NEW ZEALAND ARCHAEOLOGICAL ASSOCIATION

NEW ZEALAND JOURNAL OF ARCHAEOLOGY

Polynesian Settlement and Horticulture in Two River Catchments of the Eastern North Island, New Zealand

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ABSTRACT

The Uawa and Whakatane river catchments in the eastern North Island, New Zealand, had horticultural use patterns strongly dependent on soil distribution and microclimate. The means of archaeological identification of used soil areas differed in the two catchments because of gross contrasts in the underlying geological structure and soil formation. Physical soil conditions and temperature were key parameters, leading to contrasting distribution of usable soils in the two catchments. Alluvial levees were used in the Uawa Catchment, in tandem with significant use of hill soils in slope gardens under a swidden regime. Alluvial soils were relatively little used in the Whakatane study area, because of the risk of frost, and lower ridges in elevated and dissected terrace landforms were more suitable.

The soils were in use from about A.D. 1200 in the Uawa Catchment, with somewhat later use in the Whakatane Catchment. Relatively small areas were in use at any one time.
Keywords: HORTICULTURE; ALLUVIUM; HILL SOIL; PREHISTORIC POLYNESIAN; NEW ZEALAND; FROSTS; MICROCLIMATE; STORAGE PITS; SWEET POTATO; WHAKATANE RIVER; UAWA RIVER; TOLAGA BAY.

INTRODUCTION

This paper addresses the problem of the nature and use of horticultural land by prehistoric Polynesians in part of temperate New Zealand, the eastern region of the North Island (Fig. 1). The archaeological surveys reported here are of the Uawa River catchment (Tolaga Bay) and a large part of the Whakatane and Waimana Valleys (Fig. 2). Several questions are reviewed on the basis of archaeological and some eighteenth and nineteenth century historical evidence.

1. Were any soils or groups of soils clearly preferred, and why?

2. How can such preference be recognised in the archaeological record?

3. What is an acceptable range of dates for horticultural activity and settlement in these areas, and did practices change over time?

4. What are the prospects for deriving population estimates from this evidence?

At an early stage in this investigation it seemed that an approach based on "intensification" of horticulture on well drained silt alluvium would be useful. By intensification is meant the progressive adoption of practices whereby constricted areas of land yield increasing production, whether those practices involve greater labour inputs or specifically new methods of production (Brookfield 1984). The three principal crops available to Polynesians in New Zealand all flourish well in alluvial conditions. Taro (*Colocasia esculenta*) would do well in naturally swampy soils between river levees and foothills, and is a mainstay in intensive irrigated cultivation elsewhere in Polynesia. The yam (*Dioscorea alata*) prefers deep, well drained soils and would be ideally suited to levee silt loams. Sweet potato (*Ipomoea batatas*) also does well on well drained silt loams. The yam would have advantages in late summer dry conditions (Vasey 1981: 22).

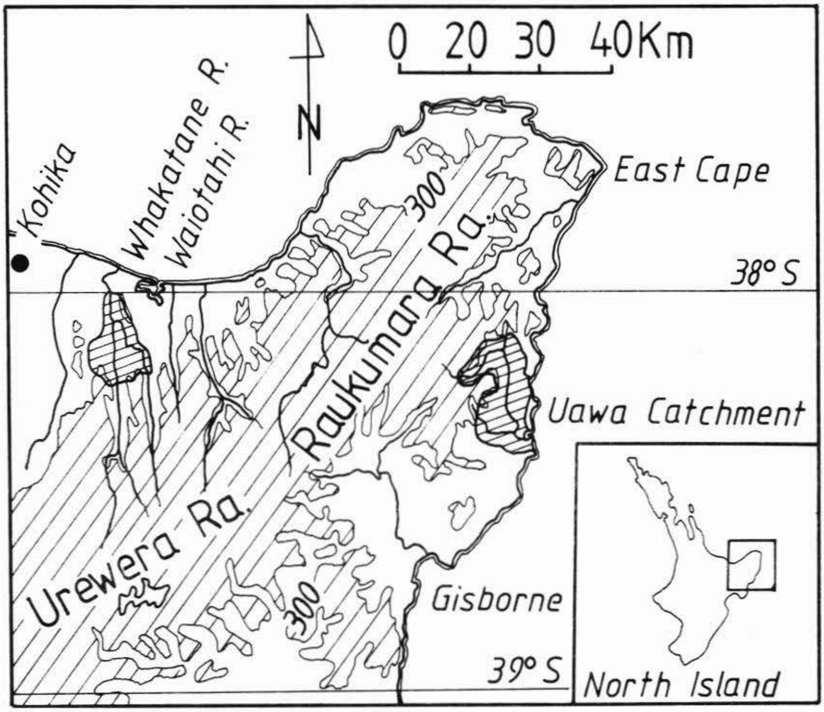


Figure 1: Eastern North Island, location of study areas and places mentioned in text.

The main difficulties with this approach arose from the relatively undemanding fertility requirements of the principal Maori crop, the sweet potato (Yen 1963), which is much more dependent on silty or sandy friable physical condition of the soil than on any inherent fertility. It is readily grown in slope gardens under a swidden regime, provided the right physical conditions exist. The sweet potato also looms large in this account of Polynesian temperate horticulture because of the need to lift and store it in underground pits for over-wintering. The storage facilities offer an unusual and very important key to volumes of crop stored, hence crop areas, and they are readily recognised in large numbers in the course of extensive archaeological surveys. Kumara storage pit numbers or volumes, among other factors, also provide a potential indication of population (Law 1969, 1970; Jones 1983a; Fox 1983).

The other crops, taro and yam, were not lifted until needed. The important carbohydrate staple, fern root (*Pteridium esculentum*) rhizome, is the product of an ubiquitous pyrophyte, and gathered rather than cultivated. These plants, along with kumara, have significantly less fertility demands than the North American crops such as maize, squash, and white potato, all of which were successfully grown by the Maori after 1769 (Leach 1984: 98–110).

CHRONOLOGY OF SETTLEMENT

Some radiocarbon dates are available for the Whakatane Valley and the Uawa Catchment. In both catchments, the available adze collections are of the Duff type 2B, i.e., Classic Maori in affinity (Golson 1959). A precise range of dates for these adzes is notoriously difficult, but they would usually be attributed to the period after A.D. 1400. The study area generally is impoverished in the availability of adze-quality stone. If this type is the result of use of localised, poor-quality stone resources, as can be argued (Jones 1972; Best 1977), the type itself could be of greater age in the study area than is generally assumed elsewhere in New Zealand.

Radiocarbon dates on shell have been obtained for a number of pa in the Opouriao and Waimana plains vicinities (Table 1). A maximum age for a gravel-added soil at Rewarau Road (see Fig. 6) is based on charcoals comprising peppertree (*Pseudowintera* sp.) 65%, maire (*Nestegis* sp.) 35%, and mapou? (*Myrsine* sp.?) 5% (Rod Wallace, pers. comm.). Of these, *Pseudowintera* and *Myrsine* are mid-canopy trees and relatively short-lived. Sample NZ 6838 therefore provides a maximum age for clearing of established forest and soil cultivation. The charcoal is mixed into the subsoil above Kaharoa Ash which dates to about 700 years B.P. (McFadgen 1982; McGlone 1980). If allowance of 50 years is made for the inherent age of the charcoal, a date for earliest forest clearance and gardening at Rewarau Road would be between A.D. 1360 and 1510. This overlaps the range of dates based on marine shell for pa in the Opouriao and Waimana vicinity, although it is somewhat earlier. However, it is consistent with McGlone's (1980) finding of extensive post-Kaharoa firing in the Bay of Plenty.

This range of dates is fully consistent with the sparse evidence of chronology for the rest of the eastern Bay of Plenty. A date in the eighteenth century has been suggested for a pa in the neighbouring Waiotahi Valley, based on the presence of Tarawera Ash (erupted 1886) at a point relatively deep in ditch infill (Jones 1984: 109–118). One of a great many kumara storage pits at Kawerau dates to the early seventeenth century (336 ± 56 yrs B.P.) (Lawlor 1983: 225), while the site of Kohika, on dunes in swampland near the mouth of the Tarawera River, has cultural material dating between the fourteenth and seventeenth centuries A.D. (535 ± 57 yrs B.P. and 353 ± 57 yrs B.P.) Lawlor 1980: 265–267).

Radiocarbon dates for Tolaga Bay are shown in Table 2. These suggest relatively early use of the Mangaheia Valley flats (N89 & 90/29, 290) in the thirteenth or fourteenth century A.D., and a fourteenth century date for hill gardening at the head of the Uawa flats (N89 & 90/222; site description in Jones 1983a). These dates are consistent with those for the lower midden layer at Cook's Cove, at the entrance of Tolaga Bay (McFadgen 1982).

PHYSICAL SETTING

The eastern North Island is on the margins of the Pacific Continental Plate. It is subject to rapid uplift in the east, with strong north-south faulting. There is an extensive north-south belt of active volcanism to the west of the region responsible for significant overlays of airfall pumice in much of the area, petering out in the north-east. The geological structure leads to striking contrasts east and west of the principal dividing ranges (the Urewera and the Raukumara): mud, silt- and sandstones with minor ash mantling in the east, and older greywacke and argillites with some marine sediments heavily mantled in volcanic ash to the west and north. The Whakatane catchment drains to the north on the west of the dividing ranges, while the Uawa catchment drains to the south and east of these ranges.

