Mangawhai Government Purpose Wildlife Refuge Reserve:

Dune Restoration and Management Recommendations

Report commissioned by: Northland Regional Council

Report prepared by: **J. Dahm (Eco Nomos Ltd) and D. O. Bergin (ERL Ltd)**

Edited by: L. Shaft (CoastCare Co-ordinator) and K. Hansen (Biodiversity Advisor), Northland Regional Council

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Foreword

This report is intended to provide a technical review and recommendations for management of the dunes of the Mangawhai Government Purpose Wildlife Refuge Reserve It is not intended to be used as an overarching management strategy for the site but can form part of an overall management strategy developed by the Department of Conservation.

Acknowledgements

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Birds NZ (Representative from Auckland Branch)

Department of Conservation – Whangarei Office

Mangawhai Harbour Restoration Society

New Zealand Fairy Tern Trust

Northland Regional Council

Tern Point Recreation and Conservation Society

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Executive Summary

This report provides a summary of the issues faced in the management of the Mangawhai Government Purpose Wildlife Refuge Reserve (Mangawhai Wildlife Refuge) and gives some recommendations for management of the site. It is not intended to be used as an overarching management strategy for the site but can form part of an overall management strategy developed by the Department of Conservation. Feedback on the draft report provided to stakeholders has been incorporated into this final version.

The 245 ha area is primarily comprised of lightly vegetated and unvegetated sand dunes with extensive areas of bare and mobile sand and shelly deflation areas. The dune ecosystem in this area has been extensively degraded by anthropogenic destabilisation. The dunes were originally forested with mixed podocarp-coastal forest but this was destroyed by fire associated with early human settlement around 800 years B.P. Widespread wind erosion and dune instability occurred with little evidence of natural revegetation of the dunes since the original disturbance.

The site is crown administered wildlife refuge reserve, with particular emphasis on threatened shorebirds. It is an important roosting and breeding habitat for various shorebirds, including the New Zealand (NZ) fairy tern and the northern NZ dotterel. It is also a roosting habitat of varying importance for a wide variety of other migratory shorebirds and waders. Dune restoration and other desired management objectives are therefore tempered in some areas by the over-riding priority of maintaining critical shorebird habitat.

For the purposes of this report the site is divided into two areas. Area one covers the southern area of spit, including Tern Point and Area encompasses the Central-Northern Area of Spit.

Area one comprises actively migrating sand dunes extending over a width of 650-850 m along the seaward margin of the spit, including one very high dune system. The landward migrating sands are slowly encroaching on the Tern Point subdivision along the landward margin of the Mangawhai Wildlife Refuge and pose a significant long term threat to more seaward properties in the subdivision. Tern Point Recreation and Conservation Society have been planting on the dunes at the southern end of the spit since 1999. The key recommendation for this area is to facilitate the establishment of a continuous and well vegetated frontal dune by large-scale planting of native sand-binders along the coastal margin of Area 1.

The key management priorities in Area two are the protection and enhancement of habitat critical to conservation and improvement of shorebird populations, appropriate management to minimise the risk of future spit breaching and control of weeds at northern end of spit impacting on nesting areas for shorebirds. The MHRS is already significantly advanced in the restoration of an incipient frontal dune through the use of sand trapping fences but it is now critically important to establish a good width of native sand binding vegetation along the full length of this incipient dune – to intercept windblown sand and encourage natural dune building and repair. This planting should progressively work landward from the seaward toe of the incipient dune. It is strongly recommended that planting in Area 2 remains focused on the frontal dune until a well-vegetated frontal dune has been restored.

1 Introduction

1.1 Purpose

Northland Regional Council (NRC) commissioned ERL Ltd and Eco Nomos Ltd to provide recommendations on dune restoration and management within the Mangawhai Government Purpose Wildlife Refuge Reserve (Mangawhai Wildlife Refuge).

The initial recommendations were distributed for input from NRC, Department of Conservation (DOC), local community stakeholders and other relevant parties. This final version incorporates some of the feedback received.

While the dune ecosystem in this area has been extensively degraded by anthropogenic destabilisation, the site is crown administered wildlife refuge reserve, with particular emphasis on threatened shorebirds. DOC has emphasized that that status needs to be well reflected in the outcomes identified. Dune restoration and other desired management objectives will therefore be tempered in some areas by the over-riding priority of maintaining critical shorebird habitat.

1.2 Background

The Mangawhai Wildlife Refuge is located on a sand spit seaward of Mangawhai Harbour and the coastal settlement of Mangawhai Heads (Figure 1).

