

The sand dunes of Kawakaputa Bay and Haldane Bay, Southland

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1. Background

The Conservation Estate, administered by the Department of Conservation (DOC), contains areas of land of undetermined conservation value. These include coastal lands, obtained and managed by the Government of the day for other than conservation purposes. One such purpose was to stabilise coastal sand dunes where drifting sands presented a hazard to adjacent railway lines or roads. The Sand Drift Act 1908 was enacted to facilitate this process.

At Kawakaputa Bay approximately 60 ha of land was obtained by the Crown and planted in marram to protect the adjacent railway from drifting sands. These lands, today vegetated and semi-vegetated sand dunes, are currently grazed by sheep and cattle in accordance with a grazing concession. The character of the Kawakaputa Bay dunes is of interest to DOC (Southland) because of the potential to restore a mountain-to-the-sea landscape incorporating: the coastal dunes; adjacent remnant kamahi-broadleaf forest on former dunes; lakes; wetlands; and the plant and forest communities of the Longwood Range. The botany of the DOC lands has been described by Johnson (1984) but to date there has been no assessment of the distinctiveness of the coastal landforms present or the impact of grazing on these landforms. There is also interest in the potential to restore pingao (*Desmoschoenus spiralis*) should stock be removed from the dunes.

A very similar situation exists at Haldane Bay in eastern Southland. At this location Crown land covers an area of approximately 144 ha and extends from the Haldane Bay foreshore to the "Reservoir" in the north and Blue Cod Bay in the east. As with Kawakaputa Bay the site has significant botanical values (Range 1995) but there has been no assessment of the character or geomorphic significance of the dunes.

The purpose of the current study is, therefore, to:

1. provide a description of the landforms and processes at Kawakaputa Bay and Haldane Bay;
2. provide an assessment of the geomorphic distinctiveness and representativeness of the dune landforms at these locations;
3. evaluate the impact of landuse options (specifically, grazing and non-grazing); and
4. recommend management options for marram control and pingao restoration.

2. Landforms and geomorphic processes

2.1 ENVIRONMENTAL SETTING

Kawakaputa Bay lies between Riverton and Te Waewae Bay on Foveaux Strait at latitude 46.5°S. Kawakaputa Bay, Colac Bay and Oreti Bays are defined by a series of headlands composed of gabbro-granitic rocks (Longwood Intrusives). Kawakaputa Bay is enclosed by Wakaputa Point to the west and Oraka Point to the east. The apex of the embayment, which is symmetrical, is some 2 to 2.5 km north of the headlands.

This coast is exposed to the prevailing southwest and westerly winds and is one of the windiest places in New Zealand. Approximately 46 per cent of the winds recorded at Centre Island (11 km south of Kawakaputa Beach) arrive from the southwest or west; 33 per cent of winds with speeds of 11 knots or greater come from these directions; 52 per cent of winds of 21 knots or greater come from these directions; and calm periods are infrequent (5 per cent) (Rennie 1980). Mean annual precipitation is around 1150 mm.

The tidal environment is meso-tidal and semi-diurnal with a mean spring tide range of 2.1 m. Swell waves arrive from the southwest with periods of between 6 and 16 seconds and heights of 1 to 5 metres. Refraction of waves around headlands has been examined by Rennie (1980), who concluded shoaling waves are unlikely to initiate alongshore littoral sediment drift within Kawakaputa Bay. The easterly movement of sediments within embayments is more likely to occur by aeolian processes in the dune environment.

The Kawakaputa embayment has experienced substantial coastal progradation during the late Quaternary. Since no major rivers enter Kawakaputa Bay, the beach and dune sands are most probably derived from the sediments of the seafloor of Foveaux Strait during and following the last marine transgression.

In summary, the Kawakaputa study area lies within an embayment exposed to strong onshore and alongshore southwest and westerly winds. The centre and eastern areas of Kawakaputa Bay are relatively exposed to these winds. Contemporary sediment supply to this coast is likely to be low.

