

Estuarine Development and Human Occupation at Bobundara Swamp, Tilba Tilba, New South Wales, Australia

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INTRODUCTION

In Australia little direct information about past human activity has been obtained from wetlands, but they are a valuable archive of change through time against which the archaeological record from middens and rock shelters can be compared. The constant movement of small bands of hunter-gatherers has meant that there is little sign of intensive occupation, and the use of wetlands lay in their attraction as sources of water, plant foods and water birds, for which little archaeological trace can be expected. Moreover, since Australia is generally warm and dry, peat accumulations are rare and often oxidised, leading to poor preservation of features and artefacts. One exception to this, however, was the discovery of boomerangs and digging sticks preserved by peat in South Australia (Luebbers 1975).

The infilled estuaries and barrier-dammed swamps of the relatively humid southern coast of New South Wales and eastern Victoria include many significant peatlands. The continental shelf of southeastern Australia is narrow and stream valleys are incised well below modern sea-level (Chapman *et al.* 1982). The coast of southern New South Wales has a poor sediment supply and consists of quartz sand beaches and low cliffed headlands. There is a microtidal regime that maintains stable water tables so that the lakes and swamps have persisted since the early Holocene. There are few large streams on this coast and open river estuaries are rare. Instead there is a spectrum of sand barrier-impounded saline lakes through to freshwater swamps behind beach ridges or dunes. In many areas the swamps provide the only access to freshwater at the coast, the streams feeding them being some kilometres inland.

This paper reports on a combined archaeological survey and study of vegetation history from Bobundara Swamp, a major coastal peatland (Fig. 21.1). The swamp basin sediments have been dated and analysed to provide the chronology of local environmental change to set against the archaeology. A preliminary analysis of an offshore section (Narooma 3b) provides a more general history of environmental change in the area after 14,000 BP.

THE TILBA TILBA AREA

Bobundara Swamp occurs in the Tilba Tilba area which is midway between the Narooma and Bermagui

townships at 36° 25'S, 150° 06'E. An unusual Mesozoic eruptive centre, Mount Dromedary (797 m), the highest mountain in the area, dominates the region, lying only 5 km from the sea. Tilba is an Aboriginal word meaning windy, and the mountain does induce a high wind regime when compared with the undulating coastal plain to the north and south. The andesitic flows from the mountain extend to the sea and there are essexite, banatite and monzonite igneous rocks and Ordovician quartzites, graywacke and shales forming low headlands.

In this area there are few deposits of pre-Holocene sand. After sea-level rise around 6000 BP, beach ridges infilled old embayments with siliceous sand, and relatively active progradation occurred from 6–4000 BP. This is believed to be due to onshore movement of a sand reservoir (Chapman *et al.* 1982, Thom and Roy 1985) which eventually became ex-

hausted. After this time long beaches formed between the headlands, and low dunes then built behind them. Relative stability is indicated by a low carbonate content and a widespread humic soil, about 0.30 m deep, on these dunes. In many places coastal retreat and dune disturbance can be seen in truncated soil sections, sometimes buried beneath more recent sand. The dunes and beach barriers also enclose saline lakes, saltmarshes and freshwater swamps.

The climate is maritime and relatively humid, with an annual precipitation of 998 mm and a slight summer maximum, but the variability is high and evaporation is roughly equal to precipitation. Temperatures average 19.4 °C in summer and 10.1 °C in winter, when light frosts are common. The sea temperatures can be quite variable due to the incursion of cold southern water when westerly winds force the warm northern current to peel off into the Tasman Sea.

The pre-European vegetation is principally a mosaic of diverse forests dominated by different species of eucalypts (Keith and Bedward 1999), with increasingly closed canopies in shaded gullies where there occur a range of warm temperate rainforest elements, climbers and ferns such as lilly pilly (*Eugenia smithii*), *Pittosporum undulatum*, *Elaeocarpus reticulatus*, cabbage tree palm (*Livistona australis*), blackwood (*Acacia melanoxylon*), *Polyscias* and rough tree fern (*Cyathea australis*). Above 500 m on Mt Dromedary is a closed forest of plumwood (*Eucryphia moorei*), black sassafras (*Doryphora sassafras*) and coachwood (*Ceratopetalum apetalum*). On the coastal headlands the forest was dominated by potted gum (*Eucalyptus maculata*) and silver top ash (*E. seiberi*), with a seaward woodland of coast mahogany (*E. botryoides*), sheoke (*Casuarina glauca*) and swamp paperbark (*Melaleuca ericifolia*). On the dunes, woodlands of *Banksia integrifolia* and *E. botryoides* occur behind shrublands of *Acacia longifolia*, *Leptospermum*

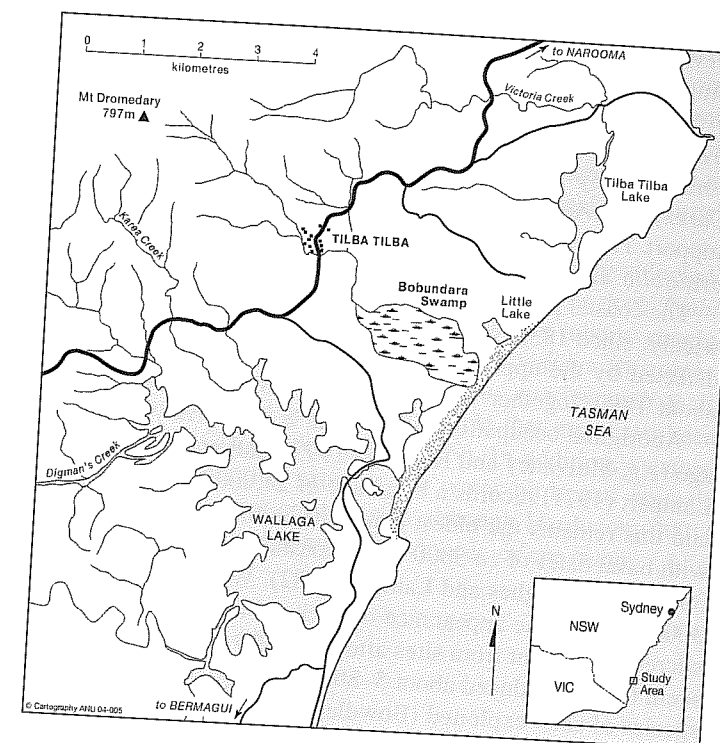


Fig. 21.1 The Tilba Tilba area.

laevigatum and *Leucopogon australis*, and grasslands of *Spinifex sericea* and *Austrofestuca littoralis* fringing the beach.

