters and processes such as distance from the inlet mouth, position above or below MLW, rate of current flow, plankton density and factors controlling recruitment of juveniles into the populations.

Cockles *Chione stutchburyi*

Comparison between regions.

Cockle material from only a limited number of sites is available for comparison with Papatowai. These sites include Tiwai Point (Awarua Bay), Te Rauone and Aramoana (Otago Harbour), Monck's Bay (Heathcote-Avon Estuary), Parekura Bay (Bay of Islands) and Whangateau Harbour (north of Kauai Island, North Auckland). Figure 2:18 shows length-frequency histograms for cockles growing at MLW immediately inside the mouths of Otago Harbour, Papatowai and Awarua estuaries. In general Papatowai cockles are smaller than those at Tiwai, which are smaller than those at the mouth of the Otago Harbour. The fastest-growing cockles at Papatowai have a growth curve similar to those at Monck's Bay and Whangateau Harbour and poorer than those at Parekura Bay (Bay of Islands) and at Otago Harbour (Fig.2:19b). (Tiwai cockles were not available for growth increment measurements.) Combining the information available from growth-rate curves and length-frequency distributions, it is likely that conditions for cockle growth at Papatowai have been only moderate throughout prehistory, and definitely poorer than at Tiwai and Otago Harbour. It would be interesting to obtain material from other inlets along the Otago coast.
Other material from Larcombe (1971) shows that growing conditions for cockles are generally better in the southern part of New Zealand. This may be a function of the greater richness of planktonic life in the colder southern waters. Secondary factors such as volume of tidal water passing through an inlet mouth during each tidal cycle obscure this general trend to some extent. Thus Papatowai cockles are slower growing than those from Te Rauone, Otago Harbour, presumably because the Papatowai estuary holds a lesser volume of tidal water than Otago Harbour does. The low growth rate at Tiwai compared to Otago Harbour may be a consequence of inadequate searching of Awarua Bay other than around Tiwai Point. Certainly the volume and planktonic richness of tidal water entering Awarua Bay should be as great as that entering Otago Harbour.

Standing crops within an estuary

Combining data on growth rates and population structure, we can bring more insight to the problem of return for effort expended in the harvesting of cockles. Cockles with high growth rates would have been of little interest to the Papatowai moa hunters unless the cockle beds were sufficiently dense and large enough in extent to make daily harvesting worthwhile over many weeks or even months, assuming seasonal exploitation.

Biologically the extent of a shellfish bed is defined by the parameters which limit the settlement and growth of individuals. For instance to a biologist it is a sufficient
definition of the upshore boundary of a cockle bed to say that it lies at a given tide level e.g. at Papatowai at about mid-tide level. For the archaeologist this is a useful beginning to considering the sedimentation history of the flats, in the hope that he will be able to estimate the extent of suitable cockle habitat throughout prehistory. Using the geologist’s philosophy of uniformitarianism, the archaeologist expects that the sedimentation processes occurring at present will have occurred in the past. At Papatowai it is more parsimonious to assume that the river has kept very close to its modern course throughout prehistory than to consider that its final meanders may have shifted markedly down stream. Firstly the river is more likely than not to have maintained its present even grade from the Maclellan Junction to the sea. Secondly the sloping rock platform of the inner estuary and the channel through the rock bar at the Point, effectively act as training walls to hold the final meanders in place. If there has been a change in sea level relative to the Catlins coast during part of prehistory this could have affected the depth of sand over the rock platform. (See Appendix 2:3 for a brief discussion of evidence for recent changes in erosion patterns on the Catlins coast.) However cockles lie only 2-3 cm below the surface and require only about 10 cm of sand over the rock platform. Much greater depths of sand than this lie over most of the mid-tide to low tide region. It would require a major lowering in sea level and consequent change in grade of the river to remove significant quantities of sand from the cockle beds. A period of increased storminess, particularly from the westerly quarter,
could have raised wind waves large enough to move sand from the cockle beds across into the river. The main beds however are sheltered by a bank about 30 metres high on the west side of the inner estuary (Fig. 2:16). Large waves from the sea are prevented from entering the estuary by the interlocking system of the Papatowai Spit and Picnic Point. So long as only normal geological processes are postulated the extent of the cockle beds during prehistory is unlikely to have been affected by changes in topography.

Vegetation surveys provided supplementary evidence for the stability of the river edges during prehistory. Where the river channel runs against the sand dunes of the Macleanan Reserve the pattern of forest species and the widely branching shapes of some of the mature trees indicate a riparian forest of at least 300 years standing. There could well have been oscillations of 10-20 metres, but trees of silver beech *Nothofagus menziesii* typical of the river edge in the upper estuary are not found more than 100 metres into the podocarp-kamahi forest of the Reserve. Where undisturbed by road-making the silver beech stand contains a full range of seedling, pole, mature and moribund trees; many of the older trees showing the wide-branching habit typical of trees which have grown all their lives in an edge habitat. More of this material is considered in Chapter 3:4 under the discussion of the ages of trees on Papatowai Point.

Certainly the river has kept to its present channel from the Papatowai Bridge to the ford for the past 70 years. Over the same period the final section of the river below the rock bar has been known to flow out against Picnic Point.
instead of swinging hard against Papatowai Point as it now does (J. Peterson: pers. comm.).

There is then some supporting evidence for the hypothesis that the extent of the cockle beds was of much the same order throughout prehistory. Some further evidence relating to population structure will be considered during the discussion of midden samples. In considering food resources the model adopted here will be that the amount of food obtainable from the cockle and pipi beds remained of the same order throughout prehistory and that this food could be obtained within ten minutes walk from the Papatowai site.

The effect of density on length and growth rates

The density of a shellfish bed can be modified by patterns of erosion and deposition and by human exploitation. It is one of the most easily obtained parameters but one of the most difficult to interpret. Its value in archaeological studies depends on its effect on variations in length and growth rates of shellfish.

Swadling (1972) proposed that change in the mean length of shells in successive layers in a midden could be shown to be the result of exploitation rather than of environmental change if the length change was accompanied by an increase in growth rate and a decrease in age range. The association of change in growth rate with exploitation depends on the supposition that the growth rate will increase as the beds are thinned out. At lower densities more food should be available per individual, and lower densities should also be correlated with increase in mean length. Larcombe (1971) found this to be true when samples were
taken from equivalent locations relative to low water mark and to the mouth of the inlet, i.e. from areas with similar plankton supplies. The cockles of a midden however may have been gathered from different locations with differing plankton supplies.

A regression analysis was performed on the mean lengths and densities of cockles from seven quadrats at Papatowai and 12 at Aramoana, the former from the transect across the river (Fig. 2:16) and the latter from a variety of locations between mid tide and the sublittoral. For the regression equation

\[ L = c + mD \]

where \( L \) = mean length (cm) and \( D \) = density per m\(^2\), for the Papatowai cockles

\[ L = 33.16 - 0.01D \]

\[ r = -0.08 \text{ (not significant at the 5\% level).} \]

For the Aramoana cockles

\[ L = 40.52 - 0.013D \]

\[ r = -0.05 \text{ (not significant at the 5\% level).} \]

Considering the rather unusual distribution of length to density (Fig. 2:21 and 2:22) the significance of the regression of length on density was also estimated (Snedecor and Cochran 1967:138). A 't' value was obtained from dividing the regression coefficient 'm' by its standard deviation. The value of 't' for the Papatowai cockles was 0.31, d.f. = 5 and for the Aramoana cockles 1.147, d.f. = 10. Both tests showed that there was no significant regression of length on density in either case. This suggests that if the cockles in a midden have been collected from a variety of locations
on the shore, the regression of growth rate on density may be obscured by the location effect. There is a second assumption involved here which has not been fully tested, i.e. that for a variety of locations, increased length will be correlated with increased growth rate. This seems probable but does require confirmation. The relationship revealed by the regression analysis suggests that Swadling's hypothesis requires modification. A change in length of shells in successive layers in a midden may still be the result of exploitation even if there is no clear increase in growth rate, because the shellfish were collected from various locations on the shore. Swadling was aware of this possibility but did not test for it (Swadling 1972:45-46).

Location effect can be considered as a vector of two forces approximately at right angles to each other. One force is the linear flow of the tide along the channels leading to the sea and the other is the lateral movement of water from the low to high water mark. The greatest supply of plankton for cockles will be near low water mark close to the mouth of an inlet, and it will be lowest near high water, in backwaters and at the heads of inlets. Places in between can be expected to vary according to the strength of the linear and lateral vectors of supply.

It can be expected that the relationship between density and dried flesh weight per m$^2$ will be strongly affected by these vectors. Suitable data were available for collections from Aramoana (Hamel: unpublished data), Whangateau Harbour, Otago Harbour and the Heathcote-Avon estuary (Larcombe 1971).
There was no significant correlation of dried flesh weight with density for any of these collections except for that taken from the Long Transect in Whangateau Harbour (\(a = -47.49, b = 0.15, r = 0.82, \text{d.f.} = 7\), significant at the 1% level).

The samples in this collection were taken from one transect where only the lateral vector of supply varied whereas both vectors varied in the other collections. The order of difference produced by location effect is indicated by the data from two quadrats with similar densities at Aramoana.

<table>
<thead>
<tr>
<th>Quadrat</th>
<th>Density</th>
<th>Meat g/m²</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV1</td>
<td>190</td>
<td>14</td>
<td>mid tide, quiet backwater</td>
</tr>
<tr>
<td>SE3</td>
<td>210</td>
<td>96</td>
<td>low tide, main channel</td>
</tr>
</tbody>
</table>

Analyses of length frequencies and sample means can be used to demonstrate the significance of the location effect. The variation in population structure across the cockle bed at Papatowai is shown graphically in Fig. 2:20. Most populations are unimodal with a longer tail in the smaller size classes than in the larger. Recruitment appears to be a slow steady process with an occasional heavy spatfall \((Q3)\), possibly where adult cockles have been removed by modern gatherers or by erosion. Larcombe (1971) also found that recruitment was light in stable beds of adult cockles. The modal group will contain cockles of many age classes over six years old, judging by the typical growth curve (Fig. 2:19).

The samples collected a year apart from the same location (North 1972 and North 1973, Fig. 2:20) suggest the merging of a smaller size class with a larger adult one and losses from some of the largest classes.

Comparison of sample means by using one-tailed t-tests (Table 2:11) showed that nearly all pairs of samples from the
cockle beds were significantly different from each other at the 0.1% level. A pair of adjacent samples on the transect (Q5-7 pooled and Q9) were not significantly different from each other, and a sample gathered at D6 (Fig. 2:16) just above low water mark was not significantly different from one at Q1, 80 m away from low water mark but on an almost level part of the mudflat. The distinctiveness of most of the samples indicates the degree of variation in supplies of plankton and also the constancy of those patterns of variation from day to day. Coutts (1969:146) found that there was a significant difference in the shell meat ratios of cockles collected from two different parts of Purakanui Inlet but he did not break down this complex parameter to discover the source of variation.

The relationship of flesh weight to shell parameters

The relationship of flesh weight to shell length can be expressed by the basic allometric equation

\[ y = bx^a \]

where \( y \) = weight and \( x \) = length (Huxley 1932:4, Simpson et al 1960:397, Valentine 1973:156). Weight has been found to be an approximately cubic function of length in animals as diverse as sea elephants (Bryden 1969), spiny lobsters (Fielder 1964) and oxen (data from Thompson 1942:201). Hence the value of 'a' for cockles may approximate to 3.0.

A sample of 30 cockles from Te Rauone Otago Harbour, which were individually weighed and measured, gave

\[ W = 0.0068 \quad 3.023 \]

\[ r = 0.99, \text{ d.f.} = 28, \text{ significant correlation} \]
at the 1% level where $W = \text{weight of dried flesh in g}$ and $L = \text{length of the shell in cm}$. These values were obtained by using an HP25 programmed calculator to fit a power curve to the data. Though the values of the allometric constants have not been calculated in other studies of bivalves, graphical representations suggest a similar relationship to that found in the Te Rauone cockles. Larcombe (1971) showed that different populations of cockles in Otago Harbour yielded similar curves with slightly different intercept values (Fig. 2:23 cf. Fig. 2:24), and Valentine (1973:55) demonstrates a similar curve for the wedge clam *Donax* (*Latonia*) *cuneatus*.

Meat weight in individual bivalves can oscillate during the year as the animals come into spawning condition and then shed their gametes, whereas shell length shows only steady cumulative change (Larcombe 1971, Hancock and Simpson 1961:37). The cockles from Te Rauone which gave a power value of 3.023 were collected at the end of April when the main spawning season was over (Larcombe 1971). When in spawning condition the power value might drop below 3.00, but rise even higher than 3.023 when the animals are in poorest condition in winter (Coutts 1971:147, Larcombe 1971).

Previous workers (Terrel 1967, Coutts 1971, Shawcross 1967a, 1972) have used the relatively crude measure of a shell meat ratio to estimate meat weight represented by midden shells. This can be expressed as

$$W_m = bW_s$$

where $W_m = \text{the weight of dried meat}$ and $W_s = \text{the weight of dried shell}$. If this is regarded as a simplified version of
the allometric formula

\[ y = bx^a \]

it can be seen that Terrell and others have assumed that \( a = 1 \), i.e. that meat weight increases at the same rate as shell weight. Differential growth of parts of the animal body is the norm rather than the exception (Simpson et al 1960:390), and Terrell even demonstrated that the shell meat ratio in pipis increased regularly with increasing length (Terrell 1967:59). Larcombe (1971:Fig.4:3) demonstrated the same trend in cockles, so long as shells from the same location were compared. It is interesting to note that samples taken from three different stations showed diverging trend lines, with large cockles from low on the shore having similar shell meat ratios to smaller cockles from higher up the shore. These data from the Long Transect in Whangateau Harbour (Larcombe 1971:Fig.4:3) also suggested that there might be a correlation of shell meat ratio with age. Coutts (1971) however found no correlation of these two parameters when he analysed samples taken from transects across the tide lines in three different inlets. Coutts criticized Terrell's data on the correlation of the shell meat ratio with length, but Larcombe's data support Terrell's and suggest that location effects concealed the trend in Coutts' material.

To test the value of the expression

\[ W = bL^a \]  \hspace{1cm} (1) \]

as an estimator of dried flesh weight, the values obtained from the Te Rauone material (\( b = 0.0058, \ a = 3.023 \)) were applied to five samples of cockles collected from Aramoana, one kilometre away on the other side of the mouth of the
Otago Harbour. The parameters of length and total dried flesh weights were known for these cockles but not the individual flesh weights. The total flesh weights for the five samples were estimated using the expression

\[ W = 0.0068 \sum L^{3.023} \]

and the results compared against the observed dried weights. In all cases the estimates were higher than the observed values and the variation appeared to be more than might be due to sampling error. If the individual weights of the Aramoana cockles had been known it would have been possible to test this proposition by the usual parametric tests. Since the data were not available, a Taylor series expansion (Kendall and Stuart 1963:231) was used to estimate the standard errors of the weights obtained by using expression (2), as well as to estimate the bias which arises from the non-linearity of the regression between weight and length (Fig. 2:24). If the observed total dry weight is more than two standard errors from the estimated value then this indicates that the Te Rauone values are not valid estimators for the Aramoana samples. Examination showed that the difference between the observed and estimated values was much greater than two standard errors (Table 2:15). Biological reasons for the inadequacy of the Te Rauone values as estimators of dry flesh weights for the Aramoana samples may include the location effect already discussed and also seasonal variation. The Te Rauone and Aramoana samples were collected in April 1975 and July 1974 respectively.

It would be necessary to carry out an empirical investigation of the annual means and standard errors of the
values of 'b' and 'a' in expression (1), as well as analyse the variation due to location effect before this formula could be confidently used to estimate dry weights of flesh represented by midden shells. Since no attempt will be made in this study to calculate the available energy represented by Catlins midden residues (see p.236), the investigation of this formula was carried no further.

The relationship of flesh weight to shell length can also be used to study the exploitation of the shellfish beds. The location of the highest meat weight per unit area is of greater importance to the collector than the distribution of any other parameter, but meat weight cannot be assessed directly during collection. It has already been shown that meat weight is not statistically correlated with density though obviously a collector will not persist in digging where densities are very low. To find out if meat weight per unit area was correlated with length a regression analysis was performed on eight samples of cockles collected from various locations at Aramoana. It was found that

\[ W = -183.83 + 76.87L \]

where \( W \) = weight per \( m^2 \) of dried flesh in grams and \( L \) = mean length of shell in centimetres. The correlation coefficient \( r = 0.72 \) which for 6 d.f. was significant at the 5% level. The importance of this relationship will be discussed later in the appropriate section (p.126).

*Pipis Paphies australis*

Very little has been published on the structure and densities of pipi populations. Wood (1960) gives densities and
distribution on a sheltered sandy shore at Howick, Auckland, and Terrell (1967) gives densities and length frequencies for Galatea Bay, Hauraki Gulf. Shawcross (1967a) gives some very generalized data for a pipi bed in Whangateau Harbour, Auckland. None of this material can be used for inter-regional comparison with Papatowai since the North Island studies were done on inter-tidal populations and the Papatowai pipis are sublittoral.

The available standing crop and the extent of the major pipi beds at Papatowai were investigated. If, as suggested in the discussion on cockle beds, it is more parsimonious to assume that the river channel has been relatively stable during the prehistoric period, then the pipi beds will have been of much the same extent throughout. The latter, unlike the cockle beds, are almost wholly confined to the river channel where it crosses the upper end of the rock bar at the mouth of the river. This part of the river can be assumed to have been particularly stable. The most appropriate model again would seem to be that the amount of food available from the pipi beds would have been of much the same order since 1000 A.D. and that this food was available immediately beside the Papatowai moa-hunter site. Further material supporting this model will be given below.

The relations between density, length and growth rates in pipis

Unlike cockles, densities vary quite regularly in the pipi beds examined. The pattern of variation for the sublittoral bed at Papatowai is shown in Fig. 2:17, and for the intertidal beds at Howick and Galatea Bay in Table 2:13. In the intertidal beds densities tend to be low close to MLW,
rise steadily upshore and drop sharply at the top of the bed. At Papatowai densities are greatest in the centre of the river and correlate fairly well with water depth.

The relation of mean length to density is similar to that in cockles (Fig. 2:27). Data from Galatea Bay (Table 2:13) and Papatowai were combined and a regression analysis gave

\[ L = 40.27 - 0.010D \]

\[ r = -0.096 \] (not significant at the 5% level)

where \( L \) = mean length in cm and \( D \) = density per m\(^2\). As with the cockle samples the significance of the regression of length on density was estimated by dividing the regression coefficient 'm' by its standard error. The value of 't' was 0.42, d.f. = 4, and was not significant.

There may be a negative correlation between density and length for locations where food supply is similar but if it is assumed that the pipis in a midden have been collected from a variety of locations then it cannot be assumed that length will have varied with density for the bed as a whole.

As with the cockle samples, the mean length was used to demonstrate the significance of the location effect. Samples from the sublittoral bed at Papatowai were all significantly different from each other (Table 2:14). Analyses of length frequencies showed that most samples were unimodal with a longer tail in the smaller size classes than in the larger (Fig. 2:26). The two samples, North 1972 and North 1973 were intended to show temporal rather than spatial variation. There is no simple interpretation of the difference between the two years as there was for cockles (Fig. 2:20).
The bimodality of the 1973 pipi sample suggests a differential migration or extinction of the classes 31 and 37 mm long.

Methods of estimating meat weights from shell length in pipis were not examined though an empirical investigation of the seasonal variation in the constants of the allometric relation between meat weight and shell length would be as valuable for pipis as for cockles.

**Densities, mean lengths and the exploitation of shellfish beds**

In determining optimum strategies for the shellfish collector at Papatowai, the physical parameters investigated so far indicate some interesting differences between the two species.

Though the cockles of the intertidal zone do not have to compete with pipis for plankton supplies, they are the same size or even a little smaller than the cockles living in the sublittoral pipi bed (Fig. 2:28). However neither the densities nor the mean lengths of the sublittoral cockle samples were correlated with water depth (Figs. 2:17 and 2:28). Pipis on the other hand showed correlation of water depth with density (Fig. 2:17) but not with mean length (Fig. 2:28). Roughly speaking pipis increased in size down the low tide flats, were absent in the low tide shallows of the outer edge of the meander and increased in size across to the inside edge of the meander (Fig. 2:16). Proceeding up river from the Papatowai ford, the pipis did increase in size from the shallows of the ford into the deeper water of the main river channel. The most probable controlling factor is current velocity of the incoming tide, as it affects deposition of the plankton over the pipi beds. Where the current slows on
the inside of the meander or over deeper water, more particles are dropped and thus more plankton is available to the pipis. Water velocities on the bed of a meander are complex and the model suggested above is greatly simplified from Leopold (1964). The cross section of the river channel across the Papatowai ford does not fit the expected cross section for a meander particularly well, and a study at this site of water velocities, particle deposition and pipi growth could be very instructive. So long as relative water depth and the approximate shape of the final meander of the river were maintained during prehistory, it can be assumed that the largest pipis occurred in their present localities.

For cockles it was shown that the location of the highest meat weight per unit area of substrate is correlated with mean shell length but not with density. No data on dried meat weights of pipis have been collected but from the argument presented on cockle weights it is apparent that \( \Sigma L^3 \) where \( L \) = shell length can be used as an estimator of meat weight for some purposes of comparison. The value of \( \Sigma L^3 \) per square metre was calculated for the pipis in the sublittoral Papatowai quadrats, and regression analyses carried out to see if there was any correlation of this estimator with mean length and density. There was no correlation between \( \Sigma L^3/m^2 \) and mean length (Fig.2:29) since \( r = 0.14 \), which for 9 d.f. was not significant. For \( \Sigma L^3/m^2 \) and density (Fig.2:30), \( r = 0.95 \) which for 9 d.f. was significant at the 1% level. For the collector it would seem that cockle beds with large individuals and relatively low densities will give good yields of meat (Figs. 2:22 and 2:23) but for pipis high
densities are crucial and mean size relatively unimportant.

Applying these findings to Papatowai, it can be assumed that the best cockle yield was on the inside edge of the meander close to the midden site, where the cockles were largest and moderately dense. The best pipi yield was in the deepest water in the centre of the river where densities were highest (Figs. 2:17 and 2:28). Though slight changes in the topography of the meander could have separated these two areas in the past it is unlikely that they were ever more than 50 metres apart (Fig. 2:16). Exploitation, bringing about removal of the larger size classes of cockles (Swadling 1972), could have changed the pattern in only a few weeks of collecting, until for all practical purposes the two areas would have merged into a single patchy zone of best yield.
SECTION 3

VEGETATION AS A SOURCE OF
ARCHAEOLOGICAL INFORMATION

Chapter 3:1

The Use of Botanical Models in Archaeology

The botanical research done during this study was wide ranging, in order to find botanical approaches best suited to testing the hypothesis that the vegetational patterns of the forests around Papatowai Point have been relatively stable over the past 1000 years, with changes in only the proportions of forest types. As already mentioned (pp. 41-43) hypotheses about the origins of clearings on valley floors were also considered.

The study of the relations between natural and man-induced patterns in vegetation can use models similar to those applied to the study of the development of soil structure after human disturbance. Both involve natural processes acting as homeostatic systems, trending towards the restoration of some previous state. Succession patterns in vegetation can reveal previous human activities such as firing of the vegetation, forest clearance and midden deposition. In New Zealand succession patterns have been used in several cases as indicators of the existence of Maori occupation sites or to provide information on the post-occupational histories of the sites (Rutland 1900, McKelvey 1958, Lockerbie 1959, Cameron 1960).

A study of vegetation generally requires a description in generalized terms and raises the problem of employing a
classification appropriate to the archaeological questions being asked. Botanists use several approaches in classifying vegetation, approaches which can be grouped into those centred around climax theories and the recognition of discrete associations (Cockayne 1928, Burrows 1962:12), and those which focus on the individual distribution of species (McIntosh 1967). Classification by some type of association unit is useful when mapping zones of utilization as in location analysis (Cassels 1972) or when correlating factors such as the functions of sites with types of neighbouring vegetation. The individualistic approach is more appropriate to such studies as dendrochronology, the past distribution of a species such as bracken or studies of succession.

Definitions of climax vegetation generally involve the concept of the tallest and/or most mesophytic vegetation which the climate of an area can support, which is capable of reproducing itself and which will remain stable so long as there is no critical change in climate. In the field it is usually very difficult to determine that a particular unit of vegetation is a climatic climax community with its implications of vegetation-climate equilibrium and the assumption of no further natural change. In New Zealand, Holloway's theories of forest disequilibrium (Holloway 1954) and the complex relations of podocarps and broad-leaved hardwoods in mature forests run counter to climatic climax theory.

It is possible to study the orderly nature of succession on disturbed ground or in modified vegetation without determining the composition or even the existence of the final climax community. New Zealand botanists generally adopt a
pragmatic approach, describing what seems to have happened to physiognomically important species of the succession (McQueen 1961, Wardle 1973), searching for factors which affect the distribution of these species (Baylis 1958), and making detailed analyses of the successive stages readily apparent in the modern vegetation (Burrows 1973). They tend to avoid problems of terminology by using the least loaded terms such as community, succession, early and late stages or young and mature forests. These attitudes have been adopted throughout this study. Where appropriate, broadly defined associations such as silver beech forest or mixed podocarp forest have been used as classificatory units but finer divisions such as rata-kamahi-Hall's totara forest are used when discussing transitional or successional forest types.

Patterns of succession in the Catlins are affected by such factors as cold air drainage, shade tolerance of seedlings and the competitive responses of different species to levels of soil fertility. Some of this information can be found in autecological papers such as the Biological Flora series (Wardle 1966, 1967, 1971a; McMillan 1972; Franklin 1968) and some in general ecology papers (Holloway 1954).

An important restraint on the use of botanical models, particularly in the field of palaeobotany, arises from the regional diversity of climate in New Zealand. De Lisle (1961) showed that short term fluctuations in annual rainfall are not in phase throughout New Zealand. From Marlborough north, there are regular 12-year oscillations but Canterbury, Otago and Westland do not show any oscillations, and the trend line in each of these regions is
different. This suggests that long term trends over a century or more, may be different in northern and southern New Zealand. Hence major events and processes in climate-vegetation relationships may not be the same throughout the country.

Wardle postulates a regeneration gap in several species of podocarps, apparently coinciding with a colder and possibly wetter period between about 1600 and 1850 A.D. (Wardle 1963). This gap has been demonstrated for Taranaki, Wellington, the major regions of the South Island and for Stewart Island. On the other hand Barton has found that in the Auckland Province, podocarps had regenerated particularly well during the same period (Barton 1972). To explain this anomaly Wardle suggests that the present Auckland climate is marginally too hot and dry for the podocarp species involved, and that the wetter cooler conditions of 1600-1850 A.D. improved regeneration in the north while suppressing it in the south. Thus botanical evidence for climatic change need not take the same form throughout the country.
Chapter 3:2

Topography and soils in the Tahakopa Valley

A description of the vegetation of the Catlins and major disturbance factors attributable to European man and his animals is given in Chapter 2:2. In this and the following chapter forest structure close to archaeological sites will be examined for evidence of natural and man-made successions. Known occupation sites in the Tahakopa Valley are clustered in three areas - at the mouth of the river and around two areas of lowland red tussock, set in the forests of the river flood plain, four and nine kilometres respectively from the coast. These three clusters are designated as Tahakopa Mouth, Cemetery Clear (at 4 km) and Stott's Clear (at 9 km) (Fig. 4:2).

Maclean Reserve, at the mouth of the Tahakopa River, with its swathes of small podocarps and numerous traces of occupation would appear at first sight to have been heavily disturbed by prehistoric clearance. Similarly the two areas of lowland red tussock in the Clear have been locally attributed to Maori fires. Soils, topography and vegetation of these areas will be described and consideration given to natural factors which might have inhibited full forest development.

Detailed studies were limited to the Tahakopa Valley but there are strong similarities of biological and archaeological pattern between the valleys of the Fleming, Tahakopa, Catlins and Owaka Rivers.
Soils and Topography of the Lower Tahakopa Valley

The lower reaches of major river valleys in the Catlins area have wide benches covered with beach, estuarine and swamp sediments. These benches were cut during a post-glacial rise in sea level, by tidal and riverine corrosion (Speden 1971: 122). Speden subdivides the post-glacial sediments of the valleys into:

1. A headwater zone of gravels and swamp deposits with recent gravel fans of coarse debris from tributary streams, drainage generally good (Fig.3:1).

2. A middle zone of estuarine sediments overlain by swamp and fine river sediments where drainage is impeded.

3. A coastal zone of mostly dune sands but with estuarine and swamp deposits (Speden 1971:122).

The relatively level benches in association with a lack of fall in the lower reaches of the Tahakopa Valley has contributed to the formation of large areas of hydromorphic soils on the valley floor. The major forest reserve of the area, the Maclennen Reserve, lies within the coastal zone of dune sands and is bordered on its seaward side by fixed dunes which increase in height towards the sea. Between these dunes are wet swales, some with standing water. This dune topography extends inland about 100 metres and then falls away to a wide sandy flat with diffuse patches of boggy ground. Close to the Tahakopa River lower narrow dunes run at approximately right angles to the main seaward set and roughly parallel to the main line of the river. Where the two sets meet there is a very complex microtopography (Fig.3:2). Speden (1971) describes
these 'river' dunes as

low beach ridges (which) ... are aligned north-south, are approximately parallel to the lower reach of the Tahakopa River, and are convex to the west. They probably originated by extreme wave refraction. Windblown dunes have modified them. (Speden 1971:127)

Forest succession will be influenced by soil type and drainage. The soils of the Tahakopa Valley have been developed from parent materials consisting mostly of the Jurassic tuffaceous sediments of the Otekura Formation, which are mainly "thin-bedded sandy mudstones and fine-grained grey-wackes" (Speden 1971), part of the southern limb of the Southland Regional Syncline. Another important soil parent material is the loessic deposits widespread throughout Otago. The loess is considered to have been derived from the wide marine strands, river beds and bare ground of the periglacial areas during glacial periods. Loess layers and redeposited loessic alluvial sediments are visible in road cuttings along the terraces and flood plains of the Tahakopa Valley but loess is not an important element in the sand dune areas which are presumably of younger origin.

The local soils developed on these materials are (New Zealand Soil Bureau 1968):

Podzolised Yellow Brown Earths and Podzols

Tautuku and Hinahina silt and stony loams,
Toetoe sandy soils.

Lowland Yellow Brown Earths

Owaka, Chaslands and Waimahaka silt and stony loams.

Organic Soils

Otanomomo and Invercargill peats, peaty loams and peaty
Waimahaka soils border the south-western edge of the Tahakopa Estuary where there are small midden deposits. At the mouth of the river there are heavy podzolised Tautuku Hill soils with some peaty patches on the tops of low cliffs, but the midden deposits are mostly in the consolidated sandy edge of the river and ocean beach at the foot of the old cliff line. The main dune area of the Maclennan Reserve is underlain by Toatoe sands (Fig.3:1) with organic Invercargill soils on the wettest part of the flats (New Zealand Soil Bureau 1968). From a study of aerial photographs it was evident that the mosaic of vegetation on the Reserve did not correlate in a simple way with this soil pattern, and a more detailed study was required.

On the other hand there was an association between the clearings mapped by the early surveyors and Lowland Yellow Brown Earths, though the correlation was far from perfect. The boundaries of the Chaslands, Deborah and Run Clear corresponded approximately to the boundaries of areas of Chaslands soils (Fig.3:1). The Cemetery and Stott's Clear in Tahakopa Valley fall within a larger area of Waimahaka soils but may have been too small to distinguish on the published map.

Waimahaka and Chaslands soils are described as silt loams, developed on loessic material over flat to rolling country with a mixed vegetation of red tussock, flax and broadleaf/podocarp forest. They can be contrasted against Hinahina and Tautuku podozols developed on steeper country under closed forests.

The presence of a distinctive soil type underlying these valley floor areas of tussock-shrubland suggests that the
association of soils and vegetation is of long standing, which supports the evidence derived from the Stott's Bog pollen core (p. 42).

Soil development in the MacInnes Reserve

Toetoe soils are described as sandy loams and loamy sands developing on 'undulating to easy rolling dunes' with a vegetation of 'red tussock and manuka scrub; some rimu forest' (New Zealand Soil Bureau 1968:282). Though rainfall is adequate for forest vegetation, these soils dry out quickly, especially under the free drainage conditions of sand dunes; the water supply for the vegetation can be inadequate in the drier months of the year. Small patches of this soil type occur on stabilised sand dunes along the coast from Summer Hill on the north side of the Clutha Mouth to Waipapa Point. Soils on younger dunes with brackish ground water and no forest are assigned to the Riverton sandy soils and these extend further west along Foveaux Strait into higher rainfall areas. All these sandy soils bordering the coastline of Otago and Southland are of archaeological importance as they are the major soil type of the coastal sites. Drought prone vegetation would be easier to clear for settlement, and a free draining soil more suitable for digging pits into for either ovens, storage or dwellings.

On the Reserve there is a very complex succession of forest from the younger soils on the outer dunes to the older
soils on the inner dunes. The analysis of these relationships is a full scale research topic in itself. In this study sufficient sampling was done to show that the vegetation pattern could be the product of natural processes and that there is no indication that man-induced fires were an important factor in the formation of the present forest pattern.

Methods

A general reconnaissance method was used to examine soil profiles. Test pits were dug on tops of dunes, in swales, on flat areas and beside shallow stream beds under the recognizably different plant associations.

Vegetation was described by laying out clusters of quadrats in three areas of differing topography and soil-vegetation characteristics, as well as over the archaeological site on Papatowai Point (Fig.3:2). The position and direction of one side of the first quadrat of a cluster was selected by using a table of random numbers to pace out a distance from a selected point within a visually-defined stand. The rest of the quadrats were laid down contiguously and the boundaries of the cluster set by subjective assessment of stand boundaries. The number of quadrats analysed was limited by the stand size and by time and labour available. Within each ten metre-square quadrat, the plants were divided into:

(a) Trees, exceeding 4 in (10.2 cm) diameter at breast height (d.b.h.), about one metre above the ground,

(b) Poles, less than 4 in d.b.h. but over 6 ft. (1.83 m) high. Tree ferns were included as poles if over six feet high. Data
collected were tree diameters, using a steel diameter tape and numbers of trees and poles of each species. From these parameters of density, frequency and basal area were derived.

Density is expressed as individuals per acre, and relative density as the percentage of trees of a given species relative to the grand total of trees in the sample (Table 3:3). Frequency is expressed as the percentage of quadrats in which a species occurs, and relative frequency shows that value as a percentage relative to all the other species in the sample. Mean basal area is the mean of the cross-section of each tree trunk measured as d.b.h., a parameter which can be totalled and expressed as total basal area per acre. Relative basal area is the percentage each species contributes to that total. Importance Value is the sum of the three relative values for each species, and should be scaled against the highest possible value of 300.

The methods of placing the samples and the parameters used are suited to the problems of describing variation between stands and to correlating vegetation differences with factors of the physical environment (Greig-Smith 1964). For further details on quadrat sampling of vegetation and justification of the techniques used, see Greig-Smith (1964).

Results and discussion

Under the cool moist climate of the Catlins there is a slow break-down of organic matter in the soils of the dune forests of the Maclellan Reserve, and several of the common tree
species, particularly kamahi and rimu tend to produce an acid
mor-type humus. Leaching and podzolisation of the mineral
sands lead to the formation of iron and humic pans which im-
pede drainage and allow the build-up of peat on the perched
water table; peat formation and podzolisation probably con-
tinuing synchronously and reinforcing each other. A podzol-
ised soil may show about 20 cm of blackened humic upper layer
with white sand grains throughout giving a leached appearance,
followed by 0.5 cm of hard, black, greasy, humic pan with
0.5 cm of hard iron pan below, underlain by iron-stained and
more or less cemented sand. These peat soils, which may be up
to 75 cm thick, extend over large areas of the inner river
dunes and swales. The lower swales and large areas of the
central flats intersect the perched water table, and layers of
waterlogged silts and gyttjas are found within and below the
peat in the wetter swales. Small meandering streams cross
the flats. Podzolisation is more weakly developed on the
outer river dunes, the latter representing a much younger stage
of dune development, and lacking peat formations. The rela-
ton of this process of podzolisation and peat development to
dune formation is obviously complex.

The younger soils of the outer river dunes are more
fertile than the soils of the inner flats and dunes, being less
leached but also better drained. The higher fertility is in-
dicated by the presence of Fuchsia, Dicksonia fibrona, matai and
ture totara, species with relatively high nutrient requirements.
There is also a decline in the number of tree species as one
passes from the dunes close to the river to the inland flats
Overall density of trees per acre tends to rise since the trees of the inner flats are smaller in diameter and more crowded. This is particularly true of rimu which rises from 5.1 trees per acre with a mean basal area of 3.6 sq.ft. on the outer dunes (Table 3:6) to 375 trees per acre with a mean basal area of 0.92 sq.ft. on the inner flats (Table 3:4). Trees of kamahi on the inner flats are not only small but tend to fall and send up a coppice of thin stems. Hall's totara, which is more tolerant of low nutrient levels than true totara (Wardle: pers.comm.1973), predominates on the inner flats but both totara species are present on the river dunes. (In the quadrats, these two species were not separated since their tendency to hybridize makes it difficult to identify every tree accurately in the field.) These forests are discussed in greater detail in the next chapter.

It is difficult to be certain that a stand of small-diameter rimu on a site with 75 cm of peat is the true first generation forest. In some places on the Reserve, large fallen logs and the presence of wood and miro berries in the peat suggest that the pole rimu is not a pioneer stand. There are areas of apparent primary succession on some of the wetter parts of the flats where the peat-filled swales carry a surface of Sphagnum moss with scattered vegetation of Coprosma foetidissima and pole manuka about five metres high, with a dense understory of small-leaved coprosmas, Gaultheria antipoda and Lophomyrtus obcordata.

Though patterns of succession are complex, the vegetation boundaries on the Reserve appear to coincide with edaphic boundaries, and the mosaic pattern of vegetation on the Reserve
cannot be ascribed to the effects of fires. It can be reasonably deduced that the soil and water regime would have encouraged a similar but shifting mosaic throughout the prehistoric period.

Soil development on Papatowai Point

The terrace on which the main Papatowai moa-hunter site has developed is part of the complex microtopography of intersecting river and seaward dunes (Fig.3:2). Part of the terrace is underlain by shallow dunes, filled level with midden deposit and the whole backed by a double crescent of higher dunes. The rest of the site is underlain by a flat bench of sand only about 60 cm above high tide, but edged by sand mounds rising to 1.2 to 1.8 m above high tide and protecting the site to some extent. Midden has also been deposited in the higher dunes behind the terrace but without markedly affecting the topography.

Judging by the natural profiles cut by the river, soil development on the site seems to have been very similar to that described for the outer river dunes; a leached and humified black sandy loam with iron-stained, lightly-cemented sand below, showing the first stages of podzolisation. A pedological description by Leslie (pers.comm,1973) for the south-west baulk of the excavation at TT1 is given in Appendix 3:1. The surface of the site has been so recently rejuvenated by human activities and the calcium and phosphorus levels increased to such an extent that no podzolisation was detectable. In general the pedological horizons coincided with the archaeological horizons. Below the Black component, Leslie distinguished
stained basement sand from the unmodified sand, and also an old surface consisting of 3.5 cm of darker sand (Fig.4:12). The sand throughout the baulk was very friable and almost structureless. The silt fraction noted by Leslie in the archaeological humus and black layers was presumably wind-blown and there was no suggestion of peat formation, alluvial bedding or of gyttja deposition. There seems to have been good drainage throughout the history of the site.

**Nutrient levels**

Nutrient analysis was carried out by the Invermay Agricultural Research Centre, Ministry of Agriculture and Fisheries, on samples taken from all levels of the TT1 excavation on Papatowai Point (Table 3:1). Nutrient levels were similar to those published for the local soils (New Zealand Soil Bureau 1968:136) except for much higher levels of calcium and phosphorus and lower levels of potassium in the midden soils. Typical of a younger sandy soil, the carbon to nitrogen ratio was lower than on the neighbouring older soils.

The pH of the midden soil, as might be expected with the high calcium levels, was very close to neutral (6.7 to 7.1), and contrasts strongly with the values of 5.0 - 5.7 for Waimahaka and 4.1 - 5.0 for Tautuku soils. In such a neutral matrix there is good preservation of bone material, and it is unlikely that there has been much loss from chemical weathering.

The relatively high levels of calcium and phosphorus and low levels of potassium in the midden soils are likely to affect the structure of the vegetation growing over the archaeological site. Using Soil Bureau standards (New Zealand Soil
Bureau 1962), the soils provide for plant growth, a moderately fertile soil with a balanced pH but lacking potassium. To test the general fertility, the growth rates of two matai growing on the site were compared against those of two similar trees growing on the nearby sand dune (Figs.3:3 and 4:9). It is generally considered that matai requires a moderately fertile, well-drained soil and thus should be a sensitive indicator of fertility. The growth of the midden matai was very fast by comparison with that of the nearby dune trees. Comparable high growth rates were also obtained for a matai growing on the Hinahina occupation site.

In summary, the morphology of soil development on the Point is similar to that on the other river dunes. Nutrient levels, however, as indicated by chemical analysis and growth responses of matai, are rather different. These factors will be taken into account when considering the pattern of vegetation on and around the archaeological site.
Chapter 3:3

**An Anthropological Approach to Vegetation**

**Prehistory**

The forests of the Catlins are available as a resource zone to nearly all the archaeological sites discussed (Section 4). Since plant residues were not available in the midden material studied, ethnographic evidence will be used to indicate species likely to have been exploited (Colenso 1860, 1880). A detailed account of edible species used on the east coast of the South Island (Kaiapoi to the Taieri River) is given by H.M. Leach (1969). From these lists, species known to occur in the Catlins have been extracted (Table 3:10). Among the edible ferns only two *Asplenium* species are listed, but it seems probable that fronds of similar flavour and texture from several other Catlins species such as *Blechnum* spp., *Phymatodes diversifolium*, and *Asplenium flaccidum* were eaten. The same could apply to the 13 species of *Coprosma* found in the Catlins lowlands. It will be noted that many of the fibre and thatch species and three important flood plants, *Cordyline*, *Pteridium* and *Sanchus*, (Table 3:10) are not forest plants, emphasising the importance of the patches of open grassland and boglands that occur within the main forest block. Other important plant resources of the Catlins are outlined in Chapter 2:2 (p.35).

