DUNE RESTORATION TRUST OF NEW ZEALAND

Technical Article No. 2.4

Zonation and Succession on Coastal Sand Dunes

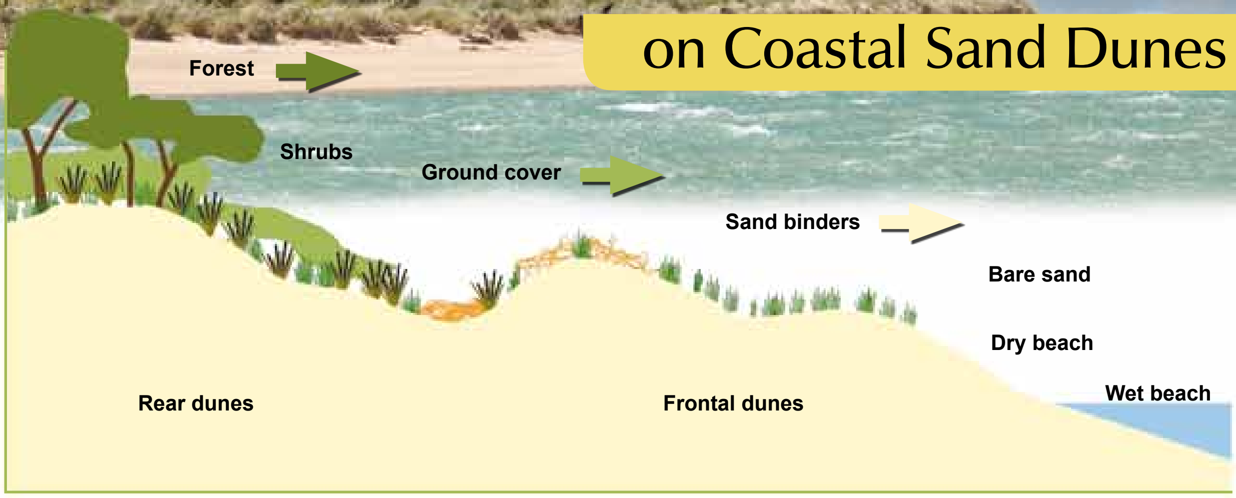


Figure 1: *Schematic and idealised diagram of dune vegetation sequence prior to human disruption. Arrows indicate that if the shoreline was moving seaward over time then the zones also moved seaward. Where the shoreline was relatively stable, the zones would have been more fixed.*

INTRODUCTION

Zonation and succession are critically important concepts in planning and designing appropriate and effective restoration in backdune environments. In simple terms, zonation is a sequence of vegetation in space, while succession is a sequence in time. This pamphlet provides a brief introduction to the two concepts and discusses some of the practical implications for planning dune restoration.

ZONATION AND DUNE VEGETATION SEQUENCES

A key feature of dune vegetation is the sequence of different vegetation communities or zones that occur with increasing distance landward (Figure 1). Each zone in the vegetation sequence has a different species composition that is related to the ability of the plant species to withstand environmental factors prevailing in that zone.

Zonation tends to reflect variations in key stressors in the physical environment (such as sand deposition and burial, salt spray episodes, sand movement, wind velocity and sand blasting) – these stressors varying with increasing distance inland and with dune landforms.

Variations in physical environment result in ecologically distinct communities of plants and animals. The changes between different vegetation zones can be quite sharp in places (Figure 2) and simply grade or blend gradually in others (Figure 3).

Figure 2: *Sequence of dune vegetation, North Piha, west Auckland, grading from sand binders through sedges and vineland to shrubland.*

Figure 3: *Coastal dune shrubland grading to coastal forest, Catlins Coast.*

Figure 4: *Coastal duneland, Waikawau (eastern Coromandel) showing a sharp break between sand binders on exposed seaward dune crest and vineland with harakeke (*Phormium tenax*) on sheltered landward side of dune ridge.*

The significant variations in exposure and shelter associated with dune landforms can cause community structure to change quite abruptly between exposed seaward faces and more sheltered landward faces (Figure 4).

Diverse dune environments

Other factors can also be important in determining zonation on dunes. For instance, in low-lying swales between dunes the water table can sometimes be close to the ground. This can give rise to occasional flooding, anoxic conditions, or wetting and drying which can result in distinct vegetation communities known as dune slack communities. The characteristics of dune slacks depend on the hydrological conditions prevailing (e.g. whether dry, moist, or standing water for parts of the year).

On fixed dunes (the typical situation for most of New Zealand prior to human settlement), zones often tend to be shore parallel as the key environmental stresses decrease with distance landward and with dune landforms, which are often shore parallel. However, where inland migrating parabolic dunes are part of the landscape (e.g. Manawatu coast in its original natural state) the natural vegetation complexes can be more complex and patchy or mosaic in nature (Hesp 2000).

