ENVIRONMENTAL MANAGEMENT PLAN

FOR

DUNE REHABILITATION

IN DURBAN

Compiled by: Vanashrie Gounder
Coastal, Stormwater and Catchment Management, Engineering Unit, eThekwini Municipality
166 K. E. Masinga Road, Durban, 4001
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Glossary of Terms and Abbreviations

Accretion - The process where coastal sediments return to the visible portion of the beach by natural factors. It is the accumulation or build-up of sand that results in the gradual increase in the size of the dune.

Aeolian processes - Processes that pertain to the activity of the winds and more specifically, to the ability of the wind to shape the surface of the Earth.

Beach berm - A beach berm is the nearly horizontal portion of a beach formed by the deposition of sediment by receding waves. The berm has a crest (top) and a face - the latter being the slope leading down towards the water from the crest.

Biodiversity - The variety of living organisms, their genetic makeup and ecological communities.

Contractor/Landscape consultant - Refers to the party/person contracted by eThekwini Municipality to carry out the dune rehabilitation process.

CSCM - Coastal, Stormwater and Catchment Management Department of eThekwini Municipality.

DAEA-RD - KwaZulu-Natal Department of Agriculture, Environmental Affairs and Rural Development.

Dune - A dune is a hill of sand built by aeolian processes. Dunes occur in different forms and sizes and are formed by interaction of the wind, waves and vegetation. Dune habitats provide niches for highly specialised plants and animals.

Dune rehabilitation - The process of restoring the dune after it has been damaged due to natural processes or human activities or a combination of both.

Dune rehabilitation plan - A plan or programme that seeks to reinstate the natural dune to a functioning state. The plan describes how activities, which have or could, have an adverse impact on the environment, will be mitigated, controlled, and monitored.

ECO - Environmental Control Officer.

EPCPD - Environmental Planning and Climate Protection Department of eThekwini Municipality.

Foredune - The first and often prominent ridge of sand behind and parallel to the beach, usually well vegetated with shrubs. These dunes can be attacked by waves during very severe or long storm events. Woody shrubs and trees dominate these dunes and their size, shape and stability depends on vegetation cover.

High-water mark - Refers to the highest line reached by coastal waters, but excluding any line reached as a result of exceptional or abnormal floods or storms that occur no more than once in ten years; or an estuary being closed to the sea.

Hind dune - The dune area behind the foredune and behind a depression running parallel to the shoreline.

Incipient foredune - A small bench or platform of accumulated windblown sand at the top of the beach, usually right in front of the foredune. This dune is the most dynamic dune type, growing upwards and outwards to the sea or can be completely removed by storm waves.

ICM Act - Integrated Coastal Management Act (Act No. 24of 2008).

Indigenous plant species - Plant species that are native to southern Africa.

Invasive plant species - Are those plant species that do not occur naturally within a region and are able to establish themselves in a natural or semi-natural habitat. They are generally habitat transformers, often displacing naturally occurring vegetation.

Low-water mark - Refers to the lowest line to which coastal waters recede during spring tides.

NEMA - The National Environmental Management Act (Act No. 107 of 1998).

Introduction

Dunes are an integral part of Durban's coastal environment. Coastal sand dunes (vegetated and unvegetated) are highly dynamic landscapes, subject to cycles of erosion and accretion caused by wave and wind action. Dunes generally experience harsh conditions and are exposed to coastal winds, salt spray and high light intensity. Dunes consist of highly porous sandy soils which have limited soil moisture content. Dune vegetation generally extends from the high-water mark along the coastline.

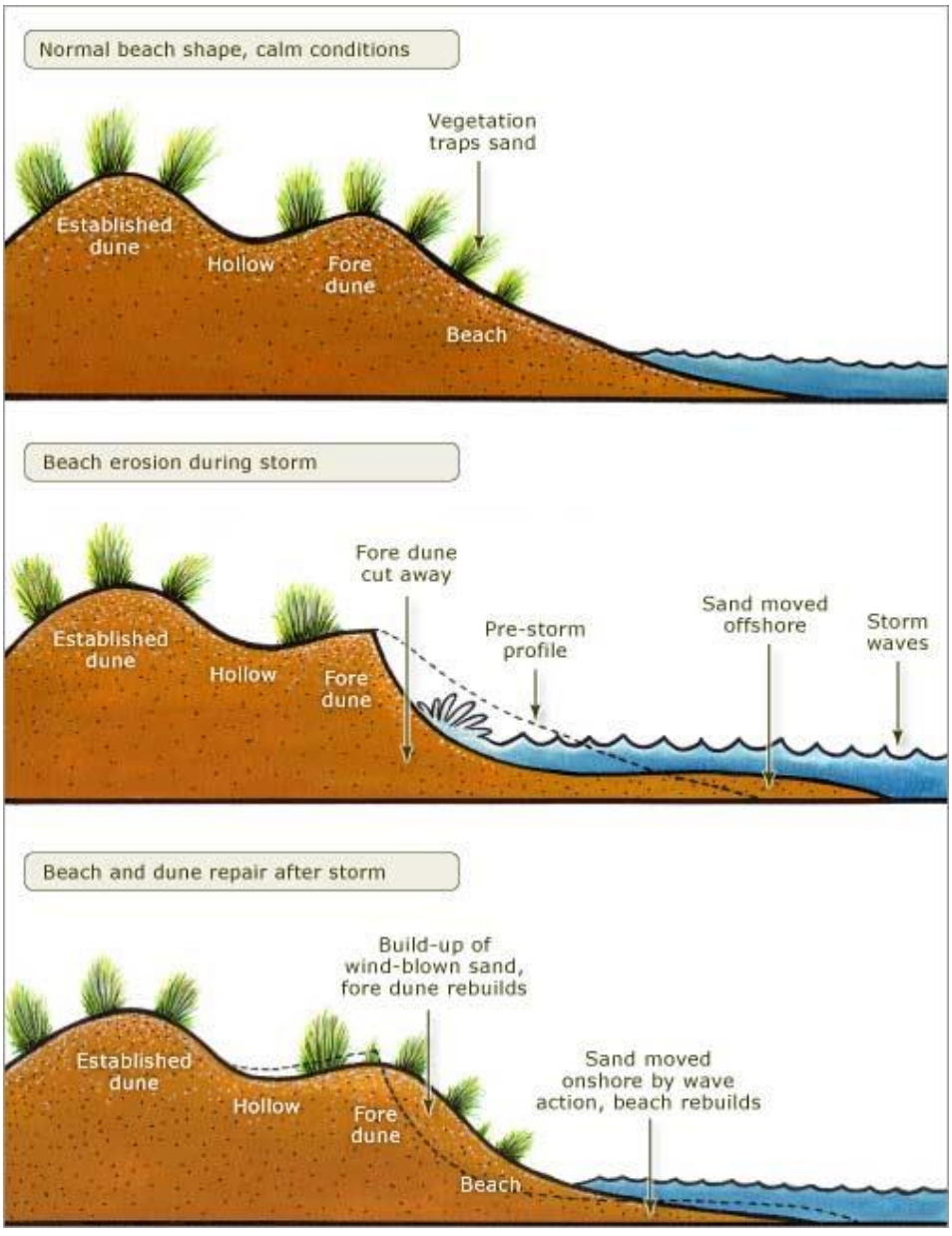


Figure 1: Beaches and fore dunes (the dunes closest to the sea) are in a constant state of change in response to waves and wind. Upper panel: fore dunes are formed when vegetation traps wind-blown sand. Middle panel: the front face of a fore dune is eroded when waves during storms crash onto the dunes and wash away

plants and sand. Lower panel: the dunes form again as vegetation is re-established on an exposed site and begins to trap sand.

A healthy dune system acts as a flexible coastal barrier that protects the coastline including property, infrastructure, recreation areas and biodiversity against sea erosion and wave damage during storms. Dunes also protect the land behind it from salt water intrusion. This sand barrier allows the development of more complex plant communities in areas protected from salt water inundation, sea spray and strong winds. The dunes act as a reservoir of sand, to replenish and maintain the beach at times of erosion. The dune system retreats under wave attack when sand is lost to form off-shore bars, and advances during calmer weather as the dune vegetation traps windblown sand that has been returned by wave action from the off-shore bars to the beach. As sand accumulates, the dunes become higher and wider. Dune systems are vulnerable and can be damaged by natural forces, by human activity or a combination of both, and when this happens, the damaged dune vegetation is no longer effective at trapping and holding windblown sand. If this condition persists, it will disrupt the natural cycle of advance and retreat of the dune and its vegetation. The failure to trap sand blown up from the beach and the continued loss of sand from the degraded dunes due to wind erosion, decreases the effectiveness of the dune to act as a coastal barrier and results in the dunes becoming unstable and migrating landward.

If the vegetation cover on a dune is damaged, areas of bare sand are left vulnerable to strong onshore winds which may cause 'blowouts' or gaps in the dune ridge. Unless repaired, these areas increase in size and the entire dune system may migrate inland covering everything in its path. Where there is an inadequate dune, properties and infrastructure near the back of the beach may be subjected to large amounts of windblown sand, inundation from the ocean, structural damage from wave attack and undermining by foreshore erosion. Meanwhile, with a diminished reservoir of sand, erosion of the beach may lead to coastal recession. Without intervention, sensitive habitats will continue to be lost due to the natural erosion potential of the dunes.

To avoid this, protecting the dune vegetation is essential. Vegetation plays a vital role in determining the size, shape and stability of dunes. The aerial parts of the vegetation obstruct the wind and absorb the wind energy and the sand is deposited around the vegetation as the velocity of the wind is not strong enough to transport the sand.

Figure 2: Damaged dunes along Durban's coastline.

Vegetation on the beach and dunes tends to occur in zones, according to the degree of exposure to harsh coastal conditions e.g. the incipient foredunes are closest to the sea and are characterised as the pioneer zone. This zone is colonised by pioneer plant species that can tolerate exposure to salt spray, sand blast, strong winds and flooding by the sea. They are often protected by waxy or hairy coverings on stems and leaves and grow low to the ground, offering little resistance to the wind.

They have strong root systems and spread rapidly; creating a mesh of creeping stems so if one part is buried in shifting sand or uprooted another part can continue growing. They thus serve to stabilise the sand, forming and building dunes. Secondary species have an important function of stabilising seaward of the foredune crest. Their survival mechanism relies on an adaptable growth habit and capacity to reseed prolifically; they cannot develop quickly and require the stabilising influence of primary species to establish successfully. Permanent tertiary species occur on and behind the ridge of the foredune. These plants are slow growing and highly interdependent in that they need to cooperatively maintain an unbroken canopy. They form the stable hind-dune.

The various zones are not fixed. As plants grow taller and humus, such as dropped leaves, accumulates, exposure to sun and soil conditions change. The soil becomes richer and holds more water. This enables scrub and woodland plants to move in, changing the type of vegetation by a process called succession.