TABLE 1

RADIOCARBON DATES FOR PA IN THE OPOURIAO AND WAIMANA PLAINS VICINITIES

Site No.	Lab. No. NZ	Material	Age (Old $T_{\frac{1}{2}}$) (Yrs B.P.)	Age (New $T_{\frac{1}{2}}$) (Yrs B.P.)	Age corrected for secular effect (Yrs B.P.)	Years A.D. (range of 1SD)	
N78/282	6791	shell	440 ± 34	453 ± 35	–	1460–1530	Maximum age for defensive bank
N78/281	6792	shell	304 ± 53	313 ± 54	–	1580–1690	Maximum age for substantial terrace and defensive scarp
N78/4	6794	shell	294 ± 53	303 ± 54	–	1590–1700	Minimum age for occupation (shell in top soil)
*N78/148	6796	shell	386 ± 53	397 ± 55	–	1500–1610	Maximum age for substantial terrace contemporaneous with ring ditch
*N78/241	6805	shell	300 ± 53	309 ± 54	–	1590–1700	Shell in top soil (Probability of age <250 yrs B.P.: 13.6%)
*N78/313	6814	shell	378 ± 53	389 ± 55	–	1510–1620	Minimum age (shell in topsoil)
N78/20	6826	shell	280 ± 44	289 ± 46	–	1620–1710	Shell in topsoil (Probability of age <250 yrs B.P.: 19.2%)
N78/569	6838	charcoal	540 ± 67	556 ± 69	565 ± 74	1310–1460	Maximum age for gravel-added soil at Rewarau Road

* Date for Waimana Plains vicinity

(Old $T_{\frac{1}{2}}$: 5568 yrs; new $T_{\frac{1}{2}}$: 5730 ± 40 yrs; secular correction as distributed at the 8th International Conference on Radiocarbon Dating by H. N. Michael and E. K. Ralph.)

TABLE 2

RADIOCARBON DATES FOR TOLAGA BAY VICINITY

Lab No. NZ	Site No. and Description	Material	Age (Old $T_{\frac{1}{2}}$) Yrs B.P.	Corrected For Secular Effect Yrs B.P. New $T_{\frac{1}{2}}$	14C Age Wrt NZ Shell Std Yrs B.P. New $T_{\frac{1}{2}}$	Years A.D. (range of 1SD)
6562	N89 & 90/222 (pits and terraces) (see Jones, 1983b)	Tree fern charcoal	564 ± 52	597 ± 54	–	A.D. 1300–1410
6570	N89 & 90/29 (pa, pits, terraces) sample either in terrace fill or eroding slope	Shell	643 ± 54	–	662 ± 56	A.D. 1230–1340
6571	N89 & 90/290 (pits) sample adjacent to pits	Shell	530 ± 54	–	546 ± 55	A.D. 1350–1460
6578	N89 & 90/500 (pa, pits and terraces); sample in terrace fill cut by road.	Shell	462 ± 30	–	476 ± 31	A.D. 1440–1510
631	Lower occupation layer Cook's Cove (see Wellman, 1962; McFadgen, 1982)	Charcoal	519 ± 41	655 ± 42	–	A.D. 1250–1340
632	As above	Shell	700 ± 56	–	820 ± 55	A.D. 1080–1190

(Old $T_{\frac{1}{2}}$: 5568 yrs; New $T_{\frac{1}{2}}$: 5730 ± 40 yrs; Secular corrections provided by laboratory.

This contrast holds the key to the micro-climates, soil formations, and river sedimentation critical to Maori use of the land.

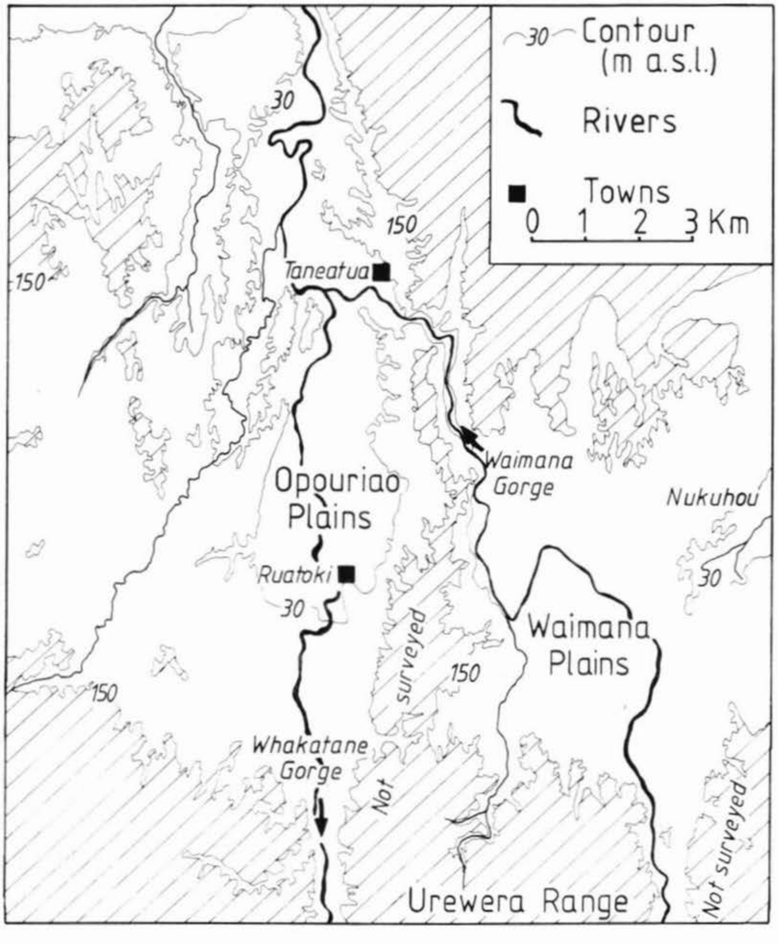


Figure 2: Topography, places mentioned in text and survey coverage of Whakatane study area.

Localities mentioned in the text are in Figure 2 for the Whakatane Valley, and Figure 3 for the Uawa catchment.

UAWA CATCHMENT (Fig. 3)

Three broad topographic distinctions may be drawn in Tolaga Bay. The Hikuwai, Uawa and Mangaheia flats form the surfaces of infilled Pleistocene valleys. In the south, rolling hill country rises sharply to form the southern edge of the catchment. Faults in the sandstone create steep cliffs in places. Topography to the north is relatively rugged with steep slopes, higher landforms generally, again often cliffed around the principal rivers.

Hill soils in Tolaga Bay are steepland central yellow-brown earths. The underlying mud- and sandstones have produced silty soils with varying clay content and volcanic ash incorporated into the upper layers (New Zealand Soil Bureau 1954). On the flats, the river banks present strips of varying widths of flood-free, well drained silt loams of high natural fertility (Pullar and Rijkse 1977; Rijkse and Pullar 1978). These are the Waihirere and Matawhero silt loams, which have formed over the last 6–700 and 3– 400 years on earlier terrace surfaces (McFadgen 1978; Grant 1984) respectively, and are now stable. The rapidly accumulating Waipaoa silt loam is found on the lowest river terraces and in the upper part of valley floors feeding into the catchment. There are extensive areas of gleyed, formerly back-swamp soils between the river levees and the base of the hills.

The Matawhero and Waihirere silt loams and the ash-mantled hill soils would have been well suited to Maori horticultural practice for kumara, as Cook noted:

> The soil both of the hills and Vallies is light and sandy and very proper for produceing all kinds of Roots but we saw only sweet Potatous and Yamms among them; these they plant in little round hills, and have plantations of them containing several Acres . . . (Cook 1955: 186).