Haldane Bay is located close to the southern tip of the South Island (Slope Point) close to the eastern limits of Foveaux Strait. The environmental context is remarkably similar to Kawakaputa Bay. This section of the Catlin's Coast may experience some shelter from Stewart Island (Rakiura) during southwest conditions, but the difference is probably of no geomorphic significance. The fetch from Haldane Bay to the west through Foveaux Strait is unlimited. The Haldane Estuary enters Haldane Bay at the western end of the Bay but the catchment is small and probably contributes minor amounts of sediment in the sand size grade.

2.2 COASTAL LANDFORMS AND PROCESSES

The dunes in Kawakaputa Bay and Haldane Bay result from conditions commonly found along exposed sandy coasts: onshore or alongshore winds; significant volumes of sediment supplied (at some time) to a wide sandy beach; sand-binding vegetation and a hinterland topography conducive to the landward transport of sediment. Of these conditions the last is the least influential. The climbing dunes of the west coast of Stewart Island at West Ruggedy and Big Hellfire and The Sisters (near Bluff) show that wind-blown sand is able to transgress very steep topography in southern New Zealand.

The Holocene geomorphology of Kawakaputa Bay has been discussed by Johnson (1994). The sequence of events he proposes (summarised in his figure 1) is, in general, consistent with the contemporary pattern of landforms and soils and my own interpretation, with one major exception. The episode of coastal progradation that impounded Lake George and deposited sediments to form a terrace along much of the south coast is of last interglacial (Pleistocene) age (Wood 1966) rather than Holocene age as Johnson implies. In summary the development of the Kawakaputa Bay landscape has involved the following episodes:

- i. deposition of marine and fluvial sediments during the last interglacial (c. 120 000 y B.P.) when sea level was 2-8 m above modern mean sea level;
- ii. erosion of the seaward edge of the Pleistocene deposits following the culmination of the last marine transgression (c. 6500 y B.P.);
- iii. development of a simple foredune complex, perhaps 50-100 m wide under pingao, with occasional episodes of instability, blowout development and landward sand movement (until c. 1850);
- iv. disturbance of the Kawakaputa Bay foredune, blowout and parabolic dune formation with dunes reaching 1.5 km inland (c. 1850-1910);
- v. introduction of marram grass, lupin and (later) pasture grasses following Crown purchase, resulting (over the next 90 years) in the stabilisation of the transgressing parabolic dunes and accretion of a marram-dominated foredune complex.

Dunes are an important element of the landscape of the eastern half of Kawakaputa Bay but are relatively minor foredunes along most of the western half of Kawakaputa Bay. In contrast the eastern dunes extend inland between 100 m (adjacent to Ourawera Stream) and 900 m near Dryden Road. The explanation is straightforward. The western side of Kawakaputa Bay is afforded significant protection from prevailing winds by the hill country south of Wakaputa Road. Furthermore, shoaling waves lose some of their energy and ability to transport sediments as they are refracted around Wakaputa Point and adjacent subtidal reefs. Less sediment is delivered to the coast, and the ability of winds to transport sediment off the beach is also reduced. The landscape of Kawakaputa Bay, specifically beach form and dune forms, therefore comprises two geomorphic regimes: the sheltered coast west of the beach

access off Round Hill Road and, secondly, the relatively exposed coast east of this point. The bays to the east of Kawakaputa, Colac and Oreti have a similar character.

The dunes of the eastern half of Kawakaputa Bay comprise two types - a geomorphically active foredune (complex) bordering the beach and, secondly, stabilised parabolic dunes to landward.

Foredunes are a characteristic feature of many sandy coasts. The foredune borders the beach and therefore receives sediment blown from the beach during episodes of strong onshore winds. Sand is trapped in the foredune by the primary sand-binding plant species (pingao or, more commonly in Otago and Southland, marram). On a prograding coast new foredunes may form, producing, over time, a sequence of dune ridges (e.g. eastern Oreti Beach). On coasts that are not prograding or are in dynamic equilibrium with the environment, with movements landward or seaward about a mean position, a single large foredune (or complex of dune elements constituting a "foredune") may develop. It is likely that the dune landscape along Kawakaputa Bay was dominated by such a feature early last century.

