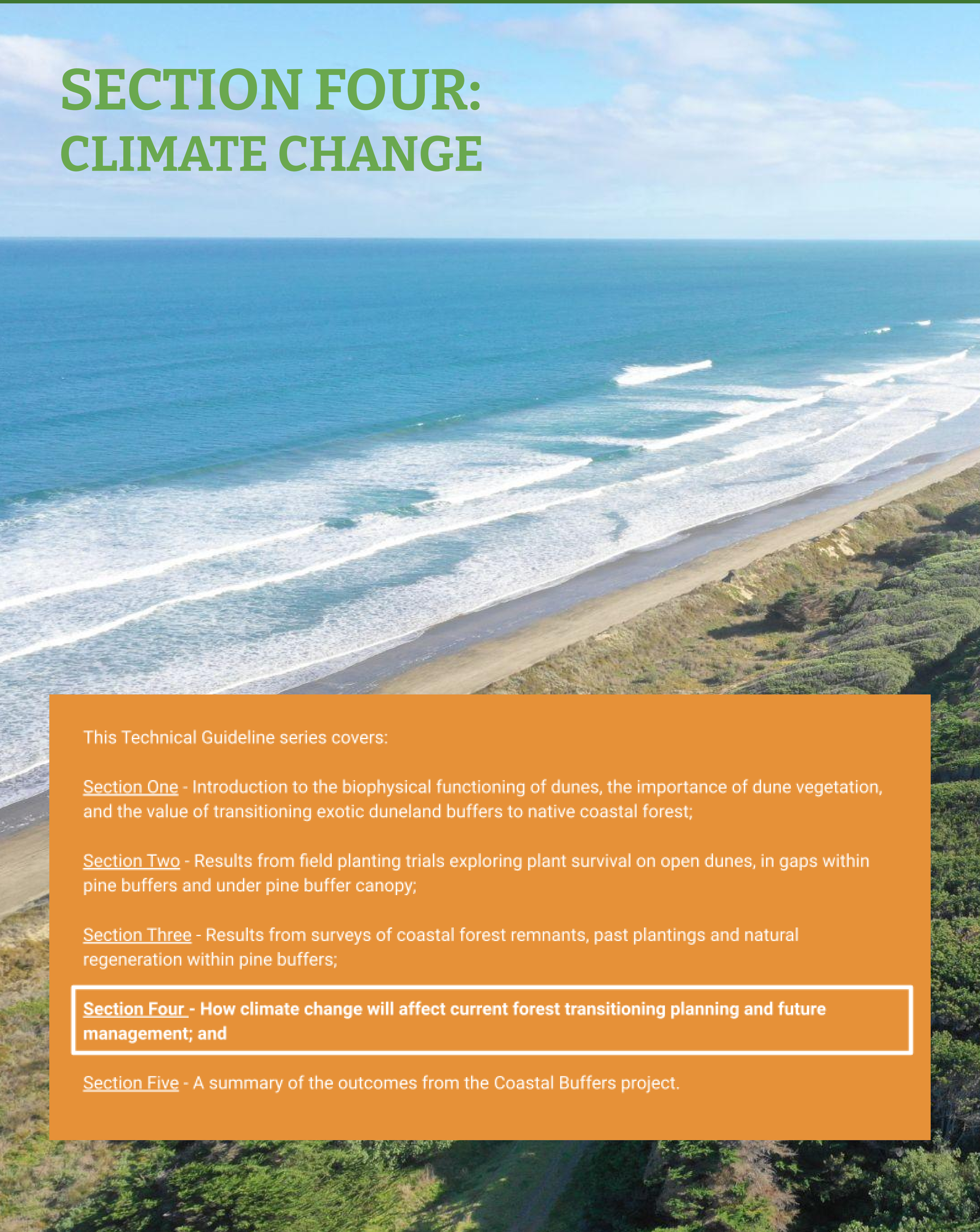
Tāne's Tree Trust
NATIVE FORESTS FOR OUR FUTURE
Hereherea te Wao-nui-a-Tāne

