

**Managing coastal sand drift in the Anthropocene: A case study of the  
Manawatū-Whanganui Dune Field, New Zealand, 1800s-2020s**

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## ABSTRACT

In the Anthropocene, predicted sea-level rise is expected to continue, threatening human life and activities along the coast. Dunes play a vital role in providing protection from this threat, aside from the ‘ecosystem’ services that they supply. This article uses scientific, popular and unpublished sources from the nineteenth century and twentieth to examine New Zealand’s largest coastal dune system: the Manawatū-Whanganui dune field. Extending south from Pātea to Paekakariki, it comprises approximately 900 square kilometres. Here, destabilized dunes drifting inland caused social, economic and political problems over the last 150 years. In the nineteenth century, human activities were responsible for setting the dunes in motion. Debates about the matter and attempts to prevent and stop it were then occurring in many parts of the world. Since dunes were a common concern, knowledge and practices were shared and travelled between countries through experts and migrants. The consequences of the solutions implemented and new environmental conditions explain that dunes are still a major issue in the Manawatū-Whanganui region. This article presents a comparative analysis of historical and present-day human responses to dune management to better understand long-term dune drift, its mechanisms and responses. Despite looking at a local case, this study can be extrapolated to dunes worldwide. It shows that holistic management of coastal ecosystems must take into account interdisciplinary analyses of long-term relations between dunes and society. Otherwise, the full picture about the present situation of dunes cannot be apprehended, compromising the implementation of future adaptation measures.

**KEYWORDS:** European settlement, Dune stabilization, Afforestation, Biodiversity

## INTRODUCTION

Coastal dunes form and evolve in response to fluvial and marine sediment supply and transportation processes. These, in turn, respond to tides, waves, and wind, as well as soil moisture content, geomorphology of the nearshore and the beach, and the extent and type of vegetation cover. Coastal dunes fulfil many different functions: they provide habitat for animals and plants adapted to extreme conditions; contribute to the shore sediment budget, thus playing a dual role as a sediment sink or source to maintain the long-term stability of a coastal system; and they protect the hinterland from flooding caused by sea-level rise and storm surges.<sup>1</sup>

Dune destabilization generated by natural processes or human activities can lead to persistent inland sand movement, which has the potential to inundate settlements and overwhelm infrastructure and fields, while the infilling of sand into rivers and estuaries can inhibit navigation by silting and creating marshlands.<sup>2</sup> Faced with disturbance, their deterioration has serious socio-economic and environmental impacts.<sup>3</sup> Sand drift has

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<sup>1</sup> C.R. Sloss, P. Hesp and M. Shepherd, 'Coastal Dunes', *Nature. Education. Knowledge***3** (10) (2012): 21, 2; P. Hesp. 'Dune Coasts', *Treatise on Estuarine and Coastal Science***3** (2011): 200-213; A.E. Esler. 'Manawatu sand dune vegetation', *Proceedings of the New Zealand Ecological Society***17** (1970): 42-45; O. Durán and L.J. Moore. 'Vegetation controls on the maximum size of coastal dunes', *Proceedings. National. Academy of Sciences of the United States of America***110** (43) (2013): 17217–17222; F. Sabatier, E.J. Anthony et al. 'Morphodynamics of beach/dune systems: Examples from the coast of France', *Géomorphologie: relief, processus, environnement***1** (2009): 3-22; J.M. Sigren, J. Figlus et al. 'The Effects of Coastal Dune Volume and Vegetation on Storm-Induced Property Damage', *Journal. of Coastal. Research***34** (1) (2018): 165-173; J.G.S. Keijsers, A.V. De Groot and M.J.P.M. Riksen. 'Modeling the biogeomorphic evolution of coastal dunes in response to climate change', *Journal of Geophysical Research: Earth Surface***121** (6) (2016): 1161–1162.

<sup>2</sup> C.D. Whitcombe. 'On the Reclamation of Land devastated by the Encroachment of Sand', *Transactions and Proceedings of the New Zealand Institute***5** (1872): 108; M.C. Clarke and H.R. Rendell. 'Atlantic storminess and historical sand drift in Western Europe: implications for future management of coastal dunes', *Journal of Coast Conservation***15** (2011): 227–236.

<sup>3</sup> J.M. Sigren, J. Figlus and A.R. Armitage. 'Coastal sand dunes and dune vegetation: restoration, erosion, and storm protection', *Shore Beach***82** (2014): 5–12; K.K. Arkema, G. Guannel et al. 'Coastal habitats shield people and property from sea-level rise and storms', *Nature Climate Change***3** (2013): 913– 918.

affected much of the coast throughout the world.<sup>4</sup> In Europe, problems originated in at least the fourteenth century.<sup>5</sup> In Aotearoa New Zealand, in particular in the Manawatū-Whanganui region, sand drift intensified with the arrival of Europeans due to both an acceleration of coastal deforestation and the introduction of agricultural, farming and industrial activities.<sup>6</sup>

In New Zealand, several scientists in the 1870s began to call for government action to arrest what they described as an evil imperilling agriculture. In other countries, many nineteenth-century scientists used a similar rhetoric to highlight the problem caused by sand drifting and to urge action.<sup>7</sup> This was a deliberate rhetorical mechanism used throughout the colonial world, as James Beattie has argued, that sought to magnify the impact of the threat, and which reflected the nature of a slow-moving catastrophe whose impacts were medium- or long-term rather than immediate or immediately visible. Even now, as coastal scientists D.F. Sherman and K.F. Nordstrom note, sand drift as a natural hazard ranks well below the impact of tsunamis, hurricanes or flooding, in that the

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<sup>4</sup> S. Frosini, C. Lardicci and E. Balestri. 'Global change and response of coastal dune plants to the combined effects of increased sand accretion (burial) and nutrient availability', *PLOS ONE* **7** (10) (2012.): 47561; J. Beattie, *Empire and environmental anxiety: health, science, art and conservation in South Asia and Australasia, 1800–1920*. (UK: Palgrave Macmillan, 2011); M.L. Clarke and H.M. Rendell. 'Effects of storminess, sand supply and the NAO on sand invasion and coastal dune accretion in western Portugal'. *The Holocene* **16** (2006): 341–355; A. Wiedemann and A. Pickart. 'The *Ammophila* problem on the NW coast of North America', *Landscape and Urban Planning* **34** (1996): 287-299; R.A. Lubke, U.M. Hertling and A.M. Avis. 'Is *Ammophila arenaria* (Marram grass) a threat to S. African dune fields?', *Journal of Coastal Conservation* **1** (1995): 103-108.

<sup>5</sup> M.L. Clarke and H.M. Rendell. 'This restless enemy of all fertility': exploring paradigms of coastal dune management in W. Europe over the last 700 years', *Transactions of the Institute of British Geology* **40** (2005): 414-429.

<sup>6</sup> P. Hesp. 'The Manawatu Dunefield: Environmental change and human impacts', *New Zealand Geographer* **57** (2001): 33-40; L. Cockayne. *Report on the dune areas of New Zealand their Geology, Botany, and Reclamation*. (New Zealand: Department of Lands, 1911); J.D. Cowie. 'Dune-building phases in the Manawatu district, New Zealand', *New Zealand Journal of Geology and Geophysics* **6** (1963): 268-280.

<sup>7</sup> Beattie, *Empire and environmental anxiety*, pp. 177-213.

problems it causes tend to be chronic rather than acute.<sup>8</sup> Nevertheless, the number of papers and writing on the topic, coupled with the human and financial resources expended by many governments and private citizens to immobilize dunes, speak to the significance of drifting sand.<sup>9</sup> Reactions to it also illustrate the manner in which perceptions, ideas and fears—including of hazards—are able to become drivers of human action.<sup>10</sup>

The “sand menace” reported in historical sources can be compared, in a way, with the later dust bowl imagery, as mentioned by Janette-Susan Bailey. Narratives built on the sand threat in many regions and in New Zealand are powerful stories about nature and civilization, the Western ideas of progress, the conceptualization of deserts and the notion that lands were better if productive through agricultural use and forestry<sup>11</sup>. But, contrary to the dust bowl stories that historians have examined,<sup>12</sup> not much scholarship has examined sand dunes, a much older and more widespread ‘problem’. A thriving literature exists on coastal dunes in New Zealand and internationally, however, this literature is mainly dominated by scientists, whose focus is largely on the contemporary period and on natural systems evolution.<sup>13</sup> For New Zealand, aside from a monograph by forester Peter McKelvey on sand forests, historical analysis of sand dunes has been undertaken

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<sup>8</sup> D.J. Sherman and K.F. Nordstrom ‘Hazards of wind-blown sand and coastal drift sands: a review’, *Journal of Coastal Research*, **SI12** (1994): 263.

<sup>9</sup> J.G. Freitas, ‘A Política Florestal nos Últimos Dois Séculos: Estudo sobre as Intervenções nas dunas do Litoral Português’, in A. Ferro Tavares, M. Ferro Tavares and J. L. Cardoso (eds.), *Evolução Geohistórica do litoral português e fenómenos correlativos. Geologia, História, Arqueologia e Climatologia*. (Lisboa: Universidade Aberta, 2004), pp. 599-626.

<sup>10</sup> T. Dunlap. ‘Creation and destruction in landscapes of empire’, in J. Diefendorf and K. Dorsey (ed.), *City, Country and Empire, Landscapes in Environmental History* (Pittsburg: University of Pittsburgh Press, 2005).

<sup>11</sup> J.S. Bailey, *Dust Bowl. Depression America to World War Two Australia* (New York: Palgrave MacMillan, 2016)

<sup>12</sup> D. Worster, *Dust Bowl. The Southern Plains in the 1930s* (Oxford-New York: Oxford University Press, 2004).