The modern foredune is a complex of features characteristic of marram-covered foredunes. It attains maximum dimensions midway between Ourawera Stream and the eastern end of Kawakaputa Bay. It is a minor feature west of the stream and along the eastern 400-500 m of the beach. The foredune was described by Johnson (1984) as a marram-dominated feature approximately 100 m wide and up to 8 m in elevation. The foredune complex has since increased in elevation (by, say, 3-5 m) but is still approximately 100 m wide. The numerous small blowouts and associated depositional lobes have created a chaotic topography across the foredune typical of marram-covered dunes.

Marram grass appears to be actively colonising a strip of sand, approximately 80 m wide, that extends almost a kilometre north of Ourawera Stream. A new foredune may develop in this area, although there appears to have been little change since the 1970s. This is the source area of sand for dune development to the east, and erosion is probably severe during high-wind events. A small area of pingao is present in this area, approximately 700 m east of the Ourawera Stream.

Parabolic dunes develop from blowouts caused by disturbance of foredunes or other dune forms. They develop in conditions of limited sediment supply, the presence of sand-binding vegetation, and subdued hinterland topography. The Kawakaputa Bay parabolic dunes display the characteristic features of the dune type - parabolic configuration, deflation zones, trailing arms, and depositional lobes. There are two very large examples, with longitudinal dimensions of 600-900 m and widths of 200-250 m, and several smaller and less distinct examples. The parabolic dunes of the mid bay comprise unconsolidated sands of late Holocene age and are very well-defined features. An older and very much less distinct example transgresses the last-interglacial marine terrace towards the eastern end of the bay.

The parabolic dunes are at an acute angle to the coast, in contrast to, for example, the parabolic dunes of Mason Bay. The angle relative to the shore-

line varies between 5 and 60 degrees. Interestingly the angle becomes less acute towards the east. The longitudinal axis of the parabolic dune adjacent to Ourawera Stream is oriented at an angle of 5° to the shoreline (a little south of due west). The older parabolic dune discussed above is oriented at an angle of 60° (approximately southwest). The orientation of these dunes is due to the angle of the shoreline relative to the prevailing westerlies. The variation in orientation is unusual - it is probably related to local variations in wind direction caused by the hill country west of Kawakaputa Bay.

The parabolic dunes appear relatively recent features that have become progressively vegetated and stabilised since the 1950s (though a few small patches of bare sand associated with farm tracks remain). Though there has been some secondary dune development and minor instability, the introduction of marram has effectively "frozen" these dunes. Comparison of aerial photographs taken in 1952, 1976 and 1996 suggests the form of the dunes has changed little since the early 1950s. The vegetation cover has changed in that time from marram and lupin to pasture grasses (landward of the modern marram foredune complex) but, more importantly, now almost completely covers the dunes. At the same time the source of sand for these dunes has been lost as a new marram-covered foredune has developed by trapping sand blown off the beach.

What triggered the erosion of the former foredunes and formation of these parabolic dunes? There are several possibilities. The south coast has numerous archaeological sites and it is possible the foredune vegetation was destroyed by midden fires. However, no middens were observed. Secondly, rabbits have been implicated in the degradation of the Oreti dunes, which were liberated along the Southland coast around the 1850s. Introduced stock may have contributed to or been the cause of the problem. Thirdly, the erosion of the original (pingao) foredune may have been triggered by natural events, say, a particularly severe storm (or tsunami!). Instability may also have been triggered by a combination of natural events, for example, a particularly dry summer followed by a severe southwest storm producing foreshore and dune erosion by waves and winds.