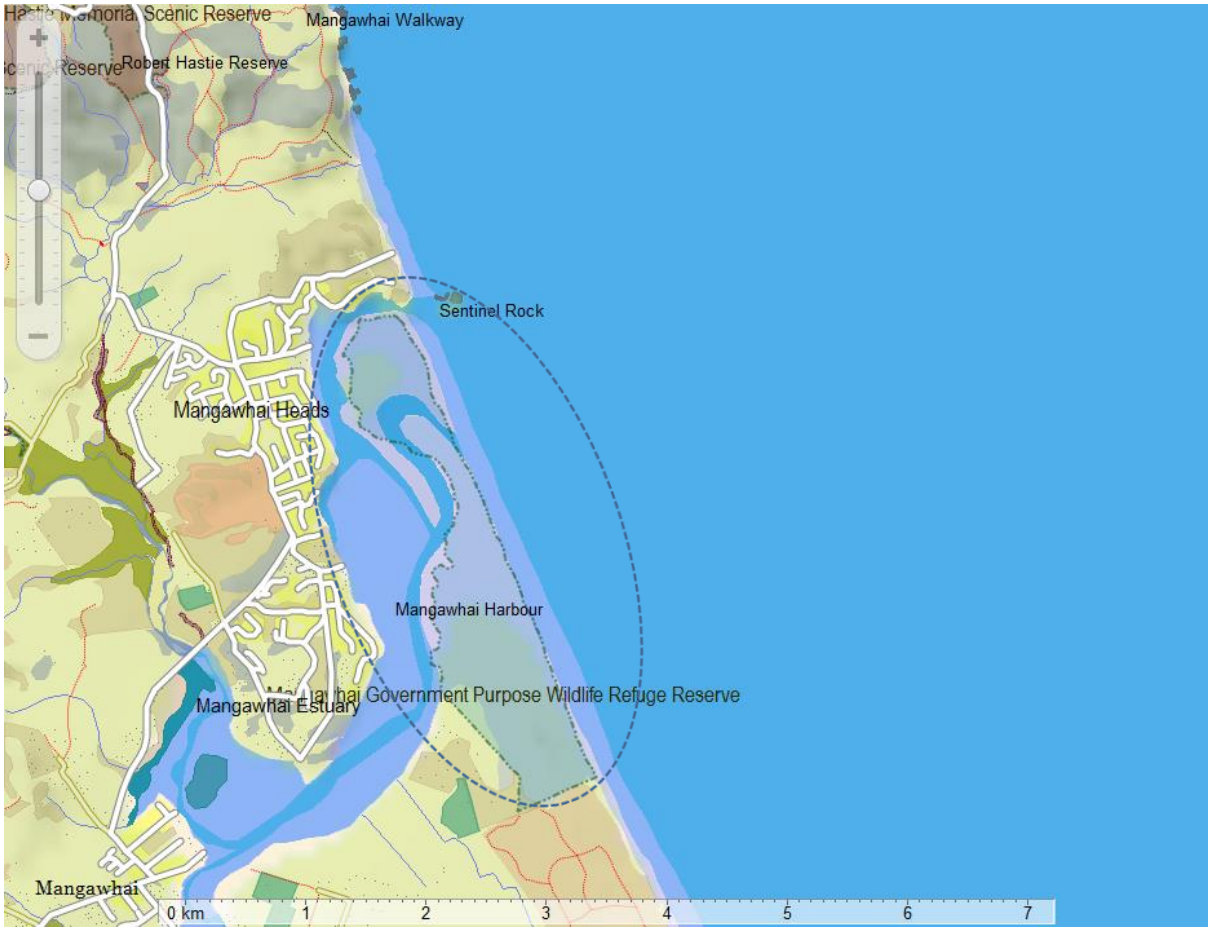

Figure 1: Location of Mangawhai Government Purpose Wildlife Refuge Reserve (Mangawhai Wildlife Refuge)

Figure 2: Recent aerial view (July 2015) of the Mangawhai Government Purpose Wildlife Refuge Reserve (Mangawhai Wildlife Refuge) and various locations referred to in text with key nesting areas for NZ fairy terns marked. Northern NZ dotterel and variable oystercatchers also nest in these marked areas, as well as elsewhere within the refuge. These key nesting areas can change from year to year.