<sup>13</sup> The literature is voluminous. We reference some of it in this paper.

by Beattie, whose book is the first transnational study of sand drift in Australia, New Zealand and South Asia.<sup>14</sup> His work uses the framework of environmental history and ends in the early twentieth century. So, there is clearly room for an approach to coastal sand dunes drift and management in a historical perspective, taking a local example to throw a light on this matter as a broader global issue, like Worster and Bailey did for the dust bowl.

Using a case study of sand drift in the Manawatū-Whanganui region, this paper seeks to combine historical and scientific analysis of sand dune spread to examine the long-term social, economic and ecological outcomes of environmental disturbance and management dating from the nineteenth- to the twenty-first century. It examines the various solutions adopted for coping with these environments. In the nineteenth century and early twentieth, this included notably the gradual adaptation of European ideas of dune reclamation to local circumstances, based both on introduced plants and the use of native New Zealand ones. The drifting sands, seen by European settlers as waste lands and evil hazards, were planted with vegetation and trees to fix and turn into forest areas. Later, the set of values and the economic driver changed and new environmental global and local issues arose. Ecological thinking and more sophisticated geomorphological knowledge came to inform understandings of dunes formation and processes. These are now the object of ecological restoration projects to rehabilitate their natural functioning. Yet, the purpose is not consensual. The measures taken to convert dunes into indigenous fauna and flora habitats may not be compatible with the ones necessary to assure they work as coastal defences against sea erosion and inundation. This paper combines detailed

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<sup>14</sup> Beattie, *Empire and environmental anxiety*, pp. 177-213.

archival research over 150 years and contemporary scientific analysis, and is the product of collaboration between a scientist and two environmental historians. Such long-term, interdisciplinary research presents a unique opportunity for a study of a nationally and internationally significant dune region as well as addressing coastal management issues that are common to many other areas in the world.

## REGIONAL SETTING OF THE STUDY AREA

The Manawatū-Whanganui dune field is New Zealand's largest. Extending south from Pātea to Paekakariki, it comprises approximately 900 square kilometres of the south-western coast of the North Island.<sup>15</sup> In New Zealand, sandy coasts comprise less than one-third of the total coastline; the rest are rocky cliffs.<sup>16</sup> The Manawatū coastal strip between Paekakariki and Whanganui consists of 24km of settlements, 50km of forest plantation, with the rest mostly farmland.<sup>17</sup> Geomorphologically, the region has incised-valleys, estuaries, and a prograding coastline with transgressive dune fields that have now largely evolved into a parabolic system (Figure 1).<sup>18</sup> The coastline progrades because of an abundant supply of sediment into the coastal sediment cell. Dunes receive continuous supplies of sand from waves and tides. Landward movement (or transgression) of dune fields mainly occurs because of a strong forcing wind. Sand can blow over several kilometres inland as the shape of the grain size enhances aeolian drift. Prevailing wind

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<sup>15</sup> Cowie, 'Dune-building phases in the Manawatu district', p. 269.

<sup>16</sup> The encyclopaedia of New Zealand. <https://teara.govt.nz/en/natural-environment/page-2> (accessed November 15, 2019)

<sup>17</sup> G.L. Rapson, A.R. Smith and A.L. Murphy, *Sand-dune vegetation of the Foxtangi region, Manawatu coast, New Zealand* (Report to Department of Conservation, 2016), p. 5.

<sup>18</sup> Hesp, 'Dune Coasts', 204-207.

direction and intensity impact on drift. For example, wind data for Ohakea Air Base shows that west-to-north-west wind direction accounts for about 50% of frequencies.<sup>19</sup>

Here, wind speed averages 17km/hr while gusts can reach 96km/hr and may be sustained over 6 days.<sup>20</sup> The upper 10% of the wind speed in Whanganui is 14.8m/s.<sup>21</sup> Manawatū beach's foredunes accrete 20m<sup>3</sup>/m per year and their morphology varies alongshore from well-vegetated stabilised, incipient and established foredunes to poorly vegetated blown-outs.<sup>22</sup>

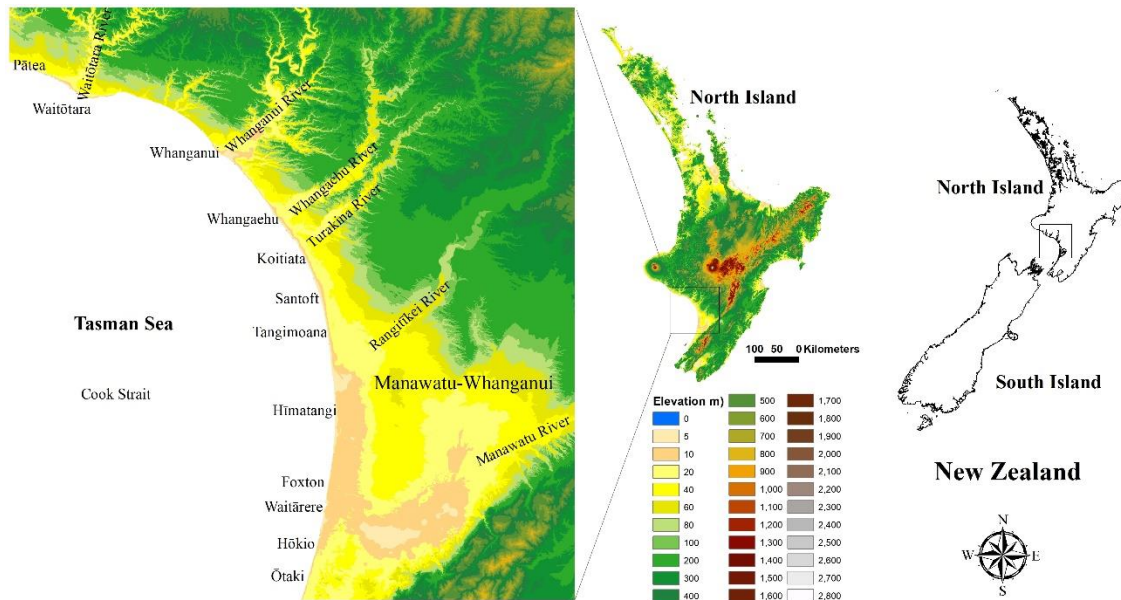


Figure 1: Study area: A Digital Elevation Model of the North Island and the Manawatū-Whanganui dune field (author: Ruwan Sampath)

<sup>19</sup> A.E. Esler. 'Manawatu sand plain vegetation', *Proceedings of New Zealand Ecological Society* **16** (1969): 32-35; Esler, 'Manawatu sand dune vegetation', 41.

<sup>20</sup> Rapson et al., *Sand-dune vegetation*, pp. 5-10.

<sup>21</sup> R.D. Shand, D.G. Bailey, and M.J. Shepherd. 'An Inter-Site Comparison of Net Offshore Bar Migration Characteristics and Environmental Conditions', *Journal of Coastal Research* **15** (3) (2001): 750-765.

<sup>22</sup> Hesp, 'The Manawatu Dunefield'.



The Manawatū-Whanganui region is subject to a temperate maritime climate. Rainfall increases from 800 millimetres at the coast to more than 5000 millimetres along the inland ranges, without any significant seasonal variability.<sup>23</sup> The mean wave height is 1.2m and storm wave height is 3.2m, while the mean wave period is 7.8 seconds and the maximum wave period (modelled) may reach 20 seconds in extreme events.<sup>24</sup> Along the Manawatū coast, waves approach from the southwest (Cook Strait) with a medium energy fetch of about 100km. Waves approaching from the west (Tasman Sea) have a much greater fetch, resulting in a dominant westerly swell.<sup>25</sup> As the wind angle at the coast varies from 20 to 43 degrees, the westerly swell approaches the coast at an oblique angle, resulting in a southward moving long-shore drift.<sup>26</sup> South of the Whanganui River, the present coastline has a preponderance of fine-grained sandy sediment derived from Plio-Pleistocene Whanganui Basin sediments and the greywacke axial ranges to the east.<sup>27</sup> North of the same river, coastal sediments are mostly volcanic detritus from the Taranaki and Central Volcanic regions, transported by rivers and carried southwards by dominant littoral drift.<sup>28</sup> The coast is characterised by low gradients due to the fine-grained nature of the sand, a relatively low tidal range (2-2.5 m) and moderate wave energy.<sup>29</sup>

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<sup>23</sup> A.J.H. Clement, C.R. Sloss and I.C. Fuller. 'Late Quaternary geomorphology of the Manawatu coastal plain, North Island', *New Zealand. Quaternary International***221** (2010): 36; R.G. Heerdegen and M.J. Shepherd, 'Manawatu landforms- product of tectonism, climate change and process', in J.M. Soons and M.J. Selby (eds), *Landforms of New Zealand*, (Auckland: Longman Paul, 1992), pp. 308-333.

<sup>24</sup> Shand et al., *Journal of Coastal Research*, p. 755; E. Atkin. *Mowhanau Cliff Line Retreat Review* (eCoast Ltd Marine Consulting and Research, 2012).

<sup>25</sup> Clement et al., 'Late Quaternary geomorphology', 36.

<sup>26</sup> Shand et al., 'An Inter-Site Comparison of Net Offshore Bar', 755.

<sup>27</sup> Clement et al., 'Late Quaternary geomorphology', 36-37.

<sup>28</sup> C. Muckersie and M.J. Shepherd 'Dune phases as time-transgressive phenomena, Manawatu', *Quaternary International***26** (1995): 61-67; Clement et al., 'Late Quaternary geomorphology', 37.

<sup>29</sup> Shand et al., 'An Inter-Site Comparison of Net Offshore Bar', 750-765.

