Sand movement and the protection of natural areas on Pouto Peninsula, Northland

Colin Ogle
Conservancy Advisory Scientist
Department of Conservation
Wanganui

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Abstract

In the dunes of the Pouto Peninsula, north Kaipara, Northland, re-mobilised sand is invading remnants of native forest and scrub, and filling dune lakes and swamps. Some of the affected native vegetation is botanically important as remnants of regionally and even nationally rare plant communities and as the habitats of threatened plant species. The wetlands are important waterbird habitats. At least part of the sand movement can be traced to past human disturbances such as fire and animal grazing. It is recommended that sand stabilisation be attempted by a combination of methods, including applying fertiliser to existing areas of marram and pingao, and pest control.

1. Introduction

Staff of Northland Conservancy, Department of Conservation (DOC) have recently expressed concern over a number of possible threats to natural areas on the southern half of Pouto Peninsula. These include dune sand encroachment into significant natural areas (native forest remnants, wetlands and dune lakes) and the pine forests of adjoining landholders. Weeds are another problem, and recent wide-scale die-back of pingao is also suspected.

In February 1994 I was invited by DOC Northland Conservancy to join a DOC party on an inspection of some of these perceived problems.

2. The Survey

2 February: L. Humuhumu, Pretty Bush, North Head lighthouse and dunes, Stick Lake.

3 February: Glinks Gully to dune areas 24 km south (no map names, but for the purpose of this report I shall refer to the southern-most area we reached as "Camp Stream" because the site has wooden tables and posts which are used by casual campers, and a stream which runs on to the beach).

Place names in the following text follow topographic maps NZMS 260 P09, Q09.

Common names are used for plants wherever possible and, for wetland plants, these mostly follow Johnson and Brook (1989). Because the report makes some comparisons between dunes at Pouto and in other parts of New Zealand the common names used are those in widespread use. Some species will be known to local iwi by names other than those in this report, although

Northland names are included at the first mention of several species. Appendix 1 gives the formal names for all common names used in this report.

3. Observations

3.1 LAKE HUMUHUMU

About one hour's inspection was made of part of the western edge. The lake level was regarded by local DOC staff as being lower than average. There is an almost flat riparian strip with several "steps" (shore levels) on which the vegetation is dominated by native herbaceous plants, but herbaceous weeds are also common. Swampy areas are dominated by tall reeds such as raupo, kapungawha (=kuawa), kukuraho (=purua), jointed twig-rush and swamp millet. Shorter-stature vegetation has the native swamp willow-weed and willow herb. Exposed wet sand at water's edge has native turf plants (*Lilaeopsis* sp. [*L. rutbiana*?], *Glossostigma elatinoides*, *Myriophyllum votschii* are common). (Peter de Lange, [pers. comm.] reports the nationally vulnerable [Cameron et al. 1995] wetland herb, *Hydatella conspicua*, in this kind of plant community on the island in Lake Humuhumu.) I made a plant list for the lake edge, and gave it to Northland Conservancy staff on site.

The adjoining steep dunes are stable (marram with some native plantings, eucalypts, and pines beyond). The weed with the greatest potential to change the area is pampas; others which are prominent in certain communities are *Ludwigia palustris*, Yorkshire fog and other pasture grasses.

3.2 PRETTY BUSH

3.2.1 Location and description

This southern-most patch of forest on Pouto Peninsula was missed during surveys of wildlife and forest types in the late 1970s (e.g. Ogle 1982), but has been described as a result of more recent visits by DOC staff and members of the Auckland Botanical Society. Its isolated position is sufficient to make it an important remnant regionally. In addition, its existence as a remnant of dune forest (a very depleted type of forest community nationally), plus its range of forest species, its possibly unique forest composition, and the presence of nationally uncommon species make Pretty Bush an area which should be protected at almost any cost.

The party split up during our visit. Two people traversed the perimeter while the rest of us entered the forested main valley via a steep dune face which had recently engulfed part of the forest at its northwestern end. We crossed this valley into subsidiary valleys to the west, and emerged at a point about half way along the southwestern side.

3.2.2 Forest composition and notable plants

Several plants were added to those listed on the Sites of Special Biological Interest (SSBI) data base by previous visitors, including two trees of kohekohe, plus akeake, mamaku, *Olearia albida*, *Asplenium gracillimum* and an *Astelia* (probably a young plant of *A. solandri*, growing terrestrially). Revised identifications are suggested for several species recorded in 1991 on the SSBI data sheets held in the Northland Conservancy office of DOC at Whangarei. These include an unnamed species of *Carex* related to *C. testacea* s.s. and *Uncinia distans* rather than "*U. ?scabra/rubra*". A list of vascular plants recorded by all known observers is attached as Appendix 2.

The main canopy of Pretty Bush is formed of either tall kanuka, or kanuka mixed with titoki and karaka, and a mahoe understorey. There are parts where narrow-leaved maire (*Nestegis montana*) is the main canopy tree, and others where this maire is mixed with kanuka. I have not seen any other place in New Zealand where narrow-leaved maire is the dominant canopy tree. Wright and Young (1991) report "local dominance" of narrow-leaved maire at Tapu Bush, some 9 km to the north of Pretty Bush.

We found two specimens of fierce lancewood (*Pseudopanax ferox*), a tree which has a national "local" status. The species had been recorded here before by DOC personnel (though missed by Auckland Botanical Society personnel?). The two saplings seen by us were about 5 m apart, both about 5 m tall, branched at the stem tips, and beginning to grow adult foliage. A single 1.5 m-tall plant was seen of a likely hybrid between fierce lancewood and houpara. Two leaves were collected from this shrub for the herbarium at Landcare Research New Zealand Ltd, Lincoln (CHR). One leaf was undivided and the other had three leaflets. This putative hybrid differed markedly from the many surrounding plants of hybrids between common lancewood and houpara, in having crisped leaf margins and mottled brown colourings.