The 245 ha area is primarily comprised of lightly vegetated and unvegetated sand dunes with extensive areas of bare and mobile sand and shelly deflation areas (Enright and Anderson, 1988; Hansen, 2006) (Figure 2). For the purposes of this report the Mangawhai Wildlife Refuge has been broadly broken down into two areas as shown in Figure 2; these areas are discussed later in the report.

1.2.1 Geology and Geomorphology

The Mangawhai Spit is part of the larger (approximately 25 km long) Mangawhai-Pakiri sand system, a Holocene beach and dune system that has developed over the years since sea level stabilised at or about existing levels (about 7700 cal yr BP – Clement, 2011) following the most recent post-glacial rise in sea level. Most of the sands for the Holocene beach and dune system were derived from onshore migration of sands from the adjacent continental shelf.

Investigations of the Mangawhai-Pakiri sand system by Nichol et al. (1996) found that the beach prograded rapidly to its present position following sea level rise and has been relatively stable since. Studies of nearshore and inner shelf sediments and morphology in the Mangawhai-Pakiri sand system also indicate that the inner shelf has now essentially "run out" of beach grade sediment (Hilton, 1995; Hilton and Hesp, 1996). Accordingly, it is very unlikely that there is now any significant onshore net supply of sand to the Mangawhai-Pakiri beach system and it is very unlikely that the sand system is continuing to experience any significant net seaward progradation/advance. The extraction of large volumes of beach grade sand from the nearshore beach system over the last few decades (and presently continuing) also raises concern that net shoreline retreat may eventually occur to counterbalance these losses (Hilton and Hesp, 1996).

The beach and dune sediments are typically fine-medium sands. The beach and foreshore sediments typically comprise well or moderately well sorted medium sands (mean grain size of 1.2-1.9 phi or 0.44-0.22 mm); grading offshore to very well sorted fine sands (2 phi, or 0.25 mm) which extend to about 15 m depth on the inner continental shelf (Hilton, 1995).

Investigations of cross-shore sediment transport suggest the seaward edge of the active beach system typically occurs at about 8 m depth; with this beach-shoreface area essentially a closed system with little no significant sand exchange with areas further offshore (Hicks et al., 2002). During storm conditions, cross-shore sand movements move sediment offshore, with offshore sand fluxes peaking over the outer bar and pinching out at about 8 m depth (Hicks et al., 2002). During swell-dominated accretionary periods, onshore sand fluxes occur with shoreward migrating bars often evident in the swash zone and upper beachface (Hicks et al., 2002).

1.2.2 Dune Destabilisation and Sand Encroachment

The dunes of Mangawhai Spit were originally forested with various species including totara (*Podocarpus totara var. totara*), maire (*Nestegis sp.*), matai (*Podocarpus spicatus*) and titoki (*Alectryon excelsus*); but this mixed podocarp-coastal forest was destroyed by fire associated with early human settlement around 800 years B.P. (Enright and Anderson, 1988). Palaesol (buried soil) remnants exposed in various areas of the present migrating dunes indicate the former forest-stabilised Holocene dune surface (Enright and Anderson, 1988).

Following human settlement and removal of vegetation cover, widespread wind erosion and dune instability occurred with little evidence of natural revegetation of the dunes since the original

disturbance (Enright and Anderson, 1988). Accordingly, the dune ecosystem remains in a significantly altered and severely degraded condition. In other words, the existing state which is characterised by bare and mobile sand with only limited areas of light vegetation is largely anthropogenic in origin.

Problems with mobile sands (Cockayne, 1909 & 1911) led in the early-mid 1900's to extensive work around New Zealand focused on stabilising these sands. This work was generally not undertaken with the purpose of restoring native dune ecosystems but rather with a focus on productive land use, particularly forestry. McKelvey (1999) provides a useful summary of the establishment of pine (*Pinus radiata*) forests on sand dunes. He notes that early limited attempts at dune stabilisation were undertaken within the Mangawhai-Pakiri sand system by the former Public Works Department in the 1930's using the exotic sand binder marram (*Ammophila arenaria*) (McKelvey, 1999). However, migrating dunes and sand sheets continued to dominate the spit and dune area further south in the 1940's and 50's with only isolated patches of vegetation (Figure 3).

In southern areas, the migrating dunes are slowly advancing on the Tern Point subdivision. The migrating dunes also re-work and irretrievably disrupt and destroy cultural deposits in the dunes.