PRELIMINARY TECHNICAL GUIDELINE
Adaptive Management of Coastal Forestry Buffers



SECTION FOUR: CLIMATE CHANGE

This Technical Guideline series covers:

Section One - Introduction to the biophysical functioning of dunes, the importance of dune vegetation, and the value of transitioning exotic duneland buffers to native coastal forest;

Section Two - Results from field planting trials exploring plant survival on open dunes, in gaps within pine buffers and under pine buffer canopy;

Section Three - Results from surveys of coastal forest remnants, past plantings and natural regeneration within pine buffers;

Section Four - How climate change will affect current forest transitioning planning and future management; and

Section Five - A summary of the outcomes from the Coastal Buffers project.

Contents

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Introduction

Research has been under way to determine methods for transitioning duneland exotic pine buffers to a buffer of native species that would resemble prehuman coastal native forest. Surveys of existing exotic buffers and associated native vegetation were undertaken and planting trials set up to determine appropriate methods for transitioning exotics to native.

In designing restoration of nearshore coastal forest buffer zones, it is important to consider existing and potential future shoreline movements. Numerous studies of shoreline change on northern North Island beaches indicate these shorelines are not static, they move, and that projected future climate change is likely to exacerbate erosion in the future (e.g. see Dahm and Munro, 2002; Dahm and Gibberd, 2009; Focus, 2012 & 2020a,b; Tonkin and Taylor, 2017 & 2020; Auckland Council, 2021) . Physical coastal features such as dunes can also have a significant influence on exposure and shelter, influencing forest structure and growth rates in nearshore areas. Then there are other pressures from climate change such as drought and fire risk which are likely to increase in severity.

As forest recovery takes time, and the intent is to have a coastal forest that is sustainable long term, the potential future influence of projected future climate change needs to be considered.

This technical article provides a summary of the existing dynamics and potential effects of climate change on sand dune coastlines of the upper North Island - North Cape to Bay of Plenty on the east coast, and to the North Taranaki Bight on the west coast.

Shoreline Change with Existing Sea Level - East Coast

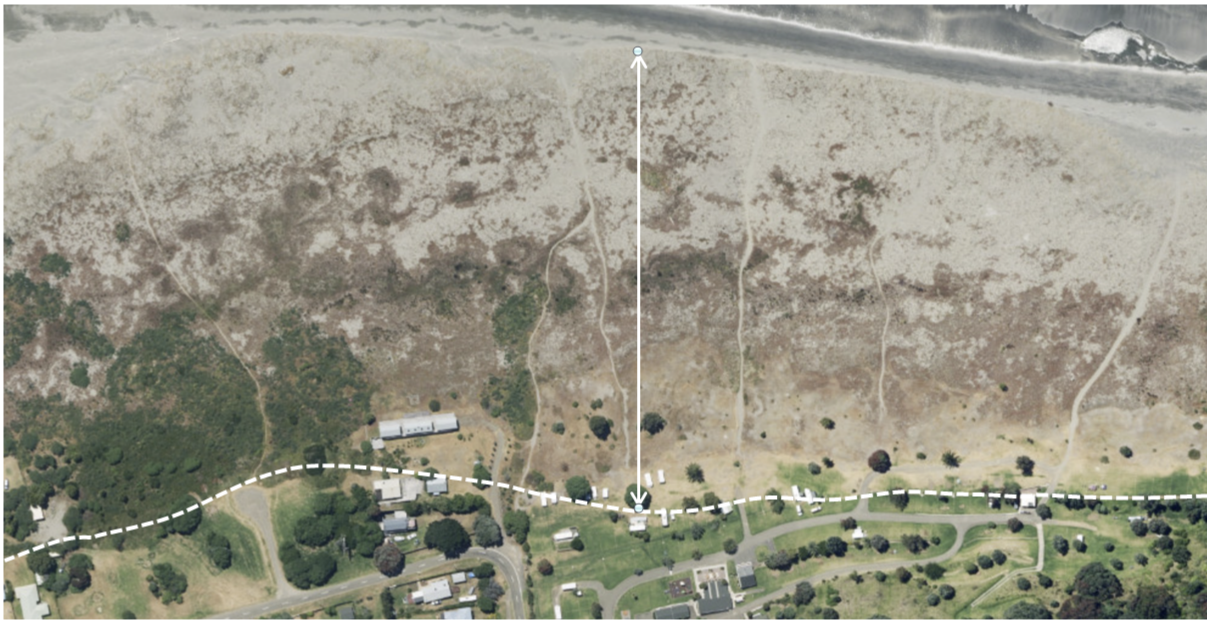
The east coast beaches of the northern North Island are typically embayed beaches. In general, they do not have significant sediment exchange with adjacent beaches apart from some Bay of Plenty and Northland beaches which are interconnected by longshore drift.

