Guidelines for Restoring Lowland Sand Fynbos Ecosystems

Contributors:

PM Holmes,
KJ Esler,
S Geerts,
DK Ngwenya,
AG Rebelo,
C Dorse,
J van der Merwe,
K Retief,
SW Hall,
P Grey,
MM Nsikani.

February 2022

ISBN:

978-0-620-98765-3

Contributor affiliation and contact details:

Holmes[1]; Holmes.patricia.m@gmail.com,

Esler[1]; kje@sun.ac.za,

Geerts[2]; geertss@cput.ac.za,

Ngwenya[1]; dudun@sun.ac.za,

Rebelo[3]; t.rebelo@sanbi.org.za,

Dorse[4]; clifford.dorse@capetown.gov.za,

van der Merwe[4]; jacques.vandermerwe@capetown.gov.za,

Retief[4]; jacobus.retief@capetown.gov.za,

Hall[5]; ecostu@gmail.com,

Grey[6]; waller.penelope@gmail.com,

Nsikani7; M.Nsikani@sanbi.org.za.

[1]= Stellenbosch University, Department of Conservation Ecology and Entomology
[2]=Cape Peninsula University of Technology, Department of Conservation and Marine Sciences
[3]=South African National Biodiversity Institute; University of Cape Town, Department of Biological Sciences
[4]=City of Cape Town, Biodiversity Management Branch, Environmental Management Department
[5]=Capensis Environmental Consultants
[6]=Consulting restoration practitioner
[7]=South African National Biodiversity Institute

Contents

Cover figure: Cape Flats Sand Fynbos at Basariesfontein with *Protea scolymocephala* (Vulnerable) in the foreground and wattle invasion in the distance (CD)

Renosterveld Spring flowers at Tienie Versveld reserve, Darling (KE)

A. Introduction and Purpose of the Guidelines

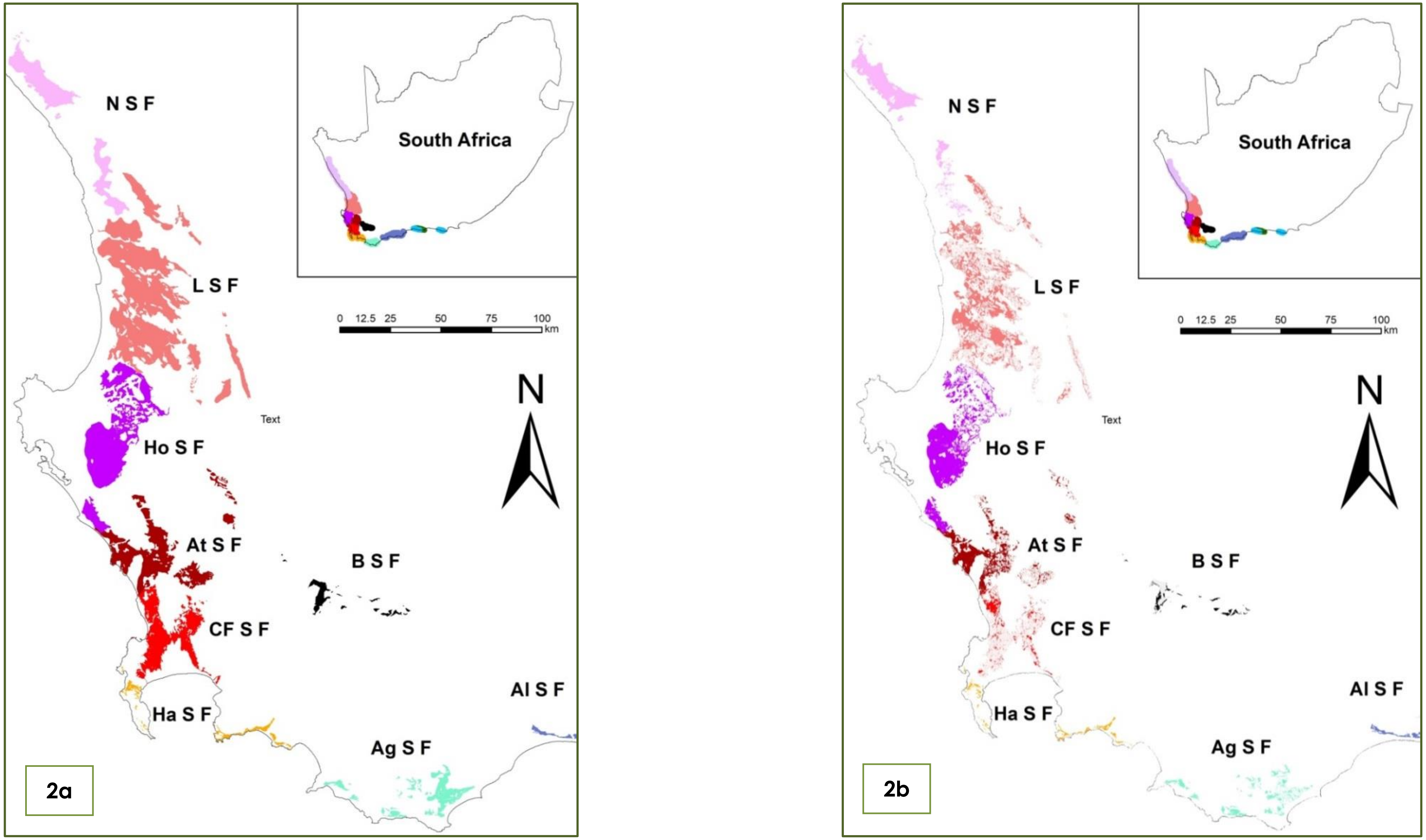
Lowland Sand Fynbos ecosystems are among the most threatened terrestrial systems in South Africa (Figures 1, 2a,b). Of the ten Sand Fynbos veld types, seven are Critically Endangered or Endangered according to the IUCN Red List of Ecosystems. They are all either poorly protected, or not protected at all in the conservation network (Skowno et al. 2019; http://hdl.handle.net/20.500.12143/637).

Sand Fynbos ecosystems harbour unique biodiversity, but owing to their lowland locations experience extensive losses to other land uses (Figures 3a-c). Some natural pockets remain scattered within agricultural or urban developments. They are, however degraded due to invasive alien plants, inappropriate fire regimes or pollution and are an urgent priority to restore (Figures 4a,b).

National biodiversity targets aim for a minimum proportion of an ecosystem type to be retained in a natural or near-natural state. The minimum target for Sand Fynbos ecosystems is mostly 30% of the original extent – a target no longer attainable for several of these ecosystems, such as Cape Flats Sand Fynbos (Rebelo et al. 2006, 2011). For many of these precious systems, this means a necessary focus on their restoration (Figure 5).

The purpose of these guidelines is to assist managers and landowners of degraded Sand Fynbos vegetation to restore biodiversity and contribute to the conservation of these threatened ecosystems. The guidelines outline appropriate methods to restore degraded Sand Fynbos ecosystems, based on the latest research and field trial outcomes.

Figure 1: Atlantis Sand Fynbos at Riverlands Nature Reserve with *Amphithalea ericifolia* in flower (PH).



<u>Figure 2a,b</u>: Maps showing the distribution of Sand Fynbos vegetation types in the western part of the Western Cape (small areas extend further East to Port Elizabeth: Albertinia Sand Fynbos (**Al S F**) and Knysna Sand Fynbos (remnants lie east of the maps); and North into Namaqualand: Namaqua Sand Fynbos (**N S F**) (AGR); **a)** original extent of different Sand Fynbos vegetation types; **b)** remaining extent of Sand Fynbos remnants (natural and degraded): Leipoldtville Sand Fynbos (**L S F**), Hopefield Sand Fynbos (**Ho S F**), Atlantis Sand Fynbos (**At S F**), Cape Flats Sand Fynbos (**CF S F**), Hangklip Sand Fynbos (**Ha S F**), Agulhas Sand Fynbos (**Ag S F**) and Breede Sand Fynbos (**B S F**).

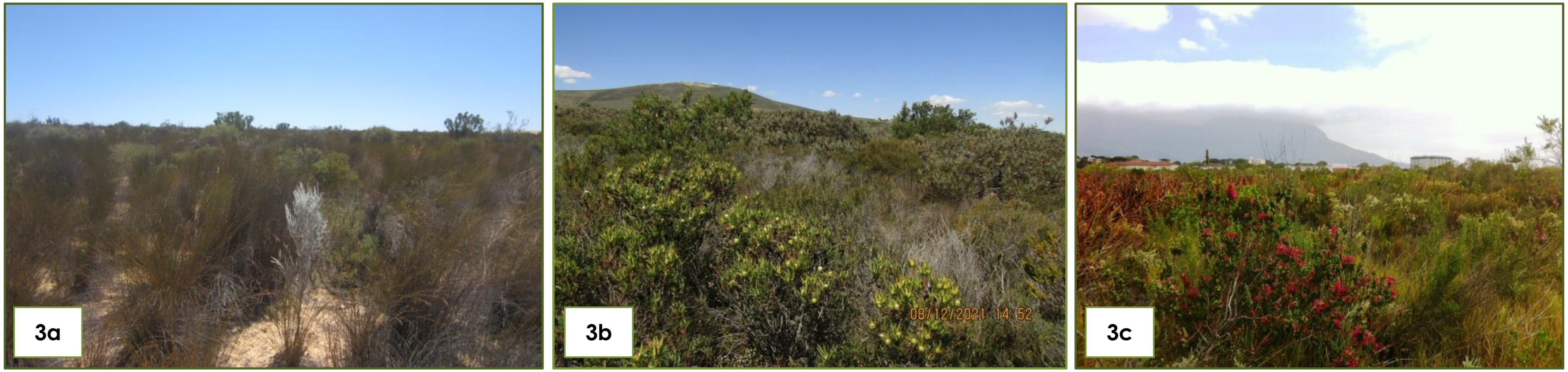


Figure 3a-c: Sand Fynbos vegetation types form a gradient of aridity up the West Coast with the driest types to the north; **a)** Leipoldtville Sand Fynbos (PG); **b)** Cape Flats Sand Fynbos near Morningstar (AS); **c)** wetter Cape Flats Sand Fynbos at Kenilworth Racecourse (PH).

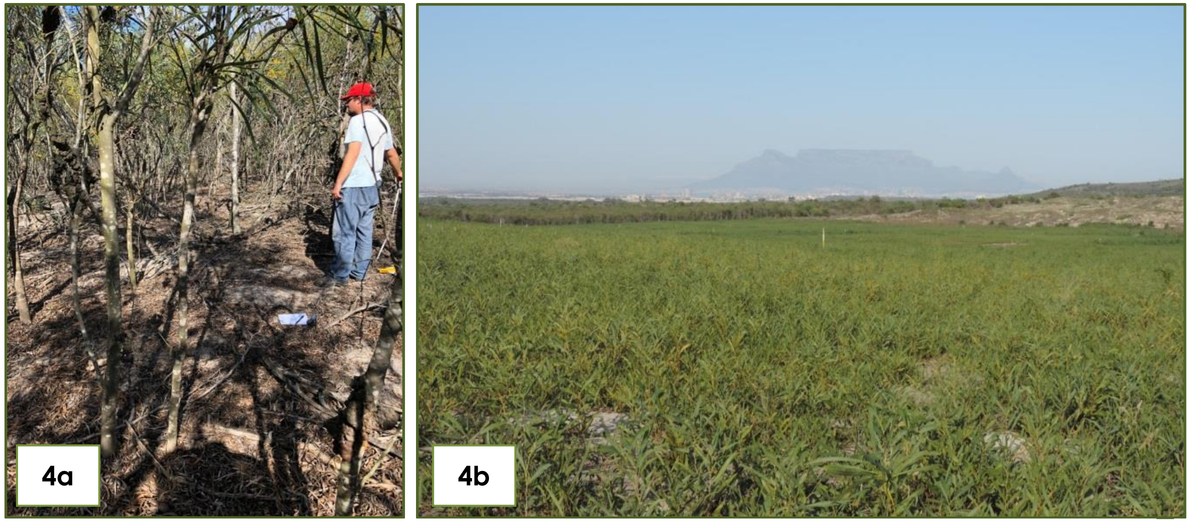


Figure 4a,b: Highly degraded Sand Fynbos at Blaauwberg NR densely invaded by wattle (*Acacia saligna*); **a)** mature wattle (KE); **b)** dense wattle recruitment post-fire (PH).

Figure 5: Blaauwberg NR Sand Fynbos – an old ploughed field dominated by grasses; considered extremely degraded (PH).

Ecological Restoration

a) Why should we restore degraded ecosystems?

The UN Decade on Ecosystem Restoration (2021-2030; https://www.decadeonrestoration.org/) is a global call to scale up ecosystem restoration in response to the major threats of climate change and escalating biodiversity loss. Furthermore, intact and restored ecosystems contribute many diverse ecosystem services to humanity and support the economy. This has been framed as 'Nature's Contributions to People' by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

For seven of these Sand Fynbos ecosystems it is no longer possible for us to meet the national conservation targets. This is because the total area of remaining natural habitat is now less than the minimum target area. Therefore, it is critical to attempt to restore any degraded habitats so that in time they can contribute to the conservation of the respective ecosystem. It is especially critical to restore these systems within our protected area network.

It is hoped that land managers and conservators of Sand Fynbos remnants will use the guidelines to implement ecological restoration projects and so contribute to the following three initiatives:

1. South Africa's ecosystem targets (Skowno et al. 2019; http://hdl.handle.net/20.500.12143/6370);
2. South Africa's plant conservation strategy (http://biodiversityadvisor.sanbi.org/planning-and-assessment/plant-conservation-strategy/); and
3. The global ecosystem restoration initiative (https://www.decadeonrestoration.org/).

b) What do we restore a degraded ecosystem to?

It is important at the outset to agree on an appropriate restoration goal for the degraded ecosystem. The Society for Ecological Restoration (SER; www.ser.org) provides a generalised framework to explain a range of restorative activities, from 'reduced impacts' in the most highly modified sites through 'remediation' and 'rehabilitation' to 'full ecological restoration' where possible (www.ser.org/page/SERStandards; Gann et al. 2019) (Figure 6). The appropriate restorative goal will depend on the context of the site (e.g. urban, agricultural, or natural) and the degree of degradation to that ecosystem.