1.2.3 Dune Stabilisation and Invasive Vegetation

The mobile dunes to the south of the Mangawhai Wildlife Refuge were subsequently stabilised with development of the Mangawhai Forest, this work commencing in 1963 (McKelvey, 1999). The stabilisation work to establish pine forestry used exotic species, including marram and various exotic nitrogen fixers (initially lupin (*Lupinus sp.*) and, later, other species); which species can be seriously invasive on coastal dunes.

Sydney golden wattle (*Acacia longifolia*) was introduced as a nitrogen fixer for the pine forests further south and is now a serious invasive in south-western areas of the wildlife refuge. This species is likely to continue to spread over time and so potentially poses a significant longer term threat to the Mangawhai Wildlife Refuge. The species forms a dense monoculture and produces masses of long-lasting seeds. It is a very labour intensive and difficult species to manage.

The perennial yellow tree lupin (*Lupinus arboreus*) was also widely used as it played a significant role in nitrogen supply to pine forests (e.g. Gadgill, 1979). From a forestry perspective, the species was ideal as it significantly limited the need for applications of nitrogenous fertilisers and, with prolific long lasting seeds, was essentially self-sustaining (Dick, 1994). However, this species became a serious invasive on New Zealand dunes. Fortuitously, from an ecological perspective, it is now limited by a blight (*Colletotrichum gloeosporioides*) (Dick, 1994) and is not presently a significant issue within the Mangawhai Wildlife Refuge. However, the species needs to be monitored in case blight resistance develops.

Figure 3: Views of Mangawhai Spit and area immediately south dating from 1949 (top) and 1955 (bottom) (Whites Aviation photos - Alexander Turnbull Library).

1.2.4 NZ Fairy Tern and other Shorebirds

The Mangawhai Wildlife Refuge is an important roosting and breeding habitat for various shorebirds, including the New Zealand (NZ) fairy tern (*Sternula nereis davisae*), the northern NZ dotterel (*Charadrius obscurus aquilonius*), pied stilt (*Himantopus himantopus*), variable oystercatcher (*Haematopus unicolor*), banded dotterel (*Charadrius bicinctus*), Caspian tern (*Hydroprogne caspia*), and white-fronted tern (*Sterna striata*) (Hansen, 2006; Dowding, 2006). It is also a roosting habitat

of varying importance for a wide variety of other migratory shorebirds and waders (Dowding, 2006), particularly the Eastern bar-tailed godwit (*Limosa lapponica baueri*) and lesser knot (*Calidris canutus rogersi*) both of which are threatened. The birds prefer the lightly-vegetated and bare sand areas, with shelly (e.g. dune deflation) areas also favoured.

The Mangawhai Wildlife Refuge is critically important in regard to the endemic NZ fairy tern, also known as the tara-iti, a subspecies of the fairy tern. This species is probably New Zealand's rarest indigenous breeding bird, with the population estimated to number only 35 to 45 individuals and approximately only 12 breeding pairs (Hansen, 2006; DOC, undated). The species now only breeds at five locations in the North Island, with the Mangawhai Wildlife Refuge the single-most important of these sites (i.e. having the highest number of breeding pairs). The NZ fairy tern is listed as 'Nationally Critical' in the NZ Threat Classification System (Robertson et al., 2012).

The NZ fairy tern population within the Mangawhai Wildlife Refuge has been subject to active protection and recovery work since at least 1983 when the number of NZ fairy terns at Mangawhai, Waipu and Papakanui Spit dropped to only 3-4 breeding pairs (Hansen, 2006). This very challenging work, co-ordinated by DOC but involving a wide range of parties, has slowly increased the number of breeding pairs nationally (listed as varying from 8-12 in the period from 2006-07 through to 2010-11 – DOC, undated); with 12 NZ fairy tern chicks produced and protected in the 2013-14 breeding season (DOC, undated).

The Mangawhai Wildlife Refuge is also a nationally significant breeding site for the northern NZ dotterel, being the single-most important breeding site in New Zealand, the variable oystercatcher, and Caspian tern (Dowding, 2006).

The conservation and recovery of NZ fairy tern, other shorebirds and threatened species is a key purpose of the Mangawhai Wildlife Refuge. It is therefore critically important that restoration of a natural dune ecosystem within the Mangawhai Wildlife Refuge is undertaken in a manner that preserves and ideally enhances the habitat critical to the survival of the NZ fairy tern and other threatened species (e.g. northern NZ dotterel and Caspian tern). Given the preference of the NZ fairy tern and other shorebirds for open areas, this inevitably means that restoration of appropriate native dune vegetation cannot occur in all areas. It also means that active intervention is likely to be required in some areas where maintenance of bare or sparsely vegetated areas is particularly critical. Accordingly, clear (and precautionary) identification of the areas critical to bird habitat is a key pre-requisite for effective management of the Mangawhai Wildlife Refuge.