The existing beach and dune systems have formed over the last 7500 years that sea-level has been at or about present elevation, following a rise of about 120m since the last glaciation. The majority of the beach and dune sands were moved onshore from the adjacent continental shelf, with relatively insignificant current supply from rivers. An exception was large volcanic eruptions in this period which did supply significant volumes of sand to parts of the Bay of Plenty coast via rivers. However, most east coast beaches no longer have any significant net sand supply; they essentially have all the sand they are likely to get.

East Coast shoreline change

With existing sea-level, most beaches on this coast appear to be largely in dynamic equilibrium, with shoreline change primarily associated with dynamic shoreline fluctuations, periods of erosion followed by periods of beach and dune recovery over years and decades. Very few beaches presently show evidence of significant (>5m/century) permanent net seaward advance or erosion when considered over long periods.

The largest dunelands typically occur adjacent to estuary or river entrances which can experience significant shoreline changes (often 100-200m+) over many years or decades (e.g. Ohiwa Spit).



View of severely eroded Ohiwa Spit shoreline in 1979 near the peak of an erosion phase (above) compared to a more recent photo showing the shoreline in an accreted state (below). The white dashed line shows the shoreline position at the peak of the last erosion phase.

Away from river and estuary mouths, shoreline fluctuations are most commonly associated with storm cut (erosion) and recovery, and with multi-decadal shoreline fluctuations.

The process of storm cut and recovery is common on most sandy beaches. During storms, the beach and dune are eroded with sands transferred offshore to a bar (and sometimes from one end of a beach to another – known as beach rotation). Subsequently, the sand returns and dunes are repaired by native dune building plants (spinifex and pingao).

Multi-decadal shoreline fluctuations are also common at many east coast beaches and involve lengthy periods dominated by beach and dune erosion, followed by lengthy periods dominated by beach and dune recovery. These multi-decadal shoreline fluctuations cause much larger shoreline fluctuations than individual storm cut and recovery events. The fluctuating widths vary between beaches but are commonly 20-50m and can be up to 100-200m in areas close to some river and estuary entrances.

Shoreline Change with Existing Sea Level - West Coast

Unlike the compartmentalised beaches of the east coast, the beaches from Taranaki to the North Cape are dynamically interconnected with sands moved alongshore by wave-driven littoral drift. While waves move sand in both directions, there is a net northwards movement of sediment over time. The coast is also subject to high energy waves and so beach profiles are much flatter (dissipative) than east coast beaches.

West Coast shoreline change

As with the east coast, the shoreline is subject to estuary/river mouth dynamics, storm cut and recovery and multi-decadal shoreline fluctuations; with the most significant changes typically associated with estuary and river/stream mouths.

However, there is considerable complexity and uncertainty associated with shoreline movements on this coast. For instance, shorelines can be relatively stable for decades and even centuries with dynamic duneline changes commonly <30-50m, and then undergo much more significant shoreline movements, sometimes even erosion or accretion up to hundreds of metres.