The presence of *Hebe diosmifolia* is important because it is endemic to Northland, and has a patchy distribution even here. Murray et al. (1989) stated that all the different looking plants which have been called *H. diosmifolia* in the past are forms of one species, but this view is not accepted by all botanists (e.g. Druce 1992). Among the reasons for believing that *H. diosmifolia* comprises more than one species are the existence of two different chromosome numbers (2n=40 or 80), though no single population is known to contain both. In cultivation, plants retain low or tall growth forms, dull or shiny leaves, and exhibit different flowering times, but the origins of many cultivated plants are doubtful. There is still debate as to the discreteness of such characters, whether they are exhibited by wild plants, and whether they correlate with differences in chromosome number (e.g., Murray et al. 1989; Druce 1992; Eagle 1982; Peter de Lange pers.comm.). Because it is possible that future taxonomic research may reveal at least two species in *Hebe diosmifolia*, one or more of which could be sufficiently uncommon or threatened to rank on the national listing of threatened plants, it is important to retain wild populations of *H. diosmifolia* across its full range.

3.2.3 Comparisons with other dune forests

Smale (1990) reviewed the occurrence of "coastal kanuka communities in sand dunes in the North Island", but omitted both Pretty Bush and Tapu Bush from his inventory. He also omitted all forest on dunes in the Foxton Ecological District, including kanuka forest near Hokio west of Levin, and identified as Pakipaki by Ravine (1992).

I was personally delighted to see Pretty Bush, because it bears some remarkable similarities to Pakipaki dune forest near Levin, which I visited as part of the Foxton Protected Natural Areas Programme (PNAP) survey (Ravine 1992). Appendix 2 combines several authors' lists of indigenous vascular plants for three areas of dune forest, Pakipaki, Pretty Bush and Tapu Bush. Before drawing conclusions from a comparison of these lists, it should be noted that, for each of the three forests, more than one list of plants exists, and each of them differs to some extent in the species listed. It proved impossible to be sure of the accuracy of some records. Some species were listed by only one observer, and others listed by one observer were replaced by a related or similar species by another recorder in the same forest patch. Doubtful records are listed at the end of Appendix 2.

For Pakipaki forest, Levin, the most comprehensive list of plants is that of Druce (1972 and subsequent revisions), but his list is for an area which includes dune forest and adjoining non-forested dunes and wetlands. I have used my own knowledge of these same areas, and the lists of other recent observers (Cooksley and Townsend 1992, Rapson et al. 1992) to extract the forest species from Druce's list. It is possible that I discarded some species listed by Druce for the forest.

For Tapu Bush, a surprisingly large number of woody plants (14 species) was recorded by Reid (1977) but not subsequent observers. The species recorded only by Reid include tawa, northern rata, *Astelia trinervia*, putaputaweta, wharangi, pukatea, fierce lancewood, two species of white rata vines, two of clematis and two of *Gahnia*. Reid's records are accepted for plants he was unlikely to have confused with other species. Wright and Young (1991) recorded about nine woody species at Tapu Bush which had not been not listed by other observers. Tapu Bush is perhaps five or six times the area of Pretty Bush and has probably not been thoroughly explored by any botanist to date.

A comparison of tree and shrub species shows that Pretty Bush and Pakipaki dune forest share some 23 species, which is 50% of Pakipaki's woody plants and 58% of those at Pretty Bush. For ferns, the two places share 14 species, 70% of the fern species at Pakipaki and 78% of those at Pretty Bush. This similarity would be strengthened if one were to exclude the eight species of trees, shrubs and ferns in one or other site which are not available to be shared, i.e. species such as *Hebe diosmifolia* or matagouri which do not occur in both Northland and the southern North Island (see Appendix 2).

The three dune forests share nationally uncommon combinations of plants. These include somewhat localised species such as narrow-leaved maire, akeake, *Coprosma crassifolia*, and korokio, with more widespread species such as totara, kanuka, titoki and karaka. I believe that such similarities show that

such forest was once widespread on dunes, in the North Island at least. Dune kanuka stands in the Bay of Plenty, described by Smale (1990) are in much earlier successional stages, are less diverse floristically, and cannot be compared with Pretty Bush, Tapu Bush, or Pakipaki. Peter de Lange (pers. comm.) reports similar "assemblages" of plants on dunes around Kawhia and Raglan, "except that narrow-leaved maire is absent".

Being very dry and close to areas of settlement, most dune forest probably disappeared in Polynesian fires before Europeans arrived (as stated by McFadgen [1995] for the Horowhenua coast), and anything left was cleared by Europeans for fencing materials, firewood and farmland. Indigenous forest on dry dunes must be one of the most depleted forest types in New Zealand. Remaining areas, therefore, should be among the highest priority places for protection.

3.2.4 Sand drift and Pretty Bush

As stated earlier, the main reason for visiting this forest was to assess the threat posed by dune movement into the forest, and to suggest ways of preventing this. Pretty Bush may lie on an area of Schofield's (1969) Holocene fixed dunes, but re-mobilised sand from the west is now covering the surface (Schofield's "drifting dune sand" in Fig 7, p.789 [1969]).

The evidence of accelerated sand movement in recent times is plain to see. Prevailing westerly winds are maintaining extensive areas of moving sand over the land that lies between the central part Pouto Peninsula (now stabilised with pine forests), and the western and southern coasts.

Before 1987, when DOC came into existence, extensive areas of marram were planted on what is now DOC administered land around Pretty Bush. This land has not been actively managed since, and much of the marram is dead or unthrifty, with few plants of other species to be seen over most of it. As discussed in Section 3.2.6(a), the poor growth of marram here is likely to be the result of the nutrient-poor sand, which is elevated and well away from the coast. This means the sand has been leached and receives fewer wind-carried nutrients from the sea than more coastal sites.

Different parts of the northwestern and southwestern margins of Pretty Bush have different degrees of sand mobility close by. Some parts of the forest edge are bordered by quite vigorous patches of marram with no evidence of recent massed sand drift. Within healthy marram beside the forest, kanuka seems to universally present as young plants, up to 60 cm tall. Kanuka densities range as low as 1 shrub/25 m^2, to 15 shrubs in a 1 m^2 quadrat. Shrubs in this latter quadrat have a height range of 3-60 cm; seven tufts of marram are in this quadrat as well.

