

Rosedale Beaches: Dune health report and action plan

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This report was prepared for The Rosedale Association by Associate Professor Hannah Power of the School of Environmental and Life Sciences, University of Newcastle, with contributions from Katie Moore.

All photos contained in the report were taken by Hannah Power or Katie Moore unless credited otherwise.

Aerial imagery used in the report was obtained from the Historical Imagery Viewer provided by NSW Spatial Services and referenced using maps from NSW Spatial Information Exchange and nearmap.

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Executive summary

Coastal dunes are a critical component of the coastal system representing a buffer between marine and terrestrial processes and ecosystems. This report uses a combination of historical aerial imagery analysis, in-situ surveys, morphological observations, and vegetation surveys to assess the health of the dune systems at four beaches in Rosedale, NSW: Tranquil Beach, Nuns Beach, Rosedale Beach, and North Rosedale Beach. The goal of this report is to assess dune health, identify areas of concern, and provide recommendations that can form the basis of a community action plan.

Analysis of the extent of the dune vegetation using historical aerial imagery and data collected in-site shows that dune vegetation extents are variable but approximately stable over the observation period (1977 to 2021) with no clear trends of net losses or gains for all four beaches. Dune morphologies vary between the beaches and along the length of Rosedale Beach. Tranquil, North Rosedale, and Nuns Beaches have relatively small dune systems due to a limited amount of space for dune systems to develop in and/or a low degree of exposure to wind and waves. The size and morphology of the dune on Rosedale Beach vary along the length of the beach with the largest and most well-developed dunes present in the central region of the beach owing to the exposed nature of this section of the beach and sufficient accommodation space to allow for dune development. Smaller and more condensed dune systems are present in the northern and southern regions of Rosedale Beach.

In general, the dune vegetation presents with a diverse array of native species that are comparable to other dune vegetation assemblages observed in the region. The dunes in the central region of Rosedale Beach had the sparsest vegetation and had trees present in the dune that were burnt in the 2019 fires with some regenerating from the base. While some weeds are present, the dunes are not overrun with weed or invasive species.

Recommendations

Based on the results of this report which are summarised above, it is recommended that the community:

- Increase community awareness of the importance of dune systems and dune vegetation through community workshops and education initiatives that promote the environmental, social, and financial benefits of a well-maintained and well-vegetated dune system
- Continue to implement existing strategies that control weed and pest species (e.g., rabbits) that have negative impacts on dune structure, biodiversity, and ecosystem health
- Implement and maintain a minimum of access paths from access points (e.g., roads, houses) to the seaward limit of vegetation with fencing or otherwise to avoid trampling of dunes and dune vegetation
- Continue to revegetate the dunes using a mix of primary, secondary, and tertiary native dune species with sand-fencing as required, ensuring a diverse range of species are planted, monocultures are avoided, and that there is a focus on a densely vegetated foredune and hind-dune to increase dune stability and resilience and improve dune biodiversity and ecological function
- Take a targeted and staged approach to dune revegetation such that a section of dune is more fully restored (as opposed to partial restoration of a wider area) with a follow-up maintenance program for areas of revegetated dune

- Prioritise dune revegetation on the central region of Rosedale Beach over other regions due to the impact of the 2019 fires on the dune vegetation
- Implement community monitoring program to regularly assess dune health that monitors the dune morphologies and volumes as well as dune vegetation assemblages
- Only remove weeds in sparsely vegetated areas if areas can be immediately revegetated with native species to ensure sufficient plant cover to prevent wind erosion of the dune system
- Only remove dead plants and trees once replacement local native vegetation is sufficiently established such that there is no loss of sediment stabilisation, wind buffering, or ecosystem structure

1. Background

On open-coast, sandy shorelines, coastal dunes are often present in varying sizes and forms. Dunes are an accumulation of sand deposited by the wind and are often the last line of defence between an eroding beach and coastal infrastructure. They are thus a critical component of the coastal system representing a buffer between marine and terrestrial processes and ecosystems. Further, they limit the ingress of waves, salt-spray, and wind, as well as acting as a barrier to ocean inundation.

In many locations along developed coastlines, dunes have been modified or removed to facilitate development. This dune modification or removal limits the buffering action of the dune system. It also decreases the volume of sand accessible to the beach in the event of major storms or instances of erosion, a critical role of the dune in the dynamic coastal environment. In a natural, unmodified setting, the coastal dune will be comprised of a series of zones: the tertiary vegetation zone containing the incipient dune; the secondary vegetation zone containing the foredune; and, the tertiary vegetation zone containing the hind dunes. Each of these zones is characterised by distinctive morphologies and vegetation assemblages (e.g., Figure 1).

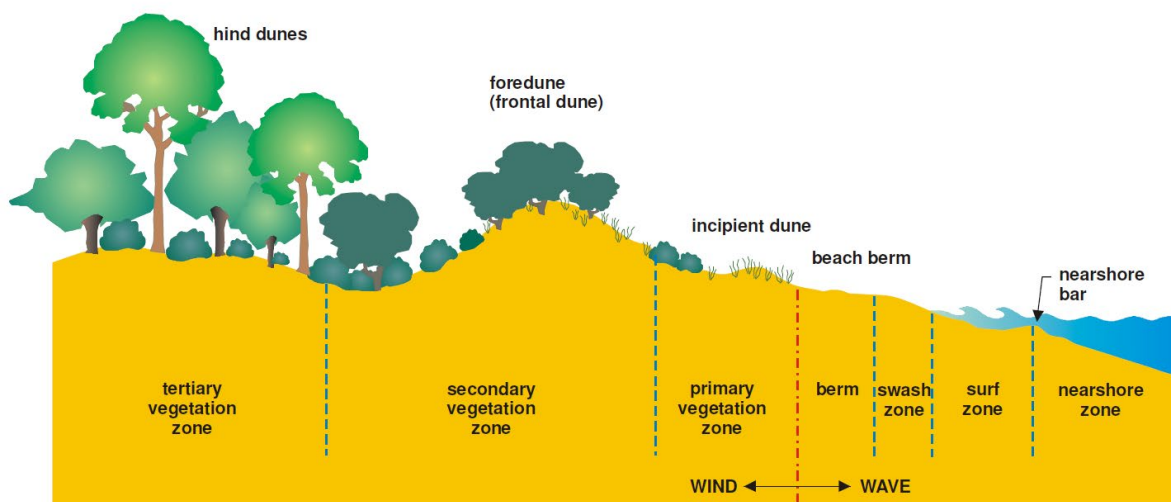


Figure 1. Typical features of a dynamic beach and dune system. Source: NSW Department of Land and Water Conservation (2001).

On 31 December 2019, Rosedale was severely impacted by fires in the 2019-2020 Black Summer bushfires experienced in southeast Australia. Fire affected large areas in the community including sections of the dunes and the associated vegetation. This report was commissioned by the Rosedale Association to examine the current dune health and obtain advice on how to best manage the dune systems.

This report assesses the historical and present health of the dunes at four beaches (herein referred to collectively as Rosedale Beaches; see Figure 2) surrounding the suburb of Rosedale: Tranquil Beach; Nuns Beach; Rosedale Beach, with three regions of dunes along the beach: the southern, central, and northern regions; and, the beach to the north of Rosedale Beach which is referred to by varying names including Rocky Beach, Little Beach, Nudies Beach, Incident Cove, and North Rosedale Beach (herein referred to as North Rosedale Beach). The southern region of Rosedale Beach is

bounded by the rock platform at the southern end of the beach and the cliff fronting Knowlman Rd at the northern end, the central region of Rosedale Beach extends from the cliff fronting Knowlman Rd to the creek, and the northern region extends from the creek to the rocky headland at the northern end of the beach.

This report has a particular focus on the present state of the dune system and presents recommendations to protect and enhance dune health. The report is structured as follows. Section 2 describes the approach taken to investigate the dune health at Rosedale Beaches including data collection and analysis. Section 3 presents the results of the analysis of both historical aerial imagery and the data collected in-situ. Section 4 concludes with key observations and recommendations which can form the basis of the community action plan.



Figure 2. Map of Rosedale and surrounds showing the four beaches examined in this report and the three regions of dunes along Rosedale Beach. Imagery source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Map coordinate system: WGS1984.

2. Approach

2.1. Historical imagery assessment

To assess the historical state of the dunes at Rosedale Beaches, six historical aerial images of Rosedale Beaches were obtained from the NSW Spatial Services Historical Imagery Viewer. These images covered the years: 1975, 1977, 1989, 1991, 1997 and 1999. All six historical aerial images were georeferenced using the NSW SIX maps as a base-map to reference all imagery. Due to poor image quality and a lack of suitable reference points resulting in poor georeferencing, the 1975 image was discarded from further analysis. A further three aerial images were obtained from nearmap™ for the years 2018, 2019, and 2020. See *Appendix A: Raw historical imagery* for each image.

For each of these nine images, the edge of the dune vegetation line was manually digitised to assess the change in dune vegetation extents through time. All spatial analyses were completed using ArcGIS and ArcMap. Further, the extent of dune vegetation along each of the dune monitoring transects identified during the in-situ data collection (see next subsection) was measured to obtain baseline data should the Rosedale Association wish to implement a community dune monitoring program.