The most significant shoreline changes appear to relate to slugs of sediment moving along the coast, which can cause very large shoreline changes (both erosion and accretion) over decades to centuries. These "slugs" of sediment are not yet well understood but may be related to clumps of sediment bypassing obstacles (e.g. river or estuary mouths, headlands) and/or to pulses of sediment supply (e.g. from cliff erosion or river floods).

One of the most significant examples over the last 150 years is the large-scale accretion and erosion that has occurred from Port Waikato to Muriwai. For instance, Port Waikato Spit has extended over 3200m northwards since 1863 pushing the Waikato River mouth northward and causing erosion up to 1300-1500m inland on the northern side (Figure 1). In the 1800s, local Maori advised that a low dune plain once extended from Port Waikato to the Manukau Harbour entrance but was eroded away. Significant bank and channel changes occurred in the Manukau Harbour entrance during the 1800s and 1900s, probably related in large part to this large slug of sediment bypassing the entrance. Large-scale accretion (in places >1300-1500m) also occurred at Whatipu in the 1900s as the large slug of sediment arrived at that location. Some of the sediment has since moved northwards causing large shoreline advance at Piha and, since about 2010-2012, ending a long-standing erosion trend at the southern end of Muriwai Beach.

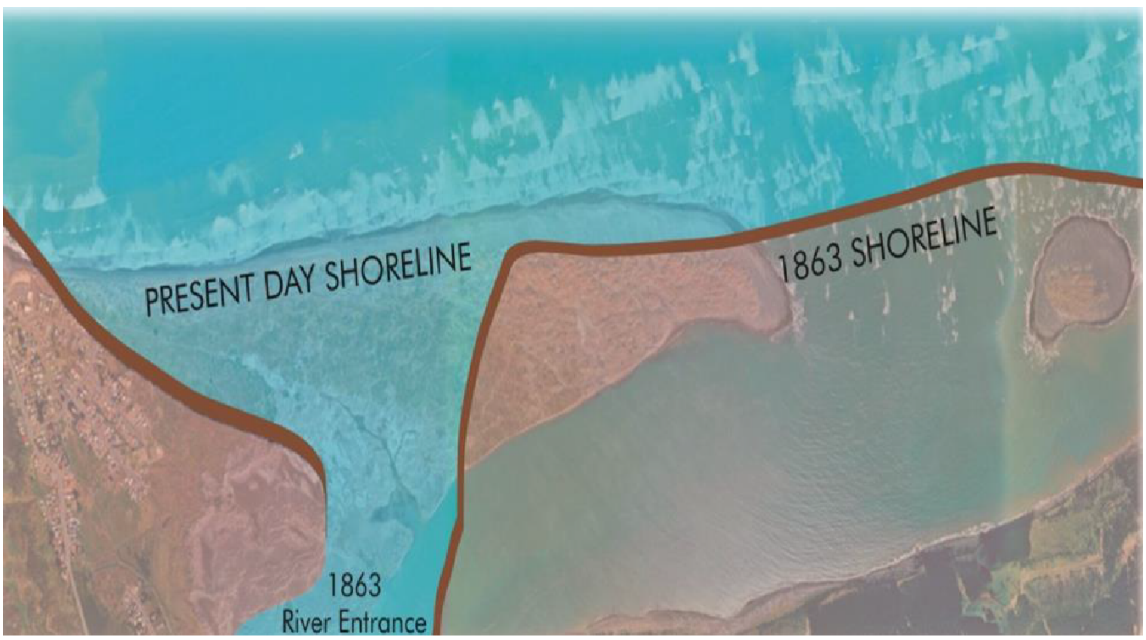


Figure 1: Diagram illustrating overall shoreline change at the Waikato River entrance between 1863 and the present.

Climate Change

Over the next century and beyond, significant warming and climate change is projected to occur in response to emissions of greenhouse gases from human activities. Climate change is likely to affect several drivers which influence coastal forest buffers including sea-level rise, shoreline dynamics, winds, waves, droughts, fire hazard, ground water levels and ground water salinity.