Babiana villosula (AGR)

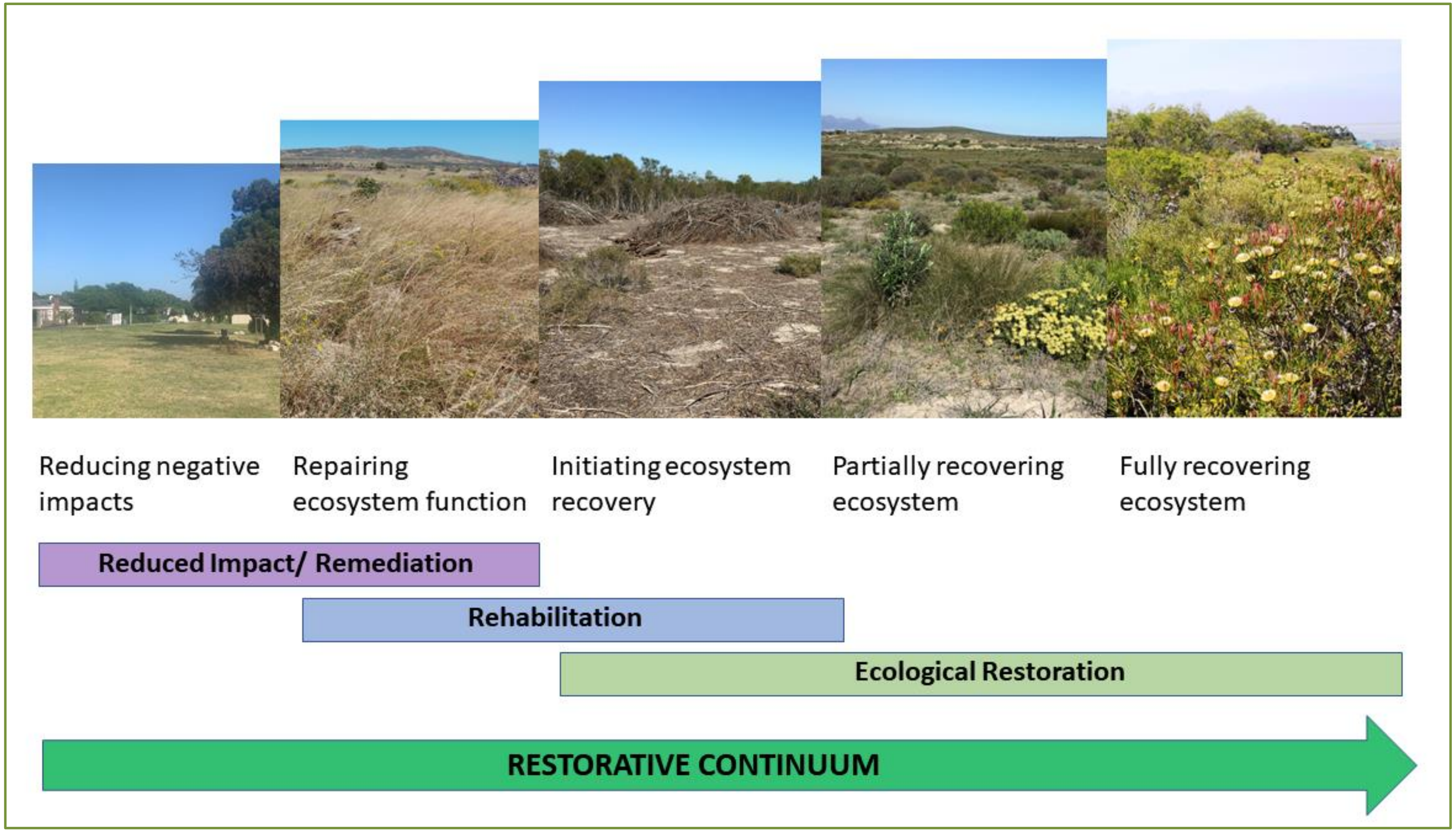


Figure 6: The Restorative Continuum illustrated with examples from Cape Flats Sand Fynbos (JvdM, PH, CD; after Gann et al. 2019).

Remediation generally applies to highly modified systems (e.g. mined or urban sites) where pollution may need to be reduced or soil decontaminated (or even re-introduced) before introducing indigenous vegetation again.

Rehabilitation refers to repairing ecosystem functions such as soil formation, nutrient cycling and erosion control. This activity is appropriate in highly degraded areas, such as: 1) old farm lands, where indigenous species cannot thrive; or 2) sites where key ecological drivers, such as fire or flood regime, cannot be re-instated due to fundamental changes in the landscape (e.g. an urban road reserve). With time, some rehabilitated sites may be ready for ecological restoration.

These guidelines focus on ecological restoration, with a goal to restore a natural ecosystem, either partially or fully, to its reference condition (see section A.1.c below for definitions). This entails restoring ecosystem functions, as well as vegetation structure and composition. Thus, it underpins the restoration of biodiversity (Figures 7a-d). In some cases, it may be necessary to consider climate change in planning the restoration if it is considered that the restoration site will no longer be suitable for certain species (e.g. will become too warm or dry).

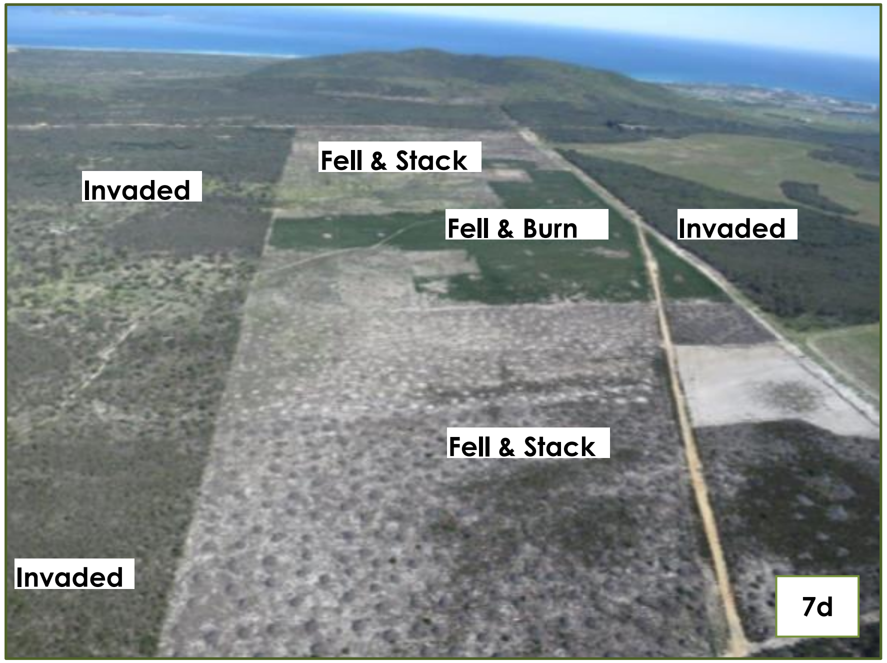


Figure 7a-d: Sand Fynbos in various stages of degradation and restoration; **a)** near natural vegetation restoring passively following wattle control (JvdM); **b)** degraded/ medium-restoration potential vegetation restoring passively following wattle control by the Fell & Burn treatment (PH); **c)** highly degraded/ low restoration-potential area after clearing by a Fell & Stack treatment and a Fynbos mix sown after 18 months (KE); **d)** aerial image of Blaauwberg NR showing the 100ha area under various restoration treatments (PH).

c) *Ecological Restoration Definitions*

Some terms used by ecologists may be confusing and we define a few of them here.

- ***Indigenous*** (=native) refers to species that historically belong to an area or ecosystem, but are not necessarily confined to that area and may occur more widely.
- ***Endemic*** refers to species that are confined to a defined area or ecosystem and do not occur elsewhere. If an ecosystem is under threat, it often follows that its endemic species are threatened with extinction and may be Red Listed (e.g. Red List of South African Plants).
- A ***Red List*** is a comprehensive inventory of threatened species (or ecosystems), determined by a set of quantitative criteria to help assess extinction risk.
- ***Passive restoration*** refers to removing the cause of degradation, such as invasive alien plants, and then allowing the ecosystem to self-restore (i.e., spontaneously regenerate). Passive restoration is often possible in ecosystems that have only recently become degraded and where indigenous seeds remain in the soil or nearby and can recolonise the degraded site. It may also be necessary to reinstate a natural disturbance regime, such as Summer fires, for successful passive restoration to occur.
- ***Active restoration*** refers to re-introducing indigenous species, by seed or rooted material, in addition to the actions undertaken for passive restoration. Active restoration is generally necessary in highly degraded sites where seed banks have been depleted but soils remain intact, and may only be economically justifiable for the highest priority ecosystems.
- ***Reference ecosystem*** refers to a local example of the ecosystem prior to degradation. This is generally considered the target for full ecological restoration and guides the structure and composition of the plant community to be restored.

Figure 8: *Leucadendron cinereum* (Vulnerable) in Atlantis Sand Fynbos (AGR).

1. Lowland Sand Fynbos Ecosystems

a) General description of Sand Fynbos

Sand Fynbos is mostly coastal, occurring on leached sands of marine and aeolian origin (i.e., sand deposits derived from the action of wind). Eight Sand Fynbos types are in the western portion of the Fynbos Biome, but Albertinia and Knysna Sand Fynbos are located in the Southern Cape (Figures 2a,b).

There is a broad soil pH gradient from alkaline nearest the coast (generally supporting Strandveld vegetation – not considered here) to neutral (pH 6-7, often supporting Fynbos) to acidic (<pH 6, supporting Fynbos) (Figures 9a,b; 10a,b). The dominant structural type of Sand Fynbos depends on the water table. Where the water table is deep, with plant access to water mainly in Winter, restioids (Cape reeds) dominate and shrubs are scarce. On the other hand, a more accessible water table commonly supports asteraceous Fynbos dominated by ericoid-leaved shrub species, such as *Metalasia*, *Passerina* and *Phylica*. At the wettest end of the spectrum where the water table is more accessible, proteoid Fynbos dominates and the vegetation canopy is denser with fewer annuals and geophytes. Ericaceous Fynbos (where *Erica* species are common) is localised and rare. It usually occurs in the higher rainfall south and is associated with seeps and peaty soils (Rebelo et al. 2006).

Figure 9a,b: Sand Fynbos along the coastal forelands forms an ecotone with Strandveld; **a)** the ecotone between Atlantis Sand Fynbos (foreground) and Cape Flats Dune Strandveld (background) (JvdM); **b)** heavily grazed Strandveld along the coast showing a display of Spring annuals in openings among the shrubs (KE).

b) Importance of Sand Fynbos vegetation

Sand Fynbos is the second largest Fynbos type, accounting for 15% of the entire Fynbos Biome area. However, it also is one of the most threatened Fynbos types due to its lowland location that facilitates high levels of loss to other land uses (Rebelo et al. 2006). From a biodiversity conservation perspective, Sand Fynbos supports many endemic and threatened plant species (e.g. for Cape Flats Sand Fynbos, 16 and 120 respectively). It also serves an important corridor function by connecting coastal Strandveld vegetation with inland Renosterveld and other inland Fynbos types (Figures 10a,b). These linkages are important for climate change adaptation, faunal (including pollinator) movement and long-term evolutionary processes. These are all essential processes to ensure conservation of biodiversity in the longer term.

Figure 10a,b: Sand Fynbos often abuts other lowland vegetation types such as; **a)** Strandveld – here a Cape Flats Dune Strandveld foredune community on the West Coast (AGR); and **b)** Renosterveld – Swartland Granite Renosterveld at Tienie Versveld reserve near Darling (KE).

c) How to determine a reference community

As indicated before, various factors including local climate, soil depth, topography (the natural forms and features of the landscape), water table accessibility and soil pH determine the structural vegetation type and local plant community. This list of factors should guide the selection of appropriate reference communities for ecological restoration. Plant community dominants and key structural species that are important for restoration should be noted from these closest representative remnants (Figures 11a,b).

Figure 11a,b: Reference sites for ecological restoration should be as undisturbed as possible and represent the same plant community as the one being restored; **a)** Atlantis Sand Fynbos (JvdM); **b)** Cape Flats Sand Fynbos (AS).

d) Other lowland vegetation types

While many features of Sand Fynbos are shared, Alluvium Fynbos, Granite Fynbos, Limestone Fynbos and Renosterveld are quite different vegetation types. Whereas some of the approaches to ecological restoration will be similar among these lowland vegetation types, there may be different requirements related to nutrient levels, hydrology and vegetation growth rates, to name a few.

B. Ecological Restoration Guidelines

Right from the beginning, a long-term vision for the site must be articulated to facilitate the setting of appropriate goals for management and restoration. For Protected Areas (PAs) the vision is stated in the Reserve Management Plan. Outside PAs, where the vision is 'conservation of biodiversity', full ecological restoration will be the ultimate goal for degraded areas. However, resource constraints may limit the extent and intensity of interventions that are feasible. A lesser goal may be more appropriate in the short-term. If the site has priority ecological attributes (Figure 12) and restoration potential (see section B.2) then it could warrant status as a Conservation Stewardship Agreement site (www.capenature.co.za/protected-areas-and-stewardship). This could potentially assist with funding and an official conservation organisation would be better able to commit resources to assist.

Note that each ecosystem and its constituent species may be different and respond differently to the recommended treatments, as well as from year to year depending on the vagaries of the weather or by the type of degradation incurred. For this reason, each restoration attempt may be considered an experiment and, where possible, should be implemented in replicated areas across the site (to account for local variation). Restoration attempts should then be monitored, so that additional lessons may be learnt. Some of the most important indicators to monitor initially are plant establishment, survival and seed set, and at a later stage post-fire (i.e., after a fire event) recruitment. It is also important to publish the results, including failures and costs, on accessible ecological restoration platforms or appropriate local websites, to help support the restoration 'community of practice'.

To be successful, ecological restoration projects require sufficient lead-in time to: engage local stakeholders; assess and map the degree of degradation across the site; set realistic goals; and prioritise the various areas for intervention. In addition, where active restoration is required, it is advisable to allow at least a 12-month period to ensure sufficient time to collect the full range of seeds, produce rootstock, prepare the site and align interventions with the appropriate seasons for burning, seeding and planting.

It is important to note that well-intended but badly designed restoration efforts could have significant negative impacts on biodiversity (e.g. using incorrect genetic material that cause hybridisation risks; introducing soil pests or weeds). Ecological restoration is a specialist activity that needs to be planned well to align with Fynbos restoration principles and strict protocols (Table 1).