2.2. In-situ data collection

A site visit to Rosedale Beaches was conducted in April 2021 to undertake qualitative and quantitative assessments of the dune extents, vegetation, and morphologies. Nuns, Rosedale, and North Rosedale Beaches were assessed on 9 April 2021 and Tranquil Beach was assessed on 16 April 2021. At each location, the following tasks were undertaken:

- The edge of the dune vegetation was surveyed using a Trimble R4 real-time kinematic (RTK) GPS with horizontal and vertical accuracies of ~0.01 m (e.g., Figure 3);
- A cross-dune transect was surveyed to assess dune elevations and volumes;
- The dune vegetation was examined and key species were noted;
- Significant dune vegetation communities and zonations were examined, including the presence of primary and secondary vegetation zones; and
- Major morphological features, such as incipient dunes, foredunes, and erosion scarps, were noted.

An example of the survey data collected at Nuns Beach is shown in Figure 4 showing the edge of the dune vegetation along with the temporary benchmark and the cross-dune transect line.

Further, six temporary surveying benchmarks (fence posts) were installed at Nuns and Rosedale Beaches to facilitate a community dune monitoring program should the Rosedale Association wish to implement this (e.g., Figure 3). One benchmark was installed at Nuns Beach, one in the southern region of Rosedale Beach, and two in each of the central and northern regions of Rosedale Beach. Cross-dune transects for these beaches were conducted from these temporary benchmarks. At Tranquil Beach and North Rosedale Beach, cross-dune transects were surveyed from temporary benchmarks that were not installed for ongoing monitoring.



Figure 3. Surveying using the Trimble R4 RTK GPS and the temporary benchmark installed at the northern end of Rosedale Beach (metal fence post with numbered yellow safety cap).



Figure 4. Example of survey data points collected at Nuns Beach on 9 April 2021 showing the temporary benchmark, the surveyed edge of the dune vegetation, and the cross-dune profile. Imagery source: nearmap (2019).

2.3. In-situ data analysis

The in-situ data collected during the site visits in April 2021 were analysed using several techniques with data analysed for each beach independently as well as comparing data between the beaches. Data collected on Rosedale Beach was analysed in three sections comprising the three regions of Rosedale Beach.

The surveyed edges of the dune vegetation on each beach were used to develop a present-day outline of the vegetation edge. These dune extents were then compared to the edge of the dune vegetation identified in the historical aerial imagery analysis described above. Cross-dune transect profiles were created using the survey data to allow for examination of the dune morphology. The transect profiles were also used to obtain the distance between the temporary benchmark and the edge of the dune vegetation. These distances were compared to distances extracted from the historical image analyses to obtain a history of dune widths through time to identify any long-term trends in dune growth or erosion.

Notes compiled during the site visits were used to develop a list of key plant species present and vegetation zonation and succession through the dune as well as to identify key features such as morphological features and local infrastructure, such as paths and fences.

3. Results

3.1. Dune vegetation extents

Across the four beaches, a total of 293 survey points were obtained over the two days of data collection (Table 1), with the majority obtained along Rosedale Beach. This consisted of 172 points mapping the edge of the dune vegetation and 121 points representing eight cross-dune survey transects, one each on Tranquil, Nuns, and North Rosedale Beaches, and five on Rosedale Beach (Table 1). All the survey points collected over the two days of data collection are shown in Figure 5.

Table 1. Summary of survey data collected, showing total number of survey points per beach or region of beach, number of survey points collected to map the dune vegetation edge, number of cross-dune transects conducted, number of survey points in each cross-dune transect, and number of temporary benchmarks installed (see Figure 3).

| | Total survey points | Vegetation edge survey points | Cross-dune transects | Cross-dune transect points | Benchmarks installed |
|----------------------------------|----------------------------|--------------------------------------|-----------------------------|-----------------------------------|-----------------------------|
| Tranquil Beach | 38 | 28 | 1 | 10 | - |
| Nuns Beach | 42 | 27 | 1 | 15 | 1 |
| Rosedale Beach (Southern) | 42 | 31 | 1 | 11 | 1 |
| Rosedale Beach (Central) | 83 | 49 | 2 | 34 | 2 |
| Rosedale Beach (Northern) | 66 | 22 | 2 | 44 | 2 |
| North Rosedale Beach | 22 | 15 | 1 | 7 | - |
| Total | 293 | 172 | 8 | 121 | 6 |

Combined analysis of the historical aerial imagery and the data collected in-situ allowed for an analysis of the change in the spatial extent of dune vegetation over time from 1977 to 2021. This was done using both the full extent of the dune vegetation along the length of each beach and by assessing the intersection of the vegetation edge with the transect line through time. It should be noted that while the vegetation edge from the 1977 aerial image is included in the subsequent figures detailing the results of the qualitative historic dune analysis (e.g., Figure 6 and equivalent figures for other beaches), poor image quality resulted in some uncertainty in digitising the dune vegetation edge. As such, these data are not included in the analysis of the width of the dune relative to the benchmark (i.e., Figure 7). This section details the results of this analysis for each beach and then summarises compares results between beaches.

Tranquil Beach

Over the period of 1977 to 2021, the dune vegetation grows seaward initially but is significantly reduced in 1989 (Figure 6). This is followed by a stable dune extent or dune growth through to 2021, particularly since the mid-1990s. There is no clear net trend in the position of the edge of the dune vegetation at Tranquil Beach, with the width of the vegetated dune (relative to the temporary benchmark) oscillating between 2.5 and 28.7 m over the 32 year observation period (i.e., 1989-2021; Figure 7).

Nuns Beach

Nuns Beach, like Tranquil Beach, shows variability in the position of the edge of the dune vegetation with the width of the dune oscillating over ~20 m over the observation period (Figure 8). In general, the dune is narrower in the period to 1999, with the dune extending between 11.8 and 21.1 m from

the benchmark (BM1), with the dune progressively widening from 1999 onwards, extending up to 33.0 m from the benchmark in 2020 (Figure 7).



Figure 5. All survey data collected during the two days of in-situ data collection. Temporary benchmarks that were installed are labelled with "BM" and the benchmark number. Imagery source: nearmap (2019).

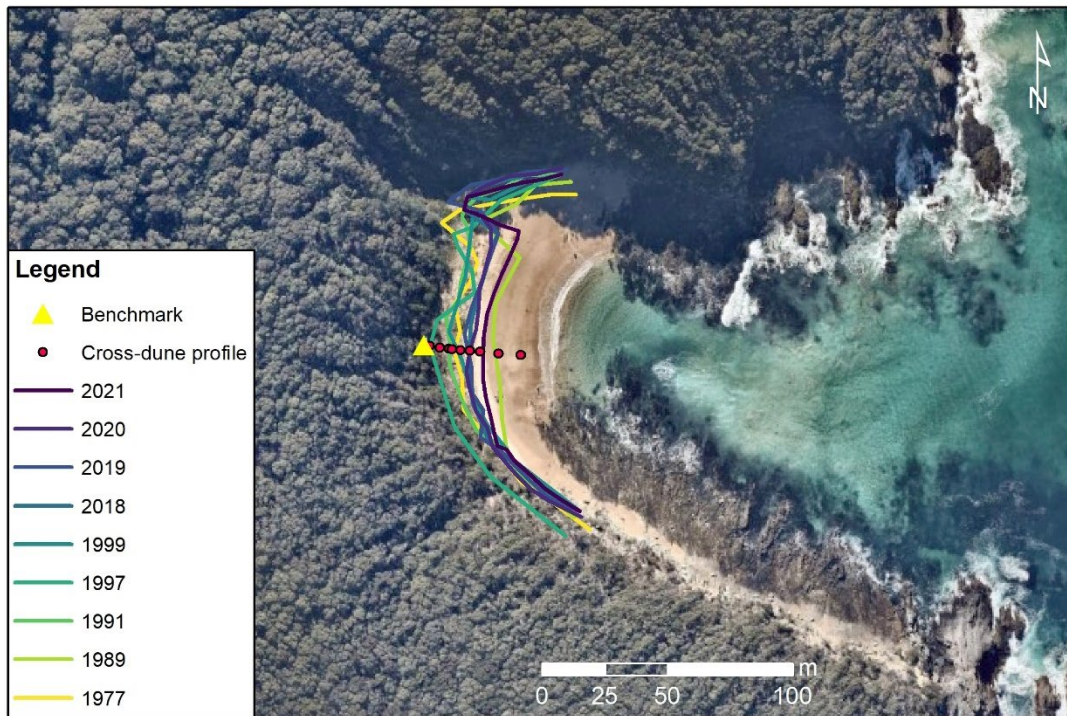


Figure 6. Results of the historic dune analysis and April 2021 dune vegetation edge survey for Tranquil Beach. The cross-dune profile and benchmark used for the profile are also shown. Imagery source: nearmap (2019).