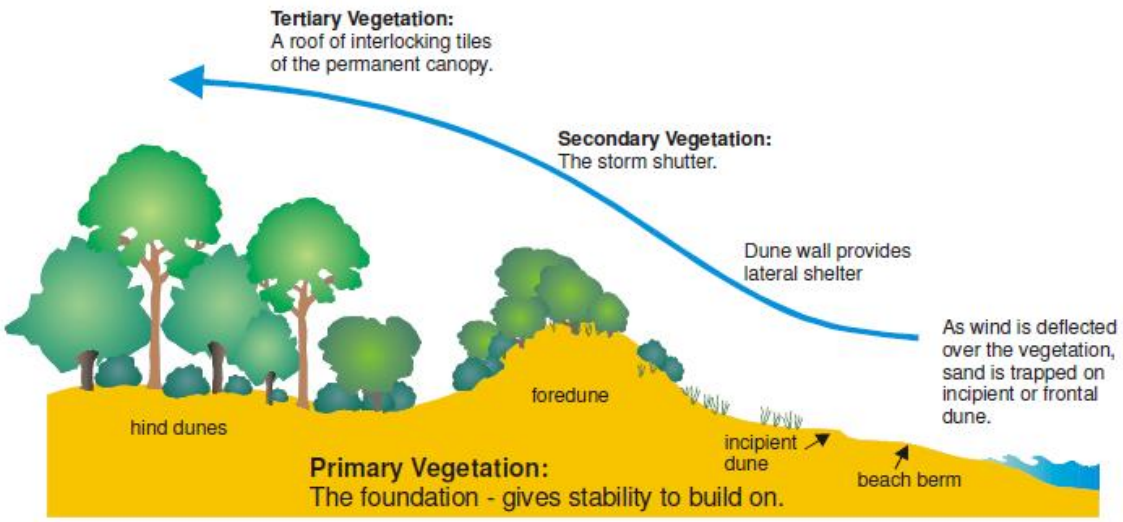


Figure 3: Three plant zones are usually recognised: primary, secondary and tertiary.

An undisturbed system of coastal foredunes is in a complex state of dynamic equilibrium and its stability, shape and position depend on the interplay of the effects of wind, waves, tides and vegetation. Dunes and their vegetation can be damaged by many natural forces such as waves generated by storms, saltwater inundation, strong winds, droughts, fires and by insects and parasites. Many human-directed activities including grazing, burning, urban development and pedestrian and vehicular traffic have also contributed to the damage and destruction of vegetated

dunes. Severely damaged dunes may require reestablishment to provide a stable and effective coastal barrier.

In implementing a dune restoration and maintenance programme, it is important to note that sandy beaches are an important ecosystem that links the ecology of sand dunes, the surf zone, intertidal zones, and nearby rocky reefs. Sandy beaches are rich ecosystems, which harbour a great number of species adapted to cope with this harsh environment. Beaches are a unique environment occupied by animals that have adapted to the constant motion of sand. Hence, they also provide a unique habitat for invertebrate species which typically include tiny crustaceans, worms and burrowing animals, clams and scavenging plough snails as well as many important birds, reptiles and other animals which nest, breed, feed and rest on the dunes or open beach. Most invertebrate phyla are represented on sandy beaches, either as meiofauna or macrofauna. Their habitat is dynamic and defined by 3 factors: tides, waves and sand characteristics Other associated factors that influence faunal assemblages include the erosion/accretion dynamics of the sediment, freshwater discharge, food supply, slope of the beach, aeolian transport mechanisms and storm events. Meiofaunal species are known to be sensitive indicators of environmental perturbations and pollution. Thus the state of meiofauna assemblages may reflect the overall health of the marine benthos. Beach face organisms are more resilient to smothering with sand and are better able to re-colonise. The ability of certain organisms to survive by behavioural means is a key feature of many sandy shore animals. Invertebrate macrofauna have a high degree of mobility, including the ability to burrow rapidly. Coastal ecosystems can potentially be disrupted when sand is taken from beaches. Where organisms are affected on a wide scale or over long periods, the coastal ecosystem may not be able to recover. In general when sand is taken from the beach in close proximity to the sand dune toe, the beach and dunes eventually readjust through movement of sand from offshore and from the sand dune, depending on sea conditions. Organisms in nearshore beach and dune ecosystems tend to be resilient to these sand movements as beaches are a naturally high-energy environment, and sediment is transported regularly as a result of storms, waves and currents.

Principles of dune re-establishment

The re-establishment of coastal dunes may involve the physical replacement of a mass of sand of appropriate size, shape and location to provide sufficient protection against storm waves. Placement of the sand mass will be followed by stabilisation so that it will not be reshaped or relocated by wind action. Although the methods used in individual locations may vary, the following steps are common to dune re-establishment programs.

1. The design and construction of a dune of appropriate size, shape and location, using one or more of the following:
    a. Accumulation of windblown sand by sand trapping devices such as brush matting or semi-permeable fences to lower wind velocities and deposit moving sand where it is required.
    b. Importing sand from onshore sources using earth moving machinery.
    c. Reshaping the existing dunes, particularly where they have been seriously affected by wind erosion or where sand has blown inland.
2. The immediate temporary stabilisation of the constructed dune to prevent deformation by wind action using brush matting or a suitable surface stabiliser until a stable cover of indigenous vegetation can be established.
3. The establishment of indigenous vegetation to prevent long-term wind erosion of the dune, encourage further sand deposition, and to allow the dune to regenerate naturally after storm damage.
4. The protection of the vegetative cover by physically excluding people and vehicles, both of which may cause localised or general destruction of dune plants, and result in wind erosion.
5. On-going maintenance to create a permanent self-sustaining dune system. This may require replacing the plants that have failed to establish and/or the use of fertilisers to help plants establish.

Legislative Framework

1. The Constitution of the Republic of South Africa Act (108 of 1996)

The Constitution of the Republic of South Africa forms the foundation of all law, including environmental law, in South Africa. The Bill of Rights is fundamental to the Constitution of South Africa and in, section 24 of the Act, it is stated that:

"*Everyone has the right (a) to an environment that is not harmful to their health or well-being; and (b) to have the environment protected, for the benefit of present and future generations through reasonable legislative and other measures that (i) prevent pollution and ecological degradation; (ii) promote conservation; and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.*"

2. National Environmental Management Act (NEMA) (107 of 1998)

NEMA is South Africa's overarching environmental legislation and has, as its primary objective to provide for co-operative governance by establishing principles for decision making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions exercised by organs of state and to provide for matters connected therewith. The Act provides for the right to an environment that is not harmful to the health and well-being of South African citizens; the equitable distribution of natural resources, sustainable development, environmental protection and the formulation of environmental management frameworks.

3. The National Environmental Management Act (NEMA): EIA 2010 Regulations and the Listing Notices

In June 2010, the new Environmental Impact Assessment (EIA) Regulations 2010 in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998) was promulgated. Activities under Listing Notice 1 (GNR 544) that pertain to dune rehabilitation include,

- **Activity 17** - The planting of vegetation or placing of any material on dunes and exposed sand surfaces, within the littoral active zone for the purpose of preventing the free movement of sand, erosion or accretion, excluding where the planting of vegetation or placement of material relates to restoration and maintenance of indigenous coastal vegetation or where such planting of vegetation or placing of material will occur behind a development setback line.

- **Activity 18** - The infilling or depositing of any material of more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock from
  (i) a watercourse;
  (ii) the sea;
  (iii) the seashore;
  (iv) the littoral active zone, an estuary or a distance of 100 metres inland of the high-watermark of the sea or an estuary, whichever distance is the greater but excluding where such infilling, depositing, dredging, excavation, removal or moving

  (i) is for maintenance purposes undertaken in accordance with a management plan agreed to by the relevant environmental authority; or
  (ii) occurs behind the development setback line

4. Integrated Coastal Management (ICM) Act (24 of 2008)

The objectives of the ICM Act are to:

- Determine the coastal zone of South Africa;
- Provide within the framework of the National Environmental Management Act, for the co-ordinated and integrated management of the coastal zone by all spheres of government in accordance with the principles of co-operative governance;
- Preserve, protect, extend and enhance the status of coastal public property as being held in trust by the State on behalf of all South Africans, including present and future generations;
- Secure equitable access to the opportunities and benefits provided by the coastal public zone; and
- Give effect to South Africa's obligations in terms of international law regarding coastal management and the marine environment.

Aim of the EMP

To restore and maintain the structure, function, dynamics and diversity of the dune ecosystem by undertaking dune rehabilitation timeously and effectively.

Objectives

To undertake dune rehabilitation timeously to ensure rehabilitation is effective in

- Reducing soil erosion;
- Reducing dune instability;
- Reinforcing the soil profile of the dune;
- Reinstating the natural vegetation of the dune;
- Minimising the threat of alien plant invasion; and
- Minimising maintenance commitments by providing vegetation that regenerates naturally.

Implementing a Dune Restoration and Maintenance Program

Dune rehabilitation projects vary greatly in scale and complexity depending primarily on the extent to which the existing dune system has been degraded. At all dune rehabilitation sites the primary goal will be to try to establish a landscape that resembles as closely as practicable, the dunes that were present before the degradation began. At some sites, erosion or other damage maybe so severe that the first task will be to reshape the sand mass into a landform that might reasonably be

expected to have developed naturally. At other sites the dunes themselves may not have suffered any erosion, and degradation may be limited to invasion by weeds or alien invasive plant species, in which case rehabilitation may only involve some access and weed/alien invasive plant control.

The dune rehabilitation process will consist of the following phases:

1. Identification of dune rehabilitation site including,
    a. The cause of the damage and whether it results from natural forces or from human activities will be identified.
    b. If the cause is due to human activities it is likely to be of an on-going nature. The possibility of removing or controlling the cause by changing management practices will be investigated.
2. Design phase - A detailed dune rehabilitation plan that considers the following will be developed where,
    a. The cause of the damage will be removed or controlled where practicable.
    b. The technical requirements will be determined (e.g. reinstating the dune, the type of earthmoving machinery, required volume of sand to be moved, vegetation to be planted, fertilising, estimation of costs etc.).
    c. A time schedule will be determined.
    d. Sources of finance will be investigated.
4. The rehabilitation phase - Reinstating and revegetation of the dune.
5. Maintenance and monitoring phase -The final phase of the rehabilitation process to ensure the process is successful. This phase ensures that the on-going maintenance requirements are understood and incorporated, and that progress is periodically inspected and evaluated until a satisfactory level of vegetation cover is reached.

Where significant movement of sand has occurred due to non-human disturbance, the justification for stabilisation and rehabilitation of the dune will be given careful consideration, noting that mobile dunes are also natural landscape features in their own right.

Environmental Monitoring

The Coastal, Stormwater & Catchment Management Department (CSCM) and the Environmental Planning and Climate Protection Department (EPCPD) of eThekwini Municipality will undertake environmental monitoring on a regular basis. This monitoring will be undertaken to ensure compliance with all aspects of the environmental management plan.

Numerous dunes along Durban's coastline require rehabilitation. Taking into account that many of these sites will be rehabilitated simultaneously as well as costs and time associated with contracting an independent Environmental Control Officer (ECO) to monitor these sites, the municipality will use municipal staff to monitor compliance of the EMP. Municipal staff that will be involved in the dune rehabilitation process and the monitoring of all activities are listed in Appendix C.

Non-Compliance of the EMP

Difficulties may be encountered with carrying out mitigation measures that could result in future non-compliance. The responsible person shall put in place measures to motivate staff members to comply with the EMP, and to deal with acts of non-compliance, or malicious damage to the environment by any staff member.

EMP Amendments and Instructions

No EMP amendments (relaxation or revision of any mitigation measure) shall be allowed without approval from the relevant authority (i.e. DAEA-RD). Motivations for amendments to the EMP shall be discussed with DAEA-RD. These amendments or instructions issued by DAEA-RD shall be implemented within the specified time frame or incorporated into the generic EMP.