Fig 1. Western edge of Pretty Bush, Pouto Peninsula. The fringe is dominated by tall (c. 6m) kanuka. Dunes in the foreground are stabilised with marram. Kanuka and toetoe can be seen establishing among the marram. 2 February 1994.

Fig 2. An unnamed lake in a dune slack, western Pouto Peninsula showing the dynamic nature of dune wetlands. Kanuka on the far edge of the lake has been drowned by rising water levels. Sand from dunes to the west is reducing the lake's area. 3 February 1994.

Of the forest fringe that I saw, about 80% would be clothed in relatively stable marram communities with varying amounts of young kanuka (Fig. 1). As well as kanuka, these places have toetoe as a common component (usually as plants with 1-3 tillers), sparse shrubs of coastal karamu and native broom and small amounts of small-leaved pohuehue (=tororaro) and club sedge. If this invasion by native plants can be enhanced and expanded, Pretty Bush will have a more effective buffer against future sand movement.

Although I believe that the Department should be using indigenous plants in revegetation projects, there are times when exotic species can be used to achieve long-term goals. Marram grass around Pretty Bush is an example. It is already providing a nursery for the natural spread of native species, most notably kanuka, which can eventually lead to the expansion of the native forest patch. The rate at which native species invade the marram areas depends upon a number of factors, which include the proximity of seed sources, the stability of the marram communities, and physical conditions of the site (e.g. aspect, slope, drainage).

3.2.5 Natural establishment of kanuka

It was noted that kanuka plants among the marram at the northwest end of the forest were almost all of similar height (40-60 cm), suggesting that they established at the same time. Those on the southwest edge were more varied in height, though about three main size classes seemed to be present. (A correlation of height with age should be possible by counting annual growth rings in stem sections, but this would be unnecessarily destructive in a situation where every kanuka plant has a valuable ecological role.)

If my hypothesis is true, kanuka must be establishing in only a small proportion of years. This could be the result of

(a) infrequent flowering/seeding of kanuka

(b) failure of kanuka seed to arrive in the marram areas

(c) germination failure, either because the kanuka seeds do not germinate or the seedlings desiccate soon after germination.

Of these three possibilities, the first seems unlikely, because kanuka flowers every year in other locations (though seed set varies, Peter de Lange, pers. comm.).

The second possibility above might seem unlikely because each kanuka capsule produces about 50 wind-dispersed seeds (Esler and Astridge 1974). Unlike the capsules of manuka, which release seed intermittently over the year or which can persist unopened for several years, capsules of kanuka do not persist unopened. Kanuka seed is released over only a short period each autumn. Because the forest edges where sand drift is occurring are on the upwind side of prevailing westerly winds, it is quite possible that all the seed produced in some years is blown eastwards and is therefore not arriving in the marram areas.

Germination failure is the other likely reason for the irregular establishment of kanuka. Viable kanuka seeds have been found in the soil seed bank under bracken fern and native forest on Banks Peninsula (Partridge 1989), although the age of these seeds was not established. I am not aware of any data on the longevity of kanuka seed on an open surface, but the seeds are very small with few food reserves and are probably short-lived. If so, they would need to germinate and become established soon after dispersal. A period of dry weather might desiccate seeds on the sand surface, or kill young seedlings before they establish deep roots. Different aged cohorts of kanuka would be recognisable in the field because weather conditions suitable for both seed germination and seedling growth probably occur in only a small proportion of years. This may account for the different height classes of kanuka plants which can be distinguished around the fringes of Pretty Bush.

Kanuka is not a panacea for re-establishing forest on the Pouto dunes, but it is the native plant which is most successfully establishing here of its own accord, in the second seral stage. Evidence of past sand movement into areas of kanuka shows that it is not a species that copes well with moving sand. Burying of the bottom of kanuka trunks leads to the death of the trees. Kanuka is also quite susceptible to fire, as discussed later. Nevertheless, kanuka shrubland on these dunes becomes a nursery for other native plants, initially of open sites (e.g. coastal karamu) and later of forest species. If a wide buffer of kanuka can be encouraged to grow around the exposed edges of Pretty Bush, the immediate threat of sand encroachment into the forest will be alleviated.

3.2.6 Assisted establisbment of kanuka

What is the best way to encourage kanuka establishment? Without any local model, we are into a "research by management" project, but there are some promising leads based partly on what our brief inspection showed and partly on dune stabilisation lessons from other places.

Observations at the edge of Pretty Bush show that kanuka will only establish in dune sand which has been largely prevented from moving. Marram is the only species there at present which is stabilising the sand and I believe that it is going to be easier to enhance the growth of marram than to try and establish native sand binders. Spinifex and pingao are the obvious alternatives, but neither is growing well in the area at present and, compared to marram, both are susceptible to rabbit browsing, particularly as young plants. They are also difficult to establish in old dry dunes, preferring damper hollows and/or the front slope of fore-dunes.

3.2.6(a) Use of fertiliser

Pine forest managers on the Wanganui-Manawatu coast have enhanced the growth of spinifex, pingao and marram by annual applications of urea, in September, at the rate of 50 kg/ha (Pat McCarthy, Ernslaw 1, pers. comm. 1993) At least one pastoral farmer on the coast near Foxton has adopted the same procedure with obvious success (pers. obs.). I recommend this as a first step for marram areas just outside the edges of Pretty Bush. It would be prudent to set up a simple trial in the first year, in which only part of the area was treated with urea, leaving untreated control plots.

It would be useful also to establish at least two permanent line transects which extend from the forest edge out through any young kanuka to the edge of dunes occupied only by marram. One should be in an area treated with urea and other in a control area. The number, height, and position of each kanuka, toetoe and other perennial native plants can be noted along a 0.5 m or 1 metre-wide strip between the end posts of the transect. (The width of the strip is mainly determined by the time available to survey it, which, in turn, is at least partly determined by the number of shrubs along the transect.) This survey method means that individual plants do not need to be tagged.