Wetlands include saltmarsh dominated by samphire (*Sarcocornia quinquefolia*) and sea rush (*Juncus kraussii* ssp. *Australiensis*), with the sedges *Baumea juncea* and *Isolepis nodosa*. Freshwater swamps are dominated by the tall aquatic grass *Phragmites australis*, bullrushes (*Typha domingensis*), the sedges *Carex*, *Cyperus*, *Eleocharis* and *Isolepis* species and ribbon weed (*Triglochin striatum*). Aquatic habitats support *Triglochin procerum*, *Myriophyllum* spp., *Ranunculus inundatus* and water lilies such as *Ottelia ovalifolia* and *Nymphoides crenata*.

The coastal plains have been partly cleared, particularly on the volcanic soils, and the forests logged very widely, since 1835. Mines were operated at Tilba for several decades after 1870. European arrival can be detected by the appearance of the pollen of introduced weeds such as *Hypochoeris* spp. and *Pinus* after about 1890, together with changes in grassland extent.

Aboriginal occupation of Australia is now firmly established as having occurred more than 40,000 years ago (e.g. Mulvaney and Kaminga 1999), although Pleistocene sites have remained rare on the eastern coast. Lampert (1971) records a basal age of 21,000 BP at Burrill Lake rockshelter, about 120 km north of Tilba, and this remains the oldest dated site in the coastal region south of Sydney. Shell middens are Holocene, with basal dates of ca 5000 BP in coastal sands and increasingly common shell sequences spanning the last 3000 years (Hughes and Lampert 1982). Within the archaeological sequences there is a shift at around 5–3000 BP with the appearance of backed blades added to core and scraper types. Backed blades of chert or silcrete are absent from sites after 19–1600 BP and quartz is increasingly used. Fish hooks made from shell seem to be introduced about 5–800 years ago, and their appearance may be associated with a change in the species of shell exploited (Bowdler 1976) and more diverse resource gathering. Some have argued that this is evidence for intensification of coastal use in the last two millennia (Mulvaney and Kaminga 1999, 289), possibly a result of increased extractive efficiency. Hughes and Sullivan (1981) have suggested that an increasing use of fire led to increased rates of geomorphic infill over the past 2000 years.

Prior to European settlement, Aboriginal use of the coast was relatively intense, as it was an important resource zone. The most notable evidence for occupation are the shell scatters behind beaches and on headlands, but wherever surveys have been undertaken in forests (e.g. Sullivan 1983, Boot 1994), small sites of hearths with a few artefacts have been found, so it appears that all habitats were exploited. The visibility of the shell and paucity of bone or plant material has led to a concentration on its role in coastal subsistence, and represents a clear bias in the record.

Ethnographic evidence is restricted to a few explorers' accounts and settlers' letters, although the area was described in 1844 by G. A. Robinson (Mackness 1941) and later studied by Howitt (1904) and Mathews (1904). The Tilba area is thought to have been occupied by clans of the northern group of the Yuin tribe (Howitt 1904), and Tindale (1974) records the area as a Djiringanj language group, although the location of the language boundaries has been disputed. Attenbrow (1976) interpreted the limited data on contact time ethnohistory to propose that bands were quite mobile, tending to occupy the coast during winter and to spread into the hinterland during summer. Aboriginal people live in the Tilba area today, some still at Wallaga Lake Reserve, which was established in 1891 (McKenna 2002). They are descended from Yuin peoples, mainly from the Bega Valley to the south. Some traditional knowledge is intact and is being preserved by the Umbarra Cultural Centre, Wallaga Lake.

Fishing from canoes with spears or lines and shell fish gathering were important marine activities, the resources being supplemented by seals, stranded whales and dolphins from time to time. A wide range of fauna, including kangaroo, possum, echidna, frogs, snakes and birds, were exploited, and visits made to offshore island sea bird nesting sites (rookeries). Insect grubs, worms and honey also made an unquantified contribution to the diet. A wide range of plant foods were available (Cribb and Cribb 1974, Gott 1982,

Hardwick 2001) from the rainforest (shoots of the palm, *Livistona australis*, growing tips of some ferns, bracken rhizomes, fruits from trees and shrubs such as *Eugenia smithii*, *Ficus* spp. and *Citriobatus spinescens*), coastal woodlands and dune scrub (fruits of Epacridaceae, *Exocarpos cupressiformis*, *Persoonia* and *Solanum*, *Banksia* flowers, orchid tubers, daisy yam tubers and leaves of New Zealand spinach, *Tetragonia tetragonioides* and coastal saltbush *Atriplex cinerea*). The seeds of the common cycad, *Macrozamia communis*, which requires careful pre-treatment before cooking, were a seasonally important starch source. Several *Acacia* species provide seeds that were roasted and ground.

Possibly more important were freshwater swamp plants with starchy rhizomes and tubers. These include *Phragmites australis*, which has delicious young shoots and a thick underground rhizome, as does *Typha domingensis* (Gott 1999). The aquatic *Triglochin procerum* and *T. microtuberosum* has tubers, starchy rhizomes and edible fruits (Hardwick 2001). Sedge species include *Schoenoplectus validus* (rhizomes, seeds and young shoots) and water chestnut-like tubers from several *Bolboschoenus* species such as *B. caldwellii*, *B. medianus* and *B. fluviatilis*. Thus swamps provided an important staple that may have been managed by fire and husbandry (Hope and Coutts 1971, Clark 1983, Head 1989). In addition, swamps provided fish and crustacea, as well as being important hunting grounds for water birds and animals coming to drink. By contrast the saline swamps around estuaries are less rich although Hardwick (2001) notes that the leaves of samphire (*Sarcocornia quinquefolia*) and some saltbush species are eaten.