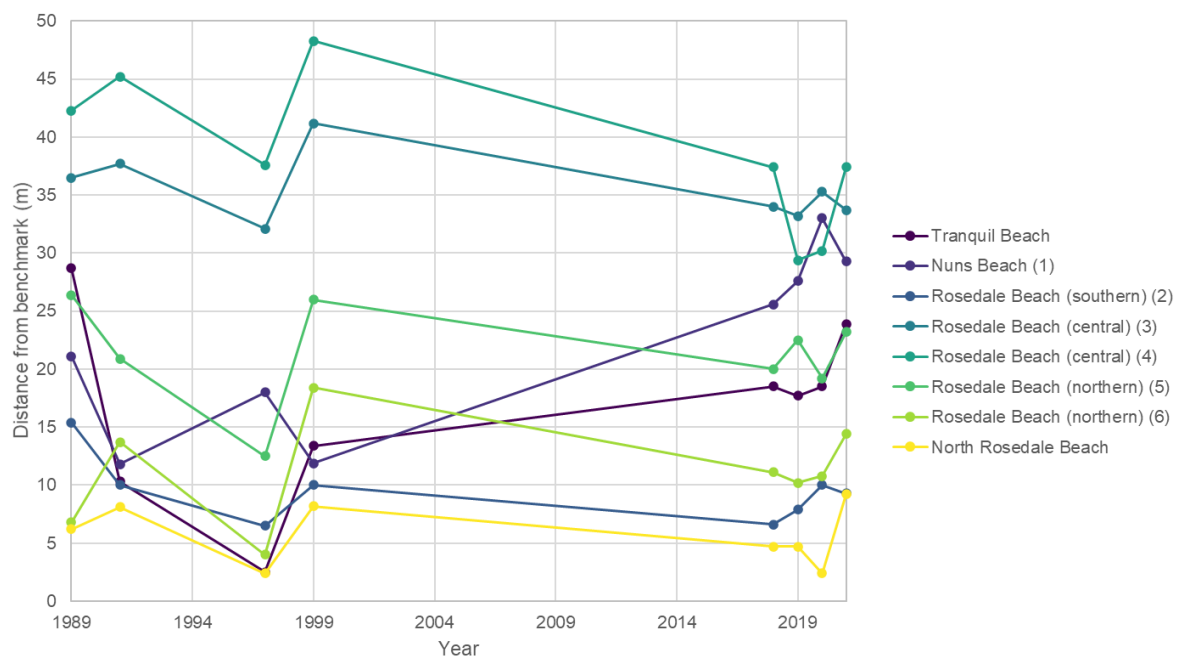


Figure 7. Width of vegetated dune along transect line extending seaward from temporary benchmarks at Tranquil Beach, Nuns Beach, Rosedale Beach (one transect in the southern region, two transects in the central region, and two transects in the northern region), and North Rosedale Beach. Note that benchmark numbers are given in brackets in the legend.

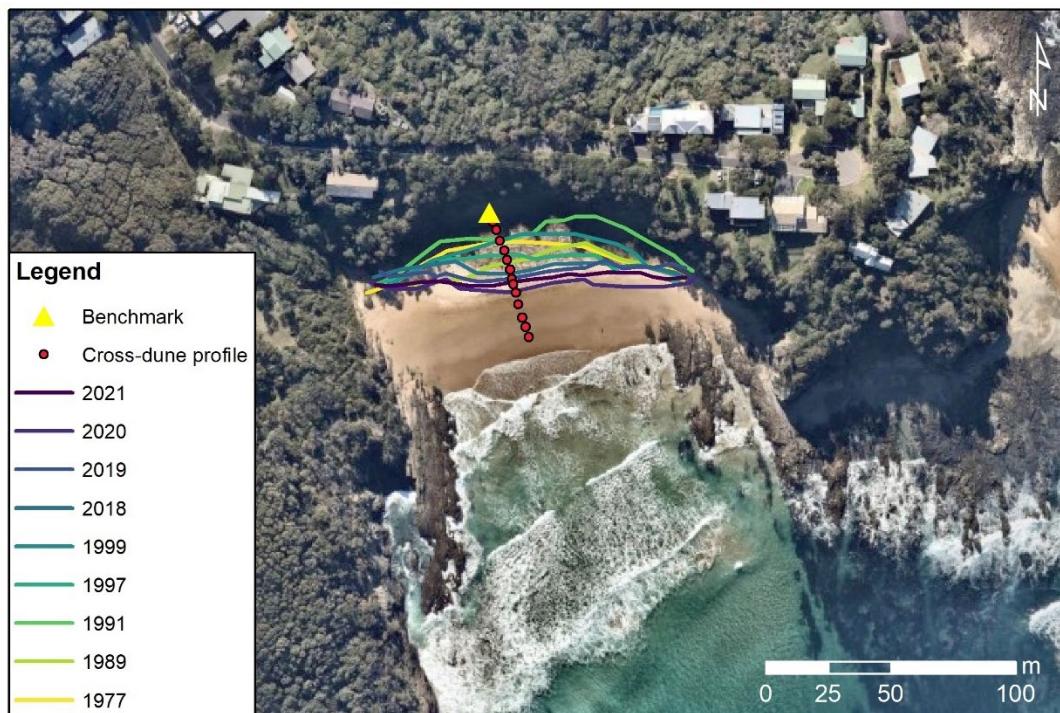


Figure 8. Results of the historic dune analysis and April 2021 dune vegetation edge survey for Nuns Beach. The cross-dune profile and benchmark used for the profile are also shown. Imagery source: nearmap (2019).

Rosedale Beach

The extent and variability of dune vegetation on Rosedale Beach varies along the length of the beach. In general, the southern region of the beach varies the least, followed by the northern region, while the central region of the beach has the greatest variability (Figure 9). This is consistent with the varying exposure to wave energy along the beach with the central region of the beach being the most exposed part of the beach to storm waves.

In the southern region of Rosedale Beach, the edge of the dune vegetation is observed to be relatively stable with variability increasing with distance from the southern end of the beach (Figure 9A). This is consistent with the low wave exposure in this region of the beach. Fore-dune vegetation appears quite sparse in 1977, however, this may be due to poor aerial image quality. In the 1990's, the extent of vegetation on the incipient dune fluctuates, while the fore-dune vegetation becomes denser. From 2018 onwards, aerial imagery suggests that the extent of the fore-dune vegetation has expanded, while minimal vegetation is present on the incipient fore-dune. The lack of vegetation on the incipient fore-dune is likely due to below average rainfall in 2018 and 2019¹. The width of the dune varied less than 10 m throughout the observation period as measured at the benchmark (BM2) with no clear net trend in dune growth or erosion (Figure 7).

In the central region of Rosedale Beach, the edge of the dune vegetation varied more than in the southern region (Figure 9B). Variability also increased with distance northwards and proximity to the creek. This is consistent with a variable location where the creek breaks through the beach berm during heavy rains thus impacting on the dunes in this region. As with the southern region of Rosedale Beach, incipient fore-dune vegetation was minimal in 2018 and 2019. The impact of the December 2019 bushfires on the fore-dune vegetation is apparent in the 2020 aerial image, however,

¹ Annual rainfall recorded at Moruya Airport AWS: 2018: 724.6 mm; 2019: 492.4. Mean annual rainfall for Moruya Airport AWS: 809.4 mm. Source: Bureau of Meteorology; Product Code: [IDCJAC0001](#), station number: 69148, reference: 76885017 [accessed 5 July 2021].

vegetation is approximately constant or increasing from 2020 to 2021. Two benchmarks (BM3 and BM4) were positioned in this region and the width of the dune relative to these varied by 9.1 m and 18.9 m for the southern and northern sections of this region of the beach respectively (Figure 7). No strong net trends in dune growth or erosion were observed over the period of analysis, however, there is a general decrease in dune width from 1999 onwards, particularly in the region of the beach access paths.

In the northern region of Rosedale Beach, the edge of the dune vegetation was more stable than observed in the central region of the beach, with the magnitude of variability approximately consistent along the length of this region of the beach (Figure 9C). The relatively stable nature of the dune in this region of the beach is consistent with its relatively low exposure to wave energy. Fore-dune vegetation appears quite sparse in 1977 (noting that this may be due to poor aerial image quality) but has grown and remained steady since. Dune extent in this region has grown over the period of 2018 to 2021 but has not been as extensive as it was in 1999. Two benchmarks (BM5 and BM6) were positioned in this region and the width of the dune relative to these varied by 13.9 m and 14.4 m for the southern and northern sections of this region of the beach respectively (Figure 7). No net trends in dune growth or erosion were observed over the period of analysis.

North Rosedale Beach

Variability in the extent of the dune at North Rosedale Beach is small over the observation period (Figure 10). This is most likely due to the sheltered nature of the beach and the lack of accommodation space for a dune to form in. The width of the dune varies by ~7 m, however, significant shadowing on the dune from the northern headland in many of the aerial images make analysis challenging. No overall net trend in dune growth or erosion is observed at North Rosedale Beach (Figure 7).

Combined analysis of the historical aerial imagery and the data collected in-situ across the four beaches shows that there are no major net trends in dune growth or erosion, indicating that the dunes are dynamic but approximately stable over the 32 year period analysed in this report. Notable points are that the dunes at both Tranquil and Nuns Beaches have grown in extent since the mid-1990s, while the dunes in central region of Rosedale Beach has lost extent since 1999.