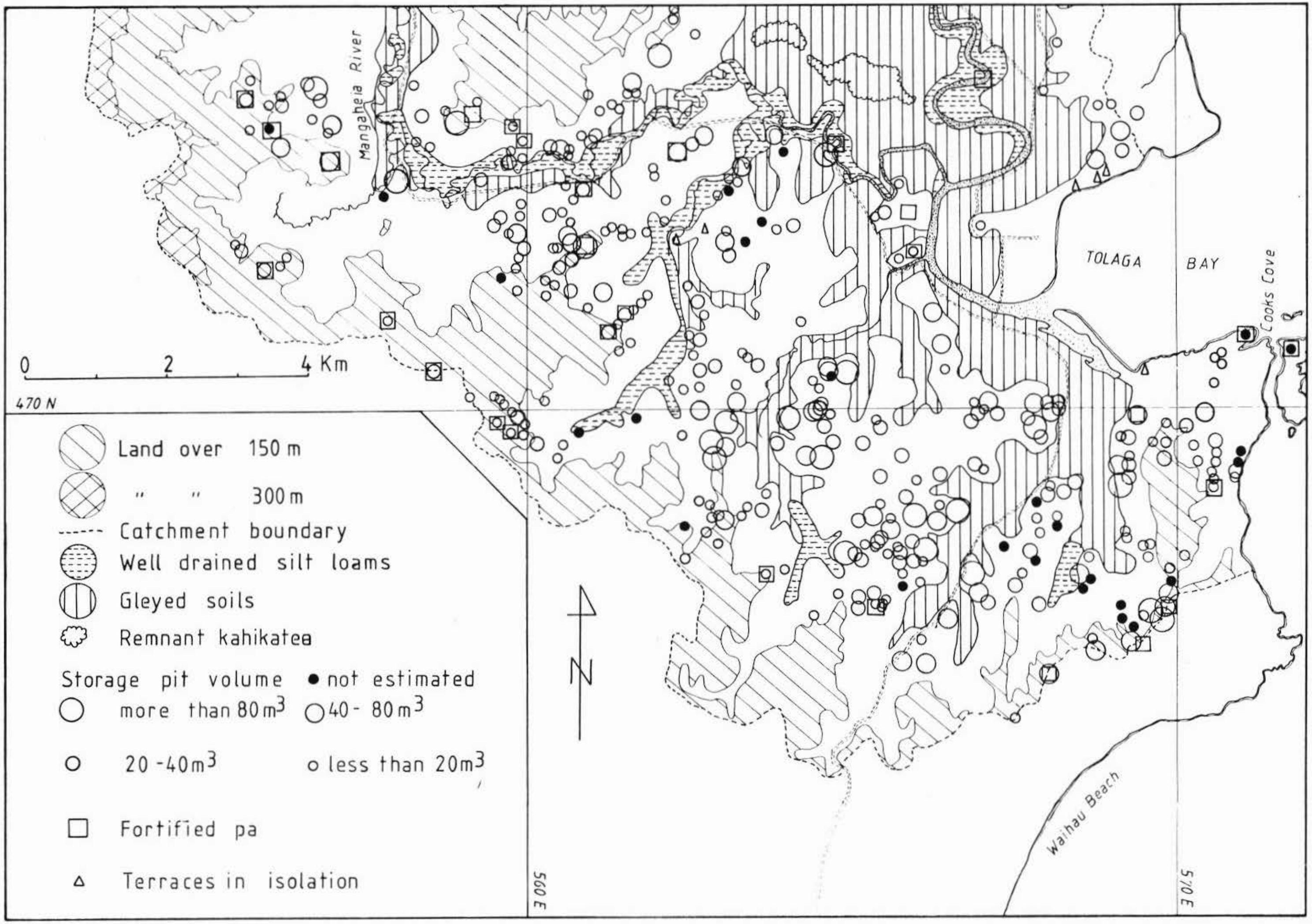
The available radiocarbon dates for occupation of the Mangaheia Valley (Table 2) indicate that the earliest use of alluvium must have been on the Waihirere soils, which are extensive in the vicinity of the pa and pits from which the dates are derived.

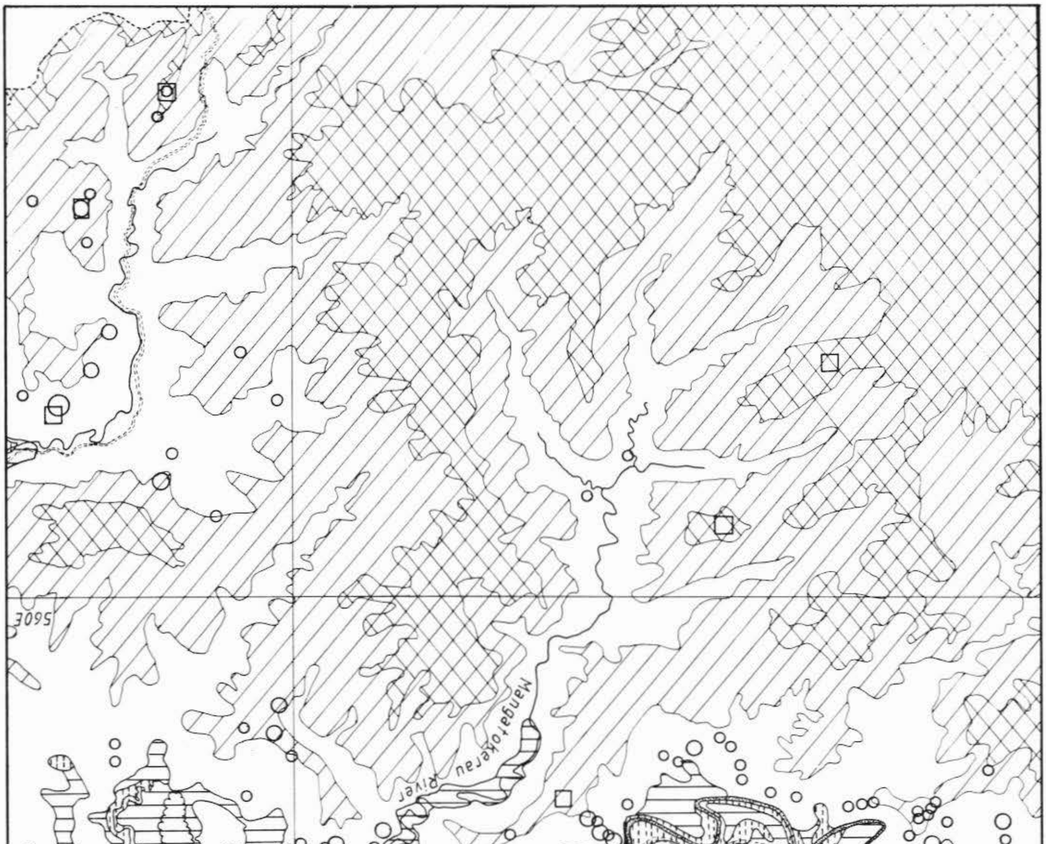
The dates are also consistent with human fire-induced erosion leading to the build-up and formation of the Matawhero soils. However, the demonstrations of New Zealand-wide burning by Polynesians (McGlone 1980), for Tolaga Bay at least, must be matched against the probability that the Uawa flats had only been completely infilled a short time before Polynesian arrival in New Zealand. The East Coast region has been demonstrated to have extreme instability of slope soils, and corresponding rapid deposition of colluvial and alluvial soils (Green and Pullar 1960; Wellman 1962; Pullar and Rijkse 1977). Therefore, the sudden availability of a set of alluvial soils not long after the generally accepted dated human arrival in New Zealand in about A.D. 900, in Tolaga Bay at least, has to be considered coincidental. This contrasts with the apparent situation in many Pacific contexts, e.g., Aneityum (Spriggs 1982), where formation of alluvium followed human occupation and is postulated to have altered the settlement pattern.

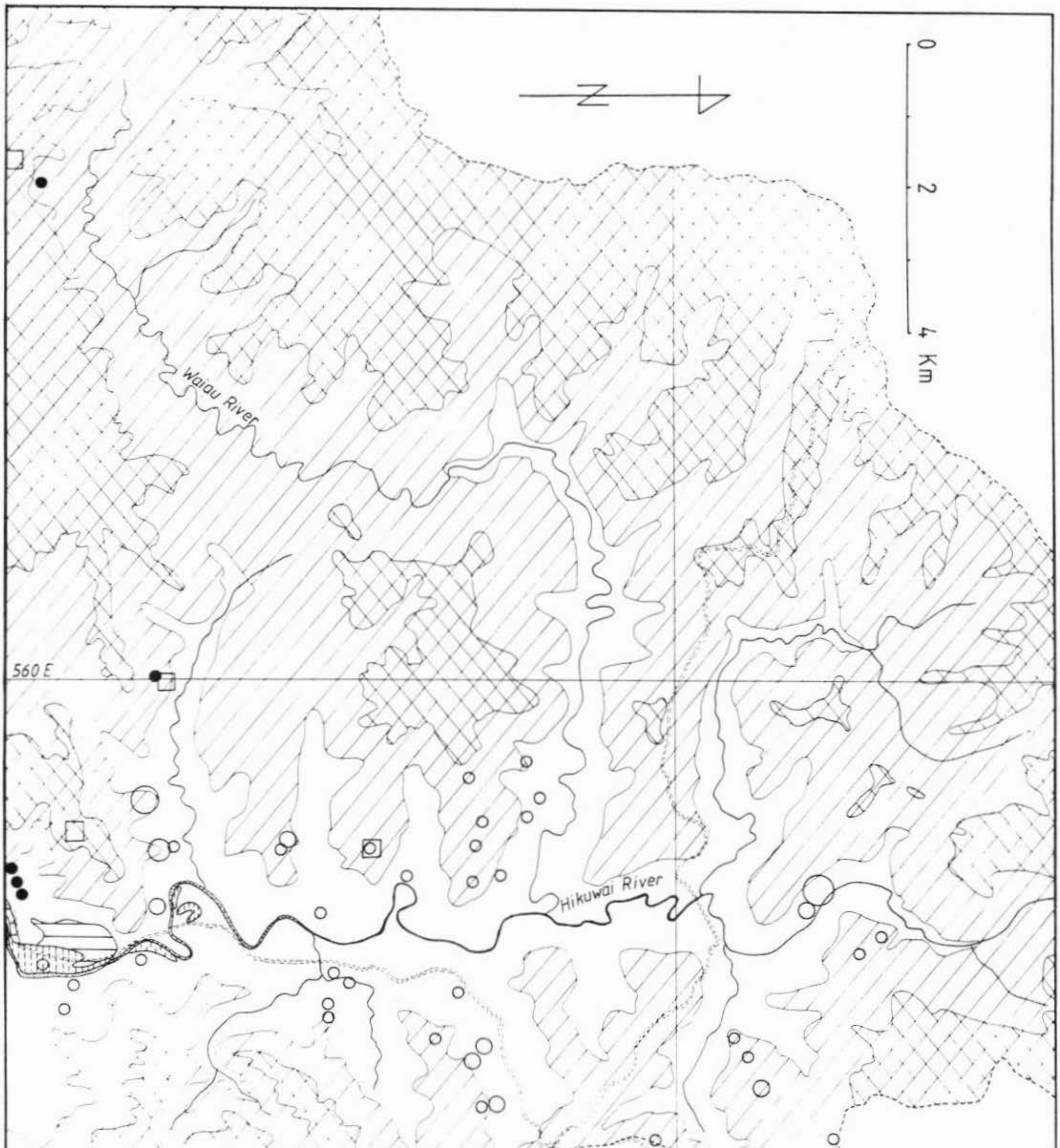
LOWER WHAKATANE CATCHMENT (Figs 2, 4)