Conservation of the NZ fairy tern and other shorebirds is therefore a critical consideration for dune restoration work within the Mangawhai Wildlife Refuge. Dune restoration within the Mangawhai Wildlife Refuge has to be conducted in a manner that is consistent with the objectives of the NZ fairy tern recovery plan (Hansen, 2006) and wider shorebird conservation and enhancement work.

1.2.5 Spit Breaching and the Mangawhai Harbour Restoration Society (MHRS)

In its natural state, erosion on the outside of the main channel significantly eroded and narrowed Mangawhai Spit in the lower estuary near the harbour entrance (Figure 3). The wind erosion of the dunes also lowered the frontal foredune in this area increasing susceptibility to wave overtopping during major coastal storms. Consequently, in a major coastal storm of July 1978 the spit was breached at its narrowest point developing a dual inlet configuration (Flood et al., 1993). It is

probable that similar inlet breaching has occurred in or near this area in the past (McCabe et al., 1985).

By the early 1990's, the dual inlet configuration had caused significant deterioration of the harbour in several important respects and was considerably impacting on human use, particularly boating (Flood et al., 1993). Government agencies decided against intervention despite community requests because it was considered that the expensive restoration work may not be successful (Flood et al., 1993). This led to community action to address the issue through the Mangawhai Harbour Society (now Mangawhai Harbour Restoration Society – MHRS); with successful closure of the breach and restoration of the main entrance achieved in 1996.

The MHRS has continued channel dredging work to realign the channel along the landward margin in an effort to reduce erosion along this shoreline. A wide, high dune/bund has also been established along this margin with the deposition of dredged sand and shell and use of sand-trapping fences.

Since 1996 (MHRS, undated), the MHRS has also undertaken very extensive growing and planting of native dune species (particularly spinifex (*Spinifex sericeus*) and pingao (*Ficinia nodosa*)) to revegetate dunes on the spit; propagating and planting over 100,000 plants to date (MHRS, undated). This work has successfully revegetated the large dune built along the landward margin as well as extensive areas of the spit further seaward. The restoration of the native sand trapping vegetation has significantly reduced mobile sands and initiated natural dune building over significant areas of the spit. In recent years, the MHRS has also focused on restoration of a natural frontal dune along the seaward margin of the spit using both sand fences and planting. An incipient frontal dune has now been established using sand fencing with revegetation presently still in progress.

The distal end of the spit (Area 2 in Figure 2) has been the focus of MHRS efforts to date reflecting the desire to minimise the risk of future spit breaching. The fact that this area of the spit area has also recently been the most important area for shorebird nesting means that a strategy is required to ensure dune restoration is conducted in a manner that is consistent with conservation and enhancement of shorebird habitat, particularly for NZ fairy terns and other species breeding on the spit.

2 Area One: Southern area of spit, including Tern Point

2.1 Description and Issues

This area (Figure 2) comprises actively migrating sand dunes extending over a width of 650-850 m along the seaward margin of the spit, including one very high dune system. The landward migrating sands are slowly encroaching on the Tern Point subdivision along the landward margin of the Mangawhai Wildlife Refuge.

Figure 4: Aerial view of landward migrating sands/dunes encroaching on Tern Point

The landward migrating dunes pose a significant long term threat to more seaward properties in the Tern Point subdivision. Accurate assessment of the average rate of sand advance and encroachment over time would require analysis of data extending over decades. Indicative results from analysis of shorter term data (aerial photographs from 2006 and 2014) suggest the average rate of landward migration probably ranges from 1-3 m/yr. However, residents of Tern Point estimated this drift to be 5 metres per year on average, based on the rate of burial of a boundary fence put in place during the initial Tern Point development.

Tern Point Recreation and Conservation Society have been planting on the dunes at the southern end of the spit since 1999. They initially planted pingao until 2010 when NRC became involved and started providing spinifex to the group. Planting of spinifex has been undertaken every year since.

The migrating dunes have also extensively disrupted and reworked Māori cultural sites in the area and previous dune soils. The dune erosion over time has been sufficiently serious that an iron pan is now exposed over extensive areas, particularly in the deflation pan landward of the large high dune evident in Figure 4. This iron pan originally formed at depth under the naturally-vegetated dunes near the top of the water table and hence considerable loss of overlying sands has occurred to expose this feature on the surface. Coastal wattle is also extensively invading the Mangawhai Wildlife Refuge in southwestern areas.