The major forest types of the Catlins, important in terms of resources, are the silver beech forests of the upper altitudes which may have contained kakapo; the rata forests of the middle altitudes important during the flowering season
for kaka; the hardwood-podocarp forests of the lower altitudes, river terraces and younger sand dunes with a rich assemblage of plant and bird foods; and the montane podocarp forests, relatively poor in plant foods and probably poor in avifauna (Fig. 2:12a).

The extent of each forest type would have fluctuated very little during the prehistoric period. Though there were changes in climate which affected regeneration of some species (Wardle 1963), most of the major canopy species are so long-lived that standing forest would be reduced only by climatic oscillations lasting for several centuries. It can be assumed that the proportions and distribution of the forest types listed above would have been fairly stable throughout the prehistoric period.

The tussock clearings, swamplands and shrublands within the main forest block were markedly different resource zones from any of the forests, and their extent and distribution during the prehistoric period must be considered in detail. It would also be useful to distinguish the different forest types developed on and around archaeological sites in response to edaphic and topographic factors, in order to understand how the natural vegetation may have been modified by human activities.

Methods

Material on forest structure, regeneration and seral stages was gathered from published material and from the four clusters of quadrats laid out on the Reserve as described in the previous chapter. A general reconnaissance was also made
of the major lowland forest types in the Owaka, Catlins, Maclellan, Tahakopa, Fleming and Tautuku Valleys. Valley floors were searched for remnants of tussock clearings from Ahuriri Flat south to Longbeach Stream. The inland margins of the forests from the Puerua River to the headwaters of the Waikawa River were examined and the effects of fires, slope and aspect noted. Farmers were interviewed about forest clearance and the occurrence of logs in historic grasslands. The latter material was also used in Chapter 2:2. The temperature data, described in Chapter 2:1, are critical to the discussion on valley floor clearings. Increment cores as well as discs were taken from selected stands of trees and the rings counted to determine the date of establishment. There are however several problems connected with tree dating which require elucidation before the results of these vegetation analyses are presented.

Problems of dating vegetation

Before dating a stand of trees, the population structure of the major canopy species, in terms of seedlings, poles and frequencies of diameter classes must be analysed so as to show the nature of succession on the site. Relevant species and diameter classes can then be selected for sampling.

A pair of cores or a disc from the trunk of the largest tree on the site will not show the age of the stand per se, since the sampled tree may be a relic from earlier vegetation, or a young individual of unusually vigorous growth. Samples should be taken from a range of diameter sizes. If the stand is even-aged, counts of annual rings from trees of different
diameters will have a short time-spread relative to the longevity of the species, and the approximate date of the establishment of forest can be determined. If the site is in old forest and recruitment has been relatively steady, there should be a reasonable correlation of age to diameter class, and a minimum age of afforestation can be gained from the oldest age-class.

Human clearance of forest cover can be more selective than clearance by ice or water, in that single trees or small groups may be left standing for shelter or other purposes. Photographs and drawings showing Maori settlements in North Island forests of the eighteenth and early nineteenth centuries, give no indication that trees were left standing within the area where the houses were placed. Obviously clearance will vary greatly with degree of permanence of the settlement. Webber's watercolour of 'Captain Cook with the Natives of Queen Charlotte Sound' (Begg and Begg 1969:139) shows five temporary huts which are apparently on a naturally unforested coastal terrace close to the forest edge. The two little huts described by Wales in Dusky Sound, which sound to be very similar to those drawn by Webber at Queen Charlotte Sound, were on the other hand

built in the thickest part of the bushes, I suppose for the sake of more shelter so that I could not see their length without creeping amongst the bushes which I did not choose to do for fear of surprize. (Beaglehole 1961:777)

With so much obvious variation it would be unwise however to assume that large trees were entirely cleared from moa-hunter settlements, and hence that the age of a single large tree on
a site will not necessarily date the final abandonment of the site.

In selecting a suitable tree species for dating a surface, the archaeologist should look for either a species which has formed an even-aged stand covering a reasonable proportion of the surface, or for a species such as matai or rimu which requires a well-developed canopy for seedling establishment.

Seedlings of tree species vary in their shelter requirements. If a species is one which can establish on open ground, e.g. Hall's totara, a minimum age for the forest can be estimated from the oldest abundant diameter class. Rimu, miro and matai, however, cannot become established until there is a nurse-crop of other tree species and hence afforestation must have begun prior to the establishment of seedlings of these species. Wardle (1973) discusses this problem in considering the use of tree ages and succession for dating the deposition of moraines less than 1000 years old on the west of the Main Divide near Mt. Cook. He dated several of the oldest shrubs and trees on each moraine surface, and then deduced from the local regeneration patterns and dated photographs of recent moraines how soon each species would be able to colonize the ice-freed moraine. It appeared that

the first seedlings of Olearia, Dracophyllum, Nothofagus, Weinmannia and Metrosideros are likely to appear on favourable spots within 5 or 10 years. Podocarpus ferrugineus and Dacrydium cupressinum on the other hand do not enter primary successions on these moraines until over 100 years have elapsed. (Wardle 1973:354)

In the Catlins, Nothofagus, Podocarpus hallii and Metrosideros seedlings establish along the open edges of the
Tahakopa Reserve forests but Weinmannia seedlings are usually under at least a light cover of shrubs. Rimu, miro and matai seedlings, 15 cm high, are appearing under the Papatowai Occupation site totaras which are now 70 years old, suggesting that these podocarps enter a succession on fertile ground lacking fern cover after about 50 years. Pole Weinmannia on the site probably entered about the same time but grew faster. The totaras seem to be able to establish as soon as there is a growth of large herbs, as they invade rough pasture or pasture on uneven ground on nearby farmland. The following are estimates of when some species enter the forest succession on fertile, well-drained sites in the Catlins lowlands.

- **Podocarpus hallii**
- **Podocarpus totara**
- **Griselinia littoralis** 1 year
- **Aristotelia serrata**
- **Fuchsia excorticata**

- **Nothofagus menziesii** 5 years
- **Metrosideros umbellata**

- **Melicytus ramiflorus** 10 years
- **Weinmannia racemosa** 30 - 50 years

- **Podocarpus spicatus**
- **Podocarpus ferrugineus** 50 years
- **Dacrydium cupressinum**
Evidence for these estimates was gathered from second growth on cut-over areas of farms and forestry land.

The date arrived at from discs or increment cores, cut at about 0.75-1.0 m above the ground, indicates the year in which the seedling reached that height. Seedling growth in podocarps tends to be very slow and variable in the early stages (Cameron 1963), and it is not until the seedling exceeds about a metre that the root system becomes sufficiently well developed to maintain steady growth. Thus the standard sample can be considered as dating the establishment of the tree, a more useful event in many respects than germination.

The collecting of cores and slabs is laborious for the worker and possibly deleterious to the forest. Probably fewer than 10 trees will be sampled from a stand. By selecting cores from trees of varying diameter, measuring the diameters of a much larger sample of trees and then correlating age to diameter class, the age-class structure of the sampled population should become apparent. Each age-class will contain a range of diameter sizes and the frequency distribution within a class is likely to approximate to the normal distribution. The oldest and youngest classes will tend to be more skewed than the central classes. This supposition depends on a steady recruitment of individuals of a species to the forest population and does not necessarily apply to an even-aged stand, particularly in its early stages. The assumption that the diameters of most age classes will approximate to a normal distribution also depends on effectively similar climatic and edaphic conditions throughout the lifespan of the distribution.

Anatomical factors must also be taken into consideration.
Some species do not produce clear annual rings, and some of those that do commonly fail to produce one clear ring per year. Young trees are more likely to produce non-annual rings than older trees and so the inner section of a core taken at about a metre from the ground tends to be less reliable than the outer section. The tendency for a species to produce non-annual rings can be judged fairly well by following rings round the full circumference of whole discs. A year's increment is rarely missing from the whole circumference and a double ring rarely remains looking convincingly like two separate years growth for the whole circumference (Glock et al. 1960; Franklin 1969). For New Zealand podocarps Wardle (1963) found that rimu showed no splitting or fusing of rings, the material used being discs cut from the bases of four Westland-grown rimus.

For the purposes of this study, Wardle's evidence for annual ring formation in rimus was accepted as applying to Catlins rimus, growing under very similar climatic and edaphic conditions to those in Westland. Annual ring formation in matai, totara and silver beech however had to be assessed in the course of this work. Discs were cut from two matais on a river terrace near Tahakopa township, and these showed a very low proportion of double or fusing rings (Table 3:7). Totara tended to be more variable. Three discs from a tree of each of the two totara species on Papatowai Point were examined. Double rings were so frequent that the ring count for a fifty year old tree might be increased by 10-20% (Table 3:8). Wells (1972) took slabs from trees of Hall's totara on the Pisa Range, Central Otago, where the species is relatively slow
growing. "False (double) rings were not obviously present but near the outside of the fluted section, discontinuous rings were found" (Wells 1972:412).

Annual ring formation of the Papatowai tories was further tested by placing inhibiting discs against the outer layer of the wood of 50-year old trees (see Appendix 3:3 for method) and leaving them in place for 5 years. Of the six trees which gave satisfactory results, five trees put on one ring each year. The sixth tree showed only four rings. A similar experiment was carried out on silver beech at the river edge of the Maclellan Reserve (Fig.3:4), where the trees were about 75 years old. Of the five trees tested, all had added five rings during the last five years. The age of this riparian beech was less crucial to the vegetation analyses and no discs were cut from the tree trunks.

Estimation of the age of a tree from a pair of cores, neither of which pass through the anatomical centre is complex. The rate of annual increment often follows a sigmoid curve, with slow growth during the seedling-pole stage, rapid growth when the crown reaches the canopy and then slower or even a falling rate of growth as a mature tree (M3 in Fig.3:3), or the growth curve may be almost linear (M14 in Fig.3:5). The use of average ring width or number per centimetre is obviously unreliable. The accumulative growth curve, plotted in 10 or 20 year units, usually shows a smooth curve and can be approximately positioned on the vertical growth coordinate by calculating the distance of the core from the centre. Unfortunately the anatomical centre may not be in the geometric centre of the tree, or the cores may pass through areas of
eccentric growth. If a pair of cores are taken directly opposite each other from each tree, and their accumulative growth plotted, these errors can be partially eliminated (Fig. 3:5). Extrapolation of the plotted line gives an estimate of the date of establishment. Fig. 3:5 shows that the accumulative growth curves tend to converge within 10 cm of the centre, but that a core of less than one third the radius e.g. M21, may yield an age with an error of ± 100 years.
There are two published accounts of the Maclennan forests by Mark et al. (1962) and by Jowett (1965). The latter gives a synchronic description of the associations in the present day forests, defined on their overall physiognomy (Fig. 3:4). Jowett also points out that rimu and miro are regenerating vigorously in a wide band across the Reserve, interspersed with pockets of kamahi regeneration.

Mark et al. (1962) were more concerned with succession and regeneration, a synchronic approach of greater interest to archaeologists. Mark sampled at four different sites, three of them in the transition from the coastal edge of the forest on Tahakopa Beach into the denser forest of the consolidated sand dunes, and the fourth in mature forest on the inner edge of the river dunes about 1.2 km from the coast (Table 3:4).

Mark's first stand in the narrow fringe of the coastal forest, where sand was actively invading, was "dominated by thin-barked Hall's totara which together with kamahi and rata, appear to tolerate salt spray" (Mark et al. 1962). The important understory trees and shrubs were *Griselinia littoralis*, *Myrsine australis*, *Psuedowintera colorata* and *Pittosporum tenuifolium*, a very similar association to that on Papatowai Point (Table 3:2).

The second stand was immediately inland and carried an open, spray-damaged canopy of chiefly rimu and kamahi. Tree ferns of *Dicksonia squarrosa* were abundant, but podocarp regeneration appeared to be repressed by a dense ground layer of
Blechnum discolor. This type of forest is well developed on the high dune immediately behind the Papatowai site.

The third stand was immediately inland again in a complex forest with a high density of small podocarps and kamahi. There was a dense small tree-shrub layer of divergicating shrubs and lancewood Pseudopanax crassifolius. The forest floor was only sparsely vegetated and podocarp regeneration strong. Adult rimu was far more abundant than totara and miro, but rimu regeneration was nil and seedlings of totara and miro numerous. Numbers of trees and seedlings per acre were:

<table>
<thead>
<tr>
<th></th>
<th>Totara</th>
<th>Miro</th>
<th>Rimu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees</td>
<td>16</td>
<td>40</td>
<td>258</td>
</tr>
<tr>
<td>Seedlings</td>
<td>273</td>
<td>643</td>
<td>Nil</td>
</tr>
</tbody>
</table>

The same pattern of replacement of small rimus by miro and totara was apparent in the fourth stand, where rimu, miro and kamahi were important canopy trees with an occasional large totara. Kamahi and coprosmas dominated the small tree-shrub layer, and though there were high numbers of ferns and herbs there was not a dense layer of Blechnum discolor. Densities of podocarp seedlings per acre were totara 2473, miro 10065, and rimu 993. A similar pattern of podocarp regeneration was found at Lake Wilkie, a few kilometres to the south. These high values for seedlings do not support Holloway's theory (1954) that South Island podocarp forests are declining through a failure of regeneration caused by climatic deterioration. The dynamic process of replacement of rimu by miro and totara indicate that the composition of mature podocarp forest is a function of age as well as of edaphic and climatic factors.

When considering the low frequency of rata in the coastal
stand on Tahakopa Beach, Mark noted that the margin of Tautuku Beach to the south, with a similar topography, has a dense fringe of rata which is not being actively invaded by sand. This rata is not regenerating however, and Mark suggests coastal rata is a seral stage which has been passed through at Tahakopa. The frequency of rata on Papatowai Point is also very low and yet tree ring counts of totaras (Tables 3:9 and 3:11) show that the forest on the site is only about 70 years old. According to Mark's theory the site should be well stocked with rata, which is important on the opposite bank of the river (Fig.3:4). It is likely that the high levels of phosphorus and calcium in the midden soils of the Point have given totara a competitive advantage over rata. Though rata is much more tolerant of low nutrient levels than totara, it loses competitive advantage as soon as nutrient levels rise (Wardle: pers.comm.1973). The composition of the vegetation on the Point will be considered in more detail later in this chapter.

The material presented by Mark et al. (1962) has delineated a sequence of forest types, passing inland from the shoreline across the dunes. This consists of a transition from rata-kamahi-Hall's totara, through a rimu-kamahi stand to a podocarp-kamahi forest where rimu was dominant but being replaced by totara and miro. There is also a primary succession from wet shrub-covered swales described in Chapter 3:2 through an early forest stage, similar to the rimu-dominated podocarp-kamahi forest of the coastal-inland transition, to a more mature forest. On the flattest and wettest soils of the central area this mature forest consists of kahikatea, along with
rimu, miro and totara in smaller numbers. The forests of the younger and older dunes were described in the last chapter.

It has been assumed that the rimus of the "Early Forest" stands (Mark et al. 1962), represent even-aged stands of comparatively young individuals. The peaty soil, however, does not favour rimu growth and the stands could consist of old suppressed trees. To test this, cores were taken from five trees in each of two stands at selected points on the Reserve (Fig. 3:2). Five trees at the "Early Forest" site (Table 3:4), selected from the full range of diameter sizes, proved to have become established in 1700, 1705, 1725, 1795 and 1802 A.D. respectively (Fig. 3:6b), a spread of about a century. Distribution of age to diameter showed that this is an even-aged stand, in the sense that seedlings established during only one century, recruitment then ceased and, after some natural thinning, most trees are likely to survive for another 700-800 years, to be replaced mostly by miro and totara. Considering the edaphic conditions, distribution of age to diameter is compatible with the hypothesis that this is an early forest stage which established rather slowly after an earlier manuka-coprosma shrub-bogland, which could have been present throughout the prehistoric period.

A second stand of small-diameter podocarps was chosen in a flat area with a perched water table over peat. Kahikatea, miro, Hall's totara shared the canopy with rimu. The five rimus chosen for sampling fell in the lower half of the diameter range present, and two (R105 and R106, Fig. 3:6b) proved to be suppressed trees. Otherwise the trees showed the same relationship of diameter to age as those in the Early Forest.
site. Rimu recruitment ceased about 1800 A.D., and the presence of poles of Kahikatea, Miro and Hall’s Totara suggest that these species will replace the rimu.

It would appear that during the prehistoric period, the sites now occupied by stands of young rimu on the Maclennan Reserve, were wet swales of Sphagnum, Coprosma foetidissima and other small shrubs. In this mosaic of vegetation, forest/shrubby bogland ecotones would have been more extensive than at present. It is argued in Chapter 2:3 that such ecotones provide particularly high energy forage for large browsing herbivores such as moas. Hence the flats of the Maclennan Reserve could have been particularly good moa habitat between 1000 and 1700 A.D.

The third sequence on the Reserve is the transition from riparian silver beech forest to the mixed podocarp forest of the river dunes (Fig. 3:4). The tendency for beech forest to occur along stream and river edges within hardwood-podocarp forests is a common phenomenon in Southland and Otago, and well documented by Holloway (1954). The seed is most readily dispersed by water and, since silver beech is competitive in the disturbed alluvium on sites subject to cold air drainage, stands become established along river margins. The stand on the river edge of the Maclennan Reserve contains mostly young trees about 65 years old, i.e. established about 1910, close to the time when the Sand Road and the Papatowai Bridge were built. Hence it may be mostly regrowth on ground cleared by Europeans. Silver beech has a maximum life span of about 600 years (Wardle 1967), and the largest trees at the downstream
end of the stand which have large dead branches and diameters of over 100 cm could be 400-500 years old. The understory throughout is well stocked with beech seedlings and poles, but also includes seedlings of Hall's totara and other broad-leaved species of the adjacent forest. Some manuka is present on the outer and upstream edges of the stand. Silver beech may not be stable on this site, but a seral stage in a succession of first manuka, then beech and then a podocarp forest rich in Hall's totara, rimu, matai and miro. It is likely that there were always small strips and pockets of riparian beech along the less stable parts of the Tahakopa River during the prehistoric period, but it is unlikely that they were ever more than a minor element of the forest.

This analysis of the successions over space and time, reinforces the findings of the previous chapter that there is no sign of modifications which could be ascribed to the activities of prehistoric populations. It may seem surprising that during 800 years or more of occupation that there is no evidence for the origination of fires from the Papatowai Point site. Observations of the efforts of the local farmers to clear forest for farmland made it very apparent that Catlins forests are generally difficult to burn. Great care must be exercised in totally felling trees and undergrowth at an appropriate time before the hoped-for dry period in either September or February. The felled wood must have had time to dry but not rot. Numerous even-canopied patches of second growth on the hillsides mark areas where burning has been unsuccessful. Fires which escape into standing forest usually burn only small areas, and local residents know of only one
major fire in the region which occurred in the late 1930s.

Having described the major successions, it should now be possible to show which forest type should be found on the midden material at Papatowai Point, and to highlight any man-induced modifications. Twenty quadrats which did not contain tracks or clearings, were selected from the 36 laid down over the whole site, and figures on tree frequencies, size and density recorded (Table 3:3). For methods and explanation of the parameters used, see p.137.

The vegetation on the Papatowai moa-hunter site consists of a mosaic of small trees, about 5-7 m high, with different species dominant in different areas. Pole thickets of both Podocarpus hallii and P. totara (50-80 stems per 100 sq. yards) dominate most of the site, sharing dominance with mahoe on the inland north east corner, and with kamahi on the seaward south west side (Fig.4:9). Where the dune rises to the north east the totaras give way to a stand of pale manuka along the Sand Road and to a mixed podocarp-kamahi forest on the less disturbed part of the dune. Where the terrace swings round the Point towards the sea there is a dense stand of pepper trees under a broken canopy of mature podocarps, and there is a particularly strong stand of matai, miro and rimu on the dune immediately behind this part of the terrace. The dates of establishment of matais around the site range from 1280 to 1720 A.D. (Table 3:11).

Undergrowth is sparse over much of the terrace probably because of continued disturbance by the many visitors to the site. Where the shrub layer is present it consists of seedlings
and poles of the two totara species and of kamahi, shrubs of *Myrsine australis*, *Coprosma rhamnoides*, pepper tree with some *Fuchsia*, manuka and other broad-leaved shrub species. There are large areas of dry litter-covered ground under the tightly closed canopy of totaras but there are areas of denser fern cover with *Polystichum vestitum*, *Asplenium flaccidum*, *Asplenium bulbiferum* and *Phymatodes diversifolium*, ferns which generally require fertile soils. The fern typical of sour infertile soils, *Blechnum discolor* is absent. Regeneration of the totaras is very strong. Only two of the 36 quadrats examined lacked seedlings, and poles were present at the rate 1371 per acre. Occasional poles and seedlings of matai, rimu, miro and kamahi also occur but in very small numbers (rimu 1.4 poles and 5.5 seedlings per acre, matai 4.1 seedlings per acre and kamahi 16 poles and 8 seedlings per acre, miro not in quadrats). A list of the plant species found on the terrace is given in Appendix 3:2.

Samples of charcoal taken for radiocarbon dating from the three main occupation layers in TT1 were identified by Dr. B. Molloy, Botany Division, Christchurch (Table 4:21, compare with Table 3:2). The charcoal represents species used for firewood and could be quite unrepresentative of the forest around the site. In fact the species used are all present in the modern vegetation on the Point and are typical of disturbed forest-edge vegetation in this area. Certainly the presence of manuka in the charcoals indicates intermittent clearance and regeneration, since
manuka is short-lived and will not establish under other vegetation. The species used for firewood are those which would be readily available to occupants of the site today, the only notable omission being rata which is a component of the coastal edge forest and makes excellent firewood.

Increment cores and discs were used to find the ages of seven totaras and two matais on the Papetowai Point middens. On the totara cores all faint rings were rejected as the discs showed that they were likely to be false rings (see Table 3:8).

The presence of two matais as metre high seedlings in 1810 (near TT1) and 1780 A.D. (near Teviotdale's IId site, Fig. 4:8) implies that there was a forest with a closed canopy and moderately open floor cover at that date and for about 50 years previous to 1780 A.D. There are no other large trees which require a substantial 'nurse crop' on the site itself. The totaras on the terrace fall into two categories; numerous, small, straight-boled trees with small crowns and a few larger trees with wide-spraying branches, the lowest branches being well below the canopy. The morphology of the latter shows that they have grown in the open or on the edge of an open area during most of their lives. As pointed out in the previous chapter, the ages of such trees may not date the time of reafforestation after the abandonment of an occupation site.
The small straight-boled trees on the main part of the terrace seem to have been 0.75 - 1.00 m seedlings in the period 1905 to 1910 (Table 3:9 and 3.11). Since totaras, particularly Hall's totara, establish readily on open ground in the Catlins, it would appear that the whole stand from 10 cm (4.0 in) to 40 cm (15.8 in) diameter trees is an even-aged stand which began growing about 1900 A.D. There are a few large stumps of over 50 cm diameter with level tops which appear to have been cut with metal saws. It seems highly probable that the present totara stand on the terrace represents regrowth after clearing by Europeans during construction of the Sand Road, a coach road put across the site without markedly disturbing the substrate in the last decade of the 19th century (Mackenzie, 1889, Hcken 1892). Sand was pulled down from the dune behind the terrace to form a ramp across the terrace.

Three of the large totaras with wide spreading branches were dated. One of these, from which a disc was taken, was a double-boled tree of Podocarpus totara, dated by Lockerbie and Bell (Lockerbie 1959) as being a 43 cm (1.5 ft) seedling in 1699 (Lockerbie: pers. comm. 1972). The disc taken in this study showed that the tree was a 122 cm (4 ft) seedling in 1730, a reasonable confirmation of Lockerbie's data. The tree was growing on the edge of the modern river bank, with midden material eroding under it, and fell in about
1935. Lockerbie's radiocarbon-dated section at Papatowai (Lockerbie 1959) was about 20 m to the east. Lockerbie used this single tree to date the abandonment of the Papatowai site. Two other old totaras on the site gave dates of 1850 A.D. for a river bank tree and 1750 A.D. for a fallen tree on the terrace close to Teviotdale's Area 3 (Fig. 4:8). The five older podocarps dated thus indicate that afforestation of the site had started by 1730 A.D. at the latest, a reasonable approximation to Lockerbie's 1700 A.D. date (Table 3:1).

At Pounawea Lockerbie (pers. comm. 1973) selected a similar tree, a widely branched large totara growing on the river edge of a stand of smaller totaras (Table 3:12). However a radiocarbon-dated section of midden material was situated immediately below this tree (Lockerbie 1959:85). Lockerbie's radiocarbon and tree dates confirm each other satisfactorily but the method of dating afforestation of a site on the basis of a single tree date is not to be recommended.

The total density of trees on Papatowai Point is relatively high (642 trees per acre) but not uniquely so. Mark et al. (1962) found higher values in a similar type of forest of kamahi, totara and pokaka Elaeocarpus hookerianus at Lake Wilkie (869 trees per acre); and in the Early Forest stage (Table 3:4) on a swale of the inner river dunes on the Reserve there were 558 trees per acre. Mature forest on the more
fertile dunes tends to range from 200 to 400 trees per acre.

Basal area is usually inversely correlated with density. If densities are high, tree diameters are generally small (Fig. 3:8). The values for Papatowai Point fall in an appropriate position for a stand of very young trees on the curve derived from other quadrat groups on the Reserve.

Examination of species composition in the four areas of quadrats (Tables 3.3 to 3.6) shows that an unusual characteristic of the Papatowai Point vegetation is the presence of mahoe Melicytus ramiflorus, which is second in importance to the totaras. It is not common elsewhere on the Reserve but does occur on the outer river dunes, though not in groves as it does on the site. Even on the site it is almost confined to one area, the sheltered base of the sand dune in the region of Tii. Elsewhere in the Catlins it is associated with four other archaeological sites which still carry forest - Pounawea (at the base of the causeway), Tautuku Beach (north end), Hinahina and Kings Rock. In natural stands of Catlins forest it occurs along lake and river edges on well-drained fresh alluvium and above 600 ft. elevation in mixed podocarp-hardwood forest such as that at Morris Saddle, Owaka Valley. Species composition at these sites suggests that they are all on relatively well-drained and fertile soils. The importance of mahoe on the Papatowai site is presumably a reflection of the high nutrient levels of the soils.

Considering the long history of fires and human disturbance on Papatowai Point, there is a relatively low frequency of the fire-resistant shrub, pepper tree. This species does form a dense shrubbery on the exposed seaward end of the
terrace where there is little midden material. Its absence from the midden area is presumably due to competitive exclusion by species which are at an advantage on the calcium- and phosphorus-rich soils.

The totaras on the site form a mosaic of Hall's and true totara with many intermediate forms. Wardle (pers. comm. 1973) considers that these two species hybridize readily in forest disturbed by erosion and human activity. There was a visual impression of co-dominance on the Point, neither species grossly outnumbering the other.

Totaras are not the only hybridizing species-pair on the terrace. Fuchsia excorticata and forms referable to F. colensoi (which is possibly a hybrid between F. excorticata and F. perscandens) occur in small numbers in the shrub layer along the edges of the totara thickets. Pittosporum tenuifolium does not occur in the small-leaved form with strongly undulate margins typical of the Dunedin population, but neither do all the Papatowai individuals fit the smooth-leaved P. colensoi common around Bluff. Intermediate plants form small pole thickets along the eroding banks of the dunes on the seaward side of the site with an occasional plant which does fit P. tenuifolium. No typical plants of P. colensoi were seen. (These hybrid populations were confirmed by Wardle.) Though long term human disturbance of the vegetation in the area could be a factor in the existence of these three hybrid populations, marine and river erosion are also likely influences. The distribution of hybrid forms of totara in relation to archaeological sites could be an interesting index of prehistoric disturbance of the vegetation in view of the longevity of the species. The
frequencies of hybrids in the different age classes of trees, in relation to other evidence of Polynesian disturbance, could be a useful archaeo-botanical tool.

It was not possible to analyse in detail the native vegetation of the clearings in the Tawakapa Valley or elsewhere, since they have had a long history of modification by fire and farming activities. Relic stands of tussock and shrubs in gullies and along roadsides indicated that the species likely to have been present in these clearings were lowland red tussock *Chionochloa rubra*, manuka, small divaricating coprosmas, *Carmichaelia ramosa* and *Hebe elliptica*, with various species of *Juncus* and *Carex*, jointed rush *Leptocarpus similis* and flax on wetter ground. The native vegetation of the raised bogs and swamps is still relatively intact and contains a rich collection of species, usually dominated by *Sphagnum* and wire rush *Calorophus minor* (Appendix 2:2).

The traces of clearings with their central bogs could still be deduced from soil profiles and relic stands of native vegetation. These signs coincided satisfactorily with the clearings marked on the early surveyors' maps and with the accounts of older residents in the area. The encroachment or retreat of forest beside the clearings during the prehistoric period could not be assessed since none of the adjacent forest was sufficiently intact.

Once the recent boundaries of the clearings had been approximately established, thermometers were set up in Stott's Clear to determine the incidence of summer frosts. The frequency of summer frosts at screen height on the valley floors is shown in Fig.2:9b. Wardle's (1971) observations on inverted
timber lines are discussed in Chapter 2:2, p.43. As previously noted the data are sufficient to show that the clears are likely to be a natural response of the vegetation to the soil, water and temperature regime. There is no evidence that their origin is due to prehistoric fires.

Summary

In this section edaphic and botanical evidence has been presented to delineate the general structure of the vegetation in the Tahakopa Valley during the prehistoric periods. Without analysis of plant residues in the middens, there is little point in making detailed analyses of available plant resources, other than to indicate the ones which are relatively abundant (Table 3:10).

Though the extent of each forest type is unlikely to have fluctuated much during the last thousand years, there is some evidence that shrub and reed boglands were once more extensive, especially in the Maclean Reserve.

Charcoal from the Stott's Bog pollen core (p.42) indicated that the prehistoric occupants of the Tahakopa Valley burnt the bog-shrubland of Stott's Clear, and possibly they regularly burnt the other clearings to prevent forest encroachment. Edaphic and climatic data confirm the pollen core evidence that these clearings predate Polynesian occupation.

The extent of peat formation presupposes a long period of time since the mineral sands of the Maclean Reserve became available for colonization, and it can be assumed that the forest found by the earliest Polynesian settlers was a mosaic
of depauperate forest types on the wet flats and older dunes, with a floristically richer forest of larger trees on the younger dunes.

The vegetation of the Papatowai middens had a distinctive feature of an even-aged stand of totaras, a phenomenon not found elsewhere in the present Catlins forests except on the Pounawea site. Rutland (1900) reports that in the lower Pelorous Valley, _Podocarpus totara_ occupied the Maori clearings abandoned in the 1860s, and that where stands of older totaras were cleared in the Rai Valley, ovens and other Maori remains appeared. Thus regrowth of totara on soils enriched by midden material could be a useful indicator of occupation material in lowland forested areas throughout the South Island.

Other distinctive features of the Papatowai middens were the presence of a nutrient-demanding species such as _Melicytus ramiflorus_, the suppression of species typical of poor soils such as _Pseudowintera colorata_ and _Metrosideros umbellata_, and the encouragement of naturally-occurring hybridization in shrub species. However none of these features can be used as absolute indicators of an archaeological site out of the context of the local pattern of vegetation and topography. The forest on the site can be seen as a response, within the pattern of local successions, to an improved level of fertility on a well-drained soil. The Papatowai site does indicate that in the course of site surveying, a study of local patterns of succession and fertility responses can help reveal the extent of buried midden deposits.
SECTION 4

PREHISTORY AND THE ECOLOGICAL CONTEXT

Chapter 4:1

Settlement Pattern in the Catlins

Introduction

The location of settlements in relation to resources can be used to explore the economic strategies of a prehistoric society. The food resources available to Polynesian man in the Catlins district were discussed in Sections Two and Three, in terms of exploitable species rather than in terms of resource zones. The zones themselves can be defined as:

1. Marine
2. Estuaries and sheltered sandy shores
3. Exposed rocky and sandy shorelines
4. River and wetland
5. Forest
6. Forest and grassland ecotones

In this chapter settlement patterns will be described for the area from the mouth of the Clutha River, south to the Waikawa River and inland to the Mokoreta River. This is the area discussed in Chapter 1:1 as forming an archaeological entity. The grasslands of the Mataura and Clutha catchments are not considered to be part of this entity.

Methods

Sites along the Catlins coastline and the Tahakopa and Mokoreta Valleys were located by interviewing local inhabitants and by site surveys. Despite many interviews, no sites were
recorded for areas covered by the 19th century forests. Accordingly site surveying was not extended to these areas. For each site the following characteristics were recorded: grid reference, aspect and slope of ground, distance from relevant topographical features such as water supply, surface appearance and the extent of the site. Data was collected from excavations of three charcoal and stone patches, one inland oven, part of the coastal site of Papatowai Point and by grab sampling a series of eroding coastal middens.

Sites

Though over 70 sites were recorded (Fig. 4:1), much more site surveying is required in the Catlins, particularly along the coastline and wherever there has been a forest-grassland ecotone during the prehistoric period. The known sites are however sufficient to demonstrate a pattern of exploitation of definable resource zones in the Catlins. Sites are here classified by criteria of structure and content into clusters or categories, and these categories related to resource zones. It will be noted that the site types do not include many which are characteristic of prehistoric New Zealand.

1. Find spots; usually of isolated adzes, lacking occupational context,

2. Burials; isolated or associated with Occupation or Midden sites,

3. Charcoal and stone patches; circular patches of charcoal and burnt stone, no more than 2-3 m across and lying about 10-30 cm below the turf,

4. Isolated ovens; round pits with charcoal and burnt stone in the centre but no food remains,
5. Midden sites: food remains but no artifacts, usually smaller than Occupation sites.

6. Occupation sites: food remains, artifacts and often complex stratigraphy, includes the largest sites in the district.

'Occupation' and 'Midden' are used here in a restricted sense to indicate the defined site types, and are capitalised to prevent confusion.

There is a remarkably clear cut division between the types of sites found inland and on the coast. Midden and Occupation sites are found only on the coast, and the Isolated ovens and Charcoal and stone patches, which are assumed to be the remains of open fires, are found only at the inland sites. Since no midden material has been found associated with the inland sites, there is no direct evidence as to which species were being exploited at these sites.

Virtually all sites are located on the boundaries of major resource zones. The inland sites tend to be concentrated along forest-grassland ecotones or along rivers. The oldest and largest of the coastal sites are located at the junction points of resource zones, where the largest number of natural habitats can be exploited from a single locus.

Isolated adzes have been found on both coastal and inland resource zone boundaries (Table 4:3, Appendix 4:1). A concentration of about six adzes was found close to an area of regenerating podocarp forest on the lower hill slopes of the Mokoreta Valley (5170/5).

Six burial sites are known from the Catline, Teviotdale (1938, Diaries 25.5.40:ms. Hocken Lib.) and Lockerbie (1959)
recorded three burials at Long Point (S184/30), Cannibal Bay (S184/4) and at Kings Rock (S184/6). There are reports only of human bones in two caves in the Tahakopa Valley (S184/25) and near Tahakopa Township. Two isolated skeletons have eroded out of sand dunes at Dummy's Beach (S183/5) and at Waipati Beach (S184/23). Two Contact Period cemeteries are also known for Tautuku and Papatowai Points (Hocken 1892 and local informants). Otago Museum files record burials from Tautuku Peninsula, and one from each of the following places: Tokanui Mouth, Curie Bay, Chaslands, Owaka and Kaka Point (George's Oven S179/17).

Grave goods were rare: one of the three Cannibal Bay skeletons was associated with a real-type necklace with 17 units (Lockerbie 1959), and the Waipati Beach burial was associated with a Duff 1B type adze.

The recorded burial positions are varied. The Kings Rock burial was extended, slightly flexed on the left side facing west with the head towards the sea and the arms crossed on the chest (Teviotdale 1938). The Dummy's Beach burial was crouched on the left side facing north with its back to the sea (S183/5). The Tokanui Mouth burial was trussed (Otago Museum files).

As already discussed, ethnographic evidence from the Historic Period suggests that these skeletons could be part of one spatially interbreeding population, divided into small groups which were relatively mobile along this length of coastline. A sample of only 16 skeletons (Table 4:11), derived from a period of up to 600 years is however, too small to take as representative of the population structure.
Dating these burials is difficult. The Long Point burial was associated with some fragmentary moa bone, seal and penguin bones. Comparing this with the sequence at Papatowai Point suggests a date in the middle of the period of occupation. The Cannibal Bay skeleton with a reel necklace was associated with a midden dated by C14 to the sixteenth century. There is however no archaeological correlation between the burial and the nearby midden. The King's Rock burial was found just below the surface of the turf and above the seventeenth-eighteenth century midden material (Teviotdale 7.12,37:3s, Hocken Library). Hence the burial is recent. The dating evidence suggests that the Catlins burials could cover a period from the fourteenth to the eighteenth centuries.

It is possible to subdivide the site category of charcoal and stone patches into those with relatively small round stones and those with larger flat ones. There are intermediate forms. From Sutton (1971) it can be deduced that the former were probably used for spit cooking and heating and the latter for baking. These sites are easily overlooked and therefore are probably under-represented. It is the commonest site type in the finger-like clearings of lowland tussock which extend deep into the Catlins forest block. Five were found in Stott's Clear, Tahakopa Valley; one at Pukepito, Catlins Valley; one at Ahuriri Flat and an ambiguous one near the coast at Sandy Bay (Table 4:3 and Appendix 4:1). Their prehistoric status turns on their location below the turf of rough unploughed pasture, where they are discovered when the pasture is ploughed. Moreover, Europeans seldom use stones and flat rocks in open camp fires.
One site in Stott's Clear (S183/8) comprised ten circular concentrations of burnt stone and charcoal (Fig. 4:2), suggesting simple open fires. They were scattered over about 200 m of boggy flat close to the Tahakopa River. The patches varied in size from 0.6 to 2.0 m across and mostly lay 30-40 cm below the surface. Three newly ploughed patches were examined but there was no undisturbed material. In one case it could be seen that the stones had been laid out as two circular patches about 40 cm across. The stones in most of the patches were rounded river boulders approximately 10 cm in diameter, and lay in redeposited, stone-free loessic clay. They probably came from the nearby Tahakopa River which lies 400 m away across the flats. The three sites of this type in Stott's Clear were distributed over 1.2 kilometres. Two of the largest patches (two to three metres across) were on very slight knolls which would have been drier than the surrounding marshy ground. On one knoll (S184/36) the stones had been lying in a slight depression.

The two slab hearths in Stott's Clear were distinguished by their large flat boulders, but considering the variation in shape and size of the stones it is obvious that slab hearths could easily grade into the open fires described above. The hearth at Digger's Creek (S103/6) contained six burnt, water-worn boulders of a local greywacke and one piece of shattered bedrock, a mudstone from the nearby hillside. Of these the largest measured 40 x 22 x 4 cm and the smallest 22 x 9 x 9 cm. This hearth lay within 20 m of Digger's Creek and, according to an examination of the age structure of the local podocarps, was close to the prehistoric forest edge (Fig. 4:3). The
occupants of the site would have been able to exploit the resources of the river, hillslope forest and the tussock-shrubland of the alluvial flats. The site would have been well sheltered from stormy weather.

The second slab hearth (5184/35), on the edge of the Tahakopa River, contained eight, burnt, greywacke stones. Four were flat river boulders and the rest were fractured and weathered. During the prehistoric period the site probably lay between a strip of riparian silver beech and the mixed tussock-shrubland of Stott's Clear. It was well positioned for people wishing to exploit the eels, lampreys and crayfish of the Tahakopa River and the birdlife of the tussock-shrublands on the valley floor. The site would have been sheltered from the north, west and east to some extent by the riparian forest but open to the south.

Another site (5179/15) near Pukepiko Hill, comprised two patches of charcoal and burnt stones, about 1 m across and lying about 30 cm below the turf. It was situated at the downstream end of a boggy tussock flat, which in the pre-European period was at the end of a long finger of tussock grassland extending southwest down the Catlins Valley. This site would have been more accessible from the Southland Plains than from the coast. These open fires had been built on a slightly raised levee about 10 m from the river, with a back-swamp between the levee and the hillside. The shallow falls nearby would have made the site particularly attractive for exploiting runs of lampreys and eel elvers. Relative to the grasslands upstream and to the beech forests downstream, the local mixed podocarp stands were capable of supporting an abundant forest
avifauna.

All the above sites were located near rivers with long stretches of habitat particularly favourable for adult eels, and where there were seasonal runs of whitebait, eel elvers and lampreys.

Two other sites (S179/10 and S179/16) have associated artifacts. The site at Otekura had flakes of obsidian and was near to both an isolated raised rim oven (S179/9) and to a group of ovens at Ahuriri Flat (S179/11). Ahuriri Flat was also an area of lowland red tussock mixed with shrubland, which is likely to have extended through Otekura towards the coast.

The final site (S179/16) which is near the coast at Sandy Bay, included a burnt sinker. The association of these two sites with artifacts, and the time which has elapsed since their destruction makes their incorporation in this category problematical.

It is assumed here that Charcoal and stone patches are the remains of open fires. This category, with its scatter of rounded or slab-shaped stones, can be archaeologically distinguished from the stone fireplace which is defined as a patch of ash, burnt stone and charcoal surrounded by regular-shaped, large stones placed in a rectangle, oval or circle (H.M. Leach 1972a). It would appear that though ethnographically known, the remains of open fires have not been previously distinguished by archaeologists as sites in their own right. This is hardly surprising since they are difficult to find when isolated, or to distinguish when part of an occupation site, which may also include firepits, various forms of earth ovens and their rakeout of charcoal, ash and burnt stone.
In Murihiku, isolated circular hollows each with a raised rim of throw-out material, have been found on excavation to contain straight-walled, conical or basin shaped pits, filled with oven-stones and charcoal but seldom associated with artifacts or macroscopic food remains (Knight 1966). The surface feature of a circular raised-rim with a central hollow can, on the present evidence, be confidently designated as an oven, but oval rims require investigation. This was demonstrated by Simmons' excavation of an oval pit at Glenorchy (5123/7, N.Z.A.A. Site Recording Scheme). In that particular case there were postholes within the rim and a relatively small circular pit filled with burnt stone and charcoal in the centre. In the following review, therefore, it will be held that isolated circular hollows with raised rims are ovens until excavation shows otherwise.