The higher valley margins (above 250 m a.s.l.) are formed along fault lines in the underlying greywacke and argillite (Fig. 4). Dissected terrace landforms of medium height (80 m a.s.l.) of the marine sedimentary Wanganui series (New Zealand Geological Survey n.d.) occur in a number of places, principally on the western margin of the Whakatane Valley from Taneatua to Ruatoki, and on the eastern margin south of Taneatua and the Waimana Gorge debouchment. In the Waimana Plains, a similar sedimentary landform occupies the centre of the plain, cut by the river to the east, and again at the upstream entrance of the Waimana Gorge. These landforms are referred to subsequently as the "greywacke" and "sedimentary terrace" landforms.

Figure 3: (following pages): Topography, pit volumes and pa, in relation to alluvial soils in the Uawa catchment.


Mangaheia River
TOLAGA BAY
Cooks Cove
Waihau Beach
0 2 4 Km
470 N
560 E
570 E
Land over 150 m
" " 300 m
Catchment boundary
Well drained silt loams
Gleyed soils
Remnant kahikatea
Storage pit volume
• not estimated
more than 80 m3
40 - 80 m3
20 - 40 m3
less than 20 m3
Fortified pa
Terraces in isolation
N


Mangatokerau River
Hikuwai River
Mangatuna
Uawa River
KAIAUA BAY
ANAURA BAY
480 N
490 N
560E
570E


0
2
4 Km
Waiau River
Hikuwai River
State Highway
Redoubt
560 E
570 E
TOKOMARU
BAY
500N
490N

Soils on the "greywacke" landforms are characterised as Urewera steepland soils (Rijkse, pers. comm.). On the "sedimentary terrace" landforms, the soils are Whakatane hill soils (Pullar 1978). The landform terms are retained in this account, since it is the climatic and tactical advantages of these landforms that provide the element sought by Maori society. All the older landforms are mantled by tephra, with greatest depths on the older landforms of easy contour (i.e., the "sedimentary terrace" landforms).

The section of the Whakatane River described here is to some extent downgrading, leaving a terrace system, and a broad flood plain. There are many valley-side fans, and the river terraces have been dated by analysis of their tephra cover as being earlier than any possible human occupation (Pullar *et al.* 1967). Strips of land along the edges of the higher terraces are naturally well drained and free from flooding. These "Opouriao soils", well drained, fine sandy loams, are also extensive on the massive fans formed at the debouchment of the three principal gorges of the study area (Fig. 4).

The broad flood plain around the river course is the result of aggradation from increased sediment loads in the last hundred years or so. There are large areas of poorly drained soils and swamps on the valley margins and in the adjacent valleys where there is little sedimentation.

PREHISTORIC VEGETATION

The eighteenth century records indicate extensive "forests" on the East Coast of the North Island. With specific reference to Tolaga Bay, Banks (1962: 3) referred to an "immense quantity of woodland" while Cook noted,

> I went upon some of the Hills in order to view the Country, but when I came there I could see but very little of it, the sight being interrupted by still higher hills; the tops and ridges of the hills are for the most part barren, at least little grows on them but fern. But, the Vallies and sides of many of the Hills were luxuriously clothed with Woods and Verdure and little Plantations of the Natives lying dispers'd up and down the Country. (Cook 1955: 186)

Landsnail assemblages for sites at the entrance to Tolaga Bay confirm this forested condition for lowland sites, other than the major river valleys. Cook's "barren" ridges suggest a pattern of regular firing, presumably with considerable areas of the pyrophyte, manuka (*Leptospermum ericoides*), that would have been interpreted as "forest" (as opposed to grassland). Otherwise the forest would have been mixed podocarp and hardwoods (Jones 1983a: 9–10).

On swamp soils in both Tolaga Bay and the Whakatane Valley, kahikatea (*Dacrycarpus dacrydioides*) stands still survive, while on the well drained soils a mixture of podocarp forest and manuka would have occurred, mainly manuka in the Whakatane Valley. In the late nineteenth century, there was a substantial area of forest on the higher graywacke landforms of the Whakatane Valley. Landsnail assemblages suggest clearings and regularly burned ridge tops with fern (*Pteridium esculentum*) widespread.

CLIMATE

Mean annual temperature is 13 degrees C and both areas have rainfalls of 1000–1600 mm p.a., rising in the hill country (McLintock 1950). Both study areas are in the Iwitini geographical region, the most populous and horticulturally favoured region of temperate New Zealand (Green 1975).

For Polynesians, the key to horticultural success in inland areas in this climate lay in controlling the effects of radiation frosts in the marginal early spring and late autumn.

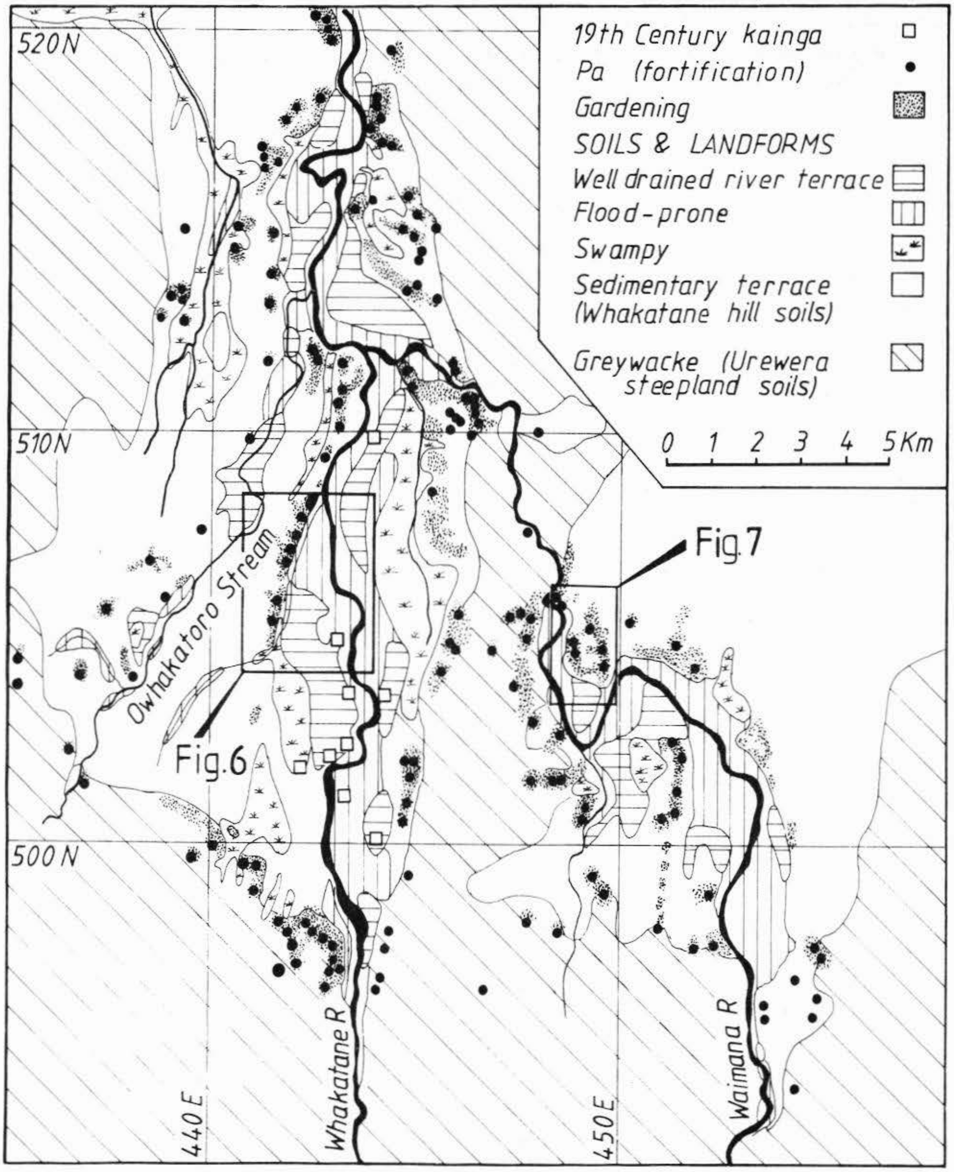


Figure 4: Gardened areas, nineteenth century *kainga* (after Best 1925), and pa, in relation to soil types in the Whakatane Valley. Actual areas of gardening are somewhat enlarged and shown schematically.