## EARLY HUMAN SETTLEMENTS AND SAND DUNE DRIFT

According to the latest research, Polynesians arrived in Aotearoa New Zealand around 1280-1300AD. Initial settlement appears to have been coastal; later settlements fanned out along inland waterways. The second major group of humans (Europeans and small numbers of others) arrived from the late eighteenth century, first as sealers, whalers, traders and missionaries. Only from 1840 did significant numbers of settlers arrive. Māori effected major environmental changes, in the realms of Tangaroa (god of the waters) and Tāne (forest). New plants and animals arrived with the Polynesians, alongside new ways of looking at and exploiting the environment. Over the centuries of occupation, Māori adapted their horticultural techniques to the challenges of living in a colder and cooling climate. They engaged in deforestation and hunting, leading to the extirpation of some species. Māori firing reduced overall forest cover in Aotearoa from almost 100% on the eve of human arrival around 1300AD, to about 50% in 1840.<sup>30</sup> By then, the North Island retained roughly two thirds of its forests.<sup>31</sup> Nevertheless, Whanganui's inland forests remained beyond the transforming hand of Māori until the nineteenth century. Unlike the forests of New Zealand's eastern coast, west coast forests burnt less easily due to the regions' prevailing high rainfall.<sup>32</sup> Meanwhile, the impact of Māori was greatest on the coastal belt of vegetation, possibly from as early as 450 years ago.<sup>33</sup> By the time European

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<sup>30</sup> M. Roche, *A History of Forestry* (Wellington: GP Print, 1990), p. 9.

<sup>31</sup> G. Wynne, 'Destruction under the guise of improvement: the Forest, 1840-1920', in E. Pawson and T. Brooking (eds.), *Making a New Land: Environmental Histories of New Zealand* (Dunedin: Otago University Press, 2013), p. 127.

<sup>32</sup> A. Walton, 'Archaeology of the Taranaki-Wanganui Region', *Science for Conservation* **154** (2000): 1173-2946; Cathy Whitlock et al., 'Past and Present Vulnerability of Closed-Canopy Temperate Forests to Altered Fire Regimes: A Comparison of the Pacific Northwest, New Zealand, and Patagonia', *BioScience* **65** (2) (2015): 151-163.

<sup>33</sup> M.S. McGlone and V.E. Neall. 'The late Pleistocene and Holocene vegetation history of Taranaki, North Island, New Zealand', *New Zealand Journal of Botany* **32** (1994): 251-269; M.R. Bussell. 'Mid and late Holocene pollen diagrams and Polynesian deforestation, Wanganui district, New Zealand', *New Zealand Journal of Botany* **26** (3) (1988): 431-451.

travellers started to describe the region, Māori had burned and cleared large areas of the coastal strip, leaving a mosaic of scrub- and fern-land stretching some 5-6km inland.

Newcomers, primarily from Britain, arrived in increasing numbers from the 1840s, after New Zealand formerly became a colony in 1840. They brought new ways of looking at the environment and of transforming the territory. From the late 1850s onwards, the European population increased significantly by reason of the implementation of a series of assisted migration schemes, the arrival of soldiers for wars and the discovery of gold.<sup>34</sup>

Like Māori before them, Europeans concentrated their settlements on low-lying coastal areas. They intensified activities already initiated by Māori, like forest clearing for agriculture, and started others, such as timber milling and cattle breeding. Notably they introduced stock into an environment that had not previously known hoofed animals. Settlers were also responsible for introducing other exotic species as food sources and for sport, like rabbits and sambar deers, which ran freely in the sand hills.<sup>35</sup> Consequently, the removal, by humans and animals, of native sand-binding plants, such as spinifex and pingao, contributed to dune destabilization.<sup>36</sup> In 1839, the New Zealand Company made the first attempts to buy land in Whanganui region. Negotiations with Māori extended into 1848, ending in a purchase clearly unfavourable to Māori interests. The Company sought to form a settlement there because of the lack of cultivatable land in Wellington. In the 1870s and '80s, the Crown started acquiring land in the region as well, for settlement purposes, using the mechanism of the Native Land Court to individualise

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<sup>34</sup> J. Phillips and T. Hearn, *Settlers: Immigrants to New Zealand from England, Scotland and Ireland, 1800-1945* (Auckland: Auckland University Press, 2008).

<sup>35</sup> K.A. Wodzicki. 'Introduced mammals of New Zealand', Department of Scientific and Industrial Research Bulletin **98** (1950): 107–141.

<sup>36</sup> New Zealand Forest Service. Notes on Woodhill Sand Dune Area (New Zealand Forest Service, 1957); Whitehead, 'Sand dune reclamation in New Zealand'.

Māori land title and so make it easier to purchase land. Elsewhere, further north, as in Taranaki and the Waikato, the Crown seized land by force. The 1870s were characterised by government-directed migration and infrastructure schemes, the latter exemplified by the construction of a network of ports, roads, railways and telegraph lines. By 1907, as a consequence of the policies mentioned above, approximately 70% of Whanganui's lands and forests, had been transferred from Māori ownership to Crown or private settlers.<sup>37</sup>

Based on local newspapers, recurrent problems with dunes in the Manawatū-Whanganui region appear from the 1870s, although drifting sands were a much earlier phenomenon. In 1849, Te Atiawa voiced concerns about drifting sand blocking the window of their abandoned church<sup>38</sup>. In that same year, —Lieutenants C.H. Smith and C. Hutchison reported on the movement of the sand hills along the coast as well as their own experience of being blasted by sand.<sup>39</sup> However, other sources present a different picture. Early European accounts of this area from the 1840s report passing 'through a fairly dense growth' of forest, 'which covered the hills and valleys behind Putiki and away to the Manawatu'.<sup>40</sup> Even by the 1860s it seems that shifting sands did not present a major hindrance to movement, or to settlement. For example, Rod MacDonald recalled that 'with the exception of one partly covered littoral dune or ridge, immediately along the shore, the whole of the country from Otaki to the Manawatu was grassed and remained so until the '80s, when the first drift began'.<sup>41</sup> From these early observations it may be

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<sup>37</sup> S. Cross and B. Bargh. *The Wanganui District: Working Paper* (Waitangi Tribunal, 1996), part I, pp. 34, 58, 61, 117, part II, p. 94.

<sup>38</sup> McKelvey, *Sand Forests*, pp. 24-25. The period of the 1830s to 1850s was marked by large-scale movements of Māori, as a consequence of the knock-on effects of inter-tribal warfare. Although regions might appear 'abandoned' to Europeans, tribes still retained mana whenua over such lands.

<sup>39</sup> Cockayne, *Report on the dune areas of New Zealand*, p. 45.

<sup>40</sup> *Wanganui Herald*, "Sand Drift", October 12, 1909.

<sup>41</sup> E. O'Donnell. *Te Hekenga. Early days in Horowhenua. Being the Reminiscences of Mr. Rod McDonald*. (Palmerston North: Bennett and Co., 1929), p. 24; R.A. Wilson. *Fifty years' farming on sand country*

inferred that drifting sand was already occurring in this coastline as a natural phenomenon, one induced by Māori activities, or both, but it did not represent a widespread issue at the time, since vegetation still covered most of the area.

This seems to have changed in the 1870s. Manawatū's inland forests retreated rapidly in the face of milling and fires. The removal of forest, notes Catherine Knight, was a 'condition of the deferred payment scheme under which' settlers purchased land.<sup>42</sup> At the same time, in the lowlands, living on sandy soils presented some challenges: there were frequent complaints about sand piling up on streets, and covering roads and railway tracks. Travelling was quite difficult on this dune country since it was hard to build roads on the sand and coaches got stuck often.<sup>43</sup> Meanwhile, sand drift became an issue due to increasing settlement and changes in land use. The establishment of farms along river valleys as well as deforestation contributed to soil erosion. Devastating floods carried more sediments from the high country to the seashore feeding beaches and sand-hills. The removal of native vegetation and wandering stock broke the surface of dunes, destabilising sand dunes and making them more vulnerable to the eroding winds. Attempts at finding solutions were running parallel to the problem itself.<sup>44</sup>

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(Palmerston North, Keeling & Mundy Ltd., 1959); Cowie, 'Dune-building phases in the Manawatu district', 268- 277.

<sup>42</sup> C. Knight. 'Creating a Pastoral World through Fire: The case of the Manawatu, 1870-1910', *Journal of New Zealand Studies* **16** (2013): 103, 116.

<sup>43</sup> *Wanganui Herald*, 'Borough Council. Correspondence', July 1, 1874; 'Important meeting at Foxton', August 8, 1874; 'Exciting journey by coach from Foxton to Otaki', April 10, 1878; 'Manawatu County Council', June, 12, 1878; *Manawatu Times*, 'untitled', May 15, 1878.

<sup>44</sup> James Beattie, 'Environmental Anxiety in New Zealand, 1850-1920: settlers, climate, conservation, health, environment' (Ph.D. diss.: University of Otago, 2005 253-292. C. Knight. 'Totara Reserve: A Window into Manawatu's Environmental History', *The Manawatu Journal of History* **4** (2008): 52; Whitcombe, 'On the Reclamation of Land', 108-111; W. Keene. 'Notes on the fixing of sand-hills', read by J.C. Crawford, *Proceedings of the New Zealand Institute* **6** (1873): 377-378; T. Kirk. 'Notes on the plants best adapted for the reclamation of sand wastes', *Proceedings of the New Zealand Institute* **6** (1873): 45-54; G.W. Williams. 'Remarks on forest planting and conservation with reference to particular localities in the Wellington district', *Proceedings of the New Zealand Institute* **12** (1879): 429; W.T.L. Travers. 'Remarks

Taranaki politician C.D. Whitcombe pointed out that for Taranaki, for New Zealand's west coast generally and possibly even for the east coast, 'reclaiming land devastated by the encroachment of sand is one of the greatest importance'. The north-to-south and south-to-north tide, allied with rivers bringing 'loose virgin soil' downstream, he warned, would increase river bars and impede river navigation. Whitcombe's argument was significant, because in this period, the main form of transportation in New Zealand was by boat. Sands, Whitcombe continued, 'choke up the smaller streams', forming 'swamps and marshes along the line of their course'. If left unchecked, the inland drift of sand would create 'ever-increasing areas of desert land.'<sup>45</sup> Employing a language of fear, he wrote: 'Everyone can see with their own eyes the rapidity with which ... land is drifting in this [Taranaki] province and elsewhere in the colony from fruitfulness to desolation.'<sup>46</sup> Whitcombe pursued his campaign beyond the confines of the *Transactions and Proceedings of the New Zealand Institute*, the forerunner of the *Journal of the Royal Society of New Zealand*. He published a two-page letter to the Legislative Council, New Zealand's upper house, repeating the earlier arguments he had made.<sup>47</sup> While his letter appeared in the parliamentary notes for that year, it seems to have had no legislative impact.