Shorebirds use the lightly vegetated dunes and deflation areas within this zone for nesting and roosting. They generally don't use areas that have thicker vegetation or weed cover, or the mobile dune areas for nesting. Both NZ fairy terns and other threatened shorebirds (northern NZ dotterel, banded dotterel (*Charadrius bicinctus*) and variable oystercatcher) will nest within this zone. Adequate areas of sparsely vegetated or bare dunes with some debris present should be maintained to provide shorebird breeding habitat, over and above the mobile dunes that are not being vegetated for spit stabilisation/reduction of wind-blown migrating sand.

2.2 Recommendation: Stabilisation of Landward Migrating Dunes

It is recommended that planting of appropriate native species and improved management of human use is undertaken to stabilise the migrating dunes. These plantings should emphasize use of spinifex and pingao and adopt a planting density sufficient to stabilise the sands while retaining a relatively open habitat favoured by shorebirds. There may also be scope for patches of rare or threatened (particularly low and relatively open) plant species to be introduced in some backdune areas.

However, no planting should be undertaken in the vicinity of areas critical to shorebird breeding (some of which are included in Figure 2). It is important to note that preferred breeding areas change so that management would need to be able to adapt to this. When planting outside of these critical areas care should also be taken to avoid planting during the shorebird breeding season (August to February inclusive). Control of vegetation cover and/or density may also be required to maintain these open areas.

2.2.1 Existing Dune Planting

The present native dune planting is located along the boundary of the Tern Point estate at the extreme western margin of Area 1 (Figure 2). The planting in this area has focused on the use of spinifex and pingao to stabilise the landward migrating dunes. Tern Point Recreation and Conservation Society has also planted native trees in the adjacent backdune area.

This small-scale planting will not be adequate to address the longer term threat posed by encroaching sands and there will need to be an increased focus on larger-scale plantings further seaward - as discussed in the next section. Nonetheless, the existing plantings will be very useful and effective in the short-term and should be continued. It is recommended that these plantings focus on establishing a good cover of spinifex and pingao on the seaward face and the top of the dunes in this area before planting on the lee/landward side, i.e., work from seaward to landward with the plantings. This approach will make the most effective use of the plants available in reducing sand supply to the landward migrating face.

Hand application of urea could also be used as a temporary measure to increase density of the spinifex in open areas.

2.2.2 Future Emphasis – Large-Scale Stabilisation of more Seaward Areas

In the short-medium term, it is strongly recommended that the focus of the dune planting and management should move to the large area of migrating dunes further seaward. It will not be possible to completely address the threat posed by landward migration dunes advancing on Tern Point until this large area of migrating sands is stabilised. The stabilisation will also protect any remaining cultural/archaeological sites buried in the dunes, which sites will otherwise be irretrievably destroyed by the migrating dunes.

The most effective strategy for this large area is to work from seaward to landward to progressively cut off sand supply to the landward migrating dunes. At present, large volumes of sand are being fed into the migrating dunes through extensive unvegetated gaps in the existing frontal dune. Accordingly, the highest priority is to restore a naturally-vegetated frontal dune along the seaward margin. This will markedly reduce new sand supply to migrating dunes further landward. This initial

work should focus on revegetating gaps in the existing frontal dune, working from existing areas of spinifex and other sand binders to gradually close the gaps off.

Once a continuous and well vegetated frontal dune has been established, focus can then move progressively landward; prioritising the major sand transport paths. Shells could be put on the back of the planted dunes to provide nesting areas for the shorebirds. If these backdune areas are planted before a vegetated frontal dune is restored, large losses will be experienced due to burial and abrasion of the plants by windblown sands from further seaward.

It is strongly recommended that all planting work is undertaken using native sand binders (i.e. spinifex and pingao) rather than marram. Revegetation with marram is very simple and cost-effective but this exotic species will form dense, high vegetation over time. Marram also tends to promote significant changes in dune morphology (e.g. building higher, steeper dunes more prone to blow-outs) as well as ecological and habitat values. Accordingly, use of marram is not compatible with the values of the Mangawhai Wildlife Refuge. Spinifex and pingao will provide much lower and more open vegetation cover. The majority of planting should be spinifex as this is the most effective sand-binder and helps build a low, stable dune. It is also less palatable to rabbits than pingao. Pingao is very good at building up a dune and is important to include for its biodiversity values. Pingao is more susceptible to rabbit browsing

Revegetation with appropriate low, open native species will require large numbers of plants over time – probably in excess of 150-200,000 plants even using relatively low planting densities and maintaining significant open areas for shorebird habitat. However, the recommended strategy of progressively working from seaward means that the work can be staged over long periods of time. This should also significantly reduce the plantings required over time - as established plantings will tend to spread landwards over time.