Rehabilitation of the Dunes

1. Reforming (rebuilding and reshaping) dunes

Any revegetation program proposed for degraded coastal dunes requires a landform that encourages the establishment and survival of grasses or shrubs and trees. In badly degraded areas, preparing a suitable landform may involve rebuilding or reshaping the dunes. Natural dunes vary in position, slope, size and shape depending on the interplay of factors such as wind, vegetation and waves. This topographic variability also contributes to subtle but valuable variations in microclimate and habitat. Therefore, reconstructed dunes should also vary in slope, size and shape just as natural dunes do. However unnatural protruding sides or steep-sided undulations that may interrupt or concentrate wind flow should be avoided. These large irregularities can also make vegetation establishment difficult or even impossible, and frequently lead to the formation of even larger blowouts. The dimensions of the reconstructed dunes will depend on those of the remnant dune, the location of the dune and the type and availability of sand to be used for reconstruction. Dimensions may be constrained by the location of structures such as buildings, car parks or roads. This problem is common in urban areas where it is often only possible to reconstruct the seaward face of the foredune. In areas where these limitations are absent, it may be possible to reconstruct an entire dune system. Several methods can be used to reshape dune contours depending on the

scale of degradation. These include the use of earthmoving equipment or sand trapping techniques such as dune-forming fences, the spreading of brush matting and revegetation. The following factors will be considered when reforming dunes.

1.1. Material

1. The sand used in dune reconstruction should match the grain size of the sand in the adjacent remaining dune to allow for the establishment and growth of vegetation.
2. Finer sand material will not be used as this material will be more mobile and the new dune maybe eroded more rapidly than the existing dunes.
3. Larger grain size will also not be used as revegetation may be difficult because the increased porosity due to the larger grain size may lead to increased drainage and problems of low moisture and nutrient retention.
4. Foreign material such as clay, rubble, rubbish and earth fill will not be used as it is unlikely to provide the right conditions for establishment of a coastal dune ecosystem, and often creates more problems with introduced weeds and dune drainage.
5. Where it is not possible to use the preferred grain size of sand and the median grain size is too coarse, the dune will be designed so that the top 300mm of its surface consists of finer sand capable of retaining moisture and supporting plant growth.
6. Beach sand may have high salt levels. If this sand is used in dune construction, the salinity levels may cause problems in the establishment of vegetation, and an adequate period will be allowed for the salt to leach through the soil profile.

1.2. Position

1. The position of a reconstructed dune will be governed by the location of the dune prior to degradation, the existing dunes in the area and by the location of any structures that may be in close proximity to the dune.
2. A reconstructed dune will be integrated with any existing dunes and should run approximately parallel with the beach berm.

1.3. Slope and shape

1. Natural dune gradients vary considerably at any site.
2. The primary objective in reforming degraded dunes will be to re-establish the diversity of landform that existed before the initial disturbance. This should also assist re-establishment of an appropriate dune ecosystem.

3. While gentle gradients are easier to work upon and maintain, and may assist moisture retention and subsequent revegetation, reconstruction of steeper versions will not be avoided altogether.
4. Where space is limited, steeper slopes may be unavoidable.
5. Reconstructed dunes will have aerodynamically stable shapes.
6. Seaward faces of foredunes will be flat to slightly convex in shape. This will help to deflect onshore winds in an upward direction, which will then provide a sheltered area on the lee side of the dunes. This in turn will help the establishment of vegetation.
7. Where space permits, an incipient foredune may also be incorporated on the seaward side of the reformed dune. This will provide additional protection for the foredune and its emerging vegetation.

1.4. Height and width

The height and width of a reconstructed dune will depend on a number of factors including the:

1. Height and width of the existing dunes;
2. Availability of sand; and
3. Availability of space (taking into account existing dunes, infrastructure and property).

1.5. Sand Sources

1. Sand that has drifted inland from the eroded foredune will be used in the reconstruction process. This will bring the sand back into the natural coastal system.
2. Dune nourishment from off-site sources may be considered, provided the particle size and salt content is assessed.
3. Sand may not be sourced from any vegetated or unvegetated dunes, or from any other undisturbed area.
4. Sand obtained from the beach berm and below high water mark will be considered where drift sand is unavailable.
5. If the sand is obtained from the beach berm and below high water mark, the beach should be a self-sustaining beach and one that is not subjected to erosion problems.

1.6. Dune rebuilding using dune-forming fences

The principal function of a dune-forming fence is to reduce the wind velocity, thereby causing sand to be deposited in the vicinity of the fence. This technique can be used for small blowouts, for larger scale dune formation and at sites where it is not feasible to import new material. However, these fences are generally used on smaller isolated blowouts that are still surrounded by functional dunes

and vegetation. Dune-forming fences are useful in environmentally or culturally sensitive areas where it is undesirable to use earthmoving equipment or where access is difficult. The major disadvantages of dune-forming fences are their susceptibility to vandalism and the uncertainty of how long it will take for the desired dune profiles to become established. Dune-forming fences are useful if the rehabilitation program is of long duration, although their re-exposure some years later may create new hazards or beach debris.

If dune-forming fences are to be used, the following must be considered -

1. Sand trapping fences should be porous barriers that reduce the wind velocity sufficiently so that sand drops out of the wind stream and accumulates on both sides of the barrier. The function of sand fencing is to speed accumulation of sand in the location chosen for dune rehabilitation.
2. Almost any kind of fence can be used provided the structure slows but does not completely block the wind. So neither a completely solid fence such as plastic sheeting or open fencing such as wire will work as a sand fence.
3. Natural materials such as branches or reed stakes should be used, where possible, for fence construction, because these materials break down once they have accomplished their sand-trapping objective.
4. Wooden slats or pallets joined together with wire and hessian may also be used.

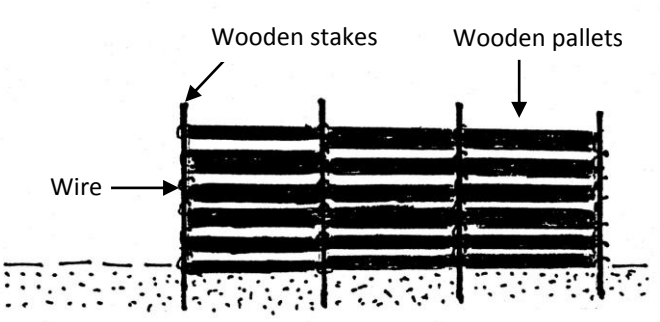


Figure 4: Sand trapping fence using wooden pallets.

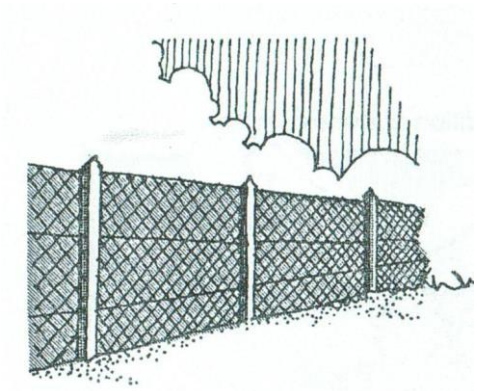
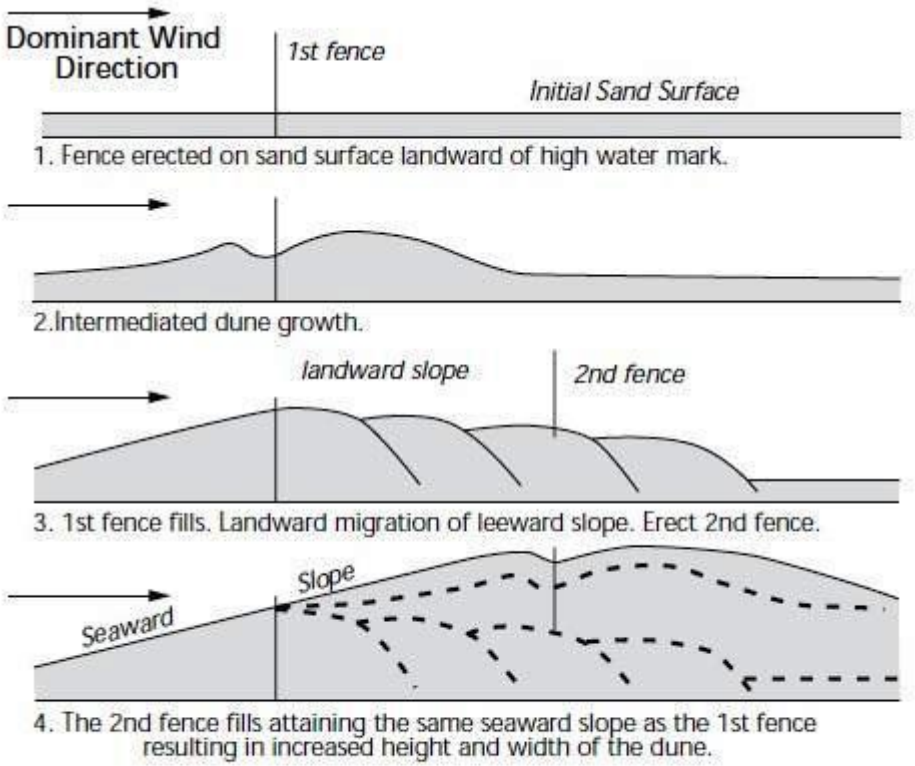


Figure 5: Diamond mesh fence with shade-cloth attached.

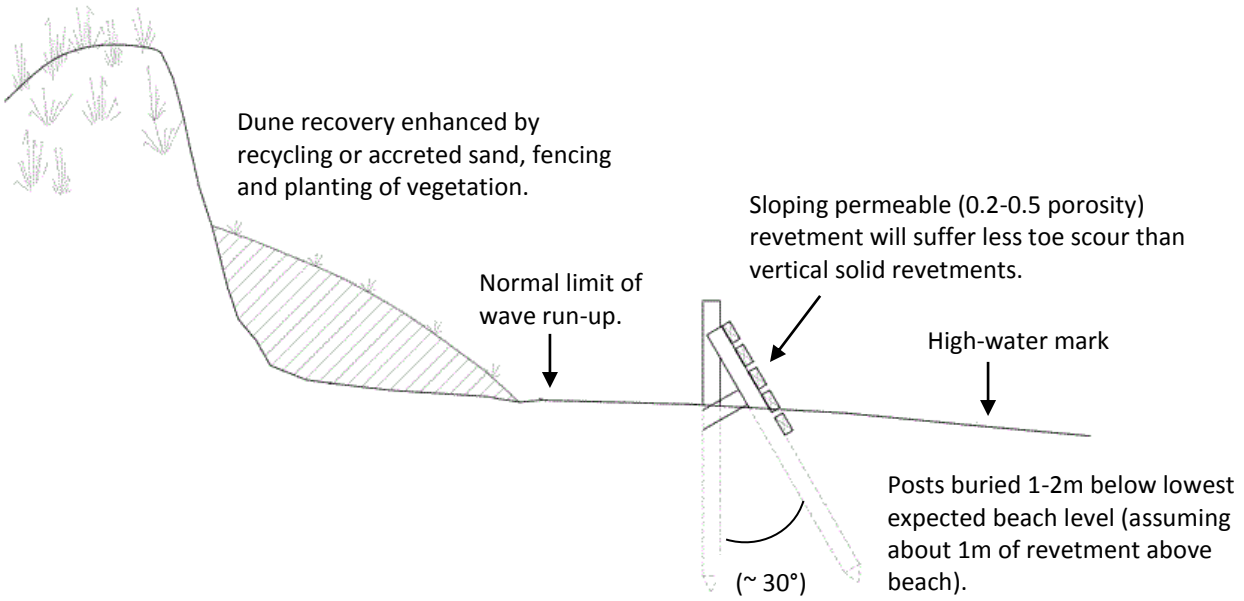
5. If natural material is unavailable, dune-forming fences should be made of a porous material such as a woven synthetic cloth with approximately 40% porosity. Synthetic cloth materials afford flexibility of design, ease of construction, durability and economy. This material should be attached to plain wire strained between treated pine/wooden posts.
6. Other designs will be considered depending on local circumstances and availability of materials.