Separate measures could be made of marram cover, either by an estimate of cover over walking transects and/or (more time-consuming) by permanent plots in which the cover is recorded by vertical photographs (which can be analysed for cover by an optical scanner linked to a computer) or measured by traditional point analysis in the field.

3.2.6(b) Enhancing seed establishment

Areas which are already "fixed" by marram, both in the future and those already existing, could be used for trials in kanuka seed establishment. These could be based upon the reasons suggested above for infrequent establishment of kanuka to date. Fresh kanuka seed could be hand sown in trial plots in the field, and a germination trial could be done off-site (e.g., in Whangarei) with sand scraped from one or more plots.

Such experiments may show whether the "problem" is simply that seed is not often reaching the marram areas.

My guess is that drought is the main reason for seed failure most years. The remoteness of the Pretty Bush area makes it difficult to test this hypothesis in the field, because it would involve watering plots when seed is applied and until seedlings are established. Alternatively, provision of a little shade might be possible in an experimental plot, and the use of kanuka slash with ripe but unopened capsules could be considered as both the seed and shade source.

Herwi Scheltus (DOC Turangi, pers. comm.) advises that he has had no success in establishing kanuka from slash, though the system works well for manuka (=kahikatoa). Scheltus's failure may have been because of the much lower seed production in kanuka than manuka, or the critical timing of the release of seed from kanuka capsules.

The remoteness of Pretty Bush makes investigations of any of these factors difficult. From a practical point of view, it will be easier for managers to accept that there will be only one year in five (or eight, or ten, or whatever) in which kanuka will establish naturally, and not worry about trying to enhance this aspect of the succession. The main short-term objective of management would be then to have marram swards ready as a kanuka habitat, for the times that kanuka seed arrives and conditions favour seed germination and establishment.

3.3 WESTERN DUNE LAKES (STICK LAKE, AND UNNAMED LAKES NORTH OF LAKES MOKENO AND KARAKA)

3.3.1 Origins of dune lakes

These lakes are dealt with as a group because of the similarities in their physical origins, landforms, and patterns of recent change which have led to perceived threats to their future.

The central axis of Pouto Peninsula is rolling hill country up to more than 200 m in altitude, which formed from sands blown from the exposed seabed to the west, during periods of lowered sea level during the Quaternary (Schofield 1969). The eastern side is dominated by early Pleistocene sands and clays (loc. cit.). The western side comprises Holocene fixed dunes (loc. cit.), the base of which represents a sea coast against which more recent, low-relief sand dunes have built up. Sand continues to accumulate on the coastal edge of these dunes.

A string of lakes and swamps is sandwiched between the recent dunes and the Holocene fixed dunes. In addition, sand is continually being blown inland from land behind the foredunes (dune deflation) until the water table is reached. This process results in broad sand plains behind the fore-dunes, which become swamps or shallow lakes, as described for the Manawatu coast by Esler (1969, 1970). The western Pouto dunes, therefore, have two strings of wetlands parallel to the coast: young, shallow swamps and lakes behind the fore-dunes, and older, deeper lakes against the hill country.

It has been shown for the Manawatu region (Cowie 1963) that phases of land clearance by humans are correlated phases of sand instability and dune formation. Widespread burning of native vegetation by Polynesians occurred some 750 years ago, and the mid-1800s saw a new phase of land clearance when European settlers arrived in large numbers. Cowie (1963) related the 750 year b.p. dunes to on-site burning, and the 150 year b.p. dunes to land clearance in the river catchments, which mobilised more sediment to the coast.

However, because the Maori also cleared forest from inland country (e.g. in Hawkes Bay where the Manawatu River rises), and European settlers cleared secondary growth from the dunes, Cowie's (1963) separation of the sources of sand is probably not as clear as he stated. Today the Manawatu coast is in a phase of new dune formation, which can be correlated with hill country clearance over the past few decades.

Dune-forming events in the Manawatu are likely to have parallels in Northland. Much or all of the low-relief, young dunes and wetlands on the west side of Pouto Peninsula, i.e., those west of Schofield's (1969) Holocene fixed dunes, probably postdate human arrival. This needs to be recognised in any attempt to halt or reverse current trends in sand movement. In both time and location, the causes of sand movement may lie well away from where the "problems" are observed.

3.3.2 *Recent sand movements and dune lakes*

Fred Brook (pers. comm., DOC, Whangarei) notes that early aerial photographs of the Pouto Peninsula show crescent-shaped dunes. These are largely gone now, because the sand was re-mobilised after burning of the vegetation cover. The timing of the fires could not be determined from our inspection, but the type of vegetation can be inferred from the composition of remnants of woody vegetation which escaped fire. Pretty Bush is obviously one example, but dune forest was probably already rare when Europeans arrived. What was almost certainly widespread was kanuka scrub. Remnants still occur at Stick Lake and on the hind dunes around wetlands we inspected near "Camp Stream", north of Lake Karaka (Fig.2).

It is very likely that most of the sand which is currently entering various western Pouto lakes is sand which has been re-mobilised by burning of kanuka-dominant scrub on the dunes. We saw several lakes, including Stick Lake, in which there is a vegetated buffer between the fore dunes and the unstable hind dunes. In such cases, accretion of fore dunes cannot be blamed for the encroachment of sand into the hind dune lakes.

Any management to "save" the string of lakes against the old coastline should be directed at restoring vegetation cover on the hind dunes. As at Pretty Bush, marram is already at most sites. However, little evidence was seen near the western lakes of a natural spread of kanuka into areas of marram. Sand is also tending to build very high and very steep dunes against the base of the old coast, and marram is likely to exacerbate this (Esler 1970). Steep marram dunes in the Manawatu inevitably become oversteep and blow out again.

There were several patches of spinifex on hind dunes on the coastal side of a lake immediately inland of Camp Stream, and a trial use of urea (see under Pretty Bush, above) could be made here. Rabbits are browsing the spinifex at this site.