BOBUNDARA SWAMP STUDY SITE

Tilba Creek drains 1425 ha from the southeastern slopes of Mt Dromedary, eastwards in a broad valley south of Little Dromedary Mountain. Bobundara Swamp is a freshwater tall grassland/sedgeland of *Phragmites australis* and *Typha domingensis* about 120 ha in extent that follows the lower valley and backs against a seaward dune (Fig. 21.2). This sand barrier is linked to the Tilba Tilba headland and an over-steepened bank on the northern margin of the swamp, but southward it is separated from former headlands to the outlet of Wallaga Lake 3km to the south. Water draining from the swamp runs southwards behind the beach barrier into Merriwanga Swamp, a saltmarsh that is probably an infilled arm of Wallaga Lake. This large estuarine lake is intermittently connected to the sea across the sand barrier, and it provides a habitat model for former lake phases at Bobundara. The beach barrier was able to form without being breached

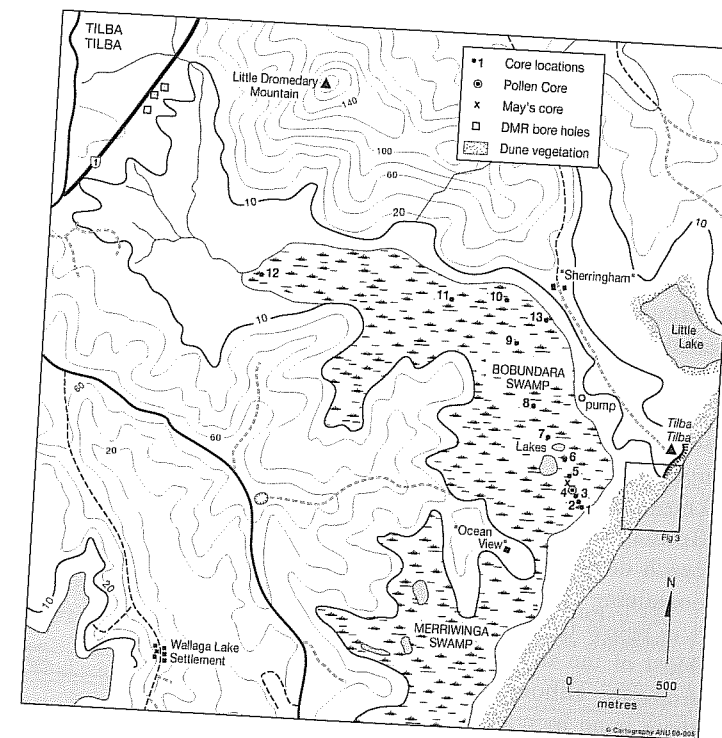


Fig. 21.2 Bobundara Swamp study site.

by water building up in the swamp due to a separate channel to the larger estuary to the south. North of the headland, Little Lake regularly breaches the barrier to the sea, despite having a very small catchment.

ARCHAEOLOGICAL SURVEY

An archaeological survey was carried out around the swamp, on the Tilba Tilba headland and on the beach barrier complex to the north and south (Coddington 1983). In addition, the Dibden artefact collection, made some time ago by a local farmer from the study area and the next beach to the north, was inspected. This included hammerstones, pebble percussion stones (showing an anvil pit), pebble choppers, both bifacially and unifacially flaked, edge-ground axes, possible 'oyster picks', horsehoof cores, scrapers, thumbnail scrapers, bondi points and other points and blades, knives, fabricators and elouras. Several playstones (very round pebbles) and quartz crystals (of possible ritual significance) were found from the barrier north of the headland. Stone type varied and included silcrete, chert and silicified tuff used for blades, and ferruginised sandstone pebbles used for anvils, hammerstones and edge-ground axes. Quartz pebbles were uncommon, possibly having been neglected by the collectors.

A large number of sites, principally shell scatters preserved in sand, were found along the beach barrier to the north and south of the swamp. Only a few sites were found which contained stone such as quartz, silcrete and chert, and these were usually close to headlands. A major blowout in the dunes near the entrance to Tilba Tilba lake in the north of the survey area, has exposed a wide range of stone artefacts, but elsewhere sand erosion has buried the older dune surface. Hence many sites near the sea are probably concealed beneath recent sand accumulations or by dense vegetation. The dune behind the northern beach is made from recent sand and only a few shell scatters were found. Mr Norm Hoyer, the landowner of Tilba Tilba headland, reported that in the past, ploughing there had thrown up abundant shell and hearthstones. However, a careful search and several auger holes found nothing, even though shell middens are known from headlands at Narooma and Bermagui. Eroded parts of the southern beach dune revealed a dark humified layer containing charcoal and shell, usually about 1 m below the surface layer of yellow sand. Most of the shellfish consisted of *Anadara trapezia*, although towards Wallaga Lake there is an increase in oysters (*Crassostrea* and *Ostrea* species) and the mud whelk *Pyrazus ebeninus*.

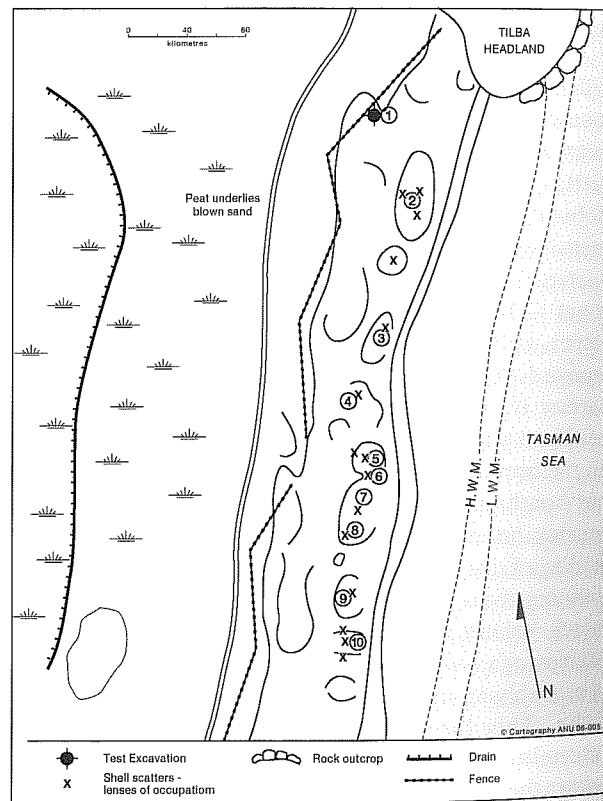


Fig. 21.3 Plan of archaeological deposits on the Bobundara barrier.