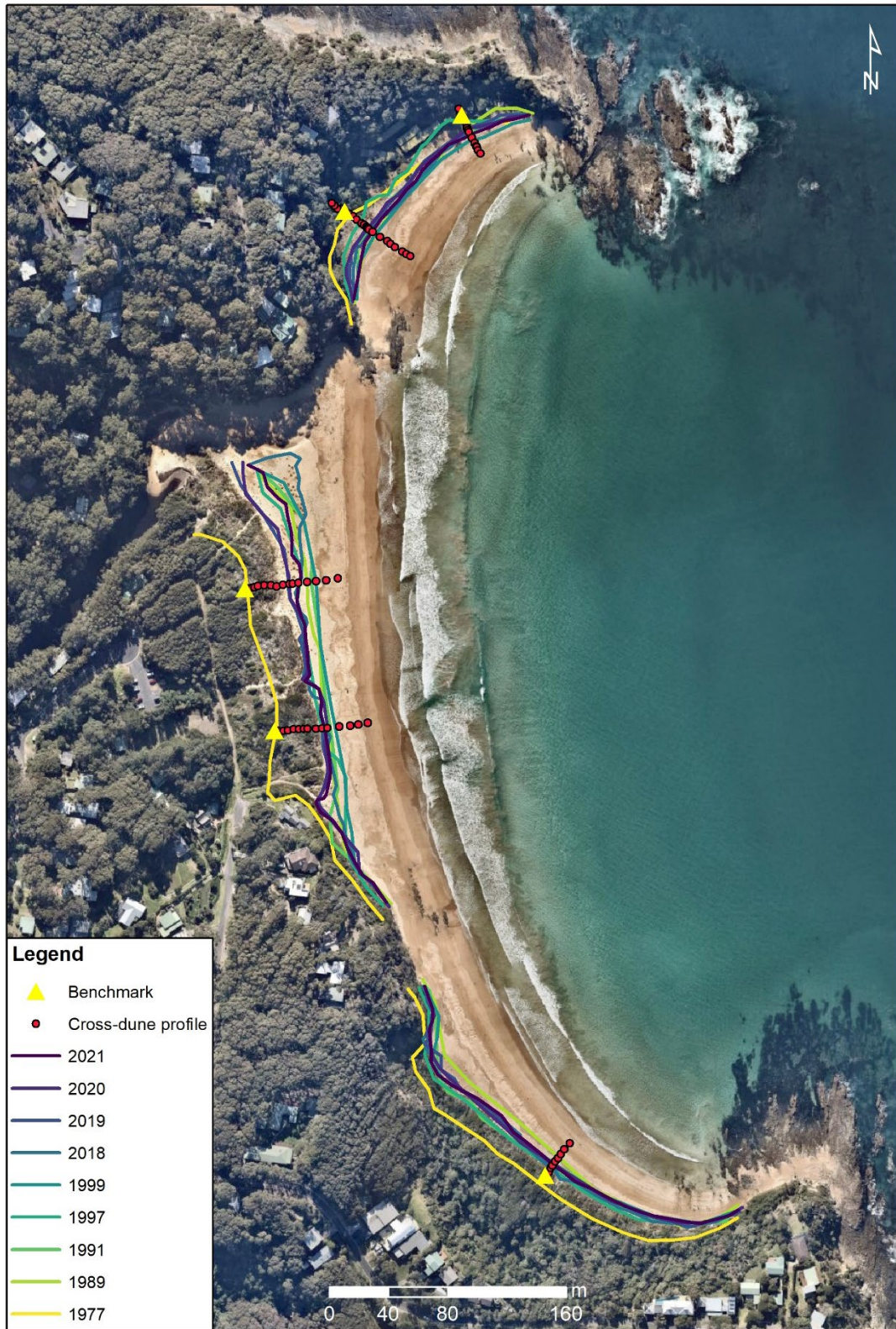


Figure 9. Results of the historic dune analysis and April 2021 dune vegetation edge survey for Rosedale Beach. The cross-dune profiles and benchmarks used for the profiles are also shown. Imagery source: nearmap (2019).



Figure 10. Results of the historic dune analysis and April 2021 dune vegetation edge survey for North Rosedale Beach. The cross-dune profile and benchmark used for the profile are also shown. Note that the 1977 dune vegetation edge is not shown due to poor image quality. Imagery source: nearmap (2019).

3.2. Dune morphologies

In-situ observations and analysis of the cross-dune transects (see Section 3.1, Table 1, and Figure 5 for details of cross-dune survey points collected) allowed for observations of the dune morphology as at April 2021. These observations provide information on the shape and structure of the dune, evidence of historic erosion events, and a baseline for comparison with future morphological measurements. All elevations in cross-dune transects were measured relative to Australian Height Datum (AHD) which is approximately equal to mean sea level.

Tranquil Beach

Tranquil Beach was observed to have a relatively narrow foredune (~15 m wide) with evidence of an historic erosion event at ~12-15 m from the benchmark (Figure 11). The back of the foredune grades into the hillslope vegetation without a significant or well-defined hind-dune.

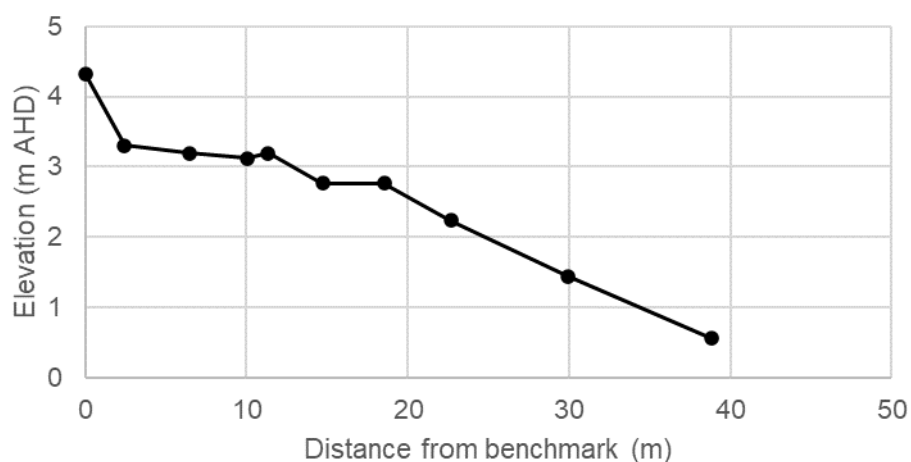


Figure 11. Cross-dune transect measured at Tranquil Beach. See Figure 5 for transect location.

Nuns Beach

Nuns Beach was observed to have a relatively wide and flat foredune that extends approximately 30 m from the base of the cliffs (Figure 12). No hind-dunes were present. The foredune sits at ~3 m above mean sea level and has minimal topographic change. No significant erosion scarps were observed during data collection.

Rosedale Beach

The morphology and size of the dunes varies significantly along the length of Rosedale Beach with the most extensive dunes observed in the central region of the beach, while the southern and northern regions of the beach presented with narrower dune morphologies.

In the southern region of Rosedale Beach, the dune system was relatively narrow, relatively low in elevation and graded quickly from the foredune to the hind-dune (Figure 13). The foredune in this region is ~10-15 m wide. There was some evidence of the erosion scarp formed by the east coast low storm event in 2016 (4-6 June 2016).

The central region of Rosedale Beach was observed to have a wide foredune (~20-30 m) which presented with varying degrees of topography along this extent of the beach (Figure 14). In some areas, the foredune presented with two dune crests before transitioning into the hind-dune region (e.g., the region around BM4, see Figure 5 and the grey profile in Figure 14). No significant erosion

scarps were observed and a lack of rabbit warrens was also noted. A storm-water outflow at the southern end of this region of the beach (adjacent to the northern end of Knowlman Rd) is resulting in significant but localised erosion of the dune and beach.

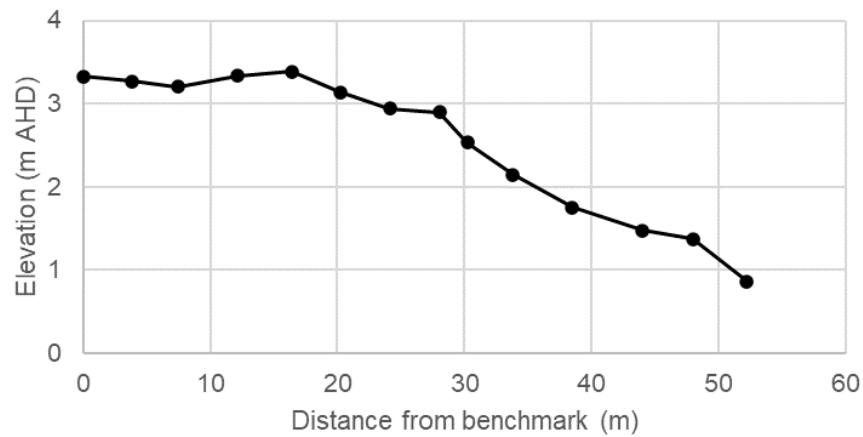


Figure 12. Cross-dune transect measured at Nuns Beach. See Figure 5 for transect location.