Forty isolated ovens distributed in eleven concentrations have been found in the study area (Appendix 4:1, Table 4:3). A further 50 isolated ovens (5179/7) were found, covering a distance of 30 kilometres, along the north face of Glenomaru Hill, through the Puerua Gorge and so along the south face of the Kaihiku Range (Rogers 1922). Other reports suggest that this line of ovens continues 15 kilometres further into Wairuna Station. They lie on a vegetational boundary zone between the 19th century Catlins Hill forests and the Southland-Otago tussock grasslands. The four isolated ovens found in the Mokoreta Valley (5170/1-4) lie in a similar vegetational ecotone. The rest of the sites are on the boundaries of pre-European tussock areas set within the forest block of the Catlins, i.e. in the Stott's and Cemetery Clear, Tahakopa Valley; the Purakauiti Clear and the Ahuriri Clear (Fig.4:2).
On excavation, the Woolshed Oven near Stott's Clear (S184/34) proved to consist of three successive oven scoops of different sizes (Fig. 4:4). The site lay on ground sloping gently to the south and was moderately exposed to the south and west. Before forest clearance it may have been sheltered by nearby stands of podocarps. During the excavation of one quadrant, the layers of the rim were stripped back to the outside edge where it met the natural turf, and the central pit was excavated down to the natural.

The re-use of the two upper ovens is suggested by the charcoal staining of the rake-out in the rim layers. The bottom oven was apparently used only once. The upper oven, scooped out of the charcoal and stone matrix of the two lower ovens, is lined with carefully packed stones. The sides of the lower ovens were formed in the natural clay, but presumably the upper scoop required the stone lining to give it shape and possibly insulation. It also contained a large proportion of fine, black, 'greasy' carbon, compared to the lower ovens.

The three nested ovens all showed different features. Each successive oven was about half the volume of its predecessor. Each was so differently shaped that the thermal characteristics must have been different in each case. The bottom oven represented a massive effort in stone collection compared to the others, even if new stones were collected for the upper ones. The top oven must have been fired in a different way or had different food cooked in it, to have produced the large quantities of finely divided carbon.

It is difficult to assess how much time elapsed
between the formation of successive pits. Any layers of silt which may have been washed down onto the surface of each oven would have been removed by the construction of the next pit. The presence of rim layers 0-10 cm thick (Fig. 4:4), belonging to the two upper ovens, would be useful if we knew that the site was an area of erosion. At present, under a turf of introduced pasture, aggradation rather than degradation is occurring. It is impossible to be certain as to which condition prevailed under the pre-European vegetation.

Isolated ovens and Charcoal and stone patches in the Catlins are situated on gentle or flat slopes, usually on river terraces and often well back from the river itself. They do not relate closely to the major river courses. This would not seem to be just a factor of differential survival, since two well-preserved sites, a slab hearth at 5104/35 and Wyndham Three Oven 5178/3, were both in positions very vulnerable to flooding. From field observations, it would seem that Catlins floods are generally moderate in their effects of silting and scouring which might lead to site destruction. There is a relationship to a minor supply of water in that all sites of both categories were within 300 m of water, and Rogers (1922) noted that the 50 Isolated ovens which he surveyed from Romohapa to Clinton averaged about 6 m from water. There is no indication that direction of slope or shelter from the south and west were regularly constraining variables in site location. Thus the Mokoreta One Oven was notably exposed to the south and west.
The most striking locational regularity of the 40 Catlins Isolated ovens and of the Charcoal and stone patches is their close association with a pre-European forest-grassland ecotone, where bird and vegetational resources would tend to be both more varied and more abundant. Bracken _Pteridium aquilinum_, which normally forms a seral community rapidly shaded out by shrub and tree species seems to be particularly persistent in this zone. At present bracken is most successful on warm, north-facing slopes where regular fires prevent recolonization by forest, but the deeper forest soils protect the bracken rhizomes from being burnt. As previously discussed (p.52), there is evidence for widespread forest fires in the Southland tussock grasslands during the prehistoric period. Bracken can be assumed to have been present as a fire-induced community of the forest-grassland ecotone.

Middens have been separated from Occupation sites mostly for convenience of comparison, but the two categories currently grade into one another. Middens contain food remains, charcoal and burnt stones, the latter suggesting the presence of oven pits, but inspection of eroding middens has not revealed any oven pits in their matrices. On the available evidence, Middens also lack post holes and burials. As exposed at the surface or on eroding edges they are usually less than 5 m across and 30 cm deep. Larger areas of midden associated with artifacts, and which may have oven pits, burials, post holes or flaking floors have been classified as Occupation sites. Destruction by fossicking and erosion has made it difficult to classify some sites such as the large
midden areas at Tautuku Point S184/20 and Long Point S184/29 (Appendix 4:1).

The numerous Midden sites (Table 4:3) are all coastal or estuarine, having been mostly revealed by water erosion. No inland Middens have been recorded. The small shell Midden of less than 2 m diameter and 30 cm depth, containing only mudsnails, pipis and cockles, should be distinguished as an economic entity of importance, and quite separate from other areas of occupation material. Within estuaries they are placed on low headlands wherever there is firm ground over bedrock adjacent to the tidal flats. Along the coast they tend to be in the most sheltered position close to the mouth of a stream.

Of the sites ascribed to this category, Tautuku Point is the most problematical, because its location at the mouth of an estuary is very similar to those of the large Occupation sites at Papatowai and Pounawea. As will be seen, the latter two were clearly major sites, since they have yielded abundant moa bone, artifacts and ovens. The absence of such occupation features at Tautuku Point may be the result of the intensive fossicking and reposition that has occurred there. Indeed the presence of at least four moa species and of four species of extinct or rare small birds suggests that the site was occupied in the earliest period of Catlins prehistory.

The facilities available for radiocarbon dating are such that dates have been obtained from only the larger Occupation sites. Moreover relative dating of the small Middens by the conchiolin method was ruled out by the rarity of the priate species (Anderson 1971). Consequently no dates have been obtained for Midden sites per se.
The chronological seriation of undated middens, based on the faunal contents is a logical outcome of models such as that of Green's, developed for the prehistory of the Auckland Province (Green 1970). The technique is applicable in the Catlins, using as the key site Papatowai Point, where a lengthy sequence has been excavated with stratigraphic rigour (see Chapter 4:3 and Table 4:8). The faunal evidence is not extensive but it is the best available. In the earliest period many species of moas were hunted, as well as two species of seals and several species of small birds. Later in the period of occupation, only one or two species of moas were hunted, seals and moas decline in numbers and fish and shellfish become more important. Clearly this technique should be used with full recognition of the environmental variables of the site, and only in the absence of more refined methods.

**Occupation sites.**

Most excavations in the Catlins have concentrated on the large complex Occupation sites (Table 4:3 and Fig. 4:1), for which a variety of sources of information is available. There is some historical material on three Contact Period sites: Murikauhaka village S179/3, its associated settlement at the mouth of the Karoro Stream S179/5 and the whaling station on Tautuku Peninsula. Lockerbie (1959) has briefly described Cannibal Bay S184/4, False Island S184/3, Hinahina S184/2 and Pounawea S184/1. Fuller excavation reports are available for Papatowai and Kings Rock in Teviotdale (1937, 1938a,
1938b and diaries for 1936, 1937, 1941: ms. Hocken Library) and in Lockerbie (1940, 1953, 1959). There is some information for Tautuku Peninsula S184/7 in Lockerbie (1959), and for Kaka Point S179/14, Pillans Head S184/26 and the Cemetery Clear S184/33 in the N.Z.A.A. Site Recording Scheme. Papatowai Point has been further investigated by an excavation carried out during this study at a position labelled TT1. Papatowai Point, which includes S184/5, S184/8, S184/9 and S183/33, is the subject of Chapter 4:2 and only comparative material from it will be discussed here.

Prehistoric Occupation sites

Tautuku Peninsula S184/7

This site on top of a sand dune on the isthmus of the Tautuku Peninsula lies within easy access of rocky and sandy shores, the sea, forests, estuary, river and wetlands (Fig.4:1). Lockerbie (pers.comm. and 1959) described the site as a black occupation layer, about 40 cm deep, containing an articulated leg of Dinornis toroa, associated with flake knives. In the layers above there were disarticulated human bones and barbed fish hooks in a matrix of shell, fish bones and sand. The date of 280 ± 60 B.P. (N.Z. 146) for the moa leg bones is anomalous since *D. toroa* is a relatively specialized moa. The moas of the later occupation period at Papatowai were *Euryapteryx gravis* and/or *Emeus crassus*. 
Kings Rock 5184/6

The location of Kings Rock contrasts with Tautuku Peninsula in that there are fewer adjacent resource zones. The site lies on two narrow coastal terraces, moderately sheltered from the sea by reefs and headlands. During storms however, waves reach up to the edge of the terrace. Rocky shore shellfish, especially paua, are abundant but at present there is very little sheltered sandy substrate for pipis. The boggy backslopes of the terraces would have been ideal sites for seals to haul out on to, protected to the landward by steep, forested hillsides.

Faunal evidence is derived from Lockerbie (1940) and Teviotdale (1938b; diaries 1937 and 1939: ms. Hocken Library). Teviotdale's diaries indicate that paua and mussel were by far the most abundant shellfish as might be expected from the modern shoreline. For the whole site Lockerbie (1940) considered pipis more abundant than the rocky shore shellfish, indicating either a change in the local shoreline environment or else transport of pipis from the Tahakopa estuary two kilometres away.

Among the vertebrates from the 1937 excavation, whale is mentioned most, followed by moa, seal, small birds and fish. The species of birds include kaka, kakapo, kiwi and New Zealand falcon, typical of present day undisturbed forests. Moa bone was fragmentary throughout much of the deposit but in one area Teviotdale records finding moa vertebrae, a sternum, the upper end of a very large meta-
tarsus, the distal end of a small metatarsus and tracheal rings, indicating that at least two moas from two different species had been eaten here. Whole moa bones were restricted to a fairly small area of the bottom layer (Lockerbie: pers. comm. 1974). In contrast Lockerbie (1940) notes that seal bones "were common throughout the deposit, (and) were found most often in the bottom layer and only occasionally in the top layer" (Lockerbie 1940:407). Teviotdale in his diaries notes that there were many seal bones in the area close to the burial and a few at the small northern deposit (Lockerbie 1940:394). As at Papatowai seal bone would seem to have been about as plentiful as moa, particularly in the bottom layer, with both declining over time. Lockerbie (1940) comments that fish bones were not plentiful, though fish hooks were numerous and the modern fish populations abundant.

While the lack of quantitative data makes it difficult to assess the economic nature of this site, there is sufficient material to indicate exploitation of the forest, shore and marine habitats.

Cemetery Clear 5184/33

The site lies in an area of about 100 hectares of lowland red tussock, three and a half kilometres inland from Papatowai Point. It is well sheltered from the west and south and lies on a north-facing spur running down to the Tahakopa River. During prehistory it would have been
surrounded by river terrace forests containing large trees of matai, miro, true totara and Hall's totara as well as rimu of particularly good quality for the region. No evidence of the site is visible but the farmer reported that he had ploughed over about 10-12 hollows with raised rims, some of which were about 1.5 m across. These are relatively small ovens compared to those in the Mokoreta Valley and to the Woolshed Oven. Artifacts ploughed up included chisel-like adzes, as well as sinkers, one of the latter being 15 cm across and made of local greywacke.

The site is within one hour's travelling by canoe from Papatowai Point and could have been provisioned either from Papatowai or by catching eels in the Tahakopa and birds along the forest-grassland edge. Canoes were locally reported as having been found in a half-constructed form in the nearby forests, but none of the reports is first hand.

A living site for canoe builders seems a likely function for this site. The presence of artifacts and the clustering of the ovens lifts this site out of the category of Isolated ovens into the Occupation site category.

Papatowai Point S184/5

This very large site is located at a junction point of resource zone boundaries, where the maximum number of habitats can be exploited from one place. Forest, river, sandy and rocky shore and the sea are all within
10 minutes walking (Fig. 4:5a). The midden material, up to 2 m deep has been deposited in the hollows of a sandy terrace and dunes about 2 m above high tide level. There are at least 10 discrete areas of deep midden on the Point, with smaller lenses of midden extending up the estuary and out on to the sea beach (Fig. 4:5). The topography and soils of the terrace and dunes were discussed in Chapter 3:2, p. 141 ff, and details are shown in Fig. 4:9 with the modern vegetation included. The terrace is about 140 m long and 45-65 m across with most of the areas of occupation placed along it (Fig. 4:8).

The data from this site will be discussed in detail in Chapters 4:2 and 4:3. Briefly the faunal material (Table 4:8) shows that there was relatively light utilization of the small forest birds compared to Kings Rock and no evidence for the exploitation of river and wetland species. The only estuarine species taken in large numbers were pipis and cockles. Moas, seals, penguins, rocky shore shellfish and barracouts were the other important food sources.

Pillans Stream S184/26

The topography of this site is similar to that of the nearby middens at Waitangi Stream and Long Point. It is placed on a coastal terrace, close under the eastern side of Pillan's Head, fully sheltered from the west and open to
the south. It is related to the same resource zones as 
Kings Rock, but unfortunately the midden material has been 
so eroded that there is no faunal evidence left. Teviotdale 
(Diaries, 13.3.37:ms. Hocken Library) found midden material, 
presumably shells, some 'chart' flakes and a neatly-made 
ring of Dentalium. There are now only two areas of charcoal 
and burnt stone, 40 x 40 m and 20 x 10 m across respectively 
with Pillans Stream beside them.

Pounawea S184/1

This site, on the end of Manuka Point, lies in a 
very exposed and vulnerable position where the Owaka River 
completes its last meander into the Catlins Estuary, and has 
suffered much erosion. Its original dimensions are unknown. 
It is adjacent to the habitats of forest, river and estuary 
and within two kilometres of the sea. The estuary includes 
both rocky and sandy shorelines. The site contains a strati-
ified midden, over 1 m in depth, extending to below the high 
tide level. The most remarkable structure consists of two 
double rows of post holes which may have been the bases of 
drying racks. The lowest set, extending from the basal black 
layer into the natural, were round in cross section and al-
most as wide as the gaps between them, both within and be-
tween the two rows. The second double row, running at a sharp 
age to and across the first, was of smaller posts, and some 
at least had been dug down from or through the middle layer 
(Lockerbie:pers. comm. 1975). Whatever the posts were used 
for it seems to have been a repetitive function of Pounawea,
carried out both in the early moa-hunting period and in the middle period when moa hunting was declining.

There are more extinct species of small birds at Pounawea than at Papatowai (Table 4:8 and 4:12). It seems significant that only the Pounawea faunal list includes the extinct goose and extinct swan, and that only the Catlins Estuary widens into a shallow tidal lake. The other estuaries are essentially river channels with small areas of wetland.

In his account of the Pounawea material Lockerbie (1959:82-85) notes that in the bottom layer, dated to $810 \pm 60$ B.P. (N.Z. 58), there is evidence that "the Moa-hunter's diet consisted principally of moa flesh, with some seal, whale, fish and bush and shore birds. Few shellfish were eaten." In the succeeding layers moa becomes more scarce though it is still available in the uppermost layer dated to $290 \pm 60$ B.P. (N.Z. 54). The diet in the final phase of occupation consisted "principally of shell-fish, fish, seal and small birds." (ibid:84)

Although the description of the Pounawea material implies that seal bones were less plentiful than moa in the lowest layer, Lockerbie (pers. comm. 1975) considers that without a count of minimum numbers this cannot be determined. It would be safe to say only that there was much moa and seal bone in the lowest layer, the moa bone declining in the upper layers but the seal bones continuing to be numerous.

Hinahina 5184/2

The environment of Hinahina is similar to that of
Pounawea except that it is further from the sea by half a kilometre. The site lies on a low lake terrace at the base of a wide sand pit, Cabbage Point, across the lake from Pounawea. It is even more open to the west than Pounawea but better sheltered from the south. A basal black layer containing moa bone was dated to $740 \pm 75$ B.P. (N.Z. 53) with a shell layer above. Trees growing above the midden material are greater in trunk diameter than those on Papatowai and Pounawea. Lockerbie (1959) gives a date of 1715 A.D. for the commencement of tree growth at Hinahina. A grab sample of faunal material taken from the upper levels of an eroding midden beside Lockerbie's excavation contained a large proportion of mud snails (Table 4:12) which are abundant on the adjacent mud flat. There was no moa bone visible in this upper layer.

Cannibal Bay S184/4 and False Island S184/3

The sites in this area are adjacent to the sea, forest and to a richly varied rocky and sandy shoreline. There are not only several middens in the sand dunes of Cannibal Bay and on False Island but there is evidence of a large burial site in the southern corner of the Bay, as well as an area of naturally deposited moa skeletons on the southern side of the False Island Isthmus (Fig. 4:7). Hector (Hocken 1892) was the first to find human bone at Cannibal Bay and gave it its name after his survey in 1863. The burial aspect of the site S184/4 has already been discussed in this chapter. The midden material, which is now all redeposited, lies in three large wind deflation hollows, sheltered on all sides by dunes rising 20 m above the present level of deposition.
Lockerbie (1959) considers it was occupied late in the period of active moa hunting, but its function was more that of a fishing camp. Dated to $450 \pm 50$ B.P. (N.Z.147) this ties in well with Lockerbie's dates of declining moa hunting at Papatowai and Pounawea. Faunal material (Table 4:12) shows exploitation of moas, seals, forest and shore birds and the same seven species of fish found at Tautuku Point.

Boyce (pers. comm. 1971) reports ten sites on and near False Island where he has seen occupation material or moa bones (Fig. 4:7). A site on the western shore (S184/3 in Fig. 4:7) yielded midden material, cut bone, broken fish hooks, attrition saws and sinkers (M.Trotter: pers.comm.). Dates for unspecified sites on False Island range from $470 \pm 60$ B.P. (N.Z.141) to $215 \pm 50$ B.P. (N.Z.143) (Fergusson and Rafter 1959).

Kaka Point sites

Sites along the coastal terrace from Port Molyneux to the Nuggets were adjacent to the particularly rich fishing grounds of Molyneux Bay. Stretches of rocky shore alternate with moderately sheltered sandy bays facing north, and during prehistory forest rose up the hillsides behind the shore. The mouth of the Clutha River has changed greatly during the Historic Period but there were probably always some areas of wetlands with abundant waterfowl. Intertidal mudflats may have been more extensive before the silting up of Port Molyneux. The river and estuary could have been effectively exploited from Murikauhaka.
In most of the small middens between Port Molyneux and the Nuggets shellfish and fish bones predominate. The two midden areas with claim to early moa-hunter status are the site below Murikauhaka (5179/3), excavated by George (1944) and a site lying south of Kaka Point township (5179/14). The only information on this latter site comes from Lockerbie (pers.comm.1972) who reported charcoal, burnt stone, moa bone and some artifacts e.g. a drilled tab for a fish hook. George (1944) found three layers at Murikauhaka:

1. A top layer of 30 cm of beach sand, shell, fish bones and fish scales. No artifacts. This could be associated with the settlement at Murikauhaka which Morrell described where the only gear mentioned was "a few bags or baskets containing fishing gear and other trifles" (McNab 1907:264).

2. A middle layer of 15 cm of sand, midden shell, burnt oven stone, fine ash and artifacts. The shells included oysters which are rarely recorded in Otago middens. The artifacts included large silcrete flakes but the only moa bone was three worked tabs. The other artifacts were worked pieces of stone, one broken adze and two pieces of worked bird bone. The only unworked faunal material seems to have been the lower jaw of a seal or dog.

3. The bottom layer consisted of hard pebbly beach sand, lying on clean sand and gravel, and contained
surprisingly a considerable collection of moa bones (25 femora, 1 metatarsus and 2 vertebrae). All the artifacts recorded were obsidian flakes, five of them described as knives.

This material came from two trenches - 9 m long, 1 m wide and 0.6 m deep, dug in Jan 1937. George considered that the site covered three acres but in this he may have been including the Contact Period village.

George (1944) also excavated an oven dug into low sand dunes between Kings Creek and Karoro Creek S179/17. The oven was circular, 1.5 m in diameter and the only surface indication was an area of burnt stones lying on the sand. The oven contained burnt stone and close beside it were the skull, lower jaw and other bones of a human body (see Burials and Table 4:11). Artifacts found nearby were moa bone tabs, the blade of a rough beater, a worked pebble, two hammer stones, three rough silcrete flakes and several obsidian flakes.

**Discussion**

The inland sites raise some interesting problems, in particular the function of the ovens and open fires. Isolated ovens occur throughout Murihiku. Knight (1966) presents ethnographic and environmental evidence to suggest that the large, Otago Peninsula ovens were designed for cooking the stems and rhizomes of the cabbage tree *Cordyline australis*. He was unable to demonstrate this directly by tests of the oven contents, but the circumstantial evidence is persuasive. The Catlins ovens are situated in a vegetational zone suitable for cabbage trees, but only the largest,
Simpson's Oven, is comparable in size to the umu-ti, and excavation would be necessary to isolate other diagnostic characteristics. The Woolshed Oven (Table 4:1) lacked the fired clay found in the rim of umu-ti and was clearly fired at a lower temperature.

There is certainly no reason to assume that all the isolated Catlins ovens will have bowl-shaped pits like the Woolshed Oven, that all were used for cooking the same kind of food or even that one oven was used consistently for the same purpose. Indeed, one hypothesis to account for the variability of bowl-shape in the Woolshed Oven is that the three structures were used successively for cooking different foods. The size differences between the Catlins and Peninsula ovens could also be associated with the number of people making the oven, with the hardness of the substrate, with the type of digging implement used and with some other behavioural factors, alone or in combination. The hypothesis that all the Catlins ovens were umu-ti can be rejected on the grounds of their small size and in the case of the Woolshed Oven, its different structure. The hypothesis that some of the Catlins ovens were umu-ti however, has not yet been falsified.

All Isolated ovens and supposed open fires in the Catlins lie close to a forest-grassland boundary of the immediately pre-European vegetation. There is no evidence for the location of these sites within the forest block as defined at the time of European contact, though ovens were seen by Roberts (1895) "in all parts of the plains" of the Mataura catchment in 1856. The position of the forest-grassland ecotone during the thousand years of prehistory
must have moved as the forests of the Southland plains were reduced by fire. It could be argued that the Catlins ovens may have been established at a period when their environs were under forest. This is unlikely for two reasons. The ovens are still intact and their surface features clearly delineated. If they had been built within the forest the rim and hollow would have been rapidly overgrown and at least partially destroyed, particularly during the subsequent process of forest clearance. Secondly none of these isolated ovens has been found in the areas which, judging by the forest composition, have been continuously under forest throughout the last thousand years. They are not found in the present day forests or in places where forest has been recently cleared.

In the Tahakopa Valley the sites of open fires are closer to the river channel than are the isolated ovens (Figs. 4:2 and 4:3). More than one hypothesis could explain this pattern. The open fires could have been places of day to day living, providing heat and a place to cook the day's food. The larger isolated ovens could have been in use at the same period for processing larger quantities of food for storage and removal by a seasonally mobile group (H.M. Leach 1969, Bathgate 1969, Higham 1969). Again, the isolated ovens on the drier terraces may have been preferred sites in wet weather, and the open fires on the boggy flats preferred during dry weather. The difference may also have been chronological, the open fires now beneath 30 cm of silt being early and the ovens with their surface features still well defined being late.
An understanding of these inland sites is an important facet of Murihiku prehistory, in that they represent a considerable economic effort and expenditure of energy by prehistoric populations. The imaginative development of hypotheses and of refined methods of analyses will be needed to solve problems of function and season of use. Wide plan excavation to reveal living areas and the use of flotation to extract micro-remains such as seeds, land snails or eel scales are obvious approaches. There is also a need to explore, with the use of micro-biochemical techniques and infra-red spectroscopy, the possibility that quite specific break-down products of species cooked over these fires may still exist adsorbed on to the charcoal in the sites (Tite 1972).

Evidence of occupation in or close to the Stott’s and Cemetery Clears could be used to support the argument that the clearings are the result of, and hence post-date, the first occupations. Evidence suggesting that these clearings may be of natural origin is presented in the section on present day temperature regimes in the Catlins (Chap. 2:1 p. 30), and in the section on pre-European vegetation (Chap.2:2 p.43). It is however of interest that no traces of occupation have been found along the river terraces of the Tahakopa away from these clearings.

How were the inland and coastal sites related at different periods in prehistory? Distribution of stone materials, particularly of silcrete, has been used by Bathgate (1969) to demonstrate the integration of inland Murihiku quarry sites with coastal moa hunting sites in the
early prehistoric period. He argues that the volume of material involved indicates movements of communities rather than a pattern of trade between communities. It seems probable that the distribution of the 'porcellanites' of Central Otago and the Southland Plains will demonstrate a similar pattern (G. Mason: pers. comm.).

Any unifying model of Catlins prehistory must integrate the inland and coastal sites chronologically. The most striking characteristic of the coastal sites is the gradual change in economic base throughout the prehistoric period. The deeply stratified sites of Pounawea and Papatowai demonstrate a reduction in the number of species exploited. There is a change from an economy exploiting eight large herbivores (moas) and two species of seals to one exploiting mostly smaller animals, i.e. penguins and fish with a few seals. The model must account for this gradual change but allow for the discontinuities of stratigraphy at Pounawea and Papatowai. The relevance of these discontinuities will become apparent in the discussion of Papatowai (Chap. 4:2). Judging by the ethnographic evidence the emphasis must be on mobility rather than on sedentism and on extensive rather than intensive exploitation of resources. A detailed analysis of Papatowai and a discussion of the relation of sites to environmental factors must be considered before the construction of a settlement model can be undertaken.
Chapter 4:2

Occupation Sites on Papatowai Point

South Island prehistory, for the last 25 years, has been based largely on evidence from the deep, stratified sites of Papatowai and Pounawea. Neither was excavated with good stratigraphic control of all material and much of the available data are still in field books and diaries. The detailed study of this material, which forms the basis of this chapter, was undertaken because of the importance of the two sites. Papatowai Point which is the larger and better documented, comprises a series of discrete middens. Particular attention will be paid to the correlation of the many distinct layers in the different middens. The assumption is made that layers with similar matrices, contents and similar relative positions in the sequence represent a particular set of economic strategies and may well be of similar date.

The sites on Papatowai Point are described in several archaeological publications including three papers by Teviotdale (1937, 1938a, 1938b), two by Lockerbie (1953, 1959), by numerous references in other papers including Hjarno (1967), Duff (1956) and Simmons (1967), as well as many entries in Teviotdale's diaries (ms. Hocken Library). Teviotdale carried out extensive excavations from 1936 to 1938, often with Lockerbie's help, and Lockerbie organized two excavations in 1941 and 1956. The author undertook an excavation in 1971.

Teviotdale was principally concerned with retrieving
artifacts (H. Leach: 1972b), though he also collected many moa bones and made daily records of his excavating. His methods however resulted in the loss of much information and his three Papatowai papers are only summaries of his diaries. Lockerbie retrieved more information from excavations in 1941 and 1956 but his interests were still fairly limited, in that he wished to establish a history of Polynesian settlement in the Catlins, using artifacts and changes in major food resources as 'labels' for the various levels from site to site. He overlooked the inter-relations of the sites as part of an economic system. Neither worker recorded the accurate location of bone material. Both noted the decline in the abundance of moa bones from the lower to the upper layers, and the correlated increase in shell and fish remains. They neglected the opportunity to ascertain the order of disappearance of the different moa species. Some precautions would have been necessary to avoid recording fragmentary and re-used material in the upper layers as indicating the presence of live birds, but with care the information was available.

In 1971 two major approaches to the Papatowai site were available - re-analysis of the excavated material and further excavation. Evidence available from previous excavations consists of the published reports, Teviotdale's diaries, artifactual material deposited in the Otago Museum and a very large collection of burnt and broken moa bones. From Teviotdale's diaries it is possible to reconstruct areal differences and similarities in stratigraphy, some details of artifact distribution and occurrence of major faunal groups such as
moas, seals and shellfish. Teviotdale recorded this material, using a dichotomy between an upper shelly layer and a lower black one rich in bones. In several places he noted the existence of an intermediate, brown sandy layer. He recorded anatomical bones for the moa only. Occasionally, common shell species were listed as they occurred. The daily record of bones, shells and artifacts provides vertical associations of material but, with some notable exceptions such as the position of greenstone objects, recording by layers is inadequate. It is seldom possible to associate specific bone and artifact material in the Otago Museum with any of the references in the diaries. It was hoped that even a limited excavation might provide a framework of provenanced data which could help elucidate previously excavated material.

Excavations by Teviotdale and Lockerbie

A three-layer model of cultural change in Catlins prehistory developed from Teviotdale’s excavations in 1937-38 and culminated in Lockerbie’s major synthesis (1959). It incorporated a black layer representing moa hunting with a varied kit of adzes, many of them massive and skilfully flaked, unbarbed fish hooks, large silcrete blades and ulu-type knives (Skinner 1974:115); an intermediate layer with an ashy matrix showing a decline in moa hunting and changes in the proportions of artifact types; and a top layer with barbed fish hooks, fewer and smaller flake knives, little evidence for live moas and abundant shells and fish bones. Some sections at Papatowai and one at Hinahina had more than three layers (Lockerbie 1959:94) but Lockerbie does not
position the extra layers in the three-layer model.

Teviotdale described the layers of each section at Papatowai Point (Teviotdale 1937, 1938a, 1938b), but made very little attempt to group them between excavations. He tended to emphasize the Black component and the Upper shell component (see Appendix 4:4), and to note differences between them. In reinterpreting Teviotdale's and Lockerbie's material, Lockerbie's construct of three levels was initially set aside. The sequence for Papatowai was built up by establishing the equivalence of given layers from different sections to form components, and then interleaving the components to form the Papatowai sequence (Fig. 4:11). This is an uncertain process, dependent on finding common characteristics which will allow layers to be equated. Possibly, as Braidwood and Howe (1960:39) found at Jarmo, there will be several possible sequences.

The material on Papatowai in Teviotdale's papers and diaries will be interwoven to form a single narrative. In most cases the source of information is acknowledged, but where both the diaries and the papers are used in one sentence only the major source is cited.

Teviotdale dug in at least ten areas (Fig. 4:8), which seem in most cases to have been separated from each other by relatively sterile sand. The group of excavations in Areas 1 and 2 of Fig. 4:8 at Lockerbie's 1941 and 1956 sites and through to Teviotdale's TTA area are probably linked, at least in the upper layers. Even in TTL, the area dug during this study, the bottom black layer was present in only one of the two squares examined. The impression given by
Teviotdale and Lockerbie of discrete areas of occupation
material is thus supported by the TTL evidence.

Teviotdale's description of the Papatowai stratigraphy
was based on Area 1. "The deposit consists of a layer of
cockle- and pipi-shells about two feet in depth, then a
layer of black greasy soil containing oven-stones and ashes,
below which is clean seashand" (Teviotdale 1938:137). The
text is accompanied by an informative section drawing and
caption, showing the layers described above and also a second
15 cm shell layer below the black layer, divided from it by
15 cm of clean sand (Fig. 4:10a). The caption states that
both the top and bottom shell layers contained two moa pelves
each, and that tracheal rings, vertebrae and phalanges occurred
in all layers. There were more moa bones in the black
layer than in any of the others.

On the north-east side of the excavation, Teviotdale
reported a thin layer of sand between the upper shell layer
(Fig. 4:10b) and the black layer (Teviotdale 1937:139).
The faunal remains of the upper shell layer (Table 4:13, Area
1 US) included non-industrial moa bone in the form of pelves,
ribs, vertebrae, tracheal rings and phalanges. It is apparent
that moas were still being hunted in the late period when
the upper shell layer was deposited, although the species are
not recorded. Moas seem to have been abundant in that
Teviotdale reports finding 18 pelves in a space 3.7 x 5.2 m
(Teviotdale 1937:138). The remains of dogs, small birds and
fish were more abundant than in the black layer, the fish
including jaws of golden snappers. Artifacts were also
apparently more numerous. The upper shell layer is interpreted
as an example of the Upper shell component (Table 4:14), and the black layer, of the Black component. The most obvious characteristic of the latter is its black colour, which is assumed to be the result of an intensive type of cooking, not carried out in subsequent layers.

There was relatively little material from the black layer in this area. It is described as a black greasy soil (sic) containing ovenstones, ash and the same anatomical bones of moas as in the upper shell layer, but in larger numbers. Elephant seal is represented by two lower jaw bones at the bottom of the black layer (Table 4:13, Area 1 BL). No shell material was mentioned. Away from the river bank in Area 1, there was quite an extensive area of the Black component containing only oven stones, charcoal, sand and the fine black carbon so characteristic of early moa hunting layers. Teviotdale (Diary entries 15–18 Jan 1936: ms. Hocken Library) recorded an absence of bones in this area despite working there for three days.

On the surface of the black layer, Teviotdale (1937) described a hard, packed floor with numerous bone artifacts (Table 4:13, Area 1 WF). The ulu found was semi-circular, polished and well-made in a fine black basalt (Teviotdale 1937:Fig.26). This bone-working floor represents either a period of time between the Black and Upper-shell components or the terminal part of the Black component. At present it will be set up as the Working floor component, lying between the Black and the Upper shell components.

A thin lower-shell layer, separated from the black layer by 15 cm of clean sand is regarded as an earlier com-
ponent (Fig. 4:10a). It will be designated as the Lower shell component.

In Area 1a (Fig. 4:12; Table 4:13, Area 1a) there was an upper shell layer 30-45 cm deep with much ash. Below the shells there was a thin black layer containing 13 adzes, 8 of them small and 5 flaked but not polished (Teviotdale's diaries 1937:ms. Hocken Library). Some of these adzes lay on top of the black layer, which suggests that the Working floor component extended as far as Area 1a, i.e. almost out to the river bank.

Detailed consideration must be given to the most complex section recorded at Papatowai Point. This comes from Lockerbie's second excavation in 1956 (Lockerbie 1959) and lies inland of Teviotdale's Area 1a (Fig. 4:8). The stratigraphy is very different from that of Area 1 (Figs. 4:10d-e). The only material published on it is a drawing and photograph of one section (ibid.:84 and Plate II), a photograph of another (ibid.: Plate Ib), the film 'The Moa was Radioactive' (New Zealand Film Unit, colour, 1962) and notes with the C14 dates (Fergusson and Rafter 1959). Plate I (Lockerbie 1959) shows the upper part of the drawn section (ibid.: 84) with a moa tibia dated to 1490 ± 50 a.d. within a dark layer which as will be seen cannot at present be assigned to any of the previously described components. The two sections are similar in stratigraphy for the lower four layers which are, from the bottom, a thick grey ash layer, a shallow black layer, a sandy shell layer and a thick dark layer. In the drawn section (Fig. 4:10d), above the dark layer there is a thick lens of shells, a layer of very white sand and then about 75 cm of
root-filled humus. In the second section (ibid: Plate Ib), there is only a root-filled sandy humus above the dark layer. As in Lockerbie's 1941 excavation, the shell layer has apparently run out.

Though it is thus possible to correlate the two sections of Lockerbie's 1956 excavation one with the other, there are only radiocarbon dates (Table 4:17 and Fig. 4:13) and matrix colour available to cross reference the 1956 excavation with other excavations. Except for a tibia of *Euryapteryx gravias* in the dark component, there are so far no published faunal or artifactual data for this excavation. Interpretation of the radiocarbon dates and matrix colours is not straightforward and at present, rather than merge the 1956 material in the general sequence, it will be set up here in its own sequence. It will be referred to subsequently as the '1956 sequence', and consists of the following components:

- Upper humus component with charcoal, ash and shell,
- Sand and shell component (in only one section),
- Dark component,
- Scattered shell and ash component,
- Black component,
- Grey ashy component.

By comparison the general sequence as established so far, consists of:

- Upper shell component,
- Working floor component,
- Black component,
- Lower shell component.
It is worth noting that the Hinahina section drawing (Lockerbie: 1959:84) shows a charcoal and sand layer below a black layer dated to 1210 ± 75 a.d. It is probably misleading to equate the Hinahina layer of charcoal and sand with the Grey ash component of the 1956 excavation at Papatowai, and these with the Lower shell component of the general sequence. There are too many dissimilarities hidden by such a grouping.

In 1941 Lockerbie undertook a stratigraphically controlled excavation beside Teviotdale's Area I. He described four layers (Fig. 4:10c) with the following characteristics in chronological order: "an intermittent layer of fairly clean shells", "black greasy material", "dusty ash-like material" and "the upper...shell layer" (Lockerbie 1953:13). He listed the artifacts of the three upper layers, referring to them as the lower, intermediate and upper, and so presumably there were no artifacts in the lower shell layer, which in fact was not mentioned again in that publication. Lockerbie listed for the lower, intermediate and upper layers 41, 18 and 14 artifacts respectively. Unlike Teviotdale, who worked in the adjacent areas he did not find that his shell layer was richer in artifacts than the black layer. Teviotdale's assessment was subjective and Lockerbie's quantitative; but Teviotdale was working over the hollows and Lockerbie over the sandy ridge (Fig. 4:8). On the other hand the discrepancy may arise from the definition of the two layers at their boundary. Lockerbie does not describe the faunal material of the layers except to say that moa metatarsi and vertebrae were numerous but moa bone generally was not as abundant as in the gullies.
on either side of his site. He emphasizes that he confirmed Teviotdale's findings on the association of man and moa (Lockerbie 1953:29), so presumably non-industrial moa bone was present in all layers.

Lockerbie's artifactual material is summarized in Table 4:13. The most notable feature is the amount of fish hook working in the lower layer. The concentration of 20 tabs close together were found where the lower layer was only 20 cm deep over the sandy spur where it rises slightly towards the edge of the river. The upper layer was not present here. This area is no more than eight metres from the bone area of the Working floor component in Area 1. If most artifacts were deposited during the period of the Working floor component, they could have been trampled into the upper parts of the black layer and in other areas scuffed up into the base of the single ashy-shelly layer which Teviotdale recognized above the black layer.

Lockerbie (1953) definitely adds to the characteristics of the Black component more flake tools of porcellanite and silcrete, one unit of a reel necklace and fish hook manufacturing implements such as tabs of moa bone, pieces of fish hooks and the filing, grinding and polishing stones for working them.

Of the rarer diagnostic Moa-hunter (Lockerbie 1953, 1959) or Archaic (Golson 1959) artifacts, Lockerbie found an ulu in the intermediate layer and a reel necklace unit in the lower layer. Teviotdale had found an ulu on the bone-working floor of Area 1 less than five metres away from the
position of Lockerbie's ulu. Though rather different in cross-section and material, these are the only two ulu-like objects recorded for Papatowai, and both come from stratigraphically congruent positions in their sections.

In cross-correlating layers, Lockerbie's intermittent layer of 'fairly clean' shells is here equated with the lower shell layer seen in Area 1, on the basis of the nature of the matrix and of its position immediately below the Black component. The black layer in Lockerbie's excavation can be safely assigned to the Black component. It is suggested that the ashy layer belongs to the Working-floor component, leaving the shell layer to be placed in the Upper shell component on the grounds of position and matrix. If the latter is accepted then the Upper Shell component is not continuous over all parts of the sandy spur under Lockerbie's excavation.

Teviotdale did not distinguish an ashy layer but he does mention the presence of ash in the shell layer of Area 1a. Presumably he merged Lockerbie's ashy intermediate layer with the Upper shell component.

When Teviotdale moved to Area 2 he traced the continuity of the Upper shell layer across to that in Area 1, but there is no clear evidence that he traced the continuity of the black layers. A ridge of sand lies between Areas 1 and 2 and the black component may have lensed out against it. The black layer in Area 2 filled up a roundish hollow (Fig. 4:8) about 1.5 m deep. The deepest part of the gully underneath Area 1 was 2.1 m deep. The largest moa and seal (sea lion ?) bones were found in the bottom of the black layer.
and again the shell layer held most of the artifacts - three fragments of adzes in particular are provenanced to the shell layer, together with numerous moa bones and seal bones.

It is safe to assign the black layer and shell layer of Area 2 to the Black component and to the Upper shell component respectively. The only new characteristic is that large moa species and large fur seal or sea lions may be more common close to the bottom of the Black component.

Teviotdale found only one small fireplace, which was near the river in Area 2. One large silcrete flake and a well-made fish hook of moa bone were located nearby. In his diaries, Teviotdale describes the fireplace as a heap of ashes without mentioning whether or not they were surrounded by stones. He had described circular and rectangular fireplaces at Shag Point, Waitangi (Waitaki River), Little Papanui and Hyde (H. Leach 1972a), and presumably a fireplace in his terminology was a heap of ashes enclosed by a regular arrangement of large stones.

Teviotdale extended Area 2 into IIc (Fig. 4:6). Without provenancing to layer he listed the bones of each day's digging in such a way as to suggest that seals were about as numerous as moas (Table 4:13, Area IIc X1-X4). This association is referred to throughout Teviotdale's notes, but particularly for this region of the Point. He gives no stratigraphy for Area IIc except that the deposit was less than 60 cm in depth; and no further characteristics of components can be derived from it with any certainty.

Late in 1937, Teviotdale (Diaries 30.11.37:ms. Hocken
Library) excavated under the Sand Road close to Areas 1 and 2. Again no stratigraphy was given and the precise location is unknown. The artifacts (Table 4:13, Area 1-2) of grinding and polishing stones and fish hook material is appropriate for an area close to the bone working part of Area 1, but nothing can be deduced from this evidence to add to the characteristics of the components.

The closest site to this central complex of Areas 1, 1a, 2, IIc and Lockerbie's excavations is Teviotdale's Area 4 (Teviotdale 1937:140). This was a shallow deposit of shells overlying a black sandy deposit with shell lenses (Fig.4:10j). The artifacts (Table 4:13, Area 4) included a flattened and pointed seal bone which Teviotdale interpreted as a 'maripi'. The black layer can be safely assigned to the Black component and the shell layer to the Upper shell component of the general sequence. The association again of seal and moa bones is worth noting.

From excavating the very small site of IIIb near Area 4 (Fig. 4:8), Teviotdale reports a few inches of shell over about 12 inches of discoloured sand (Teviotdale's diaries 3.12.37:ms. Hocken Library). The moa bones (Table 4:13, Area IIIb WF) included metatarsi of two different species of moa. A small polished triangle of greenstone was found in the discoloured sand, i.e. in the Working floor component. Teviotdale also found three greenstone adzes on Papatowai Point, two of them from this same component. There was no black layer but a thin layer representing the Upper-shell component was present.