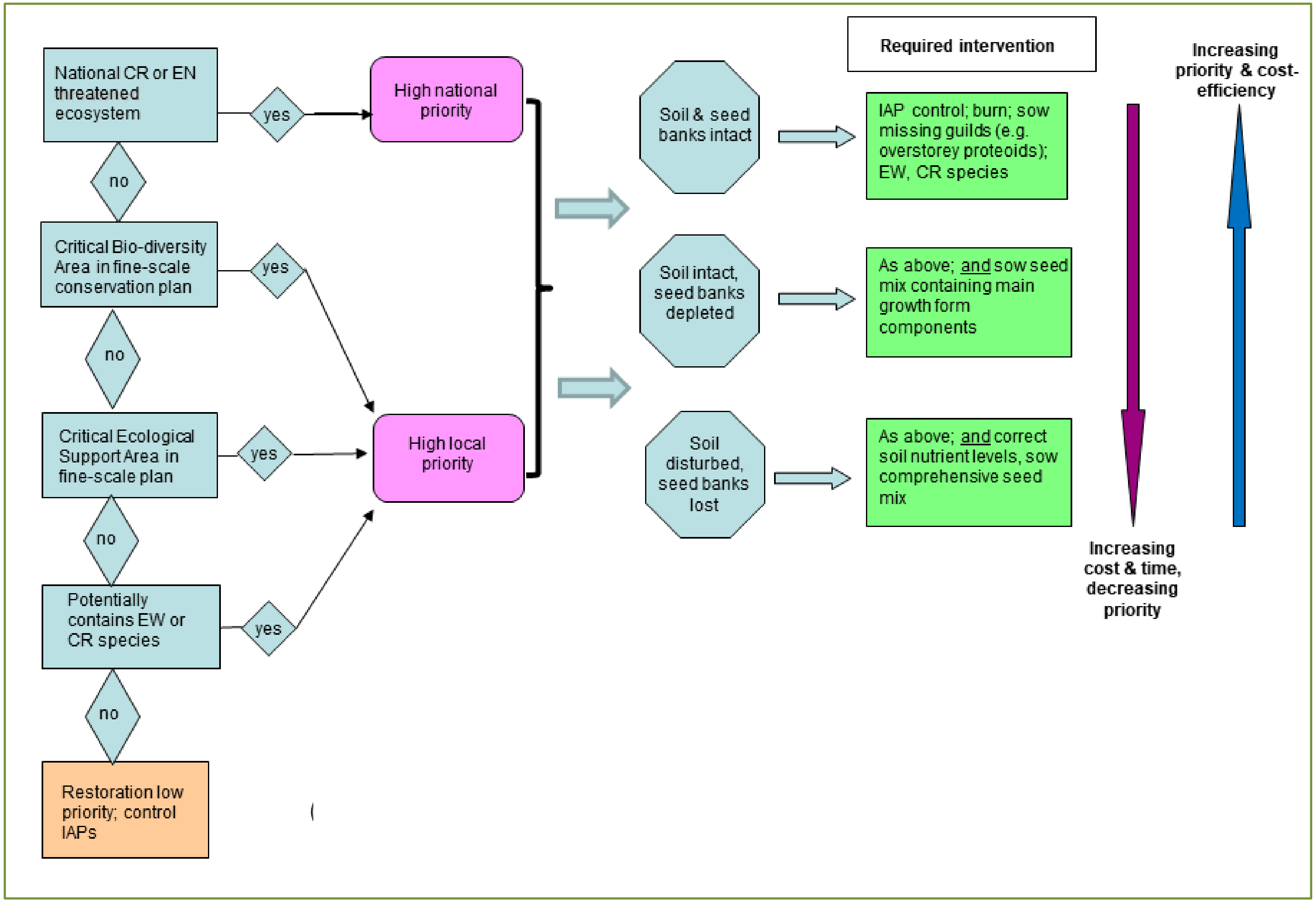


Figure 12: Decision support tool to assist in prioritizing Sand Fynbos sites for ecological restoration based on their conservation importance. **CR** = critically endangered; **EW** = extinct in wild; **IAP** = invasive alien plant.

1. Identify Partnerships/Stakeholders

Collaboration among conservation agencies, NGOs, potential project funders, land managers, policy makers, ecologists and local interest groups is key (Figure 14). It is important to acknowledge from the start that local stakeholders who may be positively or negatively impacted by the proposed restoration project should be contacted and given the opportunity to comment during a public participation process. Engagement with the Fire Protection Association (FPA; www.fpasa.co.za) is advisable where prescribed burning is a required restoration treatment. Collaborators may differ depending on whether the site is a Protected Area (PA), private nature reserve or non-protected private land area. It is helpful to follow a collaboration protocol (Figure 15).

a) For Protected Areas (PAs)

The Protected Area Advisory Committee (PAAC) may serve to identify stakeholders. In addition, the public participation process that occurs every 10 years when updated PA management plans are presented for comment could be used to communicate ecological restoration intentions and to request comments from stakeholders.

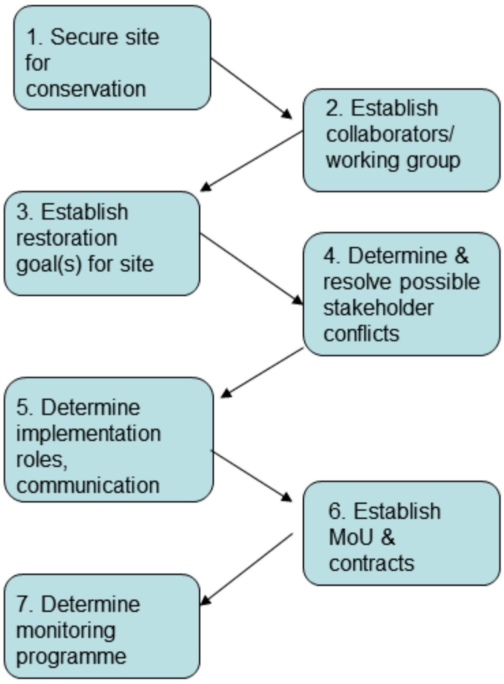
b) On private land

The landowner, consultant or contractor may be implementing the restoration project, but it may be advisable to include neighbours and other stakeholders if they could be affected by any of the restorative actions, such as re-instating the Summer fire regime.

Figure 13: Reptiles are common in Sand Fynbos, including this Angulate Tortoise (KE).

Stage in process	Collaborators	Organizations
Management Plan (including Vision for site)	Manager, ecologist; local interest groups	Conservation organization or landowner; ecologist from SANBI, SANParks, CapeNature, Municipal Environmental Dept. or ecological consultant; PAAC, local ratepayers, volunteer groups, NGOs
Decision to restore	Manager, ecologist	Conservation organization or landowner; ecologist from SANBI, SANParks, CapeNature or Municipal Environmental Dept., PAAC; or ecological consultant
Restoration Plan	Manager, ecologist; other organizations likely to be directly involved	Conservation organization or landowner; ecologist from SANBI, SANParks, CapeNature or Municipality Environmental Dept. or ecological consultant; other organizations implicated: e.g. Working for Water, Landcare, Working for Wetlands, restoration nursery
Implementation, including monitoring	Manager & reserve staff, ecologist; organizations likely to be directly involved; include communicator &/or "champion" & set up working group for larger projects	Conservation organization or landowner & operational staff; other organizations implicated: e.g. Working for Water, Landcare, Working for Wetlands; ecologist from SANBI, SANParks, CapeNature or Municipality Environmental Dept. or ecological consultant; alien, fire & restoration specialist contract teams; restoration nursery/ indigenous horticulturist; volunteer groups; skills trainer, communication expert

Figure 14: Stakeholders and collaborators to engage at various stages in planning and implementing ecological restoration.



Examples

1. Site proclaimed; *in perpetuity* stewardship agreement; or managed with proclamation application in process
2. Identify key stakeholders & collaborators
3. Restore ecosystem structure, composition or threatened species etc, determine correct microsites for species to be re-introduced, determine quantities & propagation methods; determine budgetary requirements & timelines
4. Identify negative impacts (integrated management & stakeholder conflicts, species hybridization effects etc); essential for positive project communication & avoiding conflict among stakeholders & collaborators
5. Implementation responsibilities include: budgets/ funding, permits required for activities, site preparation, seed collection, propagation, fire management, alien control, communication (or champion to promote project), monitoring of goals etc.
6. Arrange MoU (e.g. between various government organizations) & contracts (e.g. for training, propagation, seed collection)
7. Monitoring of restoration goal(s): essential to determine level of success & to implement mitigation actions if needed; determine responsible person(s) & monitoring objectives & methods

Figure 15: Protocol for collaboration in ecological restoration.

2. Assess Habitat Condition

The extent of degradation across a site must first be assessed to determine which restorative actions are required and what their costs may be. Once budgets are known it should then be possible to prioritise areas, set realistic goals and develop a restoration Annual Plan of Operation (APO) with appropriate time lines. The following steps are recommended:

a) Land-use history

Local knowledge is very useful in understanding the degree of degradation at a site. Such information includes history of ploughing, domestic stocking rates / grazing intensity, fire history and invasion by alien plants. Impressions may be obtained from local landowners and residents or by examining historical aerial imagery and other spatial databases (e.g. for fires). The restoration potential of a site is inversely related to its degree of degradation. For Sand Fynbos ecosystems, restoration potential is strongly linked to the persistence of indigenous seeds in the soil. Various factors affect the seed bank. For example, invasive alien trees shade out the fynbos vegetation and prevent seed bank replenishment, thus reducing restoration potential over time. So, the density of the alien trees, as well as how long they have invaded a site gives a good indication of the restoration potential.

In Sand Fynbos ecosystems we have also found that the aerial cover and diversity of fynbos species remaining is a good indicator of restoration potential. Based on these factors and others a table of habitat condition categories and related restoration requirements was developed by the City of Cape Town (Table 2). The presence of a large seed bank of alien herbaceous weeds, including alien annual grasses, is a significant challenge to the restoration of Sand Fynbos ecosystems.

b) Map current habitat condition states

Any site may have sections in different condition categories (Table 2; Figure 16). Tools such as Google Earth may be used to map these areas, with the benefit to delineate different habitat condition polygons and calculate the areas requiring various restorative actions. In PAs it is advisable to align polygons to management units where possible, as this simplifies drawing up APOs.

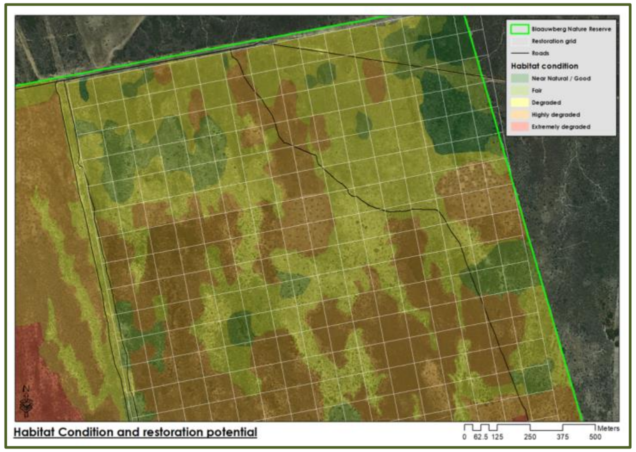


Figure 16: Example of a habitat condition map for Sand Fynbos to aid in planning ecological restoration implementation at Blaauwberg Nature Reserve, City of Cape Town. Green areas are 'near-natural', with red areas being the most degraded (JvdM).

c) Complex sites

For example, in sites encompassing dissected landscapes, slopes with different soils or slope aspects etc., it is important to map plant communities, including their current states, anticipated reference states, and emerging states following restorative actions (Figure 17).

Figure 17: Some Sand Fynbos sites contain more than one plant community as shown by a seasonal wetland at Kenilworth Racecourse, dominated by the grass *Imperata cylindrica* that forms a mosaic with terrestrial fynbos (AGR).

d) Spatial and temporal scales

Note that unanticipated habitats, such as seasonal wetlands, may emerge after restoration interventions. This sometimes occurs where alien pines or wattles dry out seasonal wetland habitats as a result of their higher water use compared to that of Fynbos. Once cleared, the wetland conditions become apparent and this could trigger changes to the restoration plan, for example in targeting seed of local wetland species. More elevated or north-facing slope aspects may require a different suite of species compared to wetter or south-facing slope aspects.

Figure 18: *Serruria decipiens* (Near-threatened) in Cape Flats Sand Fynbos (PH).

3. Decide on Restoration Goal and Restorative Actions

Once a degraded site has been mapped for habitat condition, and appropriate reference site(s) identified, the restoration goals should be agreed to. The restorative actions required to achieve these goals will then be easier to identify. At this stage it is important to confirm the available budget for the project (i.e., human and financial resources). If resources are limited, areas within the site may be prioritised for restoration. Alternatively, the restoration goals should be modified.

a) Prioritisation

Prioritisation processes may differ, depending on the situation (such as land ownership and key stakeholder perceptions). National ecosystem status will elevate the most threatened ecosystems to top priority, followed by Critical Biodiversity Areas identified in a regional conservation plan (Figure 12). However, for non-proclaimed sites and highly degraded PAs, habitat condition and available resources may be more important in determining priority. This is because the costs of ecological restoration escalate as degree of degradation increases. Thus, it may be unrealistic to aim for full restoration of a highly degraded area, unless justified by its value as a degraded remnant of the most threatened ecosystem conserved in a PA.

It follows that to optimise conservation of ecosystems and biodiversity, the least degraded areas should be restored first. These areas will generally require passive restoration only, lowering costs. Such actions would optimise the conservation of biodiversity by halting ongoing degradation, while increasing overall habitat condition. Spatial location in the landscape is also important: where potential restoration sites link to or buffer existing remnants (e.g. Critical Ecological Support Area in a conservation plan), they may be a higher priority than non-connected remnants.

b) Decision trees

Once restoration goals and priorities have been clarified, a decision tree that highlights important options in implementing the various stages in ecological restoration may be created. This could help to simplify the restoration process. A decision tree should incorporate the latest research findings, such as the example in Figure 19 created for Cape Flats Sand Fynbos following degradation by alien wattle invasion (Holmes et al. 2020; Hall et al. 2021). One key decision is whether active or passive restoration is appropriate for the site (Table 2). This depends on habitat condition. For example, passive recovery of veld is possible where invader plants have short residence times and diverse native remnants are present. But, achieving this depends on the invader, the target ecosystem and the quality of alien control.