3.3.3 *Wetlands of the sand plains*

A distinction was made above between wetlands occupying parts of the sand plain (i.e., dune slacks) and those against the old coastline. Stick Lake and a lake directly inland of the campsite at Camp Stream are examples of dune slack wetlands. They show evidence of a complex and dynamic history, in that sand is obviously entering both the lakes from the coastal side, yet dead standing kanuka in the lakes shows either that the water level has risen in the lake, or that the lake has "moved" recently to flood what was previously dryland (Fig 2). Without data on the timing and rate of these events it is difficult to give any advice on how to manage the processes to maintain habitat, e.g. for waterbirds.

As stated earlier, the dune slacks contain swampy areas as well as lakes with open water. These swamps were surface-dry during our visit, but they undoubtedly have surface water in some seasons. Ephemeral wetlands of this type have plant communities not duplicated in permanent wetlands (Ogle 1991).

Peter Anderson and I walked along a portion of moist dune slack near Camp Stream. The main plant of the slack is jointed wire-rush, among which we found a previously unrecorded population of *Thelypteris confluens.* This fern has a "rare" national status (Cameron et al. 1995).

The slack was found to be more weedy than the best comparable areas on the Wanganui-Manawatu coast. The biggest single threat is pampas grass, a species for which control measures exist. Near Wanganui, DOC staff in the period 1989-92 eradicated mature pampas from a 250 ha Scientific Reserve in dunes at the Whangaehu River mouth. An annual mopping up of seedlings is still done. Large pampas plants were cut at about 0.5m above the ground, using a chainsaw, and glyphosate (1.25%) was sprayed on to the cut stump immediately. Kill rates were better in spring (September-October) than in winter (July-August), but any regrowth and young plants were easily sprayed during the following summer (C Edwards, R Halsey, pers. comm.). The same herbicide is effective if sprayed on the uncut foliage of whole plants, but the risks to other vegetation are greater and more spray is used.

On wet sand at a lake edge, immediately inland from Camp Stream, we found a patch of African feather grass (*Pennisetum macrourum*). It occupied a zone between raupo and marram. African feather grass is a Class B noxious weed in Northland.

3.3.4 Lake edge plant communities

The edges of lakes with fluctuating water levels also function as ephemeral wetlands. A greater range of microhabitats is possible on a lake edge than on most flat sand plains, because a lake provides sites which have all degrees of wetness from permanently submerged to totally dry.

Because of its considerable changes in water levels and shallow nature, Stick Lake has a particularly good example of native turf vegetation, in which weeds are uncommon and inconspicuous. As at the edge of L Humuhumu (see 3.1 above), the main turf plants are *Glossostigma elatinoldes, Lilaeopsis* sp., water milfoil, and red pondweed, each being locally dominant in different zones. At higher levels on the shore, sharp spike sedge enters the turf vegetation and, beyond this, the turfs give way to reed beds, variously dominated by bamboo spike sedge (=kutakuta), kapungawha, raupo, jointed twig-rush, *Baumea juncea*, or swamp millet with swamp willowweed.

Although the above description was made at Stick Lake, it is possibly a pattern which is repeated at other dune lakes in the area. More detailed botanical surveys are needed to record the full range of wetland communities at Stick Lake and elsewhere. In the meantime, the conservation of native vegetation should be considered in any attempts to manage Stick Lake for waterbirds, for it has plant communities which might be among the best of their type in the region.

3.3.5 Managing dunes to preserve wetlands

It should be possible to prioritise dunes for active management along the western coast of Pouto Peninsula, on the basis of immediate threat to wetlands

and the ease with which sand stabilisation might be achieved. The latter depends upon factors such as the extent of the "feeder" area for the active dune, i.e., is the dune likely to grow or advance quickly because there is a large amount of unstable sand linked to its coastal side?

Any attempt to manage these western dunes should:

(a) be small-scale and experimental, in the first instance;

(b) prioritised in terms of risk and practicability for any larger scale work;

(c) use native sand binders (perhaps as well as marram in different sites);

(d) be accompanied by control of rabbits.

3.4 PINGAO

Peripheral to the main objectives of the dune and wetland inspection was the concern by some staff of Northland Conservancy that pingao had entered a phase of widespread die-back. We saw many examples of colonies which comprised nothing more than a mass of dead black stems, a few that were almost dead but which retained some unthrifty shoots with leaves, and only a very small number of colonies where almost all the stems had foliage. This is in marked contrast to the state of pingao on dunes of the Manawatu and Wanganui coasts, where the plant is common and seemingly healthy. My memory of dunes in Te Paki ecological region in 1990 and earlier is of similarly vigorous pingao.

There are various reasons why pingao might be in its current degenerate state. Competition from other species such as marram does not appear to be a factor and browsing seems negligible. Drought may be a factor, and rainfall records could be consulted to give some insight to this possibility. Another possibility is disease. Samples of dead and dying pingao were collected and sent to Dr John Herbert of FRI Rotorua. No evidence of pathogens was found.

Another possible cause of pingao dieback has been suggested to me by Peter de Lange since my Pouto inspection. He and Trevor Partridge (Landcare Research, Lincoln) believe that a seemingly similar phenomenon at Kaitorete Spit, Canterbury, and a number of other places, is the result of nutrient deficiencies, which in turn are a consequence of increasing dune stability with the passage of time. If this is the cause, the dieback at Pouto can be regarded as a natural process. The dying and dead pingao areas are in the same dunes which contain the unthrifty marram discussed above (3.2.5 [a]).

In the past, pingao would have been replaced by native plants of later seral stages. Today, the areas of pingao dieback are isolated from sources of other seeds, because of past fires, grazing, and re-mobilised sand. Sites with dead pingao are potentially new places where wind can re-mobilise the sand.

It should be possible to show experimentally whether nutrient availability is critical to the survival of pingao on Pouto. In the course of experimental fer-

tiliser trials near Pretty Bush (3.2.5 [a]), several patches of unthrifty pingao could be used to test the effects of adding nutrients to some patches. Subsequent growth can be monitored by measurements of individually marked rhizomes and by photographs, of both treated and untreated plants. If fertiliser induces improved growth of pingao the Pouto dunes have considerable scope for extending managed pingao areas.