Sand trapping foredune zone

The most seaward vegetation zone on New Zealand dunes tends to consist of sand trapping and dune forming species such as spinifex (*Spinifex sericeus*) and pingao (*Ficinia spiralis*) (Figure 5). These species can cope with the exposure and high rates of sand movement and burial that occur in this dynamic area. The species tend to grow seaward and can grow upward rapidly in response to burial, as well as expanding rapidly to occupy bare areas. Accordingly, sand trapping by these species plays a critical role in dune building and in repair of dunes after erosion (refer to articles on native sand binding plants in Section 7 of this Handbook).

Figure 5: *The sand binder spinifex (*Spinifex sericeus*) zone, Muriwai Beach, west Auckland.*

*Pingao (*Ficinia spiralis*)*

Figure 6: *Dense backdune vegetation dominated by knobby club rush (*Ficinia nodosa*) (top - Matakana Island, Bay of Plenty) and pohuehue (*Muehlenbeckia complexa*) (bottom – Whiritoa Beach, Coromandel).*

Ground cover zone

Further inland where sand burial and movement is less significant, the dune building vegetation typically gives way initially to vegetation communities composed of vines, sedges, herbaceous vegetation and/or low woody plants (e.g. Figure 6). Refer to Technical Article No. 8.2 – *Ground cover plants for restoration of backdunes* in this Handbook.

Figure 7: *Intact coastal dune shrubland and forest, Catlins, Otago.*

Shrub and forest zone

In the original pre-human dunes, these vegetation communities gave way further inland to higher vegetation (e.g. shrubland) and then to forests (Figure 3). The nature and width of the original vegetation zones is likely to have varied considerably, though remnant areas indicate that forests extended relatively close to the shore in some areas (Figure 7).

While the original vegetation sequences on most New Zealand dunes have been significantly destroyed or altered since human settlement, the underlying ecological processes that form these zones are still there and have to be taken into account when planning dune restoration. It is important to work with these underlying ecological processes or otherwise the restoration work may not be successful or self-sustaining and/or may require considerable maintenance.

SUCCESSION

Succession is defined as a change in species composition within an ecosystem over time. On dunes, the term succession is typically used to refer to the evolution of plant communities over time following disruption – i.e. from the pioneer species which initially colonise the bare sand following disruption right through various successive stages to some form of "climax community" where the vegetation is in dynamic equilibrium with the environment.

In practice, successional recovery may be disrupted or diverted by a wide range of factors. Moreover, even when some climax community is ultimately reached, climate change and other factors may lead to ongoing change.

At each stage of succession, the plant community alters the physical environment (e.g. soil organic matter, light/shading, improved shelter, microclimate, change in nutrient levels in soil) allowing the establishment of another later group of species better adapted to live in the changed environment.

Figure 8: *Early successional recovery of coastal dune shrubland (Otama, eastern Coromandel). It is likely to be decades if not centuries before mature dune forest develops.*

Timescales

The process of successional recovery following disruption can be relatively short in some zones and extremely long (e.g. centuries) in others.

For instance, recovery can occur very quickly (months to years) in the most seaward dune areas, the sand binder zone dominated by species such as spinifex and pingao. Thereafter, if the shoreline position is relatively stable over time (i.e. undergoes periods of erosion and recovery but is not experiencing permanent long term advance or retreat), there will generally be only relatively minor (and mostly dynamic) changes in the vegetation over time.

However, with increasing distance landward, the various vegetation zones may go through a number of quite different successional stages and the vegetation communities may change quite markedly over time (e.g. from sand binders to vineland and low woody vegetation to shrubland to forest). Each of these stages of successional recovery may take decades and the entire successional recovery to a climax community may range from several decades (e.g. where vineland and woody cover is the ultimate community) to many centuries (e.g. in areas where some form of dune forest is the climax community) (Figure 8).

In each of these stages of successional recovery, the vegetation community is often quite simple initially (e.g. composed of 2-3 dominant species) but can become more diverse over time as the initial colonisers facilitate recovery of other species that might require more shelter, soil and organic matter. The process of regeneration will also vary such as patch regeneration assisted by shelter and bird roosting provided by established trees (Figure 9) or a slow conversion of each zone to later successional species over time.

Figure 9*: Bird-sown coastal shrubland regenerating under an isolated pohutukawa tree on coastal backdune*

IMPLICATIONS FOR DUNE RESTORATION

Zonation and succession are key ecological principles - central to understanding the ecological processes operating on dunes and designing effective and appropriate dune restoration. Restoration is in fact often defined as the management or purposeful manipulation of succession to restore damaged ecosystems (Walker et al. 2007).