Other authors were also beginning to campaign for sand-drift prevention. In 1873, two articles on sand drift appeared in the *Transactions*.<sup>48</sup> The second of those was read by Thomas Kirk, the future Conservator of Forests (1886-7). Presented to the Auckland

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on the sand dune of the West Coast of the Provincial District of Wellington', *Proceedings of the New Zealand Institute* **14** (1881): 89-94.

<sup>45</sup> Whitcombe, 'On the Reclamation of Land', 108.

<sup>46</sup> Idem, *ibidem*, 111.

<sup>47</sup> 'Whitcombe to Carrington, New Plymouth, 26 August', *Journals and Appendix to the Journals of the Legislative Council of New Zealand* **16** (1872): 1-4.

<sup>48</sup> Keene, 'Notes on the fixing of sand-hills', 376-377.

Institute, Kirk made an impassioned plea for reclamation, conveying an overwhelming sense of the alarm.

It would ultimately prove advantageous to the Colony if a small portion of the money now being spent on public works could be applied to the reclamation of sand wastes. The magnitude of the evil to be remedied is admitted by all who have paid the slightest attention to the subject. In several localities the natives are compelled, year by year, to abandon their cultivations as the sand-wave advances, and settlers are helpless witnesses of the destruction of their paddocks from the same cause. Fences, large trees, and patches of bush, have been overwhelmed within the memory of settlers of comparatively recent standing, and, in some cases, still more serious injury must result unless preventive measures are taken. The danger is not confined to any one district or province; it is general, and demands prompt attention.<sup>49</sup>

Another paper, read by G.W. Williams before the Wellington Philosophical Society on September 1879, addressed ‘the evil results arising from the indiscriminate destruction of the forests’, and ‘drew attention to the large sand-dunes which might be advantageously fixed by planting.’<sup>50</sup> Action on addressing the issue of drifting sand had already begun. J.C. Crawford was conducting experiments on transplanting and spreading the *Ammophila arenaria* (marram grass), as a sand-binder.<sup>51</sup> Locally, the press was circulating information about *Sygodon Dactylon* (most probably the *Cynodon dactylon*, or Bermuda grass), a grass, brought by accident from Sydney, that was proving valuable to farmers needing to fix drifting sand. In 1877, the Whanganui Jockey Club covered two acres of the neighbouring sand hills with an (unnamed) plant to prevent the racecourse encroachment. Later, the state would take action against sand drift. In 1884, the Government bought land, planting trees and installing fences in an area from the Foxton

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<sup>49</sup> Kirk, ‘Notes on the plants best adapted’, 45-54.

<sup>50</sup> Williams, ‘Remarks on forest planting’, 429.

<sup>51</sup> Keene, ‘Notes on the fixing of sand-hills’, 376.

Race course to Carnarvon to prevent sand drifts from overwhelming the line of the Foxton and Whanganui Railway.<sup>52</sup>

## METHODS OF MITIGATING SAND DUNE DRIFT

### *Knowledge transfer and adaptation in the nineteenth century*

In his address of 1873, Whitcombe promoted the French model of reclamation for Manawatū to follow in. Whitcombe recommended the reports of Alexandre Adam, on sand reclamation using grass and pines in Pas-de-Calais in France, as the most appropriate techniques for use in New Zealand.<sup>53</sup> France's government invested a great deal of effort and expense to reclaim sand-drift areas. Under the direction of engineer N.T. Brémontier, coastal dune stabilisation in Gascony and parts of Les Landes began in the late eighteenth century and was largely complete by 1817. In that time, reclamation had changed the face of the countryside. Dune stabilisation, afforestation (principally in pine) and drainage rendered an area of 320,000 hectares of marshland suitable both for agriculture and forestry.<sup>54</sup> Other European states, like Denmark, Prussia, Hungary, Russia, Portugal, Spain, and Britain faced similar issues, and addressed them using methods matching those used in France.<sup>55</sup> Members of the New Zealand Institute referred to shifting sands in France for three reasons: to emphasise the potential threat sand drift posed to New Zealand; to stress that redemption from this 'evil' was possible; and, finally, to lend

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<sup>52</sup> *Wanganui Herald*, 'Untitled', April 22, 1873; "The Wanganui Jockey Club", August 13, 1877; *Manawatu Times*, 'Untitled', July 28, 1884.

<sup>53</sup> 'Whitcombe to Carrington, New Plymouth'.

<sup>54</sup> McKelvey, *Sand Forests*, p. 13; R. David. 'Le fixation des dunes de la région d'Aquitaine: rôle du pin maritime, influence de l'eau sur la croissance du pin'. *International Journal of Biometeorology* **18** (2) (1974): 128.

<sup>55</sup> McKelvey, *Sand Forests*; Freitas, 'A Política Florestal nos últimos dois séculos'.



authority to their arguments. What is more, they stressed, reclamation could make the government money through the exploitation of forest resources.

Whitcombe was not alone in his advocacy of French models. For instance, Leonard Cockayne,<sup>56</sup> New Zealand's pioneering ecologist of the early twentieth century, suggested that Crawford, mentioned above for his work on reclamation experiments in Manawatū, had probably introduced the French method of fixing drifting dunes in New Zealand via Australia. In a letter of 1867 to Crawford, William Keene, Inspector of Mines of the Government of New South Wales recommended planting maritime pines as the best method of dune fixing, based on the example of coastal France between Bordeaux and Bayonne. While giving his own experience on failures of grass planting in NSW, Keene pointed out other advantages of pine trees, such as the production of timber as well as resin extraction for making bottle sealers and distilling turpentine. Crawford, however, was keener on planting grasses to fix the dunes, by testing a mixture of exotic marram grass and native species. Crawford was also aware of experiments made in Edinburgh that advised engineers to puddle up the seeds of marram grass and *Elymus* with wet clay and short pieces of straw rope before sowing.<sup>57</sup> In 1873, the reclamation of sand dunes was, likewise, discussed in the Auckland Branch of the New Zealand Institute by J. Stewart, who presented a reclamation method used in the Western Isles of Scotland.<sup>58</sup> Meanwhile, in that same year, Thomas Kirk provided an extensive list of indigenous and exotic plants suitable for dune reclamation. He also discussed methods of planting or sowing them, based on particular environmental conditions, with the support of a fence

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<sup>56</sup> Cockayne, 'Report on the dune areas of New Zealand', p. 5.

<sup>57</sup> Keene, 'Notes on the fixing of sand-hills', 376-377.

<sup>58</sup> J. Stewart. 'On the reclamation of Sand on the Coast, and the prevention of their inland advance', *Transactions and Proceedings of the Royal Society of New Zealand* 6 (1873): 42-45

at the high watermark.<sup>59</sup> Kirk's suggestions were unusual for the time, in his advocacy of native plants for reclamation.

Others began to consider the issue, using Manawatū's drifting sand as an opportunity to analyse human effects on environments, more generally. In 1881, evolutionist and parliamentarian William Thomas Locke Travers described dune migration in the west coast of the Manawatū-Whanganui region.<sup>60</sup> Travers pointed out that the areas covered with vegetation were not affected by wind so long as they remained undisturbed by humans, grazing and burrowing animals. If dune disturbance could be avoided, he reasoned, the bare sand would be reclaimed naturally over 'a few favourable seasons'. While noting the steps taken to stop dune mobilization in the Netherlands, Denmark and Prussia, Travers attributed the success of the afforestation of the west coast of France to the extensive support the French government gave to Brémontier. Travers recommended the New Zealand government offer similar support to stop dune drifting. He argued that the revenue from animal husbandry could not compensate for the damage to the dunes and the adjacent agricultural areas. Taking the example of France, Travers recommended the planting of grasses such as marram and *Elymus arenarius* near the sea, *Pinus Maritima* in the lee areas and growing vineyards upon the dunes on the west coast and, in particular, to the north of the Rangitikei River in Manawatū.

As these examples illustrate, in New Zealand, as in many other countries, the main model for dune reclamation was France. The success of Brémontier's method seems to have spanned the globe as the model for fixing drifting sands. However, it was not the only

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<sup>59</sup> Kirk, 'Notes on the plants best adapted'.

<sup>60</sup> Travers, 'Remarks on the sand dune'.

one. Stewart sought Scottish solutions, while, as Beattie has pointed out, German Forestry Science had a huge impact and dissemination in Australasia, and also had their own strategies for the dune problem.<sup>61</sup> New Zealand's scientists, while well aware of the discussions and solutions implemented in Europe, also sought to adapt these techniques to local conditions, such as experimenting with local grasses, such as pingao, in stabilisation.