A second factor of importance is the choice of soils that warm quickly out of the winter season. Topography, particularly ridges and mild slopes with a northern aspect, would therefore have a strong bearing on the micro-climates most suited to the Maori traditional crops.

The key difference between the two catchments, apart from the contrasts in exposure to gross climatic patterns such as rainfall and prevailing winds, is the altitude of the surrounding landforms and the distance from the sea. In the Whakatane Valley the dominant landforms rise quite sharply to 300 m a.s.l. or more compared with Tolaga Bay where dominant landforms are seldom more than 200 m a.s.l. The Whakatane Valley study area is some 15–20 km inland, compared with the Uawa flats which are no more than 5–10 km inland. These factors mean that the Whakatane study area is significantly more exposed to the risk of frost, especially on valley flat lands, as standard texts would indicate (Bush 1945: 26–46; New Zealand Meteorological Service n.d.).

TOLAGA BAY

Physical setting markedly affects microclimates and the areas suitable for kumara horticulture. A north-west föhn wind is common in summer, with day temperatures in the low thirties. Droughts are common in late summer.

Some elements of microclimate have a bearing on the types of crops that may be grown. It is generally recognised that ridges are less prone to frost than flats, especially in still conditions when cold air can settle. On the flats, experienced horticulturalists recognise a degree of warming from the river, extending up to 150 m on either side (Savidge pers. comm). Significant air movement also occurs at the debouchment of the Hikuwai River where it enters the upper Tolaga Bay flats, reducing the incidence of frosts.

WHAKATANE VALLEY

In the study area, climate extremes are more marked, with a risk of ground frost on river flats through a great part of the year (in November 1983, at least two frosts were recorded). Summer temperatures are relatively higher and winter temperatures relatively lower than on the coast (New Zealand Meteorological Service, 1978). Occasional very high rainfalls are recorded.

In both the Waimana and Whakatane valleys the river flats and terraces have a short frost-free season (New Zealand Meteorological Service 1981: 42). Areas relatively free of frost are those elevated above the valley floor; those subject to continuous slight air movement, particularly out of the Urewera gorges; or those hill soils with an elevated northerly aspect. These essential horticultural requirements are met by the greywacke and sedimentary terrace landforms, but not by the river terraces except at gorge entrances with a northerly aspect, particularly at Taneatua and Ruatoki.

SURVEY METHODS

The Whakatane Valley and Waimana Plains had been surveyed, largely by observation of pa that are landscape features (Mabon *et al.* 1964: 29–33; Groube 1970; Fox 1976: 10; Pierce 1981; Jones 1983b: 165–173). Much related field evidence, such as terraces or storage pits outside the pa, had remained unrecorded. Surveys in Tolaga Bay had been minimal (Connor 1980; Jones 1983a). Fieldwork in both areas involved a combination of checking the locations of existing records, and walking ridges in areas deemed likely to have sites. Where an area was found to have sites it was more closely examined. Areas deemed without sites were checked by quickly walked traverses and stereo examination of air photographs at 1:25,000 scale. A fuller account of the Uawa survey methods is in Jones (1982).

Areas with known sites but not covered in the Whakatane survey were the south-eastern greywacke landforms of both the Opouriao Plains (Whakatane Valley) and the Waimana Plains. Mapping for these areas shows only existing records.

River terrace edges were walked in selected vicinities in the Whakatane Valley and exhaustively covered in Tolaga Bay. In many localities, these were near significant concentrations of pa in adjacent landforms. Any available sections in drainage ditches or from road cuttings in archaeologically significant areas were closely examined for shell for dating and environmental interpretation, and for evidence of soil cultivation. In general, the survey methods would tend to under-represent the importance of ploughed flatlands.

EVIDENCE OF HORTICULTURE

Indirect evidence of horticulture includes storage pits and climatic and edaphic suitability. Direct evidence includes disturbance of soil profiles.

The kumara storage pit is one of the commonest site types in New Zealand and occurs in two basic kinds: the roofed rectangular pit, and the underground cave pit. It is essential for over-wintering of the crop. In areas with a harder substrate, such as Tolaga Bay, the rectangular pit (Fox 1974) is the more common type.

In this study three criteria were used to infer gardening activity.

1. Flattened ridge tops or terraces with pits scattered throughout, generally with a northern aspect, and occasional oven stones from earth ovens or other domestic activity.

2. Flat or terraced areas in which there was mixing of the topsoil from 15–30 cm into the subsoil, with clearly disturbed interfaces between the topsoil and subsoil.

3. Admixture of gravels in topsoils that could not be explained by past flooding by rapidly moving water.

The mixing of gravels into soils is well documented for Maori gardening practice in many parts of New Zealand (Challis 1976: 249–254; Walton 1982: 16–29) but it has not been defined in the eastern North Island region. No indication of widespread artificial admixture of gravels was found in the course of this survey in Tolaga Bay. This is not surprising since the region's geological structure has very few hard rocks in its make-up and the river courses have very little gravel. Very small areas of admixed gravels were detected in the Whakatane Valley, and must be distinguished from gravels deposited by very large floods which can cover the margins or even the high river-terrace Opouriao soils. No obvious discrete charcoal had been found in either the Waihirere or the Opouriao soils by Pullar (1980: 109). The presence of such charcoal would be positive evidence of Polynesian cultivation.

SURVEY RESULTS

Because of the great physical and soil contrasts between Tolaga Bay and the Whakatane Valley, the criteria used to identify gardening, and the manner in which this is mapped, differ markedly. The results of the survey are therefore separately discussed for each area.

TOLAGA BAY

Pits are an important indication of the extent of Maori horticulture in the catchment. Rectangular storage pits are the most common site type in Tolaga Bay. They usually occur on ridge crests, in lines end to end, or in clusters on knolls or terraces (Fig. 5). Rather than plot individual pits, calculations have been made for the volumes of pit storage per site (Jones 1983b). A discrete group of pits counts as a single site. This more accurately reflects the volume of crops stored, and hence the importance of the adjacent soils. In particular, the balance between levee soil usage and hill soil usage is of interest.

Total pit volume per site was calculated by summing the areas enclosed by the internal sides of the pits multiplied by an assumed constant depth of 1 m. This volume may be out by a factor of 1 or 2 in absolute terms, but will be a fair measure of the relative volumes of pit storage and is usually regarded as a key to the population supported on any one site (Law 1970; Jones 1983b; Fox 1983: 5–18).

High volumes of pit storage are associated with levee soils in the Mangaheia, upper Uawa and Hikuwai catchments (Fig. 3). Pits are considered to be clearly associated with levee soils if they are on south-facing slopes and/or near the river, or on knolls in the flats. This is most clearly demonstrated on the north side of the Mangaheia and at the point where the Hikuwai enters the Uawa flats. These south-facing, often steep slopes could not have been used for cultivating the crop. By extension, at least a proportion of pits on north-facing slopes will also have been used to store crops from levee soils, e.g., the pits adjacent to the pa on the south side of the Mangaheia, or on ridges running down into these flats (Fig. 5).

In the north of the catchment near the Hikuwai River and inland, pit frequency and total volumes peter out rapidly. Some pa occur in these areas without associated pits, although most do have pits. In these inland, higher areas the small pit groupings are usually in favoured, north-facing mid-slopes, and the crops would have been grown in slope gardens.

The rolling country in the south of the catchment also has high volumes of pit storage. Most of these slopes face north and are sheltered from cold southerly winds. There are no pits on the high catchment rim, except above Waihau beach where the catchment rim is low and where there is also a concentration of pa. No pa have been recognised in the midst of the rolling country in the south of Tolaga Bay, except on the edges of the settled area. These pits are probably late prehistoric, and represent the crop storage of the gardens noted in the eighteenth century as "little Plantations of the Natives lying dispers'd up and down the Country" (Cook 1955: 186). An image of the gardening style at Anaura Bay may be gained from Spoering (Lysaght 1979: 62) where in 1769 some 100–200 acres were estimated to be cultivated (Davidson 1981: 12).

WHAKATANE VALLEY

In contrast to Tolaga Bay, the central Bay of Plenty has heavy deposits of tephra. While the rectangular pit does occur, the subterranean bell-shaped pit, known as *rua* (Daniels *et al.* 1979: 29), is the type most frequently found. One reason for this is the relative ease of digging in younger tephras. The *rua* may also have been a desirable means of freeing surface space in circumscribed defended areas, since the rectangular pit occupies a much greater area.