7. Dune-forming fences will be installed during the non-planting season to allow for a gradual build-up of sand.
8. Fences should be installed such that windblown sand is trapped on both the windward and leeward sides of the structure to form the new dune.
9. Planting should commence when the fences have filled with sand.
10. The woven cloth needs to be secured at the base by digging it at least 200mm into the sand and attaching it to the top, intermediate and bottom wires. The ends of the fence should be firmly embedded and anchored within a stable object such as the side of the blowout to prevent sand from moving under or around the fence.
11. Dune-forming fences should be positioned at right angles to the prevailing wind to be most effective. They should be straight where possible. Zigzag patterns are not recommended.
12. The fence and the material will be designed to be buried by drifting sand.
13. Recovery of the fence will not be attempted.
14. In planning fence installation, sand can be expected to accumulate in a zone whose width is 5-10 times the fence height. The actual width will vary according to wind and sand characteristics. To build a very wide dune, a series of parallel fences will be constructed at 2-5 metre spacing.
15. To build up dune height, additional fences may need to be constructed above the original fences when they have filled with sand. This should be repeated until the height of the sand trapped by the dune fences approximates the height of the surrounding dunes.

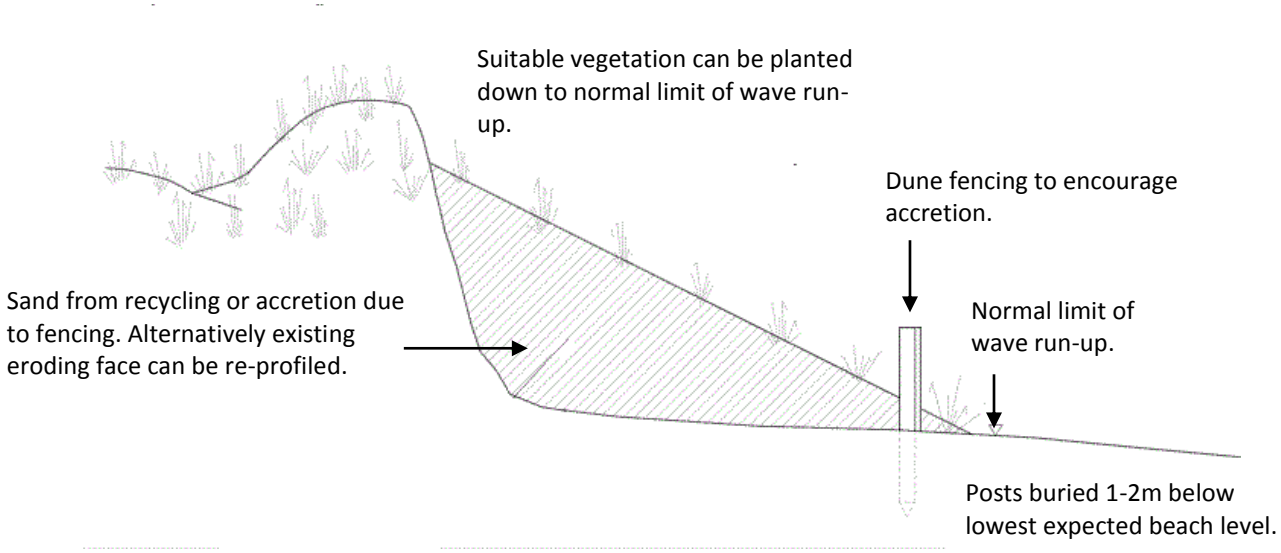


Stages in Dune Formation Using Semi-Permeable Sand Accumulating Fences

Figure 6: Stages in dune formation with the use of semi-permeable sand accumulating fences.



(a)



(b)

Figure 7 (a) and (b): Placement of fences either at an angle (sloping) or vertically. Toe scour may occur at vertically placed fences during storms, reducing the structural stability of fence and dune.

1.7. Dune rebuilding using earthmoving equipment

In many situations dune reconstruction requires the use of earthmoving machinery. Earthmoving equipment is used to push the sand up from the beach or areas were the sand has accumulated and then to construct a dune of the required size and shape at the correct location. This is an expensive option but it has the advantage of reconstructing large sections of eroded dunes to desirable size, shape and location within a short time frame. Earthmoving equipment that can be used in dune reconstruction includes:

1. Bulldozer - May be used where sand is readily available, extensive reshaping is required and the pushing distance is short.
2. Front-end loader - May be used for carrying smaller quantities of sand moderate distances. They are valuable for accurately placing sand where required with minimal environmental disturbance and for transplanting primary vegetation.
3. Excavator - May be used to excavate sand from the source and progressively place the sand by an excavator at the site of rehabilitation. Excavators have an extendable arm with a digging bucket, grasper or auger attachment. The digging bucket can move large quantities of sand in a short space of time and the grasper can be used to collect and spread large quantities of brush. A competent excavator operator may be able to trim the slope of the dune to the required angle from either the crest or toe of the sand dune.

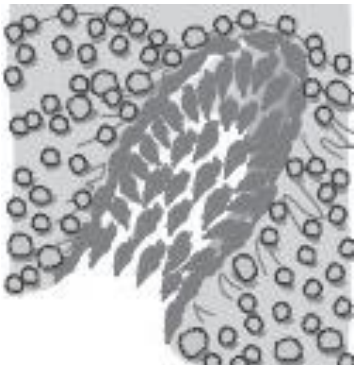
If earthmoving equipment is to be used, several aspects will be considered.

1. Care should be taken not to disturb significant areas of existing vegetation.
2. All vehicles and equipment used on site will be operated by appropriately trained and/or licensed individuals in compliance with all safety measures as laid out in the Occupational Health & Safety Act (OHSA).
3. Vehicles and machinery are to be kept in good working order.
4. No vehicles or equipment will be refuelled or serviced at the site.
5. External contractors appointed by the Municipality to undertake dune rehabilitation in the coastal zone must be in possession of a letter from the Municipality delegating authority for vehicle use in the coastal zone. This letter must include vehicle registration number(s), the maximum period of validity, the area and the scope of operation. This must be produced when requested by any relevant enforcement official (Note: Failure to do so will result in prosecution in terms of NEMA).
6. Where possible, access to the beach must be via existing designated access points only.

The Code of Conduct for the use of off-road vehicles (ORVs) in the coastal zone must be adhered to, to ensure that there is no further degradation to the coastal zone (Appendix A).

(a) Using earth moving equipment, push sand from blow-out lip into hollow.

(b) Place brush on exposed areas where blow-out lip has been disturbed.



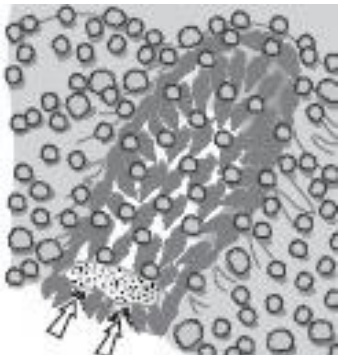


Figure 8: Repairing a blow-out with the use of earth moving equipment.

1.8. Timing of reconstruction

Dune reconstruction works using earthmoving equipment will be timed carefully so that completion of the various stages of reconstruction coincides with the appropriate season for planting primary dune stabilising vegetation. If the works are completed too far in advance of planting, the likelihood of dune erosion by wind is extremely high. This will necessitate further dune reconstruction. However, if planting is undertaken too soon after the dune has been constructed, the vegetation may fail to establish because there was insufficient moisture in the reworked sand, the sand was not suitably consolidated to aid plant growth, or salt had not yet been leached from the plant root zone.
The timing of dune reconstruction work will take into account climatic conditions, planting season, availability of planting materials and the experience of the program managers and supervisors.

2. Dune stabilisation

Once the dune has been reformed, the next step will be to immediately stabilise the sand surface against wind erosion so that vegetation can be established. A common technique is to stabilise the dune surface with plant material using brush matting or spreading of mulch. This will stabilise the dune if time is required for sand moisture and salinity conditions to become more favourable for the establishment of dune vegetation as well as encourage sand trapping. Pioneer species can be planted in conjunction with the use of plant material stabilisers, but should only be done if the moisture and salinity conditions are favourable.

2.1. Mulch

In less exposed dune areas where the susceptibility to wind erosion is lower, a satisfactory level of surface stability can be obtained by using mulch. Mulch assists with retaining soil moisture and

provides protection for seedlings from strong winds, sun and rain. Suitable materials for mulch include grass cuttings, leaves, bark chip and sawdust. Materials that provide coarse, fibrous mulch that will not easily blow away are preferred. Other sources of mulch such as chipped waste from tree pruning and clearing operations will be considered if they are not a source of weed seeds. Seed, cuttings or potted stock of dune-stabilising plants can be planted prior to spreading the mulch. Mulches have the advantage of being commercially available and are easier to handle and transport than brush. However, unlike brush, mulches are not effective on exposed areas with strong winds and large amounts of windblown sand. Mulch that will be used during the dune rehabilitation process,

1. Will not be harvested from natural areas surrounding the site.
2. Will be free of weeds.

2.2. Brush matting

Applying brush matting involves placing a layer of leafy branches over the bare sand surface. As the wind passes the brush and leaf tips, velocities are reduced and the sand surface remains intact. Windblown drift sand drops through and is trapped beneath the brush. The amount of sand that can be accreted by brush is significant and the degree of protection it affords an otherwise bare sand surface is excellent. The area can be planted and fertilised before brushing, or otherwise, seed and fertiliser can be planted over the area after the laying of the brush. The seed will then be buried as the brush matting traps the windblown sand. Brush matting is most effective if laid evenly over the area with some overlap.

The following features of brush matting make it a useful technique in dune stabilisation:

1. Dune vegetation establishes well and grows easily through brush matting. The sand-trapping qualities of brush matting are useful for burying seed that can be planted over the brushed area. It is incorporated into the soil profile as windblown sand is trapped and deposited on top of it.
2. Brush matting withstands strong winds while keeping the sand surface stable.
3. The original dune shapes are retained as the brush traps a uniform layer of windblown sand and it gradually buries itself.
4. With competent supervision, the brush can be obtained and spread by relatively unskilled staff.
5. Seed or seedlings can be planted and fertiliser applied either before or after the brush is laid. Brush matting provides shelter for the developing seedlings.

6. As the brush eventually decays it adds organic matter to the sand, improving its nutrient status and moisture-holding capacity.