Knowledge transfer from Europe to New Zealand also took place beyond the books and lectures of elites and experts. Letters from family and friends in distant places, as well as newspapers and magazines also carried advice on drifting sand (Figure 2).<sup>62</sup> A letter sent to the *Wanganui Herald*, in 1888, exemplifies knowledge transfer through local know-how and word-of-mouth. D. MacDonald, a settler from North Uist, in Scotland's Outer Hebrides, describes the use of bent grass (*Agrostis L.*) in his native country and how successful the grass was in reclaiming large areas of barren sand hills. He recommended its planting at Whanganui Heads as a means of arresting drifting sand, citing also its successes near Waitara, Taranaki.<sup>63</sup> Since New Zealand's settlers came mainly from England, Ireland and Scotland—countries and regions that had problems with moving sands for centuries—some of the newcomers understandably may have drawn on experience to deal with similar issues in New Zealand.

From the Whanganui region comes the example of the militant attitude of farmer John Handley from Okehu, who took into his own hands the task of preventing sand drifting

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<sup>61</sup> Beattie, *Empire and environmental anxiety*, p. 123; 'Culture Forestière. Extraits des Ouvrages Forestiers de M.M. Hartig et de Burgsdorff, sur les moyens de fixer les sables et de les planter en bois', *Annales de L'Agriculture Française* **XXVI** (1806).

<sup>62</sup> P. Holland. *Home in the Howling Wilderness. Settlers and the Environment in Southern New Zealand* (Auckland: Auckland University Press, 2013), pp. 9-10, 206.

<sup>63</sup> *Wanganui Herald*, "A Practical Suggestion", April 04, 1888.

from destroying his property. He described having 500ha of sand towering some 300 feet high, threatening to overrun the south side of his lands. Handley sowed grasses, such as *Ammophila arenaria*, *Mesembryanthemum* and *Elymus arenarius*, fenced and trees planted for almost two years. In 1891, he considered himself ‘master of the situation’, appraising the value of *Ammophila* in checking sand encroachment.<sup>64</sup> This letter is also important to understand how knowledge, based on trial and error, was passing into the colony through word-of-mouth and the local press. Farmers and other private settlers exchanged and distributed sand-fixing plants. This practical experimentation, above the world of experts, meant that ‘by the 20<sup>th</sup> century settlers increasingly relied upon local, and overseas models adapted to local contexts.’<sup>65</sup>

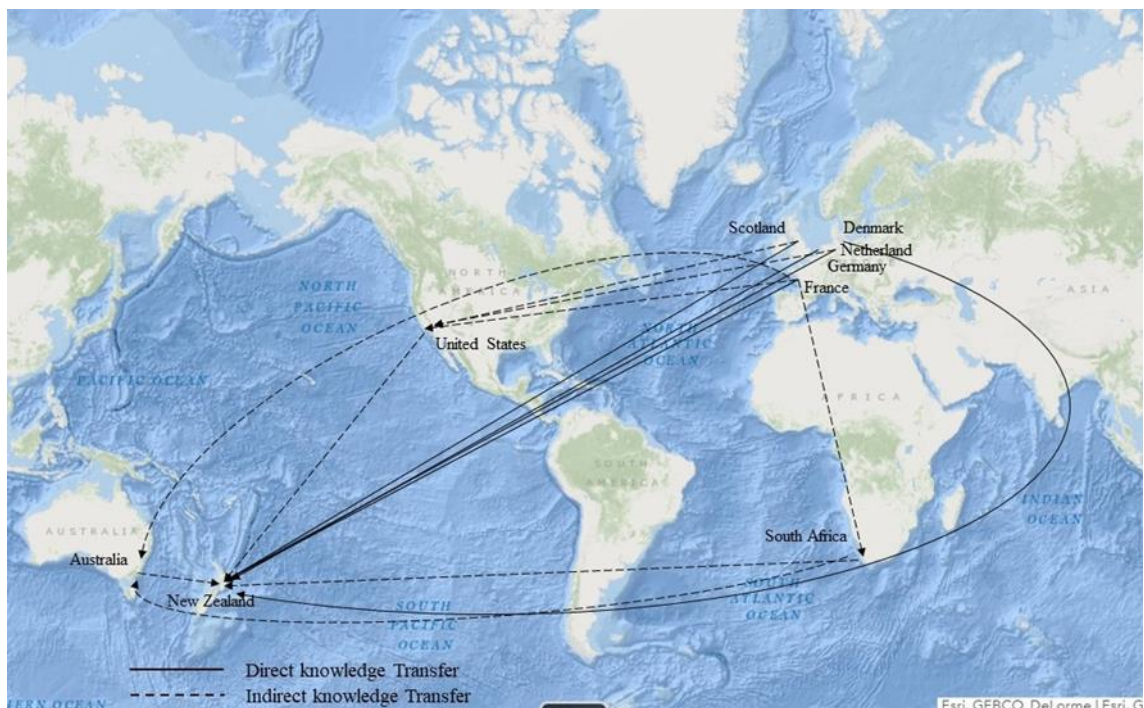


Figure 2: Direct and indirect paths of knowledge transfer to New Zealand to manage sand drifting in the nineteenth and twentieth centuries (author: Ruwan Sampath)

<sup>64</sup> *Wanganui Herald*, “Sand reclamation”, by John Handley, June 21, 1889; “*Ammophila Arundinacea*”, idem, June 03, 1891.

<sup>65</sup> Beattie, *Empire and environmental anxiety*, p. 188.

*Government intervention and scientific approaches in the twentieth century*

Until the beginning of the twentieth century, voluntarism provided the main basis of reclamation, as the example of John Handley illustrates. In some cases, however, a mix of government and local efforts developed, as authorities formed local urban bodies and contributed money to arrest shifting sands. For instance, in Dunedin, in 1884, management of the sand hills was beyond the resources of the municipal council. Government therefore formed the Ocean Beach Domain Board to deal with the sands of this public reserve. Nevertheless, sand dune issues drew little response from central government until the passing of the Sand Drift Act in 1903 (and consolidated in 1908), providing an initial legal basis to deal with the problem (Figure 3).<sup>66</sup>

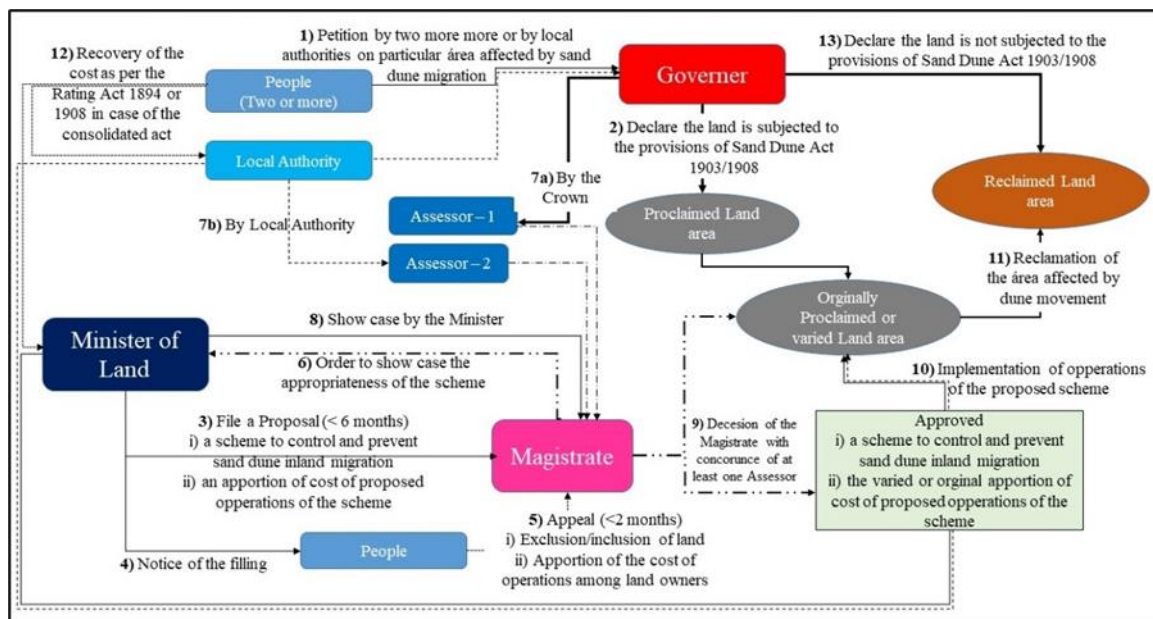


Figure 3: Scheme of the procedure adopted for implementing the Sand Dune Acts of 1903/1908, to reclaim the lands affected by sand drifting

<sup>66</sup> P.S. Whitehead. 'Sand dune reclamation in New Zealand', *New Zealand Journal of Forestry* 9 (1964): 146-153; W.J. Wendelken. 'New Zealand Experience in Stabilization and Afforestation of Coastal Sands', *International Journal of Biometeorology* 18 (1974): 145-158.

The act, introduced by Native Minister, James Carroll (1857-1926),<sup>67</sup> targeted the spread of sand dunes onto agricultural land by empowering the Minister of Lands to delegate to local councils the power to undertake reclamation work. The Act empowered the Governor to proclaim sand-drift areas ‘on the petition of any local authority or of any two or more persons interested’. Under the act, settlers assumed the burden of paying for reclamation on their own land, but could appeal against any decision to a Stipendiary Magistrate, who, in conjunction with two Assessors, would then reach a decision.<sup>68</sup>

Government also supported research and travelling missions to establish the extent and mechanisms explaining sand drift, as part of a more scientific approach that was gaining sway from the late nineteenth century. Informed by the new discipline of ecology, Cockayne’s scientific reports, from 1909 and 1911,<sup>69</sup> represented a milestone in knowledge transfer and the adaptation of overseas models to local conditions. Cockayne’s studies had great impact on policy.<sup>70</sup> In terms of New Zealand’s sand reclamation schemes, Cockayne was the first to give a detailed account of the geology, botany, structure of dunes and the processes involved in dune building and their landward drifting. He was inspired mainly by the methods used in France and Germany, by Bremonnier and Gerhardt, but also had detailed knowledge of sand-drift prevention methods from other European countries, as well as the United States of America, South Africa and Australia. Having read of the success of planting marram grass in the aforementioned countries, sometimes under exceptionally harsh environmental conditions, Cockayne recommended

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<sup>67</sup> J. Carroll, *New Zealand Parliamentary Debates*, 28 September 1903, p.4.