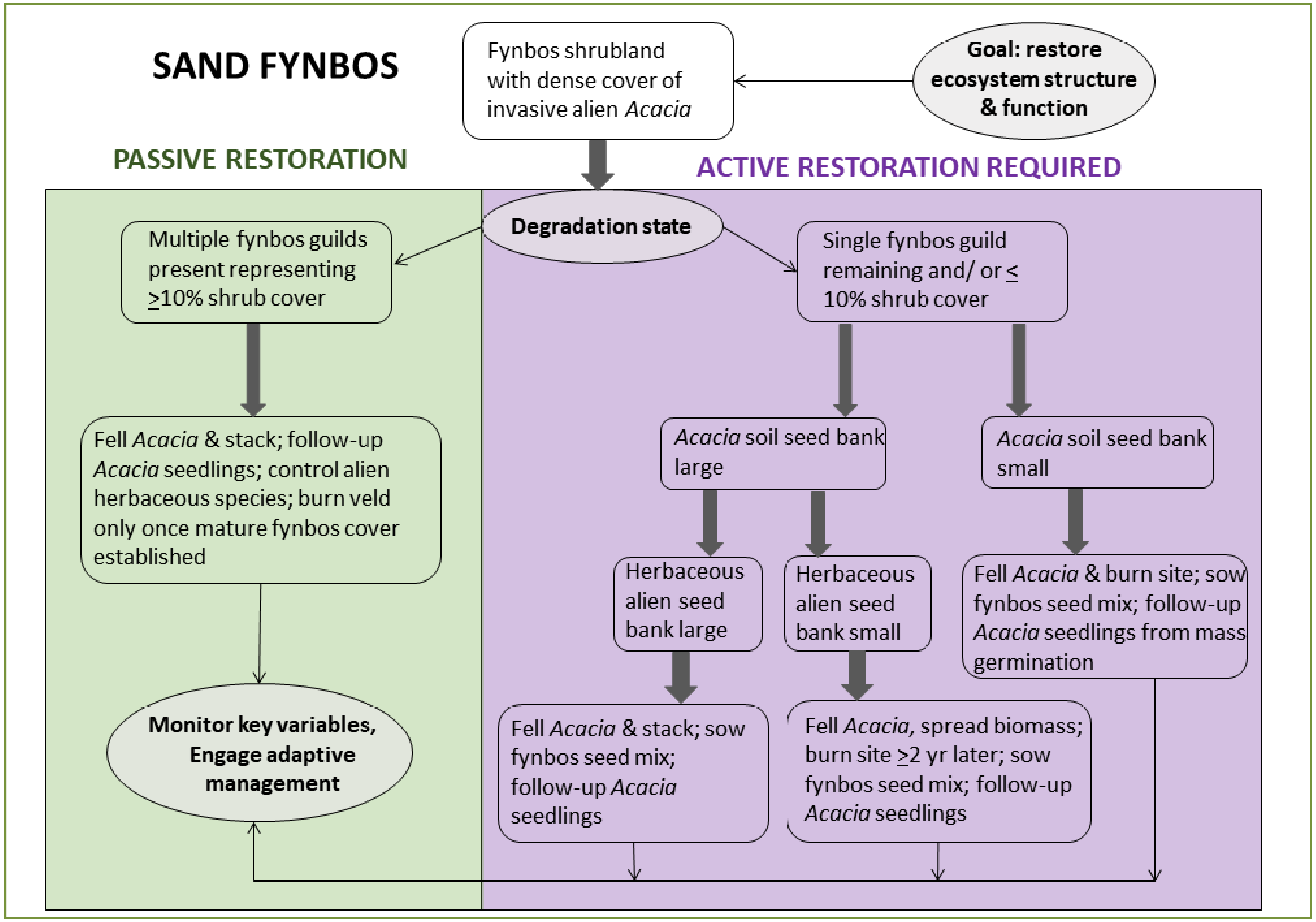


Figure 19: Example of a decision tree to aid in selecting the appropriate management options for restoring Sand Fynbos; specifically the restorative actions following dense wattle invasion in Cape Flats Sand Fynbos (Holmes et al. 2020; Hall et al. 2021).

c) *Invasive species control*

Information on the most common groups of invader species in Sand Fynbos and control methods should be integrated into an ecological restoration plan (Figures 20a,b). Various factors need to be considered, as outlined below (also, see Table 3):

- Grasses: These competitive species respond well to soil disturbance and nutrient enrichment following wattle invasion or ploughing and may outcompete Fynbos seedlings in the restoration process. Note, there are two main types: 1) alien, annual Mediterranean grasses, with shallow seed banks (eliminated by Summer fire), versus 2) perennial, indigenous weedy grasses (*Cynodon dactylon, Ehrharta calycina*) that may dominate by resprouting and reseeding after fires and, where dominant, are indicative of degraded veld.
- Woody aliens: Invasive alien trees and shrubs in the genera *Acacia, Pinus, Hakea, Eucalyptus* and *Leptospermum* are the most common in Sand Fynbos (Table 3). *Acacia saligna* (Port Jackson Willow) is probably the most widespread and troublesome species, as it resprouts vigorously post-fire and (like all wattle species) maintains a long-lived seed bank in the soil.
- Woody alien control: It is imperative that alien control is integrated with other restorative actions. Notable control methods are fire, indigenous sowing and planting. Non-sprouting pines and hakeas do not store seeds in the soil. They are best controlled by 'Fell & Burn', or 'Fell, Remove (large logs) & Burn' methods. Burning is useful in providing a good seed bed for Fynbos sowing (Figure 21). Resprouting alien species, e.g., Port Jackson Willow (*Acacia saligna*) require 'Fell & Herbicide Stump' treatment to prevent them from resprouting. For aliens that resprout and have soil-stored seeds the decision on whether to burn is important. Options include: a prescribed ecological burn; stack burn of cut slash during Winter; delayed burn after alien seed bank reduction by granivores; or no burn. The eventual method chosen will depend on the alien species and extent of degradation. Expert advice should be sought. The decision tree in Figure 19 gives an example of integrated restorative actions for *Acacia saligna*.
- Invasive "indigenous" shrubs: Species such as Bietou (*Osteospermum moniliferum*) and some *Searsia* species are not typical Fynbos species, but they are dispersed by birds into tree-invaded landscapes and thrive in the absence of fires. If too abundant, these species may need to be controlled too, by felling ahead of a prescribed burn at a restoration site.

Figure 20a: Clearing dense wattle to restore Sand Fynbos sites; **a)** contractors clearing mature trees (JvdM).

Figure 20b: Clearing dense wattle to restore Sand Fynbos sites; b) volunteers at Tokai Park weeding young wattle that recruited following a prescribed burn.

Figure 21: A prescribed ecological burn through dried wattle slash to stimulate Fynbos germination and create a seed bed for sowing Fynbos seeds (SG).

d) Time frames

In Fynbos ecosystems the opportunity for active restoration occurs only in the first year post-fire (or simulated fire), although it may be possible to increase species richness and abundance by rootstock in the second year. Thereafter the competition from established plants will be too intense for further successful Fynbos establishment. This highlights the time frame for Fynbos restoration which will occur in pulses and be measured in fire-cycles of 10-15 years rather than years. Monitoring the initial restoration success is critical to identify any missing components, and to start planning for additional interventions to address these, following a subsequent fire.

e) Site preparation

These guidelines do not address highly degraded sites, such as mined or repeatedly ploughed sites, as in most cases such sites would not have an ecological restoration goal, but a lesser goal, such as remediation or rehabilitation. However, there may be occasion where exposed, windy sites close to the coast require physical interventions to prevent wind erosion of soil and scouring of Fynbos seedlings after clearing aliens or fire. Interventions such as wind nets or brush fences erected perpendicular to the dominant wind direction can provide soil surface stability and shelter for establishing plants (Holmes & Grey 2017). Seed beds are best prepared by a prescribed burn. However, if this is not suitable, because of large *Acacia* seed banks for example, then fire should be simulated by raking areas clear of plant litter (leaves, twigs etc.) to expose the soil for sowing (Figure 22).

Figure 22: Preparation for sowing by raking the soil clear of debris and litter after clearing dense wattle without fire, using a 'Fell & Stack' treatment (CD).

f) Selecting species

First identify missing plant growth forms and species at the restoration site by comparing to the reference site(s). Where the goal is to restore growth form structure, aim to collect the dominant species of each major growth form (e.g., Table 4). The major growth forms in Sand Fynbos are shrubs (including proteoid and ericoid-leaved shrubs, resprouter and non-sprouter shrubs), graminoids (including restioids, sedges and grasses), geophytes (e.g., bulbs) and forbs (including annuals) (Figure 23). Where the goal is full restoration, a greater diversity of species in each growth form will be required.

Figure 23a-g: The major growth forms to include in the active restoration are shown by the following examples from Cape Flats Sand Fynbos (AGR): **a)** proteoid shrub resprouter (*Leucadendron salignum;* **b)** proteoid shrub reseeder (*Protea repens*); **c)** restioid (*Willdenowia sulcata*); **d**) ericoid shrub reseeder (*Erica mauritanica*); **e)** ericoid shrub resprouter (*Agathosma imbricata*); **f)** geophyte (*Moraea neglecta*); **g)** perennial forb/ subshrub (*Pelargonium capitatum)*. Note that the specific species selected for any particular site will depend on those present in the reference site.

g) Sourcing material

It is preferable to collect from Fynbos remnant sites that are not conserved, to take pressure off the PAs. However, in all cases the 'Millennium Seed Bank' protocols should be followed to prevent over-harvesting (e.g., collect <20% of seeds/plant) (Figure 24). Seeds should be sourced when ripe (i.e., starting to drop; generally a month after flowering in annuals and 2-3 months for perennials; Appendix 1). They should then be dried and treated against insect pests prior to storage in paper or canvas bags in a cool, dry seed room until sowing season. Rootstock is best collected after flowering in Spring or in Autumn. In both cases, collect material from as many individual plants as possible to capture genetic diversity (Figure 25a-c). For those species known to be difficult to establish from seeds, such as some of the resprouter shrubs, rootstock will be required. Cuttings of resprouter species tend to root better when harvested as heel cuttings from young shoots after fires (shoots growing directly from the rootstock are gently removed to include some bark tissue); however, such material is not routinely available.

Figure 24: A team of supervised contractor workers collecting Fynbos seeds for ecological restoration (JvdM).

Figure 25a-c: Preparing Fynbos rootstock at a nursery for active restoration; **a)** propagation from seed and cuttings (KE); **b)** hardening off rootstock under shade cloth and c) in full sun ahead of planting in the field (PH).

h) Seed pre-treatments

Fynbos species are adapted to germinate in response to fires. Cues include heat shock (for many hard-seeded species), smoke (for most species) and increased daytime temperature differences (following removal of insulating vegetation cover by fire for species buried by ants; Appendix 1). If it is impractical to burn the site, seeds may be pre-treated with heat-shock and smoke in the nursery as required by each species. Smoke is generally applied to all species as it has few negative impacts (Figure 26a-c). The altered temperature regime on site may be simulated by raking away the plant litter layer to expose bare soil ahead of sowing in late Autumn.

Figure 26a-c: Fynbos seed processing in preparation for active restoration; **a)** cleaned seeds of various species ready for a smoke pre-treatment (SD); **b)** seed smoking apparatus includes a large container or tent into which seed trays are placed, connected by a pipe to a drum in which Fynbos material is burnt to create smoke (SD); **c)** seeds requiring a heat pulse treatment are placed in foil packets in an oven at the required temperature for 1-5 minutes duration, depending on species (SD).

i) Cost implications

Costs are an important consideration when planning an active restoration project (Table 5). Small-scale, targeted interventions can be implemented in a relatively cost-effective way when the condition of the veld is in a 'Degraded' or better condition (Table 2) and the barriers to success are limited. As the scale of the project increases and the challenges to achieve natural recovery increases, the costs can also increase exponentially. Some of the key costs to consider include:

- **Invasive alien species** management (initial costs, but also plan for follow-up clearing). There are some very handy tools developed to help plan out the costs of these initiatives based on the density and growth form of the invasive alien species in question. Examples of such tools include the 'Working for Water Information Management System (WIMS): Annual Plan of Operations (APO)' tool and 'norms calculator' (Box 1). Using the recent 26-hectare restoration project at Blaauwberg Nature Reserve as an example, the initial clearing (in 2019-2020) of this 'Degraded' to 'Very Degraded' restoration potential area cost R12,500/ha with the two subsequent follow-up treatments costing an additional R5,600/ha each. In contrast, systematic clearing of the 'Near Natural' two-hectare 'Friends Patch' by volunteers at the reserve, followed by successful passive restoration, had zero cost implications to the reserve budget. Both areas had dense wattle invasion. This illustrates the importance of first clearing higher restoration potential areas – i.e., usually those areas where dense alien invasion is more recent and spontaneous recovery of indigenous species is anticipated.
- **Seed collecting** is a critical component of the restoration process for more degraded areas. Seed collecting might require several separate visits to a variety of local sites in order to capture a diverse collection of seeds to optimise species and genetic diversity in the restoration intervention. Seed collecting, cleaning and pre-treatment is a specialised activity that needs supervision. Costs to consider are: labour; transport; training and basic tools (i.e., garden pruning secateurs, brown bags – not plastic – for seed and permanent markers to label your bags). Using the recent 26 hectare Blaauwberg restoration project as an example, on average, eight people spent 35 days collecting seed, or 280 person days, to enable sowing of discrete patches across 18 hectares following alien control (i.e., 15.5 pd seed collecting/ ha).
- **Site preparation** for active restoration incurs labour costs (consult the Department of Labour's National Minimum Wage), transport costs (the AA vehicle rates calculator is a very handy tool to calculate your vehicle operating costs) and requires basic tools (spades and rakes) to prepare the site for active restoration, such as seed sowing. On average, four people were able to prepare and sow one ten-metre diameter seeding plot every 30 minutes, with an average of four plots per hectare (i.e., 1.0 pd site preparation/ ha).

Box 1: Simplified norms calculator for invasive alien tree work load requirements

i.e. No. of days required for 1 person to clear 1 hectare using a particular method (modified from the Working for Water project)

Density %	Felling, cutting up and stacking.			Foliar Spray
	Adult Trees	Mixed (Adult & Young Trees)	Young trees or seedlings	
< 5 %	1.23	0.89	0.79	0.16
10 %	2.06	1.49	1.31	0.27
20 %	4.37	3.17	2.06	0.58
30 %	6.69	4.85	2.80	0.88
40 %	9.07	6.57	4.90	1.19
50 %	11.44	8.29	7.07	1.50
60 %	15.93	11.54	10.17	2.09
70 %	23.60	17.09	14.39	2.96
80 %	31.89	23.10	20.38	3.83
90 %	36.14	26.18	23.10	4.34
100 %	40.40	29.25	25.81	4.85

Example 1: A 1 ha area that has a 60 % cover of adult Port Jackson trees will take 1 person 15.93 days to clear or a team of 12 workers 1.3275 days (15.93 person days/12 persons = 1.3275 actual days).

Example 2: A 6 ha area that has a 30 % cover of mixed adult and young Port Jackson trees will take 1 person 4.85 days to clear 1 ha or 29.1 person days to clear all 6 ha hectares (4.85 person days x 6 hectares = 29.1 person days). A team of 12 will take 2.42 days to clear the same 6 ha area (29.1 person days/12 persons = 2.42 actual days).

NB: The above excludes transport and herbicide costs

j) *Legal and policy imperatives*

In general, there are more issues to consider within an urban/city context than in a rural context. For example, to conduct an ecological prescribed burn in an urban area requires a permit, following approvals from the Fire and Air Quality departments, as well as the subcouncil. In addition, immediate neighbours or owners of infrastructure, within 100 m of a fire line, must be given written notice and in return give permission for the burn. Note that public consultation cannot be done during the holiday season, so early planning is required to achieve all the permissions and permits in time for a dry season burn. Participation in a Fire Protection Association will help to ensure correct procedures are followed. The National Veld & Forest Fire Act 101 of 1998 and the Fire Brigade Services Act 99 of 1987 apply, as do Municipal By-laws, such as City Fire, City Environmental Health and sometimes Traffic. A permit from CapeNature is required to collect indigenous seed and other propagation material. In addition, written permission is needed from land owners or managers of the Fynbos remnant sites where this takes place.