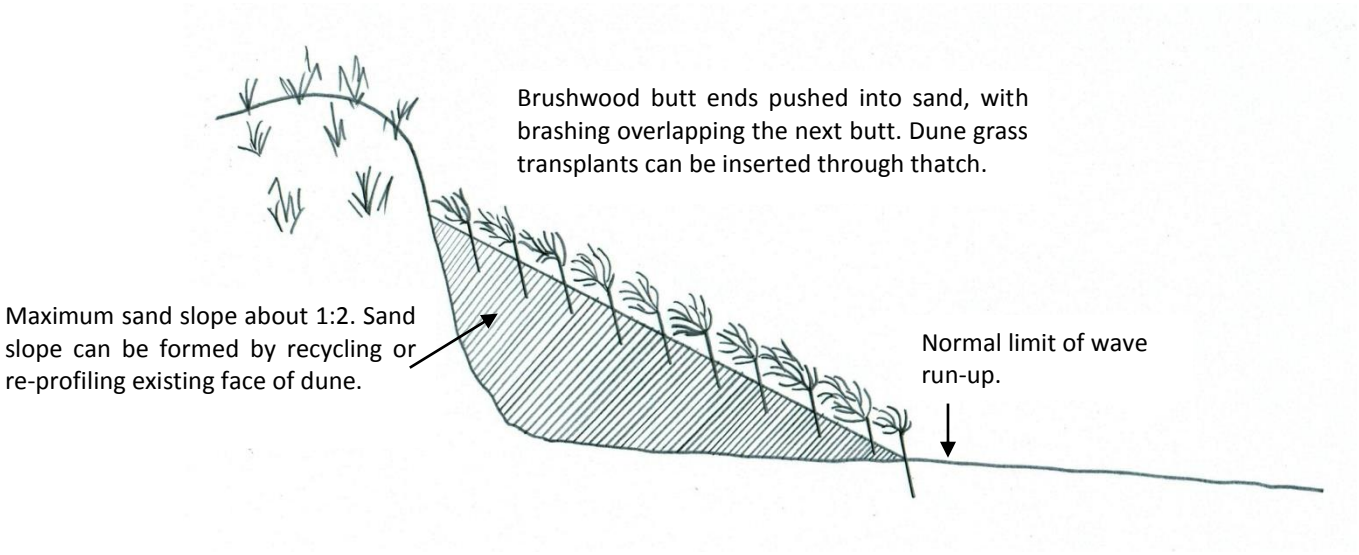


Figure 9: Stabilising a dune using brush matting.

A disadvantage of using brush matting is that the cutting, transporting and spreading brush matting is labour intensive and restricted to areas where brush is available and free from weed seeds.

During the rehabilitation of the dunes,

1. Coastal vegetation will not be used as brush except when rehabilitation coincides with the clearing of areas for development.
2. Care will be taken to avoid introducing seed from plants that are not locally endemic or indigenous.
3. Smaller branches will be broken off larger branches to make the brush cover a larger area.
4. Brush length will be at least 600mm, but less than 1000mm.
5. The butt end will be pushed approximately 150-300mm into the sand at a horizontal angle of 10-15 degrees.
6. The butt end of the branch will face the prevailing wind direction.
7. When laid the brush should cover at least 60-80% of the sand surface.
8. If brush availability is limited, it will be laid in rows 2-3 metres apart.

2.3. Liquid sprays

Liquid sprays will not be used as dune stabilising agents.

2.4. Geo-textiles

Slopes that may shift with wind or water flow will need to be protected or maintained. This may be achieved with the use of geo-fabric or geo-textiles. A disadvantage of geo-textile is that these products can only cope with a very small amount of sand accretion. Once the fabric is filled, sand continues to travel over the buried fabric.

Figure 10: Geo-textiles together with indigenous dune vegetation used to stabilise coastal embankment along Durban's coastline.

1. Products may include coconut fibre matting, woven fabric or nylon and non-woven polyester filaments.
2. Products that do not inhibit the growth of vegetation by seed will be preferred.
3. Suitable biodegradable products in conjunction with a mixture of plant species will be used.
4. A berm consisting of geofabric or other suitable sand bags should be established, as per the design of a coastal engineer, along the immediate front of the eroded dune system.
5. The bags are to be of suitable weight and to reach a height approaching that of the original frontal dune.
6. The berm should be covered with an appropriate sand fill to reach a gradient between 18° and 24°.
7. Gabion baskets with bags can be used to protect the toe of the berm.

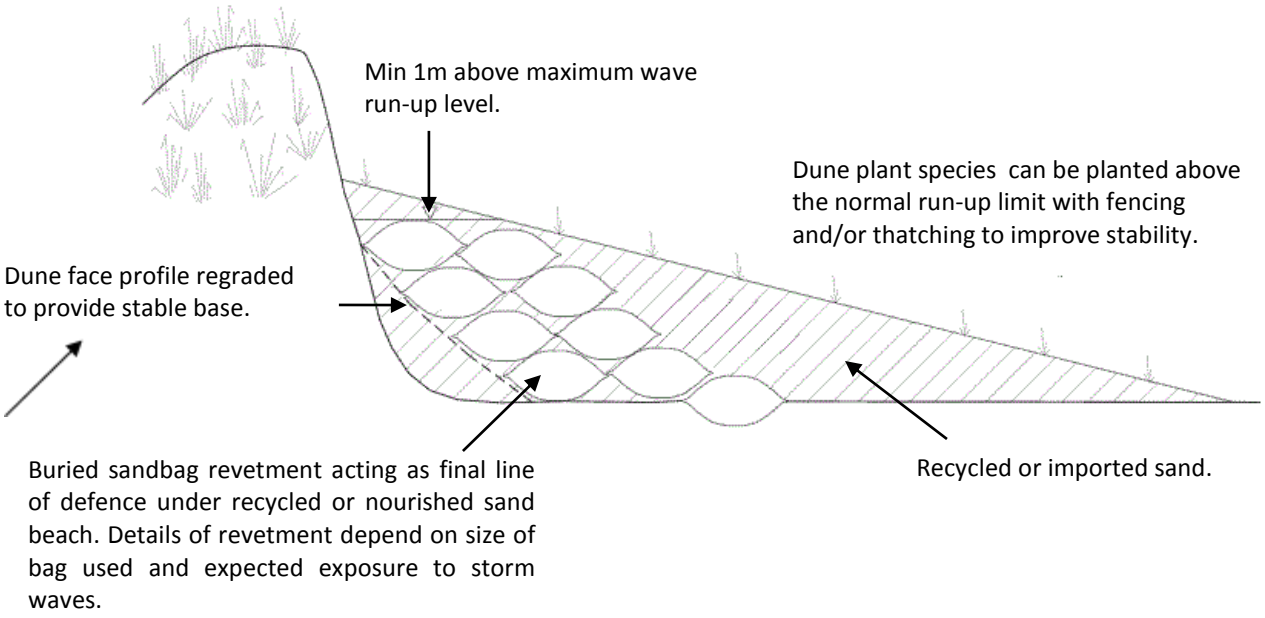


Figure 11: The use of sand bags to maintain dune slopes and stability.

3. Protective fencing

Dune vegetation is particularly susceptible to damage from pedestrian and vehicular traffic. Physical delineation of the site is critical as it defines the boundaries of the area to be rehabilitated and ensures that all parties are aware of the specific area to be rehabilitated. Fences will be used in dune areas to preserve both revegetated and naturally vegetated areas. Fencing can be used as wind breaks to reduce the drying effect of wind on seedlings and to trap sand to stabilise the dune. The type of fence to be used will depend on the location of the fence, the material used for fencing, the usage of the dune area or beach by the public and area to be protected. The type of fence will be suited to the area where it is to be constructed and should be functionally and visually acceptable to the users of that area.

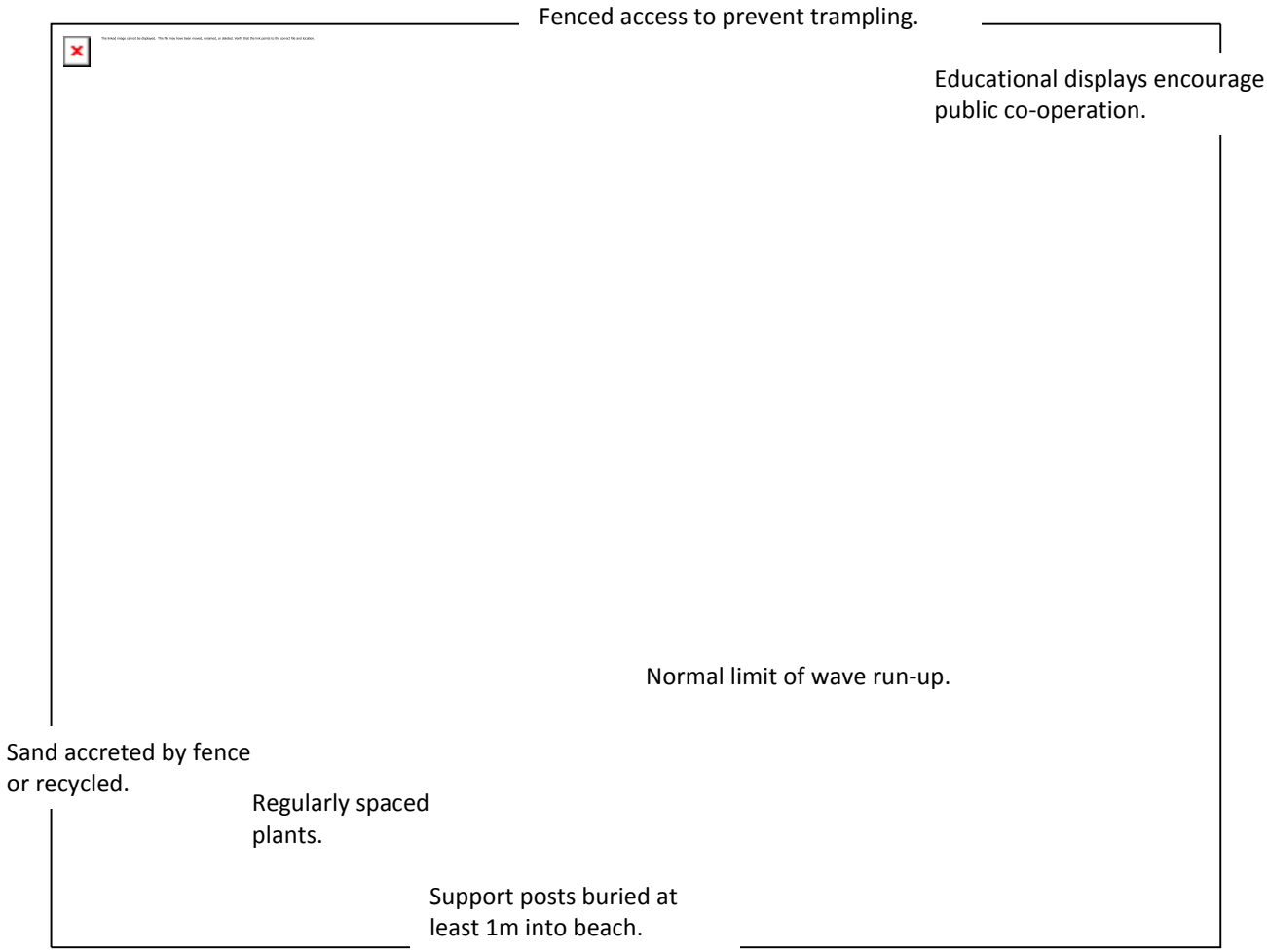


Figure 12: Fences will be used to protect the dune vegetation from being trampled by pedestrians.

3.1. Fence type and construction

1. The fence type and construction will be dictated by local site characteristics and the need for the fence.
2. Fences will be of simple construction (such as the use of shade cloth on poles) and easy to maintain.
3. Hazard tape may be used to delineate the edge of the site if the site is not subjected to movement of people or vehicles.
4. Once the rehabilitation process has concluded the fences will be removed and appropriately disposed of.