The focus of the present study is the dunefield landward of Kawakaputa Beach, but aspects of the beach itself are worthy of note. The geomorphology of the beach changes from west to east as wave energy increases. The intertidal beach west of Ourawera Stream is relatively wide, featureless and sandy. The beach east of the stream has a more complex morphology and sedimentology. The intertidal beach is sandy, narrow, steep (reflective) and capped by a gravel storm ridge. The latter is formed by gravels washed landward during episodes of high wave activity. A gravel terrace extends between the storm ridge and the base of the foredune. For most of the length of the eastern half of the beach this terrace is about 80 m wide and for the first 1000 m or so it is composed of sand. For the rest of the beach the surface of the terrace comprises well packed, stable, well rounded cobbles and gravels. The level of this section of the terrace is below the level of the storm ridge, and the resulting depressions appear relatively moist. The botany of these depressions - indeed all the gravel/cobble terrace - is most interesting as it contains a range of coastal native plant species, as a coastal turf and as isolated plants, absent from the dunes and interdune wetlands. There is a far greater number of

native plant species on this gravel terrace, including the main turf species, *Epilobium komarovianum*, than are present in either the stabilised parabolic or marram-dominated foredunes.

The degree to which the supply of sediment to the modern coast is ongoing is of interest in relation to the future development of the coastal landforms in Kawakaputa Bay. The shorelines of most similar bays along the south coast between the Clutha and Waiau Rivers appear to be prograding or relatively stable, although a few (e.g. Tahakopa Beach) have eroded over the last 20 years or so. Whether this erosion is due to some change in the nature of the coastal sediment system related to natural events or the result (or exacerbated) by human activity is seldom clear. The introduction of marram grass, for example, has significantly impacted on the geomorphology of dune systems. Finally, evidence of progradation (advance of the shoreline in a seaward direction) does not, in itself, prove that new sediment is being added to the beach (and therefore the dunes), since it might simply result from redistribution of existing sediment, as has occurred at Doughboy Bay, Stewart Island, over the last 30 years, for example.

Two studies have examined shoreline movements in Kawakaputa Bay. Gibb (1978) estimates the toe of the foredune (edge of the vegetation) advanced 20 m seaward in the period 1884-1963 at a rate of 0.25 m/y. The estimate was derived by comparing cadastral maps and is similar to the measurement error for the method employed. Rennie (1980) undertook a more detailed analysis, though over a shorter period of time, by comparing the 1952 and 1978 aerial photographs at 20 points along the Kawakaputa Bay shoreline (but excluding the 1000 m or so of beach to the east of Ourawera Stream. The change over the period ranged from -19.2 m (of erosion) to +44.8 m (of progradation), with considerable variation from site to site. For example, estimates of shoreline change for adjacent sites 13-17, located on and 1000-1300 m east of the Ourawera Stream mouth, were 0 m, 32 m, 44.8 m, 3.2 m and 0 m. In general, over the period 1952-1978, it is fairly clear that the western side of the bay has tended to erode. Sections of the shoreline of the eastern side appear to have prograded. In sum, there is no evidence for a strong long-term (say 100-year) trend in coastal progradation or erosion along Kawakaputa Bay. The changes measured in the above studies probably relate to changes in dune form and position related to the disturbance then revegetation of the coastal dunes.

3. Geomorphic distinctiveness of the dunes

The present study is partly concerned with the distinctiveness of the dunes in Kawakaputa Bay and Haldane Bay in relation to the dunes of Southland and New Zealand. Sand dunes are a common feature of most sandy coasts in New Zealand but large areas have been destroyed and/or degraded by human activity. Hilton & Macauley (1998) estimate that 70 per cent of New Zealand's

dunes have been lost as a result of afforestation, agriculture, settlement and related activities, and most remaining dunes are degraded.

Southland has lost about 33 per cent of the area of duneland, much less than most regions. The remaining dunes of Southland can be separated into two groups: the dunelands of Stewart Island and Fiordland and the dunelands of mainland Southland. The former have been relatively undisturbed by human activity; apart from the introduction of marram, which has been controlled or eradicated at many locations. The dunes of the mainland have been subject to a wider range of pressures. Almost all have well established covers of marram grass and other exotic species, but the botanical values of some mainland sites east of Fiordland, the Three Sisters and Fortrose Spit, for example, are still high.