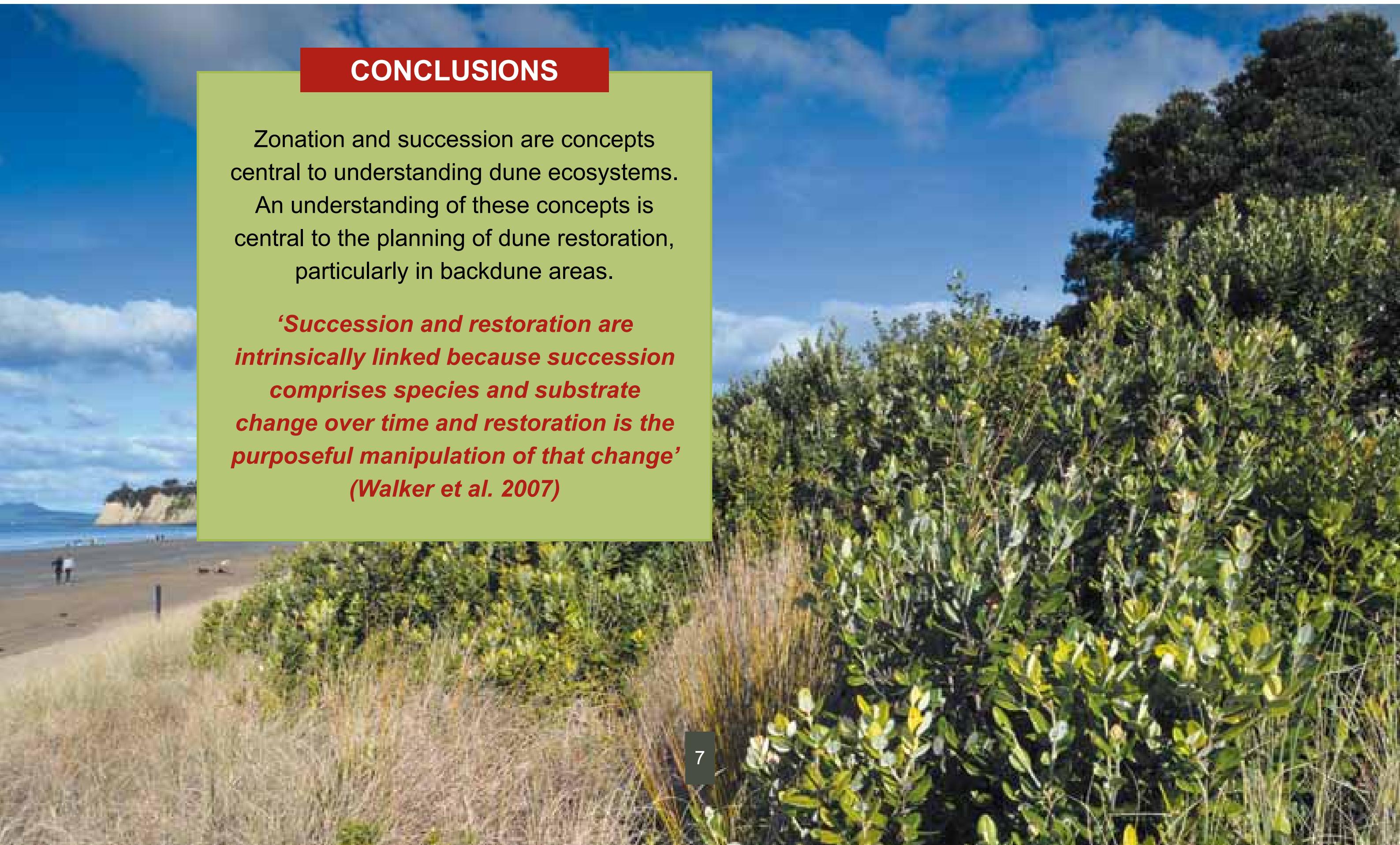
Natural recovery

It is important to appreciate that the primary ecological goal of dune restoration in most backdune areas centres on initiating or facilitating natural successional recovery rather than trying to restore any particular end state.

For example, in those backdune areas where forests were the original climax community, the nature of the original forests may be completely unknown. And, even if the characteristics were known, it may not be possible to restore that former state due to changes in the environment since human settlement (e.g. introduction of a wide range of exotic plants and animals, extinction or significant reduction of various native fauna that played a key role in structuring vegetation communities, changes in dune morphology and soils).

Moreover, natural successional recovery of appropriate, diverse and resilient forests is likely to require a number of successional stages, with the nature of the vegetation communities changing markedly over time. The nature of the successional pathway and the various vegetation communities may also be significantly altered from the past due to the environmental change that has accompanied human settlement and to factors such as historic and projected future climate change.

Accordingly, in most backdune areas, restoration is more about initiating or accelerating natural successional recovery of native-dominated dune ecosystems rather than restoring a particular dune state. Over time, the native vegetation may (probably will) change quite significantly from the vegetation communities initially established by the restoration.



CONCLUSIONS

Zonation and succession are concepts central to understanding dune ecosystems. An understanding of these concepts is central to the planning of dune restoration, particularly in backdune areas.

'Succession and restoration are intrinsically linked because succession comprises species and substrate change over time and restoration is the purposeful manipulation of that change' (Walker et al. 2007)

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"To see the majority of New Zealand dunes restored and sustainably managed using indigenous species by 2050".