<u>Box 2</u>: Restoration of Threatened species including those Extinct in the Wild (EW)

Lowland Sand Fynbos ecosystems typically have a high number of threatened species, owing to a combination of specialist habitats, narrow distribution ranges and loss of vegetation to agriculture, mining and urban developments. Once the threatened species habitat has been secured and/or restored, propagation of these species should be researched and rootstock established to bolster populations. This often requires collaboration among nurseries, botanical gardens, land owners and conservation agencies.

Example: *Erica verticillata* (Whorled Heath) is EW but was once common on the southern Cape Flats of Cape Town until its habitat was destroyed by housing and remaining populations were over-harvested for cut flowers. Genetic material was rescued by Anthony Hitchcock of Kirstenbosch Botanical Gardens from several botanical gardens, including Vienna, and trials in the nursery and at various sites to propagate and establish the plant were initiated. Establishment was successful only within a narrow wetland edge microhabitat and seed set only occurred once plants originating from the different genetic sources were inter-planted, allowing for cross-pollination.

Figure 27 shows *E. verticillata* (with pink flowers) successfully established in 2008 at the Soetvlei wetland, Tokai Park section of Table Mountain National Park, following the removal of pine plantations. This erica is happiest on the edges of Sand Fynbos seasonal wetlands: a typical peat-forming wetland plant, Palmiet (*Prionium serratum*) can be seed behind the ericas. Unfortunately invasive alien gums (*Eucalyptus* spp.) and Long-leaved Wattle (*Acacia longifolia*) have re-established in the wetland and require urgent control. At another wetland within Tokai Park which burnt in March 2021, *E. verticillata* seedlings have established from the seed bank, representing the first generation here towards its removal from the EW threat category (according to the IUCN, three generations must establish naturally for the species to be removed as EW).

Figure 27: *Erica verticillata* restored to a wetland at Tokai, Table Mountain National Park (AGR).

4. In-field Protocols

a) Species selections, collections, propagation

- For degraded sites, the initial goal is usually to restore the vegetation structure and functioning to resemble a typical Sand Fynbos community (i.e., the local reference site; Table 4). In the longer term, or for less degraded sites, an idealistic goal of also restoring floral composition and diversity may be appropriate. In Sand Fynbos ecosystems the major growth forms to restore structure are annuals, geophytes (bulbs etc.), graminoids (restios, grasses and sedges), perennial forbs (ground covers) and shrubs. Shrubs that establish from seeds after fire, including overstorey proteiods, are generally easy to restore, but those that resprout after fire produce fewer seeds and may be less successful from seed. Seed collection is required throughout the year to collect all growth forms, but is most intensive from late Spring to early Summer. In the Winter rainfall areas, seeds should be pre-treated in late Summer and sown in Autumn before the first heavy rains (Figure 28a,b; Appendix 1 provides more information on seed handling and pre-treatments).
- As resprouters are dominant structural components in Sand Fynbos, it is advisable to propagate some rootstock for re-introduction (e.g. in Cape Flats Sand Fynbos, dominant ericoid-leaved resprouter shrubs: *Phylica cephalantha, Tricocephalus stipularis, Diosma oppositifolia, Agathosma imbricata*). It is advisable to prepare rootstock in local soil (using plugs rather than large bags where possible), then to harden off before planting in June or early July after heavy rains. This would improve establishment success and minimise introduction of soil pests and weeds. It is advisable to appoint specialist indigenous nurseries to propagate rootstock.
- Where a restoration site is located near an approved, future development, this may provide the opportunity to collect valuable propagation material and possibly harvest topsoil containing an intact Fynbos seed bank. While 'Search & Rescue' from a development site is not considered an adequate way to prevent the loss of threatened habitat, it may be possible to make use of such resources according to a strict protocol. First of all, ensure that the ecosystem and habitat type are the same as at the restoration site, otherwise any translocation of material may fail. Most Fynbos species cannot be directly transplanted except as seedlings soon after fire, though some geophytes may be successfully translocated from older veld once their leaves have died back for Summer. Seed and other propagation material may be gathered as at other local Fynbos remnant sites, noting that timing is important. At a development site larger quantities of material may be gathered as the site will be lost to conservation in the future. If topsoil is desired for a highly degraded recipient area, then translocation should be done while the topsoil is dry in Summer. This is done by stripping off the upper 15 cm of soil and immediately spreading it at the prepared receptor site to avoid seed death in stockpiles.

Figure 28a,b: a) Active restoration involving the sowing of a pre-treated Fynbos seed mix onto a prepared seedbed following wattle clearance; **b)** Planting Fynbos rootstock (SD).

b) Sowing rates and ratios in seed mixes

The recommended sowing rate to restore structure in Fynbos ecosystems is about 10 kg/ha of 'cleaned seed equivalent' (i.e., if some seed dispersal structures are not cleaned off then the seed weight should be adjusted upwards accordingly). Species ratios rely heavily on the availability of good quality seed across the range of targeted growth forms and species. In more threatened Sand Fynbos types with limited Fynbos remnant sites remaining this may pose a challenge. The variable in-field establishment across species, whereby certain species recruit better than others depending on prevailing conditions, may thwart efforts to restore representative veld structure. To improve outcomes it is important to collect several species representing each major growth form. Ensure protocols are followed for correct seed storage, pre-treatment and timing of sowing to further minimise seed failures. Where possible, seed viability should be checked and seedling establishment monitored. This is necessary to build knowledge of local species and adjust the design of future seed mixes and sowing rates.

c) Spatial arrangements

Seed sources and rootstock materials are frequently limited and there is often insufficient material to have a blanket approach across a restoration site. To counter this limitation, the concept of 'applied nucleation' is currently being tested in Sand Fynbos. The concept assumes that if clusters of vegetation are actively established on site, these will – with time – 'nucleate' or grow together. Preliminary work suggests that some wind-dispersed shrubs establish up to 15 m from the original sown 25 m^2

restoration plots within the first fire cycle (T. Lehman personal observations, 2021). Natural colonisation by wind-dispersed Fynbos species may be enhanced by leaving some low, small brush fences or branches across the site to trap the seeds.

Figure 29: Volunteers planting Fynbos plugs following alien clearance and fire at Tokai, Table Mountain National Park (PH).

d) Safety and health compliance

Some restoration activities involving people as employers, employees or communities come with compliance obligations (Table 6). Appointment of a Safety Health and Environment (SHE) representative is necessary to oversee and enforce all the compliance requirements for a safe working environment (ISO 45001 Standards). Operating machines such as chain saws and brush cutters will require certified individuals to carry out the tasks. Also required are first aiders, specialised herbicide applicators and drivers with Professional Driving Permit licenses. Raising conservation and environmental awareness during SHE meetings and training field workers on care of flora and fauna will help to minimise trampling and associated negative impacts during restoration implementation.

5. Monitoring

Restoration interventions may be expensive and every site may have slightly different requirements, so it is important to keep records of the actions taken (including dates) to achieve the stated goals. This helps to assess the success of activities and initiate adaptive management if required. Please refer to 'References and Further Reading' at the end of the Guidelines for additional information on monitoring.

a) Monitoring ecological restoration goals

It is advisable to monitor veld recovery more frequently initially, in the first Spring after sowing to capture the ephemerals (annuals and seasonal geophytes), then at the end of Summer for the first three years; thereafter every 3-5 years should suffice. It will soon become apparent if any elements have failed to establish, which would require a shift to an adaptive management plan (e.g. replanting of certain species in year two; more frequent alien follow-up control). Decide on a method for monitoring specific restoration goals, such as total Fynbos cover and establishment of growth forms (Esler et al. 2014). Methods include permanent plots or line transects across the site, often supplemented with fixed point photographs (Coetzee 2016). In some restoration projects it may also be important to monitor fauna (e.g., herbivores; key pollinators; and seed dispersers) or a particular ecosystem service (e.g., water table recovery).

b) Quality assurance

To monitor whether management activities meet international best practices, refer to information given in the ISO 9001 quality management systems, www.iso.org/standard/62085.html.

c) Citizen science and public involvement in monitoring

Many reserves have 'Friends Groups' and local citizens interested in nature. Ecological restoration is a positive activity that may be used to engage the public and seek their help for projects, such as monitoring restoration outcomes or threatened species. In return this may motivate people to become ambassadors for conservation. One platform used in the South African community is 'iNaturalist': an online data platform that tracks species observations from the localities of photographs that are identified by a community of local experts and amateurs. Any species vulnerable to poaching have their localities automatically hidden. As an example, the Cape Flats Sand Fynbos at Lower Tokai Park (in the Table Mountain National Park) is undergoing restoration following over a century of pine plantations. Local amateurs (citizen scientists) assist with monitoring by attending organised surveys where they walk transects across the area to record species during Spring. Observations are uploaded onto iNaturalist in the project created for this study (see www.inaturalist.org/projects/tokai-park-restoration-study and www.inaturalist.org/projects/tokai-park-monitoring).

d) *Environmental Impact Assessment (EIA) mitigation projects*

Rather than declining a development project the competent authority may recommend mitigation in the form of 'Search & Rescue' or 'Restoration of an alternative site'. These are not considered adequate mitigation options for the loss of threatened habitat by the conservation community: too often such mitigation projects fail, e.g., translocated species do not survive in the new habitat or negatively impact on resident species, or restoration efforts are unsuccessful, after which no-one takes responsibility (Cadman 2016). Stakeholders should be aware that mitigation is better served by formally conserving an alternative non-conserved Fynbos remnant site of equal or higher conservation status than the proposed development site.

e) *Record keeping:*

It is important to keep records of the restorative actions taken. If they are different from the Restoration Management Plan or Restoration Annual Plan of Operation (Appendix 2) it is helpful to record what differed and why. Once monitoring begins data records should be kept in an appropriate format (e.g. spreadsheet) and include metadata (e.g. plot localities, size, units of measurement, etc.), so that later on datasets may be interpreted correctly and analysed. Data capturing of hand-written records (transferring records to electronic formats) is highly advisable. It is also advisable to back-up datasets to avoid losses resulting from theft or damage to computer hardware.

Figure 30: Applying herbicide immediately following a cut-stump treatment (JvdM).

6. Troubleshooting Challenges

a) Secondary invasions

Secondary invasion has been broadly defined as the proliferation of non-target alien species following efforts to suppress dominant target invaders. Secondary invaders typically colonise after the removal of target invaders, because competition has been reduced and resources freed up. These secondary invaders, especially alien annuals, either colonise from surrounding disturbed areas, or are present in the soil seed bank already (Figure 31a,b). Secondary invaders can be aided by elevated soil nutrients and human actions that change the natural disturbance regime. Once present, these secondary invaders often establish rapidly and may become dominant. In such cases they undermine restoration efforts by limiting the recovery of indigenous species.

Figure 31a,b: Secondary invasion by alien herbaceous weeds at Blaauwberg NR; **a)** Wild Mustard invasion following wattle clearance (PH); **b)** alien annual grasses, such as Wild Oats, at a highly degraded site (JvdM).

Methods for controlling secondary invaders ahead of active restoration in 'Highly Degraded' sites include herbicide application, manual weeding or methods such as mowing or selective grazing. However, at sites where restoration potential is higher, these treatments are less appropriate and where possible a prescribed burn should be used to kill the shallow seed banks of these alien annuals. In Table Mountain National Park prescribed dry season burns following pine plantation harvesting were used successfully to restore Sand Fynbos; alien annuals only established in the unburnt areas such as fire-belts. This method of invasion control may be enhanced by sowing a seed mix that includes fast growing indigenous pioneer species, such as annuals and short-lived shrubs, to outcompete the aliens. This is an example of an integrated management approach for dealing with secondary invasion in a restoration context. Yet not all situations of secondary invasion are well understood. Researchers and practitioners need to collaborate to improve our understanding of the drivers and impacts of secondary invasion and explore the feasibility and effectiveness of different integrated management strategies.

b) Drought and climate change adaptation

A natural ecosystem that is well-functioning will assist to buffer lowland Sand Fynbos from the predicted extreme weather events under climate change. The West Coast forelands area is predicted to experience higher temperatures and reduced Winter rainfall. This does not only influence fire return intervals, but also post-fire recruitment. Consecutive drought years may be detrimental for seedling establishment: although seedlings may survive the first year, they may then die in year two. Some other possible consequence of climate change is increased invasion by alien or weedy species, or increases in the frequency of extreme events, such as storms.

Restoration projects manipulate physical and biotic (factors associated with living things) variables using tools, such as alien clearing, fire, sowing seeds and planting of rootstock to enhance ecosystem structure and biodiversity. It is known that species-rich ecosystems are more resilient to extreme climate change-related disturbances. Furthermore, mitigating potential climate change impacts on biodiversity is more likely when restoration is implemented over larger areas. In addition to the ecosystem priorities discussed above, the National Protected Area Expansion Strategy (NPAES; www.dffe.gov.za) should be consulted as this is a strategy to enhance climate change resilience in the expansion of existing protected areas. Regrettably, the NPAES does not prioritise threatened ecosystems, but focuses more on cost-effective reserve expansion. Nevertheless, site selection for restoration should keep existing PA expansion and corridor initiatives in mind.

As mentioned earlier, Fynbos restoration is a slow process that occurs in pulses after each fire cycle. Drought cycles may delay this further when seeding fails owing to dry conditions. It is possible that seeds may lie dormant until more suitable conditions arise. Alternatively, plans for additional sowing in a following year or fire cycle may be required. At present there is no predictive tool for anticipating 'good restoration years' in Fynbos and this highlights the importance of monitoring restoration outcomes.

c) Social impacts

Restoration activities may have socio-economic influences on the surrounding communities. The activities may impact job opportunities, ecosystem services, culture and heritage, land-use, resettlement, and access to natural resources (e.g., harvesting indigenous flora for medicinal use in a sustainable way). As part of stakeholder identification, socially responsible practices are required to: build relationships and support from neighbouring communities; lessen, or prevent, any social impacts; and contribute towards sustainability. Generic guidance on social responsibility is provided by well referenced community management systems, such as the International Standard Organization (ISO) 26 000 and the International Finance Corporation (IFC) performance standards (see links in Reference section). These social and sustainability management systems provide guidelines and standards on what to manage in communities during operational activities. These include minimising the activities' impacts on the communities (e.g. through avoiding displacement or resettlement, establishing mechanisms for community members to voice concerns), community involvement (involve local people through stakeholder engagement to gain formal and social license to operate) and community development (skills transfer, share-holding, incentives etc.).

d) Faunal impacts

Faunal species generally play a critical role in healthy Fynbos ecosystems. However, an imbalance occurs when some species are lost from degraded veld and others increase in numbers to the extent that they may pose as an obstacle for restoration outcomes. The challenge is to try and restore some balance through targeted interventions.