Restoring a well-vegetated frontal dune will be the most difficult task. Once this feature is restored, light vegetation cover is likely to be adequate in areas further landward.

Management of animal pests, particularly rabbits, is critical to the success of the plantings – particularly in regard to establishment of more palatable species such as pingao. Management of human use is also important. Vehicle use is restricted in this area due to the reserve status of the spit. There are low levels of pedestrians on the spit.

This large-scale work is well beyond the scope of the Tern Point Recreation and Conservation Society. Accordingly, it is recommended that the Mangawhai Harbour Restoration Society (MHRS) (to which all local ratepayers contribute) progressively move the focus of their dune restoration effort to this area as the foredune restoration work further north is completed. Ideally, this progressive shift should commence as soon as practicable and within the next 1-2 years. This reflects the scale of the work required in Area One and the importance of commencing this work in sufficient time to address the serious medium-longer term threat to the Tern Point subdivision and any remaining cultural sites within the dunes. Again, it needs to be noted that planting should occur outside of the shorebird breeding season (August to February inclusive).

This large-scale work will require preparation of a detailed planting plan as only a broad overview of the required work is covered within this document.

2.3 Management of Invasive Weeds

The replacement of coastal wattle with native shrubs/trees is best left until the sand stabilisation work to seaward is well advanced. At the moment this extensive area of wattle is being buried by landward migrating sands, clearly indicating that the higher priority is to address the migrating sand issue. It will also be very difficult to successfully establish appropriate native vegetation (including appropriate native trees and shrubs) until the sand migration issue has been addressed. Extensive removal of the coastal wattle prior to addressing sand stabilisation further seaward could also aggravate problems with windblown sand and/or landward migrating dunes.

Removal of coastal wattle and replacement with appropriate native species is a difficult and resource-intensive task. Accordingly, it is recommended that an appropriate strategy and planting plan are developed prior to commencing this work to ensure the most cost-effective and efficient approach for undertaking this work.

3 Area Two: Central-Northern Area of Spit

3.1 Description and Issues

The critical issues in this area are:

- Protection and enhancement of habitat critical to conservation and improvement of shorebird populations; particularly the NZ fairy tern and other endangered species
- Appropriate management of the area to minimise the risk of future spit breaching
- Increase in weeds at northern end of spit impacting on nesting areas for shorebirds

3.2 Protection of Fairy Tern and Shorebird Habitat

The over-riding priority for the management of Area Two is protection of shorebird habitat, as the area currently contains critically important breeding and roosting habitat for the NZ fairy tern and other shorebirds.

The primary requirement is to protect the open areas required for breeding and roosting by NZ fairy terns and other shorebird species. These critical areas are identified in Figure 2.

In these areas, it is recommended that all vegetation incompatible with maintaining fairy tern and other shorebird habitat (native or exotic) is removed as a high priority – ideally within years 1 and 2. While the dune ecosystem is in a highly degraded state, dune restoration is not the over-riding priority. The site is crown administered wildlife refuge with particular focus on threatened shorebirds and accordingly that priority needs to be well reflected in the outcomes achieved.

Ongoing control of inappropriate vegetation in these areas will also be a continuing requirement – as the open areas are anthropogenic in origin and will require ongoing intervention to maintain. A plan identifying the species and areas which need to be controlled is required.

Fortunately, the most critical areas for bird breeding and roosting tend to be located on the shorelines seaward of dune vegetation, areas around the lagoons and shell-lagged areas with little sand movement. Accordingly, stabilising vegetation is generally not required in these areas.

Where dune planting is undertaken should be done outside shorebird breeding season (August to February inclusive) to minimise disturbance.

The critical habitat around the lagoons and along the landward margin of Area 2 is very vulnerable to invasion from the extensive area of moving sand further seaward. Accordingly, it is also important to reduce this landward sand movement. Obviously, this will require the establishment of a good cover of appropriate native sand binding vegetation. Particularly important in this regard is the restoration of a continuous, naturally-vegetated frontal dune along the seaward margin. This naturally-vegetated dune will intercept landward moving windblown sand from the wide beach to seaward and greatly reduce sand supply to areas further landward. As the dune grows in height it will also reduce the risk of storm-wave overtopping and associated risks of future spit breaching.