3.2. Fence position

1. The seaward or frontal fence will be located near the toe of the foredune, well above high-water levels.
2. It will also be more or less parallel to the toe of the dune. Its purpose is to protect sensitive vegetation. The positioning of the fence may be problematic as the further forward the fence is sited the more vegetation it will protect but the likelihood of damage or its removal by storm waves also increases. The fence may also be partially or completely buried by sand.
3. At remote sites a seaward fence will not be used.
4. The location of fences in hind dunes will vary according to constraints imposed by the landform, existing vegetation and the presence of developments such as car parks and roads.
5. Where possible, fences on the hind dune will be constructed behind vegetation that will screen them from view, thus maintaining a low visual impact. Alternatively, denser growing vegetation will be planted adjacent to the fence to provide both visual relief and an additional barrier to traffic.
6. Informative signage shall be erected to notify the public of the dune rehabilitation in progress.

4. Revegetation of the dunes

4.1. General planting principles

Effective dune management is based on the maintenance of a satisfactory vegetative cover. Vegetation plays a vital role in building coastal sand dunes and in stabilising them against the forces of wind erosion. In areas where dunes have been re-established and where dunes have been damaged by natural forces or by human activity, it is important to replant this vegetation quickly and effectively. The use of nursery-raised seedlings and seeds is the most common method of establishing vegetation on the dunes.

1. Planting will occur as soon the dune is reinstated in order to prevent soil erosion and the establishment of invasive alien plant species onto the site.
2. Locally indigenous species will be used as this will maintain the local biodiversity and will restore the coverage of the naturally occurring species within the area. Locally occurring plants are likely to require less maintenance and the growth rates are likely to be better and thus reducing/minimising the rate of loss of plants or die off of plants during the rehabilitation process.
3. A diversity of indigenous species will be used to avoid creating a monoculture.
4. If possible, plant material will be sourced locally.

5. Plants should generally be planted out in a manner to reproduce the natural vegetation zonation. Guidance will be obtained by observing similar undisturbed dunes in the same area.
6. Planting in straight rows will be avoided.
7. Successional planting will be established where possible and appropriate.
8. Suitable indigenous plant species for dune rehabilitation will be used, e.g. the herbaceous species that will be used to establish the pioneer zone will consists of species that are highly salt tolerant, have the ability to grow up through and stabilise accumulations of windblown sand, and spread rapidly due to its strong, creeping runners.
9. Tree seedlings will not be planted seaward of the crest of the foredune or in zones where the shifting sand levels can only be colonised by the herbaceous pioneer plants.
10. The slope of the dune will be taken into account when selecting appropriate vegetation.
11. Indigenous plants that will assist with dune stabilisation and that may deter access to the beach via the dune will be used.
12. All plants to be used are to be in a good condition.
13. All plants will be inspected to ensure that they are free from pests and diseases.
14. Potting materials should be weed free.
15. All plant material should be fully rooted in the proper growth medium to aid establishment of plants and reduce plant loss.
16. The potting soil that the plant has been growing in must be retained around its roots wherever possible when planting.
17. Seedlings will be well watered some hours before planting out so that the soil around the roots is moist.
18. The size of the holes should be sufficient that the plant's roots are well covered with topsoil.
19. Planting holes should be well watered prior to plants being planted.
20. Plant holes should be filled with well-mixed soil that contains organic matter and fertiliser if required.
21. Bark chippings or mulch should be placed around the base of the seedlings.
22. Plants should be watered immediately after planting to ensure that the soil around the plants is wet.
23. Newly planted plants will be protected from windblown sand as best as possible.
24. The combination of high temperatures and low soil moisture is the major cause of losses of planted out tree seedlings and time of planting should be planned to avoid these conditions. It is important to identify a period suitable for planting e.g. during the cooler months or after a good rainfall period.

25. Planting will not occur when it is too hot or windy.
26. Plant species will be planted at a sufficient rate and with adequate fertiliser to quickly produce a satisfactory covering of vegetation to stabilise the sand surface.
27. Planting will be planned to coincide with reliable rainfall where a reliable source of water for irrigation is unavailable.

4.2. Plants sourced from nurseries

The supply of hardy, vigorous seedlings of native dune plants is essential to the successful implementation of revegetation projects in dune areas. Many dune species can be raised in a basic plant nursery facility. This can help to provide these revegetation projects with a timely supply of tough, well-hardened plants that can survive the harsh conditions on coastal dunes. Plants will be sourced from nurseries that,

1. Have a suitable supply of indigenous dune species.
2. Take precaution to ensure that plants and seeds are free from diseases by maintaining a disease free environment and treating disease/pest outbreaks.
3. Ensure that the components of the potting mix are free of disease-causing pathogens.

4.3. Compost/General Fertiliser

Coastal dune soils have low levels of plant nutrients. A significant proportion of the total nutrient pool can be held in plant tissues, such as the leaves and stem and in leaf litter and are efficiently recycled by the plants. Indigenous dune plants often have specialised adaptations that allow them to grow effectively in low fertility sands. Depleted nutrient levels can occur in dune areas where the vegetation has been damaged or removed and in bare sand areas created by sand nourishment or wind erosion. Fertiliser applications will be a necessary part of any dune rehabilitation program to provide nutrient levels that will ensure satisfactory plant growth. Fertilisers are particularly useful for supplying the nutritional needs of young plants with small root systems. These plants have a limited capacity to extract nutrients from regular fertilisers which can be rapidly leached down the sand profile and away from their root zone. Fertilisers also minimise the time required to achieve stability against wind erosion.

Fertilisers will be used to achieve the desired level of nutrients required for the establishment of vegetation and the following will be taken into account when fertilisers are used,

1. Recommended fertilising programs will be determined according to the plants used and as per recommendations for particular plant species, the nutrient content of the soil, soil moisture frequency of application and climatic conditions.
2. Organic matter generated by garden refuse may be used as compost.
3. Care must be exercised when using fertiliser products near sensitive areas in order that contamination of these areas is avoided.
4. Organic fertilisers should be used where possible and fertiliser should be applied in a uniform manner after planting.
5. Climatic conditions such as heavy rain and strong wind should be considered prior to the application of fertiliser.
6. Eco-labelled and green certified products should be used e.g. FSC, Energy Star, Fair Trade etc.
7. Fertilisers will not be applied to establish natural vegetation on the undisturbed coastal dunes.
8. Fertilising beyond initial planting is unnecessary and is not recommended.
9. Fertiliser should not be applied before heavy rain as it maybe leached from the soil before uptake of plants if possible.
10. Fertilisers should be spread by hand ensuring that each area receives the appropriate amount of fertiliser.
11. Over-fertilising should be avoided as this can result in the production of excessive vegetative material which may create a problem.
12. Fertilisers containing phosphorus will be used cautiously, as phosphorous levels can build-up in the sand and encourage weed invasion.
13. The nitrogen component of fertilisers tends to be very soluble and heavy rainfall can quickly leach them from the relatively shallow root zone of young plants. This risk may be reduced by splitting up the fertiliser application and applying it when weather conditions are suitable.

4.4. Irrigation system

Poor survival of seedlings after planting on dunes is often due to the moisture stress encountered during the first few weeks when the root system is unable to obtain enough moisture to sustain the plant. This problem is greatly reduced if the seedlings can be watered during this critical early stage and there is much greater flexibility in time of planting if the seedlings can be watered during the critical establishment period. An irrigation system will be required at any dune rehabilitation site and therefore,

1. A temporary irrigation system must be specified.

2. An efficient system that adequately meets the needs of the plants should be chosen.
3. The irrigation system should be water-wise.
4. The Contractor shall be responsible for maintaining the desired level of moisture necessary for vigorous and healthy plant growth.
5. All seeded, planted or sodded vegetated areas shall be irrigated at regular intervals.
6. All grassed area should receive 100% irrigation coverage.
7. Care should be taken not to damage the soil structure or stability by use of excessive force of water.
8. Plants with similar water requirements should be grouped together e.g. plants with low, moderate or high water needs.
9. Weeds should be removed as these compete with indigenous vegetation for water.
10. Water loss through evaporation will be reduced by watering early morning or late afternoon.
11. The weather forecast will be checked to avoid watering before rain.

5. Access to vegetated areas

The Contractor must take into account the following when deciding on access routes into and around the rehabilitation site:

1. Tracks for both pedestrians and vehicular traffic should be designated.
2. Existing access routes will be used where possible.
3. All access routes must be planned and approved by CSCM prior to the start of the rehabilitation process.
4. No access routes should be created on an ad-hoc basis.
5. Access routes must not result in damage to any natural area or transverse any sensitive habitat.
6. Newly planted areas are to be left undisturbed wherever possible.
7. Use signage to keep people off vegetated areas.
8. Care must be exercised so as not to endanger the safety and well-being of other persons in the coastal zone.
9. Temporary access routes must be rehabilitated after usage as per prior agreement.
10. No over-tiding or night driving is supported, unless in cases of emergencies. This applies to earth moving equipment as well.

6. Maintenance and monitoring of the rehabilitation process

6.1. Alien plant clearing

1. The Contractor is responsible for controlling and removing all alien plant species from the site.
2. Alien plant species should be hand pulled when plants are still small and can be easily uprooted.
3. Hand pulling of alien plant species will ensure that the natural indigenous vegetation is given the best chance of becoming established.

6.2. Disease and pest control

1. The contractor is to inspect all plant material at least once a month to locate any diseased plant or any insects that are in the process of infesting plants.
2. The contractor shall inform CSCM of his/her planned method of eradicating the pests or disease and is to obtain the CSCM's approval, prior to doing so.
3. Physical pest/disease control methods such as removal of pest by hand or water from a hosepipe should be first attempted.
4. Infected parts or all of the plant should be removed from site.

6.3. Pesticides and Herbicides

Use of pesticides and herbicides will be avoided.

7. General site maintenance

1. Good housekeeping and a Clean Site Policy should be adopted.
2. Eating areas shall be designated and demarcated.
3. Bins will be provided and cleared to ensure that the site is maintained as litter free.
4. Temporary ablution facilities will be installed at the site if no public toilets are available.
5. All such toilets shall be secured to prevent them from toppling over.
6. The entrances to the toilets shall be adequately screened from public view.
7. These facilities shall be maintained in a hygienic state and serviced regularly.
8. The Contractor shall ensure that no spillage occurs when the toilets are cleaned or emptied and that the contents are removed from site by a licensed service provider.
9. Disposal of such waste is only acceptable at a licensed waste disposal facility.

Reporting Process

1. Key stakeholders

- KwaZulu-Natal Department of Agriculture, Environmental Affairs and Rural Development (DAEA-RD)
- Ezemvelo KZNWildlife (EKZNW)
- Coastal, Stormwater and Catchment Management (CSCM), eThekwini Municipality
- Environmental Planning & Climate Protection Department (EPCPD), eThekwini Municipality
- Others as identified during the site selection process.

2. Process

1. Site to be identified by CSCM prior to the implementation of the rehabilitation process.
2. Information about the site (Appendix B) to be provided to key stakeholders, including
    i. Location;
    ii. Aerial photo indicating the extent of rehabilitation site;
    iii. Expected duration of the rehabilitation process including start and end date; and
    iv. Contact details of relevant CSCM staff.
3. CSCM to obtain quotes and rehabilitation plans (including list of species, location of water source, type of fertilisers to be used etc.) from suitably qualified consultants (contractors).
4. Once the contract has been awarded, CSCM will submit the rehabilitation plan to stakeholders if requested by stakeholders.
5. In order to facilitate communication it is vital that a suitable line of communication is created. This will ensure that the recommendations have the full backing of the key stakeholders before being conveyed to the Contractor.
6. Once the rehabilitation process is completed, notification will be sent to the relevant key stakeholders.