- Fossorial mammals (animals that specialise in digging and mainly live underground), such as Cape Molerat and Cape Gerbil, disturb the soil through their burrowing and mounding activities. In degraded sites they may be more abundant and their disturbances can both uproot indigenous plants and incur losses through herbivory (Figure 32a,b). Molerats feed on bulbs and roots and their numbers increase in degraded sites where stoloniferous grasses, such as Kweek (*Cynodon dactylon*), dominate. Establishing a cover of deep-rooted and resprouter shrubs is the best way to counter excessive soil disturbance by these mammals.

- Granivorous rodents (specialised seed eaters) may further deplete the sparse indigenous seed banks at a degraded site, especially where natural predators are low in number (Figure 33a,b). Gerbils, which are mainly nocturnal, thrive in sites degraded by wattles (e.g. *Acacia saligna*) as they feed on their seeds. Once the aliens are cleared Gerbils intensify their consumption of indigenous seeds, bulbs and seedlings. Areas immediately surrounding their very obvious burrowing colonies should be avoided for active restoration. The Four-striped Field Mouse is mostly diurnal (active during the day) and lives in shallow burrows, often within alien tree brush piles. From there, they have a series of trails radiating outwards for gathering plant material and insects to carry back to burrows for storage or eating. As they are relatively safe within brush piles, the numbers of mice can be very high. Placing restoration sowing plots within a 10 m radius of a brush pile will result in high seed predation by these rodents.

- Granivorous birds, such as Laughing Dove and Ring-neck Dove, may hinder active restoration initiatives by consuming large quantities of indigenous seed. The introduced Helmeted Guineafowl consumes shallow bulbs as well as seeds. Granivory can be reduced by lightly raking the sown seeds into the soil. This will also help prevent the seeds from being blown off the restoration plots.
- In areas cleared of dense invasive alien trees, the brush piles are often close together making it difficult to find a suitable location with reduced granivory for sowing the active restoration plots. Burning some of these brush piles in Winter ahead of sowing, near to the restoration plots, will increase the distance between brush piles and expose rodents to increased predation while foraging for food. Another option is to erect bird of prey perches (e.g. three-metre long pole with a T-shaped, perching area on top, or retain dead alien trees) and owl boxes on poles near to restoration plots (Figure 34). This may increase predation of diurnal and nocturnal granivores, respectively. Birds of prey such as Spotted Eagle Owl, Barn Owl, Black Shouldered Kite and Rock Kestrel play a very important role in maintaining the predator-prey balance in a natural ecosystem. A regular presence of these birds near active restoration sites will reduce the feeding time for granivores as they try to limit their exposure to predators, while also maintaining the population sizes of these animals.
- Fynbos has a very low carrying capacity for large wildlife and young veld is very sensitive to grazing and browsing. This is particularly true after disturbance (e.g. fire and passive or active restoration) for three to four years until the seedlings grow and harden to become less palatable. Larger mammals, such as Eland, Zebra and Red Hartebeest, should be stocked at very conservative stocking rates. This should ideally not exceed 60% of carrying capacity, as these animals will impact on the seedling success and rate of recovery during restoration. Fencing off restoration areas from herbivory is required where negative impact is anticipated. Livestock grazing (with cattle, horses, sheep or goats) in restoration areas should be avoided altogether to ensure any chance of success: domestic animals are generally not allowed in protected areas for this reason.
- Indigenous seed dispersers and pollinators play a critical role in healthy Fynbos ecosystems by pollinating plants (e.g., many insects, sunbirds, some rodents) and dispersing seeds below ground where they are safe from granivory (e.g., ants and scatter-hoarding rodents). Fynbos ants from the genera of Anoplolepis and Pheidole (Slingsby 2017) gather seeds with a fleshy elaiosome (a nutrient-rich structure on the seed) and remove them below ground to consume the eliaosome, after which they are unable to eject the slippery seeds from their nests. Despite burying over 1,200 species of Fynbos (in this symbiotic relationship known as myrmecochory), these ants also bury wattle seeds (e.g. *Acacia saligna*) and have, as a result, been instrumental in facilitating its invasion process. Invasion by alien ants (e.g. Argentine Ant) may disrupt this symbiotic relationship between indigenous ants and plants. Some scatter-hoarding rodents ensure persistence in other Fynbos species, as not all their seed reserves are consumed (Rusch, Midgely & Anderson 2013).
- In degraded, fragmented remnants, some faunal species may have been lost. The flying species may be attracted back to an area after key plant species are re-established; however, more localised, terrestrial species, such as the seed dispersing ants, may need to be re-introduced.

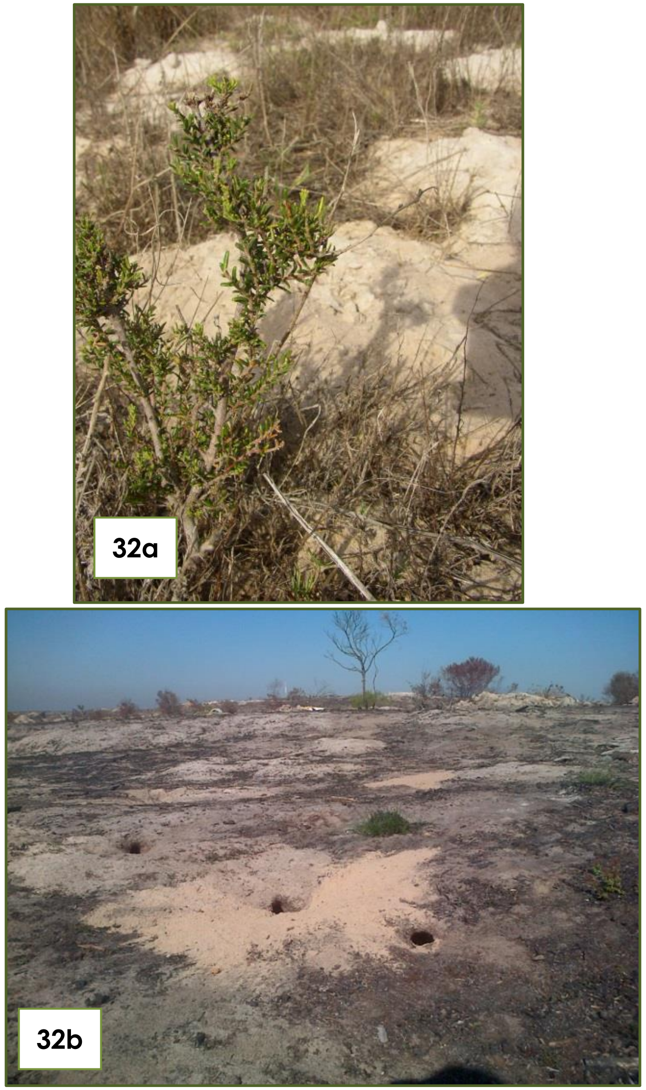


Figure 32a,b: Surface disturbance by fossorial mammals; **a)** excessive mounding by Dune Molerats in an old field (PH); **b)** soil disturbance by Cape Gerbil close to a subterranean colony (PH).

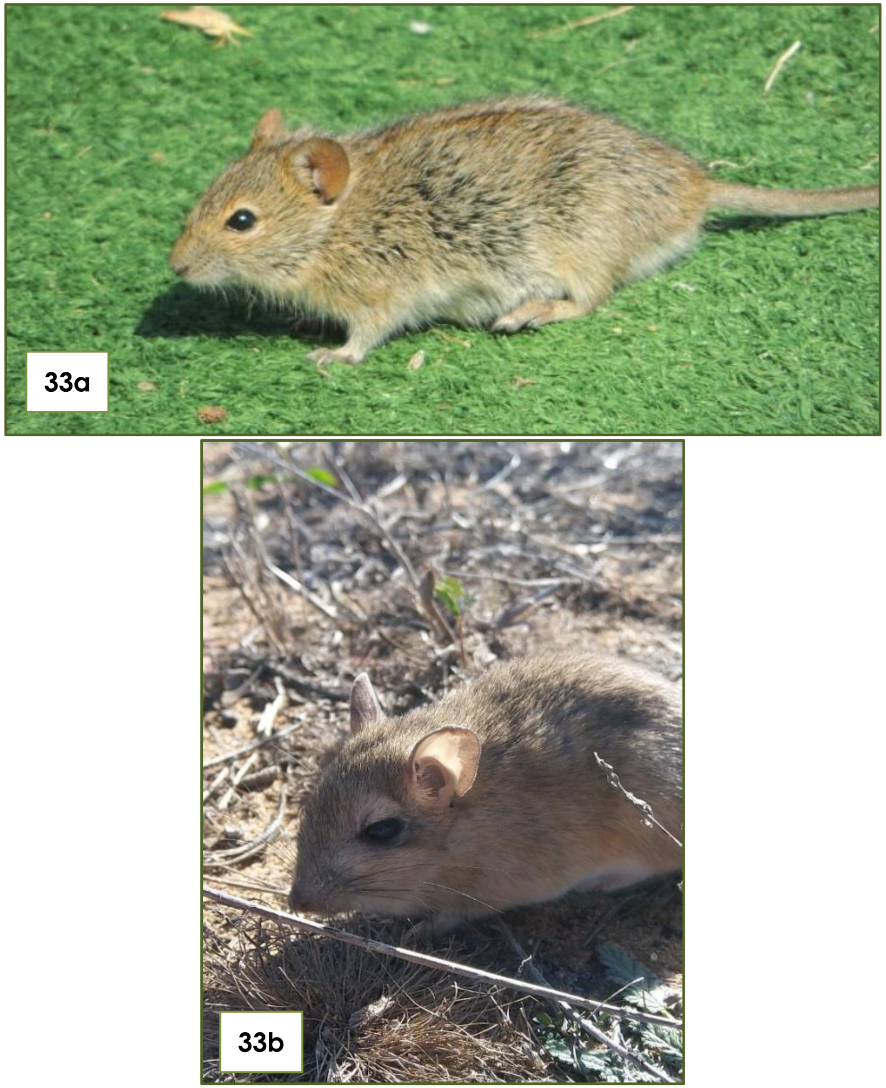


Figure 33a,b: Indigenous rodents are often abundant following clearance of wattles; **a)** Striped Field mouse – diurnal granivore (JvdM); **b)** Cape Gerbil – nocturnal granivore and herbivore (JvdM).

Figure 34: Owl box erected in a restoration area to attract nesting owls and reduce rodent pressure on seeds and seedlings (PH). These boxes must be lined with cotton wool to prevent colonization by honey bees and should be removed once seedlings are established.

e) Pollution control

Fynbos ecosystems are nutrient-poor and any pollution that causes enrichment of soils (e.g. from sewage spills, fertiliser drift from surrounding fields or enriched ground water) should be minimised if plant species are to establish and thrive. Similarly, pollution from chemicals such as pesticides, herbicides and industrial emissions, may adversely affect both flora and fauna. Such impacts may be difficult to control, but anticipating them by pro-actively communicating with adjacent land users may help, e.g., by encouraging chemical-free buffer zones and more sustainable environmental practices.

f) Managing field staff

Where ecological restoration projects are new to a reserve, staff and contracted teams should be briefed on the purpose and importance of the project and given adequate skills training to implement actions correctly and safely. It is also important to ensure close collaboration among the various line functions to avoid unexpected outcomes, including: fire belts being cut through restoration plantings; alien control teams poisoning indigenous seedlings with herbicide or trampling emerging indigenous species during alien follow-up control operations.

g) Unplanned fires

Preventing unplanned fires is critical to ensure that indigenous species establishing in the first restoration cycle are allowed to mature and set seed sufficiently to replenish seed banks. In addition, alien clearing operations should be closely aligned to the fire cycles to ensure that dense fuel loads do not build up and pose a fire risk. It is advisable to maintain a fire belt around the restoration site to facilitate fire-fighting in the event of a wild fire. Once the restoration site has matured, it can be integrated with broader reserve fire management planning.

7. Funding Options

In South Africa, public sector budgets for ecological restoration are small and therefore implementation is haphazard and often small-scale. Private sector investments are also challenging because biodiversity conservation and restoration are considered a 'public good'. However, with recent international efforts to up-scale restoration and repair, some innovative funding mechanisms have been proposed or implemented. In South Africa, these may take several forms. One is Corporate Social Investments (CSI), where companies receive points for their Broad-Based Black Economic Empowerment (B-BBEE) scorecards. Other mechanisms are Green Bonds, Parametric insurance products (designed to cater for catastrophic natural disasters, such as runaway fires due to alien biomass), or blended finance options. Coldrey (2020) explores these funding options in more detail. Landowners may access tax – and other – benefits for priority biodiversity sites through the formal signing of a Conservation Stewardship Agreement (www.capenature.co.za/protected-areas-and-stewardship) or Conservation Easement (as has been implemented for Renosterveld; www.wwf.org.za/?20241/first-conservation-easement). This potentially could unlock funding for official conservation organisations or NGOs to assist with management interventions.

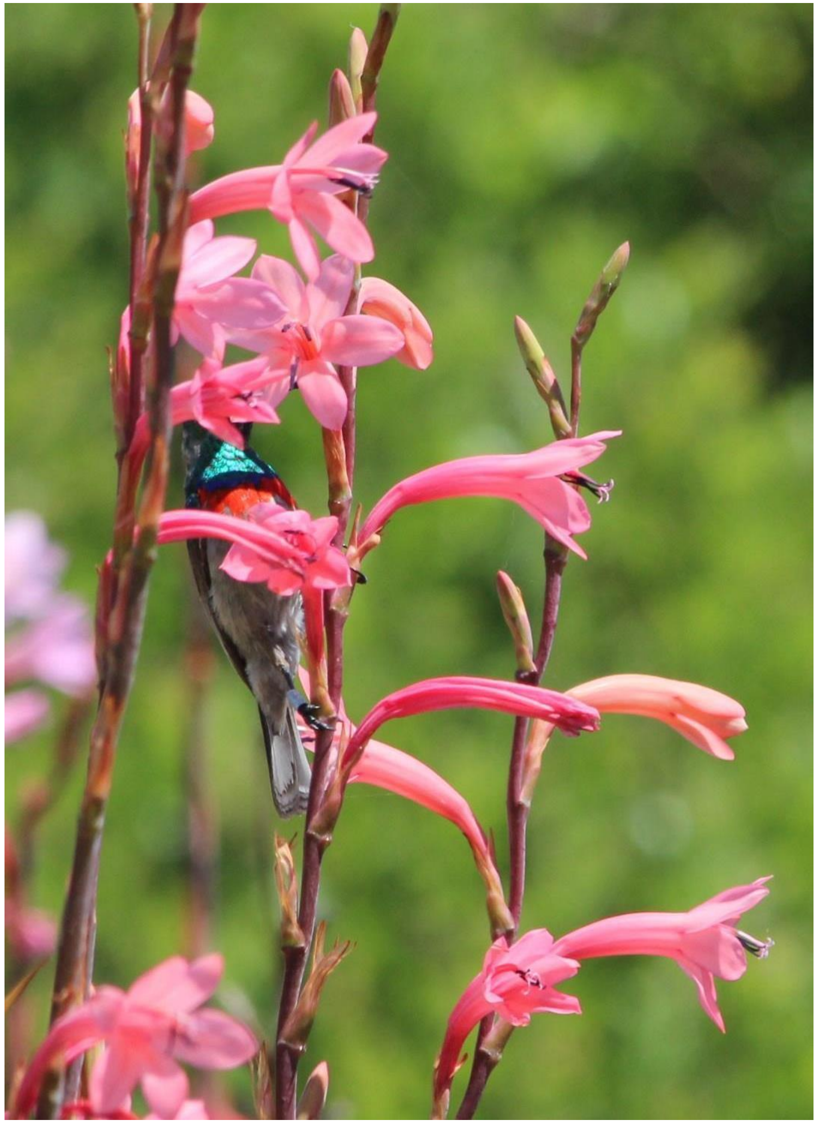


Figure 35: Lesser double-collared Sunbird pollinating *Watsonia meriana* (AGR).