The area excavated during this study at TT1 will be fully discussed in the next chapter but sufficient evidence
will be presented here for comparison with the other excavations on the Point. Apparently the site lies near the head of a shallow gully which has been filled with midden (Fig. 4:8). The upper shell layer is complex, with several lenses of shell and ash (Fig. 4:12), and is associated with three ovens of different sizes which have all been dug from it. The middle layer consists of discoloured brownish sand and the black layer is present in only one of the two squares of the excavation. As indicated by the excavation at IIIb, the black layer is not continuous on this part of the Point. The layers of TT1 will be assigned to the appropriate components after consideration of area TTA. The faunal material (Tables 4:8 and 4:13) illustrated the decline in numbers of moa species and the increase in fish and shellfish shown by other excavations. There was a much greater range of fauna in the black layer than in the upper layers. The commonest artifacts throughout were flakes of fine black tuffaceous and metamorphosed rocks, followed by porcellanites and a few flakes of silcrete.

As has been noted before for Murihiku, artifact types change very little over time, but proportions of types between layers tend to change. Teviotdale does not give sufficient quantitative data to show this sort of change effectively except for some indications for porcellanite flakes, which he describes as few in the black layer. His assessment was confirmed by the evidence from TT1 where the numbers were:
Black layer - 2 (4%)
Brown sandy layer - 32 (63%)
Upper shell layer - 17 (33%)

It is striking that TT1 retained its character as a porcellanite flaking area throughout the Working floor and Upper shell components.

Teviotdale continued work at TTA (Fig. 4:8) in November 1937, an area not described in the published papers at all. The occupation material was shallow throughout, but Teviotdale found here the greatest concentration of bones in a small area that he had seen. Close examination of the diaries suggest strongly that stratigraphy consisted of an upper shelly layer with an oven dug down from it, a discoloured sandy layer and at least under the oven, a shallow bone-filled layer (Fig. 4:10f). In the black layer seal bones were most numerous, followed by penguin and then moa bones. Though apparently only a small area, it contained three moa pelves (Table 4:13, TTA). Most of the flake material found was 'on the outside of the layer' containing the bones (Teviotdale's diaries 24.11.1937:ms, Hocken Library). The greenstone adze found was of a simple Duff type 2A shape, judging by Teviotdale's drawing.

It is easy to correlate the two black layers in TT1 and TTA with the Black component of previously described sections. The artifact-rich, brownish, sandy layer above the black layer of TT1 correlated with the discoloured sandy
layer of TTA containing numerous flakes and a greenstone adze. The artifactual material and the position of this layer at TTI and TTA can be used to correlate it with the Working floor component of Areas 1 and 1a. If this is accepted, the Working floor component can now be seen to contain an adze-using area near the river bank, a bone-working area further inland and an area of stone flaking and use, especially of porcellanite, further inland again at TTI and TTA. As can be seen from Fig. 4:8, all these parts of the Working-floor component lie in or beside the long gully running back from the river bank and following the curve of a high sand dune to the east. The Upper shell layers of TTI and TTA fit the Upper shell component of the general sequence.

Moving away from the central group of excavations there are four known excavations on the terrace to the west - areas IIb, IIe, 3 and IIId. As mentioned before, IIId will be described in association with the other peripheral sites of JP and SP.

The small site of IIb lay roughly between TTA and Area 3 (Fig. 4:8). No stratigraphy was given and the deposit was only 45 cm deep (Teviotdale 1938a:28). There were seven individual moas belonging to two different species, and in some places half the bones were seal (Teviotdale's diaries, 2-3 Feb 1937:ms. Hocken Library). The material is closer to the middle sandy Working floor component, rather than to the Black and Upper shell component.

In January 1937, Teviotdale excavated at the site IIe (Fig. 4:8) and published it very briefly (Teviotdale
This was a very shallow sandy layer close to the river bank, with a small deposit of ashes. The faunal material is very similar to that of IIb a few metres inland, but this site is much richer in artifacts (Table 4:13, Area IIe). Though there is no stratigraphic relationship with a black layer or an upper shell layer, the sandy, ashy matrix, the numerous porcellanite flakes, tabs and bone manufacturing tools, numerous adzes and a thin greenstone adze or scraper suggest that this site in toto belongs to the Working floor component.

Area 3 (Teviotdale 1937) was a large excavation in an ancient hollow in the terrace, further west again from the previous sites. It had a stratigraphy similar to part of TTI where the black layer was missing. Area 3 contained a single shell layer up to one metre deep. Below it there was an intermittent layer, occasionally separated by 15 cm of clean sand (Fig. 4:10g). The shell layer contained only 'industrial' moa bone. The lower layer contained moa pelvises, vertebrae, 2 skulls, 2 mandibles, egg shell and what appeared to be moa droppings. Unfortunately Teviotdale does not describe the appearance of the latter. The eggshell was in four patches, each approximating to one whole egg. One patch contained pieces which, when placed together, showed that a hole about 10 mm in diameter had been bored in the wider end. Seal bones were so numerous in the lower layer that in places they made up half the bones present. The lower layer has far fewer artifacts than the upper one, but it can still be readily equated with the Working floor component, particularly
through the presence of numerous flakes of porcellanite. This site adds evidence of heavy seal exploitation to the latter component, a point not shown by other excavations.
The shell layer of Area 3 can be equated with the Upper shell component of the general sequence and, as might be expected, shows that this component extends into a period when moas were scarce or extinct, but their bones were still being extensively used for manufacturing, particularly of fish hooks.

Three peripheral occupation areas, IIJd JP and SP (Fig. 4:8), are difficult to place in the general sequence. IIId is situated on the edge of the river bank immediately north west of Area 3. Teviotdale worked in this deep shell midden in February and March of 1937 (Teviotdale's diaries 8 Feb - 16 Mar 1937, 11 Nov 1937:ms. Hocken Library; 1938a: 29). The material lay on the sloping edge of the present river bank and appeared to have been thrown over a steep sand bank, presumably the old river edge, a finding which supports the previous conclusion that the river channel has been stable until very recently. The deposit was 18 m long, 6 m wide and up to 1.5 m deep in places (Fig. 4:10h), dwindling to 15 cm up the slope. Teviotdale does not describe any layers, but presumably these would be almost vertical if present and difficult to distinguish in the loose shell and sand of the matrix. With the notes for 15 Mar 1937, Teviotdale gives a section drawing, showing one thick, flat, even layer containing shells,
bones and a large adze, with sand above and below. The drawing is obviously an abstraction in that it does not match the text.

Teviotdale found moa pelves at the very bottom of the deposit and four small pelves close under the tree roots near the surface. Alongside the upper pelves among the tree roots he found a well-finished adze, Duff type Id in form, which is typologically early (Teviotdale 1936a:Fig. 2). These data suggest that stratigraphy may have been roughly as in Fig. 4:10h, but a second interpretation will be given when sites JP and SP are discussed.

Data lists from four consecutive days of excavation (Table 4:13) are relatively similar, though the first list (581) is of material from only the deepest part of the midden at the foot of the bank. There is a close association of moa and seal bones throughout, large seal bones (sea lion?) being frequently mentioned. The paucity of porcellanite flakes, the large and small moa pelves together and the large seal bones suggest that the materials might belong to the Black component but there is no mention of fine black carbon. Certainly it is improbable that this pattern of data would belong to the other two components.

The artifacts point to bone manufacture, especially of fish hooks, with some use of adzes and of hammerstones for flaking the small amount of porcellanite. These characteristics are suggestive of the Working floor component, and the abundant shells of the Upper shell component. The position of this material will be further discussed when the JP and SP sites have been considered.
The last two known sites on Papatowai Point are on the dunes behind the terrace (JP and SP in Fig. 4:8). JP was excavated between 12.11.37 and 22.11.37 (Teviotdale 1938b:114-5). The occupation material which lay in a narrow gully running north-west to south-east for about 75 metres, was about two metres in width and up to one metre deep. For the south-east end Teviotdale describes the stratigraphy as 45 cm of shell and moa bone above 30 cm of clean sand, below which was a thin 8 cm layer of dirty sand with oven stones and a very few shells (Fig. 4:10i). Throughout the rest of the deposit Teviotdale describes the material as a layer of shells with moa bones, the shells and bones being thoroughly intermixed. On 17.11.37 Teviotdale (Diaries: ms. Hocken Library) describes two fragile moa pelves lying on the sandy bottom covered and surrounded by shells. Since no species are mentioned, it is likely that the shells were of the two commonest species, pipis and cockles. There is no mention of fine black material among the shells though from the faunal material, it could be expected.

The moa bones included 11 pelves, five of them close together, and numerous broken leg bones, some of which may belong to the moa species Dinornis maximus. Moa phalanges were numerous, 93 being found in one day's digging. Most of the tabs of worked moa bone were together in one place. All but two of the porcellanite flakes were associated with a group of silcrete flakes and a scraper. Artifacts other than flakes could all be associated with fish hook manufacture. For a deposit of this size the artifacts recovered seem very sparse. Teviotdale associates the two oven depressions
on the ridge to the south with the deposit in JP but only an intermittent thin layer of material down the slope between the two links them stratigraphically.

It is difficult to place this site in the general sequence, and there is insufficient information to place the JP material in the 1956 sequence.

The high proportion of shells mixed with moa, seal and small bird bones, the lack of fish bones and the paucity of porcellanite are reminiscent of IID, considered as one layer. If the shells are ignored the other characteristics, along with the presence of a moa species the size of *Dinornis maximus* (or *robustus*), strongly suggests the Black component, especially as represented in TTL (Table 4:8). The thin layer of dirty sand with oven stones and some shells, lying only 30 cm below the shell and bone layer of SP is reminiscent of the Lower shell component below the Black component in Area 1 and Lockerbie's 1940 excavation (Fig. 4:10a,c,i). If the upper shell and bone layer at JP is considered equivalent to the Working floor component of the general sequence, then JP would be the only site where the Lower-shell component was present, but the Black component was missing.

Possibly it would be more satisfactory at present to set up the shell and bone layer of JP and IID seen as a single layer, as variants of the Black component, and to postulate that there was more shellfish processing in these sites than in the black layers of Areas 1,2,TTL and TTA. This variant will be designated the Shell and bone component.

The site at SP provides some further information on
this new component. It was excavated by Teviotdale 27-28 Jan 1939 (Diaries: ms. Hocken Library) but never published. The material lies in a shallow gully running up the sand dune to the south of TTA and TII and is described as a shell heap 12 m long, about 2 m wide and never more than 60 cm deep. No layers are mentioned. Among the abundant shell and bone material, there were bones of several different moa species and numerous seals (cf. the Black component of TII). The adze found had unusual dimensions: 28 cm long, 6.4 cm wide and 4.4 cm deep.

As in sites JP and IId, there is a close association of shells with moa and seal bones, and a lack of fish bone even though fish hook manufacturing is important. In these characteristics the sites are most similar to the Black component with added shell material. SP and JP have more porcellanite than is usual for the Black component but at IId porcellanite flakes are mentioned several times as "few" or "few and localised". SP and JP are sheltered from most winds, but IId is exposed.

Attributes of the five components of the General Sequence

In this analysis, layers from all areas except Lockerbie's 1956 excavation, have been assigned to components of a General sequence. The criteria used have been the nature of the matrix, the stratigraphical position and faunal materials and artifacts. Lockerbie's 1955 excavation presented a unique stratigraphy for the Catlins. It is particularly unfortunate that the absence of published artifactual and faunal data rules out the cross-correlation of its layers
with other excavations, and hence their assignment to the components of the General sequence. Except for the addition of the Lower shell component, this latter sequence is compatible with the Pounawea sequence as described by Lockerbie (1959).

The General sequence consists of:

a. A poorly represented Lower shell component,
b. A Black component which may be a single continuous layer,
c. A discontinuous Shell and bone component, which may be contemporary with the Black component,
d. A discontinuous widespread Working floor component,
e. An Upper shell component with a similar distribution to the Working floor component.

The distribution of the layers of these components is shown in Table 4:14.

The Lower shell component (Tables 4:13 and 4:14) contained shells, ovenstones, non-industrial moa bone, one flake of porcellanite and a one-piece fish hook. All of these are expected constituents of an early Archaic component.

The Black component is confined to the part of the terrace where there seems to have been the greatest concentration of activity, but two of the Shell and bone layers are not only peripheral to the main terrace but separated from it by low dune ridges. Both components can be up to a metre thick in the gullies but thin out to a few centimetres at the edges. Both contain more moa bone and a larger number of animal species overall than do the other components. Seal bones are large and plentiful throughout; fish hook making,
the presence of large well-made Archaic adzes and a relative
paucity of procellanite flakes characterize the artifact
assemblages. The components are differentiated by the
abundance of shell in the Shell and bone component and by
the black 'greasy' matrix of the Black component.

The layers of the Working floor component are more
widely distributed over the terrace than those of the Black
one, but the difference is not marked enough for any assess-
ment of relative change in the size of population involved.
The matrix varies from an ash-like material (Lockerbie
1941) to discoloured sand (TTA, TT1). The proportions of
the faunal components change (Table 4:14, TT1) and among
the artifacts there is a marked peak in the numbers of por-
cellanite flakes. Some relatively specialized artifacts
were found in this component: three of the four greenstone
objects found on the Point, a slate ulu (Lockerbie 1941) and
a possible basalt ulu (Area 1). There is evidence for the
flaking of porcellanite, silcrete, various argillites and
fine-grained black metavolcanics, the latter two being der-
ived mostly from broken adzes. Waste flakes, fish hook rough-
outs and adzes tend to be strongly localised in these layers,
the significance of which will be discussed later.

The layers of the Upper shell component cover much
the same area of the terrace as the previous component. The
matrix may be mostly shells or else discoloured sand with
lenses of ash and shell. This is the only component definit-
elly associated with scoop ovens, which are concentrated in a
sheltered corner of the terrace at TT1 and TTA. The propor-
tions of the faunal components are again distinctive, and fish
bones in particular increase though fish hook numbers do not. Though non-industrial moa bone is abundant over most of the terrace, in Area 3 there is only industrial material in this layer. Seals are still important but fewer in numbers. Though the variety of small birds taken seems to decrease (Table 4:8) there is an increase in penguin utilization. As in the previous component waste flakes, fish hook rough-outs and adzes tend to be clustered.

Discussion

From the preceding summary it is apparent that each component has a set of distinguishing attributes. Whereas there are sharp discontinuities between the matrices of the superimposed layers, the changes in faunal and artifactual criteria are in the form of trends rather than presence/absence differences. These trends suggest a continuity of culture over the period of prehistory, and it is argued that the marked discontinuities between the matrices of layers should be assigned to changes in strategy rather than to changes in people.

A continuity of people is supported by the tendency for a restricted area to have the same function in two or three different layers. Thus adze deposition and fish hook making continue in the same parts of the eastern gully of Area 1 throughout the time covered by the black and working floor layers. TT1 continues to be used as a porcellanite flaking floor in the Working floor and Upper shell components.

The pattern of adze deposition is complex. In the
Black and Working floor components, 13 adzes were located together by the river bank in Area 1. In the Upper shell component adzes were clustered in Area 3 where 8 adzes, nearly all broken and damaged were found. The relationship of adzes to the river bank seemed to be important. Sites were grouped and adzes counted (Table 4:15) to see if adzes were generally more common close to the river edge than away from it. A very rough estimate was made of the area of each site category and the expected numbers of adzes calculated, assuming that they might be evenly distributed. There were more adzes in the river edge sites and in Area 3 than expected and fewer in the sand dune sites (JP and SP) and around TT1 and TTA than expected. To summarize, the river edge of Area 1 seems to have been an adze-using area during the deposition of the Black and Working floor components, but when the Upper shell component was laid down the site of adze using shifted to the sheltered hollow on the western end of the terrace (Area 3).

Some functional justifications for the geographical location of some artifact clusters can be suggested.

The bone-working floor in Area 1 is sited over a deep deposit of the Black component with its abundant moa and seal bones, as if the inhabitants had established themselves beside their source of raw material to make the fish hooks and awls found on the hard-packed surface of the working floor.

The 13 adzes located together by the river bank in Area 1 could be interpreted as marking the site of some stage of boat building. Since 8 of the adzes were small this would indicate the later, finishing stages of construction, rather
than the earlier roughing-out stages. Alternatively the adzes may have been brought by canoe to the site and deposited close to the canoe-landing on the river bank, as a handy place for both storage and retrieval by parties coming and going from the Point. It seems improbable that house, storage platform or palisade construction would have been an important wood-working activity since postholes are notably lacking from the site. Their absence would not seem to be due to poor preservation in the loose sandy matrix since Lockerbie (pers. comm. 1975) found four rows of postholes in a similar matrix at Pounawea.

The two activity areas suggested for the Upper shell component, the cooking site around the ovens of TTI and TTA and the adze concentration of Area 3, were both in relatively sheltered areas of the terrace. If adzes were being used in Area 3 and food being eaten close to the ovens, shelter could have been desirable at both sites. In a later chapter, it will be suggested that there was a shift away from early sites exposed to the west to later sites sheltered from the west, and that these two activity areas of the Upper shell component are associated with this trend.

It has been noted that there is a relative paucity of fish hooks in the Upper shell layer (Table 4:13), even though fish bones, e.g. barracouta at TTI increase in quantity. For Galatea Bay, Shawcross (1967b) suggested that the lack of fish hooks (only one specimen) in the presence of abundant snapper bones might indicate net fishing and he quoted supporting ethnographic evidence for the manufacture of large nets. Shawcross was dissatisfied with this hypothesis however
because there were no net sinkers in the Galatea Bay midden. For Papatowai Point only one sinker has been recorded. It was in the upper shell layer of Area 3, which is the appropriate period, but there were three barracouta points and four portions of one-piece hooks in the same layer. The common fish of the site, barracouta, does form shoals suitable for netting, but traditional accounts (Graham 1953) suggest that this very strong and active fish was usually taken on a jabbing hook, almost by foul-hooking.

At a site such as Papatowai Point, comparison of fish-capturing gear with fish species present in the site may be wholly irrelevant. The moe bone material in the Papatowai middens was probably the largest source of raw material for fish hook making on the Catlins coast and partly worked tabs of bone are numerous (Table 4:13). Since Papatowai was a fish hook manufacturing site, it would seem unnecessary to demand that its fishing gear reflect the type of fishing pursued from the site. Hjarno (1967) notes that only 9% of the fish hooks recorded for Papatowai were barracouta points and 67% were one-piece hooks which would seem wholly unsuited to barracouta fishing. It would seem preferable to consider the decline in fish hooks in the Upper shell component as indicating a decline in fish hook manufacture rather than a decline in the use of fish hooks.

Throughout this discussion clusters of bone artifacts such as fish hooks and tabs are assumed to be in the process of manufacture from the raw materials of the middens. Since the rock source for the adzes are known to be distant it is
assumed that the clusters of adzes indicate a using or storage area rather than a manufacturing area. Broken adzes were sometimes roughly reshaped, using relatively simple flaking techniques (see Appendix 4:2). The dichotomy between using and manufacturing areas cannot be so readily applied to silcrete and porcellanite flake material, even though the rock type does not occur locally. The presence of small hammerstones and clusters of very small flakes suggest secondary working of the larger pieces of introduced rock. Obviously usable flakes are readily struck and could have been formed intermittently during a carving or butchering session.

The relationship between the Shell and bone component and the rest of the General sequence is of considerable interest. It may have been deposited at a different time from the other components, at a different season or as the result of different activities during the period of deposition of one of the other components. Information available at present rules out the testing of the hypotheses advanced to explain the relationship between this component and others. The moderate amount of porcellanite in the shell and bone layers of JP and SP suggests an intermediate position in time between the Black and Working floor components. There is the coincidence of numerous moa and seal bones, the presence of a large Dinornis species in JP and the lack of fish bones, which would suggest that the shell and bone layers were laid down when the economic strategy was very similar to that of the Black component. If the two entities are considered to be contemporary, the two types of deposit could have been laid down at different seasons of the year or at the same season but as the result of different activities.
It could be suggested that, when layers of the Black component were laid down, moa and seal meat was being processed by spit cooking before large fires. The fat dripping into the fire could be the source of the fine graphitic carbon. The season is indicated by the age groups of the fur seals at TTI as being late summer to autumn. (See next chapter for discussion of seasonality) In the cooler weather of spring and early summer it may have been necessary to depend more on shellfish with some moa and seal. These were cooked in the more sheltered gullies of SP and JP or on finer days on the river bank at IId. If fat from seals was being caught and used for preserving meat in kelp and bark bags, this would explain the absence of fine carbon in the Shell and bone component. Unfortunately meat preservation is more likely to have been carried out in late summer and autumn for winter consumption, than in spring and early summer. Part of this problem could be solved by ring counts of some well-provenanced cockle shells (Coutts and Higham 1971) from the Black and Shell and bone components. Material is available from the former but not from the latter component.

If differences in season of occupation could be shown, this does not exclude the possibility that the Shell and Bone component was laid down at a later period in time from the Black component. Testing for this would require an effective series of C14 dates from undisturbed material which it may still be possible to obtain. Good artifact typology and seriation would also be needed but would be rather less easy to obtain.
Excavation and analysis of faunal materials from TT1, Papatowai Point.

In previous excavations in the Catlins, faunal material has been identified to species but no attempt has been made to provenance species to layers, count individuals or analyse butchering patterns. The objective of the small excavation at TT1, Papatowai Point, was to obtain information of this type. The site was located in the area of the Point where scoop ovens have been recorded, and it may have been a focus of porcellanite flaking. The association within layers of faunal remains were typical, at least as to species, of the central sites on the Point. Unfortunately minimum numbers of individuals were low, precluding most sorts of statistical analysis, but the material was analysed as fully as possible.

Methods

Excavation

Two squares, each 1.5 by 1.5 m (five feet square) and separated by a 30 cm baulk, were excavated by eight members of the Anthropology Department, University of Otago, under my direction between 9-13 April 1971.

The surface of the site was covered with a typical forest floor litter of dead leaves and twigs which were dry and easily removed. Under the litter layer there was a tight mat of the noduliferous roots of podocarps, interwoven with other tree roots which had to be sliced through. This mat
was about 15 cm thick, and below it were the successive sandy occupation layers.

Material was removed by layers and lenses, and bulk samples for laboratory analysis were removed from each unit. All material other than bulk samples was passed through a 6.35 mm (¼ in) mesh sieve on the site. All the material left on the sieve was placed in plastic bags 31 x 23 cm, which were then dropped into paper bags, labelled and closed with masking tape. This was found to be a satisfactory method for handling large quantities of damp material, and provenance was lost on only two bags.

Contamination of lower layers by material from the baulks was particularly guarded against, to allow for later analysis of micro-remains. Fortunately the sand was damp and firm, and the site sheltered from wind by trees. Movement of materials from the surrounding surface and baulk was prevented by pegging down sheet plastic round the edges of the two squares and limiting movement of personnel in and out of the excavations.

**Laboratory Analysis**

Material from each bag was slowly air-dried at room temperature until it was sufficiently friable to drop through a 6.35 mm mesh sieve again without shaking or rubbing. The sieve was carefully cleaned between each sample. The fine material was put aside for further mechanical sorting along with the bulk samples. Cursory examination showed that there was very little seed and land snail material in the samples, and, considering the return
for effort expended with the present laboratory equipment, it was decided not to carry this analysis any further.

The larger materials were sorted into the major categories of stone, bone, charcoal, shell and artifacts, and the contents of each bag were steam cleaned and the rock material examined for origins in the hand specimens. Bones were sorted and identified to species, and minimum numbers of individuals estimated. The bones of seals, moas, small birds and fish were examined for butchering techniques and for the removal of parts of the body to elsewhere. To assist in interpretation of the Crested penguin bones, subspeciation in this group was briefly examined. Material from the National Museum, Wellington and from Otago Museum was compared with midden material, and a preliminary analysis carried out, sufficient to allow sorting by eye of the midden material.

A study of the post-cranial bones of fur seal *Arctocephalus forsteri* and sea lion *Phocarctos hookeri* was made to aid in separation of juvenile sea lions and fur seals (see Appendix 4:3). The shell material was sorted into species, the bivalve species sized and minimum numbers estimated from the umbo fragments and whole shells. All shells of pipis and cockles that were sufficiently whole were measured and histograms of length frequencies prepared.

Charcoal and shells for radiocarbon dating were submitted in 1971 to the Institute of Nuclear Sciences, Wellington but these proved unsatisfactory. More charcoal samples were prepared in 1976 from material which had been
stored in tightly tied plastic bags, and these were submitted prior to their analysis to Dr. B. Molloy, Botany Division, Christchurch, for identification of the woody species involved.

**Chronology**

The stratigraphy, as described in the previous chapter, consisted of relatively even layers (Fig. 4:12), with three ovens dug down from the upper shell layer. Oven 3 was about 30 cm deep and almost filled the 1.5 m square which is not illustrated in Fig. 4:12. The boundary between the upper shell layer and the working floor was diffuse around Oven 3 but otherwise layer boundaries were very sharp. The disturbed material above the upper shell layer (Fig. 4:12) was interpreted as build-up of humus and displaced cultural debris resulting from 70 years of European activities. In this well drained and generally well aerated soil, pH 6.7-7.1 (see Appendix 3:1), preservation of bone and shell material was moderately good, but only carbonised plant material was preserved and except for charcoal, this was very sparse. Water flotation for carbonised seeds was attempted but did not yield useful results.

Initially it was hoped that material obtained from this excavation for radiocarbon dating would provide a subsidiary means of correlating its stratigraphy with other excavations on the Point. At the time when the samples were chosen it was not realised that Lockerbie's 1956 excavation (Fig. 10d-e) from which the only previous radiocarbon samples had been obtained (Table 4:17 and Fig. 4:13),
had a unique stratigraphy and that all other excavations on the Point would fall into a different sequence. Only the black layer of TT1 was sampled at first in the expectation that this would be sufficient to 'tie' the TT1 sequence into Lockerbie's 1956 sequence. Two samples were taken. One of blocky lumps of charcoal gave a date of 1039 a.d. ± 76 (N.Z. 1332) and the other of shells of Paphies australis a date of 1647 a.d. ± 40 (N.Z. 1333). The two samples were excavated by the same person from places 1.5 m apart in the black layer which was almost flat, even and continuous. There were no known logistic, stratigraphical or technical reasons for the shell date being so late. X-ray diffraction showed the crystal structure of the shell to be aragonite, which should have contained only the carbon incorporated during growth. All previous dates for a lower black layer at Papatowai (N.Z. 134, 135, 136) fall in the 12th to 14th centuries. These can be associated with the black, moa-bone filled layers at Hinahina (N.Z. 1210 a.d. ± 75) and Pounawea (N.Z. 58 1140 a.d. ± 60). The shell date of 1647 a.d. is distinctly anomalous.

The second series of dates, which were all from charcoal, consisted of two from the Black component, one from the Working floor component and three from different structures assigned to the Upper shell component, i.e. a lens of shell and Ovens 1 and 2 (Fig. 4:12). The dates were all in sequence (Table 4:17) and gave means calculated according to Leach (1972) of:

- Black component 1140 ± 50 a.d.
- Working floor component 1290 ± 50 a.d.
- Upper shell component 1380 ± 50 a.d.
Whereas Lockerbie's 1956 dates indicated a span of occupation on the Point from the late 12th to the 17th century, the TT1 series extended only from the early 12th to the late 14th century. The Pounawea series indicated occupation there from the 12th to 17th century (Lockerbie 1959).

There are two ways of resolving the conflict between the two series of dates for Papatowai. Either the TT1 sequence was truncated and the Point was occupied intermittently for six or seven centuries, or the late dates for the 1956 sequence are incorrect and occupation lasted only three centuries.

It is not easy to establish that the TT1 sequence is truncated relative to Lockerbie's 1956 one. TT1 fits into the General sequence described in the last chapter which is supported by all the excavations on the Point except for Lockerbie's 1956 one. If the dates N.Z,137-140 (Table 4:17) are excepted, then the General sequence must be fitted at the very bottom of the 1956 sequence (see p. 206) and it follows that the Upper shell component of the former is equivalent to the Scattered shell and ash component of the latter, that the Working floor component is missing from the 1956 sequence and that only the Black components in both are fully similar and equivalent. Stratigraphically this is possible but not particularly satisfactory, considering that the two excavations are only 30 metres apart and in the same gully. This model would also imply that the only place where post-14th century material can be recognised on the
Point is in Lockerbie's 1956 excavation. It does allow for a similar period of occupation at both Papatowai and Pounawea but puts the change from a diet of predominantly moa and seal to one of mostly fish and shellfish three centuries earlier at Papatowai than at Pounawea. All of these objection to the longer period of occupation on the Point could be set aside if the dates N.Z.137-140 can be supported. It is relatively easy, however, to cast doubt on their technical validity since they were all done on moa bone carbonate or fixed carbon (Fergusson and Rafter 1959), before it was realised that these materials can equilibrate isotopically with soil carbonate in a well-drained sandy environment such as is typical of the Papatowai middens (Polach 1971). This would imply that all of Lockerbie's dates for the middle and upper layers of 1956 sequence are too young, and that these layers could belong to the 13th and 14th centuries. If the T1 series of dates do cover the whole period of occupation, then Papatowai was abandoned about 1400 - 1450 A.D. The absence of trees older than 250 years on the occupation area can be explained by European roadmaking activities.

In the light of this argument it is interesting to find that the Pounawea dates (Fergusson and Rafter 1959) show good agreement between charcoal, bone carbonate and fixed carbon taken from the intermediate layer. The 15th century date for this layer and a shell date of 1660 ± 60 a.d. for the upper layer cannot be easily set aside. It is possible to argue that there must have been very little younger carbon available in the environment of the middle layer bones so that the date was little if at all raised by isotopic
equilibration. Likewise the bone dates N.Z.137-140 for Papatowai may be only slightly raised. With so many uncertainties involved, both long and short periods of occupation at Papatowai must be considered possible.

No corrections for secular effects have been applied to radiocarbon dates in this thesis. The calculation of exact calendrical dates is still a subject of controversy since some of the basic assumptions on probability distributions of carbon isotope fractionation may well be in error (Polach 1972). Also the secular corrections applicable to the Catlins dates are in the order of only 10-50 years.

Faunal materials

In the light sandy soil, shell and bone would have been readily scattered by people and dogs living on the Point, and minimum numbers of individuals are likely to be more revealing than weights or volumes of residues. Numbers of individuals in each layer were assessed by counting the numbers of the commonest bone, e.g. the left dentary of barracouta (Table 4:6). A visual check of the remaining bones was made for any grossly larger or smaller individuals than those represented by the counted bones. Checks were made between layers, as the formation of three ovens could have raised material from the lower layers into the upper shell layer. The vertical distribution of moa bone was probably affected by its use for artifact manufacture, material from the lower layers being utilised and redeposited in the upper layers when moas were uncommon. Moas were therefore assessed
on bones unlikely to have been used for artifacts, such as pelvises and vertebrae.

The excavation was small relative to the total extent of the site and hence no attempt was made to calculate the available energy represented by the food residues. Apart from sampling problems, unknowns such as the meat weight of the different species of moa and of the various sizes of seal would have produced errors of even greater magnitude than those of Shawcross (1967).

**Mollusca**

The species present (Table 4:8) indicate that the sandy shores of the estuary and the rocky reef to the south of the river mouth were exploited for shellfish. Abundant populations of pipi and cockle, and moderate populations of mud snails, green and blue mussels and paua could have been obtained within 15 minutes walking distance of Papatowai Point. Of the naturally-occurring modern populations, the only species absent from TT1 is the blue mussel but this is present as very eroded shells on other parts of the Point. The collection of pipis, pauas or the larger sizes of cockles involves bodily submersion in cold water and these activities could have been unprofitable in terms of energy loss and gain during the winter. At spring low tides however, green and blue mussels could have been collected easily without so much heat loss.

It seems significant that the Papatowai Point site is located beside one of the most productive and stable beds of pipis and cockles along this part of the coast. The topography and natural parameters of this bed are described in Chapter
2:4 and it is mapped in Fig. 2:16. As a rough estimate of food availability, it was found that two people working together for one hour in the river at low tide (15 - 40 cm of water) could collect between 500 and 1700 shellfish of the size frequencies common in the adjacent midden (Table 4:19). Obviously a shell lens such as Lens 2, upper shell layer in TT1, containing about 300 pipis and 250 cockles represents less than 2 man-hours of collecting.

Pipis and large cockles can be effectively collected for about one hour around low tide at any one position. The topography of the river however allows a longer period of collection than on the open shore. The rock bar and first meander of the river delay the tide so that a gatherer could work for an hour around low water on the west side of the ford, and then wade across the ford in ten minutes to have another full hour of low water beside the occupation site. This applies to average and spring low tides, not to neap low tides.

The shells of the Black component consisted almost entirely of pipis, and counting showed the proportion to be 97%. Throughout most of the pipi bed, the proportion of cockles present ranges from about 40 to 60% and generally the gatherer would have to constantly reject cockles if he wanted to obtain only pipis. Rather than assume an unexpectedly high preferential selection of pipis, the pipi bed was searched for an appropriate distribution of the two species. This was found at the upstream end of the modern pipi bed, where a small area close to the river bank and immediately below
the occupation site, yielded 95% pipis (D5, Table 4:20). Hence the particular combination of physical conditions associated with this frequency can exist in the present river channel and could have existed in the past.

It is possible to test further the hypothesis that the pipis in the Black component of TT1 were taken from this part of the shellfish bed in the prehistoric period? The stability of the river bed, discussed in Chapter 2:4, suggests that it is reasonable to assume that growing conditions for shellfish in the estuary during the prehistoric period were very similar to modern conditions. A series of modern and midden samples of cockles and pipis were available to test this proposition. These consisted of the 20 modern samples of pipis and cockles described in Chapter 2:4 (p. 106), and all the midden shells of pipis and cockles which could be measured from the upper shell and working floor layers of TT1 as well as the pipis from the black layer. There was only a trace of cockle shell in the black layer (Table 4:8). The series of t-tests performed on the length frequencies from these samples (Table 2:11 and 2:14) showed how distinctive the different parts of the shellfish bed were in respect to this parameter. In general, differences between mean lengths were significant at the P < .001 level of probability for nearly all pairs of samples. The pipis of the Black component and Upper shell component however were not significantly different from some samples taken from the area immediately below the occupation site, i.e. the samples with about 95% pipis
The pipis and cockles in this area also tended to be some of the largest in the bed (Figs. 2:25 and 2:29), though present in rather low densities. The matrix of t-tests (Table 2:11) showed that the cockles from the Upper shell layer in TT1 were also not significantly different from a natural sample taken from this area. Though there was no significant difference between the cockles of the two midden layers (Upper shell and Working floor components), the Working floor cockles could not be "matched" against any of the natural samples. Considering all five midden samples (3 of pipis and 2 of cockles), the length frequencies of three of those samples could be matched against samples from a modern natural population, which had some of the highest mean lengths in the shellfish bed.

The material was not adequate to perform the within-layer testing for change in mean length carried out by Anderson (1973) and McFadgen (1972). Both these latter studies showed decrease in length within layers suggesting heavy exploitation, but with some recovery between occupation periods. There is no decrease in length between consecutive layers at Papatowai (Fig.4:14) but this may mask changes within the layers. There could have been heavy exploitation during each period of occupation but sufficient time between occupations for the shellfish beds to recover. In fact the mean length of the pipis from the upper shell layer is significantly greater than that from the black layer ($P < .001$) and the Working floor component ($P < .001$).
The volumes of midden analysed from the upper shell and working floor layers at TT1 were very similar but since the black layer occurred only in one square of the excavation its volume was about half that of the others. The increase in numbers of shellfish from the lower layers to the upper indicated by the minimum numbers from TT1 (Table 4:8) is therefore a valid trend and was noted repeatedly by Lockerbie (1959) and Teviotdale (1937). The absence of cockles from the black layer at TT1 is difficult to account for and is not known to occur elsewhere on the Point.

Marine Fish

Three species of fish were found in TT1 but only barracouta was abundant. The bones of a single medium to large, golden snapper were found in the Upper shell component. An unidentified fish in the Black component was only 10 cm long and unlikely to be a food fish. Barracouta, the dominant food fish of the Catlins and present in every coastal midden examined, was absent from the earliest occupation material in TT1. Fish bones scatter easily through the sandy substrate of this type of deposit, and were not found in concentrations or in articulation. Their absence from the Black component of TT indicates that food gathering and preparation which included about 100 pipis, 3 or 4 small birds, about 6 moas, 7 seals and a dog, did not include any fish. The presence of fish hooks in the Black component, elsewhere on the site,
suggest that fish populations were being exploited at this period, but the absence of fish from TT1 suggests that exploitation was intermittent. This may be because this part of the midden was deposited during successive winters when barracouta were not being caught. The presence of the bones of a Fur seal pup of about 7 weeks of age, however, suggests deposition in late January - early February. Also the bones of an adult Sooty shearwater indicate deposition between October and April, which covers the barracouta catching season of October to February. Only the general conclusion seems feasible; that fishing was so intermittent an activity that a considerable amount of midden could be deposited without it containing fish bone.

The barracouta bones of the Working floor and Upper shell components were analysed to see if there was any indication that:

1. whole fish were being eaten on the site (appropriate proportions of head bones and vertebrae present),
2. the bodies were being removed for consumption elsewhere (high proportion of head bones to vertebrae present),
3. the bodies (dried?) were being brought from elsewhere for consumption on the site (low proportion of head bones to vertebrae present).

Since there should have been 35 vertebrae to the 11 head bones distinguished, it was possible to calculate the
expected numbers of head bones to vertebrae in each layer. In both layers about 20-25% of the expected head bones and vertebrae were present and there was no great disparity in any of the values. Apparently the bones of whole fish were being deposited on the site. If any of the meat was being dried and taken elsewhere it was as boneless fillets.

Small birds

The assemblage of small birds found in TT1 was of minor importance, considering the range of extinct and rare species found at other Catlins sites. Penguins predominated, with a few native pigeons and other species in the Black component. Some butchering practices can be inferred from these bones.

The 16 penguins assumed to be present in TT1 material were represented by 16 tibiae, 10 femora and 2 metatarsi. Only 12 of the very durable vertebrae from these birds were found, the other body bones being 1 scapula and 6 ribs. Of the wing bones, only 6 humeri and 1 phalanx was found. The absence of the very durable bones of the lower flipper suggests that these were not brought to the cooking area. Penguins can deliver a painful blow with their flippers and they may have been captured but immobilized by breaking and removing the flipper at the distal joint of the humerus. A similar technique is used on Sooty shearwaters by the Maori families who at present
harvest Sooty shearwater nestlings on the off-shore islands around Stewart Island. They disable the birds by wrenching the wings across behind the back. Plucking must be done as soon as possible after death and the delay in killing the birds makes it easier to handle large numbers. If the penguins were being taken in considerable numbers from a colony during the prehistoric period, it may well have been advantageous to remove the lower flippers at the colony and carry the birds alive to the cooking area. The shortage of vertebrae, as well as most of the other body bones, supports the hypothesis that the birds were being collected for preserving, probably in their own fat. Penguins have a fatty insulating layer under the skin and could be effectively preserved in kelp bags.

The very few bones of native pigeons from the site suggest a similar butchering technique. The three humeri from the black layer have the distal end damaged or broken off. This pattern of breakage is similar to that reported for material from Ruapuke Island, Foveaux Strait (Coutts and Jurisch 1972).

**Moas**

Of the eight species of moa known to occur at Papatowai, four or possibly five are present in the small TTL excavation. Bone material was fragmentary throughout, most being found in the Black component. Present in the Black component were leg and toe bones, pelvic bones, vertebrae, ribs, sternal fragments and a scatter of tracheal rings. In the Working floor component there were ischial bones, fragmented leg bones and rib and vertebrae fragments, an assemblage which suggests the presence of live moas. In the Upper shell component there were
fragmented leg bones, also toe bones, broken ribs and fragments of vertebrae and sternae. The fragmented nature of the bone in this layer suggests that it might have been reworked material from a lower layer. However considering the numbers of bones and fragments compared to individuals:

<table>
<thead>
<tr>
<th>Layers</th>
<th>Upper Shell</th>
<th>Working floor</th>
<th>Black</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum number of individuals</td>
<td>1</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Number of bones and fragments</td>
<td>68</td>
<td>96</td>
<td>100</td>
</tr>
</tbody>
</table>

along with parts of the body listed above, it does seem reasonable to assume that a few whole moa were brought to the site during the deposition of the upper shell layer. Possibly leg bone material was being taken from the black layer for artifact manufacture. This would account for the high proportions of bones and fragments to individuals in the upper two layers.

**Seals**

The proportions of seals to moas at TT1 supported the deduction made from Teviotdale's notes, that about the same weights of seal and moa meat were being eaten at Papatowai. Of the three Sea lions in the black layer, two were juvenile and the other an adult female. Of the other three Fur seals in the black layer, two were juvenile and one was a medium sized adult. There were no seal bones in the Working floor component, but in the Upper shell component there were two Fur seals, a juvenile and an adult female. Exploitation strategy seems to have been focussed on the juveniles and smaller adults, particularly the females, of both species.
The juveniles of both species were large enough for the bones to be identifiable to species (Appendix 4:3), but it was not possible to set even approximate ages to the bones, due to a lack of comparative material. One immature Sea lion was close to an adult male in size and the other was no larger than a female fur seal. The larger could have been a breeding animal, since epiphyseal closure in marine mammals may not occur until after breeding age has been reached. The three immature Fur seals were all approximately half grown and may have been male or female. Bones of three seal pups were found, two being in the disturbed top layer. Bones in the black layer were the same size as those of a seven-week old pup collected from the Otago Peninsula at an unknown date. The bones of the other two pups were a little larger. These pups are assumed to be Fur seals, since the only other possible species of eared seal, Hooker's sea lion, breeds only on the Auckland Islands, and there is no evidence that it ever bred on the mainland of New Zealand.

Recent work on breeding of Fur seals (Wilson 1974) indicates that seven-week old pups would be available in early February, along with females and half grown juveniles. The territory holding males leave the colonies by February, making access to the females considerably less hazardous. The young males then move on to the main breeding platforms to "practice" territory defence, and the females are intermittently present to feed their pups. According to the available data on the distribution of age/sex categories at breeding and non-breeding colonies of Fur seals (Smith 1976), this group at Papatowai of adult females, juveniles
and small pups is typical of the exploitation of a breeding colony.

The other two species of seals present in TT1 were Elephant seal, represented by a piece of rib, and Sea leopard, represented by portions of the skull and ribs.