Pingao is a most important species in dune ecology, and its welfare is also of concern for its cultural uses. *Desmoschoenus* is a monotypic genus endemic to New Zealand, which makes its importance on a level with monotypic endemic animal genera, such as *Anarhynchus* (wrybill).

4. Summary

- Pouto Peninsula has dune plant communities (dry dunes and wetlands) of regional and national importance
- Dunes and dune communities are inherently dynamic - natural processes involving moving sand should be allowed to continue wherever possible
- Many of the natural communities are at immediate risk from sand movement which has been accelerated by human interference
- The causes of accelerated sand movement are complex, some of which lie in prehistoric and historical events
- Specific management techniques for revegetating sand areas which threaten important natural areas could be trialled (research by management). These include:
  - fertilising key patches of marram grass, spinifex and pingao to improve their growth
  - enhancing natural establishment of kanuka seedlings
  - control of rabbits
  - monitoring of sand movement in important places where no immediate management is done
- Wetlands should not be managed for wildlife alone; native vegetation needs to be considered
- Weeds, most notably pampas grass, need at least local control to protect examples of natural plant communities and colonies of threatened and local plants

- Further biological survey is needed to show whether the wetland plant communities that we saw were representative of the peninsula and whether other colonies of threatened species remain unrecognised to date.

5. Acknowledgements

I wish to thank Ray Pierce and other staff of Northland Conservancy who assisted in any way with this investigation, for their help, advice and companionship. Because Wanganui Conservancy also has so much sand country, the experience I gained from the Pouto survey has been invaluable to me for making comparisons about dune and vegetation dynamics, native flora and fauna of dune country and management problems, especially weeds. I especially thank Peter de Lange (Science and Research, DoC, Auckland) for his detailed advice on a draft of this paper, and the comments of many other colleagues were also appreciated.

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APPENDIX 1: Formal names for plants named in the text

Common Name	*Formal Name*
African feather grass	*Pennisetum macrourum*
akeake	*Dodonaea viscosa*
bamboo spike-sedge	*Eleocharis sphacelata*
club sedge	*Isolepis nodosa*
coastal karamu	*Coprosma macrocarpa*
common lancewood	*Pseudopanax crassifolius*
fierce lancewood	*Pseudopanax ferox*
houpara	*Pseudopanax lessonii*
jointed twig-rush	*Baumea articulata*
jointed wire-rush	*Leptocarpus similis*
kahikatoa	*Leptospermum scoparium*
kanuka	*Kunzea ericoides*
kapungawha	*Schoenoplectus validus*
karaka	*Corynocarpus laevigatus*
kohekohe	*Dysoxylum spectabile*
korari	*Phormium tenax*
korokio	*Corokia cotoneaster*
kuawa	*Schoenoplectus validus*
kukuraho	*Bolboschoenus fluviatilis*
kutakuta	*Eleocharis sphacelata*
mahoe	*Melicytus ramiflorus*
mamaku	*Cyathea medullaris*
manuka	*Leptospermum scoparium*
marram (marram grass)	*Ammophila arenaria*
narrow-leaved maire	*Nestegis montana*
native broom	*Carmichaelia cunninghammi* var.
pampas (pampas grass)	*Cortaderia selloana* and/or *C. fubata*
pine	*Pinus radiata*
pingao	*Desmoschoenus spiralis*
purua	*Bolboschoenus fluviatilis*
raupo	*Typha orientalis*
red pondweed	*Potamogeton cheesemanii*
small-leaved pohuehue	*Muehlenbeckia complexa*
sharp spike sedge	*Eleocharis acuta*
spinifex	*Spinifex sericeus*
swamp millet	*Isachne globosa*
swamp willow weed	*Polygonum salicifolum*
titoki	*Alectryon excelsus*
toetoe	*Cortaderia spendens*
tororaro	*Muehlenbeckia complexa*
totara	*Podocarpus totara*
water milfoil	*Myriophyllum propinquum*
willow-herb	*Epilobium billardiereanum*
Yorkshire fog	*Holcus lanatus*

APPENDIX 2: Indigenous vascular plants of three forest areas on dunes:

(a) Pakipaki, near Hokio, Levin, Horowhenua district (Druce 1972 [1991 revision]; Cooksley and Townsend 1992; Rapson et al. 1992; pers. obs. 1991, 1996)

(b) Pretty Bush, Pouto Peninsula, north head of Kaipara Harbour, Northland (Forester and Beechman 1987; Wright 1991; pers. obs. 1994)

(c) Tapu Bush, Pouto Peninsula, Kaipara, Northland (Miller 1992; Reid 1977; Wright and Young 1991)

X = recorded as present
(X) = previously present (now extinct on site)
O = not within recorded geographic range for this species

GYMNOSPERMS

		Pakipaki	Pretty	Tapu
Dacrycarpus dacrydioides	kahikatea	X		
Podocarpus totara	totara	X	X	X
Prumnopitys ferruginea	miro		X	
Prumnopitys taxifolia	matai	X		

MONOCOT TREES

Cordyline australis	ti kouka, cabbage tree	X	X	X
Rhopalostylis sapida	nikau			X

DICOT TREES AND SHRUBS

Alectryon excelsus	titoki	X	X	X
Beilschmiedia tarairi	taraire	O		X
B. tawa	tawa			X
Brachyglottis repanda	rangiora	(X)		X
Carmichaelia australis	NZ broom	X	X	X
Carpodetus serratus	putaputaweta			X
Cassinia leptophylla (incl. *C. retorta)*	tauhinu	X	X	X
Coprosma acerosa	sand coprosma	X	X	X
C. areolata		X		X
C. crassifolia		X	X	X
C. grandifolia	kanono, raurekau		X	X
C. lucida	shining karamu		X	X
C. macrocarpa	coastal karamu	O	X	X