8. Benefits, Job Opportunities and Way Forward

Our focus in these guidelines has been on the restoration of threatened biodiversity, however such interventions often have many co-benefits. These co-benefits are context-dependent, but may include 1) improved livelihood security through employment and the development of new value chains (e.g., plant propagation; biomass for fuel); 2) protecting infrastructure (e.g., by avoiding catastrophic fires by clearing invasive alien trees; reducing criminal activity under the cover of alien trees); or 3) providing important ecosystem services (e.g., providing pollinator services to agriculture; increasing water security). Such co-benefits in turn provide important buffers for society from the impacts of global change (such as increased incidence of droughts or fires). Often, it is these co-benefits that help to leverage funding for ecological restoration efforts (Rebelo et al. 2021; SEBEI 2021).

In the UN Decade on Ecosystem Restoration, the prerogative is to promote ecologically appropriate, strategic and adaptive interventions. These interventions need to be scaled-up significantly if we are to slow global and local losses of biodiversity, improve the flow of ecosystem services and, as a result, increase socio-economic benefits provided to society from such actions. We hope that these practical guidelines will pave the way for Cape Lowland vegetation to flourish, and help to inspire similar efforts elsewhere.

Figure 36: *Leucadendron levisanus* (Critically Endangered) stores seeds in cones on female plants (AGR).

9. References and Further Reading (with online links)

Part A. Introduction and Purpose of the Guidelines

Gann GD, McDonald T, Walder B, Aronson J, Nelson CR, Jonson J, Hallett JG, Eisenberg C, Guariguata MR, Liu J, Hua F, Echeverría C, Gonzales E, Shaw N, Decleer K, Dixon KW 2019. International principles and standards for the practice of ecological restoration. Second edition. *Restoration Ecology* 27(S1): S1–S46. www.ser.org/page/SERStandards.

Rebelo, A., Boucher, C, Helme, NA, Mucina, L, Rutherford, MC, et al. 2006. Fynbos biome. In: Mucina, L, Rutherford,MC (editors), *The Vegetation of South Africa, Lesotho and Swaziland*: Strelitzia, 19, pp. 52–219; http://bgis.sanbi.org/Projects/Detail/101.

Rebelo AG, Holmes PM, Dorse C, Wood J 2011. Impacts of urbanization in a biodiversity hotspot: Conservation challenges in Metropolitan Cape Town. South African Journal of Botany 77 (2011) 20–35; https://www.sciencedirect.com/science/article/pii/S0254629910001390.

Skowno, AL, Raimondo, DC, Poole, CJ, Fizzotti, B & Slingsby, JA (eds.) 2019. *South African National Biodiversity Assessment 2018 Technical Report Volume 1: Terrestrial Realm*. South African National Biodiversity Institute, Pretoria; http://hdl.handle.net/20.500.12143/6370.

The Society for Ecological Restoration; www.ser.org.

The South African Biodiversity Institute (SANBI) Biodiversity Advisor; http://biodiversityadvisor.sanbi.org.

The UN Decade on Ecosystem Restoration (2021-2030); www.decadeonrestoration.org.

www.capenature.co.za/protected-areas-and-stewardship
CapeNature works in partnership with private landowners, communities, agricultural businesses and other stakeholders to ensure biodiversity survives in a changing climate outside protected areas with tangible benefits to the local communities and shareholders.

Part B. Ecological Restoration Guidelines, sections 1-6

Cadman M. (editor) 2016. *Fynbos Forum Ecosystem Guidelines for Environmental Assessment*. http://biodiversityadvisor.sanbi.org/wp-content/uploads/2012/04/Ecosystem_Guidelines_Ed2.pdf.

Coetzee 2016. *Practical Techniques for Habitat and Wildlife Management. A Guide for Game Ranches, Conservation Areas and Farmland*. New Voices Publishing Services, ISBN: 978-0-620-70843-2; www.newvoices.co.za.

Esler KJ, Pierce SM & de Villiers C (editors) 2014. *Fynbos Ecology and Management*. Briza Publications, ISBN 978-1-920217-37-2. (also available in Afrikaans, ISBN: 978-1-920217-36-5); www.briza.co.za/mediareviews.php?page=6.

Gann GD, McDonald T, Walder B, Aronson J, Nelson CR, Jonson J, Hallett JG, Eisenberg C, Guariguata MR, Liu J, Hua F, Echeverría C, Gonzales E, Shaw N, Decleer K, Dixon KW 2019. International principles and standards for the practice of ecological restoration. Second edition. *Restoration Ecology* 27(S1): S1–S46. www.ser.org/page/SERStandards.

Hall SA, Newton RJ, Holmes PM, Gaertner M, Esler KJ 2017. Heat and smoke pre-treatment of seeds to improve restoration of an endangered Mediterranean climate vegetation type. Austral Ecology 42: 354–366. https://onlinelibrary.wiley.com/doi/epdf/10.1111/aec.12449.

Hall SA, Holmes PM, Gaertner M, Esler KJ 2021. Active seed sowing can overcome constraints to passive restoration of a critically endangered vegetation type. South African Journal of Botany, 138: 249-26; https://tokaipark.com/wp-content/uploads/2021/02/Hall-S-Active-seed-sowing-2021.pdf.

Holmes PM, Esler KJ, van Wilgen BW, Richardson DM 2020. Ecological restoration of ecosystems degraded by invasive alien plants in South African Fynbos: Is spontaneous succession a viable strategy? Royal Society of South Africa 75: 111-139, doi.org/10.1080/0035919X.2020.1781291. https://www.researchgate.net/publication/342959908_Ecological_restoration_of_ecosystems_degraded_by_invasive_alien_plants_in_South_African_Fynbos_Is_spontaneous_succession_a_viable_strategy.

Holmes PM, Grey P 2017. Guidelines for the Rehabilitation of Leipoldtville Sand Fynbos. https://www.researchgate.net/publication/315779242_Guidelines_for_the_Rehabilitation_of_Leipoldtville_Sand_Fynbos.

Rusch UD, Midgley JJ and Anderson B 2013. Competing seed consumers drive the evolution of scatter-hoarding: Why rodents do not put all their seeds in one larder. *African Zoology* 48: 152 – 158; https://www.sciencedirect.com/science/article/pii/S0254629912001482.

Slingsby P 2017. *Ants of Southern Africa: the Ant Book for All*. Slingsby Maps, Muizenberg Cape Town; https://www.nhbs.com/ants-of-southern-africa-book.

www.dffe.gov.za Department of Forestry, Fisheries and the Environment website, which provides access to e.g.: NEM:BA 2014 Invasive Species Regulations, the listed invasive species and the National Protected Area Expansion Strategy.

www.fpasa.co.za Fire Protection Association.

www.inaturalist.org Citizen science platform to view images of species and to upload your own images for confirmation of identification; note that images must show diagnostic features for a positive identification – usually details of flower structure or seeds and leaves in addition to the whole plant.

www.iso.org/standard/63787.html ISO 45001 International requirements for an occupational health and safety management system.

www.iso.org/standard/62085.html ISO 9001 International quality management systems.

www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Sustainability-At-IFC/Policies-Standards/Performance-Standards International Finance Corporation (IFC) Performance Standards for risk management, labour, resource efficiency and community.

https://asq.org/quality-resources/iso-26000 International Standard Organization (ISO) 26 000: guidance on social responsibility.

Part B. Ecological Restoration Guidelines, sections 7-8

Coldrey, KM 2020. *Options for financing ecological infrastructure interventions in South Africa: lessons from international experience*. A report for the Socio-Economic Benefits of Investing in Ecological Infrastructure (SEBEI) project, University of Cape Town; http://www.acdi.uct.ac.za/socio-economic-benefits-ecological-infrastructure-sebei#Outputs.

Rebelo AJ, Holden, PB, Esler, K and New, MG 2021. Benefits of water-related ecological infrastructure investments to support sustainable land-use: a review of evidence from critically water-stressed catchments in South Africa; https://royalsocietypublishing.org/doi/pdf/10.1098/rsos.201402.

SEBEI Policy Brief 2021. *How can investment in Ecological Infrastructure increase water security and alleviate poverty*, University of Cape Town, http://www.acdi.uct.ac.za/socio-economic-benefits-ecological-infrastructure-sebei.

www.capenature.co.za/protected-areas-and-stewardship CapeNature works in partnership with private landowners, communities, agricultural businesses and other stakeholders to ensure biodiversity survives in a changing climate outside protected areas with tangible benefits to the local communities and shareholders.

www.wwf.org.za/?20241/first-conservation-easement First Conservation Easement example for South Africa.

10. Acknowledgements

We are extremely grateful to the Hans Hoheisen Charitable Trust for funding three years of Sand Fynbos restoration ecology research, as well as the complementary ecological restoration implementation at Blaauwberg Nature Reserve. We acknowledge the long-term partnership (since 2012) between managers from the Biodiversity Management Branch, City of Cape Town, and researchers from the Conservation Ecology and Entomology Department at Stellenbosch University (SU) as being fundamental to effective progress in Sand Fynbos ecological restoration outcomes. This collaboration has periodically involved staff or students from the South African National Biodiversity Institute, the Centre for Invasion Biology at SU and the Cape Peninsula University of Technology. Thanks are due to BM van der Linde for text editing and P Grey for document design.

Figure 37: *Serruria trilopha* is a critically endangered resprouter shrub, with a few individuals remaining in the population, that will benefit from species restoration (PH).

Photograph credits:

AGR – Tony Rebelo

AS – Abraham Saaiman

CD – Clifford Dorse

DvE – Deon van Eeden

JvdM – Jacques van der Merwe

KE – Karen Esler

PG – Penelope Grey

PH – Patricia Holmes

SD – Suretha Dorse

SG – Sjirk Geerts

11. Tables

Table 1

General principles for Fynbos ecological restoration

Principle	Examples
1. Planning & resources	• After defining the site restoration goal(s), ensure sufficient resources by developing an appropriate restoration management plan with annual plan(s) of operation; assign human resources or draw up a bill of quantities where work has to be outsourced
2. Remove/ameliorate degradation factor	• Control invasive alien plants (by Fell & Burn, Fell & Stack, Stack Burn, Retain Stack, Fell & Remove Fuel, as appropriate) • Consider prescribed burn to volatilise excess nutrients in soil, litter layer & kill surface seed banks of alien annuals • Plan for alien control follow-ups – most important where wattles present & after fires
3. Promote passive restoration	• In higher restoration potential areas, plan an ecological prescribed burn to stimulate spontaneous regeneration from soil-stored seed banks. Timing (immediate versus delayed a few years) depends on extent of Fynbos cover & presence of wattle in seed bank; seek advice from plant ecologist • Re-introduce any missing growth forms (e.g. overstorey, serotinous *Protea* & *Leucadendron* species not present in soil seed bank) by sowing following fire
4. Ground preparation for active restoration	• For unburnt sites, rake litter layer to expose soil and provide suitable seed bed • In highly degraded, exposed, coastal areas consider erecting wind nets or brush fences to prevent soil erosion & scouring of seedlings
5. Avoid mistakes in species re-introductions	• Ensure best selection of benchmark reference site(s): correct veld type, plant community and closest example(s) • Don't introduce closely-related species that could hybridise with local species • In preparing rootstock ensure sufficient individual plants harvested to avoid future inbreeding • Be wary of alien earthworms, soil pathogens & weed introduction with rootstock: bare-rooted or plugs less likely to cause problems than larger bagged rootstock
6. Select plant material linked to restoration goal	• Collect seed of locally dominant growth form species (shrubs, restios, forbs) to initiate partial ecological restoration; note: shrubs that resprout after fire often best established from rootstock • Collect diverse, locally indigenous species representing all important growth forms & main families, for full ecological restoration; some rarer species may also require re-introduction by rootstock
7. Sowing & planting	• Implement in correct seasons: sowing: late Summer/early

	Autumn; rootstock planting: late Autumn/ early Winter following first heavy rains (for Winter-rainfall areas) • Seed pre-treatments greatly increase germination success: give hard-seeded species a heat-pulse pre-treatment & all species a smoke treatment prior to sowing
8. Anticipate set-backs	• Rodent control: excessive granivory may undermine active restoration following wattle clearing; erect owl & raptor perches to encourage predation • Alien annual weeds: in rural areas adjacent to fields species, e.g. Wild Radish, Wild Oats, may rapidly invade; include Fynbos pioneers (annuals, short-lived shrubs) in seed mix to hold weeds at bay until other perennials establish
9. Monitor & maintain	• Treat each restoration as an experiment to track progress, learn & adjust methods as required • Monitor plant cover per growth form, including alien species, in the first Spring then annually at the end of Summer for three years if possible; note any species that failed to establish • Adjust restoration maintenance plan if required (e.g., alien follow-up control, augmenting rootstock planting)

Table 2

Habitat condition categories for mapping restoration interventions: definitions and restoration actions*^