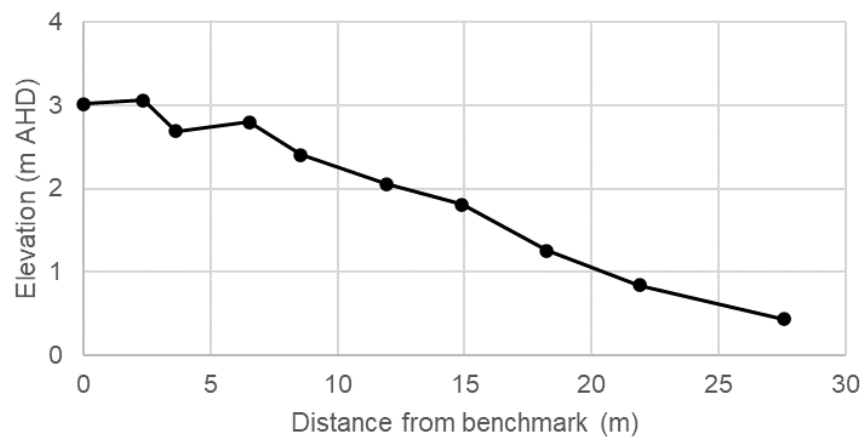


Figure 13. Cross-dune transect measured in the southern region of Rosedale Beach. See Figure 5 for transect location.

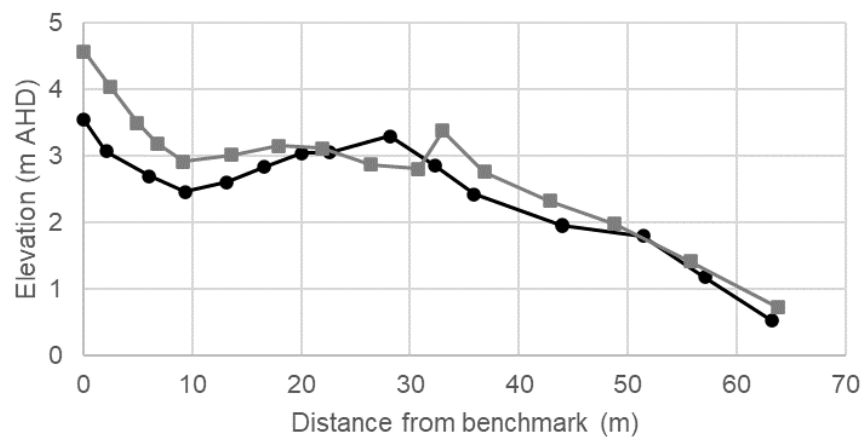


Figure 14. Cross-dune transects measured in the central region of Rosedale Beach. The black line and circle markers represent the transect originating from BM3 while the grey line and square markers represent the transect originating from BM4. See Figure 5 for transect locations.

The northern region of Rosedale Beach is characterised by a relatively narrow dune profile that grades steeply into the hind-dune (Figure 15). The foredune is narrow (~10-20 m wide) and the transition between the foredune and hind-dune is defined by relict erosion scarps of 0.5-1.0 m in height including the scarp formed by the 2016 east coast low as well as a second historic erosion scarp that formed after the 2016 event.

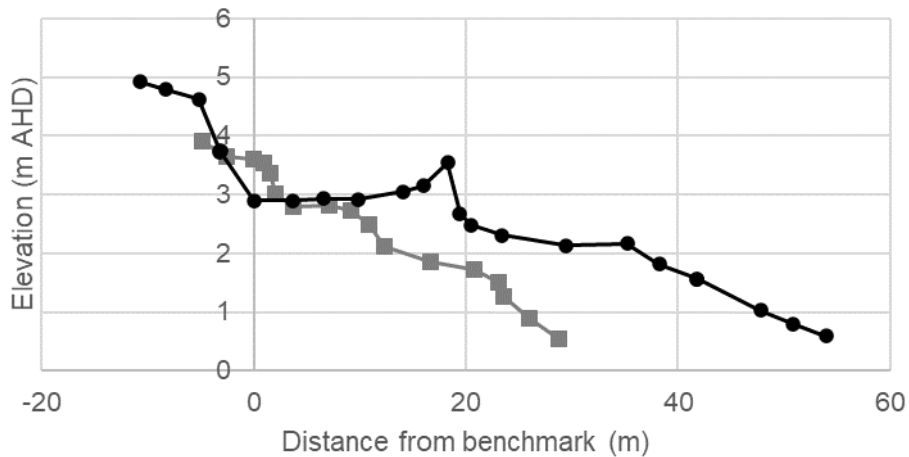


Figure 15. Cross-dune transects measured in the northern region of Rosedale Beach. The black line and circle markers represent the transect originating from BM3 while the grey line and square markers represent the transect originating from BM4. See Figure 5 for transect locations. Note that both transects extend landward of the benchmarks resulting in negative distances.

North Rosedale Beach

The dune system at North Rosedale Beach is the narrowest of the four beaches. The dune was observed to have a very small incipient dune of less than 10 m width sitting at the base of the hillslope (Figure 16). The back of the foredune grades into the hillslope vegetation without a significant or well-defined hind-dune. There was no evidence of historic erosion scarps present.

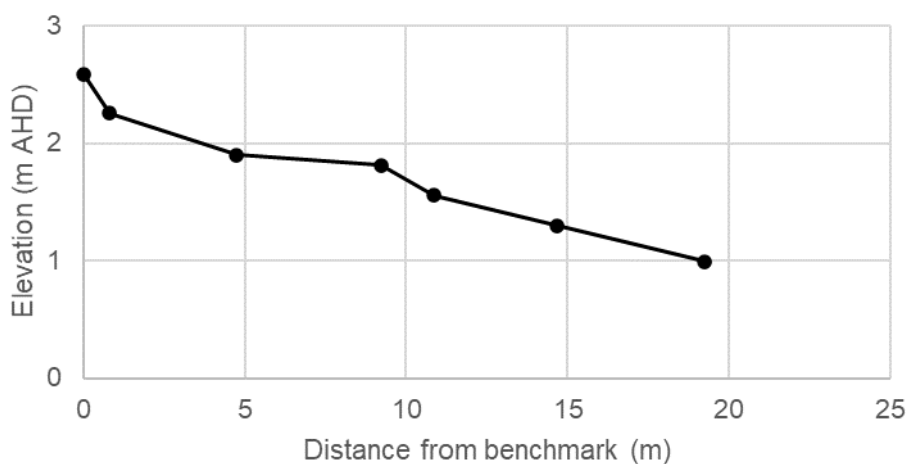


Figure 16. Cross-dune transect measured at North Rosedale Beach. See Figure 5 for transect location.

Dune volumes are a complementary measure to assess dune health in conjunction with dune widths as they represent both the width of the dune as well as the elevation of the dune and hence can demonstrate sand accumulation or loss in a dune system with a constant dune width. Measured dune volume data for each of the surveyed cross-dune transects are shown in Figure 17. It should be

noted that volumes are not comparable between transects due to the variable elevations and positions of the benchmarks within the dune systems but serve as a baseline measure should the community wish to implement a local monitoring program.

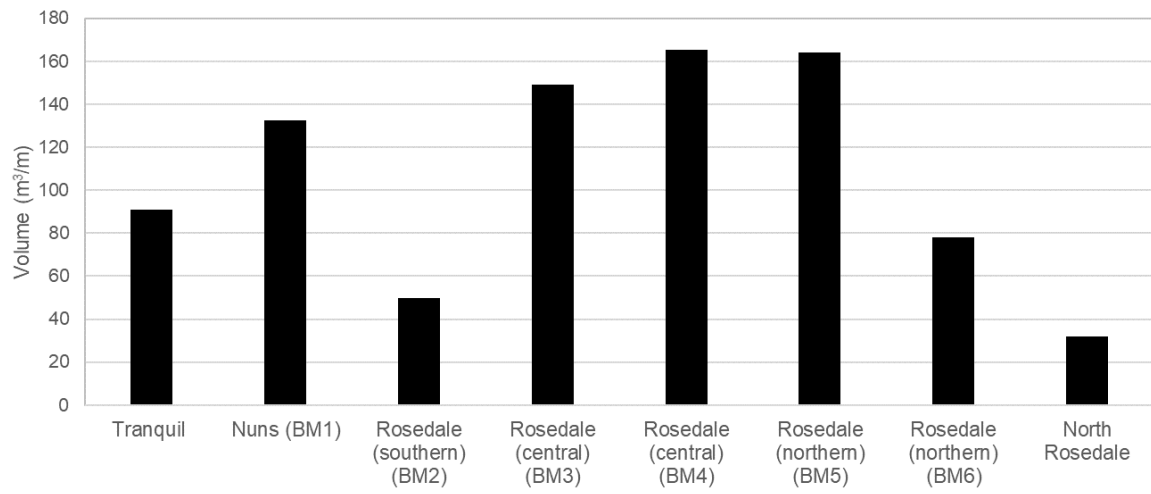


Figure 17. Volume of dune from benchmark to vegetation edge for each of the surveyed cross-dune transects.

3.3. Vegetation assemblages

In-situ observations of all four beaches allowed for identification of key dune species and assemblages at Rosedale Beaches. These observations allow for identification of vegetation diversity and presence and abundance of weed species within the dunes. In general, the dunes at Rosedale Beaches comprise a diverse assemblage of native dune vegetation with relatively low abundance of weed or invasive species. Comparisons with vegetation assemblages at other beaches on the south coast of NSW indicate that the vegetation assemblages observed at Rosedale Beaches are comparable to those observed at other beaches, such as Long Beach and Warilla Beach (Williams and Wiecek, 2017). Table 2 presents a summary of where key species were observed at each beach.