The dunes of Southland have been recognised as being of national importance for the conservation of native duneland flora. The Sand Dune and Beach Vegetation Inventories (Partridge 1992; Johnson, 1992) identified 53 dunelands of national importance. Of these 22 (42 per cent) are located in Southland and Stewart Island. Kawakaputa Bay received a rating of 13/20. Though it scored highly for diversity of communities (and/or landforms) and presence of native species, the extent of habitat modification and weed infestation reduced the overall rating. The Inventory entry for this site does not record the interesting flora associated with the gravel berm/terrace of the eastern third of Kawakaputa Bay; the high rating for "natives" probably relates to the forest on older dunes between the parabolic dunes and the former railway line. Haldane Bay received a rating of only 7/20 (Partridge 1992), including 3/5 for community/landform diversity.

Southland and Stewart Island collectively contain a remarkable diversity of dune landscapes and dune landforms. There is no systematic classification of New Zealand dune forms, but almost all New Zealand forms known to the author are present in Southland. Large transverse dunes, a feature of the north-west coast of the North Island, are absent.

This diversity of dune forms results in large part from the wide range of coastal settings in Southland, in particular the range of embayment shapes and orientations, the general exposure of the Southland coast, and the presence of large quantities of sediment. The south and east coasts of the mainland and west coast of Stewart Island have provided a diverse range of sites for extensive dune development. In addition, there is a surprising number of dunes in Fiordland.

Two dune forms are unusual and possibly unique to Southland - the climbing dunes of the northwest coast of Stewart Island and the Three Sisters and the parabolic dunes of Kawakaputa Bay and Haldane Bay. The parabolic dunes of the two study areas are not exceptional in themselves - parabolic dunes occur at a number of sites along the exposed coasts of New Zealand and are a feature of the Manawatu coast. The distinctiveness of the Kawakaputa parabolic dunes stems from their orientation relative to the coastline. The long axis of parabolic dunes is normally oriented at 60° to 90° to the adjacent shoreline. The Kawakaputa Bay dunes are oriented at an acute angle to the shoreline. This is due to the angle of the prevailing westerly winds to the

coast. This coastal environment is unlikely to be replicated elsewhere in New Zealand.

From a geomorphic perspective the dunes of Kawakaputa Bay are of national interest and importance as a record of environmental change along the south coast of the South Island of New Zealand. They are fossil features, in that they are now stabilised by marram grass and pasture grasses. Were the modern foredune to be destabilised, a new phase of parabolic dune development might be initiated. The parabolic dunes of Haldane Bay are of similar importance.

The gravel terrace between the toe of the foredune and the storm ridge east of Ourawera Stream is an important feature of Kawakaputa Bay. This terrace supports an interesting coastal flora. The feature itself is unusual and possibly exceptional in the Southland context. Similar habitats might occur where prograding barriers composed of gravel and sand occur on exposed coasts. Some sand/gravel beaches in Fiordland may have similar gravel surfaces. These are stable pavements in which fine sediments have collected over time. Drainage is impeded.

The juxtaposition of the (apparently) stable gravel terrace, foredune complex and parabolic dunes creates a landscape of special geomorphic interest at Kawakaputa Bay. In comparison the Haldane Bay dunes are interesting but not exceptional.

4. Impact of land use on dune stability

The brief requires consideration of the effect of current land use (i.e. farming) on dune stability. Kawakaputa Bay contains two very different dune landscapes - the modern foredune and the adjacent parabolic dunes. The foredune is largely covered in marram grass which is effectively trapping most if not all of the sand blown from the beach. It is actively accreting and so growing in height and width. The parabolic dunes have a mixed cover of marram, pasture grasses, lupin, an area of gorse, some native wetland species and a range of exotic weed plants. This vegetation cover has been established and maintained by the concessionaire and his predecessors. Sand transport has been arrested so that the parabolic dunes are now relict features.