Sea-level rise

Over the last 100 years, average relative sea-level rise around NZ was around 1.8 millimetres a year. Future warming is expected to accelerate this rate of sea-level rise due both to thermal expansion and to melting of mountain glaciers and polar ice sheets. There is uncertainty around the rate and scale of future sea-level rise as it will depend critically on how well greenhouse gas emissions are managed. Accordingly, government guidance usually provides a range of sea-level rise scenarios based on low, medium, high and extreme emissions scenarios. These scenarios are updated following each review of projected future climate change by the Intergovernmental Commission in Climate Change (IPCC), typically every 6-7 years. Over the last 25 years, projected future sea-level rise has steadily increased with each review.

The 2017 government guidance suggests sea-level will increase by 0.5-1.5m over the next 100 years (i.e. to 2130), with continued increase beyond this period (Figure 2).

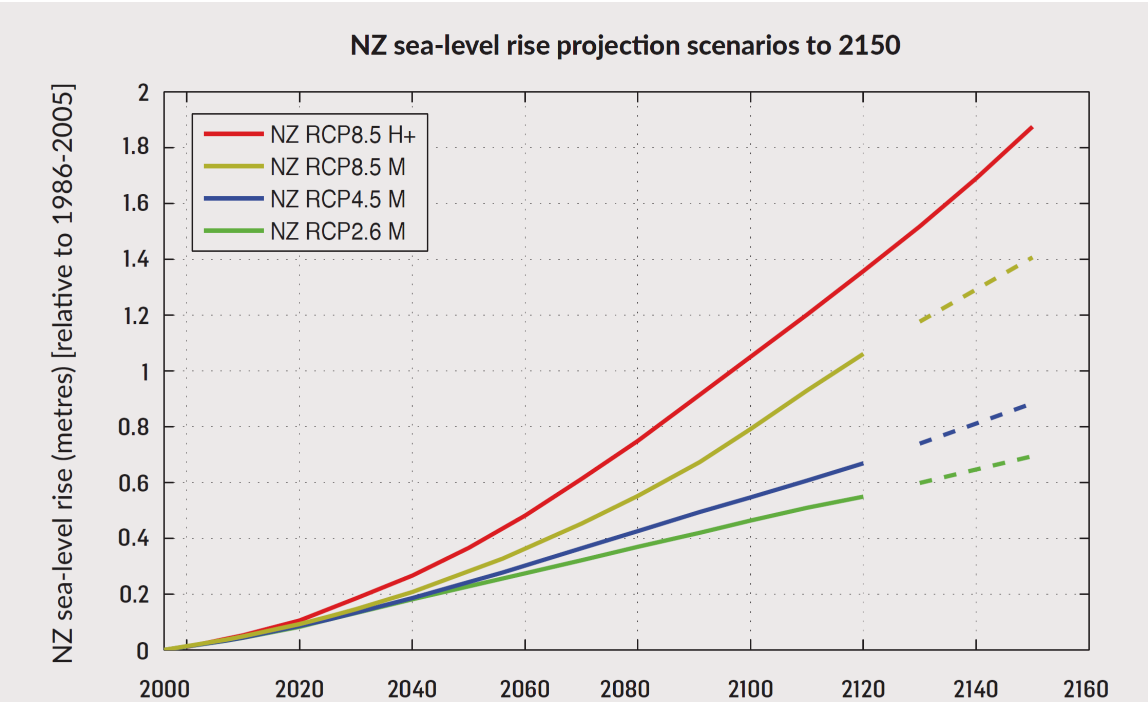


Figure 2: Future sea-level rise scenarios from 2017 government guidance. The different lines (RCPs) reflect different greenhouse gas emissions scenarios which depend on how effectively these are managed.