Tranquil Beach

Tranquil Beach is characterised by a relatively flat foredune that grades into the hillslope vegetation (Figure 18). The incipient dune is characterised by colonising species such as *Spinifex sericeus*, *Hydrocotyle bonariensis*, *Atriplex cinerea*, *Carpobrotus glaucescens*, and grasses. As the incipient foredune grades into the foredune and then into the hillslope vegetation, more established vegetation is present including species such as *Lomandra longifolia*, *Westringia fruticosa*, *Correa alba*, *Ficinia nodosa*, and *Alyxia buxifolia*. Some weed species are present, but they do not dominate the vegetation (Table 2).



Figure 18. The back of the foredune at Tranquil Beach grading into the hillslope vegetation.

Nuns Beach

Nuns Beach is characterised by a wide flat foredune with minimal dune topography and relatively little established vegetation (Figure 19). The majority of the area of the dune is vegetated with *Spinifex sericeus*, *Hydrocotyle bonariensis*, and grasses. Towards the back of the foredune, a small area of more established vegetation is present. Dominant species in this region include *Banksia integrifolia*, *Pittosporum undulatum*, *Ficinia nodosa*, and *Lomandra longifolia*, amongst others. There is good diversity of species within the dune system at Nuns Beach and, while some weed species are present (e.g., *Verbena bonariensis*), they do not dominate the dune system (Table 2).



Figure 19. Nuns Beach dune showing the wide flat foredune with established vegetation species located close to the cliff.

Rosedale Beach

The southern region of Rosedale Beach has densely vegetated foredune and hind-dunes with a high variety of plant species (Figure 20). The foredune is fronted by a two- to five-meter-wide incipient foredune dominated by *Spinifex sericeus*, *Carpobrotus glaucescens*, *Cakile edentula*, and other grasses. *Ficinia nodosa*, *Muehlenbeckia adpressa*, and *Commelina cyanea* are also interspersed in this section. The back of the foredune and hind-dune have well-established *Banksia integrifolia*, *Casurina glauca*, *Melaleuca armillaris*, and *Alyxia buxifolia*, as well as a dense ground cover including *Tetragonia tetragonioides*, *Lomandra longifolia*, *Oxalis perennans*, and *Myoporum insulare*, amongst others. Weeds, such as *Rubus fruticosus*, *Rumex sagittatus*, and *Bidens pilosa*, are present in the foredune but do not dominate the vegetation assemblages (Table 2).

Vegetation was generally less dense in the central region of Rosedale Beach (Figure 21), particularly near the walkway and stormwater outlet, however, there was still a rich variety of species observed. *Spinifex sericeus*, *Hydrocotyle bonariensis*, *Rumex sagittatus*, and *Cakile edentula* partially cover the incipient foredune. Reeds and grasses, such as *Ficinia nodosa* and *Imperata cylindrica*, dominate the swale behind the incipient dune. The primary dune has similar ground cover species as the foredune in the southern end of the beach but with additional species such as *Dichondra repens*. *Casurina glauca*, *Melaleuca armillaris*, and *Banksia integrifolia* that were burnt in the 2019 fires were present and were acting to stabilise the sediment in the foredune with many regrowing from the base (Figure 22). As well as stabilising the dune sediment, these burnt trees also provide a wind buffer and ecosystem structure and were a key feature of the primary dune along with *Atriplex cinerea*. The

number of weed species observed was greater in this region and included *Conyza sp.* and *Solanum sp.* (Table 2).

The incipient and foredune vegetation in the northern section of Rosedale Beach is similar to that of the southern region of Rosedale Beach. The hind-dune has similar species, however, areas have invasive vines, such as *Asparagus asparagoides* and *Ipomoea cairica* (Figure 23). Other weeds, such as *Solanum sp.* and *Rubus fruticosus* are also present in the hind dune while *Lysimachia arvensis* is present in the incipient dune vegetation. A native grape, *Cayratia clematidea*, and *Pteridium esculentum* were also present (Table 2).

North Rosedale Beach

There is very limited dune formation at North Rosedale Beach and vegetation is correspondingly sparse (Figure 24). The incipient dune is populated with *Hydrocotyle bonariensis*, *Rumex saggitatus*, *Cakile edentula*, and *Rhagodia candolleana*. Other species including *Lomandra longifolia* and *Tetragonia tetragoniodides* also feature in the foredune (Table 2).



Figure 20. Well-vegetated foredune in the southern region of Rosedale Beach.



Figure 21. Sparse vegetation on the foredune of the central region of Rosedale Beach.



Figure 22. Fire-damaged Melaleuca sp. regenerating from the base of the tree.



Figure 23. The hind-dune in the northern region of Rosedale Beach.



Figure 24. The small foredune fronting the hillslope at North Rosedale Beach.

Table 2. Key vegetation species (with common names in parentheses) observed in the dunes of each of the Rosedale Beaches and the location the species was observed as observed in April 2021, where "I" is incipient dune, "F" is the foredune, and "H" is hind-dune. Note that this list does not capture every species present in every location but focusses on common species present. Native species are marked with a ^, non-native or invasive species are marked with *, and plants not identified to the species level may be marked as both native and non-native. Also note that no hind-dune was present on Tranquil Beach, Nuns Beach, or North Rosedale Beach.

| | Tranquil Beach | Nuns Beach | Rosedale Beach (Southern) | Rosedale Beach (Central) | Rosedale Beach (Northern) | North Rosedale Beach |
|---|----------------|------------|---------------------------|--------------------------|---------------------------|----------------------|
| <i>Spinifex sericeus</i> (spinifex grass)^ | I, F | I, F | I, F, H | I, F, H | I, F, H | I, F |
| <i>Hydrocotyle bonariensis</i> (pennywort)^ | I, F | I, F | I, F, H | I, F, H | I, F, H | I, F |
| <i>Suaeda australis</i> (austral seablite)^ | | | I | I | I | I |
| <i>Rhagodia candollei</i> (seaberry saltbush)^ | | | I | | | I |
| <i>Correa alba</i> (white correa)^ | F | | | I | I | |
| <i>Ficinia nodosa</i> (knobby club-rush)^ | F | F | F | F | F | F |
| <i>Imperata cylindrica</i> (blady grass)^ | I, F | | | F | F | |
| <i>Lomandra longifolia</i> (spiny-headed mat-rush, honey reed)^ | F | F | F, H | F, H | F, H | F |
| <i>Plantago hispida</i> (coastal plaintain or hairy plaintain)^ | F | F | F | F | F | F |
| <i>Actites megalocarpus</i> (dune thistle)^ | F | F | F | F | F | F |
| <i>Dichondra repens</i> (kidney weed)^ | | | | F | F | |
| <i>Carpobrotus glaucescens</i> (pigface) | F | | I | F | I, F | |
| <i>Pelargonium australe</i> (native storksbill, wild geranium)^ | | F | | F | F | |
| <i>Tetragonia tetragonoides</i> (Warrigal greens)^ | I, F | | F, H | F | F | F |
| <i>Atriplex cinerea</i> (grey saltbush)^ | F | F | | F | | |
| <i>Westringia fruticosa</i> (coastal rosemary)^ | F | | | | | |
| <i>Muehlenbeckia adpressa</i> (climbing lignum)^ | | | F | F | | |
| <i>Oxalis perennans</i> (grassland or yellow wood-sorrel)^ | | | F, H | F | F | |
| <i>Commelina cyanea</i> (scurvy weed)^ | | F | F | | F | |
| <i>Olearia sp.</i> ^ | | | | | F | |
| <i>Cayratia clematidea</i> (native grape)^ | | | | | H | |
| <i>Alyxia buxifolia</i> (sea box)^ | F | F | F, H | | F | |
| <i>Pittosporum undulatum</i> ^ | F | F | | | | |
| <i>Casurina glauca</i> (swamp oak)^ | | | F, H | F, H | F, H | |
| <i>Banksia integrifolia</i> (coast banksia)^ | F | F | F, H | H | H | |
| <i>Melaleuca armillaris</i> (bracelet honey-myrtle)^ | | | F, H | F, H | H | |
| <i>Eucalypt sp.</i> ^ | | | H | F | H | |
| <i>Acacia longifolia</i> (coastal wattle)^ | | | | | H | |
| <i>Myoporum insulare</i> (boobialla)^ | F | | H | | | |
| <i>Pteridium esculentum</i> (bracken)^ | | | H | | H | |

| | | | | | | |
|---|------|------|------|------|------|------|
| <i>Solanum sp.</i> (nightshade)^* | | F | | F, H | F, H | |
| <i>Cakile edentula</i> (American sea rocket)* | I | F | I, F | I, F | I | I |
| <i>Asparagus asparagoides</i> (bridal creeper)* | | | | | H | |
| <i>Rumex saggitatus</i> (turkey rhubarb)* | I, F | I, F | I, F | I, F | I, F | I, F |
| <i>Ipomoea cairica</i> (coastal morning glory)* | | F | | | H | F |
| <i>Lysimachia arvensis</i> (scarlet pimpernel, blue pimpernel)* | | | | | I | |
| <i>Rubus fruticosus</i> (blackberry)* | F | | F | F | F, H | |
| <i>Conyza sp.</i> (fleabane)* | F | | | F | F | |
| <i>Verbena bonariensis</i> (purpletop)* | | F | | | | |
| <i>Bidens pilosa</i> (cobblers pegs, pitchforks)* | | F | F | F | F | |

4. Conclusions and recommendations

This report has used a combination of historical aerial imagery analysis, in-situ surveys and morphological observations, and vegetation surveys to assess the health of the dune systems of four beaches at Rosedale, NSW, with the goal to report on dune health, identify areas of concern, and provide recommendations that can form the basis of an action plan.