Conclusion

If the above-mentioned management recommendations are adopted it is anticipated that most of the negative environmental impacts that may result during the dune rehabilitation process will be mitigated. CSCM will monitor the site throughout the rehabilitation process to ensure that the required environmental controls are in place and working effectively.

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11. The Constitution of the Republic of South Africa Act No. 108 of 1996.
12. The National Environmental Management Act (NEMA): EIA 2010 Regulations and the Listing Notices
13. http://www.lakemac.nsw.gov.au
14. http://www.teara.govt.nz/en/coastal-shoreline

Appendix A: Code of Conduct - Use of Off-Road Vehicles (ORV's) in the Coastal Zone

(Provided by Ezemvelo KZN Wildlife)

1. Access to the beach with ORV's must be for official reasons only.
2. Vehicles and vehicle drivers must be licensed and vehicles must be roadworthy.
3. Vehicular access onto the beach is not encouraged within 100m of the following environmentally sensitive areas, unless in cases of an emergency where there is a danger to human life or to mitigate potential environmental threats or disasters:
    a. Mangrove forests, wetlands, salt marshes, estuaries, river mouths, or any other areas of fragile, rare, relict or vanishing vegetation.
    b. Unsuitable physical attributes of beaches or natural barriers such as rocky headlands, ledges, wave-cut platforms;
    c. Areas of fragile natural features or scientific interest, such as turtle nests during nesting season (October – February), and bird roosting and nesting sites;
4. Vehicle Specifications
5. Only 4x4 vehicles for routine beach work e.g. litter collection with a weight not exceeding 3 tonnes (except earth-moving equipment);
6. A minimum tyre width of 205mm and maximum pressure of 1.5 BAR is required.
7. Use of quad bikes supported only for use by official lifeguards responding to emergencies;
8. Official ORV's must be clearly marked with the departmental logos. Heavy earthmoving machinery and vehicles of external contractors that have been appointed by the municipality should have magnetic decals that are returned to the municipality once work has been completed.
9. External contractors appointed by the municipality to undertake any task in the coastal zone must be in possession of a letter from the said municipality delegating authority for vehicle use in the coastal zone. This letter must include vehicle registration number(s), the minimum period of validity and the area and scope of operation. This must be produced on request by the relevant fishery control officer. Failure to do so will result in prosecution in terms of NEMA.
10. Access to the beach must be via existing designated access points and boat launch sites only, three hours before the low tide. After accessing the beach at the approved vehicle access point, the vehicle must operate *below* the high water mark when traversing the beach.
11. The operational zone of the vehicle undertaking any dune rehabilitation work must be demarcated prior to work commencing. All measures must be taken to prevent vehicles "straying" into intact adjacent vegetation.
12. Vehicle use must be restricted to the period three hours either side of low tide only, except in the case of a *bona fide* emergency.
13. No driving above the high water mark, except during an emergency, at designated beach onramps, launch sites or at the area to be maintained.
14. No vehicles allowed on dunes or dune vegetation, and no parking allowed on these features.
15. A maximum speed limit of 30km/h applies on the beach and care must be exercised so as not to endanger the safety and well-being of other persons in the coastal zone.

16. No over tiding or night driving is supported, unless in cases of emergencies or enforcement.
17. The municipality must make sure that its operators take reasonable care in ensuring that there is no pollution as a result of their ORV activities i.e. repairs, refuelling of vehicles etc. are not supported. These must be checked prior to accessing the beach.
18. Beach driving should be restricted to a minimum i.e. single round-trip per day, and exceeded only if there is an emergency.

Appendix B: Dune Assessment

ASSESSOR DETAILS	
Name of individual:	
Department:	
Contact details (email & tel. no.):	
SITE DETAILS	
Site name:	
Date of assessment:	
Site location:	
Aerial photo attached:	Yes/No
Condition of dune:	
Photo of site attached:	Yes/No
Physical characteristics of dune to be rehabilitated -	
Length:	
Width:	
Height:	
Reforming of dune -	Yes/No
Movement of sand:	Yes/No
Approximate volume of sand required to reform dune:	
Possible source of sand:	
Re-vegetation of dune	Yes/No
Presence of existing dune systems:	Yes/No
Fencing required:	Yes/No
Beach access -	Yes/No
Vehicular access:	Yes/No
Pedestrian access:	Yes/No
Source of water for irrigation:	Yes/No
Site ownership:	

Comments (Need for rehabilitation):	

Appendix C: Municipal Staff

	Name	Designation	Department
1.	Godfrey Vella	Manager: Coastal Engineering	CSCM
2.	Greg Williams	Manager: Stormwater Engineering	CSCM
3.	Nishal Misthry	Professional Engineer	CSCM
4.	Joe Brahmin	Professional Engineer	CSCM
5.	Clinton Chrystal	Engineer	CSCM
6.	Vanashrie Gounder	Environmentalist	CSCM
7.	Greg Mullins	Environmentalist	EPCPD
8.	Warren Botes	Environmentalist	EPCPD
9.	Cameron McLean	Specialist Ecologist	EPCPD
10.	Natasha Govender	Specialist Ecologist	EPCPD

Appendix D: List of Indigenous Coastal and Dune Plant Species for Durban

The list of plant species provided below is merely a guideline of potential plant species that could be used for dune rehabilitation along the Durban coastline. This is not a complete list and the list may be amended as further information is gained on plant species that are suitable for dune rehabilitation along Durban's coastline.

Scientific Name	Common Name	Form
Abrus precatorius	Lucky Bean Creeper	Climber
Abutilon sonneratianum	Forest Abutilon	Shrub hedge
Acacia ataxacantha	Flame Thorn	Tree
Acacia gerrardii	Red Thorn	Tree
Acacia karroo	Sweet Thorn	Tree
Acacia kraussiana	Dune Creeping Thorn	Scrambler
Acacia natalitia	Coastal Sweet Thorn	Tree
Acacia nilotica	Scented Thorn	Tree
Acacia robusta	Splendid Thorn	Tree
Acacia schweinfurthii	River Climbing Thorn	Climber
Acacia sieberana	Paperbark Thorn	Tree
Acacia tortilis	Umbrella Thorn	Tree
Acokanthera oblongifolia	Dune Poison Bush	Shrub
Acokanthera oppositifolia	Common Poison-bush	Shrub hedge
Acridocarpus natalitius	Moth-Fruit	Climber
Adenia gummifera	Green Mamba Vine	Climber
Adenopodia spicata	Spiny Splinter Bean	Climber
Agapanthus campanulatus	Bell Agapanthus	Groundcover
Agapanthus nana	Dwarf Agapanthus	Groundcover
Agapanthus praecox	Common Agapanthus	Groundcover
Albizia adianthifolia	Flat-crown	Tree
Allophylus natalensis	Dune False Currant	Tree
Aloe arborescens	Krantz Aloe	Shrub hedge
Aloe barberiae	Tree Aloe	Tree
Aloe chabaudii	Chabaud's Aloe	Groundcover
Aloe ferox	Bitter Aloe	Form plant
Aloe kraussii	Broad-leaved Yellow Grass Aloe	Shrub
Aloe maculata	Soap Aloe	Groundcover
Aloe pluridens	French Aloe	Form plant
Aloe pruinosa	Mkondeni Aloe	Shrub
Aloe thraskii	Dune Aloe	Form plant
Antidesma venosum	Tassel Berry	Tree
Aphloia theiformis	Mountain Peach	Tree
Aspilia natalensis	Wild Creeping Sunflower	Creeper

Apodytes dimidiata	White Pear	Tree
Asparagus densiflorus	Dune Asparagus	Groundcover
Asparagus plumosus	Fine-leaved Asparagus	Creeper
Asystasia gangetica	Creeping Foxglove	Groundcover
Baphia racemosa	Natal Camwood	Tree
Barleria gueinzii	Early Blue Barleria	Groundcover
Barleria obtusa	Dune Blue Barleria	Groundcover
Barleria repens	Creeping Red Barleria	Groundcover
Barringtonia racemosa	Powder Puff Tree	Tree
Bauhinia galpini	Pride of de Kaap	Shrub
Bauhinia tomentosa	Bush Neat's Foot	Shrub
Berkheya speciosa	Thistle Flower	Groundcover
Bersama lucens	Glossy Ash	Tree
Brachylaena discolor	Coastal Silver Oak	Tree
Bridelia micrantha	Coastal Gold Leaf	Tree
Buddleja dysophylla	White Climbing Sage	Climber
Buddleja saligna	False Olive	Tree
Bulbine frutescens	Bulbine	Groundcover
Bulbine natalensis	Broad-leaved Bulbine	Groundcover
Burchellia bubalina	Wild Pomegranate	Shrub
Calpurnia aurea	Natal Laburnum	Shrub
Canavalia rosea	Dune Bean	Creeper
Canthium inerme	Common Turkey-berry	Tree
Capparis tomentosa	Woolly Caper Bush	Creeper
Carissa macrocarpa	Matungulu Dune Num-num	Shrub
Carpobrotus dimidiatus	Ice Plant	Groundcover
Celosia trigyna	Forest Celosia	Groundcover
Celtis africana	White Stinkwood	Tree
Ceratotheca triloba	Wild Foxglove	Groundcover
Chaetacme aristata	Thorny Elm	Tree
Cheilanthes viridis	Lip Fern	Fern
Chionanthus peglerae	Giant Pock Ironwood	Tree
Chloris gayana	Rhodes Grass	Groundcover
Chlorophytum comosum	Hen & Chicken	Groundcover
Chlorophytum saundersiae	Weeping Athericum	Groundcover
Chrysanthemoides monilifera	Bush Tick-berry	Shrub
Cissus fragilis	Fragile Grape	Creeper
Clausena anisata	Horsewood	Shrub
Clerodendrum glabrum	Cat's Whiskers	Tree
Coccinia palmate	Wild Cucumber	Creeper
Coddia rudis	Small Bone-apple	Shrub
Cola natalensis	Coshwood	Tree
Combretum kraussii	Forest Bushwillow	Tree
Commiphora harveyii	Red-stem Corkwood	Tree

Commiphora woodii	Forest Corkwood	Tree
Cordia caffra	Septee	Tree
Crassula alba	Common Crassula	Shrub
Crassula multicava	Crassula	Groundcover
Crinum macowanii	River Crinum	Groundcover
Crinum moorei	Forest Lily	Groundcover
Crocosmia aurea	Falling Stars	Groundcover
Crotalaria capensis	Cape Rattle Pod	Shrub
Croton sylvaticus	Forest Fever-berry	Tree
Cryptocarya woodii	Cape Quince	Tree
Cryptocrya latifolia	Broad-leaved Laurel	Tree
Cussonia nicholsonii	Natal Coast Cabbage Tree	Form plant
Cussonia zuluensis	Zulu Cabbage Tree	Form plant
Cyathea dregei	Common Tree Fern	Fern
Cynodon dactylon	Bermuda Grass	Lawn
Cyperus rupestris	Russet Rock Sedge	Grass
Cyperus solidus (Mariscus solidus)	Saw Sedge	Grass
Cyperus textilis	Tall Star Sedge	Grass
Cyphostemma flaviflorum	Dune Grape	Creeper
Cyphostemma hypoleucum	Doublestemmed Grape	Creeper
Dactyloctenium australe	Berea Grass	Lawn
Dalbergia armata	Thorny Rope	Creeper
Dalbergia obovata	Climbing Fat-bean	Creeper
Deinbollia oblongifolia	Dune Soap Berry	Shrub
Dichrostachys cinerea	Sickle Bush	Shrub
Dicliptera heterostegia	Forest Acanth	Groundcover
Diclis reptans	Dwarf Snapdragon	Groundcover
Dietes bicolor	Fortnight Lily	Groundcover
Dietes grandiflora	Large-flowered Dietes	Groundcover
Dietes iridioides	Forest Dietes	Groundcover
Dioscorea dregeana	Wild Yeam	Climber
Diospyros simii	Climbing Star-apple	Shrub
Dissotis canescens	Pink Wild Tibouchina	Shrub
Distephanus angulifolius	Trailing Vernonia	Shrub
Dodonaea angustifolia	Cape Sand Olive	Shrub
Dombeya burgessiae	Pink Wild Pear	Shrub
Dombeya rotundifolia	Common White Pear	Tree
Dombeya tiliacea	Forest Wild Pear	Shrub
Dovyalis caffra	Kei Apple	Shrub
Dovyalis longispina	Natal Apricot	Tree
Dovyalis rhamnoides	Common Sourberry	Shrub
Dracaena aletriformis	Dragon Dracaena	Form plant
Drypetes natalensis	Natal Ironplum	Tree
Duvernoia adhatodoides	Pistol Bush	Shrub