In the Whakatane area, volume of rectangular pit storage is a relatively unreliable indicator of stored kumara, because of the frequency of *rua*, the volume of which cannot be so easily quantified. Intact open *rua* are rarely found (a hazard to stock and wandering archaeologists), and their presence is usually inferred from circular depressions, 1–2 m in diameter, in the ground surface. Many more *rua* probably exist for which there is no clear surface evidence. Because of the difficulty of estimating both volume and incidence of *rua* no reliable estimate of crop volumes can be made. However, it is possible to estimate the

Figure 5: Kumara storage pits (foreground) and middle section of Mangaheia River. The C14 dates cited in Table 2 (NZ 6570, 6571) come from sites in this section of the valley. Photograph: Kevin Jones.

areas of crops if the suitable soils are defined by topographical differences, either terraces or restricted areas on ridge or plateau tops (Fig. 4, 6).

Mixing of topsoils (criterion 2) was noted in two locations in the south of the Opouriao Plains. Areas in which gardening is inferred under criterion 1 are common on the surfaces of large areas of the sedimentary terrace landforms, with peak intensities at the top of scarps cut by the river into the sedimentary terrace landforms. Important large areas are the sedimentary terrace landforms in the central Waimana Plains, at both ends of the Waimana Gorge (Fig. 7), and on the western escarpment of the Opouriao Plains. Road cuttings in these terraces invariably show a considerable depth (greater than 50 cm) of mixed soils (criterion 2). The gardened areas are interspersed with frequent pa. Likewise, there are many pa and associated garden terraces on the north-facing foothills and the lower ends of ridges in the greywacke landforms. Some gardens are formed on natural higher river terraces and on mildly sloping ridges. Virtually all north-facing slopes are occupied, with particular concentrations near the main rivers and streams. This leads to the striking concentrations of pa and terraces visible as landscape features in the south of the Waimana and Opouriao Plains.

There are contrasts in archaeologically recognisable productivity between the differing landforms of the Whakatane Valley. In the Rewarau Road vicinity on the western escarpment of the valley (Fig. 6), six separate ring ditch pa are associated with a total of 16–20 ha of sedimentary terrace soils. Horticultural use of these soils is indicated by levelled or naturally level, terraced ridge tops with occasional rectangular storage pits or *rua* scattered throughout. In addition, there is a limited but poorly defined extent of modified soils on the immediately adjacent river terrace (Opouriao) soils. If a productivity of 5–10 tonnes/ha is allowed, each pa has on average a support base for 50–100 people—an acceptable rough estimate of the population occupying such pa.

On the eastern side of the valley, on the lower margins of the greywacke landforms, the apparent area of terraced soils is much more limited. N78/33, 53 and 55 has an artifically terraced area (interpreted as gardened) of 0.27 ha and is associated with two defended areas, one a substantial ring ditch pa. In this case, an argument for use of the alluvial silt loams (Opouriao soils) is strong—although such gardening has yet to be demonstrated. Similar relatively small areas of artificial terraces are associated with other large ring ditch pa in the greywacke landforms elsewhere in the valley.

The area of sedimentary terrace soils at the upstream entrance to the Waimana Gorge (Fig. 7) is 6 ha. This is associated with three definable pa, while the central ridge system itself has several transverse ditches and could be readily segmented for defence. Allowing the same productivity figures, a population of 100–200 people for the whole complex is possible.

There remains a significant ambiguity over the use of river terrace soils in the Whakatane Valley. Only a small area for which there is archaeological evidence of gardening has been identified on river terraces in the Whakatane Valley (Fig. 6). The known areas where gravels occur can generally be explained by probable flooding in the past. The reason for the small areas may be the result of climatic problems, particularly the short length of the frost-free season and the risk of frost throughout. The matter cannot be further discussed here, although nineteenth and early twentieth century *kainga* (undefended villages) on the river terraces are documented by Best (1927: maps).

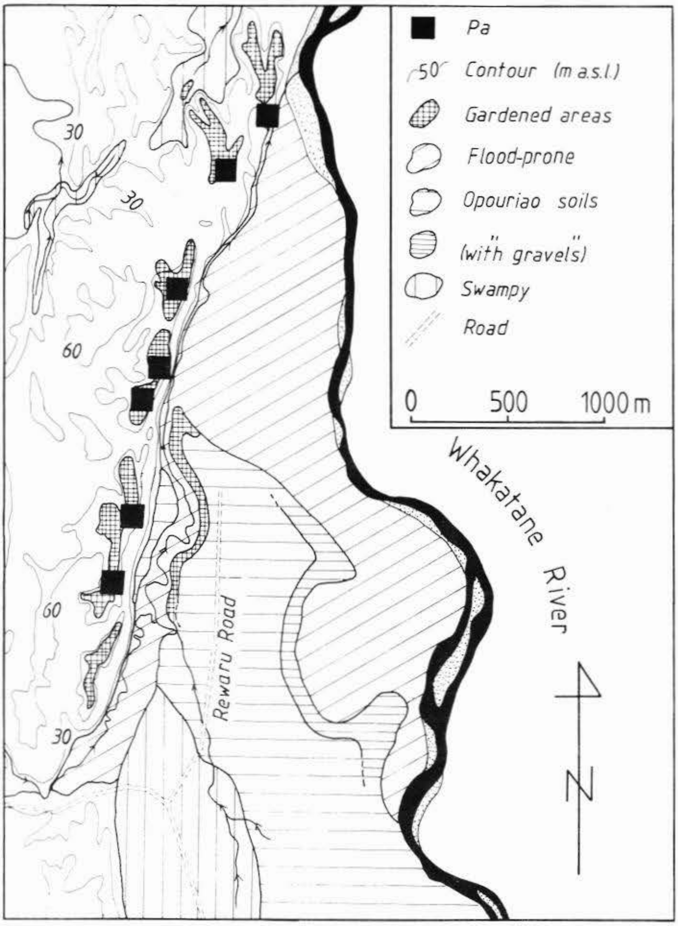


Figure 6: Transect of Whakatane Valley at Rewarau Road, showing gardened "sedimentary terrace" soils and pa, and adjacent small areas of upper river terrace soils (Opouriao soils) with admixed gravels.

INTERPRETATION OF SETTLEMENT AND GARDENING PRACTICE

The reasons for these distinctive and contrasting patterns of settlement and horticultural evidence warrant close discussion. Furthermore, the relatively close definition of either stored crops or areas of gardened soil should allow some inferences about population supported in these catchments.

The different methods applicable to each of the valley systems mean that estimates and comparisons of population cannot be readily made. The over-riding difficulty, however, is that of setting the settlement system in any one time plane, broad or narrowly defined. Nevertheless, there is an apparent close agreement between identified pit storage volumes in the Mangaheia Valley, part of the Uawa Catchment, and the availability of levee soils there. Such enticing agreement cannot be struck so readily in the Whakatane Valley, except in some locations.

The question of a central place or places (Irwin 1974; Steponaitis 1981) is not the prime concern of this paper. However, it is suggested that the availability of river transport, with its advantage of low effort (Drennan 1983), will be both a key determinant of central places as well as the prime reason for the linear distribution of settlement along rivers defined in this paper (Figs 3, 4). It should be noted in passing that the bulk of traditional and nineteenth century evidence points to central places about 1 km up from the mouth of the Uawa River, at the intersection of the Mangaheia, Waimaunu and Uawa Rivers (Jones 1983c: 18–20). Detailed discussion of this issue will have to await other papers.

While the pa (fortified living area) may be treated as an artefact of defensive technology, and is mainly recorded as such—a large earthwork artefact—it is really the most obvious part of a less readily defined complex of activities such as gardening, access to rivers for transport, etc. Taken within its immediate vicinity, pa location appears to be largely determined by the greatest defensive tactical advantage, rather than settlement advantages. Nevertheless, most pa have related garden areas which follow the configuration of soils and microclimates suitable for the Maori crops. The pa itself may provide an area for the defence of stored crops as well as the population, and is a key to the relationship between settlement and gardening practice.

TOLAGA BAY

There is a major concentration of pa in the Mangaheia Valley (Fig. 3). The dates of between A.D. 1230 and 1410 for the Mangaheia Valley, and A.D. 1300–1410 for hill gardening in the upper Uawa vicinity (Table 2), indicate relatively early occupation of alluvial soils, particularly the Waihirere soils. The area of these soils in the Uawa catchment is some 260 ha (Rijkse and Pullar 1978: 64), with the later-forming Matawhero soils, some 370 ha in area, becoming stable and usable from about A.D. 1500. The extent to which these soils were used, and the population size that would have fully occupied them is a matter of some interest. If we accept a usage-to-follow ratio as low as 1:3, areas of about 90 ha were available up to A.D. 1500 and 220 ha from then. Using a figure for annual production of 5 tonnes per ha for sweet potato and an annual consumption of 250 kg per person, these cropping areas allow for populations of 1,800 before A.D. 1500 (based solely on Waihirere soils) and 4,400 after about A.D. 1500. If fallow ratios are increased to 1:7, the figures become 800 and 1800 respectively for the Uawa catchment. The latter figures compare well with the maximum population estimated by Williams (1974: 75, 101, 103) in 1840 of 1200. Methods for determining prehistoric population are still being explored.