The lagoons are an important feeding area for shorebirds and therefore these features should also be maintained as long as practicable. It is important to appreciate that these features were formed after the earlier breach and will naturally infill and reduce in area over time. However, this process can be considerably slowed by reducing windblown sand from both seaward and landward areas by maintaining well-vegetated dunes either side.

Another threat to the habitat values of the lagoons is the ongoing invasion by saltwater paspalum (*Paspalum vaginatum*) (Figure 5). This is an extremely aggressive invasive species and in the absence of effective control will continue to spread rapidly over extensive areas of the lagoons and adjacent sand flats. DOC has begun work to control this species, trialling different equipment, herbicides and application rates, with varied success to date. DOC aims to eradicate this weed, with further trials and improvements to best practice.

DOC have begun to do some trials using different equipment, herbicides and application rates with varied success.

Other potentially serious invasive species such as pampas (*Cortaderia selloana*) also occur and will need to be proactively controlled. Pampas can spread very rapidly if small initial infestations are not promptly eradicated. The scale of work required for control will escalate exponentially with delays.

There is not much that can be done to facilitate flushing of these temporary lagoons without extensive earthworks. Moreover, any hydraulic connection between the lagoons and the adjacent estuary would need to be done very carefully to avoid aggravating erosion during storm-elevated extreme sea level events. It might however be possible to deepen the lagoons simply by excavating them to below the existing water table. This would provide an alternative feeding area when the sea is too rough or there is disturbance in the estuary.

Obviously, ongoing control of bird predators should be continued and is of a very high priority as identified in earlier recovery and other related plans (e.g. Hansen, 2006).

Figure 5: Views of dense (top) and actively expanding (bottom) saltwater paspalum around the lagoons in Area 2.

3.3 Reducing Risk of Future Spit Breaches

Spit breaching occurs through the combination of erosion along the landward margin of the spit and storm-wave overtopping along the seaward margin.

At present, a wide spit has been restored by channel dredging and deposition of sediment along the landward margin. Accordingly, the risk of spit breaching in the near future is negligible. However, the high bund established along the landward margin will tend to erode over time as the main tidal channel moves back towards a more natural alignment.

It is equally important to restore a naturally vegetated frontal dune along the seaward margin to reduce the risk posed by storm over-topping. This feature will also reduce invasion of critical shorebird habitat by windblown sand from the coast. Ideally, a vegetated frontal dune of at least 30-50 m width should be established over time. The restoration of this feature will significantly reduce the potential for future spit breaching even if the dredging is eventually ceased and erosion along the landward margin narrows the spit markedly – similar to the natural state shown in Figure 3. It is extremely unlikely that the breaching in July 1978 would have occurred, despite the narrowing of the spit, if a wide natural frontal dune had existed at that time.

The MHRS is already significantly advanced in the restoration of an incipient frontal dune through the use of sand trapping fences. However, it is now critically important to establish a good width of native sand binding vegetation along the full length of this incipient dune – to intercept windblown sand and encourage natural dune building and repair. This planting should progressively work landward from the seaward toe of the incipient dune.

The planting work to establish the frontal dune is much higher priority than any other planting in this central-northern area of the spit. Accordingly, given the critical importance of the shorebird habitat areas further landward, it is strongly recommended that planting in Area 2 remains focused on the frontal dune until a well-vegetated frontal dune has been restored.

Initial planting should aim to establish at least 15-20 m width of vegetated dune. This vegetation will tend to naturally expand landward over time and therefore planting requirements further landward may be minimal. Any application of urea to boost expansion of the vegetation should be applied manually, targeting only existing and any new plantings within the area of the frontal dune.

As discussed above, it is also very important that the focus of future planting by the MHRS should now progressively move to frontal dune restoration along the coastal margin of Area 1. This work can commence in parallel with the work in Area 2.

Given existing rabbit problems, ongoing rabbit control will also assist in establishing the naturally vegetated frontal dune.

No plantings should occur seaward of the existing incipient dune – as the vegetated foredune will naturally grow seaward as appropriate once the foredune is established.

Successful restoration and maintenance of a frontal dune will require only control of human use and vehicle access. In our view, the importance of human activity in ongoing vegetation disturbance is probably under-estimated.

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