Analysis of the extent of the dune vegetation shows that dune vegetation extents are variable but approximately stable over the observation period (1977 to 2021) with no clear trends of net losses or gains. While there is some uncertainty in identifying the vegetation extents in earlier aerial imagery due to poor image quality, vegetation extents are approximately stable in the latter part of the observation period, consistent with overall observations.

The dune morphologies varied between the four beaches. Tranquil Beach and North Rosedale Beach had the smallest and lowest elevation dunes of the four beaches due to the embayed nature of the beaches, their relatively sheltered aspects, and a lack of accommodation space to allow a dune system to form. Nuns Beach has a larger dune than both Tranquil Beach and North Rosedale Beach but it is also relatively small due to the cliffs at the back of the beach limiting the available space for dune growth. Both the northern and southern regions of Rosedale Beach have well developed dune systems with incipient foredunes, foredunes, and hind-dunes. The sheltered nature of both these regions of the beach, however, has resulted in condensed dune zonation such that the whole dune system is relatively narrow and grades quickly and steeply from incipient foredune to hind-dune. The central region of Rosedale Beach has the largest and widest dunes of the Rosedale Beaches due to sufficient accommodation space and exposure to wind and waves. There is also clear zonation from incipient dune through to hind-dune in this region.

Observations of dune vegetation demonstrate that the dunes generally present with a diverse array of native species and the vegetation assemblages observed at Rosedale Beaches are comparable to other beaches in the region. The dunes in the central region of Rosedale Beach had the sparsest vegetation and had trees present in the dune that were burnt in the 2019 fires with some regenerating from the base. While some weeds are present, the dunes are not overrun with weed or invasive species.

The historic data available and data collected for the compilation of this report have been used to derive recommendations to guide dune preservation and restoration activities for the Rosedale Beaches. The Rosedale community can use these recommendations to form an action plan to best preserve and maintain the health of their dune systems and ensure their dune systems are well placed to provide a buffer between marine and terrestrial processes and systems. Based on the results of this report, it is recommended that the community:

- Increase community awareness of the importance of dune systems and dune vegetation through community workshops and education initiatives that promote the environmental, social, and financial benefits of a well-maintained and well-vegetated dune system
- Continue to implement existing strategies that control weed and pest species (e.g., rabbits) that have negative impacts on dune structure, biodiversity, and ecosystem health
- Implement and maintain a minimum of access paths from access points (e.g., roads, houses) to the seaward limit of vegetation with fencing or otherwise to avoid trampling of dunes and dune vegetation

- Continue to revegetate the dunes using a mix of primary, secondary, and tertiary native dune species (see Figure 25 and Appendix B for recommended species) with sand-fencing as required, ensuring a diverse range of species are planted, monocultures are avoided, and that there is a focus on a densely vegetated foredune and hind-dune to increase dune stability and resilience and improve dune biodiversity and ecological function
- Take a targeted and staged approach to dune revegetation such that a section of dune is more fully restored (as opposed to partial restoration of a wider area) with a follow-up maintenance program for areas of revegetated dune
- Prioritise dune revegetation on the central region of Rosedale Beach over other regions due to the impact of the 2019 fires on the dune vegetation
- Implement community monitoring program to regularly assess dune health that monitors the dune morphologies and volumes as well as dune vegetation assemblages
- Only remove weeds in sparsely vegetated areas if areas can be immediately revegetated with native species to ensure sufficient plant cover to prevent wind erosion of the dune system
- Only remove dead plants and trees once replacement local native vegetation is sufficiently established such that there is no loss of sediment stabilisation, wind buffering, or ecosystem structure

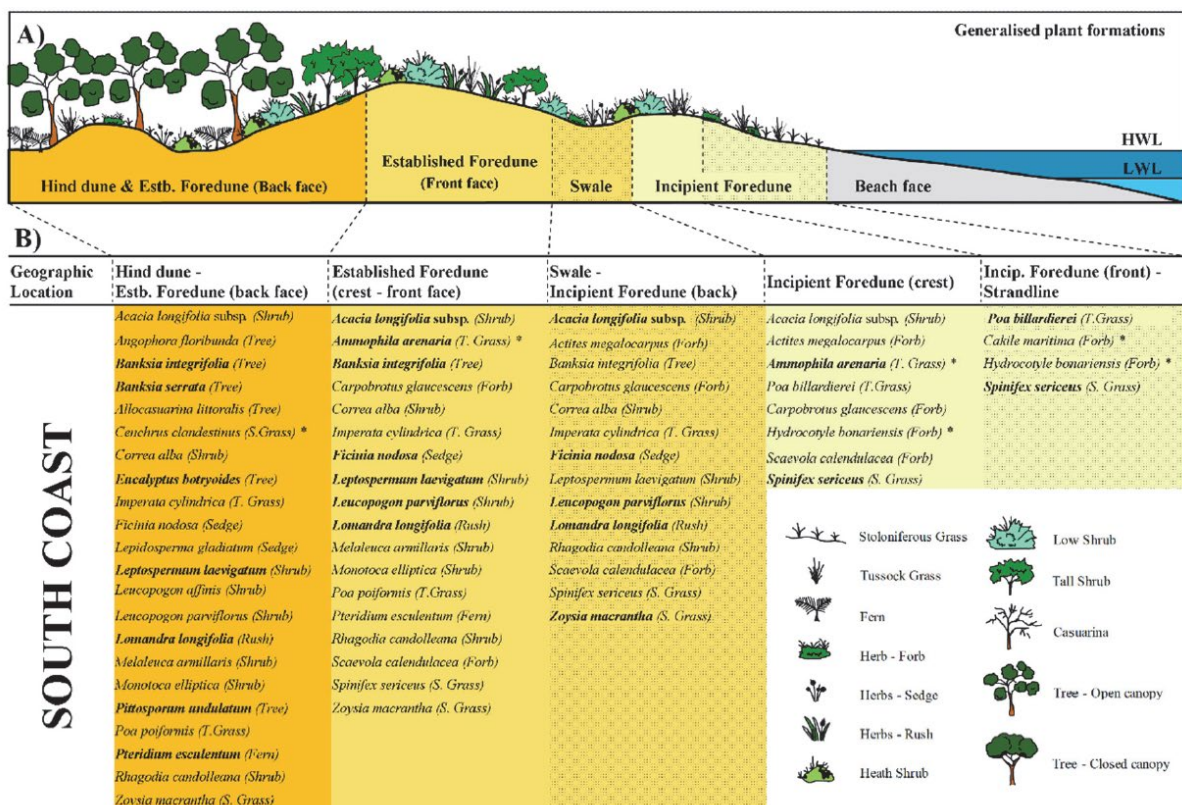


Figure 25. Dominant species found in the key geomorphic zones across the foredune environment, for the south coast region of NSW. (A) Illustrates the generalised plant structural formations (and habits) across the dune system, and (B) lists the dominant species occurring in each zone. Note the species habit is given in brackets. More common species are shown in bold and non-native species are marked with *. Source: Doyle (2019).

References

- Doyle, T. B., 2019. *Foredune morphodynamics in New South Wales, Australia*. PhD thesis, School of Earth and Environmental Science, University of Wollongong, Australia.
- NSW Department of Land and Water Conservation, 2001, *Coastal Dune Management: A Manual of Coastal Dune Management and Rehabilitation Techniques*, Coastal Unit, DLWC, Newcastle, 114 pp.
- Williams, A. and Wiecek, D., 2017, OEH Environmental Assessment of the Long Beach Coastal Wattle Management Project, Eurobodalla Shire Council and NSW Office of Environment and Heritage Report, 36 pp, <http://www.coastwatchers.org.au/wp-content/uploads/2018/03/Long-Beach-coastal-wattle-management-project-OEH-evaluation.pdf> [accessed 14 June 2021].

Appendix A: Raw historical imagery

All historical aerial images were sourced from the Historical Imagery Viewer provided by NSW Spatial Services.