The land around Bobundara Swamp was also surveyed, but only scattered artefacts were found, mainly on the slope to the south of the swamp. The slopes and swamp margin are grass-covered, so artefacts were mainly located on eroded or bare track edges. These included several quartz flakes, one silcrete and one chert flake, a large edge-ground axe of banatite and a pitted anvil stone. The axe was large and flat, and resembles several that have been found over time around Sherringham farmhouse on the northern side of the swamp (N. Hoyer pers. comm.). To the west of the swamp only two flakes were found, perhaps because post-clearance slopewash has covered the original surface.

Blowouts seaward of the swamp revealed numerous sections with shell and charcoal eroding from a buried organic-rich soil horizon (Fig. 21.3). A reconstruction of several sections suggests that the deposit in this area is complex, with several discontinuous lenses separated by pale white sand. Disturbance of the dune may have been associated with occupation. The major shellfish recovered was *Anadara trapezia*, although *Cabestana spengleri*, *Ostrea angas*, *Crassostrea commercialis*, *Plebidonax* and *Velectuctea flammea* were also present. Size measurements of the *Anadara* suggest that they were 3–4 years old when collected.

ARCHAEOLOGICAL EXCAVATION

Site 1, close to the headland, contained abundant artefacts eroding from a 0.8 m thick organic-rich horizon, which was subsequently selected for excavation. An adult human skeleton was temporarily exposed nearby in the same horizon. The excavation was sited in the deepest section available, determined by augering. This revealed that the organic-rich section thinned away from the exposed face, indicating that the deposit is lens-like, eroded, and possibly infilling a small hollow. A 0.5 x 1.0 m test pit was excavated in spits and the material sieved using 9, 5 and 2 mm sieves (Table 21.1). The stratigraphy is shown in Fig. 21.4.

The excavation recovered limited cultural material. Quartz becomes more common in the upper spits, coinciding with a decrease in average stone size. *Anadara trapezia* was the dominant shellfish found (Table 21.2).

Bone is rare but includes fragments of bird or mammal and two fish vertebrae, possibly from snapper or bream, which were found in Spit 2. Three fragments of the chiton *Ischnoradsia australis* were recovered from Spit 3. Several seeds of swamp rush, *Juncus* sp. (possibly *Juncus kraussii*) were found in Spits 2 and 3. *Juncus* seeds were ground to a paste and eaten by Aborigines (Cribb and Cribb 1974), and the plant is particularly common in saline marshes such as Meriwingia Swamp, to the south of Bobundara Swamp.

The material from the site is not very diverse but it does reveal that the diet included plants and animals other than shellfish. The *Anadara* were most likely brought from Wallaga Lake, 2–3 km distant, since at

Spit	Depth cm	Sediment
1	0–30	Clean very pale brown dune sand without artefacts
2	30–48	Mottled light yellowish brown sand with some cultural material
3	48–66	Dark grayish organic rich sand with shell, stone and charcoal fragments
4	66–85	Dark brown organic rich sand with occasional cultural material and charcoal Dates of 320 ± 110 yr. BP (ANU 3678) on charcoal and 730 ± 70 yr. BP (ANU 3708) on <i>Anadara</i> shell were obtained
5	85–>95	Light yellowish brown sand with occasional charcoal

Table 21.1 Stratigraphy of dune deposit near Tilba Tilba headland. Shell dates are liable to a marine reservoir correction of ca -350 years.

SPIT	Artefacts	Stone fragments	Anadara (g)	Other shell (g)	Juncus seeds	Bone
2	Scraper (Q)	38Q1S	17	1.4	3	-
3	Scraper (QZ) 3Flakes (Q)	42Q	72.3	5.8	1	4
4	Nil	10Q 2S	47.9	9.8	-	4
5	Scraper(S)	4Q 3S	6.0	3.0	-	1

Table 21.2 Materials from test excavation. Q quartz, QZ quartzite, S silcrete. Other shell includes Cabestana spengleri, Ninella torquata, Dicanthis orbita and Ostrea angasi.

the time of occupation it seems unlikely that there was a local supply, because Bobundara was already a fresh water lake. The deposit thus provides evidence that people visiting the Bobundara area brought shells and seeds, or that they were based there and sought food some distance to the south. In either scenario it is likely that it was the resources of the swamp that bought them there. The dune soil indicated by the organic-rich horizon suggests that dune stability was maintained through the occupation, and that the covering of sand is the result of recent dune disturbance by cattle, rabbits and fire.

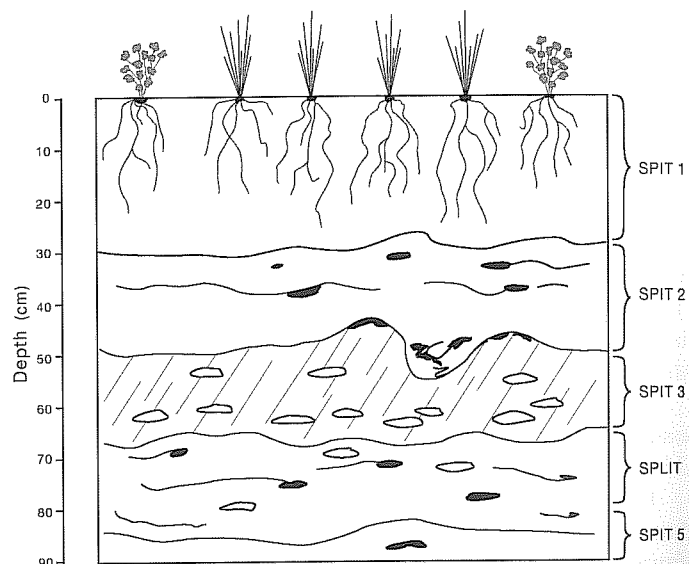


Fig. 21.4 Stratigraphy of the northern face of the archaeological section.