C. propinqua		X		
C. parviflora s.s.		O		X
C. rhamnoides		X	X	X
C. rigida		X	?	X
C. robusta	karamu		X	X
C. spathulata				X
C. macrocarpa x C. robusta			X	
Coriaria arborea	tutu	X		
Corokia cotoneaster	korokio	X	X	X
Corynocarpus laevigatus	karaka		X	X
Cyathodes juniperina	prickly mingimingi	X	X	X
Discaria toumatou	matagouri	(X)	O	O
Dodonaea viscosa	akeake	X	X	X
Dysoxylum spectabile	kohekohe		X	X
Elaeocarpus dentatus	hinau	X[1]		X
Gaultheria macrostigma		(X)	O	O
Geniostoma rupestre ssp. *ligustrifolium*	hangehange	X	X	X
Hebe stricta var. *stricta*	koromiko	(X)	X	X
H. sp. (*H. diosmifolia* agg.)		O	X	X
Hedycarya arborea	pigeonwood	X		
Ileostylus micranthus	mistletoe	(X)		
Knightia excelsa	rewarewa	X	X	X
Korthalsella salicornioides	dwarf mistletoe	(X)		
Kunzea ericoides s.l.	manuka	X	X	X
Laurelia novae-zelandiae	pukatea			X
Leptospermum scoparium	manuka	X	X	X
Leucopogon fasciculatus	mingimingi	X	X	X
L. fraseri	patotara	(X)		
Litsea calicaris	mangeao	O		X
Lophomyrtus bullata	ramarama			X
L. obcordata	rohutu	X	X	X
Macropiper excelsuin	kawakawa	X	X	X
Melicope ternata	wharangi			X
Melicytus micranthus				X
M. ramiforus	mahoe	X	X	X
Metrosideros robusta	northern rata			X
Myoporum laetum	ngaio	X		
Myrsine australis	mapou	X	X	X
M. divaricata	weeping mapou			X
Nestegis lanceolata	white maire	X[2]	X	X

[1] Druce (1972, 1991) recorded *Elaeocarpus dentatus*; Cooksley and Townsend (1992) recorded *E. hookerianus* in their species list (p. 65), but *E. dentatus* in their figure on p. 67, and have told me (pers. comm. 1996) that *E Hookerianus* was an error; Rapson *et al.* (1992) recorded *E. hookerianus* only. I have seen *E. dentatus* only. No observer has recorded both species unambiguously, so *E. dentatus* only is retained at present on the above list.

[2] The only *Nestegis* species recorded by Druce (1972, 1991) is *N. montana,* a species I also saw at Pakipaki in 1991 and 1996, along with *N. lanceolata.* Cooksley and Townsend (1992) and Rapson *et al.* (1992) record *N. cunninghamii* (but not *N. montana*), and Rapson *et al.* also list *N. lanceolata. N. cunninghamii* may be an error for *N. lanceolata* and is not retained in the above list.

N. montana	narrow-leaved maire	X	X	X
Olearia albida		O	X	X
O. furfuracea	akepiro	O	X	X
O. paniculata	akiraho	X		
O. rani	heketara			X
Pennantia corymbosa	kaikomako	X		
Pimelea tomentosa		(X)		
Pittosporum tenuifolium s.l.	kohuhu	X	X	X
Pomaderris ericifolia		(X)		X
Pseudopanax arboreus	five finger	(X)	X	X
P. crassifokus	lancewood	X	X	X
P. ferox	fierce lancewood		X	X
P lessonii	houpara	O	X	
P. crassifolius x P. lessonii			X	
P. ferox x P. lessonii			X	
Schefflera digitata	pate		X	
Sophora microphylla	kowhai	X	X	X
Streblus heterophyllus	small-leaved milk tree			X
Vitex lucens	puriri	O		X

DICOT LIANES

Clematis cunninghamii		O		X
C. forsteri		X		
C. paniculata		X		
Metrosideros diffusa	white rata vine, aka			X
M. perforata	white rata vine, aka			X
Muehlenbeckia australis	pohuehue	X		
M. complexa	small-leaved pohuehue	X	X	X
Parsonsia capsularis	NZ jasmine	X	X[3]	X[3]
P. heterophylla	NZ jasmine	(X)		
Rubus australis	bush lawyer	(X)		
R. cissoides	bush lawyer	(X)		X
R. schmidelioides	bush lawyer	X		
Tetragonia trigyna	NZ spinach	X		

MONOCOT LIANE

Ripogonum scandens	supplejack	X		

[3] Most references for the Northland forests do not identify the *Parsonsia* to species level, except that Reid (1977) listed *P. heterophylla* and not *P. capsularis*. Broad-leaved forms of *P. capsularis* are locally common in Northland, and only the latter is retained in the above list.

FERN ALLY

Lycopodium varium	clubmoss			X

FERNS

Adiantum aethiopicum	maidenhair fern			X
A. cunninghamii	maidenhair fern		?	X
A. hispidulum	rosy maidenhair		X	X
Asplenium flabellifolium		X		
A. flaccidum	hanging spleenwort	X	X	X
A. gracillimum		X	X	X
A. hookerianum		X		X
A. oblongifolium	shining spleenwort	X	X	X
A. polyodon	sickle spleenwort	X	X	X
A. flaccidum x A. gracillimum		X		
Blechnum filiforme	climbing blechnum			X
Cyathea dealbata	ponga			X
C. medullaris	mamaku	(X)	X	X
Dicksonia squarrosa	wheki	X		
Doodia media	pukapuka		X	X
Grammitis ciliata				X
Hymenophyllum bivalve		(X)		
H. dilatatum			X	X
H. flexuosum				X
H. multifidum		(X)		
H. revolutum				X
H. sanguinolentum		(X)	X	X
H. scabrum				X
Hypolepis ambigua		(X)		
Paesia scaberula	ring fern	X	X	
Pellaea rotundifolia	button fern	X	X	X
Phymatosorus pustulatus	hound's tongue fern	X	X	X
P. scandens				X
Polystichum richardii		X	X	X
Pteridium esculentum	bracken	X	X	X
Pteris tremula	shaking brake	X	X	X
Pyrrosia eleagnifolia	leather leaf fern	X	X	X
Trichomanes reniforme	kidney fern	(X)	X	X