The bones of the Fur seals and Sea lions were examined for patterns of butchering. It seemed likely that the distal part of the flippers would have been chopped off; and certainly bones distal to the carpals and tarsals were almost entirely missing. Only four bones were found (1 metacarpal, 1 metatarsal, 1 tarsal and 1 phalanx) from the many lower flipper bones which should have been present from the eight animals. The flippers seem to have been chopped across the distal end of the ulna and radius in juveniles and possibly between the bones in the adults. Two ulnae and two radii of immature Fur seals were broken close to the distal ends but an adult radius and an adult ulna were intact. This difference could be a function of the relative hardness of the adult bones. Ulnae from two pups were intact. The tibiae of three immature seals and one adult seal had the distal ends all broken off.

There were signs on the four ulnae that the muscle attached close to the proximal end, just below the lateral epiphysis, had been sawn or chopped through, removing some of the cortex of the bone in the process. All of the available humeri (from 3 pups, 2 immature Fur seals and 1 immature Sea lion) had been chopped across the deltoid ridge, and the two Fur seal humeri broken in half. Femora, which are short stout bones, were unmarked and unbroken.

Butchering seems to have been done to a very regular
pattern, flippers being removed according to the age of the animal at different levels. The distal portions of the flippers may often have been left on the kill site, since there were so few of the appropriate bones in the cooking area. It is not possible to say whether the cuts on the humeri and proximal tibiae were made before or after cooking.

Seal ribs and forelimb bones were found with abrasions of the size which could have been produced by dogs gnawing on them. No evidence of rat gnawing was found though rats were present in the Black layer. The pattern of marks on the rib bones was unusual. The anterior ribs of Sea lions have a broad flattened blade running ventrally forward on the thorax. The edge of this blade is of a size and shape that should be attractive for a dog to chew on, and yet none of these edges had been attacked. The marks on these anterior Sea lion ribs were always close to the head of the rib and dorsal on the outside of the curve. There is a suggestion in this pattern that the ribs were still joined laterally into a rib cage when the dogs had access to them. If the ribs were still joined to the entire backbone, the easiest place for a dog to get a grip on the main body of the rib would have been dorsally where it curves over to articulate with the backbone. Of the Fur seal ribs, anterior ribs were few and unmarked. Some posterior and middle ribs had been strongly bitten into equally on the curved proximal and straighter distal ends. The pattern of marks again suggested that the rib cage could have been whole when gnawed. None of these ribs and vertebrae were in articulation when found.
Discussion

The material of TT1 shows a slight but steady change from the exploitation of many species to the exploitation of fewer (Table 4:8). Species which were almost certainly utilised decrease from 16 to 14 to 11. The following species are present in the Black component but are absent in the Upper shell component: three or four species of moa, the Sea lion, Native rat, Sooty shearwater, Native pigeon, Erect-crested penguin and paua. New species which appear in the Upper shell component are two groups of Crested penguins, snapper, barracouta, catsye and mudsnail. Some of these gains and losses may be due to sampling error. In theory, this problem cannot be solved unless the whole midden is excavated. Except for the loss of the moas by extinction, the other losses are equally likely or unlikely to be due to sampling errors. The TT1 excavation does represent only a very small portion of the site, and the evidence from it must be used with caution.

Over the period of occupation there was an increase in shellfish exploitation. Length frequency analyses suggest that it was the beds closest to the site, where the individuals were largest, which were used by the people who deposited the TT1 midden material at all periods. Many species of fish can be caught relatively easily in Tahakopa Bay and estuary, but only barracouta and a species rare to the region, the golden snapper, are present in the TT1 material. There is no trace of exploitation of the large flounders which can be caught in the estuary at present. The barracouta were apparently eaten on the site,
there being no indication that the bodies were preserved for consumption elsewhere. An unusual factor of economic activity in the Black component is that fishing must have been very intermittent, as there are no fish bones in this layer in TT1 but fish hooks are present in it elsewhere on the Point. The Black component seems to represent a period of heavy exploitation of moas and seals, intermittent fishing and light exploitation of small birds and shellfish. Dog bones are present throughout the excavation. All were adult, and the three individuals grade in size from the largest in the black layer to the smallest in the upper shell layer. The dog bone was so sparse and fragmentary that no further analysis was carried out.

Butchering patterns, where evident (on penguins, pigeons (?) and seals) showed considerable regularity. The butchering practices and proportions of parts of the body suggested that penguin bodies were being preserved and removed from the site (or to another part of the site) for consumption.

The season of occupation is indicated by the presence of barracouta (October - May), adult Sooty shearwater (October - April) and a seven-week old seal pup (late January - late February). If penguins were taken at nesting colonies when at their fattest, this would be just prior to moulting in March and April. The distribution of these indicators through the three layers points to a similar season of occupation throughout the prehistoric period. It would have been possible for all the indicator species to have been deposited during a short period of occupation in February. There is nothing,
however, to indicate absence from the site for any season of the year, and occupation could have been all year round.

Indicators of winter occupation of New Zealand sites are so few that their absence from TL is of little relevance. Patterns of deposition which could possibly indicate winter occupation in the Catlins environment, would be:-

(a) a preponderance of vertebrae and other body bones of penguins, associated with a lack of leg and wing bones,
(b) the presence of body bones of juvenile Sooty shearwaters,
(c) a high proportion of vertebrae to head bones of barracouta,
(d) selection against shellfish from near or below low water mark, such as pipis, green mussels, pauas and large cockles; and selection for species easily collected between the tides, e.g. blue mussels, catseyes and mudsnails.

The first three phenomena would suggest the consumption of preserved foods. If a site is occupied even intermittently during summer, these winter patterns of deposition are likely to be merged and lost in the summer-deposited material, and their absence cannot be used as an argument against winter occupation.

An important food species for which there is no archaeological evidence in the Catlins is bracken. At present bracken grows in small patches in European clearings on the Point. Its growth in the fertile midden soil is very vigorous and rhizomes of about 3.0 cm in diameter are abundantly produced. At present bracken is a common plant in the Tahakopa Valley, taking over large areas of the warmer hillslopes where
forest has been clearfelled and burnt. It is common
on disturbed alluvium all along the river edge, and during
the prehistoric period it seems likely that this ecotone
would be a reliable source of bracken. However if occupat-
ion of the Point was at all intermittent, or even if the
occupants tended to shift camp from one part of the Point
to another, the enriched soils around the midden areas
were likely to have been vigorously colonised by bracken
if left untrampled for more than a year. It would have been
ideal terrain for a simple form of bracken horticulture.

There is reasonable evidence that live moas were
being brought to the site throughout the whole period of
occupation. The evidence from TT1 indicates this and, for
most of his excavations, Teviotdals states that he found
tracheal rings and other non-industrial moa bone in all
layers. It is significant that Papatowai and Pounawea, two
of the richest sites on the Catlins coast in terms of
available food resources, show a decline in moa exploit-
atation prior to abandonment. Presumably the abandonment of
the coastline generally coincided with the loss of an
available moa population (Lockerbie 1959). If we add to
the species shown as present in the Upper shell component of
TT1 (Table 4:8), species known to have been abundant during
the Contact Period, e.g. eels, lampreys, whitebait, native
pigeons, kakas, groper, blue and red cod, yellow-eyed
mullet, flounders and bracken, food resources would appear
to have been quite adequate for summer occupation by at
least small groups of hunters and gatherers.

The hypothesis is presented that the crucial factor
was the lack of access to the inland hills and plains of Southland and Otago. The Catlins forest is judged by foresters to be particularly difficult to travel through, because of its dense wet undergrowth. The resources of estuaries and coastline were equally available to the north and south of the Catlins forests and there it was easier to travel inland to exploit the food and stone resources of the inland areas. The small birds of the forest were just as abundant along the forest-grassland ecotones as along the forest-coastal ecotone. Once the moa populations were depleted, the cool wet coastline of the Catlins forests held no advantages, and had the one disadvantage of reduced inland access, compared to the neighbouring coastline. In terms of year-round, economic strategy, life was easier if the summer months were spent at the mouths of the Clutha and the Mataura, and hence the Catlins coast was abandoned at least by 1700 A.D. if not earlier.
Chapter 4:4

_relations of Sites to Environmental Factors_

Many of the details of site location relative to vegetational boundaries, to rivers and to the junctions of resource zones were brought out in Chapters 4:1 and 4:2. Analysis of TTI, Papatowai showed changing patterns of resource exploitation. The settlement pattern of the Catlins coast overall is now considered, and in particular the relationships of the coastal Middens and Occupation sites to local maritime resources. First the way in which shelter from the coldest winds affected site location will be discussed.

Shelter

Throughout winter and early spring, the Otago coast is subject to the effects of outbreaks of cold Antarctic air, with cold south-westerly winds and showers of sleet, hail and snow down to sea level. Shelter from these winds may have been a crucial factor in determining the location of occupation sites of all types in the Catlins, and particularly of winter sites. Tables 4:2 and 4:5 give some details of aspect and shelter of inland and coastal sites.

It is a noticeable feature of the Occupation sites at Pounawea, Hinahina, Papatowai and Teutuku Point, that they are exposed to the west but sheltered from the south. By contrast many of the smaller Midden sites are open to the south but sheltered from the west. The Midden sites between Pillans Head and Long Point are particularly interesting in this respect. Each is well sheltered by a nearby headland from the west but
fully open to southerly gales off the sea. Southerly swells have a very long, direct fetch on to these beaches since this coast is quite unprotected from the south.

If protection from the west could be shown to be important during the coldest periods of the Little Ice Age (LIA), the Midden sites could be interpreted as the cold period occupation sites. Pounawea, Hinahina, Papatowai and Tautuku Point could then be seen as economically desirable sites from which people were occasionally driven due to their exposure to the west. The latest series of radiocarbon dates (R5379/1-6, Table 4:17) even suggest that Papatowai may have been abandoned shortly after the first major fall in temperature about 1400 A.D. Evidence of these colder periods has been derived from several independent lines of investigation: lichenometry and glacial advances (Wardle 1973), speleothem $^{18}O/^{16}O$ analysis (A.T.Wilson: pers.comm.1973) and podocarp regeneration (Wardle 1963). Bray's (1973) review placed the New Zealand phenomena within a worldwide pattern of glacial advance and retreat, supported by independent data on vegetation distribution and crop successes. The evidence for several cold periods between 1400 and 1800 A.D. (Fig.4:6) can no longer be doubted.

Does the lie of the Catlins topography tend to channel strong storms from the south-westerly quarter into locally westerly or locally southerly gales? The Catlins ranges lie at right angles to winds from the south-west and will channel winds one way or the other. As noted in Chapter 2:1, pp 27-28, a circulation model has been developed
by climatologists which calls for an increase in south westerly storms during the LIA (Lamb 1967). The log of Cook's first voyage provides a short record of weather conditions at the end of the prehistoric period. Data extracted from this log (Beaglehole 1961) indicate that there was a high frequency of winds from the south-west (Table 4:6) when Cook sailed from Cape Palliser, Feb 11 1770, round the South Island to Farewell Spit, Mar 23 1770. On 11 of the 42 days over this period the winds were from the south-west. Cook also gives a verbal description of wind strength for each day which will be comparative for the period of time involved. By assigning ranks, one to four, to his categories of light, fresh, strong and gale force winds, a mean value can be obtained for each wind direction of Cook's eight-point compass (Table 4:6). The values for winds centred around west (SW - NW) are higher than for those centred around south (SE - SW). No modern wind data are given here because of problems of comparability, even as to the points of the compass used (cf. the modern twelve-point compass with Cook's eight-point compass). Cook's data show a high frequency of winds from the south-west with a greater strength component from the west rather than from the south, but this does apply to only six weeks of the year 1770 A.D.

The validity of using modern climate data to interpret weather patterns of 200 years ago may seem uncertain. One basic similarity which emerges from Cook's data for Table 4:6 is that seven, anticyclonic, low pressure systems passed across the South Island in the 42 days of recording (Beaglehole 1961). This six day cycle is close to the average of seven days observed by modern meteorologists at present. Cook generally
mentioned whether the wind veered or backed, which greatly aided interpretation of the pressure system which he was experiencing.

Considering wind directions within the Catlins valleys themselves, data from the climate stations set up during the study period showed, as already discussed in Chapter 2:1 (Table 4:7), that during a dry year, sites exposed to the south had the highest rainfall but during a wet year sites exposed to the west had the highest rainfall (Fig. 2:7). This suggests that the local topography tends to swing strong south-westerly storms on to a westerly heading so that they drive down the valleys and out to sea, whereas lesser storms are swung more southerly and tend to come in off the sea and drive up the valleys. These diversions of winds could also affect the ease of canoe landfalls on to southerly and easterly facing beaches. During strong westerlies the south-facing beaches of Long Point, with their sheltering headlands cutting off the westerlies close to shore, may have been easier to reach into by a sailed or paddled boat. Direct approach to Tahakopa Beach in the full face of a storm blowing down the Tahakopa Valley would have demanded much energy.

Clearly the data on climate and shelter are tenuous and require some degree of chronological correlation. If shelter from the south was desirable prior to the LIA, then sites established before about 1400 A.D. should be sheltered from the south and later sites sheltered from the west. Radio-carbon dating of Catlins sites is quite inadequate and only a very approximate seriation by faunal remains is possible for some of the small sites.

The earliest levels of occupation at Pounawea, Hinahina
and Papatowai have yielded radiocarbon dates in the 11-13th centuries, and are all exposed to the west. At Papatowai the oven area, belonging to a late level of occupation dated to about 1400 A.D., is in a hollow of the dunes which is moderately sheltered from all directions. Also the site of adze-using in the early and middle levels was on the edge of the river, exposed to the west, but in the late occupation period adze-using seems to have been concentrated in a sheltered hollow back from the river bank. These moves to more sheltered micro-environments coincide with a major fall in temperature at the beginning of the 15th century, as demonstrated by oxygen isotope ratios in speleothems and a failure in podocarp regeneration.

Turning now to the sites for which there are no radiocarbon dates, Tautuku Point is probably the most enigmatic. It occupies a similar geographical position to Papatowai and Pounawea, and it is apparent that it is faunally very similar to Papatowai (Tables 4:8 and 4:9). It has an even greater variety of small birds, in particular several of the extinct species. There is also a much greater variety of fish species than at Papatowai but a similar variety of moas and penguins. Like the other large estuarine Occupation sites it is well sheltered from the south but, unlike the others, it is moderately sheltered from the west as well. On the evidence available, this site can be assumed to have been established at about the same time as Papatowai and Pounawea. The site on Tautuku Peninsula (5184/7) with a late moa date (Dinornis torosus 1670 ± 60 a.d., N.Z. 146) is sheltered from the west but is so high on the dunes that it would have been relatively exposed to the south.
The faunal lists from Picnic Point, Waitangi Stream East and West, Long Point South and Cannibal Bay (Tables 4:9 and 4:12) all lack extinct species of birds, except for fragments of moa bone, suggesting that these sites are relatively late. Kings Rock contained three extinct species of small birds and two other species for which there are no European records for the Catlins - kiwi and kakapo. However the paucity of moa bone, which was confined to one part of the bottom layer, suggests that this site was not established until late in the moa hunting period. All of these sites are notably sheltered from the west and all show faunal indications of having been established in the middle to late rather than earliest centuries of Catlins occupation.

The inland sites of Isolated ovens and charcoal and stone patches, and the small coastal middens consisting of one lens of shells do not contain any useful evidence as to their chronological position. The inland sites do not show any consistent patterns of shelter, some being topographically exposed to the south and some to the west. Since all are close to the immediately pre-European forest edge, some may have been sheltered by trees, or they may all have been summer and autumn sites when factors other than shelter were dominant in determining site locations. Their position close to the recent forest edge, which it is postulated fluctuated considerably during the prehistoric period (Chap.2:2),
does hint that they are largely recent sites. There are no data available at present to test these hypotheses.

The small shell middens around the Papatowai estuary and the small sites with limited faunal remains at Haldane Estuary, the northern end of Tautuku Beach and Hukihuki Creek are all sheltered from the west. All of those on the sea coast are exposed to the south, but the Papatowai Estuary sites are quite well sheltered from the south. For these sites it is tempting to infer that they were settled during the colder periods of Catlins prehistory because they are sheltered from the west. However if this inference is accepted, it should be remembered that it is a second-order inference, depending on evidence external to the sites concerned. By contrast the inference that a site such as Picnic Point is a late site is a first-order inference, depending on evidence internal to the Picnic Point site, i.e. its own faunal material. It should be emphasised that the absence of extinct bird species does not mean a site must be late. It could have been an early site at which the extinct small bird species and moas were not exploited.

In the development of a chronology for the Catlins, functional differences between sites are as much a problem as elsewhere.

Of the factors affecting site location, shelter from cold wet winds may have influenced the finer adjustments of sites to landscape, but obviously the major factors would have involved availability of resources,
particularly food resources. Seasonal, as well as spatial availability of resources, must also have affected the overall pattern of site location.

The largest sites or clusters of sites on the Catlins coasts are located at junction points of resource zone boundaries, where the largest number of natural habitats can be exploited for the least possible effort. At Papatowai Point, Pounawea and Tautuku Point, the resource species of sea, estuary, river, forest and shoreline were available within one kilometre of the Occupation sites. Though located on estuaries, it would be a mistake in emphasis to refer to them as estuarine sites. Archaeological evidence shows that at each site a wide range of species was exploited from all habitats, except for some anomalies with respect to rivers and wetlands which will be discussed later.

It would seem likely that such a strategy of exploitation would indicate a long season of occupation at these sites. The presence of barracouta and shearwaters at Tautuku Point and Papatowai and of barracouta at nearly every other well-sampled Occupation or Midden site indicate summer occupation. The strictures which applied to Papatowai on determining winter occupation will apply to these other sites.

Small sites within the estuaries and on the shoreline close to the river mouths, are still within easy walking distance of the full range of resource zones, but tend to be more specialised. Thus the small middens
within the Tahakopa Estuary are simple shell middens, containing only those species present on the adjacent intertidal flats. The Picnic Point middens out on the shoreline contain barracouta, and the shellfish species which could be collected from the sand flats of the river mouth, less than one kilometre to the north, and from the rocky reef of the adjacent shore (Table 4:9). There is no evidence that forest birds were taken, though dense forest lies only 10 m behind the site. The midden is a specialised barracouta and shell fishing midden, and possibly limited to summer occupation.

The middens between Pillans Head and Long Point are of the same order of size as Picnic Point but tend to be less specialized (Chapter 4:1, Middens: Table 4:9). Each was close to both rocky and sandy shores, with coastal forest behind and the shallow waters of Tahakopa Bay in front. As at Picnic Point, common fish species and rocky and sandy shore shellfish were being exploited. Birds and mammals of the shoreline (penguins, shags and seals) occur in the middens but the only suggestion of forest utilization is the presence of bones of moas and of the native rat. The bays in which these middens lie also have small areas of sand dunes which seem to have been favoured moa habitat (see Chapter 2:3). The fragmentary moa bone of these sites therefore, need not imply forest hunting. Likewise the native rats could have lived in the middens themselves. The presence of
barracouta at Waitangi Stream East indicates summer - autumn occupation (October - May), and if penguins were taken when fattest just prior to moulting, Long Point was occupied at least in late summer (February - March).

The larger sites of Cannibal Bay and Kings Rock (Table 4:12) show wider habitat exploitation, even though these and the previous sites all lie adjacent to the same resource zones. The relationship of Kings Rock to its terrestrial environment is particularly interesting. Bird species, typical of the least disturbed of present New Zealand forests (kakapo, kiwi, kaka and parakeet), appear in this midden with falcon and a small extinct weka. The present forest reserve on the hill slopes between Kings Rock and Papatowai carries a rich podocarp-hardwood forest, well stocked with rimu, miro, matai, broadleaf, supplejack and other berry-producing species, a vegetation likely to have carried a rich avifauna prior to the introduction of mustelids and rodents. The Kings Rock site, however, is on a narrow coastal terrace enclosed by steep hill-sides and cliffs, and there is no access into the forest via navigable streams. By comparison, forest access from Papatowai Point could have been by canoe on the Tahakopa River for 10 kilometres up the valley, giving access to a 3 - 5 kilometre wide strip of terrace and hillslope forests of similar floral composition to the Kings Rock reserve. In terms of energy required for
travel and transport per unit area of forest, Papatowai Point is much more favourably situated than Kings Rock. Yet at Papatowai (Table 4:8) forest bird exploitation is limited to the most abundant and most easily caught species, the native pigeon. At the other two large Occupation sites, Pounawea and Tautuku (Tables 4:9 and 4:12), there is however more indication of forest exploitation; with kakapo and small kaka found at Tautuku and kaka and kiwi at Pounawea. The midden species at Kings Rock show that all the adjacent resource zones of shoreline, sea and forest were exploited. Most of the small birds and the few moas could have come from the adjacent forests. Common species of fish were caught, the presence of barracouta indicating summer-autumn occupation. Penguins, Sooty shearwaters, seals and a presumably stranded whale were taken from the shoreline. The extinct crow may also have been a coastal bird since this is a common habitat for crows in other countries. The mussels, pauas, catseyes, Cooks turban shells and shield shells are all available on the rocky reefs. The relatively high frequency of pipis (Lockerbie 1940:407) is unexpected, since the small sandy beaches are now too unstable for shellfish beds and there are no indications of live pipis and cockles being present. The sand may have been more extensive and sufficiently stable in the past for pipi beds to establish, or the pipis may have been brought round from the Papatowai estuary two kilometres away. The presence of extinct
coot also suggests estuary-wetland exploitation. If the pipis were brought from the Papatowai bed it is anomalous that there are no large cockles mixed with them (see Chapter 4:3), but Lockerbie (1940) does not record cockles at all. Assuming that the pipis and extinct coot were brought from the estuary, this suggests that Kings Rock was preferred to a site on the shores of the estuary where the same resource zones could be exploited but the shellfish would not have had to be transported two kilometres. The most obvious advantage of Kings Rock over any site around the estuary is its shelter from westerly winds.

Cannibal Bay is faunally comparable to Kings Rock with all adjacent habitats of forest, shoreline and sea exploited during at least summer occupation. Mollusc species however have not been recorded and so evidence for shoreline exploitation is limited to the two species each of seals and of shags.

The data from Hinahina (Table 4:12) are derived from a less adequate grab sample than those taken from the other sites and there are no faunal lists available from Lockerbie's excavations (Lockerbie 1959). There is little erosion at this site and the material would represent only late occupation material. The species recorded could all have been derived from the adjacent waters of the estuary, but absence of species from other habitats cannot be taken to indicate a lack of exploitation of those habitats. The ubiquitous barracouta bones indicate summer occupation.

Seen in the context of these other coastal middens,
Papatowai reveals an interesting anomaly. There is virtually no evidence of exploitation of inland habitats. Not only is there a lack of exploitation of known forest avifauna (cf. Kings Rock) but there is an absence of wetland birds and of freshwater fish. If eels were eaten with any regularity at the site, their distinctive vertebrae and head bones should have been detected in the TTI material. Eel bones have been found in similar open sandy sites at Foxton (McFadgen; pers. comm.) and at Washpool, Wairarapa (B.F. Leach; pers. comm.). It is almost inconceivable that the eels of the Tahakopa River were not exploited. (See Chapter 2:4 for an estimate of the available resource.) Just as Kings Rock seems to have been the focus for exploitation of forest avifauna in the area, some other site such as the Cemetery Clear may have been the focus for eeling activities. This latter site is anomalous in that it contained both 'Isolated ovens and artifacts. Early surveyors' maps indicate that during the prehistoric period, it was probably surrounded by river terrace forests containing numerous large trees of several podocarp species. The site is within easy distance of Papatowai Point for canoe transport and could have been provisioned either from Papatowai or by catching eels in the Tahakopa River and birds along the forest-shrubland ecotone. In terms of resources its most likely function was as a boat building site. Boats were locally reported as having been found in a half-constructed state in the nearby forests, but none of the reports was first hand. It is probable that at this site there is material below the plough level which could be located by proton-magnetometer survey.
Assuming some degree of contemporaneity between the sites around the Tahakopa estuary and adjacent shoreline, there is a possibility that sites were complementary to some extent. At Picnic Point and around the estuary there are small shell middens where the species of the adjacent shore or flat had been cooked. The relationship between these sites and Papatowai Point may be seasonal in that at certain times of the year, e.g. early spring or late autumn, the resources usually exploited at Papatowai Point may have been in short supply. It would then become good strategy to exploit resources, particularly shellfish beds, at a short distance from the Point. This relationship seems most probable between small shellfish middens (subsistence sites) and larger ones such as Papatowai Point and Kings Rock. In economic terms the latter are likely to have been 'surplus' sites, where, at some time of the year, more food could be gathered and processed than was required for immediate subsistence.

Evidence from the sites around the other two major estuaries, Tautuku and Catlins, support this pattern of a constellation of complementary sites at a river mouth. During a recent site survey for the New Zealand Historic Places Trust (Hamel: in prep.), numerous small shell middens, containing only the nearby species of the mudflats, were found along the shores of both estuaries. Tautuku Point and Pounawea show much more complete habitat exploitation than Papatowai, in that both show evidence of exploitation of forest and wetland avifauna. Eels are not recorded at either site but this could well be due to deficiencies in sampling and recognition. Otherwise Pounawea and Tautuku show
exploitation of all major habitats, along with considerable utilization of moa species.

Sites around the Catlins estuary, associated with Pounawea, include those on the coast at Cannibal Bay (S184/4), False Island (S184/3) and at Jack's Bay (S184/20) and within the estuary at Hinahina (S184/2). The main site in the dunes at Cannibal Bay was probably always well sheltered from all quarters, as was the small midden (S184/3?) at the base of False Island. The location and aspect of a midden with artifacts recorded by Trotter (also under the site record number S184/3) is not known. Lockerbie (pers. comm. 1969) associated the False Island and Cannibal Bay sites with the middens at Jack's Bay which is well sheltered from the west and south. Lockerbie considers that each of these areas has slightly different and distinctive fish hooks with a mixture of styles in a few areas. These coastal sites he sees as later than Pounawea and Hinahina, and as the places to which the people of Pounawea and Hinahina moved in the period between 1650 and 1725 A.D. The latter date for the abandonment of Pounawea he obtained by growth ring dating one of the larger totaras growing on the edge of the Pounawea site. Lockerbie's model incorporates change from sites strategically placed for moa hunting to those more suitably placed for fishing and shell fishing. Pounawea is situated only an hour's walk from the False Island-Cannibal Bay sites, but the latter would provide easier access and safer anchorage during storms from the west. Faunal data are available for only
Cannibal Bay and Hinahina. It is difficult to assess whether or not Cannibal Bay, as a fishing site, and Hinahina, as an estuarine site, were functionally or seasonally complementary to Pounawea. The simple presence-absence data of fauna used for all of these assessments are inadequate except for showing up the major trends.

As discussed in Chapter 4:1, it is difficult to assess exploitation strategies for the inland sites since no faunal material has been found in them. The 90 ovens recorded represent a considerable expenditure of time and effort, both in travelling to the sites and in constructing the ovens. Ethnographic material suggests that eels, lampreys, forest birds, bracken and cabbage trees were important inland resources (H. Leach 1969). The artifactual evidence from the coastal sites adds the rock resources of silcrete and porcellanite known to occur inland. The silcrete is most abundant in the early period of occupation and the porcellanites in the middle and later periods. The number of ovens is sufficient to indicate that some or all of the inland resources were of critical importance.

Throughout this discussion of exploitation of resource zones, the place of moas in prehistoric economic strategy has been deliberately avoided. For most extinct species, e.g. extinct goose, we can confidently infer their habitats from
those of living relatives. It is not possible to do this for moas, since they have no close living relatives. What can be deduced about moa habitats from subfossil natural deposits was discussed in Chapter 2:3, where it was suggested that the most productive moa habitats were likely to have been forest ecotones of various types, particularly forest-wetland and forest-coastal shrubland ecotones. However it would be wrong to infer from the above reasoning, that the moas in the Pounawea, Papatowai, Kings Rock and Tautuku middens represent exploitation of the above ecotones. Rather it is more logically defensible to argue that, since the general pattern of exploitation is one of harvesting abundant resources from habitats immediately adjacent to sites, it is probable that the moas were also captured close to the sites in which their bones are found. The fact that appropriate forest ecotones occur close to all these sites supports the argument that moas favoured such habitats.

Discussion

In this chapter sites have been given approximate chronological order of establishment according to their faunal material and available radiocarbon dates. It is postulated that sites established before 1400 A.D. tend to be exposed to the west while sites established later tend to be sheltered from the west but are often exposed to the south. This is associated with an increase in cold wet westerly winds during the cold periods of the Little Ice Age. This model will be elaborated on in the next chapter.
It is suggested that the large and early occupation sites on Papatowai Point, Pounawea and Tautuku Point were placed at positions on the landscape where the largest possible number of habitats could be exploited and that they may have been inhabited for most of the year. There is some evidence for the establishment of complementary sites along the estuaries for better exploitation of mudflat shellfish at a short distance from each of the major sites. Other sites along the coast and inland tended to be related to fewer resource zones and to be more specialised in their exploitation strategy. The presence of barracouta bones in nearly all coastal middens suggests that there were no exclusively winter sites, but possibly some of the summer sites were occupied during winter. The most likely wintering sites would be Pounawea, Papatowai and Tautuku Point, but winters may have been spent elsewhere than on the relatively wet Catlins coast.

Overall, occupation sites are very unevenly distributed on the landscape, and closely adjusted to the resource zone boundaries. The lack of chronological control for the smaller sites makes it difficult to give them their proper place in the settlement pattern. However the concentration of sites along the coast and the lower densities of inland sites does suggest that the prehistoric population was able to maintain itself for most of the year where the living was easiest, i.e. on the coast. Inland resources of food may have been of secondary importance compared to rock resources such as porcellanite and silcrete. A lack of records of eel weirs and associated structures for most of Southland and Otago (see Coutts 1970
for possible occurrence at Manapouri) suggests that the prehistoric population was able to avoid such labour intensive devices, and could afford light exploitation of this important food species. However it seems necessary to postulate that, whether it was for food or rock resources, the prehistoric populations of Murihiku consistently chose to exploit inland resources. The lack of access to these desired resources may have been one of the factors which brought about the abandonment of the Catlins coast after 1700 A.D.
Chapter 4:5

MODELS AND ECONOMIC STRATEGIES

The archaeological evidence and available radiocarbon dates indicate that the Catlins coastline was settled between 800 and 1000 A.D., by a Polynesian people with an artifact assemblage typifying the Archaic Phase of New Zealand Eastern Polynesian Culture (Golson 1959). In the absence of a suitable environment for kumara or other tropical crop plants, they adopted a hunting and gathering economy.

The present analysis has demonstrated that the initial economic pattern was one of multi-resource zone exploitation, from estuarine ecotonal sites. Compared to other forested coastlines of New Zealand, moas were numerous, both in numbers of species and numbers of individuals, and there were breeding colonies of fur seals as well as non-breeding Sea lions. The climate was at least as warm if not warmer than at present and storms probably tended to come from the south rather than from the west. The coastal forests were rich in podocarp and broad-leaved trees, and supported a rich avifauna, including such large species as kakas, kiwis, kakapo, wekas and takahe. Extinct species of crow, goose, swan, eagle and coot were also present. Beds of pipis and cockles and shoals of barracouta were exploited. Some species, including river flounders, yellow-eyed penguins and eels, seem to have been ignored at the coastal sites throughout the prehistoric period, although there is little doubt that they were present.

In later occupation levels the same resources were exploited but in changing proportions. The larger animal species
decreased in importance and smaller animals, particularly fish, penguins and shellfish were being taken. Finally as moas and seals declined in numbers or availability, a broader spectrum subsistence strategy developed, with greater reliance on the resources of the inland rivers and forest-grassland ecotones. It has been postulated that the heavy forest of the Catlins hills so restricted access to the inland areas that there was a move away from the Catlins coastline to the mouths of the Mataura and Clutha Rivers. Sites on these latter coastlines could be more readily incorporated into seasonal schedules which exploited a full range of inland, coastal and maritime resources.

Within the period of occupation, there may have been movements away from the large exposed sites at river mouths with their numerous resource zones, to smaller sheltered sites where subsistence was more difficult because there were fewer adjacent resource zones to exploit. Logically these movements should have coincided with the periods of lowest temperatures. Papatowai may even have been abandoned entirely after the first period of climatic deterioration in the 15th century.

Taking into consideration the 17th century dates for Pounawea, False Island and Cannibal Bay, the Catlins coastline does not seem to have been finally abandoned until about 1700 A.D. The area around Papatowai which is the part of the coastline furthest from the Clutha and Mataura river mouths may have been abandoned earlier. Though the final movement away from the Catlins coastline seems to have occurred only a century before the Contact Period, there are no traditions of warfare initiated by people moving north or west. This
may be indicative of a low population density, or of a simple change in the seasonal round of people who always spent part of the year outside the Catlins, e.g. at Fortrose or Kaka Point. Instead of moving to semi-permanent camps on the Catlins coast for the summer and autumn, they may have simply changed to a more nomadic existence, visiting Lake Tuakitoto, the inland plains, rivers and forests for eels, lampreys, birds and bracken.

There is no direct evidence that the wetter Catlins coastline was abandoned during the winter months. Certainly indicators of winter occupation have not been found but these are so few that their absence is not a reliable index of a lack of winter occupation. Winter houses of relatively light timbers and thatch roofs must have been considerably more durable in the lower rainfall areas adjacent to the Catlins forest, particularly at the mouth of the Clutha. Drier conditions would also significantly improve the storage qualities of dried and fat-preserved foods. Given Polynesian technologies, the Catlins climate militates against the storage of preserved foods. The problem of transport and storage of preserved foods in Murihiku requires examination if the hypotheses of Leach (1969) and Higham (1969) are to be considered further. Provision for subsistence during winter and spring may have been a key factor determining population density and growth, relative to the prehistoric environment of the region.

This discussion has assumed that the prehistoric occupants sought the greatest material gain for the least effort, a tendency modified, of course, by socially-determined prefer-
ences and impositions, such as the demands of gift exchange. A further assumption is made that despite these modifying factors, the species found in the middens represent the most abundant and most easily harvested edible species of plants and animals, sufficiently varied as a group to provide a satisfactory diet. Where food species were apparently abundant but ignored, it is worth considering the hypothesis that their addition to the diet represents an undesirable lowering of the energy input/output ratio. How much variation is introduced into the diet will be determined partly by social factors and partly by the overall energy input/output ratio resulting from efforts to increase variability in the diet.

No attempt has been made to fit the archaeology of the Catlins into a predetermined model of spatial or temporal patterns. Layers and sites have been classified inductively according to the evidence available.

It has been argued in previous chapters that spatial divisions in the Catlins, reflect economic rather than cultural boundaries. There is, for instance, no evidence for separate group territories, and some evidence that the prehistoric population was a mobile one (Chapter 1:1). Spatial models in consequence were based on environmental criteria, linked to the concept of resource zone exploitation.

Resource zones may be seen as small-scale habitats, such as individual pipi beds, or as larger units such as all the estuaries of a defined part of a coastline. Archaeological studies are so varied that resource zones
are designed in the light of particular problems. In this study it was sufficient for the discussion of settlement pattern (Chap. 4:1) to use large subdivisions such as "marine" or "forest". Estuaries and sheltered sandy shores were grouped together because both carry beds of pipis and cockles. The unifying element here was the resource species, rather than a topographical boundary. Thinking in terms of hunter-gatherer strategies, obviously a continuous area of exploitable terrain such as sea is a useful concept. When, however, a resource zone has a linear form such as that of the shoreline, and a particularly favoured species is found in two such linear zones, the areal concept may be restrictive.

Important groupings of sites, based partly on simple spatial criteria and partly on resource zone criteria, are:

(a) Large coastal sites adjacent to numerous resource zones, e.g. Pounawea, Papatowai, Hinahina and Tautuku Point.

(b) Smaller coastal sites adjacent to fewer resource zones, e.g. the Long Point - Pillans Head group, Picnic Point, Kings Rock, Tautuku North, False Island, Cannibal Bay.

(c) Small coastal middens, each consisting of a lens of shells and exploiting only the adjacent beds of shellfish, e.g. Tahakopa Estuary shell middens.

(d) Inland isolated ovens and charcoal and stone patches, which it must be assumed express exploitation of the forest-grassland ecotone and the rivers, e.g. the Mokoreta ovens, the Charcoal and stone patches and Woodshed Oven at Stott's Clear.

(e) The sites of the Catlins coast as contrasted to the
sites at the mouth of the Clutha, the former being grouped together because they were abandoned by 1700 A.D. while occupation at the mouth of the Clutha continued into the Contact Period.

Obviously the economic history and the spatial groupings of the settlement pattern so far discussed, require the addition of a time scale. Two chronological models will be proposed which integrate settlement patterns, stratification, economic history, multiplicity of resource zones and climate changes. They take into account two related phenomena; the sharp discontinuities of layer matrices at Papatowai and Pounawea and the obvious continuities of faunal exploitation and artifact assemblages at both sites and of activity foci at Papatowai. Though the most recent radiocarbon dates for Papatowai suggest that occupation there may have lasted for only three centuries, as compared to six centuries at Pounawea, there is sufficient ambiguity in the dating to make synchronization of activities at the two sites a possible assumption. If the two major discontinuities in the sections at Papatowai are contemporary throughout and are correlated with the similar discontinuities at Pounawea, then these could mark significant periods of temporary abandonment of the two sites. The change may have been only the loss of summer moa hunting camps but even this would have initiated changes in economic strategy and possibly in social organisation. These, as well as possible environmental changes, may have permitted experimentation and involved new strategies when re-occupation occurred. Whatever the cause, the contents of the successive
occupation layers were quite distinctive in their relative proportions. These differences may involve the periodicity of occupation, the proportions of time devoted to harvesting given species and the methods of food preparation.

At the crucial periods of abandonment, the occupants of Papatowai and Pounawea may have left the Catlins coast entirely or they may have moved to other sites. Alternate models (Figs.4:17 and 4:18) can be based on these two possibilities. The models are so constructed that seasonality is not a relevant variable: occupation of the coast line could have been all the year round or only during summer, without affecting their validity. Seasonal factors should however be incorporated when data become available.

In both models periods of occupation are set beside a graph of temperature change as demonstrated by oxygen isotope ratios in speleothems from the central North Island (Fig.4:6), since this is the most refined index of the three lines of evidence for cold periods (p. 255). Radiocarbon dates and faunal materials were used to position each lozenge representing a component or site. It was noted that the occupation layers of Papatowai, Pounawea and Hinahina could be positioned such that the periods of abandonment coincided with periods of low temperatures on Wilson's curve. These are the sites exposed to the west (Chapter 4:4). The components of the smaller sites, not exposed to the west, could be positioned either to cover the periods of abandonment (Model I), or to coincide with the later parts of occupation periods at Papatowai and Pounawea (Model II). Except for occupation at False Island and Cannibal Bay, both models
can be fitted to the available radiocarbon dates and frequencies of extinct bird species. In Model I the occupants of the coast are assumed to have moved to the more sheltered sites during the coldest periods and the population is seen as relatively stable. Model II assumes population expansion to sites with fewer resource zones at the end of each occupation period, these new sites being chosen for their sheltered location, since temperatures were dropping. Further it is assumed that at the time of the lowest temperatures the population left the Catlins coast entirely, and when temperatures increased again fewer people returned. In this latter model, a separate explanation is required for the anomalous positions of the False Island and Cannibal Bay sites relative to their radiocarbon dates. It is not at all apparent why they should have been occupied at a different date from the other sites which also have few resource zones. Model I is therefore somewhat more parsimonious of the evidence and simpler in structure, but on the other hand the expanding population of Model II is more in keeping with Groube’s (1970) population curve for New Zealand as a whole. The inland sites are given a late position on the grounds of their correlation with the immediately pre-European forest edge and to emphasise their position in a postulated new economy of the post-Catlins era. The small shell middens of the coast and the inland quarry sites are assumed to have been features of the settlement pattern throughout the prehistoric period.

These models represent a synthesis of available material and require extensive verification before they could
be used to support other hypotheses. The dotted lines in Figs. 4:17 and 4:18 for Tautuku Point, the upper occupation at Hinahina and the inland quarries are all hypothetical components for which there is only circumstantial evidence. There are no radiocarbon dates to show that occupation began and ended for the major sites at the calendar dates associated with the coldest periods of Wilson's curve (Fig.4:6). There are no dates or faunal evidence to indicate that all the Long Point—Pillans Head middens and Tautuku North are contemporary. They could have been occupied at either or both of the first two cold periods when moas were available. The faunal material from the Murikauhaka middens, the position of this site near to the mouth of the Clutha River and the significant three layer sequence suggest a similar pattern of occupation to that at Pounawea and Papatowai, but again there are no dates to confirm that its periods of abandonment coincide with those at Papatowai and Pounawea.

As against these strictures, both models present an integrated pattern which does not contradict any of the available data. Time may falsify either or both,
Appendix 2:1

CALIBRATION OF INSTRUMENTS FOR CLIMATE STATIONS

Rain gauges

After the research period the six rain gauges were set in short pasture at the Tahakopa climate station in a block, 2 x 3, with one metre spaces between, fenced from stock and the grass kept clipped. The instruments were read at about three week intervals from Aug 8 1972 to 1 May 1973 (20 readings). A small degree of variation, presumably due to measuring errors and to minor variation in the positioning of the rain gauges was found but this never amounted to more than 2.5% of the mean. This 2.5% variation could be either positive or negative for a given rain gauge and could not be corrected for. It is unlikely that the rain gauges were in themselves a source of error but no doubt the particular relations of the rain gauges to nearby objects at the research stations did affect the amount of water entering the funnel especially on windy sites. No corrections were made to rainfall values.

Thermometers

Seven plastic-cased, zeal, maximum-minimum thermometers (graduated Celsius and Fahrenheit) were calibrated prior to the research period and six, which were reading consistently together, put out. At the end of the first year the spare thermometer was substituted for the Papatowai instrument which seemed to be reading too low. At the end of the period all seven were tested together at the Tahakopa climate station,
eleven readings being taken over 27 hours and over a temperature range of -2.0$^\circ$C to 13.0$^\circ$C. The mean deviation of each instrument was calculated and it was found that only the instruments at Tahakopa and Kahuika were showing a measureable deviation, 0.5$^\circ$C too high and too low respectively. The readings for these two stations were adjusted accordingly.

Evaporimeters

The instrument consistency of porous pot evaporimeters is sufficiently low to require calibration of the instruments against one another (Cooper 1970). The causes of variation are not always obvious. Minor differences in colour of the evaporating surface due to the accumulation of dust and the growth of micro-organisms will affect its surface temperatures. This may be a major variable as it seems likely that the darker the porous pot the higher the rate of evaporation.