<sup>68</sup> *The Statutes of New Zealand* (Wellington, 1903), pp.57-58.

<sup>69</sup> L. Cockayne, *Report on the Sand dunes of New Zealand* (New Zealand: Department of Lands, 1909), p. 40; *Idem, Report on the Sand dunes* (1911), p. 75.

<sup>70</sup> P. Star. ‘Ecology: A Science of Nation? The Utilisation of Plant Ecology in New Zealand, 1896–1930’, *Historical Records of Australian Science* **17** (2) (2006): 197–207.

the same approach be adopted in New Zealand, without experimental planting of other sand binders. His argument that marram be procured in bulk throughout the country underlines the extent and seriousness with which he regarded drifting sand. Cockayne also concluded that adaptation of overseas management models was necessary in New Zealand. New Zealand planters, he recommended, should cut marram grass to 1ft in height to reduce transpiration, blow-out effects and the weight of bundles, unlike European and American practices. In another example of local adaptation, Cockayne suggested using mānuka (*Leptospermum scoparium*), gorse (*Ulex spp.*), tree-lupin (*Lupinus arboreus*), *Cupressus macrocarpa* and *Pinus insignis*, for fencing. Based on a model from Gascony - of creating foredunes with fences - Cockayne also proposed the erection of a series of protection belts to safeguard areas with buildings. He stressed dune afforestation as highest goal of sand reclamation—a method which was not the final step of dune fixing in New Zealand.

Cockayne's findings, allied to sand's ongoing spread, informed passage of the Sand Drift Act. In keeping with the thinking of the time, the 1903 Act represented a compromise between private and public investment. Along with Cockayne's reports it also indicates a more interventionist role for Government<sup>71</sup>. But how effective was this Act in the long-term? According to a historian, foresters and ecologists, although the Act made progress towards arresting sand drift, in reality it enjoyed little success, especially in sparsely

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<sup>71</sup> Later, Government also sent experts to investigate sand fixing overseas. Prime Minister William Massey sent both R.G. Robinson, superintending nurseryman of the Lands Department, and K.W. Dalrymple, territorial officer and farmer, to France, to study sand dune forestry. Robinson was working on his study when the Great War started and he had to return to home, so Dalrymple was charged with finishing it, while on leave from active service. Dalrymple's notes were published in 1922. Hamish Levack, "Current relevance of the New Zealand Forestry League", *New Zealand Journal of Forestry* **54** (1) (2009): 27-28.

populated areas.<sup>72</sup> A close analysis of the act reveals its success in combating sand-drift in urban areas, but not rural areas. Urban areas generated a higher rating revenue than rural ones and so contributed more to reclamation. Moreover, as illustrated in the legislation, there was also an ideological resistance to the Government simply taking over reclamation of dunes on private land. The requirement, instead, was to have joint government/locally funded responses to sand drift. Despite national legislation, the scale on which measures operated remained at the local level. However rational, however scientific on paper, environmental legislation could not be introduced without the will—or funding—for its implementation.

In the following years, more government-directed sand reclamation initiatives took place, though usually on a limited scale. In 1915, under the supervision of the Forestry Branch of the Department of Lands and Survey, small-scale experiments took place in North Auckland and Tangimoana, Manawatū, to test the capability of native and exotic plants to survive in harsh conditions and consolidate the sands. These trials expanded after the creation of the State Forest Service in 1919.<sup>73</sup> Post-war, the role of government in society expanded. Accordingly, with a broader brief, government began to assume greater responsibility for addressing issues of sand drift. After the Great Depression, the Public Works Department undertook sand stabilisation and afforestation works as a mean of providing relief to unemployed labour, setting in motion a series of reclamation projects. The purpose of these schemes – like the ones at Waiuku, Woodhill, Te Kopuru and

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<sup>72</sup> McKelvey, *Sand Forests*, pp. 29-30; R.L. Gadgil and F.J. Ede. 'Application of Scientific Principles to Sand Dune Stabilization', *Land Degradation and Development* 9 (1998): 131-142; Hesp, 'The Manawatu Dunefiled', 33-40; Wendelken, 'New Zealand Experience in Stabilization', 149

<sup>73</sup> Wendelken, 'New Zealand Experience in Stabilization', 149-150; G.H. Hocking. 'Sand Country of the Wellington West Coast', *New Zealand Journal of Forestry* 9 (1964): 128-138.



Kaitaia, all in the upper North Island – was to offer work to the unemployed, prevent sand encroachment to farmlands and create productive forests. According to Whitehead, the Forest Service was also involved in those operations, which were limited to essential maintenance level during the war years.<sup>74</sup>

In the 1950s, the Forest Service again took control of sand fixation, but a major issue arose concerning the uses of these reclaimed areas. For the Land Department, under the Land Act of 1948, the main goal of land development was farming, but the Forest Act of 1949 also gave the Forest Service authority to use it for afforestation. A working arrangement needed to be set: stabilisation and afforestation of sand in Crown lands had as a primary objective the protection of agricultural and pastoral activities.<sup>75</sup> In the 1950s, a major innovation introduced in sand reclamation—the mechanisation of some procedures—enabled planting of marram and trees on a larger scale and more quickly than before, reducing labour costs and releasing Forest Service staff for specific manual work such as foredune construction. After 1952, commercial operators started to copy state mechanised planting.<sup>76</sup> As timber requirements increased and new methods improved the scope of activity, dune afforestation became the subject of many foresters' reports in the 1950s and 1960s. These reports show that reclamation works—after many years of trial and error experiments—had now developed a set of standardised and very specific procedures.<sup>77</sup>

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<sup>74</sup> Whitehead, 'Sand dune reclamation in New Zealand', 149.

<sup>75</sup> Wendelken, 'New Zealand Experience in Stabilization', 150; Hocking, 'Sand Country of the Wellington West Coast'; M.J. Conway. 'Mechanisation in Sand Dune Afforestation', *The Empire Forestry Review* **35** (1956): 142-148.

<sup>76</sup> A.A. Restall. 'Sand Dune Reclamation on Woodhill Forest', *New Zealand Journal of Forestry* **9** (1964): 154-161.

<sup>77</sup> Conway, 'Mechanisation in Sand Dune Afforestation', 142-148.

In 1964, P.S. Whitehead,<sup>78</sup> a senior Forest Ranger, explained the three-step method of dune stabilization (Figure 4). A primary stabilizer developed ‘establishing’ foredunes with the help of catching fences and the close planting of marram. As primary stabilizers did not achieve complete fixing of the dune sands without further aid, secondary cover involved plantings of shrubs such as mānuka, *Olearia*, *Cassinia* and *Pimelea*. As their growth was usually slow and sparse, other quicker-growing species, such as tree-lupin and *Acacia sophorae*, were required for the success of reclamation work. Against Cockayne’s recommendations, post-war foresters sowed tree-lupin after the marram had

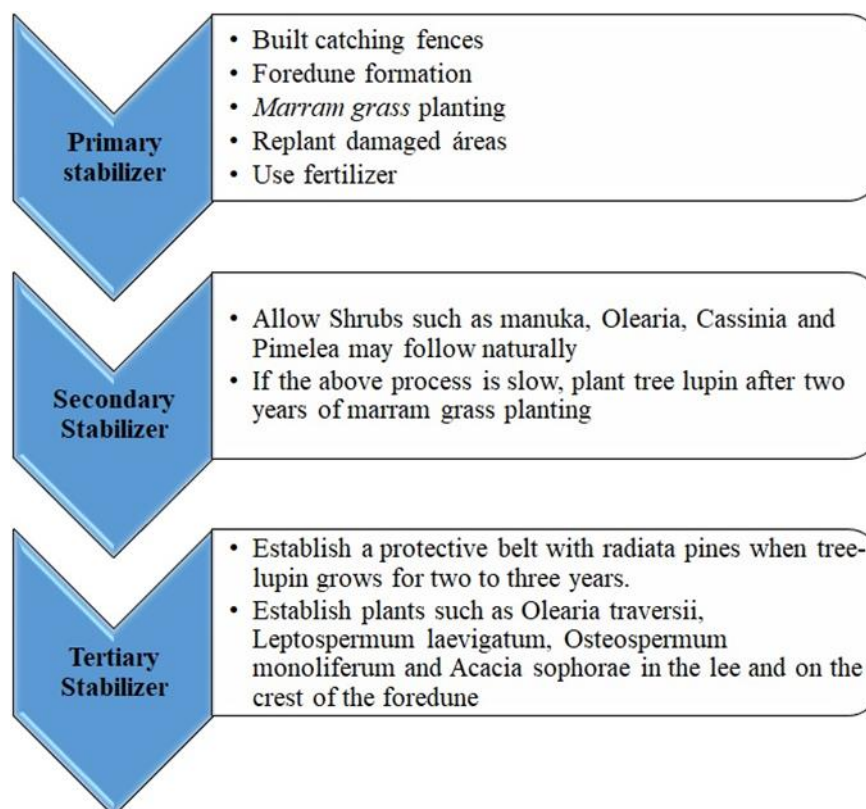


Figure 4: The sequence of the dune stabilization approach adopted in the 1960s.