MONOCOT HERBS

Acianthus sinclairii		X	X	X
Astelia solandri	perching lily		?	X
A. trinervia	kauri grass	O		X
Bulbophyllum pygmaeum				X
Caladenia catenata (.?)		(X)		
Carex dipsacea		(X)		
C. dissita		(X)		

C. virgata		X		
C. sp. (cf *C. raoulii, C. testacea*)[4]		X	X	X
Chiloglottis cornuta		X		
Collospermum hastatum	perching lily			X
C. microspermum	perching lily			X
Cortaderia splendens	toetoe	O	X	X
Corybas cheesemanii		(X)		
C. trilobus agg.	spider orchid	X	X	X
Cyperus ustulatus		X		
Cyrtostylis oblonga		X		
Dendrobium cunninghamii	bamboo orchid			X
Dianella nigra	turutu		X	X
Drymoanthus adversus		X		X
Earina autumnalis	autumn orchid		X	X
E. mucronata		X	X	X
Echinopogon ovatus	hedgehog grass	X		
Gahnia setifolia				X
G. xanthocarpa				X
Gastrodia minor		(X)		
Isolepis nodosa	club sedge	X	X	X
I. reticularis?			X	
Lepidosperma australe	four square	(X)		
L. laterale		O		X
Luzala picta s.s.	woodrush	X		
Leptocarpus similis	jointed wire-rush			X
Microlaena polynoda	bamboo ricegrass		X	X
M. stipoides	meadow ricegrass	X	X	X
Microtis unifolia	onion-leaved orchid	X		
Morelotia affinis				X
Oplismenus imbecillus			X	X
Phormium tenax	harakeke, NZ flax		X	X
Poa anceps s.l.		X	X	X
P. pusilla				X
Pterostylis alobula	greenhood orchid	X	X	X
P. montana s.l.	greenhood orchid	(X)		
Rytidosperma gracile	danthonia			X
Schoenus tendo		O		X
Uncinia banksii	hook grass		?	X
U. distans	hook grass		X[5]	
U. uncinata	hook grass	X	X	X
U. zotovii	hook grass			X

[4] This unnamed *Carex* species has double-folded leaves (similar to those of *C. raoulii)* and, like *C. testacea,* has glabrous (not hispid) utricles, and the male spikes without fruits at their distal ends. The unnamed species seems to be largely coastal or semi-coastal. I lodged a CHR voucher from Pretty Bush.

[5] Most plant lists from Pretty Bush contain one *Uncinia* species in addition to *U. uncinata* (Wright 1991 recorded "*U. ?rubra/scabra*" and Forester and Beachman recorded *U. banksii).* In 1994 I saw only one fine-leaved species of *Uncinia* in Pretty Bush, *U. distans.*

DICOT HERBS

Acaena anserinifolia	bidibidi	(X)			
Cardamine debilis agg.	bittercress	X			
Dichondra repens	Mercury Bay weed	X			
Drosera peltata ssp. *auriculata*	sundew	(X)			
Galium propinquum		X			
Gnaphalium gymnocephalum	cudweed	X			
Gonocarpus incanus					X
Hydrocotyle moschata	hairy pennywort	X			
Lagenifera pumila		X			
Oxalis exilis	creeping oxalis	X			
Parietaria debilis		X			
Pseudognapbalium sp. (*P. luteo-album* agg.)	cudweed		X		
Ranunculus reflexes	bush buttercup	X			
Senecio bispidulus	fireweed	(X)			X
S. minimus	fireweed	(X)			X
S. quadridentatus		(X)			
Solanum americanum	small-flowered nightshade	X	X		X
Stellaria decipiens		(X)			X
Urtica incisa		(X)			

DOUBTFUL RECORDS

NAME USED	AUTHOR(S)[6]	PLACE	PROBABLE IDENTITY
Agropyron scabrum	C Duguid 1990)	Pakipaki	*Glymus rectisetus* (adventive; see Connor 1994,
Asplenium bulbiferum	Ra, Re	Pakipaki,Tapu	*A. gracillimum*
Asplenium bulbiferuin x *A. faccidum*	C	Pakipaki	*A. faccidum x A. gracillimum*
Astelia banksii	Re	Tapu Bush	*A. solandri?*
Carex fuviatilis	C	Pakipaki	?
Carex littoralis	C	Pakipaki	?
Carex testacea	Wr, Wy	Pretty, Tapu	*Carex* sp. unnamed (see plant list above)
Cladium baumea	C	Pakipaki	? etiolated *Isolepis nodosa*
Coprosina lucida x C. macrocarpa	F	Pretty	? *C. macrocarpa x C. robusta*

6 C = Cooksley andTownsend (1992);F = Forester and Beachman (1987,1990); M = Miller (1992); Ra = Rapson et al. (1992); Re = Reid (1977); Wr = Wright (1991); Wy = Wright and Young (1991)

Cortaderia fulvida	M	Tapu Bush	*C. splendens?*
Elaeocarpus hookerianus	C, Ra	Pakipaki	*E. dentatus*
Hydrocotyle elongata	C	Pakipaki	*H. moschata?*
Isachne globosa ("small bush grass")	M	Tapu Bush	? *Oplismenus imbecillus*
Mida salicifolia	C	Pakipaki	*Nestegis* sp. or spp.
Nestegis cunninghamii	Ra	Pakipaki	*N. lanceolata*
Parsonsia heterophylla	Re	Tapu Bush	*P. capsularis?* (see footnote)
Pterostylis areolata [reported seen 13.7.92]	Ra	Pakipaki	*P. alobula?*
Sophora tetraptera	C	Pakipaki	*S. microphylla*
Stellaria gracilenta	C	Pakipaki	*S. decipiens?*
Uncinia banksii	F	Pretty	*U. distans?*
Uncinia "rubra/scabra"	Wr	Pretty	*U. distans?*
Urtica linearifolia	C	Pakipaki	Not in forest portion?
Wahlenbergia gracilis	C	Pakipaki	*W. marginata* (adventive to NZ)