SEDIMENT CORING

Bobundara swamp was cored with a D-section Russian corer along an east-west transect 2.2 km in length, revealing that the swamp peats form a 2–2.5 m layer over lacustrine sediments. Road test bores a further 2 km up valley found a 3 m layer of fibrous peat. This was buried beneath 3 m of recent sands and clays, probably derived from slope erosion following clearance for pasture. Thus the swamp at one time extended 4 km up valley. In the easternmost 100 m of the transect, only shallow organic sections were obtained as beach sands of the former sea spit were encountered a few metres down. Near the dunes even these shallow peats are buried beneath recent sand. The lacustrine sediments thin up valley from the deepest section, located about 400 m from the northern and eastern margin. Levelling from the trigonometric station on Tilba Tilba headland showed the modern swamp surface to be close to mean sea-level. Repeated coring here provided a 14 m sequence of peats, lake muds and estuarine sandy muds covering the last 8000 years.

The record can be extended back to 14,000 BP by including data from a marine core. The Narooma NB3b core is a 343 cm gravity core taken by Peter Roy in 1988 at 36° 08.2'S, 150° 12.3'E in 89 m of water on the continental slope, 7.2 km offshore and about 24 km northeast of Bobundara swamp. The core

Site	Depth cm	Stratigraphy and dating
BOB	0–210	Brown fibrous telmatic peat with sedge stems, pH3.5. The base at 190–210cm dated as 460 ± 130 BP (ANU 3546)
BOB	200–520	Dark brown nekron mud with scattered charcoal fragments at 300cm and sand lenses around 400cm, increasingly sandy to base. pH 3.5. A date from 390–410 is 2540 ± 190 BP (ANU 3545)
BOB	520–610	Transition from sandy clayey nekron mud to grey clay containing organic muds, with shells of <i>Parcanassa buchari</i> and <i>Notospisula parva</i> . The end of the transition at 520–540cm is dated at 3590 ± 150 BP (ANU 3544)
BOB	610–1320	Gray clay with abundant shell, becoming sandy below 1100cm pH 2.5–3.5, LOI 9–12% above 1130cm, <0.5% below. The level at 830–845cm is dated at 5410 ± 110 (ANU 9474) and the top of the sand at 1120–1130 is dated at 6940 ± 170 BP (ANU 9475)
BOB	1320–1385	Grey clayey medium sand with low organic content
NB3b	155–180	Olive grey muds with very fine sand and scattered bivalves. Shells at 155cm give an uncorrected age of 8140 ± 115 BP
NB3b	180–335	Dark grey very muddy very fine sand with 40% shell. Shell dates of 10,100 ± 160 BP at 215cm and 13,880 ± 160 BP at 330cm were obtained

Table 21.3 Stratigraphy and dating of Bobundara Swamp and the lower part of the Narooma-Bermagui (NB3b) core. The dates from Bobundara are acid washed organic fines (<500µm) and those from NB3b are shell dates, from which a marine correction of 350 years should be subtracted.

consists of olive-grey fine calcareous sandy muds and muddy sands, with scattered shell fragments. It covers the period from 15,000 to ca 1700 calendar years ago (P. Roy pers. comm.), thus marking the transgression and deepening water across the Pleistocene-Holocene boundary. The lower part of the core (160–340 cm) thus reflects shallow nearshore marine conditions before 8000 BP which complement the open shore conditions encountered in the lowest part of the Bobundara Swamp record (Table 21.3).

The dates noted above were adjusted for marine carbon or carbonate effects and calibrated using CALIB 4.2 (Stuiver and Braziunas 1993). They provide an almost linear accumulation model for the NB3b core, averaging 2.35 cm per 100 calibrated years. The Bobundara estuarine phase accumulates at 18.35 cm per 100 calibrated years above 1125 cm, and the sands below this point may have built up even faster, since the dates from 1125 and 1345 cm overlap. The reducing clay content suggests that the accumulation rate slowed gradually to a linear 9.7 cm per 100 calibrated years in the lacustrine phase above 600 cm. However, the peat above 200 cm accumulated extremely quickly, averaging 38.05 cm per 100 calibrated years, but possibly accumulated even faster since forest clearance began.

PALYNOLOGY

Samples at approximately 20 cm intervals were subjected to standard pollen preparation methods. Pollen was extremely sparse in the marine core and in some samples from both the basal sands and near-surface peats at Bobundara. Microscopic charcoal was estimated using counts of the particles >5 µm as a proportion of the pollen sum, as well as the point count method of Clark (1982). Pollen diagrams (Figs 21.5 and 21.6) show the changes through time from the two sections, with the lowest levels being represented by the marine core (NB3b on both diagrams).

CONISS analysis of common, non-aquatic pollen types distinguishes the estuarine muds and the marine core from the sediments above 570 cm (Fig. 21.5). At a lower level of significance the marine core is separated from the lower Bobundara section, and the upper peat phase is distinguished from the shallow lacustrine unit at 250 cm. Although aquatic pollen types were excluded from the analysis, they show significant responses at the same boundaries, indicating that changing aquatic environments might be affecting the influx of dryland pollen, particularly the input of pollen carried by streams.

NB3b (15,000–8130 cal yr BP)

The marine core is dominated by fern spores from rainforest gully and stream bank habitats, yet does not record any wet forest elements except possibly in the non-eucalypt Myrtaceae. The *Casuarina* and Asteraceae percentages are high, and may reflect riparian or estuarine margin taxa, since eucalyptus is entirely absent. This is supported by the presence of Chenopodiaceae in one sample, possibly derived from saltmarsh. The spectra are typical of those with water-carried pollen sources, and are in turn characteristic of marine samples. Charcoal is abundant in all samples. *Casuarina* declines and ferns increase after 10,300 cal BP, possibly reflecting changes in the vegetation or stream sources due to continuing transgression and climate change. Carbonised plant material is common in all samples.