Narrowing the focus to the Mangaheia River valley, the total area of well-drained silt loams available after A.D. 1500 is 270 ha. This is associated with about 1800 m^3 of pit storage, estimated to reflect 900 tonnes of stored kumara (cf. Law 1970; Jones 1983a). Allowing for a much smaller proportion of the total available soils and pit volumes to be in use in any one season, these figures are still in fair agreement and warrant much closer modelling than the scope of this paper allows. They are nevertheless persuasive measures of the adequacy of the survey results presented here.

How did this alluvial gardening on levees relate to the southern hill gardening noted by Cook in 1769? The gardening identified in 1769 as the "little Plantations of the Natives lying dispers'd up and down the Country" (Cook 1955: 186) was undoubtedly in the rolling hill country in the south of Tolaga Bay. Both the Mangaheia and the Uawa flats are obscured from vantage points in the Cook's Cove vicinity, and there are no records of *Endeavour* observers travelling up the river, as they did at Thames. We can safely assume, however, that there was gardening of the Mangaheia and Uawa flats in 1769. So, by A.D. 1300 (see Table 2) gardening was undertaken in the Mangaheia Valley, and in 1769 it was established both on the flats and in the rolling hill country in the south of the bay. Did these two practices begin at the same time? Or did the hill gardening follow the gardening on the silt alluvium? The question cannot at present be answered, but it holds the key to a consideration of horticultural intensification in the Uawa catchment. If hill gardening occurred after alluvial gardening, then we are dealing not with *in*tensification but *ex*tensification, and our account and theories of settlement have to recognise that fact. These hill sites are probably best interpreted as part of the valley settlement system. In particular, there are relatively few pa in the southern hills, except on the catchment boundary, and on the inland edge of permanent forest. Small numbers of terraces are commonly associated with these pit sites (not separately mapped in Fig. 3). These southern sites most clearly suggest a hamlet style of settlement (Jones 1983a) perhaps because of the wide extent of suitable hill soils usable under a swidden regime. The hamlets could have had the function of seasonal gardening and winter crop storage, linked with larger nucleated settlement near the major river system.

The reason for this pattern could be to spread risks from a number of sources, particularly crop failure due to frost or flooding. Waddell's (1975: 257–259) description of the planting patterns of the Enga in the New Guinea Highlands holds some interest. The Enga planted sweet potato both in the valley floors, in mounds to avoid ground frost, and in subsidiary gardens on hill slopes. The co-existence of simple hill fallowing and relatively intensive valley-floor horticulture has also been noted by Brookfield (1984: 23).

Further consideration should also be given to one of the important difficulties facing any settlement pattern study—the virtual impossibility of deciding on the duration of any particular occupation. This is crucial when considering the importance of pit storage. Pits next to good alluvial soils could have long if intermittent duration of use, say 10–100 years; while pits used in a hill gardening regime might only be used once for 2–3 years and never used again. Although this study can demonstrate relatively greater volumes of pit storage adjacent to alluvium, a better understanding of duration of use could indicate even greater importance for such pit storage. Some modelling of duration of pit storage is envisaged for a future study of population in the Uawa catchment.

Social factors, particularly rivalry between relatively small kin groups, could also have a bearing on this dispersed hill settlement pattern.

TOLAGA BAY IN THE NINETEENTH CENTURY

Some mention can usefully be made of the nineteen century observations which followed the adoption of North American-sourced crops such as maize and white potato.

On April 14 1839 Richard Taylor passed through the Hikuwai and the Uawa flats. Speaking of the lower Hikuwai or upper Uawa, probably in the vicinity of present-day Mangatuna, he noted:

> The people residing in this place belong to the pa near the sea to which they only retire in time of war for defense, at other times attending to the cultivation of the ground thus in time of peace comparatively speaking few reside in the pas, being spread about wherever there is a fertile spot of ground. I note a curious way of speaking respecting these pas situated in valleys thus the one near the sea is termed the pa *outside* whilst the one up the vale is called the pa inside. (Taylor 1838–44: 139)

This passage clearly suggests both the hamlet style of gardening practice and a spread of pa within a defined territory. Unfortunately, although the location of Taylor's people can be identified, the reference to the pa outside by the sea could be either a reference to pa at the mouth of the Uawa or to pa directly across the hills eastwards to the coast. If the latter, then this is a clear indication of a strip of territory taking in the coast and the inland valley alluvium. Yet no pa are to be found between the Hikuwai alluvium and the coast, whereas there are numerous pa down the length of the Uawa to the sea. The strip of levee soils along the Uawa River between the Hikuwai River and the sea is therefore preferred as an interpretation.

The nineteenth century accounts must be handled with some caution, however, since gardening on the flats on a large scale was also noted by Taylor (1838–44: 136–138). These gardens were also in the lower Hikuwai or Upper Uawa flats. Taylor noted that 3000 bushels (about 80 tonnes) of maize were sold to Turanganui (Gisborne), which gives an idea of scale. The names of many pa or *kainga* on the Uawa flats are recorded on a survey map (ML431, 1867, Department of Lands and Survey, Gisborne) although it is not clear what status these pa have. They are unlikely to be a contemporary record of existing pa in 1867, and are more likely to be a traditional record reflecting claims to land by various kin groups.

The value of these lands in the upper flats was readily recognised by all missionary observers. Baker, resident at the Uawa River mouth, notes:

> Went up the river to see the Nga te Wakamara who have commenced a cultivation on the banks of the river. Ever since I have been here I have pressed upon the people the importance of their cultivating the interior instead of confining themselves to the very inferior land found at the seaside—they have at length made a move. (Baker Journal, July 31, 1845)

The nineteenth century accounts therefore indicate mixed usage of soils and contrasting patterns of settlement. The use of river levee soils does indicate greater linear concentrations of population. Maori interest perhaps lay more in having the hill country close by the levee soils as in the Mangaheia, Hikuwai or Upper Uawa. This meant that the hill country was readily available for defence in earthworks or naturally steep places, for hunting, gathering, and for gardening (Fig. 8a). The striplike territories on the levee silt loams would encompass these zones and include the sea as well. It is significant that greater areas of the levee soils occur in the places where the rivers enter the hill country.

WHAKATANE VALLEY

Pa occur mainly on the lower margins but seldom on top of the greywacke landforms which provide the dominant landscape element of the study area. On the relatively small areas of tephra-mantled sedimentary terrace landforms, there is a very heavy linear concentration of pa and gardened areas, especially but not exclusively on the river-cut scarps which offered ease of access to the river, tactical advantages, and a warmer climate with lower incidence of frost (Fig. 8). There is a very strong concentration of pa at the entrances of the Waimana and Whakatane gorges on the southern boundary of the study area.

Associated with the pa are storage pits and modified soils. In the greywacke landform, the pits and gardens are on ridge tops or are cut down the adjacent ridges toward the valley floors. On the sedimentary terraces, the gardening is on the narrow and near-level surface forming the ridges of the dissected sediments (Fig. 6). The steep access to these garden areas would have been a defensive advantage, but essentially the gardens are so located for the soil and climate. Fig. 7 shows pa, terraces and pits at the upstream entrance of the Waimana Gorge.

While there is only limited evidence of prehistoric gardening areas on the river terrace landforms, forming the now heavily cultivated valley floor, there is evidence for the use of the valley floor river terraces in the nineteenth century (Best 1925).

These villages are on the borders of the Opouriao soils (well drained, fine sandy loams) as mapped in recent soil surveys (Rijkse, pers. comm.) and would have been using a mix of European-introduced and traditional Maori crops.

The key determinants of gardening would be the availability of warmer, frost-free, well drained, friable soils. In the study area, these conditions occur on the lower margins of the greywacke and on the sedimentary terrace landforms, but apparently not on the river terraces. The sedimentary terraces are used in all locations with good river access. The greywacke forms are settled mainly in the south, providing usable and used north-facing slopes at the lower heights.

The reasons for the clear linear concentration of pa and gardening relate to river access and the potential for gardening. Few pa are more than 2 km from the present course of rivers or streams, and pa do not occur in the areas where stream or river access is poorest, e.g., in the south-western part of the Whakatane valley (south of the area of Fig. 6), or the north-eastern part of the Waimana Plains. The topography away from the river-cut scarps may also have offered less tactically desirable locations, since it is significantly lacking in steep-sided hill forms.

Because of the relative tribal complexity in the Whakatane Valley, the fluid dividing ground between the Tuhoe and Ngati Awa tribes, central places will be less easy to define. The substantial concentrations of pa in the elevated country at gorge entrances have already been noted.

CONCLUSIONS

A superficial examination of the settlement and horticultural patterns in the Uawa and Whakatane valleys misleadingly suggests a close similarity between the two. In both cases, settlement is markedly linear and follows the course of the river. However, only the Uawa settlement pattern results from the use of the river levees for gardening, and use of the flanks of the valley for defence and storage in those areas where there is little or no intervening backswamp. There is also dispersed hill settlement, probably linked with the river settlements. Figure 8 shows schematic sections of the two study areas with the functions of the various topographic zones.