<sup>78</sup> Whitehead, ‘Sand dune reclamation in New Zealand’, 149, 151.

been growing for two years.<sup>79</sup> Tree-lupin, native to the dunes of central and northern California, also addressed the nitrogen deficiency of sandy soils. The tertiary stabilizer saw the establishment of a forest belt, planted after two-to-three-years' growth of tree-lupin.<sup>80</sup> Radiata pines and *Macrocarpa* suited sand country environments in which plants had to withstand salt-laden winds and survive in infertile soils. For the lee and on the crest of the foredune, foresters planted shrubby hardwoods such as *Olearia traversii*, *Leptospermum laevigatum* and *Acacia sophorae*. Significantly, Whitehead made it clear that the principles of sand reclamation had not change much since the works had begun in the Tangimoana experiment station in 1915. W.J. Wendelken, writing in 1974, also presented a stabilization and afforestation scheme very similar to this one.<sup>81</sup> This long-term analysis reveals that all of these procedures from the nineteenth century to the twentieth were based around the old method of Brémontier, but adapted to local environmental conditions (vegetation species and materials used in fences), using modern innovations, such as mechanization and a stronger institutional support (in human and financial resources).

#### *The case of the Manawatū-Wanganui district*

How did national scale trends in sand-dune stabilisation affect the Manawatū-Wanganui region? Following Cockayne's report of 1911, in 1913 the Lands Department promoted the first experimental dune stabilization in region. They sponsored the plantation of

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<sup>79</sup> Cockayne, *Report on the dune areas of New Zealand* (1911), pp. 44-45; Hesp, 'The Manawatu Dunefiled', 36.

<sup>80</sup> McKelvey, *Sand Forests*, pp. 24-25.

<sup>81</sup> Wendelken, 'New Zealand Experience in Stabilization', 150-154.

marram at the Rangitikei (Tangimoana) and Waikato River mouths. Yet, according to geomorphologist Patrick Hesp, two-thirds of the planting failed.<sup>82</sup> In 1915, the Forestry Branch of the Department of Lands and Survey began a small-scale demonstration of reclamation at Tangimoana by planting marram and erecting fences. By 1916-17, fences were built on a 4.8km-long foredune using driftwood and manuka brush, as suggested by Cockayne. Experiments stopped during the Great War, but the newly-created State Forest Service resumed them in 1921 and also set up the Rangitikei Sand-Dune Experiment Station. In 1927, the *Evening Post* of Wellington published a report on works there, praising the merits of sand reclamation as a way of conquering a ‘great waste asset’, by assuring stabilization and producing profitable forests at a safe distance inland.<sup>83</sup> By 1930, the Forest Service was growing a 671-hectare forest in the area. As a means of solving unemployment issues during the Great Depression, the Public Works Department engaged in a reclamation project in Hokio, near Levin, planted marram south of the Rangitikei River mouth in 1935, and initiated tree-planting the following year.<sup>84</sup> Later, the works expanded to the Waitarere district,<sup>85</sup> the area now known as the Waitarere Forest. Dune stabilization also received support from several civil organizations. A notable example was the work done by the Flock House Farm of Instruction near Bulls that established 700 hectares of pine forests between 1924 and 1936.<sup>86</sup>

The breakout of war in 1939 caused the suspension of new activity. Works were kept on a maintenance level of the existing dune reclamation and afforestation projects. After the

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<sup>82</sup> Hesp, ‘The Manawatu Dunefiled’, 36 .

<sup>83</sup> *Evening Post*. ‘Land or Sand? Wind-driven dunes of Rangitikei. Plant –fixing Campaign’, November 5, 1927.

<sup>84</sup> Idem, “Manawatu Sand Dunes Afforestation Scheme”, September 11, 1934.

<sup>85</sup> McKelvey, *Sand Forests*, pp. 24-25

<sup>86</sup> Whitehead, ‘Sand dune reclamation in New Zealand’, 148.

war, several inventories were carried out to estimate the extent of active dunes. For example, reports by the Catchment Board of Manawatū indicated that 8000 hectares were affected by dune drifting between Waitarere and Tangimoana in 1948. At this time too, significant attention was given to land reclamation in order to increase the area for farming for producing primary products for export.<sup>87</sup> In 1951, the Government assigned all coastal sand reclamation schemes, including the Waitarere project undertaken by Public Works Department, to the responsibility of the Forest Service of the Lands Department. In 1952, the Santoft project began on the coastal sector between Rangitikei and Turakina rivers in the Wellington Conservancy. According to G.H. Hocking, at that time the Forest Service administered around 18700 hectares of sand country, having planted 5200 hectares. There were also widespread private interventions for dune control, but rarely beyond a mile of the beach. Some sawmilling companies had their own forests in the area. Hocking also drew attention to the changing use of dunes as beaches were becoming more important as recreational areas and as seaside housing was coming to occupy frontal dunes.<sup>88</sup> Foredues that were present along the Manawatū-Whanganui coast by 1870s had fully or partially disappeared in the 1950s, as evidenced in aerial photographs and according to the observations of Hesp.<sup>89</sup> Thus, foredues were re-established in front of large forests from 1974 at the rate of 3km per year. By the time the Forest Service was abolished in 1987, large pine forest areas existed in the Manawatū-Whanganui region: 3347 hectares in Santoft, 420 in Tangimoana and 1652 in Waitarere.<sup>90</sup>

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<sup>87</sup> Whitehead, 'Sand dune reclamation in New Zealand', 149.

<sup>88</sup> Hocking, 'Sand Country of the Wellington West Coast', 135-136.

<sup>89</sup> Hesp, 'The Manawatu Dunefield', 36-37.

<sup>90</sup> Id., *ibid.*, 37.

As this research demonstrates, human activities over almost 150 years have extensively modified dunes in Manawatū-Whanganui. A significant reduction of around 81 per cent in the area of active dunes took place from the 1950s to 1990s through reclamation. To this extent, sand dune stabilization efforts initially by private groups and then Government had succeeded in many areas. In this process, pastures, pine tree forests, and gorse as well as other exotic species replaced dunes.<sup>91</sup> Despite this, dunes in the best natural condition remain in a 9 km long strip, stretching from Foxton Beach to the settlement of Himitangi.<sup>92</sup> According to geologist M.J. Shepherd, dune migration rates over low scrub and through the forest registered 17-and-1.5 metres per year respectively, from 1965 to 1987. From 1995, there was a new episode of parabolic dune formation, due to increased rates of urbanisation.<sup>93</sup> Parabolic dunes form with ruptures to the foredune, due to high levels of unstable sand accumulation, or to disturbance by storm episodes or human action.<sup>94</sup> The strength of blowouts and the degree of lee-side stabilization with vegetation, also determines the dune roll-over by giving it a parabolic shape.<sup>95</sup> In the study region, parabolic dunes migrated landward at an average rate of 20-to-25 metres per year, while older parabolic dunes, which developed from 1990 to 1995, migrated 50-80 metres per year from 1995 to 2001. Dune migration rates vary as per the type of leeward habitat. For instance, by 2007, the maximum advance rates through the forest were 1-10 metres per year, through low scrubs 70 metres per year and grasslands 100 metres per year. At

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<sup>91</sup> M. Hilton. 'The loss of New Zealand's active dunes and the spread of marram grass (*A. arenaria*)', *New Zealand Geographer***62** (2006): 105–120.

<sup>92</sup> Rapson et al., *Sand-dune vegetation*, p. 7.

<sup>93</sup> M.J. Shepherd. 'Holocene alluviation and transgressive dune activity in the lower Manawatu Valley, New Zealand', *New Zealand Journal of Geology and Geophysics***30** (1987): 175-187.

<sup>94</sup> Rapson, *Sand-dune vegetation*, p. 6.

<sup>95</sup> P. Hesp. 'Foredunes and blowouts: initiation, geomorphology and dynamics', *Geomorphology***48** (2002): 245-268.

some localities, dune migration is 100 metres per month, which is the highest in the world.<sup>96</sup>

## MANAGEMENT OF DUNES IN THE TWENTY-FIRST CENTURY

### *Institutional strategies*

Around the world, the practice of ecological restoration has become a panacea for enhancing recovery of ecosystems damaged by humans.<sup>97</sup> In New Zealand there has been a corresponding interest in support for native species in major ecological restoration works,<sup>98</sup> as reflected in the Resource Management Act (RMA) of 1991.<sup>99</sup> This Act entrusted the minister of the Department of Conservation with developing a strategy for the sustainable management of the coastal environment. As a result, the New Zealand Coastal Policy statement was established in 1994. Policy 1.1.2. identifies ‘the preservation of the natural character of the coastal environment to protect areas of significant indigenous vegetation and significant habitats of indigenous fauna’ as a national priority, notably the preservation of ‘ecosystems which are unique to the coastal environment and vulnerable to modification.’ This includes dunes systems. Moreover, Policies 3.4.2. and 3.4.3 recognize the ability of natural features, like beaches and dunes, to offer some defence against erosion and/or inundation, recommending their integrity

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<sup>96</sup> C. Walrond, ‘Dune lands’, *The Encyclopedia of New Zealand*. <https://teara.govt.nz/en/dune-lands/print> (accessed on November 20, 2019).

<sup>97</sup> J. Aronson, A.F. Clewell et al. ‘Ecological restoration: a new frontier for nature conservation and economics’, *Journal for Nature Conservation* **14** (2006): 135–139.

<sup>98</sup> B.D. Clarkson and C.L. Kirby. ‘Ecological restoration in urban environments in New Zealand’, *Ecological Management & Restoration* **17** (3) (2016): 180-190.