Sea level rise along beach systems of the upper North Island is expected to drive an overall trend for shoreline retreat with beach profiles adjusting landwards and upwards in response to the higher water level (see hazard reports cited earlier).

At present, available methods only enable indicative estimates of this erosion.

On the east coast, these methods typically suggest 20-45m of erosion for every 1m of future sea-level rise. The issue is more complex on the west coast due to alongshore sediment transfer between beaches. However, indicative estimates by various researchers suggest that sea-level rise alone may result in 50-75m permanent erosion for every 1m of sea-level rise. **This is permanent landward retreat that will be superimposed on the existing dynamic shoreline fluctuations.**

Dune erosion, Kawhia

Storms and Extreme Winds
Projections for future changes in storms and extreme winds are not as clear and consistent as for sea-level rise. Current government guidance suggests changes in storm frequency, wave heights and winds will be relatively modest or inconclusive, but recommend consideration of a 0-5% increase in waves and winds for the upper North Island.

Temperature, rainfall and drought
Climate projections for New Zealand developed by NIWA in 2016 based on the IPCC Fifth Assessment scenarios suggest an increase in minimum, mean and maximum temperatures, varying with emissions scenarios. Annual precipitation is expected to decrease in the north and east of New Zealand, with an increase in dry days of about 5% by 2090 for the north and east of the North Island with the changes most marked in winter and spring. Droughts will also increase in severity and frequency.

These changes will likely affect forest structure over time and influence the success of new plantings (e.g. our trial plantings across all northern North Island sites had a very high failure rate during the 2019-2020 summer drought.

Fire
Increasing temperatures, droughts and winds will all exacerbate the risk of fire in forested landscapes, especially those that are dominated by highly flammable species such as many exotic pine, gum, wattle and Hakea species and gorse, as well as native species like kanuka and manuka. Establishing a diverse native coastal forest buffer dominated by lower flammability species will act as a green fire-break reducing the fire risk of coastal ecosystems, as well as for neighbouring plantation forests.

Ecological disturbances such as fire shape and restructure our natural ecosystems. New Zealand historically had a low occurrence of fire until human settlement, so few of New Zealand's indigenous plant species show any real adaptation to fire.

Monocultural pine buffers are very vulnerable to fire. Establishing a diverse native forest buffer that will eventually replace the pine canopy will reduce the fire risk. To establish a green fire resistant diverse native coastal forest, plant a dominance of low to moderate flammability coastal native species.

Groundwater levels and salinity
The relationship between sea-level and groundwater levels in coastal dunes is highly localised and complex. However, in many coastal dunelands, groundwater levels are influenced by sea-level. In such areas, groundwater levels may rise with future sea-level. In rare cases, some very low-lying dune swales may even become permanent or seasonal wetlands where raised groundwater levels intercept the surface.

In some areas, there is also potential for increased saltwater intrusion into groundwater aquifers with sea level rise; particularly in combination with land use and land cover changes that increase groundwater drawdown.

Implications for coastal forest buffers

Upper North Island beach shorelines are not static and existing erosion is likely to be further aggravated by climate change. Native coastal forest buffers must be sufficiently wide to allow for future landward movement of dune vegetation zones.

- On both east and west coasts, existing shoreline change is generally most significant in the vicinity of estuary and river entrances.
- In areas well removed from estuary and river entrances, dynamic shoreline movements on the east coast are generally less than 50m. On the west coast, it is more complex and consideration has to be given to historic shoreline trends and the potential for larger-scale (>200m) shoreline change.
- Future sea level rise is likely to result in additional and permanent shoreline retreat. Current (2021) national guidance suggests that sea-level rise of at least 1.5-2m should be considered for the next 150 years. On the east coast, this could result in permanent shoreline retreat of 40-90m, depending on the site. On the west coast, permanent erosion of 75-150m could occur.
- Therefore, to provide long-term protection coastal buffers must be wide enough to absorb dynamic shoreline movements and increasing sea level. Potential changes in exposure may also occur if existing protective high frontal dunes are removed by future erosion. This is a particularly important consideration for exposed west coast shorelines.