The evaporimeters were run together before and after the research period and for 20 hours in the middle of the period. When breakdowns occurred further calibration runs were made of replacement instruments against a reserve of two or three instruments of known performance. The evaporimeters at Tautuku and Kahuika, where the lowest temperatures were expected, were set in plastic bottles to prevent frost breakage. Their rate of evaporation was consistently 80% that of the glass reservoir instruments during the calibration tests. Only one evaporimeter, No. 7 at Tautuku, ran without breaking down throughout the research period and the subsequent calibration period, and this was used as the standard instrument to which all others were calibrated, so as to remove some of the variation between instruments.
This gave relative values between the six stations. To give values useful for comparison with other instruments, further corrections had to be made. The use of 20% ethanol to reduce frost damage given a mean evaporation rate 5% higher than that of distilled water (Cooper 1970), and so values were reduced by dividing by 1.05. The adjusted values were then converted to give an approximate comparison with the standard raised pan evaporimeters of the New Zealand Meteorological Service, by applying Jessep's (1964) regression formula, \( y = 0.0029 + 0.0025x \), where \( y \) = estimated inches of evaporation and \( x \) = ml of evaporation from the field instrument. These converted values must still be used with caution when comparing them with values from raised pan evaporimeters.

The conversion sequence in total was:

(a) Reduce glass reservoir instruments to the plastic reservoir standard instrument,

(b) Raise all values by an average value of the glass reservoir instruments and then reduce them to allow for the 20% ethanol used instead of distilled water, so as to be comparable with the instruments calibrated by Jessep (1964).

(c) Apply Jessep's regression equation to give an approximation to the standard raised pan evaporimeter, converted to millimetres.
Appendix 2:2

PLANT SPECIES ON STOTT'S DOG

Mosses, lycopods and ferns

Blechnum minus (R.Br.) Allan
B. penna-marina (Poir.) Kuhn
Gleichenia circinata Swartz
Lycopodium ramulosum Kirk
Pteridium aquilinum (L.) Kuhn
Sphagnnum sp.

Grasses and other monocotyledons

Astilea nervosa Hook.f.
Bulbinella hookeri (Hook.) Cheesem.
Calorophus minor Hook.f.
Carex coriacea Hamlin
Carex secta Boott in Hook.f.
Chionochloa rubra Zotov
Herpolirion novae-zelandaiae Hook.f.
Hierochloe antarctica
Juncus gregiflorus L. Johnson
Juncus effusus L.
Luzuriaga parviflora (Hook.f.) Kunth
Phormium tenax J.R. et G. Forst.
Schoenus pauciflorus (Hook.f.) Hook.f.
Thelymitra sp.

Dicotyledons

Celmisia gracilenta Hook.f.
Coprosmaspp.
Cyathodes empetrifolia Hook.f.
Dracophyllum longifolium (J.R. et G.Forst.) R.Br.
Drosera binata Labill.
Drosera stenopetala Hook.f.
Geranium cf. sessiliflorum Cav.
Gunnera prorepens Hook.f.
Haloragis micrantha (Thunb.) R.Br. ex Siebold et Zucc.
Leptospermum scoparium J.R. et G.Forst.
Nertera depressa Banks et Sol. ex Gaertn.
Oreostylidium subulatum (Hook.f.) Bergg.
Pentachondra pumila (J.R. et G.Forst.) R.Br.
Pernettya macrostigma Col.
Appendix 2:3

CHANGES IN EROSION PATTERNS ALONG THE EAST COAST OF OTAGO

On a world scale, changes in sea level relative to the land have had a complex history. In the past 1000 years vertical movements of land masses seem to have been of greater moment than changes in world-wide sea levels. This implies that there can be no single overall synthesis for coastal change around New Zealand, since the rate of vertical movement is known to vary in amplitude and direction around our coasts; and this discussion will be limited to the east coast of Otago.

Lockerbie (1959:82) notes evidence for coastal submergence at Pounawea, where the lowest levels which are dated to the twelfth century, lie at or a little below mean high tide. The lowest levels of sites at Shag River and Waimataitai also extend below the high tide line (Lockerbie 1959:82, and pers. comm.). However evidence that these levels were living surfaces and not just midden thrown into damp hollows and low tide pools is not presented.

Moa-hunter midden is being eroded from numerous sites along the Otago coast from Waitaki Mouth to Haldane. Geologically this coast has been considered to be a relatively stable block with a slow rate of deposition on sand- and mud-flats, accompanied by erosion of points and headlands. The evidence of present-day erosion of sandy points at the mouths of rivers such as the Tahakopa and Catlins Rivers is quite clear. Embayments in the region of the Otago Peninsula however are thought to be closing up. Tomahawk and Hawkesbury lagoons are now
breckish enclosures, Hooper's Inlet has closed more frequently in the past eight years than previously, and the Otago Harbour entrance requires dredging. This latter pattern suggests an emerging shoreline. A recent study of Waitati Bay (Whitman 1974) produced surprisingly early and quite consistent C14 dates (between 5000 and 7000 B.F.) for deposits only 10-50 cm below the surface of the sand flats in the embayment. This suggests that east Otago embayments could be being stripped of material by tidal currents where they are not influenced by river flow. This evidence suggests a submerging coastline, at least since 5000-7000 B.P.

Erosion of sandy points at the mouths of rivers (where sites are so often located) may be much more the effect of river flow than tidal flow. The most vigorous erosion of Papatowai Point during the study period occurred in late April 1972, after a month of heavy rain followed by flooding. Where previously few logs had been stranded in the inner estuary, after 27 April there were about thirty young totara trees from the Point strung over the estuary. A large totara with spreading branches which fell in about 1933, and had been used by Lockerbie (1959) for dating abandonment of Papatowai Point, had been broken up and could not be found. The river edge of the moa hunter site had been cut back a little but the most intense attack had been on the more sterile end of the Point, where a vertical bank, three metres high, had been cut into the sand. This 'cliffing' of the sand dune gradually fell away to a normally sloped dune edge about 400 metres along the sea beach. The peak of flooding had occurred on 22 April but had coincided with only neap tides. The time
and amplitude of the main peak in river flow was not recorded but if it had coincided with even a neap high water, this could have created a highly destructive current around the Point at ebb tide. It would be very instructive to document the precise nature of erosion events such as this. The volume of water associated with flood peaks is likely to have increased over the past one hundred year, since European modification of vegetation cover has tended to increase the rate of run-off.

Erosion patterns of Otago beach middens generally need to be examined in terms of both river flow and the long term tendency for the sea to attack headlands and steep shores and to build up embayments. There may have been changes in both strength and direction of prevailing winds and currents along the coast, which have changed the angle of attack of on-shore swells. Such a change would affect the normal processes of headland erosion and infilling of bays, and could bring about erosion of middens, such as that at Seacombe, without any change of land-to-sea levels. Levison (1974) presents some evidence for changes in current patterns in the South-west Pacific over the past 1500 years. A particularly effective factor which Levison mentions may have been longitudinal changes in the seasonality and intensity of blocking anticyclones to the south-east of New Zealand, as postulated by Lamb (1967) for the past century. These changes can be associated with north-south movements of the Antarctic ice-limit, and could influence the frequency and intensity of the southerly and south-easterly swells in the seas south-east of Otago.
Appendix 3:1

PEDOLOGICAL ANALYSIS OF MIDDEN SOIL, TT1, PAPATOWAI

Mr. D. Leslie, Soil Bureau, Dunedin.

Soil Layers

(1) 15 cm Colour 7.5YR, 3/2-2/2. Slightly silty sand, very friable, almost structureless, abundant roots. Equivalent to archaeological Layer 1 (Fig. 4:12). Boundary fairly distinct. (Colour due to organic component forming a mosaic with quartzo-feldspathic sand.)

(2) 10 cm Colour 7.5YR, 2/1. Sand with occasional shell, very friable, very weak blocky structure, fewer roots but still numerous. Boundary indistinct.

(3) 13 cm Colour 10YR, 3/2. Sand very friable, very weak blocky structure, many woody roots. Boundary fairly distinct.

(4) 18 cm Colour 7.5YR, 4/3. Sand very friable, very weak blocky structure, a few roots. Boundary irregular but distinct.

(5) 10 cm Colour 7.5YR, 2/2. Very slightly silty sand, very friable; weak, medium to coarse blocky structure, many roots. Boundary irregular and indistinct with apparent worm mixing into layer below.

(6) 18 cm Colour 10YR, 5/4. Sand very friable, very weak medium blocky structure, occasional roots. Equivalent to stained substrate below occupation material. Indistinct boundary.

(7) 20 cm Colour 10YR, 6/4. A coarser sand than above, very friable, structureless. Unstained substrate below
occupation material. Boundary indistinct.


(9) Sand similar to (7).
Appendix 3:2

PLANT SPECIES OF PAPATOWAI POINT

Trees and shrubs

Podocarpus hallii                         Hall's totara *
P.totara                                    True totara
P.totara X hallii                           Hybrid totara
P.ferrugineus                                Miro
P.spicatus                                   Matai
Dacrydium cupressinum                        Rimu
Weinmannia racemosa                           Kamahi
Griselinia littoralis                         Broadleaf
Melicytus ramiflorus                          Mahoe
Fuchsia excorticata                           Fuchsia
Pseudowintera colorata                        Peppertree
Myrsine australis
Leptospermum scoparium                         Manuka
Carpodetus serratus                           Marbleleaf
Pseudopanax crassifolium                      Lancewood
P.edgerleyi
Pittosporum tenuifolium                      Lancewood
P.tenuifolium X colensoi
Coprosma foetidissima                        Stinkwood
C.rhamnoides
Hebe salicifolia                              Koromiko
Aristotelia serrata                           Wineberry

Lianes and epiphytes

Ripogonum scandens                           Supplejack
Rubus cissoides                                Lawyer
Loranthus micranthus                           
Earina autumnalis

**Herbs**

Senecio (Erechtites) minima
Sonchus littoralis
Sonchus asper
Corybas sp.
Uncinia uncinata
U. clavata
Lagenophora sp.
Nertera depressa

**Ferns and allies**

Polystichum vestitum
Asplenium flaccidum
A. bulbiferum
Phymatodes diversifolium
Rumohra adiantiformis
Dicksonia squarrosa
Pteridium aquilinum var. esculentum Bracken
Blechnum penna-marina
Grammitis heterophylla
Pyrrosia serpens
Lycopodium fastigiatum
Tmesipteris tannensis

* Common names are given where appropriate.
USE OF INHIBITING DISCS IN THE STUDY OF ANNUAL INCREMENTS OF WOOD

The aim of this technique is to prevent the addition of wood over a small area of a tree trunk, for a known number of growing seasons, and then to make a comparison with the number of rings added to an untreated area (Wells 1972).

Aluminium discs about 3 cm diameter were used. Circles of bark were cut about 0.75 m above the ground from 20 trees of two species, using a sharp auger. A disc was nailed into the cut circle on each tree, flush against the most recently-formed wood. The nail used was fitted with a sleeve so that it held the disc firmly in place but projected end would be visible as the wood and bark grew over the disc. When the discs were removed, the inhibited area was cut out as one block. A pair of increment cores taken from within and beside the inhibited area was unsatisfactory, as they tended to break up too readily. When the blocks were sawn across and trimmed with a sharp knife, the contours of the last five years' growth rings were clearly visible. In the totaras the cambium had not been cut cleanly through, and the rings of the last five years could be distinguished as having been compressed beneath the disc as compared to the uncompressed rings of earlier years' growth. In silver beech the last five years' growth appeared as thick rings of callous tissue, bulging inward over the disc.
Appendix 4:1

CHECKLIST OF SITES IN THE NORTHERN
AND WESTERN CATLINS

Site number - as given on the N.Z. Archaeological Association
Site Record Form.

Grid reference - six figure grid number taken from the
N.Z.M.S. 1 (1 inch to 1 mile) series.

Name and comments. - The name is usually that of a nearby
topographical feature. Sites marked + are those which I have
not seen. Some sites such as ploughed-over ovens and small
eroded middens whose position is fairly exactly known are con-
sidered to have been 'seen' if the immediate topography and
ecology have been examined.

Map N.Z.M.S. 1, S 179.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Grid Ref.</th>
<th>Name &amp; comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>570018</td>
<td>Tirihanga, Nugget Point. Coastal midden on narrow terrace 1-2 m above high water mark, being eroded by the sea. Burnt stone, charcoal, black sandy matrix, fish and bird bones, no shell.</td>
</tr>
<tr>
<td>2</td>
<td>572017</td>
<td>Tirihanga, Nugget Pt. Coastal midden 300 m SE of Site 179/1. As above with the addition of a few cockles, broken blue mussel shell and a pig vertebra.</td>
</tr>
<tr>
<td>3</td>
<td>550100</td>
<td>Murikauhaka, Port Molyneux. Contact</td>
</tr>
<tr>
<td>Site No.</td>
<td>Grid ref.</td>
<td>Name &amp; comments</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>Contact Site? Port Molyneux. Possibly a secondary number for 179/3.</td>
</tr>
<tr>
<td>5</td>
<td>c.556069</td>
<td>Post-European village at mouth of Karoro Stream. Inhabitants of Murikauhaka moved to Karoro Stream after an epidemic of measles. Deposits of charcoal and shell midden.</td>
</tr>
<tr>
<td>7</td>
<td>c.419223</td>
<td>A zone of large ovens on hillslopes stretching from Romahapa, through Puerua Valley, Lochindorb, Waipera headwaters to Clinton. No trace could be found of the two ovens reported to be on The Mound, Kirks Corner, Puerua River. J. Polynes. Soc. 31:155-56.</td>
</tr>
<tr>
<td>8</td>
<td>c.370090 + Flaking floor? &quot;A great number of</td>
<td></td>
</tr>
<tr>
<td>Site No.</td>
<td>Grid ref.</td>
<td>Name &amp; comments</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>9</td>
<td>c.513038 +</td>
<td>Otekura. Oven now ploughed over. Adze of hard green stone nearby.</td>
</tr>
<tr>
<td>10</td>
<td>c.515012 +</td>
<td>Otekura. Spread of charcoal and burnt stone with some obsidian ploughed up. No surface hollow.</td>
</tr>
<tr>
<td>11</td>
<td>513042</td>
<td>Karoro Bank. Three oven dimples where Karoro Stream turns in to Ahuriri Flat.</td>
</tr>
<tr>
<td>12</td>
<td>537050 +</td>
<td>Karoro Stream. Two adzes found when ploughing; one of sandstone nearly 2 feet long and one side hafted of green argillite.</td>
</tr>
<tr>
<td>13</td>
<td>535048 +</td>
<td>Tributary of Karoro Stream. Three oven dimples with burnt stone and charcoal.</td>
</tr>
<tr>
<td>14</td>
<td>555077</td>
<td>Kaka Point. Midden on edge of shore with moo bone, burnt stone, charcoal and some artifacts e.g. drilled tab for fish hook.</td>
</tr>
<tr>
<td>15</td>
<td>274032</td>
<td>Pupepiko. Two circular patches of burnt</td>
</tr>
<tr>
<td>Site No.</td>
<td>Grid ref.</td>
<td>Name &amp; comments</td>
</tr>
<tr>
<td>----------</td>
<td>-----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>16</td>
<td>554003+</td>
<td>stone and charcoal beneath one foot of turf. Situated at lower end of pre-European boggy tussock clearing on floor of Catlins Valley. Sandy Bay. Charcoal and burnt stone, and a burnt sinker.</td>
</tr>
<tr>
<td>17</td>
<td>7</td>
<td>George's Oven. Between King's Creek and Karoro Creek, on low sand dunes. A circular oven 1.5 m across with the bones of a human body and several artifacts.</td>
</tr>
</tbody>
</table>

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Map N.Z.M.S. 1, S 184

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Grid ref.</th>
<th>Name &amp; comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>407976</td>
<td>Pounawea. A deep midden with a stratigraphy running from blackened sand at the bottom to ashy and shelly layers above. Numerous mammal-bones, as well as seal, bird and fish bones. Sited on peninsula between the Catlins and Owaka Rivers adjacent to the Catlins estuary. Dated 1140 ± 60 to 1660 ± 60 A.D.</td>
</tr>
<tr>
<td>2</td>
<td>c.409968</td>
<td>Hinahina. Similar to Pounawea but with less occupation material in the upper layers. Sited at the base of a low sandy point (Cabbage Pt) projecting into the Catlins estuary. Dated A.D. 1210 ±</td>
</tr>
<tr>
<td>Site No.</td>
<td>Grid ref.</td>
<td>Name &amp; comments</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>----------------</td>
</tr>
<tr>
<td>3</td>
<td>c.537972 +</td>
<td>False Island. At least four different areas of occupation as well as skeletons of moas naturally preserved in the sand dunes at c.527975. At least two sites should be differentiated - a large midden at c.532975 probably excavated by Lockerbie and a midden with artifacts at c.532971 recorded by Trotter. Considered to be fishing camps.</td>
</tr>
<tr>
<td>4</td>
<td>c.532976</td>
<td>Cannibal Bay. Eroding midden and burials with sub-fossil moa bones. Artifact evidence and C14 dating places both this and the False Island sites as later (16th century) than Pounawea, Hinahina and Papatowai. Bones from the midden include fish (barracouta dominant), small birds, dog, rat and seal. Fish hooks and bird spears numerous from this area.</td>
</tr>
<tr>
<td>5</td>
<td>306865</td>
<td>Papatowai Point. Several patches of deep midden with small shell middens extending along the shore in both directions and up the Tahakope River Estuary. The deeper middens contain</td>
</tr>
</tbody>
</table>
### Site No.  Grid ref. | Name & comments
--- | ---
6 | 299849 | Numerous moa, seal, bird and fish bones, and are sited on a sandy point where the Tahakopa River meets the sea. Dated $1039 \pm 76 - 1640 \pm 60$ A.D.

6 | 299849 | **Kings Rock.** Two areas of midden in two small sheltered bays almost enclosed by reefs and cliffs. Middens not as deep as at Papatowai but appear to cover a similar period. Moa, seal, bird and fish bones numerous. The lack of flake material and presence of numerous fish hooks and tabs as well as location of the site suggest this was mostly a fishing camp.

7 | 262810 | **Tautuku Peninsula.** Articulated leg of *Dinornis torquus* in occupation layer on sloping surface of sand dune, dated A.D. $1690 \pm 60$. Flake knives in black layer, human bones and barbed hooks above. Site could be from 16th century to Contact Period.

8 | 306868 | **Papatowai.** A midden face, part of S184/5 complex.

9 | 306869 | **Papatowai.** Another midden face, part of S184/5 complex.
<table>
<thead>
<tr>
<th>Site No.</th>
<th>Grid Ref.</th>
<th>Name &amp; Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>304873</td>
<td>Papatowai. One of estuary midden near S184/5.</td>
</tr>
<tr>
<td>11</td>
<td>330875</td>
<td>Papatowai Bridge. Extensive area of shell on low river dunes. No good evidence that it is occupation material.</td>
</tr>
<tr>
<td>12</td>
<td>292876 +</td>
<td>Upper estuary, Papatowai. Shell midden exposed in upper part of river dunes.</td>
</tr>
<tr>
<td>13</td>
<td>299071</td>
<td>Papatowai Bridge. Shallow midden of charcoal and shell on river edge terrace.</td>
</tr>
<tr>
<td>14</td>
<td>299(8)869</td>
<td>West Bank, lower Papatowai Estuary. Shallow shell midden, probably a small lens on rocky bank of estuary.</td>
</tr>
<tr>
<td>15</td>
<td>299868</td>
<td>West Bank, lower Papatowai Estuary. Another shallow? lens of shell midden.</td>
</tr>
<tr>
<td>16</td>
<td>299865</td>
<td>West Bank, lower Papatowai Estuary. Similar to S184/14 and S184/15.</td>
</tr>
<tr>
<td>17</td>
<td>298867</td>
<td>Tahakopa/Maclennan confluence. Shell midden on edge of upper Papatowai Estuary.</td>
</tr>
<tr>
<td>Site No.</td>
<td>Grid ref.</td>
<td>Name &amp; comments</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>210920</td>
<td>Find spot of flaked adze in dark green stone. River terrace in Stott's clearing.</td>
</tr>
<tr>
<td>19</td>
<td>310866</td>
<td>Small shell midden with burnt stone, high on dune of seaward beach just east of main Papatowai Point site 5184/5.</td>
</tr>
<tr>
<td>20</td>
<td>264018</td>
<td>Tautuku Point. Thin lenses of charcoal, blackened sand and broken shell and bone in the sand against the forest edge. Seal, fish and bird bones. Moa bones may be sub-fossil. Probable dates around 16-18th centuries.</td>
</tr>
<tr>
<td>21</td>
<td>284846</td>
<td>North Tautuku Beach. Two lenses of burnt stone, charcoal, burnt bone including moa bone and broken shell.</td>
</tr>
<tr>
<td>22</td>
<td>295837</td>
<td>Rainbow Is. Find-spot of greenstone adze (Lockerbie, pers.comm.).</td>
</tr>
<tr>
<td>23</td>
<td>c.202790</td>
<td>Waipati Beach, south end. A human skeleton with paua shell disc and small greenstone adze eroded out of sand hills.</td>
</tr>
<tr>
<td>24</td>
<td>304857</td>
<td>Picnic Point. Two lenses of shell, burnt stone, charcoal and blackened</td>
</tr>
</tbody>
</table>
Map N.Z.M.S. 1, S 164.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Grid ref.</th>
<th>Name &amp; comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>c.325878+</td>
<td>Puaho Cliffs. Human bones in cave at foot of cliffs. Seen by Mr. E. McTainsh.</td>
</tr>
<tr>
<td>26</td>
<td>358865</td>
<td>Pillans Stream. Eroded hangi area on an easy slope facing north across Pillans Stream close to where it emerges on sandy beach. Large burnt stones and large pieces of charcoal - two areas, 40 x 40 metres and 20 x 10 metres. No sign of shell or bone. Teviotdale found midden, some 'chert' flakes and a neatly-made ring of Dentalium.</td>
</tr>
<tr>
<td>27</td>
<td>374866</td>
<td>Waitangi Stream Beach, west end. Eroding midden with charcoal, burnt stone, mussel and limpet shells. On low terrace at the back of sheltered beach.</td>
</tr>
<tr>
<td>28</td>
<td>375866</td>
<td>Waitangi Stream Beach, east end. Sandy heap of midden c. 30 metres</td>
</tr>
<tr>
<td>Site No.</td>
<td>Grid ref.</td>
<td>Name &amp; comments</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>29</td>
<td>365863</td>
<td>Long Point, south side. Eroding lens of midden about 15 metres across; burnt stone, charcoal, bird and seal bones, fragments of moa bones, and shells. On a small grassy flat behind fore dune of a sheltered bay.</td>
</tr>
<tr>
<td>30</td>
<td>Equivalent to either 5184/27 or 5184/29</td>
<td>Teviotdale dug twice in a midden of burnt stone, mussel and paua shell with seal, dog, penguin, moa bones, and small bird bones, which had contained a human burial with 2 adzes, one &quot;over a foot in length, the other about half that size&quot;. It was more probably 5184/29. Also 2 broken adzes and chert flakes.</td>
</tr>
</tbody>
</table>
Map N.Z.M.S. 1, S 184.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Grid Ref.</th>
<th>Name &amp; comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>307865 +</td>
<td>Near Papatowai Point complex. On sea-ward side of Point about 200 yards from end of Sand Road. Midden material under large rimu - material held by J. Leckie and L. Lockerbie. A small pocket now completely eroded.</td>
</tr>
<tr>
<td>33</td>
<td>273887</td>
<td>Cemetery Clear. About 12 oven hollows, some about 1.5 metres across. In the same area artifacts, including adzes and sinker (about 15 cm across with groove) were found when ploughing.</td>
</tr>
<tr>
<td>34</td>
<td>212915</td>
<td>Woolshed Oven. Edge of Stott's Clearing. Oven dimple with burnt stone in centre. One quarter excavated 1972. Had been used three times. Stott's Clearing was boggy tussock-covered flats with cabbage trees.</td>
</tr>
<tr>
<td>35</td>
<td>212923</td>
<td>River Hearth. About 7 large flat river-worn pebbles each about 15-20 cm across and 4 cm thick lying in a circular patch with charcoal about 7-10 cm below turf on edge of low terrace in Stott's Clearing above Tahakopa River.</td>
</tr>
<tr>
<td>36</td>
<td>201924</td>
<td>Airstrip Knoll. Spread of charcoal with burnt stones 2-3 metres across,</td>
</tr>
<tr>
<td>Site No.</td>
<td>Grid ref.</td>
<td>Name &amp; comments</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>37</td>
<td>c.206932</td>
<td>Map 7-10 cm below turf. Stones in slight depressions. A moa bone found nearby. On flood plain 300 yards from Tahakopa River in Stott's Clear. See 5183/6 for associated sites in this clear. Dunlop's Ovens. Two groups of three and two ovens respectively on low spurs about 7 metres above swampy flood plain of Stott's Clearing. Oven hollows about 70-90 cm across, 30 cm deep with burnt stone and charcoal in the middle. Had been under forest on edge of Stott's Clearing.</td>
</tr>
<tr>
<td>38</td>
<td>379901</td>
<td>Purakauiti Ovens. A group of about 13 oven dimples revealing burnt stone and charcoal when ploughed; one oven very large. Situated in a natural clearing with cabbage trees on the rolling spurs near junction of Purakauiti and Purakaunui Rivers, about one mile from Purakaunui Falls.</td>
</tr>
<tr>
<td>39</td>
<td>418893</td>
<td>Purakaunui Bay. A small midden in sand hills at northern end dug out by Teviotdale.</td>
</tr>
<tr>
<td>40</td>
<td>c.496945</td>
<td>Jacks Bay. Midden material collapsing</td>
</tr>
<tr>
<td>Site No.</td>
<td>Grid ref.</td>
<td>Name &amp; comments</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>41</td>
<td>215805</td>
<td>down a bank, being eroded by the sea. Hukihuki Creek. Small middens eroding out of stream edge for about one mile up the creek from the sea. The one at the mouth on the south side of the stream was about one metre deep with a few scraps of moa bone and one 'nice owl or borer' (Teviotdale's diaries: ms. Hocken Library).</td>
</tr>
<tr>
<td>42</td>
<td>458977</td>
<td>Hinahina Bridge. Find spot of large greenstone mere, held by Mr. F. Berney, Waipati, H.D. 2, Maclennan.</td>
</tr>
<tr>
<td>43</td>
<td>302888</td>
<td>Maclennan Bridge. One adze, 31.3 cm long, Skinner Type 5 or Duff Type Id. Black stone.</td>
</tr>
<tr>
<td>44</td>
<td>c.300865+</td>
<td>Papatowai Estuary cave. A small cave with 46 cm of shells in which Teviotdale found the lower half of a barracouta hook.</td>
</tr>
</tbody>
</table>

Map N.Z.M.S. 1, S 183

1 785729 Waipapa One. Two or three ovens and midden c.22 cm deep exposed in sand dunes. ½ mile from Waipapa Point. Burnt stone, charcoal, flake material,
<table>
<thead>
<tr>
<th>Site No.</th>
<th>Grid ref.</th>
<th>Name &amp; comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>?</td>
<td>mussel and pipi shells.</td>
</tr>
<tr>
<td>5</td>
<td>?117773</td>
<td>Haldane Estuary. Midden on edge of estuary about 8-9 metres across. Shells include pipi, cockle and Lunella amaranda. Moa and possibly seal.</td>
</tr>
<tr>
<td>6</td>
<td>?191924</td>
<td>Dummy's Beach burial. Skeleton of child about 7 years old in eroding front dunes of the beach. A crouched burial, apparently primary.</td>
</tr>
<tr>
<td>7</td>
<td>?191924</td>
<td>Digger's Creek Hearth. On edge of Stott's Clearing, a boggy tussock area on flood plain of Tahakopa River. (Associated with S104/34-36.) Stones about 7-10 cm below turf, 7 stones of which 4 are very flat - flattest one is 40 x 22 cm and 4 cm thick.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Digger's Creek open fire. A circular patch of charcoal and burnt stone about 7-10 cm below turf and about 100 cm thick.</td>
</tr>
</tbody>
</table>
Site No. 8  Grid ref. 196924

Name & comments
yards from the Digger's Creek Hearth (S183/6).

Turnip Paddock open fires, Stott's Clearing. About 10 circular patches of charcoal and burnt stone mostly about 60 cm across and one about 2 metres across. All were 30-40 cm below turf; the large one was on a slight knoll and very similar to Air-strip Knoll, S184/36. They were about 400 m from Tahakopa River in the boggy tussock flat of Stott's Clearing, and scattered over about 200 m. Excavation of one patch showed it to be about 4 cm thick.

Map N.Z.M.S.1, S 178

1 034057

Wyndham Station One. Large oven on low spur above flood plain of Mokoreta River, about 300 metres from a tributary. Sheltered from east and north, open to south and west with good view down valley. Raised rim about 2.1 - 2.7 metres across and about 60 cm deep in centre with lot of burnt stone, charcoal and blackened soil. Close to early European forest edge.
<table>
<thead>
<tr>
<th>Site No.</th>
<th>Grid ref.</th>
<th>Name &amp; comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>015045</td>
<td>Wyndham Station Two. Large oven on spur 200' above Mokoreta River, which is about 800 m distant. Slope of ground to north. Close to present bush edge with cabbage trees nearby. About 300 metres from stream. Raised rim about 2.75 metres across and hollow about 60 cm deep. Burnt stone and charcoal in centre.</td>
</tr>
<tr>
<td>3</td>
<td>012056</td>
<td>Wyndham Station Three. Large oven beside Mokoreta River, right on river edge. Present forest edge less than 800 m away. Sheltered from the south by rise of terrace. Hollow about 3 metres across with almost no raised rim, and about 50 cm deep, with charcoal and burnt stone in the centre. A second similar oven reported about 800 m up the river in similar site beside the river.</td>
</tr>
<tr>
<td>4</td>
<td>049091</td>
<td>Simpsons Oven. A very large double oven, 4½ metres across the raised rim of the main pit and 8½ metres overall. A subsidiary small oven earlier than big oven (lying a little under the big oven's rim on SSW side) and 2.75 m</td>
</tr>
<tr>
<td>Site No.</td>
<td>Grid ref.</td>
<td>Name &amp; comments</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>----------------</td>
</tr>
<tr>
<td>5</td>
<td>973012</td>
<td>across the raised rim. Large oven stands 30 cm above general ground level and the small oven about 30 cm. Ground slopes NE down a spur, to a stream 200 metres away. Early European forest edge about 1.5 - 2.5 k away. Charcoal and burnt stone about 20 cm below turf. Mecales Reserve. About 6 adzes found near a small area of regenerating Hall's totara, which local farmers attribute to Maori clearance. No evidence of ovens or charcoal in the vicinity.</td>
</tr>
</tbody>
</table>
Appendix 4:2

ADZE MATERIAL FROM PAPATOWAI POINT

When adze manufacture is considered over time, changes in adze forms can be seen as evidence of adaptive change in human behaviour patterns. There may be considerable inertia but I shall assume that a prehistoric adze technology was, (a) sufficiently suited to the economy for survival of the group, (b) technological changes moved in the direction of greater productivity for less or equal effort expended. Boserup (1965) argues that this is generally true for hunter-gatherer groups, and Cassels (1972) makes these assumptions in his locational analysis of Waikato people with a mixed economy.

Since prehistoric economies varied so markedly from one region of New Zealand to another, the adaptiveness of adze forms should be related to the region in which the adze was used. (The place where an adze was made is related to rock source as well and would be misleading in an analysis of adaptiveness.) From this point of view a broken adze showing haft polish and use marks is of greater interest than an unbroken adze with no use marks. The former is more likely to have been dropped near to where it was last used, though the pieces could be carried elsewhere for reworking.

It is not possible here to discuss how the assemblage of adzes at Papatowai was adaptive for the work performed. Any available evidence was lost in the process of Teviotdale's excavations. It should still be possible to describe the assemblage in terms of effort and skill required to make the
adzes, the evidence being drawn from the flake scars of the adzes themselves. There is evidence for a change during New Zealand prehistory in the amount of effort and skill expended on adze making, e.g. a change from well finished to rough unfinished surfaces, a move away from skilful high platform-angle flaking to more general use of low platform-angle flaking (Leach, Leach and Sutton, n.d.). If a framework of adaptiveness is used, then the hypothesis can be set up that the early, well-polished, skilfully made adzes were adapted to the functions (socio-psycho-religious and technological) required of them, and that the later more simply made adzes were also adaptive, the required functions of adzes having changed over time. The forms of adzes made were the forms that people wanted, and considered worth making, owning and using. As already noted this hypothesis cannot be tested here, particularly since only two of the Papatowai adzes are provenanced to layer.

Adzes collected from Papatowai and deposited in the Otago Museum were examined. Their general shape and the flaking techniques used in their manufacture were recorded. The descriptive framework used is that developed by Leach, Leach and Sutton (n.d.) in describing the Riverton material. I gratefully acknowledge the particular assistance of Mrs. H.M. Leach in the application of this framework.

Flake removal can be initially divided into high platform-angle flaking, requiring considerable mechanical force skilfully applied, and low platform-angle flaking requiring less force and skill (B.F. Leach 1969). A quadrangular adze
requires high angle flaking along all four edges (quadrilateral working) and is the most difficult form to achieve. On a thick hogback adze, two edges must be flaked by a combination of low and high angle blows, each directed to different surfaces, the third edge receiving bidirectional, low angle flaking, usually in alternate series, a form of trilateral working (Leach, Leach and Sutton n.d.). Trilateral working can also be used to produce subrectangular adzes.

When an adze is bilaterally worked by striking low angle blows bidirectionally along two edges the result is usually an ovoid adze of a typical 2B cross section. Bilateral working was probably the quickest and easiest way of making an adze. This framework applies to core adzes. The making and trimming of adzes made on large flakes involves a different set of skills, such as the striking of long flakes, snapping of rounded flakes to give the long adze shape and the striking of small high angle flakes for retouching.

The collection of Papatowai adzes in the Otago Museum

Analysis of Teviotdale's diaries (1936-1938: ms. Hocken Library) and of the Otago Museum catalogues showed that most of the adzes which Teviotdale excavated from Papatowai are apparently deposited in the Otago Museum. Teviotdale records finding 45 whole and 21 broken adzes. The Museum holds 50 whole adzes and about 50 pieces of adzes from Papatowai, mostly deposited by Teviotdale. Only the Duff holotype ID (D37:164) can be provenanced. About 9 of the broken pieces are too small a part of the adze for further analysis.
Adzes made on cores consist of one well-finished adze (D37.164), two in a primary and unfinished state and 33 broken adzes which have been used as cores and reworked to a greater or lesser extent. Of the 39 flake adzes, including 8 broken pieces, 18 had been ground and polished to some extent and 13 are in a rough unflaked condition. All the flake adzes are small enough to have been struck from old adzes. The waste flake material of fine-grained rocks found at TT1 (see Chap. 4:2) could all have come from the reworking of old adzes, and there is no need to suppose a primary source of quarried rock.

The McPhee Cove Conglomerate outcrops along the northern side of Tahakopa Valley, crossing the river close to Papatowai Point. This conglomerate carries blocks of actinolitic tuffs, granodiorites and Southland 'argillites' up to two metres in diameter but more usually rounded pebbles up to 30 cm in diameter. There is however no good evidence for their utilization in artifact manufacture at Papatowai, possibly because of deep weathering of the pebbles.

Of the two unbroken core adzes still with a flaked finish, one is a reasonably well-formed quadrangular adze with even planes on the four long sides, but the longitudinal edges are not straight. The other core adze might be classified as a hogback but is very misshapen.

Of the 33 reworked core adzes, 22 had been rectangular to subrectangular and presumably quadrilaterally worked. One had been trilaterally worked and the rest were too broken to be definable. When reworked a bilateral flaking technique had been used on all except four of them. These four seemed to
have been prepared as hogbacks, using a trilateral technique and then skilfully striking the bevel end so that a long flake sloughs off the front without smashing the cutting edge. All four were very misshapen but show some ability in striking the bevel flake.

The flake adzes show considerably more skill. Following Leach, Leach and Sutton (n.d.), a flake adze may be struck skilfully as a long flake from a prepared core, the bulb of percussion lying at the proximal end of the resultant adze; or there may be little core preparation, a rounded flake struck and then snapped across so that the bulb of percussion lies on one side of the new adze.

Of the 26 flake adzes sufficiently unfinished for analysis to be possible, 17 had been struck laterally and then shaped, and only 9 had been formed on long blades with the bulb of percussion proximal. Five of the latter were very small, only 4-7 cm long and had only a bevel ground at one end without any further flaking. The other four had been bilaterally flaked as well. All the laterally struck flakes had required further bilateral retouch, some of it very steep and regular. In summary most of the adzes had been made by the simpler techniques in common use rather than by the more skilful ones.

Reworking of old adzes at Papatowai seems to have been usual throughout the whole period of occupation. In his Papatowai diaries, Taviotdale mentions the state of finish of most of the adzes as he found them, and of the 60-70 adzes described 20 can be stratigraphically placed. These latter and
their condition were listed out and sorted into components (Table 4:16). Of the 70 or so adzes in the Otago Museum Papatowai collection, all but two are reworked core adzes or flake adzes which could have been struck from old adzes. It is highly probable that all of Teviotdale's provenanced adzes were reworked cores or flake adzes. (The greenstone material which was also carefully provenanced is omitted since it is worked by totally different techniques of sawing and grinding.) They were distributed:

- Black component - 13
- Shell and bone component - 6
- Working-floor component - 6
- Upper-shell component - 3

These frequencies are very difficult to interpret, and it is possible to say only that reworking of adzes occurred in all components. Adze reworking throughout seems to have been done by the simplest technique of bilateral working with some evidence of skill shown in striking long flakes and performing steep retouch on flake adzes. This can be seen as further evidence of a cultural continuity at Papatowai. From an adaptive point of view we must consider that this type of working was the most desirable in terms of return for effort expended. It is possible that the occupiers of Papatowai Point, even in the early period, lacked the skills for quadrilateral and trilateral working, but we should remember that they may also have been motivated by the simple adaptive concept of most return for least effort. They chose to use bilateral working rather than tri- or quadrilateral. Both hypotheses are tenable but both will have to be tested elsewhere than at Papatowai.
Appendix 4:3

**IDENTIFICATION OF POST-CRANIAL BONES OF THE SOUTHERN FUR SEAL AND HOOKER'S SEA LION**

It is difficult to distinguish post-cranial bones of New Zealand seals since New Zealand museums do not carry a sufficiently large series of each species. There are strong morphological differences between the bones of the "Earless" (Phocidae) and "Eared" (Otariidae) seals which I shall not describe in any detail. The bones of the two otariids are very similar and my main concern has been to distinguish the juvenile and adult bones of the two species and check that they could not be phocid bones. The following descriptions and figures are not intended as a self-contained means of identifying seal bones but as pointers for use with comparative material. McCann (1964) provides drawings of teeth and scapulae, and shows that canines and premolars can be identified to species.

In general the identification of midden bones can only be as good as the comparative material available. This study is based on the following materials held by the Otago Museum and the Department of Anthropology, Otago University.

**Family Phocidae**

**Leopard Seal Hydrurga leptonyx**

Otago Museum. One entire skeleton, apparently fully adult

**Sea elephant Mirounga leonina**

Otago Museum. Forelegs and scapula of juvenile.

Dept. of Anthro. One entire skeleton from
Hooper's Inlet, Otago Peninsula.

Family Otariidae

Sea lion Phocarctos hookeri
Otago Museum. One entire skeleton, an almost adult animal.
Dept. of Anthro. Fragmentary material from Tautuku Beach. Miscellaneous material from the Auckland Islands.

Fur seal Arctocephalus forsteri
Otago Museum. One entire skeleton, adult.
Scapulae, humeri, pelvis and vertebrae of a juvenile skeleton.
Dept. of Anthro. Three entire skeletons, Palliser Bay. One part skeleton, Aramoana, Otago.
One entire skeleton, 7-week old pup, Alans Beach, Otago Peninsula.

Identification of humeri

Seal humeri as such are very distinctive, short and thick with a greatly accentuated deltoid ridge. This ridge has a flange curling round on to the posterior surfaces of the shaft. The flange and the surface adjacent to it on the posterior side of the shaft possess three characteristics which can be used to distinguish the two species. Separately the characters are 'weak' but taken together the humeri of the two species can be identified with considerable certainty. In Sea lions the proximal end of the flange, viewed posteriorly, is relatively wide and flat and widens only a little distally
to terminate rather abruptly (Fig. 4:13a). The widest part of the flange tends to be close to the distal end. In Fur seals this flange tends proximally to be narrow and rounded in cross section, widening markedly towards the distal end, but then tapering off. The widest part is well back from the distal end. This distal taper and the overall shape of the flange are sometimes lost on archaeological specimens as the flange is easily eroded. The third character is of more use archaeologically but is anatomically variable. It consists of the shape of the surface of the shaft under and beside the flange of the deltoid ridge. In Sea lions the surface of the shaft is relatively flat and rises smoothly to the main ventral ridge of the shaft. In Fur seals there is a distinct groove beneath the overhanging flange of the deltoid ridge and then a distinct step up on to the surface of the shaft. In the Sea lions and Fur seals from T1, Papatowai, this was the most distinctive character, and where the flange was entire the flange and shaft characters correlated well. Some of the comparative material, however, did not show the distinguishing shaft characteristics.

Other post-cranial bones

From the available material it appeared that it might be possible to distinguish femora, radii and scapulae of the two otariids on morphological grounds but the characteristics were not as clear cut as in the humerus. The femora of Sea lions are proportionately broader than those of Fur seals, and the interior distal condyle tends to project laterally more than in the Sea lion (Fig. 4:13b). There is however a tendency
for seal femora to be distorted laterally and this character may not be clear. The posterior surface of the radius of the fur seal tends to have a single strong groove running down its surface (Fig. 4:13b) though it is not always as well defined as in the one illustrated. In the sea lion this surface is flattened with only a trace of a groove. Fur seal scapulæ are thinner and lighter in weight than those of the same size from sea lions, with sharper ridges and deeper grooves. The posterior and outside edge tends to be thinner and sharper and the neck below the articulating surface less massive. The posterior extension of the blade in fur seals is sometimes but not always drawn out as illustrated (Fig. 4:13c). This has not been observed in sea lions.