BOB1 1380–570 cm (7600–4175 cal yr BP)

The sandy sediments at the base of the Bobundara core are derived from the final phase when the valley was open to the sea, a time when the over-steepened shoreline developed. A sand spit must have been forming at this time and finally cut off a large coastal lagoon, connected perhaps at high tide to Wallaga Lake. This long zone has lower levels of ferns such as *Blechnum* but significant wet forest elements such as *Elaeocarpus*, *Tasmannia* and possibly some Asteraceae and Rutaceae. Coddington (1983) reports occasional *Eucryphia* at 650 and 700 cm. With the decline in *Elaeocarpus* above 780 cm, *Pomaderris*, a wet forest shrub that responds to fire, increases. A ground fern of shaded forest, *Culcita dubia*, and the gully treefern, *Cyathea*, are present in large numbers, probably indicating a water-borne component. Dry forest taxa, particularly *Casuarina*, are prominent although *Eucalyptus* declines to a low at 1200 cm, being replaced by other Myrtaceae, a group that could include both dry and wet forest taxa. *Casuarina glauca* forms stands around Wallaga Lake at present, so at least some of this pollen type may indicate stands marginal to a developing saltmarsh. Chenopodiaceae, also indicating saltmarsh, are at a maximum in this zone, declining above 800 cm as other aquatic taxa such as *Typha* and sedges appear. *Phragmites*, an aquatic grass, becomes common above 940 cm, suggesting that a freshwater swamp may have been developing up valley as pollen inputs from the seaward saltmarsh diminished. Hystrichospheres and saline-tolerant snails indicate that the lake was saline or brackish throughout the zone. Charcoal is common throughout, with a relatively constant input above 1200 cm other than single peaks that may represent fire events.

BOB2 570–250 cm (4170–1010 cal yr BP)

Pomaderris remains at medium levels and *Casuarina* fluctuates in this zone. Asteraceae and shrub Myrtaceae increase while ferns decrease. This is consistent with disturbance of the forests by fire, although charcoal declines markedly in the middle of the zone. The aquatic and mire plants show a steady increase in taxa such as *Phragmites*, *Typha*, *Melaleuca*, sedges, *Myriophyllum*, *Ranunculus* and *Triglochin*. Shells are absent from the increasingly organic sediment and algae increase, but hystrichospheres are also present below 400 cm, indicating brackish episodes, although freshwater conditions with an expanding marginal swamp are gradually established by 400 cm. A *Phragmites* swamp around the inlet stream may have lowered the influx of water-borne pollen from streams. This may also explain the marked decline in charcoal early in the zone, with occasional peaks reflecting fire in the marginal swamps.

BOB3 250–0 cm (1010 cal yr BP–Present)

The rise in sedges, *Typha* and *Phragmites*, at the start of the zone and the presence of well preserved fibrous peat after 500 BP demonstrates that a marginal swamp expanded over the entire shallow lake during this phase, leaving only scattered ponds today. This would have changed the way in which pollen reaches the site, as surface water is only present after heavy rain. There is a steady decline in *Casuarina*, and other forest types with wet forest elements, except ferns, become rare. Dune vegetation inputs are indicated by *Banksia* and *Leptospermum*, while *Acacia* becomes more common at some levels. *Melaleuca* pollen, indicating the development of stands on the southern margin of the swamp, remains important until the most recent levels. Above 40 cm grass (non-*Phragmites*) increases greatly and *Eucalyptus* declines still further. Although *Pinus* is restricted to the top 20 cm, these changes may represent European clearing of the swamp margin. Pictures taken in 1890 show a much larger central lake, which today is reduced to two ponds. Charcoal, which is at very low levels since the swamp became vegetated, rises at this time, perhaps reflecting drainage and deliberate burning.

DISCUSSION

Environmental history

As noted above, each of the four zones represents a different environment of pollen deposition, from open sea, open to gradually enclosed estuarine lake, freshwater or brackish lake with marginal swamps, and finally closed tall graminoid peat swamp. This progression means that between-zone comparisons of the regional vegetation are difficult because each has different pollen and charcoal catchments. Given that many of the changes must be due simply to a progression from regional water-borne deposition to wind-carried and local swamp deposition, the evidence supports a picture of relative environmental stability in the area. *Eucalyptus* forest has probably remained the dominant type and there have been only minor changes in the extent of wet forest elements such as ferns. Although eucalypt pollen was not seen in the NB3b section, the upper Holocene does not differ markedly from the spectra shown here, and hence their presence can be assumed throughout. The only trend noted in the marine core is an increase in fern spore frequencies from Pleistocene to Holocene and a decline in *Casuarina*. This lack of obvious change around 10,000 years ago contrasts with evidence for increasingly warm and wet conditions further inland in New South Wales (e.g. Martin 1986, Hope 1994, Kershaw 1998).

The NB3b core was analysed for marine ostracods by Dr Iraj Yasseni, who found that a significant shift from warm water faunas commenced at about 12,700 cal years ago (P. Roy pers. comm.). By the Holocene-Pleistocene boundary at 10,350 cal BP, cold water faunas dominate, and continue to do so through the Holocene. These unexpected results suggest that in the glacial period, the average penetration of the warm eastern Australian boundary current was further south than today. The cause is unknown, but may reflect a reduced westerly flow of water into the Tasman Sea when a land bridge connected Australia to Tasmania. The lack of major change in the coastal vegetation (and the high level of diversity in the modern eucalypts) may thus be a measure of the stability caused by relatively mild maritime conditions near the coast during glacial times that changed to cooler water but warmer land conditions in the Holocene.

Within the Holocene the decline in moist forest may reflect slightly drier conditions after 3000 cal BP. However, *Pomaderris* has its best representation from 6000 to 2000 cal BP, somewhat later than in some Victorian and New South Wales sites (Kershaw 1998). *Pomaderris* may be as much a measure of fire frequency as climate, in which case its replacement of *Elaeocarpus* around 5900 cal BP may represent an increased frequency of large fires on the slopes of Mt Dromedary. Changes in the frequency of dry forests coincide with fern peaks; this too may reflect successional events following substantial fires. The microscopic

charcoal record is strongly affected by taphonomic shifts, and can only be interpreted to show that fire has been a constant feature of both Pleistocene and Holocene vegetation. During the final swamp phase it is possible that the reeds were not commonly burnt, otherwise charcoal influxes would have been much higher. However, Aborigines are reported by eyewitness account to have burnt the swamp deliberately in the 1870s (N. Hoyer pers. comm.), therefore some fire peaks may be anthropogenic.