Climate change is also likely to impact the composition and structure of dune forests.

- Drought-resistant pioneer shelter (e.g. pines) will be very important in providing shade to help native coastal forest establish during hot, dry summers.
- The choice of coastal forest species to plant will not only have to reflect the local floral character but also consider species ability to withstand drought conditions.
- Trial and other survey findings indicate that utilising the microclimates available at a site will enhance planting/regeneration success (e.g. planting in swales where dune topography provides greater shelter and water tables are closer to the surface; utilising forestry debris and existing shrubby vegetation in open situations to provide shelter from sun, wind and salt).
- A diverse native coastal forest buffer is likely to be more resilient to fire and disease than existing buffer zones comprised of a few exotic species.
- If groundwater becomes contaminated by salt this may have serious repercussions on the long-term survival of coastal forest species.

References

Auckland Council, 2021. Predicting Auckland's exposure to coastal instability and erosion. Auckland Council technical report TR2021/021 published February 2021.

Aimers, J. 2020: Green Fire Breaks. Tāne's Tree Trust article. https://www.tanestrees.org.nz/site/assets/files/1321/green_fire-breaks-_june_2020-_ja.pdf

Dahm, J. 2011. Understanding (and enjoying!) storm cut erosion and recovery. Coastal Restoration Trust Technical Article 2.2 https://www.coastalrestorationtrust.org.nz/site/assets/files/1185/2.2_storm_cut_erosion_2011.pdf

Dahm, J. 2011. Shore changes at river and tidal entrances. Coastal Restoration Trust Technical Article 2.3. https://www.coastalrestorationtrust.org.nz/site/assets/files/1185/2.3_shoreline_changes.pdf

Dahm, J and Munro, A. 2002: Coromandel Beaches: Coastal Hazards and Development Setback Recommendations. Environment Waikato Technical Report 02/06: 180pp.

Dahm, J. & Gibberd, B., 2009: Coromandel Beaches – Coastal Hazards: Review of Primary Development Setback at Selected Beaches. Report prepared for Thames-Coromandel District Council, October 2009.

Focus, 2012: Coromandel East Coast Beaches: Potential impacts of projected climate change on coastal erosion over the next century and review of future coastal erosion setback. Report prepared for Thames Coromandel District Council by Focus Resource Management Group, November 2012. 9p.

Focus, 2020: Waikato District Council Coastal Hazards. Report prepared for Waikato District Council by Focus Resource Management Group, February, 2020. 120p.

Focus, 2020: Waitomo District Council Coastal Hazards. Report prepared for Waitomo District Council by Focus Resource Management Group, October, 2020. 116p.

NZ Fire & Emergency website. Flammability of Plant Species https://fireandemergency.nz/home-and-community-fire-safety/flammability-of-plant-species/#low

Perry, G, J. Wilmshurst, M. McGlone. 2014: Ecology and long-term history of fire in New Zealand. New Zealand Journal of Ecology (2014) 38(2): 157-176. https://newzealandecology.org/nzje/3198.pdf

Richter, C., M. Rejmanek, J. E. D. Miller, K. R. Welch, J. Weeks, and H. Safford. 2019. The species diversity fire severity relationship is hump-shaped in semiarid yellow pine and mixed conifer forests. Ecosphere10(10):e02882. 10.1002/ecs2.2882. https://esajournals.onlinelibrary.wiley.com/doi/epdf/10.1002/ecs2.2882

Tonkin and Taylor, 2017. Coastal erosion hazard zone assessment for selected Northland sites. Report prepared by Tonkin & Taylor Ltd for Northland Regional Council, December 2017.

Tonkin & Taylor Ltd, 2020: Mount Maunganui to Papamoa Coastal Erosion Assessment. Prepared for TCC, February 2020. Tonkin & Taylor Ltd, Auckland, New Zealand.