No satisfactory distinguishing characters could be found for ulnae, tibiae, fibulae, ribs, elements of the sternum and vertebrae. With more comparative material however the other limb bones should be separable.
ARCHAEOLOGICAL UNITS OF ORGANISATION

At Papatowai Point there are several discrete areas of midden which may have been associated with one living area, used whenever people occupied the Point. Alternatively each midden could have been associated with a separate living area, each of which may have been occupied successively. The archaeological units used must be sufficiently flexible to accommodate these alternatives.

Initially each layer of a discrete midden is examined as an entity, which can be seen to have definable boundaries in a vertical section of an excavation. The term component will be used to group similar and apparently contemporary layers from different sections, lying close to each other as do the sections described for the various excavations on Papatowai Point. A lens is considered to be a relatively thin but homogeneous deposit set within a layer. Reference to a layer must, of course, be linked to a particular section or excavation.

In theory, similar successive components should be grouped into phases, but phase, as described by Willey and Phillips (1958:21), involves spatial and temporal definitions of cultural boundaries. Despite Golson's (1959) definition, the evidence from the Catlins is inadequate for the concept of phase to be appropriate to this study. Consequently the term 'sequence' will be used to denote a set of successive components as they appear in a delimited area such as Papatowai Point. Used on this scale, separate sequences would
have to be established for Pounawea and Hinahina. The layers of each section may demonstrate more or less completely the sequence for an area, but the sequence is constituted of components, not layers, which should each be a generalized description of at least two or more equivalent layers. Component used in this sense is only necessary where a large, more or less continuous site has been excavated in separate units, without linking trenches to show continuity of layers. Where continuity of layers is demonstrated, layer and component are synonymous. Where continuity is not demonstrated, as on Papatowai Point, the component is an inferred entity and not the equivalent of a layer.
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<td>1974</td>
<td>Physics Department, University of Waikato.</td>
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<td>WISSLER, C.</td>
<td>1923</td>
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<td>Harrap, New York.</td>
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<td>Independent Study, Otago University Library.</td>
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<td>1950</td>
<td>Introduced mammals of New Zealand.</td>
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<td><em>Trans. 10:89-115.</em></td>
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CATLINS DISTRICT

A coastline of cliffs broken by several estuaries and sandy bays, backed by a block of hills with narrow valleys. Heavily forested; lowland podocarp-broadleaved forests with silver beech at higher altitudes. Rainfall 1100-1500 mm, climate cloudy, cool and windy.

FIORDLAND - SOUTH WESTLAND

Mountainous terrain with a coastline of deep fiords. Heavily forested; some lowland podocarp-broadleaved forest, but mostly beech forests. Rainfall over 2400 mm, mild temperatures.

FOVEAUX STRAIT COASTLINE OF SOUTHLAND AND STEWART ISLAND

Strongly indented coastline backed by rolling hills, numerous offshore islands. Heavily forested; podocarp-broadleaved forests. Rainfall 900 - 1200 mm, climate cloudy, cool and windy.

UPPER CLUTHA AND WAITAKI BASINS

Wide river valleys, high ranges and large lakes. Tussock grasslands with forested mid-altitude slopes. Rainfall 750-1500 mm, warm summers and snowy winters.

CENTRAL OTAGO

Alternating horst and graben topography. Semi-arid tussock grasslands. Rainfall 300-500 mm, hot dry summers and cold winters.

SOUTH CANTERBURY AND EAST COAST OTAGO

A coastline of generally low relief backed by plains and rolling hills. Tussock grassland in the north grading into podocarp-broadleaved forests from about Dunedin south. Rainfall 500-900 mm, mild summers and cool winters.

INLAND SOUTHLAND

Wide plains with a central hill massif. Tussock grasslands with patches of podocarp-broadleaved forests, and large areas of wetlands. Rainfall 600-1300 mm, wetter and cooler than the east coast.

Table 1:1 Topographic, vegetational and climatic characteristics of seven sub-regions of Murihiku.
<table>
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<tr>
<th>District</th>
<th>'Normal' rainfall</th>
<th>Est. 'normal' rainfall</th>
<th>Mean</th>
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<td>Balclutha 686</td>
<td>Clinton 965</td>
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<td>940</td>
<td>Lochindorb</td>
<td>Nugget Point 810</td>
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<td>Owaka Valley 953</td>
<td>Owaka 917</td>
<td></td>
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<tr>
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<td>1170</td>
<td>Tawanui</td>
<td>Papatowai 1265</td>
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<td>Tahakopa 1540</td>
<td>Quarry Hills 1349</td>
<td>Waikawa Valley 1140</td>
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<td>Mokoreta 1364</td>
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<td>Gore</td>
<td>Mataura 889</td>
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<td>Invercargill 1087</td>
<td>Waipapa Point 1059</td>
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Table 2:1 Annual rainfalls in millimetres in and around the Catlins. 'Normal' rainfalls are means of about 30 years taken from New Zealand Meteorological Service publications. Estimated 'normal' rainfalls are derived from only three to five years of records.
## CLIMATE STATIONS

<table>
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<tr>
<th>Name</th>
<th>Symbol</th>
<th>m (ft) Altitude</th>
<th>Aspect</th>
<th>Site</th>
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<td>90 (300)</td>
<td>SW</td>
<td>Macclennan River, hillside 5 k inland</td>
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<tr>
<td>Kahuika</td>
<td>Kah</td>
<td>15 ( 50)</td>
<td>Flat</td>
<td>Macclennan River, river terrace 5 k inland</td>
</tr>
<tr>
<td>Tahakopa</td>
<td>Tah</td>
<td>15 ( 50)</td>
<td>Flat</td>
<td>Tahakopa River, river terrace 5.5 k inland</td>
</tr>
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<td>Papatowai</td>
<td>Pap</td>
<td>15 ( 50)</td>
<td>Flat</td>
<td>Tahakopa River, coastal terrace</td>
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<tr>
<td>Florence Hill</td>
<td>FlH</td>
<td>150 (500)</td>
<td>NE</td>
<td>Coastal hillside above Kings Rock</td>
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<tr>
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<td>Tau</td>
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<td>Flat</td>
<td>Fleming River, river flat 2 k inland</td>
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<tr>
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<td>Taw</td>
<td>60 (175)</td>
<td>NE</td>
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Table 2:2 Altitude and location of research climate stations.
<table>
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<th>Station</th>
<th>Lat.</th>
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<th>1971</th>
<th>1972</th>
<th>Normal</th>
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Table 2:3 Annual totals of rainfall (mm) and departure from normal of selected stations in Otago and Southland for 1970 - 1972. Location of the Gore station was moved in 1972.
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Table 2:4 Mean temperatures for each observation period for the six research climate stations.
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**Table 2:5** Mean annual temperatures and extreme maximum and minimum temperatures (°C) for Catlins research climate stations over two years, running from August 11 to August 10 each year.
Table 2:6

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<tr>
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<td>x</td>
<td>x</td>
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<tr>
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5 or more spp.

Alexandra            | x              | x              |
Andersons Bay        | x              | x              |
Arrowtown            | x              | x              |
Awamoa               | x              | x              |
Bannockburn          | x              | x              |
Benmore              | x              | x              |
Brighton             | x              | x              |
Castle Rocks          | x              | x              |
Catlins River        | x              | x              |
Chatto Creek          | x              | x              |
Clinton              | x              | x              |
Clyde                | x              | x              |
Colac Bay            | x              | x              |
Cromwell             | x              | x              |
Crown Range          | x              | x              |
Dipton               | x              | x              |
Dunback              | x              | x              |
False Island         | x              | x              |
Forest Hills         | x              | x              |
Glendhu Bay          | x              | x              |
Glenorchy            | x              | x              |
Greenhills           | x              | x              |
Hawksburn            | x              | x              |
Hedgehope            | x              | x              |
Highley Hill         | x              | x              |
Hinahina             | x              | x              |
Kaikorai Valley      | x              | x              |
Kaka Point           | x              | x              |
Kaikais Beach        | x              | x              |
Kakanui              | x              | x              |
Kings Rock           | x              | x              |
Kingson             | x              | x              |
Knobby Range         | x              | x              |
Little Papanui       | x              | x              |
Long Beach           | x              | x              |
Lora Gorge           | x              | x              |
Luggate             | x              | x              |
Manuherokaia         | x              | x              |
Mason's Bay          | x              | x              |
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Table 2:6 Species of moas recorded in the literature (x) from sites throughout Otago and Southland, or deposited in Otago and Southland Museums (0). Most of the Museum bones have been sighted.
Univalves

Amphibola crenata
Argobuccinum tumidum +
Cellana strigilis redimiculum
Cellana radicans
Cellana sp.
Charonia capax +
Cookia sulcata
Haliotis iris
H. australis
H. virginea
Lunella amauroga
Maoricolpus rosseus
Modiolula granulosa
Sigapatella novaselandiae
Zediloma spp.
Zethaliella zelandica

Bivalves

Paphies australis
Paphies subtriangulata +
Aulazomya maoriana
Barbatia novaselandiae
Cardita aoteana
Chione stutchburyi
Chlamys sp.
Dosinia sp. +
Modiolus neozealandicus
Mastra discores +
Mytilus edulis
Perna canalicula

Table 2.7 Species of molluscs found in drift on beach to the south of the Tahokopa River mouth. All except those marked + were in a fresh condition.
### Table 2.8: Distribution of Moa species in Otago and Southland, from both natural and midden sites. 'Near-coast' sites are those which do not come under the full influence of the inland climates. Chi-square is a 'fail-safe' test and a more refined test might show that D. robustus and Megalapteryx have a significant bias towards inland areas and E. gravis to coastal areas.

<table>
<thead>
<tr>
<th>Zones</th>
<th>D. maximus</th>
<th>D. robustus</th>
<th>D. torquus</th>
<th>Podargopsis elephas</th>
<th>E. gravis</th>
<th>E. huttoni</th>
<th>Anomalopteryx</th>
<th>Megalapteryx</th>
<th>Total no. of sites</th>
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<td>37.8%</td>
<td>54.5%</td>
<td>61.8%</td>
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<td>14.3%</td>
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Chi-square probability level: N.S. N.S. N.S. N.S. N.S. *** * N.S. N.S.
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<th>D. robustus</th>
<th>D. torquata</th>
<th>Pachyornis</th>
<th>Euryapteryx</th>
<th>Emeus cragwelli</th>
<th>E. rowi</th>
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Chi-square probability level: N.S. N.S. N.S. N.S. * N.S. N.S. N.S. N.S.

Table 2:9 Occurrence of Moa species in midden and natural sites of Otago and Southland. Six sites containing both natural and midden deposits are omitted.
Table 2:10 Occurrence of shellfish species in middens along the Catlins coast. From personal records and from Lockerbie (1940 and pers. comm.).

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<th>Paphies australis</th>
<th>Mytilus edulis</th>
<th>Haliotis iris</th>
<th>Amphibola crenata</th>
<th>Cellana trigilia</th>
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<tr>
<td>Long Point</td>
<td>-</td>
<td>A</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Papatowai Point</td>
<td>A</td>
<td>A</td>
<td>O</td>
<td>F</td>
<td>O</td>
<td>-</td>
<td>-</td>
<td>O</td>
</tr>
<tr>
<td>Papatowai West</td>
<td>A</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Picnic Point</td>
<td>A</td>
<td>A</td>
<td>F</td>
<td>F</td>
<td>-</td>
<td>O</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>*Kings Rock</td>
<td>-</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>-</td>
<td>-</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>Tautuku North</td>
<td>-</td>
<td>A</td>
<td>F</td>
<td>F</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tautuku South</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>-</td>
<td>F</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

A = Abundant, F = Frequent, O = Occasional.

* Lockerbie (1940) recorded as present but few in number:-

Haliotis australis, Paphies subtriangulata, Scutus bresculo, Cookia sulcata, Magra discors, Maoricolpus roseus, Dosinia americana (names updated).
Table 2:11  Analysis of difference between each pair of sample means of cockle lengths from natural and midden deposits at Papatowai, using one tailed t-tests.
<table>
<thead>
<tr>
<th>Quadrat Code</th>
<th>Q1</th>
<th>Q3</th>
<th>Q5-7</th>
<th>Q9</th>
<th>Q11</th>
<th>Q13</th>
<th>D6</th>
<th>D2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cockles</td>
<td>26.72</td>
<td>25.01</td>
<td>31.7</td>
<td>31.44</td>
<td>32.2</td>
<td>34.28</td>
<td>27.28</td>
<td>(Nil)</td>
</tr>
<tr>
<td></td>
<td>(102)</td>
<td>(187)</td>
<td>(31)</td>
<td>(104)</td>
<td>(70)</td>
<td>(107)</td>
<td>(129)</td>
<td>(Nil)</td>
</tr>
<tr>
<td>Pipis</td>
<td>12.47</td>
<td>16.5</td>
<td>-</td>
<td>42.2</td>
<td>40.5</td>
<td>44.0</td>
<td>-</td>
<td>52.5</td>
</tr>
<tr>
<td></td>
<td>(30)</td>
<td>(7)</td>
<td>(Nil)</td>
<td>(133)</td>
<td>(145)</td>
<td>(96)</td>
<td>(Nil)</td>
<td>(61)</td>
</tr>
</tbody>
</table>

Table 2:12  Mean lengths of cockles and pipis at Papatowai.  N values in parentheses.
<table>
<thead>
<tr>
<th>Stations</th>
<th>Howick</th>
<th>Galatea Bay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upshore</td>
<td>1425</td>
<td>196 (42.81)</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>684 (35.95)</td>
</tr>
<tr>
<td></td>
<td>420</td>
<td>592 (42.48)</td>
</tr>
<tr>
<td>Downshore</td>
<td></td>
<td>320 (44.95)</td>
</tr>
</tbody>
</table>

Table 2:13  Densities of pipis along quadrats between MHWN and MLWN. Howick figures from Wood (1968) and Galatea Bay figures from Terrel (1967). For Galatea Bay the mean lengths are given in parentheses.
<table>
<thead>
<tr>
<th>US</th>
<th>WF</th>
<th>BL</th>
<th>Nth 1972</th>
<th>Nth 1973</th>
<th>West</th>
<th>D5</th>
<th>D3</th>
<th>D2</th>
<th>Q1,3,7</th>
<th>Q9</th>
<th>Q11</th>
<th>Q13</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WF</td>
<td>-2.85</td>
<td>&lt;.001</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BL</td>
<td>-1.71</td>
<td>0.82</td>
<td>&lt;.001</td>
<td>&gt;.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nth</td>
<td>1972</td>
<td>-16.19</td>
<td>-14.15</td>
<td>-12.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1973</td>
<td>-12.00</td>
<td>-9.65</td>
<td>-8.89</td>
<td>3.86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>West</td>
<td></td>
<td>-11.54</td>
<td>-8.98</td>
<td>-8.13</td>
<td>8.02</td>
<td>2.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D5</td>
<td></td>
<td>-1.07</td>
<td>2.35</td>
<td>1.03</td>
<td>21.82</td>
<td>14.40</td>
<td>14.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.05</td>
<td>&lt;.001</td>
<td>&gt;.05</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td></td>
<td>0.48</td>
<td>3.54</td>
<td>2.23</td>
<td>10.45</td>
<td>13.50</td>
<td>13.28</td>
<td>1.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;.05</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td></td>
<td>1.72</td>
<td>1.75</td>
<td>1.74</td>
<td>1.85</td>
<td>1.83</td>
<td>1.81</td>
<td>1.73</td>
<td>1.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.005</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q9</td>
<td></td>
<td>-7.36</td>
<td>-4.31</td>
<td>-4.39</td>
<td>16.35</td>
<td>8.19</td>
<td>7.63</td>
<td>-8.96</td>
<td>-8.74</td>
<td>-1.78</td>
<td>32.05</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
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<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q11</td>
<td></td>
<td>-8.62</td>
<td>-5.77</td>
<td>-5.58</td>
<td>12.59</td>
<td>5.92</td>
<td>4.69</td>
<td>-10.55</td>
<td>-10.05</td>
<td>-1.79</td>
<td>29.29</td>
<td>-2.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Q13</td>
<td></td>
<td>-5.26</td>
<td>-2.12</td>
<td>-2.65</td>
<td>17.15</td>
<td>9.88</td>
<td>9.57</td>
<td>-5.73</td>
<td>-6.34</td>
<td>-1.76</td>
<td>32.13</td>
<td>2.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
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<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Table 2.14 Analysis of difference between each pair of sample means of pipi lengths from natural and midden TTI deposits at Papatowai, using one-tailed T-tests. D5, D3, and D2 are the quadrats combined as 'Near-site' sample in Table 2.11
<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Estimated Weight (g)</th>
<th>Standard Error</th>
<th>Observed Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I5</td>
<td>31.72</td>
<td>1.18</td>
<td>25.6</td>
</tr>
<tr>
<td>II2</td>
<td>13.49</td>
<td>0.38</td>
<td>9.2</td>
</tr>
<tr>
<td>II5</td>
<td>20.22</td>
<td>0.60</td>
<td>13.9</td>
</tr>
<tr>
<td>II7</td>
<td>17.38</td>
<td>0.62</td>
<td>14.9</td>
</tr>
<tr>
<td>III4</td>
<td>16.27</td>
<td>0.56</td>
<td>10.5</td>
</tr>
<tr>
<td>IV1</td>
<td>2.31</td>
<td>0.01</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Table 2:15  Total dried meat weights per one tenth/square metre for five samples of cockles from Aramoana.
Table 3:1  Chemical analyses of archaeological soils, TT1, Papatowai Point. From Invermay Research Station, Ministry of Agriculture and Fisheries.

<table>
<thead>
<tr>
<th>Layers</th>
<th>pH</th>
<th>Ca</th>
<th>K</th>
<th>Mg</th>
<th>P</th>
<th>C%</th>
<th>N%</th>
<th>C/N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litter</td>
<td>7.0</td>
<td>14.3</td>
<td>0.1</td>
<td>2.5</td>
<td>5.2</td>
<td>6.7</td>
<td>0.37</td>
<td>18</td>
</tr>
<tr>
<td>Upper shell</td>
<td>7.1</td>
<td>5.3</td>
<td>nil</td>
<td>1.3</td>
<td>10.0</td>
<td>1.6</td>
<td>0.11</td>
<td>14.5</td>
</tr>
<tr>
<td>Working floor</td>
<td>6.9</td>
<td>4.5</td>
<td>nil</td>
<td>0.9</td>
<td>9.6</td>
<td>1.0</td>
<td>0.07</td>
<td>14</td>
</tr>
<tr>
<td>Black</td>
<td>6.7</td>
<td>6.2</td>
<td>nil</td>
<td>1.2</td>
<td>12.4</td>
<td>2.4</td>
<td>0.13</td>
<td>18.5</td>
</tr>
</tbody>
</table>
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Weinmannia racemosa

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Metrosideros umbelZata

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Griselinia littoraZis
Fuchsia excortioata

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Myrsine austraZis

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Pittosporum tenuifolium

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Pseudopanax crassifoZium

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Carpodetus serratus

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Pseudowintera coZorata

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Dioksonia squarrosa

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Table 3.3 Parameters of trees in 20 quadrats 26 September 1970, on Papatowai Point archaeological site. Area 0.475 acre.

<table>
<thead>
<tr>
<th>Species</th>
<th>Density per acre</th>
<th>Relative density</th>
<th>Frequency (% of quadrats)</th>
<th>Relative frequency</th>
<th>Mean basal area (sq. ft)</th>
<th>Basal Area (sq.ft/acre)</th>
<th>Relative basal area</th>
<th>Importance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Podocarpus totara/P. hallii</td>
<td>448.4</td>
<td>69.8</td>
<td>95.7</td>
<td>41.6</td>
<td>0.26</td>
<td>115.49</td>
<td>71.7</td>
<td>183.1</td>
</tr>
<tr>
<td>Melaleuca fusciflora</td>
<td>120.0</td>
<td>18.7</td>
<td>47.8</td>
<td>20.8</td>
<td>0.23</td>
<td>27.60</td>
<td>17.2</td>
<td>56.7</td>
</tr>
<tr>
<td>Reinmannia racemosa</td>
<td>29.5</td>
<td>4.6</td>
<td>21.7</td>
<td>9.4</td>
<td>0.23</td>
<td>6.79</td>
<td>4.2</td>
<td>18.2</td>
</tr>
<tr>
<td>Pseudowintera colorata</td>
<td>10.5</td>
<td>1.6</td>
<td>13.0</td>
<td>5.6</td>
<td>0.14</td>
<td>1.47</td>
<td>18.7</td>
<td>6.1</td>
</tr>
<tr>
<td>Pseudopanax crassifolium</td>
<td>8.4</td>
<td>1.3</td>
<td>8.7</td>
<td>3.8</td>
<td>0.10</td>
<td>0.84</td>
<td>1.4</td>
<td>5.6</td>
</tr>
<tr>
<td>Metrosideros truncata</td>
<td>6.3</td>
<td>1.0</td>
<td>8.7</td>
<td>3.8</td>
<td>0.36</td>
<td>2.27</td>
<td>0.5</td>
<td>6.2</td>
</tr>
<tr>
<td>Myrtus australis</td>
<td>6.3</td>
<td>1.0</td>
<td>8.7</td>
<td>3.8</td>
<td>0.13</td>
<td>0.82</td>
<td>0.5</td>
<td>5.3</td>
</tr>
<tr>
<td>Carpodocis serrata</td>
<td>4.2</td>
<td>0.7</td>
<td>8.7</td>
<td>3.8</td>
<td>0.16</td>
<td>0.34</td>
<td>0.4</td>
<td>4.9</td>
</tr>
<tr>
<td>Pseudopanax crassifolium</td>
<td>2.1</td>
<td>0.3</td>
<td>4.3</td>
<td>1.9</td>
<td>0.08</td>
<td>1.71</td>
<td>0.2</td>
<td>4.7</td>
</tr>
<tr>
<td>Gispeniodia littoralis</td>
<td>2.1</td>
<td>0.3</td>
<td>4.3</td>
<td>1.9</td>
<td>0.65</td>
<td>3.59</td>
<td>0.8</td>
<td>4.4</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>642</strong></td>
<td></td>
<td><strong>230.3</strong></td>
<td><strong>19</strong></td>
<td></td>
<td><strong>161.25</strong></td>
<td><strong>8.1</strong></td>
<td><strong>300</strong></td>
</tr>
</tbody>
</table>
Table 3:4  Parameters of trees on Early Forest site, 18 April, 1970, Maclellan Reserve. No. of quadrats 20. Area 0.41 acre. (From data collected by Department of Botany, University of Otago).
<table>
<thead>
<tr>
<th>Keimania raemosa</th>
<th>Podocarpus ferrugineus</th>
<th>Eucalyptus hookeriana</th>
<th>Cupressus sp.</th>
<th>Pseudopanax arboreofolium</th>
<th>Grevillea littoralis</th>
<th>Podocarpus totara/halli</th>
<th>Dacrydium dacrydioides</th>
<th><strong>Totals</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Density per acre</td>
<td>234.9</td>
<td>41.5</td>
<td>34.5</td>
<td>13.8</td>
<td>13.8</td>
<td>6.9</td>
<td>6.9</td>
<td>6.9</td>
</tr>
<tr>
<td>Relative density</td>
<td>64.15</td>
<td>11.32</td>
<td>9.43</td>
<td>3.77</td>
<td>3.77</td>
<td>1.89</td>
<td>1.89</td>
<td>1.89</td>
</tr>
<tr>
<td>Frequency</td>
<td>100.0</td>
<td>71.4</td>
<td>57.1</td>
<td>28.6</td>
<td>28.6</td>
<td>14.3</td>
<td>14.3</td>
<td>14.3</td>
</tr>
<tr>
<td>Relative frequency</td>
<td>80.46</td>
<td>5.75</td>
<td>4.60</td>
<td>2.30</td>
<td>2.30</td>
<td>1.15</td>
<td>1.15</td>
<td>1.15</td>
</tr>
<tr>
<td>Mean basal area</td>
<td>0.97</td>
<td>0.55</td>
<td>4.35</td>
<td>0.84</td>
<td>0.09</td>
<td>0.12</td>
<td>0.24</td>
<td>1.75</td>
</tr>
<tr>
<td>(sq.ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basal area, sq.ft/acre</td>
<td>227.8</td>
<td>22.7</td>
<td>150.3</td>
<td>11.5</td>
<td>1.3</td>
<td>0.8</td>
<td>1.6</td>
<td>12.1</td>
</tr>
<tr>
<td>Relative basal area</td>
<td>52.37</td>
<td>5.21</td>
<td>34.55</td>
<td>2.65</td>
<td>0.30</td>
<td>0.19</td>
<td>0.38</td>
<td>2.78</td>
</tr>
<tr>
<td>Importance value</td>
<td>196.98</td>
<td>22.28</td>
<td>48.58</td>
<td>8.72</td>
<td>6.37</td>
<td>3.13</td>
<td>3.42</td>
<td>5.82</td>
</tr>
</tbody>
</table>

Table 3:5 Parameters of trees in 7 quadrats, 21 May 1970, on Inner River Dune site, Macalnan Reserve. Area 0.16 acre.
<table>
<thead>
<tr>
<th>Tree Species</th>
<th>Density per acre</th>
<th>Relative density</th>
<th>Frequency</th>
<th>Relative frequency</th>
<th>Mean basal area (sq. ft)</th>
<th>Relative basal area</th>
<th>Importance value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salix nigra</td>
<td>81.4</td>
<td>33.4</td>
<td>68.1</td>
<td>24.8</td>
<td>0.08</td>
<td>69.2</td>
<td>82.5</td>
</tr>
<tr>
<td>Pseudotsuga menziesii</td>
<td>57.7</td>
<td>24.0</td>
<td>57.4</td>
<td>20.9</td>
<td>0.13</td>
<td>7.7</td>
<td>47.5</td>
</tr>
<tr>
<td>Picea engelmannii</td>
<td>30.9</td>
<td>12.9</td>
<td>34.0</td>
<td>12.4</td>
<td>0.16</td>
<td>4.8</td>
<td>27.0</td>
</tr>
<tr>
<td>Pinus contorta var. murrayi</td>
<td>20.6</td>
<td>8.6</td>
<td>34.0</td>
<td>12.4</td>
<td>7.99</td>
<td>164.5</td>
<td>77.6</td>
</tr>
<tr>
<td>P. sitchensis</td>
<td>9.3</td>
<td>3.9</td>
<td>10.6</td>
<td>3.9</td>
<td>0.55</td>
<td>5.1</td>
<td>10.2</td>
</tr>
<tr>
<td>P. texidentata</td>
<td>9.3</td>
<td>3.9</td>
<td>10.6</td>
<td>3.9</td>
<td>0.28</td>
<td>2.6</td>
<td>1.8</td>
</tr>
<tr>
<td>Pinus aristata</td>
<td>5.1</td>
<td>2.2</td>
<td>8.5</td>
<td>3.1</td>
<td>0.27</td>
<td>1.4</td>
<td>0.9</td>
</tr>
<tr>
<td>P. elliottii</td>
<td>5.1</td>
<td>2.2</td>
<td>8.5</td>
<td>3.1</td>
<td>3.1</td>
<td>12.2</td>
<td>4.2</td>
</tr>
<tr>
<td>Larix occidentalis</td>
<td>3.1</td>
<td>1.3</td>
<td>8.5</td>
<td>3.1</td>
<td>2.3</td>
<td>13.7</td>
<td>6.4</td>
</tr>
<tr>
<td>Pseudotsuga menziesii</td>
<td>4.1</td>
<td>1.7</td>
<td>8.5</td>
<td>3.1</td>
<td>2.3</td>
<td>13.7</td>
<td>6.4</td>
</tr>
<tr>
<td>P. sitchensis</td>
<td>2.1</td>
<td>0.9</td>
<td>8.5</td>
<td>3.1</td>
<td>0.8</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Pinus contorta var. murayi</td>
<td>1.0</td>
<td>0.4</td>
<td>8.5</td>
<td>0.8</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>P. sitchensis</td>
<td>1.0</td>
<td>0.4</td>
<td>8.5</td>
<td>0.8</td>
<td>0.4</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Pinus contorta var. murrayi</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 3:6 Parameters of trees in 47 quadrats, 22 August 1970, on Outer River dune site, Maclean Reserve. Area 0.97 acres.
### Table 3:7 Numbers of missing and double rings in two trees of matai *Podocarpus spicatus.* Only the inner 200 rings of the 850 rings of M24 were usable.

<table>
<thead>
<tr>
<th>Tree Code</th>
<th>Height of disc (m)</th>
<th>Arc searched (°)</th>
<th>No. of annual rings</th>
<th>No. of double rings</th>
<th>No. of fusing rings</th>
<th>% error</th>
</tr>
</thead>
<tbody>
<tr>
<td>M24</td>
<td>2.4</td>
<td>35°</td>
<td>200</td>
<td>2</td>
<td>1</td>
<td>+0.5</td>
</tr>
<tr>
<td>M14 (1)</td>
<td>.31</td>
<td>110°</td>
<td>550</td>
<td>2</td>
<td>0</td>
<td>+0.4</td>
</tr>
<tr>
<td>M14 (2)</td>
<td>1.98</td>
<td>170°</td>
<td>533</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>M14 (3)</td>
<td>3.88</td>
<td>170°</td>
<td>524</td>
<td>3</td>
<td>9</td>
<td>-1.1</td>
</tr>
<tr>
<td>Tree code</td>
<td>Height of disc (m)</td>
<td>Arc searched</td>
<td>No. of annual rings</td>
<td>No. of double rings</td>
<td>No. of fusing rings</td>
<td>% error</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------</td>
<td>--------------</td>
<td>---------------------</td>
<td>--------------------</td>
<td>---------------------</td>
<td>---------</td>
</tr>
<tr>
<td>A1</td>
<td>1.98</td>
<td>360°</td>
<td>44</td>
<td>3</td>
<td>0</td>
<td>6.4</td>
</tr>
<tr>
<td>A2</td>
<td>1.06</td>
<td>360°</td>
<td>52</td>
<td>10</td>
<td>3</td>
<td>11.9</td>
</tr>
<tr>
<td>A3</td>
<td>0.15</td>
<td>360°</td>
<td>62</td>
<td>6</td>
<td>0</td>
<td>8.8</td>
</tr>
<tr>
<td>B1</td>
<td>1.98</td>
<td>360°</td>
<td>52</td>
<td>10</td>
<td>0</td>
<td>16.1</td>
</tr>
<tr>
<td>B2</td>
<td>1.06</td>
<td>360°</td>
<td>56</td>
<td>15</td>
<td>0</td>
<td>21.1</td>
</tr>
<tr>
<td>B3</td>
<td>0.15</td>
<td>360°</td>
<td>63</td>
<td>14</td>
<td>0</td>
<td>18.2</td>
</tr>
</tbody>
</table>

Table 3:8 Numbers of missing and double rings in two trees of totara (Tree A cf. *Podocarpus hallii*, Tree B cf. *P. totara*) from Papatowai Point.
<table>
<thead>
<tr>
<th>Diameter cm classes in</th>
<th>&lt;10.2</th>
<th>10.2-17.5</th>
<th>17.8-25.1</th>
<th>25.4-32.8</th>
<th>33.0-40.4</th>
<th>&gt;40.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>650</td>
<td>154</td>
<td>61</td>
<td>20</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Percentage</td>
<td>72.8</td>
<td>17.2</td>
<td>6.8</td>
<td>2.2</td>
<td>0.9</td>
<td>0</td>
</tr>
<tr>
<td>Dates of trees sampled</td>
<td>1909 A.D.</td>
<td>1908 A.D.</td>
<td>1906 A.D.</td>
<td>1907 A.D.</td>
<td>1910</td>
<td></td>
</tr>
</tbody>
</table>

Table 3:9 Frequencies in diameter classes of straight-boled totaras on the Papatowai Point occupation site, 27 September, 1975
### Edible Plants

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Habitat</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aristotelia serrata</td>
<td>OF</td>
<td>Carex spp.</td>
</tr>
<tr>
<td>Asplenium bulbiferum</td>
<td>F</td>
<td>Chionochloa rubra</td>
</tr>
<tr>
<td>A. laxum</td>
<td>C</td>
<td>Cordyline australis</td>
</tr>
<tr>
<td>Coproemia lucida</td>
<td>F</td>
<td>Cortaderia richardii</td>
</tr>
<tr>
<td>C. rhamnoides</td>
<td>F</td>
<td>Desmoschoenus spinulosus</td>
</tr>
<tr>
<td>Cordyline australis</td>
<td>BG</td>
<td>Dicksonia spp.</td>
</tr>
<tr>
<td>Coriaria spp.</td>
<td>R</td>
<td>Dracophyllum longifolium</td>
</tr>
<tr>
<td>Cyathodes juniperina</td>
<td>B</td>
<td>Festuca spp.</td>
</tr>
<tr>
<td>Daucarcarpus daucrydioides</td>
<td>F</td>
<td>Gahnia procera</td>
</tr>
<tr>
<td>Dacrydium cupressinum</td>
<td>F</td>
<td>Hierochloe arbutacea</td>
</tr>
<tr>
<td>Elaeocarpus hookerianus</td>
<td>F</td>
<td>Hemitelicia smithii</td>
</tr>
<tr>
<td>Fuchsia excorticata</td>
<td>OF</td>
<td>Juncus spp.</td>
</tr>
<tr>
<td>Hemitelicia smithii</td>
<td>F</td>
<td>Leptocarpus similis</td>
</tr>
<tr>
<td>Lophomyrtus obcordata</td>
<td>OF</td>
<td>Phormium tenax</td>
</tr>
<tr>
<td>Phormium tenax</td>
<td>BGR</td>
<td>Podocarpus totara</td>
</tr>
<tr>
<td>Podocarpus ferruginus</td>
<td>F</td>
<td>Ripogonum scandens</td>
</tr>
<tr>
<td>P. hallii</td>
<td>F</td>
<td>Typha muelleri</td>
</tr>
<tr>
<td>P. epicotatus</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>P. totara</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Pteridium aquilinum</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Ripogonum scandens</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Rubus cissoides</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Solanum laciniatum</td>
<td>OF</td>
<td></td>
</tr>
<tr>
<td>Sonchus spp.</td>
<td>CR</td>
<td></td>
</tr>
<tr>
<td>Typha orientalis</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

### Plants for Fibre, Thatch and Cordage.

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Habitat</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carex spp.</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Chionochloa rubra</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Cordyline australis</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Cortaderia richardii</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Desmoschoenus spinulosus</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Dicksonia spp.</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Dracophyllum longifolium</td>
<td>OFB</td>
<td></td>
</tr>
<tr>
<td>Festuca spp.</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Gahnia procera</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Hierochloe arbutacea</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Hemitelicia smithii</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Juncus spp.</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Leptocarpus similis</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Phormium tenax</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Podocarpus totara</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Ripogonum scandens</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Typha muelleri</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Habitat</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carex spp.</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Chionochloa rubra</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Cordyline australis</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Cortaderia richardii</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Desmoschoenus spinulosus</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>Dicksonia spp.</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Dracophyllum longifolium</td>
<td>OFB</td>
<td></td>
</tr>
<tr>
<td>Festuca spp.</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Gahnia procera</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Hierochloe arbutacea</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Hemitelicia smithii</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Juncus spp.</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Leptocarpus similis</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Phormium tenax</td>
<td>BG</td>
<td></td>
</tr>
<tr>
<td>Podocarpus totara</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Ripogonum scandens</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td>Typha muelleri</td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3:10** Important plant resources of the Catlins. Edible plants are derived from Leach (1959) and the others from Hamel (1974). Major habitats are shown:-

- **F** = forest,
- **OF** = open forest and margins,
- **C** = coastal rocks and dunes,
- **G** = grassland,
- **B** = bogland,
- **R** = riparian.
<table>
<thead>
<tr>
<th>Code No.</th>
<th>Diameter (cm)</th>
<th>Date of Establishment</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>M8</td>
<td>74.4</td>
<td>1280</td>
<td>Sand dune 200 m E of Area 1</td>
</tr>
<tr>
<td>M6</td>
<td>50.3</td>
<td>1510</td>
<td>Sand dune 200 m E of Area 1</td>
</tr>
<tr>
<td>M7</td>
<td>55.6</td>
<td>1500</td>
<td>Sand dune 200 m E of Area 1</td>
</tr>
<tr>
<td>M11</td>
<td>51.6</td>
<td>1570</td>
<td>Peppertree flat 100 m SE of Area 3</td>
</tr>
<tr>
<td>M10</td>
<td>33.0</td>
<td>1680</td>
<td>Peppertree flat 100 m SE of Area 3</td>
</tr>
<tr>
<td>M12</td>
<td>44.5</td>
<td>1650</td>
<td>Peppertree flat 100 m SE of Area 3</td>
</tr>
<tr>
<td>M21</td>
<td>110.0</td>
<td>1350</td>
<td>Sandy knoll 100 m E of TT1</td>
</tr>
<tr>
<td>M3</td>
<td>51.6</td>
<td>1545</td>
<td>Sandy knoll 100 m E of TT1</td>
</tr>
<tr>
<td>M9</td>
<td>42.4</td>
<td>1720</td>
<td>Sandy knoll 100 m E of TT1</td>
</tr>
<tr>
<td>M4</td>
<td>60.9</td>
<td>1810</td>
<td>Midden area, near TT1</td>
</tr>
<tr>
<td>M5</td>
<td>45.0</td>
<td>1780</td>
<td>Midden area, near TT1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Totaras</th>
</tr>
</thead>
<tbody>
<tr>
<td>TA</td>
</tr>
<tr>
<td>TB</td>
</tr>
<tr>
<td>T2</td>
</tr>
<tr>
<td>T3</td>
</tr>
<tr>
<td>T4</td>
</tr>
<tr>
<td>TC</td>
</tr>
<tr>
<td>TD</td>
</tr>
</tbody>
</table>

Table 3:11 Diameters and dates of establishment of matais and totaras around and on the Papatowai Point middens. See Fig. 4:8 for map of locations.
| Diameter cm | <10.2 | 10.2-17.5 | 17.8-25.1 | 25.4-32.8 | 33.0-40.4 | >40.6 |
| Classes in  | <4.0  | 4.0-6.9   | 7.0-9.9   | 10.0-12.9 | 13.0-15.9 | >16.0 |
| Frequency   | 97    | 21        | 4         | 3         | 1         | 1     |
| Percentage  | 76.4  | 16.5      | 3.1       | 2.4       | 0.8       | 0.8   |

Table 3:12  Frequencies in diameter classes of straight-boled totaras on Pounawea occupation site, 10 February, 1974.
### CATLINS OVENS

<table>
<thead>
<tr>
<th>Oven Description</th>
<th>Total Diam</th>
<th>Rim Diam</th>
<th>Depth of Hollow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simpsons Oven, Main, S178/4</td>
<td>8.20</td>
<td>4.30</td>
<td>0.40</td>
</tr>
<tr>
<td>subsidiary S178/4</td>
<td>4.60</td>
<td>2.75</td>
<td>0.20</td>
</tr>
<tr>
<td>Wyndham One, S178/1</td>
<td>—</td>
<td>2.10 - 2.75</td>
<td>0.60</td>
</tr>
<tr>
<td>Wyndham Two, S178/2</td>
<td>4.60</td>
<td>2.75</td>
<td>0.60</td>
</tr>
<tr>
<td>Wyndham Three, S178/3</td>
<td>3.60</td>
<td>3.05</td>
<td>0.45</td>
</tr>
<tr>
<td>Woolshed Oven, S184/34</td>
<td>4.60</td>
<td>2.50</td>
<td>0.25</td>
</tr>
</tbody>
</table>

### OTAGO PENINSULA OVENS

<table>
<thead>
<tr>
<th>Oven Code</th>
<th>Total Diam</th>
<th>Rim Diam</th>
<th>Depth of Hollow</th>
</tr>
</thead>
<tbody>
<tr>
<td>S164/66</td>
<td>6.30</td>
<td>4.00</td>
<td>1.60</td>
</tr>
<tr>
<td>S164/65</td>
<td>9.80</td>
<td>5.50</td>
<td>1.70</td>
</tr>
<tr>
<td>S164/64</td>
<td>9.00</td>
<td>5.00</td>
<td>1.50</td>
</tr>
<tr>
<td>S164/70</td>
<td>9.00</td>
<td>7.00</td>
<td>1.50</td>
</tr>
<tr>
<td>S164/149</td>
<td>7.50</td>
<td>4.50</td>
<td>2.00</td>
</tr>
<tr>
<td>S164/75</td>
<td>8.00</td>
<td>4.50</td>
<td>1.80</td>
</tr>
<tr>
<td>S164/71</td>
<td>6.50</td>
<td>4.50</td>
<td>1.60</td>
</tr>
<tr>
<td>S164/97</td>
<td>9.00</td>
<td>5.00</td>
<td>1.50</td>
</tr>
</tbody>
</table>

**Table 4:1** Dimensions of isolated ovens in the Catlins and on the Otago Peninsula. The data on the Peninsula Ovens is taken from Knight (1966). Dimensions in metres.
### Table 4:2  Topographical characteristics of sites of isolated ovens in the Catlins.