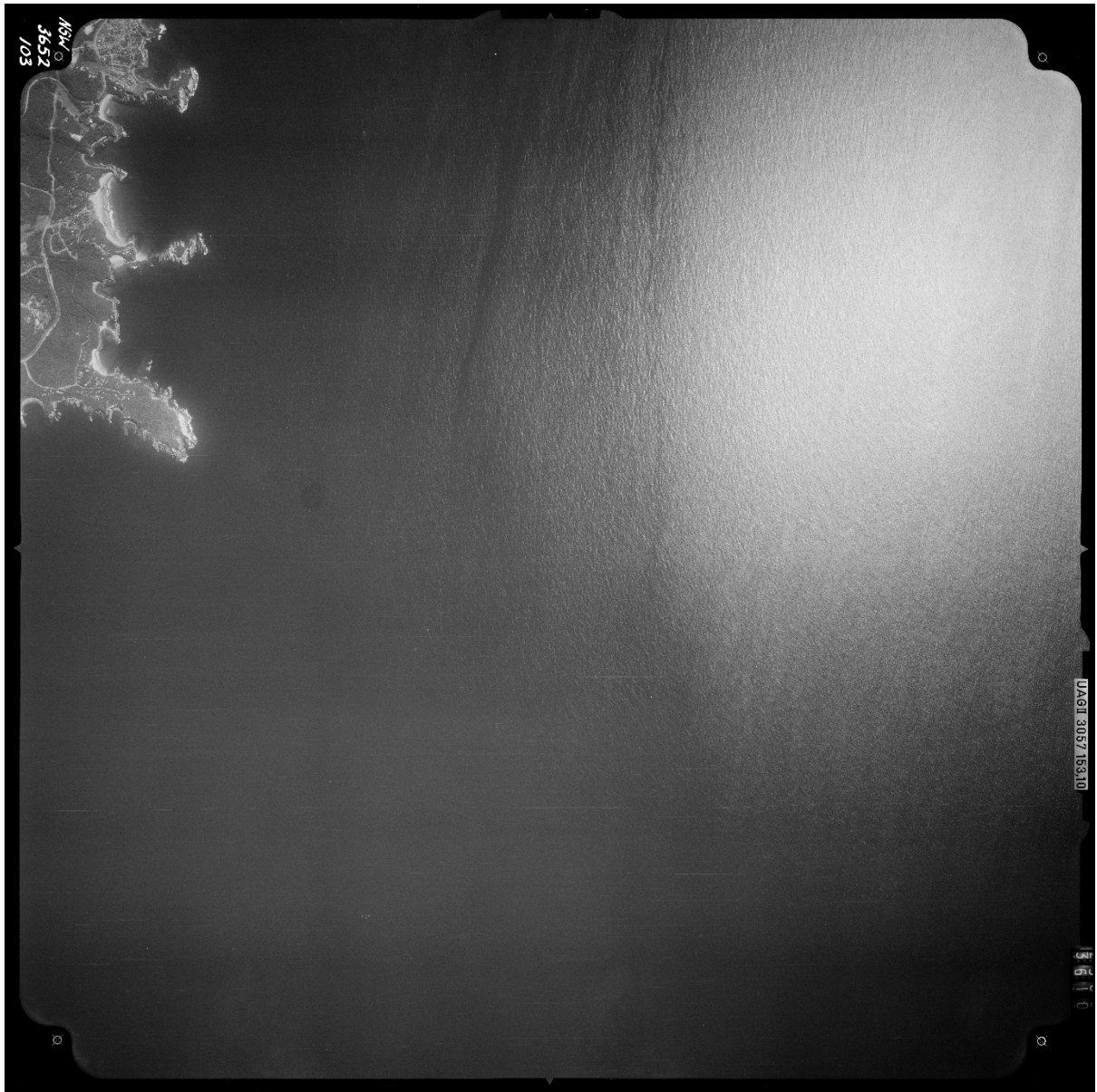
1975

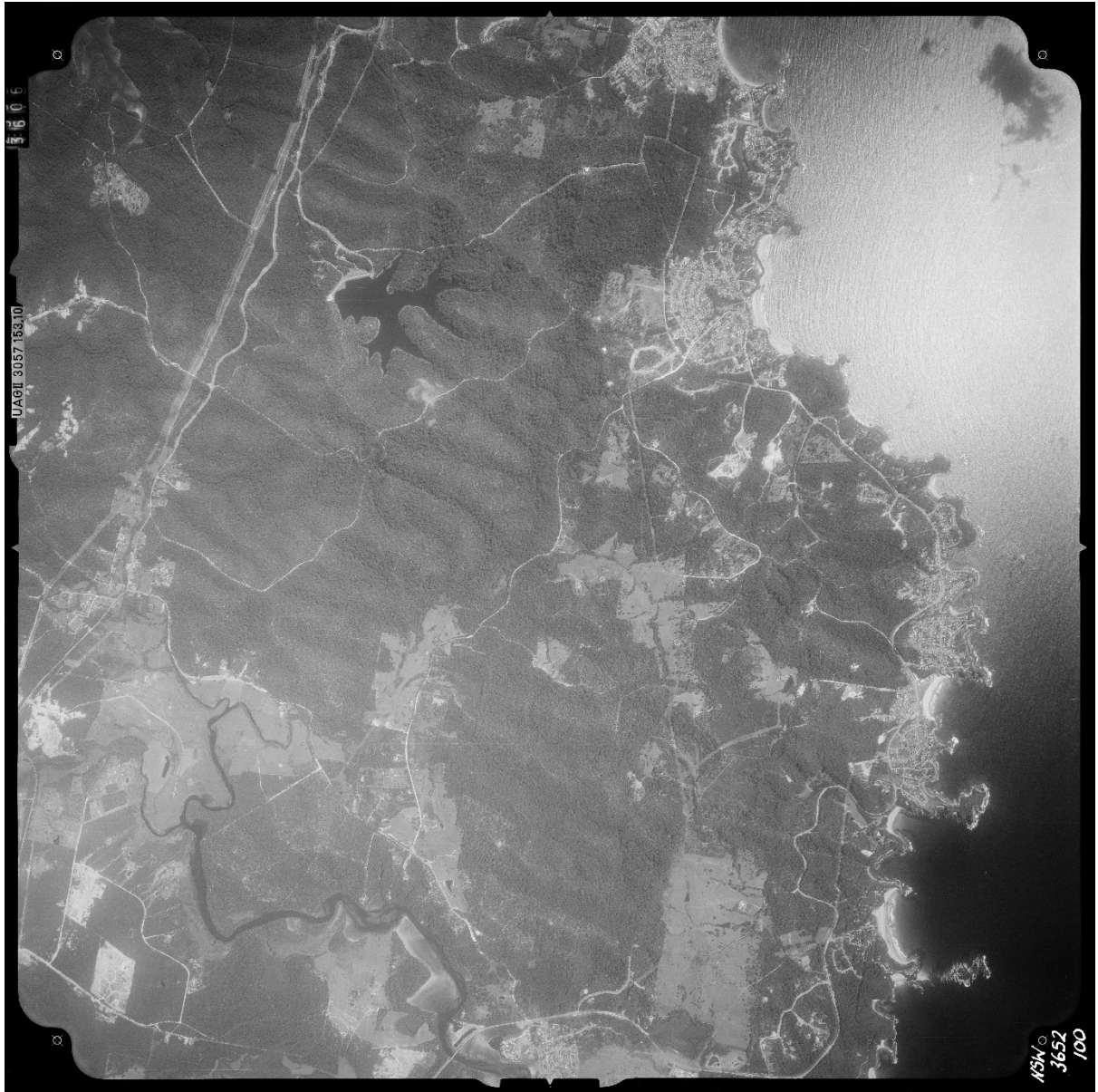


1977



1989





1991



1999



Appendix B: Species planting list

This appendix details recommended species for dune revegetation. The typical structure of a dune system (e.g., Figure 1) consists of an unstable incipient foredune vegetated with colonising herbs and grasses (primary species), a semi-stable foredune vegetated with shrubs and associated ground plants (both primary and secondary species), and a stable hind-dune region dominated by trees and more established and long-lived plants (tertiary species) with an understorey of shrubs and ground plants (a mix of some primary and secondary species typically). Recommended primary, secondary, and tertiary species for revegetation in each of these regions are detailed below.

Primary species

Primary species are recommended for the incipient foredune, the foredune, and hind-dune and are the first species that will stabilise sand and provide an environment in which secondary species can begin to establish. Recommended primary species for dune revegetation at Rosedale are:

- *Spinifex sericeus*
- *Carpobrotus glaucescens*
- *Zoysia macrantha*
- *Lomandra longifolia*
- *Ficinea nodosa*
- *Atriplex cinerea*
- *Poa poiformis*
- *Austrofestuca littoralis*

Secondary species

Secondary species are recommended for the more stable parts of the foredune and hind-dune and are typically shrubs and short-lived trees. They will grow best once primary species have started to stabilise the dune. Recommended secondary species for dune revegetation at Rosedale are:

- *Carpobrotus glaucescens*
- *Zoysia macrantha*
- *Lomandra longifolia*
- *Ficinea nodosa*
- *Atriplex cinerea*
- *Poa poiformis*
- *Austrofestuca littoralis*
- *Rhagodia candolleana*
- *Leucopogon parviflorus*
- *Correa alba*
- *Themeda australis*
- *Leptospermum laevigatum*
 - Note: While present on the dunes at Rosedale, *L. laevigatum* can form dense monocultures which should be avoided

Tertiary species

Tertiary species are recommended for the stable hind-dune regions of the dune system and are typically longer-lived trees that can only survive in more stable and sheltered environments.

Recommended tertiary species for dune revegetation at Rosedale are:

- *Banksia integrifolia*
- *Banksia serrata*
- *Eucalyptus botryoides*
- *Acacia longifolia*
 - Note: While present in the dunes at Rosedale, *A. longifolia* subsp. *sophorae* can form dense monocultures which should be avoided
- *Casuarina glauca*