The site was examined in December 1998 during a summer of exceptional warmth and drought. The dunes were being lightly grazed at the time by sheep. There was evidence of low to moderate rabbit numbers. The dunes were well grassed though the plants were clearly drought stressed. Bare sand was exposed where vehicle tracks had been cut through the dunes, along stock tracks, and where stock and/or the wind had excavated hollows. The area of bare sand was observed to be small, and one was left with the impression that the farming operations were not unduly damaging the vegetation

cover. Extreme care will be necessary to prevent overstocking. Once initiated, areas of erosion will be difficult to vegetate.

The Kawakaputa foredune is currently grazed by stock. Stock are also able to wander across the gravel terrace. A two-wire electric fence runs along the terrace but it is in disrepair and would not contain stock. The landward boundary of the foredune is not fenced.

The foredune of Haldane Bay is currently being eroded. A wave-cut scarp runs for most of the length of the eastern half of the bay. The foredune and the dunefield between the coast and the Reservoir have a dense but discontinuous cover of marram. Numerous blowouts, depositional features and hummocks create a chaotic dune landscape. Stock are free to graze the foredune and adjacent marram-covered dunes.

The dunes of the hinterland of Haldane Bay have been reactivated as a result of vegetation disturbance and sand movement. Large areas of the dunefield between Haldane Bay and Blue Cod Bay (to the east) consist of bare, mobile sands, actively transgressing the older dune landscape - indeed, the access road to the concessionaire's farmhouse has been buried by moving sand. Sand is blowing landward along existing hollows in the older parabolic dunes creating a chaotic topography of old and modern surfaces. Sand movement has probably been initiated by stock damaging the vegetation cover.

The soils exposed by this recent phase of instability are of great interest. The depth and rich staining of the soils suggests the parabolic dunes of Haldane Bay might be very much older than those of Kawakaputa Bay and must pre-date European activity. A midden located near to the old barn was found to contain moa bones, suggesting that the parabolic dunes, at least this section, are at least 400-500 years old.

In sum, farming seems to be having little adverse impact on the stabilised parabolic dunes of Kawakaputa Bay. Discussions with Mr Darnill, the concessionaire, indicated that he was aware of the potential to overgraze and destabilise the older dunes. He manages grazing to avoid undue pressure on these dunes during the summer months. Grazing of the marram-covered foredune is apparently having little adverse impact, but it would be good practice to retire the foredune complex from grazing. The plant communities of the gravel terrace should be absolutely protected from grazing and vehicle traffic. Most of the foredune and all the gravel terrace lie outside the grazing lease. The coastal strip appears to be an esplanade reserve.

Grazing appears to have destabilised the parabolic dunes of the hinterland of Haldane Bay. Areas of dune, apparently vegetated until recently, are a chaos of bare sand, blocks of older soil and midden stone. Destabilisation may be related to some climatic event and not solely a consequence of farming practice; but grazing is now incompatible with the restoration of a vegetation cover and dune stabilisation.

Dunes are, on occasion, disturbed by natural processes, and episodes of instability and sand migration are characteristic of sandy coasts. A number of plant and related animal species associated with dunes may depend on such epi-

sodes of instability to provide new habitat. It is difficult to untangle the relative importance of natural and human-related processes at Haldane Bay and so argue for stabilisation or not. In any case, the diversity of native dune species in the Haldane dunes is low and the prospects for habitat restoration by natural regeneration are small. These dunes should be stabilised in order to conserve the older dune forms, which are of geomorphic interest, and to protect archaeological sites.

5. Management options for marram control and pingao restoration

The Kawakaputa Bay dunes are of interest, in part, because of the potential to restore the native sand dune communities and so re-establish a mountain-to-the-sea sequence of native vegetation. Grazing would have to cease, and native foredune and backdune species would have to be re-established by passive or active restoration. The idea is laudable and shows considerable vision.