<sup>99</sup> *Resource Management Act. Public Act 1991* No69. (The Parliament of New Zealand, 1991), pp. 132-161.

and ability to be protected and enhanced. Also, Policy 3.4.4. states that future plans should have in consideration that these ecosystems might migrate inland as the result of dynamic coastal processes.<sup>100</sup> In 2000 the work of geographer Mike Hilton et al.<sup>101</sup> considered that in the RMA the Department of Conservation belatedly recognized the contribution of active dune areas to the preservation of the natural character of New Zealand's coastal environment. Their work also highlighted that most restoration programs being undertaken by local authorities were more concerned with the re-establishment of foredunes for coastal hazards protection than for the conservation of their function or flora. This is a worldwide tendency. Dunes provide several ecosystem services, but, since mean sea level rise is menacing infrastructure in littoral zones, they have been highly valued for coastal buffering and their management is often determined by hazard mitigation purposes rather than ecological services.<sup>102</sup>

New Zealand's Coastal Policy Statement (2010) has a similar policy aim to the RMA. It considers, in general, the need for safeguarding 'the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems' including dunes, by 'maintaining or enhancing natural biological and physical processes in the coastal environment and recognising their dynamic, complex and interdependent nature; and protecting representative or significant natural ecosystems and sites of biological importance' to preserve "the diversity of New Zealand's indigenous coastal flora and fauna". In particular, policy 14 (iv) promotes the rehabilitation of the natural character of

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<sup>100</sup> *New Zealand Coastal Policy Statement* (Te Papa Atawhai: Department of Conservation, 1994), p. 4.

<sup>101</sup> M. Hilton, U. Macauley and R. Henderson. *Inventory of New Zealand's active dune lands* (Wellington: Department of Conservation, 2000), p. 7

<sup>102</sup> N.P. Psuty and D.D. Ofiara. *Coastal Hazard Management. Lessons and Future Directions from New Jersey* (New Brunswick: Rutgers University Press, 2002), pp. 190-192, 199.



dunes. Policy 26 recognizes them as natural defences and determines their restoration or enhancement so they can act as buffer-areas for coastal land uses.<sup>103</sup> In this way, New Zealand is following a strategy common to many other countries: recognizing dunes as nationally important areas, worthy of protection as unique ecosystems in and of themselves. Yet they are also used as soft measures for coping with hazards in coastal zone management.

In the twenty-first century, New Zealand's main approach to dune restoration is centered on re-vegetation using native plant species for stabilizing—rather than fixing—sand. Native plants have greater tolerance to wind, salt spray, sand-blasting, fluctuating temperatures, periodic drought, and poor nutrient conditions than most other species.<sup>104</sup> Their cover also allows for a certain degree of dune mobilization.<sup>105</sup> Local councils, the Dune Restoration Trust, and the Department of Conservation have been supporting projects to remove marram grass and plant native sand binding species, such as spinifex and pīngao.<sup>106</sup> These restoration efforts have allowed dunes to achieve the natural character of an active system. Thus, ecologist Greg Jenks suggests that this successful, affordable dune restoration work has extensive benefits for other nations experiencing degraded coastal zones.<sup>107</sup>

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<sup>103</sup> *New Zealand Coastal Policy Statement* (Wellington: Department of Conservation, 2010), pp. 9, 18, 25.

<sup>104</sup> Hilton et al., *Inventory of New Zealand's active dune lands*, p. 7; E. Miller and T. Paul, *Measuring success: guidelines for the management of Sand Dune Revegetation Programmes. Technical Bulletin* (New Zealand Forest Research Institute, 2007), p. 7.

<sup>105</sup> Esler, 'Manawatu sand dune vegetation', 43; Durán and Moore, 'Vegetation controls on the maximum size of coastal dunes', 1

<sup>106</sup> R.J. Poole, *Valuing coastal dunes: a case study of the Manawatu Parabolic dunefield* (Master Thesis. Palmerston North: Massey University, 2003).

<sup>107</sup> G.K. Jenks. 'Restoring the natural functional capacity of coastal dune ecosystems: Utilising research records for New Zealand littoral refurbishment as a proxy for analogous global responses', *Journal of Coastal Conservation* **22** (2018): 623–665; R.L. Gadgil. 'Marram grass (*A. arenaria*) and coastal sand stability in New Zealand', *New Zealand Journal of Forestry Science* **32** (2) (2002): 165–180.

*Dune management in Manawatū-Whanganui*

Under the Resource Management Act,<sup>108</sup> a Regional Policy Statement is mandatory. In the Manawatū-Whanganui region, natural resources management and response to natural disasters are coordinated by the Horizons Regional Council, the name of the regional authority for Manawatū-Whanganui. This entity prepared, in 2014, an integrated plan, identified as “One Plan” that promotes a holistic approach for managing the present environment with a vision for preserving and enhancing it for generations to come.<sup>109</sup> Three key issues identified in the One Plan have implications for dune management: threatened indigenous biodiversity, erosion, and natural and historical heritage. The document recognizes that the region has lost much of its indigenous habitats because of over a century of landscape modification, while remaining habitats continue to be threatened by land development as well as the spread of introduced plants and animals. The policy to conserve indigenous biological diversity includes maintenance, protection of areas of significant indigenous vegetation and fauna, and division of responsibilities between the Regional Council and Territorial Authorities. On the western coast, the foredune and associated inland soils are subjected to accelerated wind erosion as the protective vegetation cover is removed for coastal development, or because of vehicle movement and other human activities. In this way, large quantities of now-released sand threaten buildings and property. Thus, under the Sustainable Land Use Initiative, vegetation clearance, land disturbance and cultivation require resource consent if they are undertaken adjacent to coastal foredune. Finally, some parts of the coastline, including

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<sup>108</sup> *Resource Management Act. Public Act 1991*, pp. 132-161

<sup>109</sup> *One Plan – The Consolidated Regional Policy Statement, Regional Plan and Regional Coastal Plan for the Manawatu-Wanganui Region*. Amendment of the 2014 report (Horizons Regional Council, 2018).

the Foxtangi Dune, Hokio Beach South Dune Field and Santoft parabolic dunes, were integrated and placed on the regional list of outstanding natural features and landscapes for their visual and scenic characteristics, geological processes, ecological and recreational value, significance to tāngata whenua (Māori) and historical heritage.

The approach to dune restoration in Manawatū involves the removal of marram grass and planting of native sand-binding species, with the support and resources available from local councils, the Dune Restoration Trust, and the Department of Conservation.<sup>110</sup> Scientists recommend dune restoration be carried out with the active participation of stakeholders, based on voluntary effort.<sup>111</sup> Yet just as the nineteenth- and early twentieth-century efforts to stabilize the dunes using exotic plants came to be the driver of environmental management, leading to the removal of the plants now considered pests, so twenty-first century responses based on new management paradigms have the potential to become the drivers of another environmental crisis in the future. Thus, the criticism of Delgado-Fernandez et al.<sup>112</sup> is possibly valid, as the assumption of new paradigms such as ‘bare sand is good’ and/or ‘mobility is natural’ may not be sustainable in the context of the current climatic and environmental conditions. In particular, such a management strategy could increase the risk of erosion of bare foredunes due to accelerated sea-level rise and storm surge events, as predicted by the IPCC.<sup>113</sup> In this way, changes associated

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<sup>110</sup> S.L. Jamieson, *Sand dune restoration in New Zealand* (Masters Thesis. Wellington: Victoria University of Wellington, 2010), p. 22.

<sup>111</sup> Gadgil and Ede, ‘Application of Scientific Principles to Sand Dune Stabilization’, 131-142.

<sup>112</sup> I. Delgado-Fernandez, R.G.D. Davidson-Arnott and P. Hesp. ‘Is ‘re-mobilisation’ nature restoration or nature destruction? A commentary’, *Journal of Coastal Conservation* **23** (2019): 1093-1103.

<sup>113</sup> IPCC, *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge Cambridge University Press, 2013).

with the Anthropocene through development and environmental change of dunes have the potential to be further destabilised by sea-level rise.

## CONCLUSION

For a better understanding of the long implications of human responses to dune mobilization in the Anthropocene, this study carried out a comparative analysis of historical and present-day management of the Manawatū-Whanganui coastal area. It found that the first settler management approaches in the nineteenth century and early twentieth adapted techniques and models from France to New Zealand environments. The strategy for dune stabilization in a later period comprised a three-tier approach: 1) a primary stabilizer using fences to create foredunes to protect the grow of exotic plants, such as marram grass; 2) a secondary stabilizer based on the planting or sowing of tree-lupin, two years after; and 3) a tertiary stabilizer, making use of pines. This methodology, even if the early-stage implementation was not successful, was continuously improved with local scientific studies and trial and error attempts, until it become quite efficient.

Sand-drift stabilisation altered natural processes and feedbacks associated with dunes and caused a significant reduction in native biodiversity. The contrast in dune management, between historic practices of the nineteenth- and twentieth-centuries and the practices of the present, is that in the earlier period the approach was to fix the dunes, preventing them from moving. The later approach was to restore stabilized dunes to activate their natural processes by removing exotic plants. These approaches reveal two different perceptions about these ecosystems. First, it shows that settlers viewed sand as dangerous wastelands, a threat to agriculture, which justified interventions to stabilize and turn them into

profitable forests. In contrast, at the end of the twentieth century, dunes had become valuable environments for cultural, ecological and geological reasons based on better knowledge of their relevance to natural coastal processes. Accordingly, they have received protection under a set of acts and policies instituted over nearly 30 years.

These changes in perception and their contexts are important to understand because ideas, values or perceptions shape human actions and their responses to the material world. In effect, this case study shows how well-intended management responses may become drivers of unintended environmental hazards many years after the event. Thus, it posits that the re-establishment of active dunes in the Manawatū-Whanganui coastal area has to be implemented in consideration of sea-level rise and foredune erosion. To facilitate holistic management of the resources in coastal ecosystems, adaptation measures should be implemented only after an interdisciplinary analysis of their impact on both the long-term evolution of coastal sand dunes and their relationship to society.

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