Dyschoriste depressa	Butterfly Heaven	Groundcover
Ehretia rigida	Puzzle Bush	Shrub
Ekebergia capensis	Cape Ash	Tree
Ekebergia pterophylla	Rock Ash	Tree
Erythrina caffra	Coast Coral Tree	Tree
Eriospermum cooperi	White Fluffy-seed	Bulb
Erythrina latissima	Broad-leaved Coral Tree	Tree
Erythrina lysistemon	Common Coral Tree	Tree
Euclea natalensis	Natal Guarri	Tree
Euphorbia ingens	Tree Euphorbia	Tree
Euphorbia triangularis	River Euphorbia	Form plant
Felicia erigeroides	Wild Michaelmas Daisy	Groundcover
Ficus burtt-davyii	Veld Fig	Shrub
Ficus natalensis	Natal Fig	Tree
Ficus polita	Wild Rubber Fig	Tree
Ficus sur	Broom Cluster Fig	Tree
Ficus thonningii	Common Wild Fig	Tree
Gasteria croucheri (local forms)	Large Gasteria	Succulent
Gerbera ambigua	Pink and White Gerbera	Groundcover
Gazania rigens	Gazania	Groundcover
Gomphocarpus physocarpus	Milkweed	Shrub
Grewia caffra	Climbing Raisin	Creeper
Grewia lasiocarpa	Forest Raisin	Creeper
Grewia occidentalis	Crossberry	Creeper
Gymnosporia arenicola	White Forest Spike Thorn	Shrub
Gymnosporia glaucophylla	Common Spike Thorn	Tree
Halleria lucida	Tree Fuchsia	Tree
Harpephyllum caffrum	Natal Plum	Tree
Helichrysum cymosum	Gold Carpet	Groundcover
Hewittia malabarica	Hewitt's Morning Glory	Climber
Hibiscus calyphyllus	Edge Hibiscus	Shrub
Hibiscus cannabinus	Jute Hibiscus	Shrub
Hibiscus peduncularis	Forest Hibiscus	Shrub
Hibiscus tiliaceus	Lagoon Hibiscus	Tree
Hoslundia opposita	OrangeBird Lantern	Shrub
Hyphaene coriacea	Ivory Nut Palm	Form plant
Hyparrhenia hirta	Thatching Grass	Grass
Hypoestes aristata	Pink Hypoestes	Groundcover
Hypoestes forskaolii	White Hypoestes	Groundcover
Hypoxis angustifolia	Small Hypoxis	
Ilex mitis	African Holly	Tree

Impatiens hochstetteri	Common Wild Impatiens	Shrub
Indigofera jucunda	River Indigo	Shrub
Ipomoea pes-capre	Dune Morning Glory	Groundcover
Isoglossa woodii	Buckwheat	Shrub
Jasminum multipartitum	Wild Jasmine	Creeper
Justicia betonica	Wasp Fodder	Groundcover
Justicia capensis	Richman's Plant	Groundcover
Justicia flava	Yellow Justicia	Groundcover
Justicia protracta	Outcrop Justicia	Groundcover
Keetia gueinzii	Climbing Turkey-berry	Creeper
Kraussia floribunda	Rhino-coffee	Shrub
Lagynias lasiantha	Natal Medlar	Shrub
Lantana rugosa	Bird's Brandy	Shrub
Ledebouria ovatifolia	Oval-leaf Ledebouria	Bulb
Leonotis intermedia	Forest Wild Dagga	Shrub
Leonotis leonurus	Wild Dagga	Shrub
Lippia javanica	Lemon Bush	Shrub
Macaranga capensis	Swamp Poplar	Wetland tree
Mackaya bella	River Bells	Shrub
Maesa lanceolata	False Assegai	Shrub
Manilkara discolor	Milkberry	Tree
Maytenus peduncularis	Cape Blackwood	Tree
Maytenus procumbens	Dune koko Tree	Shrub
Melinis repens	Natal Red Top	Groundcover
Millettia grandis	Umzimbeet	Tree
Mimusops caffra	Red Coast Milkwood	Tree
Mimusops obovata	Red Milkwood	Tree
Monanthotaxis caffra	Dwaba berry	Shrub
Moraea spathulata	Large Yellow Moraea	Bulb
Nuxia floribunda	Forest Elder	Tree
Ochna natalitia	Natal Plane	Tree
Olea woodiana	Forest Olive	Tree
Oncinotis tenuiloba	Magic Rope	Climber
Oplismenus hirtellus	Creeping Forest Grass	Groundcover
Ornithogalum juncifolium	Grass-leaved Chincherinchee	Bulb
Orthosiphon labiatus	Pink Spurs	Shrub
Oxyanthus pyriformis	Wild Loquat	Shrub
Panicum maximum	Guinea Grass	Groundcover
Passerina rigida	Dune Gonna	Shrub

Pavetta lanceolata	Weeping Bride's Bush	Shrub
Pavetta revoluta	Dune Bride's Bush	Shrub
Peddiea africana	Poison Olive	Shrub
Peristrophe cernua	Purple Acanth	Groundcover
Persicaria serrulata	Snake root	Groundcover
Phaulopsis imbricata	Sticky Acanth	Groundcover
Phoenix reclinata	Wild Date Palm	Tree
Pittosporum viridiflorum	Cheesewood	Tree
Plectranthus ciliatus	Swamp Spur flower	Groundcover
Plectranthus ecklonii	Shrub Spur flower	Shrub
Plectranthus hadiensis	Wild Purple Salvia	Groundcover
Plectranthus hereroensis	Herero Spur Flower	Shrub
Plectranthus saccatus var.	Long flowered Blue Spur flower	Groundcover
Plectranthus saccatus var. sa	Short Flowered Blue Spur flower	Groundcover
Plectranthus verticillatus	Dune Spurflower	Groundcover
Plectranthus zuluensis	Zulu Spur-flower	Groundcover
Plumbago auriculata	Plumbago	Scrambler
Podocarpus falcatus	Outeniqua Yellowwood	Tree
Podocarpus latifolius	Real Yellowwood	Tree
Polygala myrtifolia	Blue Bonnets	Shrub
Polygala virgata	Purple Broom	Shrub
Protea roupelliae	Silver Sugarbush	Tree
Protorhus longifolia	Red Beech	Tree
Pseudarthria hookerii	Velvet Bean	Shrub
Pseudechinolaena polystachya	Dwarf Forest Grass	Groundcover
Psydrax obovata	Quar	Grass
Psychotria capensis	Black Bird Seed	Shrub
Pupalia lappacea	Purple Burweed	Groundcover
Putterlickia verrucosa	False Forest Spike-thorn	Shrub
Pycnostachys reticulata	Blue Marsh Mint	Shrub
Rhoicissus digitata	Baboon Grape	Creeper
Rhoicissus rhomboidea	Glossy Forest Grape	Creeper
Rhoicissus tomentosa	Common Forest Grape	Creeper
Rhus chirindensis	Red Currant	Tree
Rhus dentata	Nana-berry	Shrub
Rhus natalensis	Natal Karree	Shrub
Rhus nebulosa	Dune Currant	Shrub
Rhus pentheri	Common Crow-berry	Shrub
Rhus rehmanniana	Blunt-leaved Currant	Tree
Rothmannia globosa	September Bells	Shrub
Scadoxus katharinae	Katherine Wheel	Bulb
Schefflera umbellifera	False Cabbage Tree	Tree
Schotia brachypetala	Weeping Wattle	Tree
Sclerocarya birrea subsp. ca	Marula	Tree

Scuti amyrtina	Cat-thorn	Scrambler
Selaginella kraussiana	Moss Fern	Fern
Senecio brachypodus	Succulent Canary Creeper	Creeper
Senecio deltoideus	Dune Canary Creeper	Creeper
Seneci otamoides	Canary Creeper	Creeper
Setaria lindenbergiana	Creeping Setaria	Groundcover
Setaria megaphylla	Giant Setaria	Groundcover
Stangeria eriopus	Stangeria	Cycad
Stenotaphrum secundatum	St Augustine Grass	Grass
Strelitzia nicolai	Wild Banana	Form plant
Streptocarpus gardenii	Major Garden's Streptocarpus	Plant
Strychnos decussata	Cape Teak	Tree
Strychnos gerrardii	Gulagula	Tree
Syzygium cordatum	Water-berry	Tree
Syzygium guineense	Water Pear	Tree
Tabernaemontana ventricosa	Forest Toad Tree	Shrub
Tecomaria capensis	Wild Honeysuckle	Scrambler
Tephrosia grandiflora	Giant Purple Pea	Shrub
Tephrosia shiluwanensis	Purple Pea	Shrub
Tetradenia riparia	River Mint	Shrub
Thunbergia alata	Black-eyed Susan	Creeper
Tinospora caffra	Climbing Fish Poison	Creeper
Trema orientalis	Pigeonwood	Tree
Tricalysia capensis	Cape-coffee	Shrub
Tricalysia lanceolata	Jackal-coffee	Shrub
Tricalysia sonderana	Coast-coffee	Shrub
Trichilia emetica	Natal Mahogany	Tree
Trimeria grandifolia	Wild Mulberry	Tree
Triumfetta pilosa	Burs	Groundcover
Tulbaghia simmleri	Sweet Garlic	Groundcover
Turraea floribunda	Forest Honeysuckle	Tree
Turraea obtusifolia	White Honeysuckle	Shrub
Typha capensis	Bulrush	Grass
Urera trinervis	Climbing Nettle	Climber
Uvaria caffra	Small Cluster-pear	Shrub
Vangueria infausta	Wild Medlar	Shrub
Vangueria randii	Natal Bush Medlar	Tree
Vepris lanceolata	White Ironwood	Tree
Vernonia capensis	Grassland Vernonia	Groundcover
Vernonia natalensis	Silver Vernonia	Groundcover
Vitellariopsis marginata	Natal Bush Milkwood	Tree
Voacanga thouarsii	Wild Frangipani	Tree

Watsonia densiflora	Natal Watsonia	Bulb
Wrightia natalensis	Saddle Pod	Tree
Xylotheca kraussiana	African Dog-rose	Tree
Zanthoxylum capense	Knob-wood	Tree
Ziziphus mucronata	Buffalo Thorn	Tree