<table>
<thead>
<tr>
<th>Site</th>
<th>Angle of slope</th>
<th>Direction of slope</th>
<th>Topographical shelter</th>
<th>View</th>
<th>Distance from stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simpsons Oven</td>
<td>Gentle</td>
<td>NE</td>
<td>From S</td>
<td>Lower Mokoreta Valley and very wide</td>
<td>200 m</td>
</tr>
<tr>
<td>Wyndham One</td>
<td>Gentle</td>
<td>S</td>
<td>From E &amp; N</td>
<td>Upper Mokoreta Valley - mod. wide</td>
<td>300 m</td>
</tr>
<tr>
<td>Wyndham Two</td>
<td>Gentle</td>
<td>NE</td>
<td>From S &amp; W</td>
<td>Across Mokoreta Valley - restricted</td>
<td>300 m</td>
</tr>
<tr>
<td>Wyndham Three</td>
<td>Flat</td>
<td>-</td>
<td>From S</td>
<td>Upper hill slopes of Mokoreta Valley - restricted</td>
<td>5 m</td>
</tr>
<tr>
<td>Woolshed Oven</td>
<td>Gentle</td>
<td>S</td>
<td>From W</td>
<td>Tahakopa Valley wall - restricted</td>
<td>100 m</td>
</tr>
<tr>
<td>Burials</td>
<td>Find-spots</td>
<td>Charcoal and Stone patches</td>
<td>Isolated Ovens</td>
<td>Midden sites</td>
<td>Occupation Sites</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>----------------------------</td>
<td>----------------</td>
<td>--------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>S183/5</td>
<td>S178/5</td>
<td>S179/10</td>
<td>S178/1</td>
<td>S179/1</td>
<td>S179/3</td>
</tr>
<tr>
<td>S184/4</td>
<td>S179/3</td>
<td>S179/15</td>
<td>S178/2</td>
<td>S179/2</td>
<td>S179/5</td>
</tr>
<tr>
<td>S184/6</td>
<td>S179/6</td>
<td>S179/16</td>
<td>S178/3</td>
<td>S179/3</td>
<td>S179/14</td>
</tr>
<tr>
<td>S184/23</td>
<td>S179/9</td>
<td>S183/6</td>
<td>S178/4</td>
<td>S183/4</td>
<td>S179/17</td>
</tr>
<tr>
<td>S184/25</td>
<td>S179/12</td>
<td>S183/7</td>
<td>S179/7</td>
<td>S183/10</td>
<td>S184/1</td>
</tr>
<tr>
<td>S184/30</td>
<td>S184/10</td>
<td>S183/8</td>
<td>S179/9</td>
<td>S184/12</td>
<td>S184/1</td>
</tr>
<tr>
<td></td>
<td>S184/22</td>
<td>S184/35</td>
<td>S179/11</td>
<td>S184/13</td>
<td>S184/2</td>
</tr>
<tr>
<td></td>
<td>S184/42</td>
<td>S184/36</td>
<td>S179/13</td>
<td>S184/14</td>
<td>S184/3</td>
</tr>
<tr>
<td></td>
<td>S184/43</td>
<td></td>
<td>S184/33</td>
<td>S184/15</td>
<td>S184/4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S184/34</td>
<td>S184/16</td>
<td>S184/5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S184/37</td>
<td>S184/17</td>
<td>S184/6</td>
</tr>
<tr>
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<td></td>
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<td>S184/38</td>
<td>S184/19</td>
<td>S184/7</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>S184/20</td>
<td>S184/8</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>S184/21</td>
<td>S184/9</td>
</tr>
<tr>
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<td></td>
<td></td>
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<td>S184/24</td>
<td>S184/26</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>S184/27</td>
<td>S184/32</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>S184/28</td>
<td></td>
</tr>
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<td>S184/29</td>
<td></td>
</tr>
<tr>
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<td></td>
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<td>S184/31</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>S184/39</td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
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<td>S184/40</td>
<td></td>
</tr>
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<td>S184/41</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>S184/44</td>
<td></td>
</tr>
</tbody>
</table>

Table 4:3: Division of Catlins sites into categories, tabulated according to N.Z.A.A. Site Recording Scheme.
### Table 4:4 Parameters of the three nested bowls of the Woolshed Oven, Tahakopa.

<table>
<thead>
<tr>
<th>Oven</th>
<th>Wgt of Stones</th>
<th>Wgt of Rotten Rock</th>
<th>Total wgt of rock</th>
<th>Mean wgt of stones</th>
<th>N-S</th>
<th>E-W</th>
<th>Basal</th>
<th>Depth at Eastern Edge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oven 1</td>
<td>29565 g (82.6)</td>
<td>6230 g (17.4)</td>
<td>35795 g</td>
<td>360.5 g</td>
<td>142 cm</td>
<td>92 cm</td>
<td>91 cm</td>
<td>63 cm</td>
</tr>
<tr>
<td>Oven 2</td>
<td>9431 g (86.2)</td>
<td>1516 g (13.8)</td>
<td>10947</td>
<td>219.3</td>
<td>178</td>
<td>192</td>
<td>122</td>
<td>66</td>
</tr>
<tr>
<td>Oven 3</td>
<td>12633 g (93.8)</td>
<td>842 g (6.2)</td>
<td>13475</td>
<td>252.7</td>
<td>126</td>
<td>138</td>
<td>61</td>
<td>95</td>
</tr>
</tbody>
</table>

Values in parentheses are percentages of sound and rotten rock.
Table 4:5  Summary of characteristics of middens recorded along the Catlins Coast.

**Abbreviations:**

Position:  CT - Coastal Terrace, CD - Coastal Dune, RT - River Terrace, RD- River Dune.

Relative size:  L - large, M - medium, S - small.

Aspect:  Points of the compass.

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Names</th>
<th>Position</th>
<th>Relative Size</th>
<th>Aspect</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>S179/1</td>
<td>Tirohanga (N)</td>
<td>CT</td>
<td>S</td>
<td>N</td>
<td>Bb, Fb</td>
</tr>
<tr>
<td>S179/2</td>
<td>Tirohanga (S)</td>
<td>CT</td>
<td>S</td>
<td>N</td>
<td>Sh, Bb, Fb, Ib</td>
</tr>
<tr>
<td>S179/5</td>
<td>Karoro Stm Mouth</td>
<td>CT</td>
<td>M</td>
<td>N</td>
<td>Sh, Ib?</td>
</tr>
<tr>
<td>S184/10</td>
<td>Papatowai Estuary</td>
<td>RT</td>
<td>S</td>
<td>SW</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/12</td>
<td>Papatowai Estuary</td>
<td>RD</td>
<td>S</td>
<td>E</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/15</td>
<td>Papatowai Estuary</td>
<td>RT</td>
<td>M</td>
<td>NE</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/14</td>
<td>Papatowai Estuary</td>
<td>RT</td>
<td>S</td>
<td>NE</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/16</td>
<td>Papatowai Estuary</td>
<td>RT</td>
<td>S</td>
<td>NE</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/17</td>
<td>Tahakopa/ Maclennan</td>
<td>RT</td>
<td>S</td>
<td>S</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/19</td>
<td>Tahakopa Beach</td>
<td>CD</td>
<td>S</td>
<td>S</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/20</td>
<td>Tautuku Pt</td>
<td>CT-D</td>
<td>L</td>
<td>E</td>
<td>Sh, Bb, Mb, Sb, Pb, Rb</td>
</tr>
<tr>
<td>S184/21</td>
<td>Tautuku Nth</td>
<td>CT</td>
<td>S</td>
<td>SE</td>
<td>Sh, Mb, Sb</td>
</tr>
<tr>
<td>S184/24</td>
<td>Picnic Pt</td>
<td>CT</td>
<td>M</td>
<td>E</td>
<td>Sh, Fb</td>
</tr>
<tr>
<td>S184/26</td>
<td>Pillans Stm</td>
<td>CT</td>
<td>L</td>
<td>NE</td>
<td>Sh?</td>
</tr>
<tr>
<td>S184/27</td>
<td>Waitangi (W)</td>
<td>CT</td>
<td>S</td>
<td>S</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/28</td>
<td>Waitangi (E)</td>
<td>CT</td>
<td>L</td>
<td>S</td>
<td>Sh, Mb, Bb, Sh, Fb</td>
</tr>
<tr>
<td>S184/29</td>
<td>Long Pt (S)</td>
<td>CT</td>
<td>M</td>
<td>S</td>
<td>Sh, Mb, Bb, Sh, Fb, A</td>
</tr>
<tr>
<td>S184/30</td>
<td>Long Pt (S) 29?</td>
<td>CT</td>
<td>?</td>
<td>S</td>
<td>Sh, Bb, Sh, Mb, Bb, A</td>
</tr>
<tr>
<td>S184/31</td>
<td>Papatowai Estuary</td>
<td>RT</td>
<td>S</td>
<td>NW</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/39</td>
<td>Purakaunui Bay</td>
<td>CT</td>
<td>S</td>
<td>SE</td>
<td>Sh</td>
</tr>
<tr>
<td>S184/40</td>
<td>Jacks Bay</td>
<td>CT</td>
<td>?</td>
<td>E</td>
<td>?</td>
</tr>
<tr>
<td>S184/41</td>
<td>Hukihuki Ck</td>
<td>RT</td>
<td>S-L</td>
<td>NE</td>
<td>Sh, Mb, A</td>
</tr>
<tr>
<td>S184/44</td>
<td>Papatowai Cave</td>
<td>RT</td>
<td>S</td>
<td>NE</td>
<td>Sh, A</td>
</tr>
<tr>
<td>S183/4</td>
<td>Haldane Estuary</td>
<td>RT</td>
<td>M</td>
<td>E</td>
<td>Sh, Mb, Sb?</td>
</tr>
</tbody>
</table>
Table 4:6 Wind data extracted from Cook's Journal of the First Voyage, 11 February - 23 March 1770. Wind strengths were ranked, (1=light, 2=fresh, 3=strong, 4=gale) from Cook's descriptions, and the mean value calculated for each direction.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>NE</th>
<th>E</th>
<th>SE</th>
<th>S</th>
<th>SW</th>
<th>W</th>
<th>NW</th>
<th>Calm</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of occurrences</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>7</td>
<td>8</td>
<td>17</td>
<td>8</td>
<td>7</td>
<td>19</td>
</tr>
<tr>
<td>% from each direction</td>
<td>15</td>
<td>15</td>
<td>0</td>
<td>10</td>
<td>12</td>
<td>25</td>
<td>12</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Mean relative wind strength</td>
<td>1.7</td>
<td>1.6</td>
<td>0</td>
<td>1.4</td>
<td>2.1</td>
<td>2.4</td>
<td>2.3</td>
<td>2.6</td>
<td></td>
</tr>
</tbody>
</table>
Table 4:7 The direction of exposure and shelter of the wettest and the driest of the six Catlins climate stations in each year of study (see Chapter 2:1 and Chapter 4:1).

<table>
<thead>
<tr>
<th>Year</th>
<th>Wettest</th>
<th>Driest</th>
<th>Wettest</th>
<th>Driest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry year 1970-71</td>
<td>Sites exposed to the south.</td>
<td>Sites sheltered from the south.</td>
<td>Sites exposed to the west</td>
<td>Sites sheltered from the west</td>
</tr>
<tr>
<td>Wet year 1971-72</td>
<td>Wettest</td>
<td>Driest</td>
<td>Wettest</td>
<td>Driest</td>
</tr>
<tr>
<td>Species</td>
<td>Litter</td>
<td>Upper shell</td>
<td>Working Black floor</td>
<td>Black layer</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------</td>
<td>-------------</td>
<td>---------------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>Mollusca</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipi</td>
<td>107</td>
<td>337</td>
<td>171</td>
<td>91</td>
</tr>
<tr>
<td>Cockle</td>
<td>77</td>
<td>252</td>
<td>99</td>
<td>3</td>
</tr>
<tr>
<td>Mud snail</td>
<td>7</td>
<td>7</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Green mussel</td>
<td>-</td>
<td>10</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Faua</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Catseye</td>
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<td>-</td>
</tr>
<tr>
<td>Argobuccinum tumidum d</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Cookia sulcata d</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Dosinia sp. d</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Macra discors d</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Protothaca crassicosta d</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Spisula aequilateralis d</td>
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<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td><strong>Fish</strong></td>
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<td></td>
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</tr>
<tr>
<td>Barracouta</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Snapper</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Birds</strong></td>
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<td></td>
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</tr>
<tr>
<td>Albatross sp.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Harrier</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Heron sp.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Penguin, Fiordland-</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>crested</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Penguin, 'Hybrid'</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Penguin, Rockhopper</td>
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<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Penguin, Erect-crested</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>N.Z. Pigeon</td>
<td>+</td>
<td>-</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Shag (large sp.)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Shearwater, Sooty</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Dinornis robustus</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Pachyornis/Eur. gravis</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Eur. gravis/Km. crassus</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Em. crassus/Anomalopteryx</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Anomalopteryx</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Mammals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern Fur seal</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Hooker's Sea Lion</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Sea elephant</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Sea leopard</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Seal pups</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Polynesian dog</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Kiore</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Rabbit</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4:8 Minimum numbers of individuals of animals found in TTL, Papatowai Point. d = shells which were probably dead when brought to the site. + = only a trace of this species found. For scientific names see Table 4:10.
Table 4:9

Tautuku Point, S184/20

Molluscs
- Cockles
- Pipis
- Blue mussels
- Mud snails

Fish
- Ling
- Sea Perch
- Blue cod
- Red cod
- Groper
- Banded Parrot Fish
- Barracouta

Birds
- Crow, Extinct
- Diving petrel
- Duck, cf. Brown Teal
- ? Falcon
- Gull, Black-backed
- Heron, small sp.
- Kakapo, small
- Kakapo
- Moas
- Anomalopteryx (?natural)
- Dinornis robustus
- Emeus crassus
- Euryapteryx gravis
- Pachyornis elephantopus
- Oystercatcher sp.
- Passerine, small

Penguins:
- Blue
- Erect-crested
- Fiordland Crested
- 'Hybrid' Crested
- Rockhopper
- Pigeon, Native
- Prion, cf. Fairy
- Rail sp. smaller than small Weka.

Shags:
- Little
- cf. Pied
- Spotted
- cf. Stewart Is.

Shearwaters:
-Fluttering
- Short-tailed
- Sooty

Tui
- Wekas; small
- South Is.

Mammals
- Fur seal (incl. juvenile)
- Sea lion
- Kiore

Aspect. Well sheltered from the south, some shelter from the west.

Surface collections by Hamel et al., identified Hamel and Scarlett.

Tautuku North, S184/21

Molluscs
- Pipis
- Blue mussels
- Pauas

Others
- Dinornis torquus
- Fur seal, adult.

Aspect. Very sheltered from the west but open to the south.

Huhiuki Creek, S184/41

Molluscs
- Species not recorded.

Others
- Moa bone

Aspect. Sheltered from the west but open to the south.

Waitangi Stream West, S184/27

Molluscs
- Blue mussels
- Large ridged limpet

Aspect. Sheltered from the west but fully open to the south.
### Table 4:9 Cont'd

<table>
<thead>
<tr>
<th>Picnic Point Middens, S184/24</th>
<th>Long Point South, S184/29-30</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Molluscs</strong></td>
<td></td>
</tr>
<tr>
<td>Cockles</td>
<td>Molluscs</td>
</tr>
<tr>
<td>Pipis</td>
<td>Mussels</td>
</tr>
<tr>
<td>Blue mussels</td>
<td>Paua</td>
</tr>
<tr>
<td>Paua - with heavy flange</td>
<td>Fish</td>
</tr>
<tr>
<td>Catseyes</td>
<td>Blue cod</td>
</tr>
<tr>
<td>Mud snail</td>
<td>Birds</td>
</tr>
<tr>
<td>Ribbed mussel</td>
<td>Moa fragments</td>
</tr>
<tr>
<td>Large trough Shell</td>
<td>Oystercatcher sp? (Awl from</td>
</tr>
<tr>
<td>Swollen trumpet</td>
<td>humerus)</td>
</tr>
<tr>
<td>Large ridged limpet</td>
<td></td>
</tr>
</tbody>
</table>

**Fish**

- Barracouta

**Aspect.** Well sheltered from the west, some shelter to the south.

<table>
<thead>
<tr>
<th>Waitangi Stream East, S284/28</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Molluscs</strong></td>
<td></td>
</tr>
<tr>
<td>Pipis</td>
<td></td>
</tr>
<tr>
<td>Blue mussels</td>
<td></td>
</tr>
</tbody>
</table>

**Fish**

- Barracouta

**Birds**

- Moa - fragments of bone
- Penguin, blue
- Shag, spotted

**Mammals**

- Fur seal

**Aspect.** Sheltered from the west but open to the south.

<table>
<thead>
<tr>
<th>Haldane Estuary, S183/4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Molluscs</strong></td>
<td></td>
</tr>
<tr>
<td>Pipis</td>
<td></td>
</tr>
<tr>
<td>Cockles</td>
<td></td>
</tr>
<tr>
<td>Catseyes</td>
<td></td>
</tr>
</tbody>
</table>

**Others**

- Moa fragments
  - Seal

**Aspect.** Sheltered from west but fairly open to the south.

---

Table 4:9 Distribution of Faunal species at unexcavated middens of the Catlins. Identified by G. Hamei and R.J. Scarlett from grab samples of badly eroded and foscicked sites. For scientific names see Table 4:10.

* For explanation of Penguin identifications see next chapter.
### Table 4:10

**Molluscs**

<table>
<thead>
<tr>
<th>Species</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue mussel</td>
<td>Mytilus edulis aotearoa</td>
</tr>
<tr>
<td>Cats eye</td>
<td>Lunella smaragda</td>
</tr>
<tr>
<td>Cockle</td>
<td>Chione stutchburyi</td>
</tr>
<tr>
<td>Cooks turban shell</td>
<td>Cookia aulacta</td>
</tr>
<tr>
<td>Dosinia</td>
<td>Beinta sp.</td>
</tr>
<tr>
<td>Green mussel</td>
<td>Perna canaliculans</td>
</tr>
<tr>
<td>Large ridged limpet</td>
<td>Cellana strigillaris redimiculum</td>
</tr>
<tr>
<td>Large trough shell</td>
<td>Mastra diacoma</td>
</tr>
<tr>
<td>Mudsnaill</td>
<td>Limnoria granicostata</td>
</tr>
<tr>
<td>Oblong cockle</td>
<td>Protothaca granicostata</td>
</tr>
<tr>
<td>Paua</td>
<td>Fallottia iris</td>
</tr>
<tr>
<td>Paua, silver</td>
<td>P. australis</td>
</tr>
<tr>
<td>Pupi</td>
<td>Paphies australis</td>
</tr>
<tr>
<td>Ribbed mussel</td>
<td>Aulacoyma australis</td>
</tr>
<tr>
<td>Swollen trumpet shell</td>
<td>Argyrocoelum tumidum</td>
</tr>
<tr>
<td>Shield shell</td>
<td>Soules bresiculatus</td>
</tr>
<tr>
<td>Triangular trough shell</td>
<td>Spicula aequilateralis</td>
</tr>
<tr>
<td>Tuatua, southern</td>
<td>Paphies subtriaangularia</td>
</tr>
<tr>
<td>Turret shell</td>
<td>Naoricolepis rosenus</td>
</tr>
</tbody>
</table>

**Fish**

<table>
<thead>
<tr>
<th>Species</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banded Parrot fish</td>
<td>Pseudolabrus pittensi</td>
</tr>
<tr>
<td>Barracouta</td>
<td>Thysites atun</td>
</tr>
<tr>
<td>Blue cod</td>
<td>Parapercis calla</td>
</tr>
<tr>
<td>Groper</td>
<td>Polyprion oxygeanais</td>
</tr>
<tr>
<td>Ling</td>
<td>Genypterus blanckae</td>
</tr>
<tr>
<td>Red cod</td>
<td>Physioulus baccus</td>
</tr>
<tr>
<td>Sea perch</td>
<td>Helicolenus percoides</td>
</tr>
<tr>
<td>Snapper</td>
<td>Chrysophryne auratus</td>
</tr>
</tbody>
</table>

**Birds**

<table>
<thead>
<tr>
<th>Species</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albatross sp.</td>
<td>Diomedea exulans or D. epomophora</td>
</tr>
<tr>
<td>Brown teal</td>
<td>A. exulans</td>
</tr>
<tr>
<td>Coot, extinct</td>
<td>Nesophararia ohakamensis</td>
</tr>
<tr>
<td>Crow, extinct</td>
<td>Paleonectes mollotum</td>
</tr>
<tr>
<td>Diving petrel</td>
<td>Paleonectes urinatrix</td>
</tr>
<tr>
<td>Eagle, extinct</td>
<td>Harpagornis moorei</td>
</tr>
<tr>
<td>Falcon</td>
<td>Falco novaeseelandiae</td>
</tr>
<tr>
<td>Goose, extinct</td>
<td>Creemorina calotrinis</td>
</tr>
<tr>
<td>Gull, Black-backed</td>
<td>Larus dominicanus</td>
</tr>
<tr>
<td>Harrier</td>
<td>Cirrocephalus approximans</td>
</tr>
<tr>
<td>Heron</td>
<td>Erythromerus sp.</td>
</tr>
<tr>
<td>Kaka, small or large</td>
<td>Nester sp.</td>
</tr>
<tr>
<td>Kaka</td>
<td>Strigops habroptilus</td>
</tr>
<tr>
<td>Kiwi</td>
<td>Apteryx sp.</td>
</tr>
<tr>
<td>Moas</td>
<td>Anomalopteryx dcdiformis</td>
</tr>
<tr>
<td>Moas</td>
<td>Dimornis maximus</td>
</tr>
<tr>
<td>Moas</td>
<td>D. robustus</td>
</tr>
<tr>
<td>Moas</td>
<td>D. orinus</td>
</tr>
<tr>
<td>Moas</td>
<td>Euryapteryx gravis</td>
</tr>
<tr>
<td>Moas</td>
<td>Megalapteryx didius</td>
</tr>
<tr>
<td>Moas</td>
<td>Pachyornis elephantiopic</td>
</tr>
</tbody>
</table>
Table 4:10 (Cont’d)

**Birds (Cont’d)**

- Mollymawks
- Mollymawks, White-capped
- Notornis
- Oystercatcher
- Parakeet
- Penguins:
  - Blue or Fairy
  - Erect-crested
  - Fiordland Crested
  - ‘Hybrid’ Crested
  - Rockhopper
- Pigeon, native
- Prion, Fairy
- Rail
- Shags:
  - Little
  - Pied
  - Spotted
- Stewart Island Shearwaters:
  - Fluttering
  - Short-tailed
  - Socty
- Swan, extinct
- Tui
- Wekas:
  - Small extinct
  - Modern

**Mammals**

- Polynesian dog
- Kiore
- Rabbit
- Sea lion
- Fur seal
- Leopard seal
- Elephant seal

<table>
<thead>
<tr>
<th>Site</th>
<th>No.</th>
<th>Age in years</th>
<th>Sex</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cannibal Bay</td>
<td>1</td>
<td>&lt; 1</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Cannibal Bay</td>
<td>3</td>
<td>&lt; 3</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Dummy's Beach</td>
<td>1</td>
<td>c. 7</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Cannibal Bay</td>
<td>1</td>
<td>c. 8</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Kaka Point</td>
<td>1</td>
<td>16-18</td>
<td>f</td>
<td>Eaten? P.</td>
</tr>
<tr>
<td>Chaslands</td>
<td>1</td>
<td>18-22</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>Tokanui Mouth</td>
<td>1</td>
<td>25-30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owaka</td>
<td>1</td>
<td>25-30</td>
<td>f</td>
<td>Killed, P.</td>
</tr>
<tr>
<td>Curio Bay</td>
<td>1</td>
<td>&lt;35</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>Kings Rock</td>
<td>1</td>
<td>&lt;35</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>Tautuku Pen</td>
<td>1</td>
<td>&lt;35</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>Tautuku Pen</td>
<td>1</td>
<td>mature</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>Tautuku Pen</td>
<td>1</td>
<td>middle aged</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Cannibal Bay</td>
<td>1</td>
<td>mature</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Cannibal Bay</td>
<td>3</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Long Pt. Sth.</td>
<td>1</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Waipati Beach</td>
<td>1</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
</tbody>
</table>

Table 4:11 Human skeletons from the Catlins coastline; all are burials except for Kaka Point.
P = indications of pregnancy in pelvic bones.
Information from D. Sutton and P. Houghton, University of Otago.
Cannibal Bay, S184/4

Molluscs
Not recorded.

Fish
Barracouta - numerous
Red cod - next most common
Groper
Pseudolabrus sp.
Blue cod.
Ling
Sea perch

Birds
Shags (2 spp).
Weka
Pigeon, native
Parakeet
Mollymawk
Moa spp.

Mammals
Kiore
Dog, Polynesian
Fur seal
Sea lion (immature)
Rabbit

Surface collections by G. Park.
Ident. by G. Hamel and M. Jurisich.

Pounawea, S184/1

Molluscs
Pipis
Cockles
Other spp.

Fish
Barracouta
other species

Birds
Crow, extinct
Eagle, extinct
Goose, extinct
Kaka
Kiwi
Mollymawk, White-capped

Moas
Anomalopteryx didiformis
Emeus oranaeus
E. hutton
Euryapteryx gravis
Nestor canicephala
Euryapteryx didius
Pachyornis elephantopus
Notornis
Swan, extinct

Mammals
Dog, native
Seal sp.
Whale sp.

From Lockerbie's excavations
Ident. by R.J. Scarlett.

Hinahina, S184/2

Molluscs
Cockles
Large ribbed limpet
Mudsnail
Pipi

Fish
Barracouta

Bird
Shag (? Spotted)

Surface collection. Identified G. Hamel.

Table 4:12
Table 4:12 (Cont'd)

Kings Rock, S184/6

Molluscs
Blue mussel
Cats eye
Cocks turban shell
Coarse Dosinia
Large trough shell
Paua
Paua, silver
Pipi
Shield shell
Tuatua, southern
Turret shell

Fish
Barracouta
Blue cod
Groper
Other species

Birds
Coot, extinct
Crow, extinct
Falcon
Kaka
Kakapo
Kiwi
Moa:
\textit{Dinornis robustus}
\textit{Euryapteryx gravis}
Sooty Shearwater
Parakeet
Penguin spp.
Weka, small extinct

Mammals
Dog
Seal sp.
Whale sp.
Man

Excavated and identified by Teviotdale, Scarlett and Lockerbie.

Table 4:12 Faunal lists from occupation sites in the Catlins.
For scientific names see Table 4:10.
Table 4:13 Distribution of fauna and artifacts in the excavations on Papatowai Point.
M = Numerous, F = Few, P = Present
<table>
<thead>
<tr>
<th>Excavations</th>
<th>No. of adzes</th>
<th>% of total area</th>
<th>Expected No. of Adzes.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>River edge</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 1</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 2</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIle</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIld</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>45</td>
<td>60</td>
<td>38.0</td>
</tr>
<tr>
<td><strong>Inland, eastern end of terrace</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIIb</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TII</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTA</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7</td>
<td>15</td>
<td>9.5</td>
</tr>
<tr>
<td><strong>Inland, western end of terrace</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIIb</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 3</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>9</td>
<td>10</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>Sand dunes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JP</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2</td>
<td>15</td>
<td>9.5</td>
</tr>
<tr>
<td><strong>Overall Total</strong></td>
<td>63</td>
<td></td>
<td>63.0</td>
</tr>
</tbody>
</table>

Chi-square = 8.945  \[ P = .05 - .01 \]

Table 4.15  Distribution of adzes in river edge and inland excavations, relative to areas of middens, on Papatowai Point.
Black component

8 small adzes, Area 1
5 unfinished adzes, Area 1

Shell and bone component

1 ID adze, Area IIId
1 small rough adze, Area IIId
1 small flake adze, Area IIId
1 unfinished hogback, Area IIId
1 broken adze, Area JP
1 large unfinished adze, Area SP

Working floor component

2 unfinished adzes, Area IIe
1 unfinished adze, Area IIb
1 small blackstone chisel, Area IIe
2 small adzes, Area IIe

Upper shell component

2 small damaged adzes, Area 3
1 broken adze, Area 3

Table 4:16 Distribution of 28 described and provenanced adzes, as described in Teviotdale's diaries (1936-38: ms. Hocken Library).
<table>
<thead>
<tr>
<th>N.Z. C¹⁴ number</th>
<th>Date B.P.</th>
<th>Date A.D.</th>
<th>Material</th>
<th>Provenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1332</td>
<td>890±80</td>
<td>1060±80</td>
<td>Charcoal</td>
<td>TT1, Black component</td>
</tr>
<tr>
<td>R5379/1</td>
<td>850±70</td>
<td>1100±70</td>
<td>Charcoal</td>
<td>TT1, Black component</td>
</tr>
<tr>
<td>R5379/2</td>
<td>760±60</td>
<td>1190±60</td>
<td>Charcoal</td>
<td>TT1, Black component</td>
</tr>
<tr>
<td>134</td>
<td>765±30</td>
<td>1185±30</td>
<td>Charcoal</td>
<td>Lowest layer,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bell</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lockerbie 1956</td>
</tr>
<tr>
<td>135</td>
<td>755±30</td>
<td>1195±30</td>
<td>Charcoal</td>
<td>Repeat run of 134</td>
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<tr>
<td>136</td>
<td>630±50</td>
<td>1320±50</td>
<td>Charcoal</td>
<td>Bottom of trench,</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lockerbie 1956</td>
</tr>
<tr>
<td>R5379/3</td>
<td>660±60</td>
<td>1290±60</td>
<td>Charcoal</td>
<td>TT1, Working floor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>1370±60</td>
<td>Charcoal</td>
<td>TT1, Oven 2 of</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Upper shell component</td>
</tr>
<tr>
<td>R5379/6</td>
<td>580±60</td>
<td>1370±60</td>
<td>Charcoal</td>
<td>TT1, Oven 1 of Upper</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>R5379/4</td>
<td>560±60</td>
<td>1390±60</td>
<td>Charcoal</td>
<td>Lens 2, Upper shell</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>component</td>
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<tr>
<td>137</td>
<td>460±50</td>
<td>1490±50</td>
<td>Moa bone</td>
<td>Bottom of dark layer,</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lockerbie 1956</td>
</tr>
<tr>
<td>138</td>
<td>460±80</td>
<td>1490±80</td>
<td>Moa bone</td>
<td>Dinornis maximus</td>
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<td></td>
<td></td>
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<td>1560±80</td>
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<td>139</td>
<td>310±60</td>
<td>1640±60</td>
<td>Moa bone</td>
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<td></td>
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<td>290±40</td>
<td>1660±40</td>
<td>Shell</td>
<td>TT1, Black component</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hamel</td>
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</table>

Table 4:17 Radiocarbon dates from Papatowai Point excavations. Lockerbie's and Bell's dates are from Fergusson and Rafter 1959. New Zealand numbers have not yet been received for some of Hamel's dates. All dates are calculated according to the old half life of carbon, 5568±30 years.
<table>
<thead>
<tr>
<th></th>
<th>Estuary and Sandy shore</th>
<th>Rocky Shoreline</th>
<th>Marine</th>
<th>Forest</th>
<th>Forest Grassland ecotone</th>
<th>River &amp; Wetland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cockles</td>
<td></td>
<td></td>
<td>Fish</td>
<td>Forest birds</td>
<td>Forest birds</td>
<td></td>
</tr>
<tr>
<td>Pipis</td>
<td></td>
<td></td>
<td>Penguins</td>
<td>Moas</td>
<td>Grassland birds</td>
<td>*Lampreys</td>
</tr>
<tr>
<td>Mud snail</td>
<td></td>
<td></td>
<td>Sea birds</td>
<td>Kiore</td>
<td>Moas</td>
<td>*Eels</td>
</tr>
<tr>
<td>* Flounder</td>
<td></td>
<td></td>
<td></td>
<td>*Edible plants</td>
<td>Kiore</td>
<td>*Whitebait</td>
</tr>
<tr>
<td>Waterfowl</td>
<td></td>
<td></td>
<td>Seals</td>
<td>*Supplejack</td>
<td>*Crayfish</td>
<td></td>
</tr>
<tr>
<td>Wading birds</td>
<td></td>
<td></td>
<td>Whales</td>
<td>*Fibrous plants</td>
<td>*Bracken</td>
<td>Waterfowl</td>
</tr>
<tr>
<td>Moas</td>
<td></td>
<td></td>
<td></td>
<td>Timber</td>
<td>*Cabbage tree</td>
<td>*Flax</td>
</tr>
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Table 4:18 Potential and exploited resources of Catlins habitats.

* No archaeological evidence of exploitation.
<table>
<thead>
<tr>
<th>Quadrat Number</th>
<th>Pipis</th>
<th>Cockles</th>
<th>Total</th>
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<tbody>
<tr>
<td>8</td>
<td>300</td>
<td>174</td>
<td>474</td>
</tr>
<tr>
<td>9</td>
<td>750</td>
<td>285</td>
<td>1035</td>
</tr>
<tr>
<td>10</td>
<td>861</td>
<td>60</td>
<td>921</td>
</tr>
<tr>
<td>11</td>
<td>1572</td>
<td>156</td>
<td>1728</td>
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<td>12</td>
<td>1770</td>
<td>411</td>
<td>2181</td>
</tr>
<tr>
<td>13</td>
<td>852</td>
<td>252</td>
<td>1104</td>
</tr>
<tr>
<td>14</td>
<td>1000</td>
<td>468</td>
<td>1468</td>
</tr>
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</table>

Table 4:19  Numbers of shellfish gathered in two man-hours of collecting at quadrat sites across the Tahakopa River. For positions of samples see Figure 2:16.
### Table 4:20

<table>
<thead>
<tr>
<th></th>
<th>1972 North Shore</th>
<th>Q3</th>
<th>Q9</th>
<th>Q11</th>
<th>Q13</th>
<th>D2</th>
<th>D3</th>
<th>D5</th>
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</thead>
<tbody>
<tr>
<td>Pipis</td>
<td></td>
<td>39.8</td>
<td>3.6</td>
<td>55.0</td>
<td>67.4</td>
<td>47.3</td>
<td>84.7</td>
<td>86.0</td>
</tr>
<tr>
<td>Cockles</td>
<td></td>
<td>60.2</td>
<td>96.4</td>
<td>45.0</td>
<td>32.6</td>
<td>52.7</td>
<td>15.3</td>
<td>14.0</td>
</tr>
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</table>

Percentages of pipis and cockles in samples taken from different parts of the pipi beds in the Tahakopa River. See Figure 2:16 for positions of samples.
Table 4:21 Species identified in charcoal samples taken for radiocarbon dating from TT1, Papatowai Point. Figures show percentages of each species present.

<table>
<thead>
<tr>
<th>Provenance</th>
<th>Podocarpus totara/hallii</th>
<th>Myrtaceae australis</th>
<th>Leptocarpus eucarpium</th>
<th>Aristotelia serrata</th>
<th>Lebe sp.</th>
<th>Pseudowintera colorata</th>
<th>Date</th>
<th>Sample</th>
<th>A.D. No.</th>
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<tbody>
<tr>
<td>Black layer</td>
<td>90</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1100</td>
<td>R5379/1</td>
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<tr>
<td>Black layer</td>
<td>85</td>
<td>10</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1190</td>
<td>R5379/2</td>
<td></td>
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<tr>
<td>Working floor</td>
<td>72</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>1290</td>
<td>R5379/3</td>
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<tr>
<td>Upper shell layer</td>
<td>80</td>
<td>-</td>
<td>16</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>1390</td>
<td>R5379/4</td>
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</tr>
<tr>
<td>Upper shell layer</td>
<td>55</td>
<td>14</td>
<td>3</td>
<td>25</td>
<td>3</td>
<td>1370</td>
<td>1370</td>
<td>R5379/5</td>
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<tr>
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<td>5</td>
<td>5</td>
<td>1370</td>
<td>R5379/6</td>
<td></td>
</tr>
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</table>
Figure 1.1 Southern New Zealand showing place names mentioned in the text.
Figure 2:1  The Catlins district, showing locations of climate stations.
Figure 2:2 Mean monthly rainfall at Tawanui for the years 1966-1970.
Figure 2:3 Raw data for rainfall at Tawanui and Kahuika.
Figure 2:4  Maximum and minimum temperatures at Tawanui and Kahuika.
Figure 2.5  Cumulative rainfall values for Tahakopa and Florence Hill, 1971-72.
Figure 2.6 Cumulative rainfall values for Caberfeidh and Papatowai, 1970-71.
Figure 2:7 Annual rainfall at the climate research stations for the years August 1970-August 1971 and August 1971-August 1972.
Figure 2:8  Mean annual temperatures at climate research stations for years 1970-72 (21 observations 1970-71, 19 1971-72.)
Figure 2:9a  Maximum and minimum temperatures at Papatowai and Florence Hill, August 1970/August 1971.
Figure 2:9b  Minimum temperatures from climate research stations on valley floors, October to April, 1970-1972. Stott's Clear, three stations.
Figure 2:10 Annual evaporation at research stations, 1970-72.
Figure 2:11 Annual rainfall and annual evaporation at climate research stations, 1970-72.
Figure 2:12 Evaporation and rainfall at Caberfeidh and Tahakopa, 1970-71.
Figure 2:12a Vegetation of the Catlins district. The forest boundaries are derived from early surveyors' maps, e.g., Strauchon 1886, and the boundaries of different types of forest from Jowett 1965 and New Zealand Forest Service 1976.
Figure 2:13 Tahakopa Valley showing clearings. From Strauchon, 1886
Figure 2:13a  Owaka Valley showing clearings. From official surveys, 1888.
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Figure 2:15 New Zealand and southern islands to show breeding distribution of penguin species.
Figure 2.16  Estuary of the Tahakopa River.
Figure 2:17  Densities of pipis and cockles across the Tahakopa River, relative to water depth.  See Figure 2:16 for locations of quadrats.
Figure 2: Length frequencies of cockles from Otago Harbour, Papatowai and Awarua Bay. Otago Harbour data from Hamel and Barr, 1974.
Figure 2:19a Growth rates of cockles from adjacent stations (S1, S2, D5) close to Papatowai Point and below MLW.
Figure 2:19b  The growth rates of the fastest growing populations of cockles from different areas of New Zealand (Larcombe 1971), with values for Papatowai superimposed (see Figure 2:19a).
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Figure 2.21 Relation of mean length to density per square metre of cockles at Papatowai.
Figure 2.22 Relation of mean length to density per square metre for cockles at Aramoana.
Figure 2.23  Dry weight/length curves for cockle populations in Otago Harbour, winter 1970 (Larcombe 1971).
Figure 2:24 Relation of dry weight to length in cockles from Te Rauone, Otago Harbour (n = 30).
Figure 2:25 Estimates of dry weights of cockle meat compared to observed weights for eight samples from Aramoana, Otago Harbour. Perfect estimates would fall on the line.
Figure 2:26 Population structures of pipi samples from Papatowai. Dates of collection: North 1972 - 8/3/73, North 1973 - 17/3/73, D2-D5 - 5/3/73, Q1-13 - 7/4/73.
Figure 2:27  Relation of density to mean length of Pipis from Galatea Bay, Gl-4, (Terrell 1967) and Papatowai, the rest.
Figure 2: Relations of lengths of Cockles and Pipis to water depth at Papatowai.
Figure 2:29 Relation of $\Sigma l^3$ to mean length of pipis at Galatea Bay, Gl-4 (Terrell 1967) and Papatowai, the rest.
Figure 2:30  Relation of $\Sigma_1^3$ to density per square metre of pipis at Galatea Bay, G1-4 (Terrell 1967) and Papatowai, the rest.
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Figure 3:2 Topography of Tahakopa River mouth, showing sites of botanical quadrats and archaeological sites.
Figure 3:3 Growth rates of matais on midden soils (M5 and M4) compared to matais on adjacent dunes (M3 and M7).
Figure 3:4 Present day vegetation around Tahakopa River mouth (after Jowett 1965).
Figure 3:5  Growth rates of four matais to show effects of different growth rates on each side of the tree (paired cores from M21, M9, M11), and compared to mean curve for three radii of M14.
Figure 3:6a  Distribution of diameter relative to estimated date of establishment in totaras on Maclellan Reserve.
Figure 3:6b Distribution of diameter relative to estimated date of establishment in rimus on MacLennan Reserve.
Figure 3:7 Relation of diameter to age in silver beech on the Maclennan Reserve.
Figure 3.8 Relationship of density to mean basal area of trees at four sites on the Maclennan Reserve.
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Figure 4:2  Enlargement from Figure 4:1, to show Tahakopa Valley.
Figure 4:3 Upper Tahakopa Valley showing the sites and resource zones of Stott's Clear (from Falkiner and McCurdie, 1892).
Figure 4:4 Woolshed Oven, Stott's Clear showing sections on west and north baulks of excavated quadrant.
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Figure 4:7  False Island showing archaeological sites.
Figure 4.8  Approximate positions of excavations on Papatowai Point.
Figure 4:9 Topography and Vegetation on Papatowai Point.
Figure 4:10  Section drawings from Papatowai Point.

4:10a  After Teviotdale 1937:137.
4:10c  Interpretation from text (Lockerbie 1953:13).
4:10b  Interpretation from text (Teviotdale 1937:137).
4:10c  From Lockerbie 1959:84.
4:10e  From Lockerbie 1959: Plate Ib.
4:10f  Interpretation from text (Teviotdale and diaries Nov 1937).
4:10g  Interpretation from text (Teviotdale 1937:146).
4:10h  Interpretation from text (Teviotdale 1938a:29).
4:10i  Interpretation from text (Teviotdale's diaries: 17 November, 1937).
4:10j  Interpretation from text (Teviotdale 1937:148).
Figure 4:10  Section drawings of excavations on Papatowai Point. All except a, d and e are interpretations from the appropriate text by Lockerbie or Teviotdale.
Figure 4:11  Schematic drawings to show how a sequence of components is derived from the layers of several sections.
Figure 4:12 Section drawings of the excavation TT1, Papatowai Point.
Figure 4:13 Radiocarbon dates from Papatowai Point.
Table 4:14 Occurrence of components at sites on Papatowai Point.

<table>
<thead>
<tr>
<th>Sites</th>
<th>Lower-shell</th>
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<th>Shell-and-bone</th>
<th>Working floor</th>
<th>Upper-shell</th>
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<td>-</td>
<td>-</td>
<td>X</td>
</tr>
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<td>?</td>
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</tr>
</tbody>
</table>

X = placed by stratigraphy and attributes.
0 = single layer, placed by attributes only.
Figure 4:13a  Humeri of Fur seal and Sea lion.
Figure 4.13b  Radii and femora of Fur seal and Sea lion.
Figure 4:13c Scapulae of Fur seal and Sea lion.
Figure 4:14  Length-frequencies of pipis and cockles from the midden material of TT1, Papatowai Point.
<table>
<thead>
<tr>
<th>Season</th>
<th>Spring</th>
<th>Summer</th>
<th>Autumn</th>
<th>Winter</th>
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</thead>
<tbody>
<tr>
<td>Year</td>
<td>1800 AD</td>
<td>1000 AD</td>
<td>1000 AD</td>
<td>1000 AD</td>
</tr>
</tbody>
</table>

- **Upper Shell Component**
- **Working Floor Component**
- **Black Component**
- **Shell & bone Component**
- **Lower shell Component**

*Figure 4:15  Reconstruction of temporal relationships of components at Papatowai Point.*
Figure 4:16  Changes over time in exploitation of major faunal resources at Catlins sites.
Figure 4:17 Reconstruction of occupation of Catlins and Murikauhaka sites, assuming abandonment of some sites during cold periods. Model I.
Figure 4:18 Reconstruction of occupation of Catlins and Murikauhaka sites, assuming abandonment of all sites during cold periods. Model II.
Figure 4:19  Pollen spectrum from Stott's Bog, Tahakopa Valley. The basis for the "percentage" calculations is the sum of tree podocarp and Nothofagus pollen only. Other species are expressed as a percentage of that sum.
Figure 4:19  Continued.