In the Whakatane and Waimana cases, the valley floors appear to have been little used for gardening, probably because of the limited frost-free season. The adjacent, dissected sedimentary terrace landforms are the most important locations of gardening, because of the heavy tephra mantle on elevated landforms with the frost-free micro-climate. Pa are often located close to the river-cut scarp principally for tactical reasons, and this leads to a clearly defined, linear pattern of settlement.

In the south of both the Tolaga Bay and Whakatane catchment there are notably high densities of settlement which depend on the availability of physically suitable soils and the climatic advantages arising from greater shelter from winds and better aspect in relation to sunshine. Access to the sea would have been important in the Uawa catchment in the south.

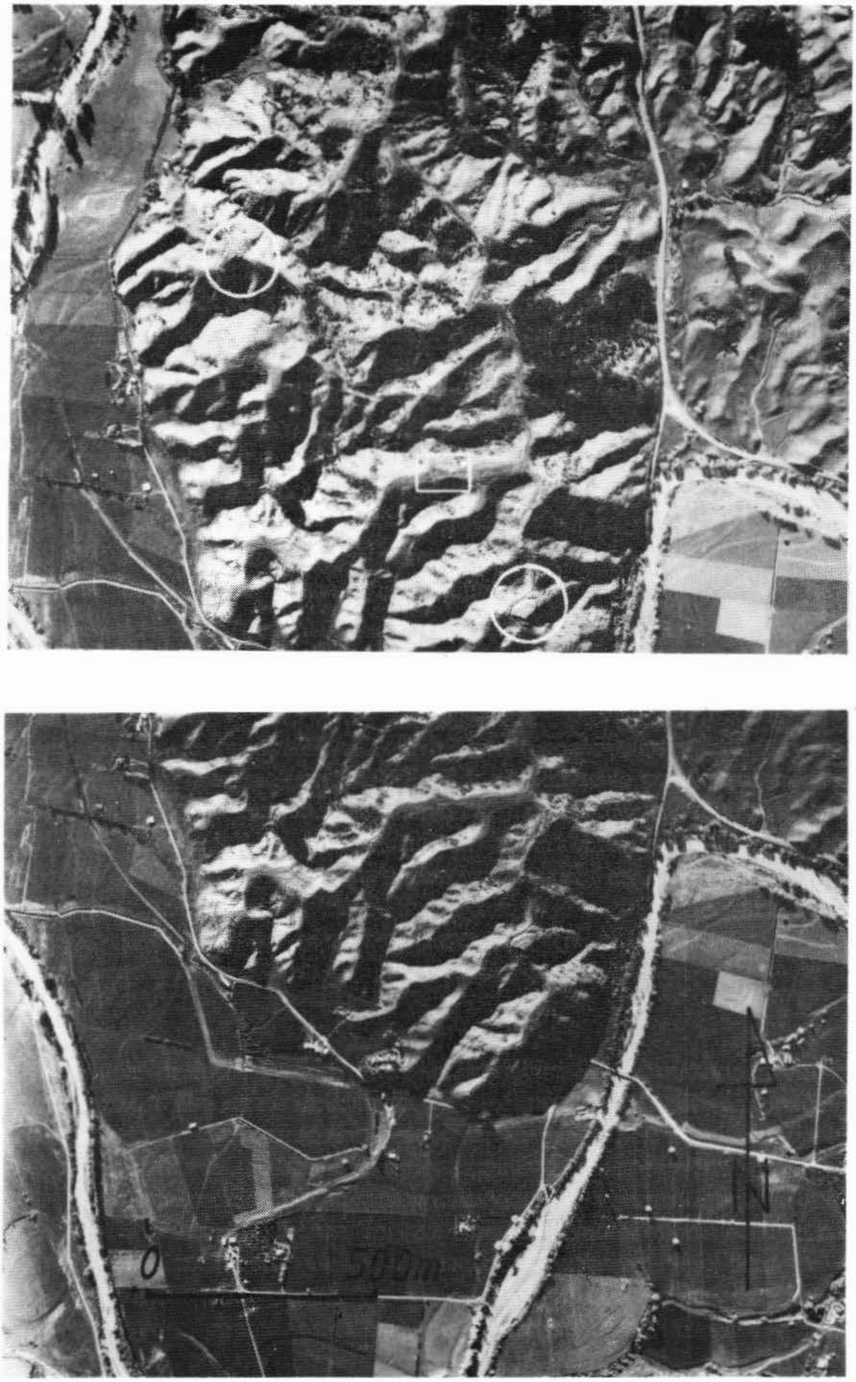


Figure 7: Vertical aerial photograph of "sedimentary terrace" landforms at upstream entrance to Waimana Gorge. Two pa are circled, and some obvious kumara storage pits are enclosed in a square. Virtually all of the ridge surfaces have been gardened, except at the top and right. The two photographs form a stereo pair.

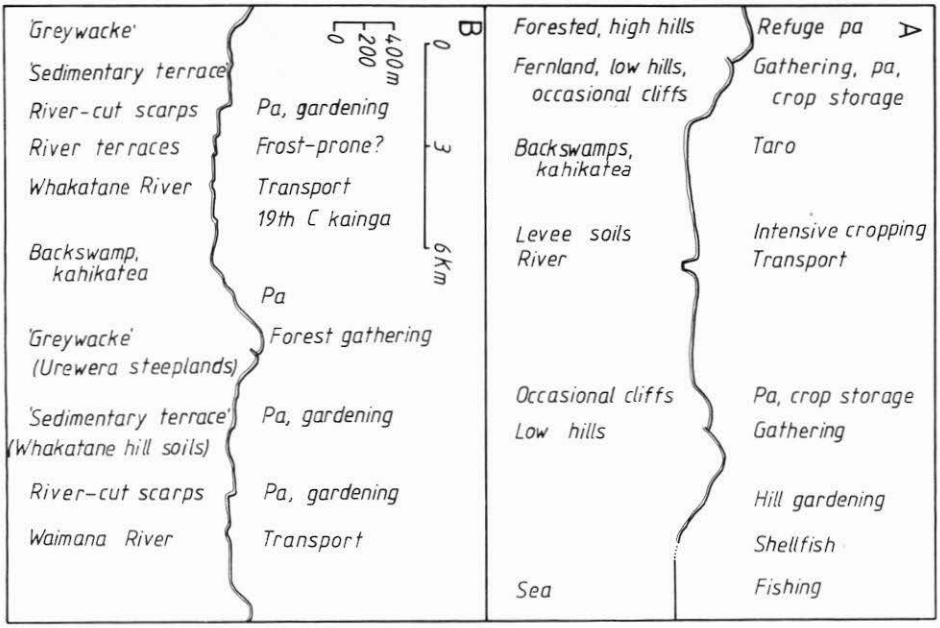


Figure 8: Schematic cross section of (a) Uawa Valley, and (b) Waimana and Whakatane Valleys, showing broad functions of topographic zones.

In the Waimana and Whakatane Valleys, access to the river and north-facing slopes led to a concentration near gorge entrances.

In general, the key determinants of settlement are:

1. accessibility to rivers and sea;
2. availability of light, sandy soils, well drained, with suitable frost-free climate;
3. that given the relatively small areas of cultivation involved, microclimates could be found in a range of hill landforms of northerly aspect, as well as flat river terraces.

The considerable diversity of soil locations and conditions in which the principal crop, sweet potato, was grown undoubtedly results from its relatively low fertility demands. Like the other important semi-cultivated staple, fern root, both would thrive in light soils, with suitable climates, and in areas where fire was a continuing method of land clearance. With the introduction of fertility-demanding crops such as maize, pumpkin and white potato, there may have been a shift in emphasis on to naturally fertile alluvial soils. In locations where such soils were free of frost during the growing season, such as Tolaga Bay, the change in overall settlement pattern need not have been a major one. Nevertheless, the reduction in population caused by introduced diseases, and changes in trading demand, would have led to large fluctuations in the actual use of such land.

Such fluctuations may have also occurred in the prehistoric period. The alluvial soils in the Mangaheia Valley were in use from A.D. 1200 and there is as yet no evidence for intensification of use in the succeeding centuries.

The prospects for deriving population sizes for the prehistoric period, and comparing these with the nineteenth century missionary accounts are good. In Tolaga Bay, methods of modelling pit storage volume, particularly the duration of pit use, need to be developed. In the Whakatane and Waimana areas, pit storage will be less useful and inferences will need to be based on actual areas of defended settlement and gardening.

ACKNOWLEDGEMENTS

I thank A. Walton for some characteristically forthright comments on earlier drafts. For assistance with fieldwork, I thank K. Gillies, R. Sheppard, A. Nowakowski, M. Hurst and A. Walton. Tasman Forestry Ltd, Hikurangi Forest Farms Ltd, and P. F. Olsen Ltd, were important and valuable contacts in afforestation.

A number of Maori authorities took an interest in the progress of the work, and I would especially acknowledge the Hauiti Incorporation, Parekura Horomia, and the Western Tuhoe Advisory Committee.

I am indebted to K. W. Moore for his long-standing interest in and records of pa in the Bay of Plenty, and W. Rijkse, N.Z. Soil Bureau, for published and unpublished soil data.

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Received 1 November 1984