The best comparative record, from Holocene dune-dammed deposits at Kurnell, south of Sydney (Martin 1994), also shows relatively minor changes through the Holocene. Burning appears to increase at Kurnell after 5000 BP but the vegetation becomes more forested initially. After ca 2000 BP there is evidence of dune erosion and more seral vegetation, which Martin suggests may reflect more intense occupation. Other Holocene records from the east coast include Bumbo Lake (Tibby 1992), Lake Curlip (Ladd 1978), Loch Sport Swamp and Hidden Swamp (Hooley *et al.* 1980), Wilson's Promontory (Ladd 1979) and the southwestern coast of Victoria (Head 1988, 1989). These sites all record relatively stable dryland vegetation, although there is some evidence for a drying trend after 5000 years ago. Ladd (1979) found eucalyptus forest from before 13,000 BP on Wilson's Promontory but suggests that rainforest became more common from 11–7000 BP, while Hope (1974) found that elevated rainforest inputs continued on the west coast of the Promontory until ca 4500 BP. This supports the notion that coastal vegetation was fairly stable despite regional changes, even across the Pleistocene-Holocene boundary. Lake Bumbo, only 30 km north of Bobundara Swamp, appears to have slightly higher rainforest inputs prior to 3000 years ago, but this may have reflected changing source areas. This site remained a saline lake through its 5500 year history, although diatom studies show an increase in salinity after 4000 years, supporting the possibility of less freshwater flushing of the system (Tibby 1992). At Loch Sport Swamp and Hidden Swamp, closed dune-dammed hollows in southern Victoria, water levels were lower and the swamps became more saline after 4000–3000 BP.

The Lake Curlip sequence, about 150 km to the south, starts as a saline lake, but shallows rapidly and continues the successional trajectory via *Phragmites* swamp to a closed tall *Melaleuca ericifolia* thicket. This would have had a very low value as a resource area, as most other species are excluded or rare. The site received sediment from the floods of the large Snowy River, and hence had a short history of lacustrine and open swamp phases. At Wilson's Promontory, the inter-dune Cotters Lake has only recently become a sedgeland, with a probable reduction in freshwater resource (Hope and Coutts 1971). In western Victoria, Head (1988) found a relatively early appearance of freshwater lakes, and also evidence that the *Typha* reedswamps were burnt, probably as a result of deliberately lit fires, suggesting some manipulation of the hydrosere.

Resource availability

Fig. 21.7 outlines the four major phases that preceded the present swamp in the Bobundara area. From the point of view of resources for human settlement, the first phase of marine flooding in the late Pleistocene would have meant little change in access to marine resources as water advanced across a relatively flat topography. *Casuarina* seems to have formed prominent coastal woodlands, and temporary saltmarsh areas would have developed. Once the water approached modern sea-level, large numbers of calm bays would have appeared and shellfish such as oysters, *Anadara trapezia* and rock platform species would have become abundant. The death of vegetation exposed the soil to erosion and wave action over-steepened slopes around the bays.

As sea-level stabilised, sand spits and barriers started to form, cutting off embayments from wave activity and creating quiet estuaries or in some cases beach ridge plains. Many rock platforms tended to become buried in sand and quiet shallow water was invaded by saltmarsh or mangrove vegetation, bordered by *Casuarina glauca*. Continued growth of the sand barriers would have made them more durable by developing