The Southland Conservancy of DOC has considerable experience in controlling marram grass using herbicide. The area of marram present at Kawakaputa Bay is large (approximately 10 ha) and so would require the use of a helicopter. To eradicate marram from Kawakaputa Bay would cost in excess of \$50,000 over three years (excluding labour costs). Re-establishing pingao in the foredune environment might be difficult and require extensive plantings. Eradication of the marram might result in localised instability and the development of blowouts and minor parabolic dunes. Some geomorphic features to landward might be buried by sand movement.

Restoration of native vegetation on the stabilised parabolic dunes might be achieved by simply retiring the land from farming and by controlling invasive weeds. The resulting growth of first shrubland and later forest would eventually obscure the parabolic dune forms.

There are two, potentially conflicting, courses of action open to the Department of Conservation. If the conservation goal is to conserve the landforms of the Kawakaputa dunes, the status quo (Crown ownership, grazing) is ideal. The parabolic dunes are exceptional features of national significance but are not being adversely affected by current farming activity. If the conservation goal is to restore the native vegetation, these features will eventually be obscured. Of course, the Department could encourage further study of these features (graduate study, for example) at little cost before the current concession expires and vegetation growth inhibits further study.

The cost of marram control using current technology is very high. Priority should be given to dunelands of greater conservation value elsewhere in the Conservancy. In any case, marram control need not be undertaken at the

same time grazing ceases. The foredune complex at Kawakaputa Bay has a poor native flora which can hardly get worse. Marram control and pingao restoration could be undertaken some time in the future, after marram has been removed from dunes of much higher conservation value.

Marram control and dune vegetation restoration at Haldane Bay is achievable but, once again, there are higher priorities in the Conservancy. The area of dune between the coast and the western arm of the Reservoir is dominated by marram and will remain so in the foreseeable future. The older parabolic dunes to the east are degraded but of geomorphic interest. These dunes should be retired from grazing or improved farming practices should be implemented. The areas of accumulating sand should be planted in marram.

6. Conclusions and recommendations

- 1 Kawakaputa Bay and Haldane Bay contain parabolic dunes oriented at an acute angle to the adjacent shoreline. This character is due to their location in Foveaux Strait relative to the prevailing westerly winds.
- 2 The parabolic dunes of both locations are young features in geological terms. The Kawakaputa Bay dunes probably formed late last century following direct or indirect disturbance of the foredunes by people, though these dunes could predate European settlement. Soil profiles and midden material suggest the stabilised Haldane Bay parabolic dunes are somewhat older.
- 3 The dune landforms of Kawakaputa Bay are of national significance as examples of well preserved parabolic dunes oriented at an acute angle to the coast and as a record of coastal environmental change. The Haldane Bay parabolic dunes are relatively degraded though still important examples of the dune type.
- 4 Farming operations are compatible with the goal of landform protection at Kawakaputa Bay. The parabolic dunes are relict features since they are fully vegetated and hence stable. The foredune complex has no particular landform merit, as similar marram-dominated foredunes are widespread.
- 5 Farming operations have caused or at least exacerbated dune erosion at Haldane Bay. The concession should not be renewed, or else the grazing regime should be modified, so as to reduce the impact of grazing on the vegetation cover. In general, there appears to be little justification for Crown ownership of much of the dune hinterland. The exchange of land proposed by Rance (1995) seems appropriate.

- 6 Vegetation would partly obscure the Kawakaputa parabolic dunes if it was decided to allow regeneration of native vegetation at the site and the concession was not renewed. DOC should encourage further research on the geomorphology of these dunes before grazing ceases if, indeed, the Department considers such a restoration project necessary.
- 7 Marram eradication at Kawakaputa Bay should not be undertaken before such work is completed at other mainland Southland and Stewart Island sites, including Fortrose Spit, the Three Sisters, Long Beach, Dum-mies Beach, Doughboy Bay, and Mason Bay.
- 8 The turf communities of the gravel terrace along the eastern third of Kawakaputa Bay require urgent protection from stock and vehicles. Stock should also be excluded from the foredune area.

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