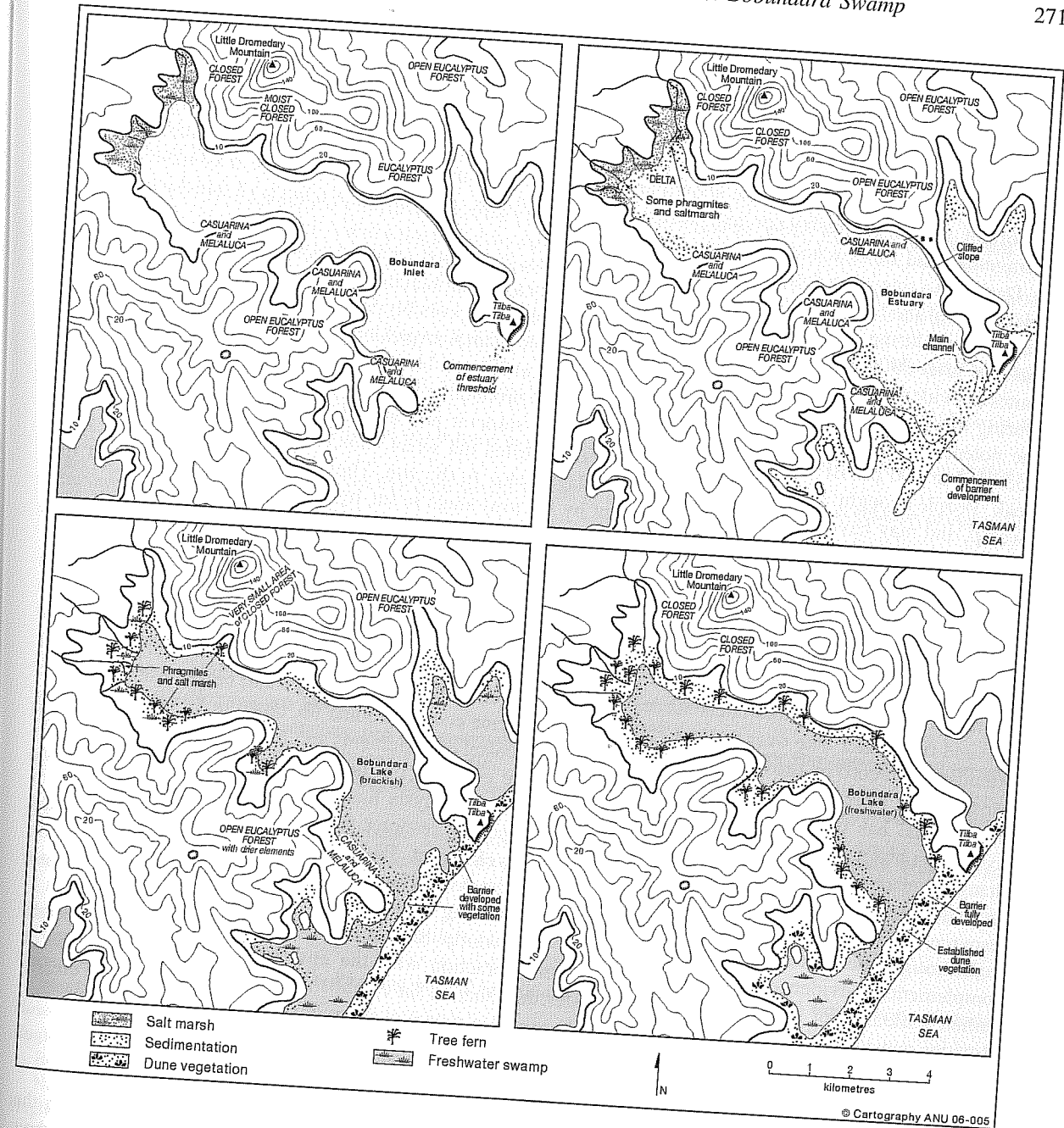


Fig. 21.7 Reconstruction of landscape changes around Bobundara Swamp.

flood tide deltaic deposits and dunes, and beach and dune vegetation resources would therefore have become available. The change from sandy to organic muddy sediment seems to have occurred by 7500 cal BP at Bobundara, suggesting that the barrier kept pace with continuing sea-level rise. After this time Bobundara Lake may have resembled the modern Wallaga Lake as a rich source of estuarine *Anadara trapezia*. This species has been recovered from 4 m depth on the northern margin of the swamp. Some saltmarsh and *Casuarina* may have occupied the shoreline. The permanent stream entering the lake may have been an important source of freshwater and access to the rainforest, as well as a source of brackish-tolerant *Phragmites* and *Bolboschoenus caldwellii* plant foods.

During the transition from estuary to freshwater lake, freshwater swamps expanded, presumably at the inland end of the lake. The development of a saltmarsh caused Bobundara Lake to be cut off from Wallaga Lake except during exceptionally high tides, and the lake was probably brackish or freshwater for most of the time after 3800 cal BP. After 2500 cal BP marginal swamps expanded. Disturbance of the barrier and dunes is evidenced by sand lenses in the lake at 2400 cal BP and bands of macro charcoal at 1500 cal BP. During this phase the lake would have been at its most productive for food plants and lake fauna, and had the potential to be a major source of starchy food in summer and autumn. The archaeological site was occupied at 400 cal BP, after the lake had partially infilled but when habitat diversity was possibly at its peak. People brought shells, probably from Wallaga Lake, to the site. They certainly burned parts of the swamp, and may have controlled encroachment by the next stage in the hydrosere – a scrub of *Melaleuca ericifolia*, ferns and cutting sedge. The dunes were used for human burial as well as a dry habitation site.

CONCLUSIONS

The southern coast of New South Wales has many types of estuaries, coastal lakes and scattered peatlands that have formed since sea-level rose to present levels, and Bobundara Swamp, one of the largest coastal peatlands, has formed as the latest successional stage from phases of an open inlet, closed estuary, saline lake and freshwater lake over the last 7500 years. A marine core, Narooma 3b, taken in 89 m of water, has extended the record by providing a general picture of coastal environments and fire history since the marine transgression after 14,000 BP. Aboriginal artefacts are common on the beach barrier enclosing the lake, and a burial has been dated at 350 BP, although pollen analysis has shown no distinctive changes in occupation history. The basin must have formed an important resource for Aboriginal groups and provided changing resources related to the stages of coastal development. People possibly manipulated vegetation successions through time, but the phase of swamp with freshwater ponds seems to have provided the highest resource diversity of staple plant starch sources and hunting opportunities.

Although the history and archaeology of the swamp lack resolution, the two records provide complementary evidence for change and human interaction with the environment. The time depth of human settlement of the area is certainly greater than that so far established, and the lake history clearly provides considerable evidence of the available resource potential through time.

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Chapter 22

Late Holocene Landscape Change Around Bwindi-Impenetrable Forest, Central Africa: Human Dimensions in Palaeoecological Research from Tropical Wetlands

Robert Marchant

INTRODUCTION

The reconstruction of vegetation community dynamics from pollen preserved within sediments is a technique that has been in a continual state of development for the past 100 years. This development has witnessed the growth of regional reconstructions of vegetation change, where the data from different sites are combined and compared within a temporal framework, usually provided by radiocarbon dating. This chapter will be based around two themes relating to this technique. Firstly, pollen data from six sites in the Rukiga Highlands of Uganda are presented as regional maps of vegetation composition and distribution, and the changes in vegetation are discussed in the context of possible forcing mechanisms, and secondly, data from palaeoecological sources and information on cultural changes are discussed in terms of interactions that may have taken place.

THE STUDY AREA

The Rukiga Highlands are an area characterised by a deeply incised and steeply undulating topography that straddles the equator in southwestern Uganda (Fig. 22.1). Within the valleys a range of swamps have been formed, in part due to tectonically induced changes in drainage patterns, and it is under these swamps that sediments and pollen accumulate. The natural vegetation of the Rukiga Highlands is montane forest, the largest remnant of which occurs within Bwindi-Impenetrable Forest National Park. This forested area has benefited from protected area status since the early 1930s, initially as a Forest Reserve and more recently as a National Park and a UNESCO World Heritage Site (Fig. 22.1). The protected status relates principally to the resident mountain gorilla population that comprises around 35% of the global population. The majority of the Rukiga Highlands is dominated by intensive subsistence agriculture that supports very high population densities of 500 km² (Taylor *et al.* 1999), and this is manifested by intensive hillslope terracing (Fig. 22.2), which becomes progressively less intensive towards the present boundary of the National Park. The Rukiga Highlands have been a focus of palaeoecological study in central Africa since the pioneering