Category		Definition	Restoration Actions
1	Natural	Structurally an intact ecosystem with no evidence of any past major unnatural disturbance; species composition 80-100% of expected.	No active restoration required. Maintain optimal disturbance regime (e.g. fire, browsing) and invasive alien species control; monitor threatened or sensitive taxa.
2	Near-natural	Structurally a relatively intact ecosystem that may have suffered some negative impacts historically (e.g. altered fire regime, alien invasion, brush-cutting, resource extraction); species composition 50-80% of expected.	No active restoration required, unless there is evidence of recent local extinctions. In the latter case, re-introductions of species from the nearest local population source could be considered. Re-introduce optimal fire regime and invasive alien species control; monitor threatened and sensitive taxa.
3	Degraded (3a & 3b)	3a. Altered ecosystem with some structural elements (e.g. overstorey shrub layer) completely missing; low to moderate species richness; soil seed banks depauperate; alien plant cover is low to closed-canopy; species composition 10-50% of expected. Area has suffered once-off, historical soil disturbance, such as ploughing or bulldozing. 3b. As above, but no obvious unnatural soil disturbance.	3a. Consider whether compacted or bulldozed soil requires scarification or replacement, respectively. Active restoration is required to re-introduce any missing structural elements, such as the overstorey proteoid layer after dense alien invasion. Plan re-introductions from nearest local populations, preferably by seed. Integrate restoration with invasive alien control and fire management plans. Over time it may be possible to re-introduce missing elements of biodiversity, in particular threatened species with small populations or those currently missing but previously recorded at the site. 3b. As above, without manipulation of substratum.
4	Highly degraded	Vegetation structure is altered with many key elements missing (mainly weedy, herbaceous species remain owing to frequent brush cutting, fires, ploughing or long-standing invasion); soil seed banks largely depleted (little evidence of geophytes); alien plant cover is low to closed-canopy; species composition 1-10% of expected.	Consider whether compacted or bulldozed soil requires scarification or replacement, respectively. Active restoration is required to re-introduce all the main structural elements of the vegetation. Plan re-introductions from nearest local populations, preferably by seed. Integrate restoration with invasive alien control and fire management plans. Focus on restoring a structurally-representative vegetation stand that can function as naturally as possible. Over time it may be possible to re-introduce missing elements of biodiversity, in particular species that are under-represented or perform a keystone function (e.g. to sustain pollinators).
5	Extremely degraded	Land has been transformed by repeated ploughing (or other land-use activity) so that vegetation	The decision to restore an old field will depend on the context of the particular site and whether it forms part of an important ecological corridor

		structure and soil-stored seed banks are destroyed and not restorable without significant intervention; species composition 0-1% of expected (some weedy indigenous ephemerals may have colonised old fields).	or buffers high quality remnants within a reserve. Active restoration is required to re-introduce all the main structural elements of the vegetation. Plan re-introductions from nearest local populations, preferably by seed. Integrate restoration with invasive alien control and fire management plans. Focus should be on restoring a structurally-representative vegetation stand that can function as naturally as possible. Over time it may be possible to re-introduce missing elements of biodiversity, in particular species that are under-represented or perform a keystone function (e.g. to sustain pollinators).
6	Extremely Modified	Hard infrastructure (buildings, hard-surfacing) now replaces the historical ecosystem and the site is considered permanently altered and non-restorable.	No active restoration recommended. In places utility areas may be landscaped using local indigenous species, but this cannot be considered as ecological restoration. Some areas may be rehabilitated by removing foreign substrata, then over time restoration may be possible.

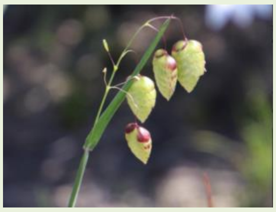
**Note that this applies to terrestrial and seasonal wetlands ecosystems, but not to permanent water bodies or perennial wetlands, which will require different assessment criteria and interventions.*

^Note that in order to maintain a restored ecosystem, the natural disturbance regime must be re-instated and maintained (e.g. fire, browsing, hydrological conditions). Table modified from City of Cape Town, Biodiversity Management Branch.

Table 3

Common Invasive Species in Sand Fynbos and Methods of Control*

Photo	Species	Control Method
	*Acacia saligna* (Port Jackson Willow)	Strong resprouter ➢ Hand-pull seedlings ➢ Cut saplings below root crown (push loppers below ground) to prevent resprouting or use popper ➢ Cut larger trees close to ground level and paint with herbicide within 60 seconds of cutting, before cut cells suberize & prevent uptake. Herbicides have a negative impact on restoration, so should be applied carefully, using recommended methods. Registered herbicide: Clopyralid 90 + Triclopyr (as amine salt) 270 g/L SL ➢ Biocontrol: seed feeder: (*Melanterius compactus)* & fungal galler (*Uromycladium tepperianum)*
	*Acacia cyclops* (Rooikrans; Red-eye Wattle)	Non-sprouter ➢ Hand-pull seedlings and small saplings ➢ Cut larger shrubs low to ground; no herbicide required ➢ Biocontrol available: seed-feeder (*Melanterius servulus*) & flower galler (*Dasineura dielsii*) - both reduce seed production
	*Eucalyptus* species; e.g. *E. conferruminata* (Spider Gum)	Strong resprouter ➢ Hand-pull seedlings & small saplings ➢ Use popper for larger saplings ➢ Cut & stump-treat larger trees. Registered herbicide: Triclopyr (as amine salt) 360 g/L SL
	*Leptospermum laevigatum* (Australian Myrtle)	Weak resprouter ➢ Hand-pull seedlings & small saplings ➢ Use popper for larger saplings ➢ Cut & stump-treat larger trees. No registered herbicide, but if cut very low may not resprout

	*Pinus pinaster* (Cluster Pine)	Non-sprouter ➢ Hand-pull seedlings & small saplings ➢ Use popper for larger saplings ➢ Cut larger trees low or ringbark
	*Hakea drupacea* (Sweet Hakea)	Non-sprouter ➢ Hand-pull seedlings & small saplings ➢ Use popper for larger sapling ➢ Cut larger trees low or ringbark
	*Raphanus raphanistrum* (Wild Radish/ Jointed Charlock)	Annual ➢ Hand-pull ➢ Foliar spray while actively growing in winter. No registered herbicide ➢ A hot prescribed burn will kill shallow alien seed bank
	*Avena fatua* (Wild Oats)	Annual ➢ Foliar spray while actively growing in Spring. Registered herbicide: Glyphosate (as isopropylamine salt) 360 g/l SL ➢ A hot prescribed burn will kill shallow alien seed bank
	*Briza maxima* (Large Quaking grass) Annual	Annual ➢ Foliar spray while actively growing in winter. No registered herbicide ➢ A hot prescribed burn will kill shallow alien seed bank
	*Bromus driandrus* (Ripgut) Annual	Annual ➢ Foliar spray while actively growing in early winter. No registered herbicide ➢ A hot prescribed burn will kill shallow alien seed bank
	*Cynodon dactylon* (Kweek) Indigenous	Resprouter ➢ Foliar spray while grass actively growing in Spring. No registered herbicide

	*Ehrharta calycina* (Veld grass) Indigenous	Resprouter ➢ No tested method in ecological restoration ➢ Suggest fire to volatilize nutrients, active restoration (especially shrub cover) combined with grazing to reduce *Ehrharta* over long-term

* The Working for Water web site provides information on commonly applied control methods: https://www.environment.gov.za/sites/default/files/docs/controltables.pdf

(Photo credits PH and AGR)

Table 4

Suggested species for restoring structure and function to degraded areas in Cape Flats Sand Fynbos post-fire or after alien clearance (example: Blaauwberg Nature Reserve)

Please note: other species may be substituted; geophytes optional (not included here); <u>resprouters underlined</u>.

Species	Growth Form	Method	Notes
Dimorphotheca pluvialis	Annual	seed	
Gymnodiscus capillaris	Annual	seed	
Helichrysum moeserianum	Annual	seed	
Heliophila coronopifolia	Annual	seed	
Oncosiphon suffruticosum	Annual	seed	
Senecio elegans	Annual	seed	
Ursinia anthemoides	Annual	seed	
<u>*Agathosma imbricata*</u>	Ericoid shrub	seed/cuttings	May be best sown in nursery
Anthospermum aethiopicum	Ericoid shrub	seed	Good pioneer
Chrysocoma coma-aurea	Ericoid shrub	seed	Good pioneer
Cliffortia polygonifolia	Ericoid shrub	seed	
<u>*Diosma oppositifolia*</u>	Ericoid shrub	seed/cuttings	May be best sown in nursery
Erica axillaris	Ericoid shrub	seed	
<u>*Erica mammosa*</u>	Ericoid shrub	seed/cuttings	
Erica plumosa	Ericoid shrub	seed	May be best sown in nursery
Metalasia densa	Ericoid shrub	seed	
Passerina corymbosa	Ericoid shrub	seed	Good pioneer
<u>*Phylica cephalantha*</u>	Ericoid shrub	seed/cuttings	Heat pulse
Serruria fasciflora	Ericoid shrub	seed	
Seriphium incanum	Ericoid shrub	seed	
Seriphium plumosum	Ericoid shrub	seed	

<u>*Trichocephalus stipularis*</u>	Ericoid shrub	seed/cuttings	Heat pulse
Trichogyne ambigua	Ericoid shrub	seed	
Senecio hastatus	Forb	seed	
Helichrysum niveum	Forb/subshrub	seed	
Pelargonium capitatum	Forb/subshrub	seed	Heat pulse
Senecio burchellii	Forb/subshrub	seed	
Pseudopentameris macrantha	Graminoid	seed	
Restio duthieae	Graminoid	seed	
Thamnochortus punctatus	Graminoid	seed	Heat pulse
Tribolium uniolae	Graminoid	seed	
<u>*Leucadendron salignum*</u>	Proteoid shrub	seed/cuttings	May be best sown in nursery
Protea repens	Proteoid shrub	seed	
Protea scolymocephala	Proteoid shrub	seed	

Table 5

Examples of Some Costs in Ecological Restoration for Outsourcing Work (ha = hectare; pd = person days). Note that person day costs are averages and exclude transport, equipment and materials (e.g., herbicide).

Restorative Action	Task	Costs/ ha (2021)	Costs/ ha (pd)	Notes
Dense invasive alien control (>75% cover)	• Wattle initial clearance • Wattle follow-up control	• R12,500 • R5,580	• 56 pd/ ha • 34 pd/ ha	EPWP rates (private rates much higher); Fell & Stack method; Follow-up more intensive after fire
Prescribed block burn (5-50 ha)	• Includes: assign Fire Boss, coordinate teams & equipment, conduct burn, mopping up	• R131,000 for whole burn area	• 40 pd for whole burn area	NB Economy of scale: larger block uses similar resources to smaller block; includes staff time, equipment costs, permits; dry season burn. Details given in Appendix 3
Stack burns	• Burn & monitor individual stacks	• R3,120	• 4.5 pd/ha	Includes staff time, equipment costs, permits; wet season burn
Seed collecting	• Seed collecting • Seed cleaning, sorting • Seed pretreatment		• 15.5 pd/ ha • 2 pd/ ha • 1 pd/ ha	Collection of ± 20 species; excludes transport, seed room & nursery costs
Site preparation	• Raking • Sowing		• 1 pd/ ha • 1 pd/ ha	Four 10m-diameter circles/ha; excludes transport
Propagation	• Seed & cutting material collecting • Rooting & germinating in nursery • Hardening off for planting	Variable (total cost from R7/ plug to R23/ 1litre bag)		Depends on no. of species & quantities. Establishment of three perennials/ m^2 is sufficient to initiate ecological restoration
Monitoring	• Assess growth form cover & total plant cover • Assess species establishment		• 1-5 pd/ session; depends on project size • Included in above	Assess growth forms during first Spring then in late Summer for 3 years; record species once identifiable; excludes transport
Contingency	Miscellaneous	10% of total		To cover unexpected issues, such as fire, resurgence of aliens, failure of rootstock etc

Table 6

Safety, Health & Environment Operational Risks

Incidences/ risks	Activities	Mitigation/ control measure	Regulation
Occupational Injuries	Field work (alien clearing, seed collection) • Operating machines • Trip and Fall • Burns • Snake bites	SHE standards and SHE Rep Certified machine operator First Aid Rep PPE Training on snakes Snake bites treatment First Aid kit on site Provision of safe water to drink Raw call Designated smoking area Water tank	Occupational Safety and Health Act, Section 3 & 8 of 1993
Fires	Operational Accidental (cigarette)	Fire beaters Fire fighters Fire truck Water tanks	National Environment Management Air Quality Act 39 of 2004
Infectious Diseases & Occupational Exposure	Insect bites (tick fever) Allergies (pollen) Chemicals (herbicides) Repetitive strains (bending) Noise from chain saws Covid 19 Hygienic (cholera) Outdoor exposure • Getting lost • Sunburn, dehydration, colds	Tick bite treatment PPE (gloves, masks, boots, ear buds, goggles) Social distancing	National Health Act 61 of 2003
Invasive Alien Pants	Sowing seeds Disposed seeds from food	Seed mix approval Designated disposal	National Environmental Management Biodiversity Act 10 of 2004
Generation & Disposal of Waste	Containers of herbicides Littering (plastic) Human waste Organic waste (peels & seeds)	Licensed waste disposal Garbage bags Mobile toilets Running water	National Environmental Management Waste Act 59 of 2008
Crime	Theft & vandalism	Controlled access	

C. Appendices

Appendix 1. Photographic Seed Processing Guide, example for Cape Flats Sand Fynbos at Blaauwberg

Seed collection and processing guide

* Seed mixes for the purpose of ecological restoration are often only partially-cleaned and in some cases, where the size of seeds and debris are similar, or seeds are very small in relation to the debris, the proportion of debris in the seed mix is high. The main objectives of seed-cleaning for ecological restoration are to reduce the bulk of the collection (to reduce the space needed for seed storage and to increase ease of handling when weighing, treating, broadcasting) and to remove covering structures that might inhibit seed germination.

** Not all genera require smoke treatment of seeds prior to sowing however in practice it is often easier to smoke all of the seeds in a seed mix, particularly since it is unlikely that the germination of Fynbos species would be negatively impacted by smoke treatment.

*** If you do not know a species you may search for a photograph on iNaturalist: www.inaturalist.org – click Explore and add the species into the species box. Choose your view (map or grid).

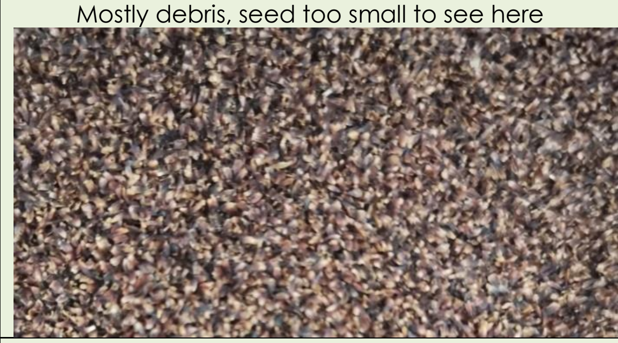
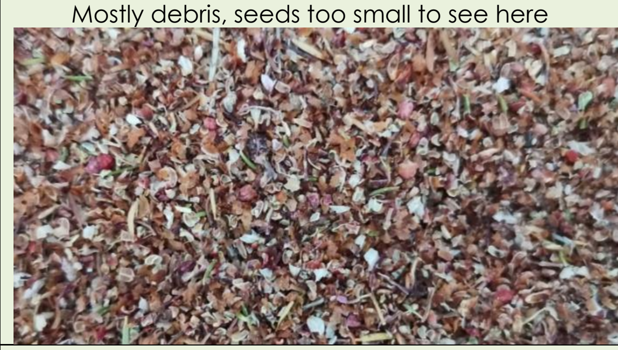
GENUS SPECIES	COLLECT SEED												REGENERA -TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Adenogramma rigida										X	X		seeder	forb				H and/or S	No
Agathosma imbricata											X	X	resprouter	ericoid shrub				H and/or S	S

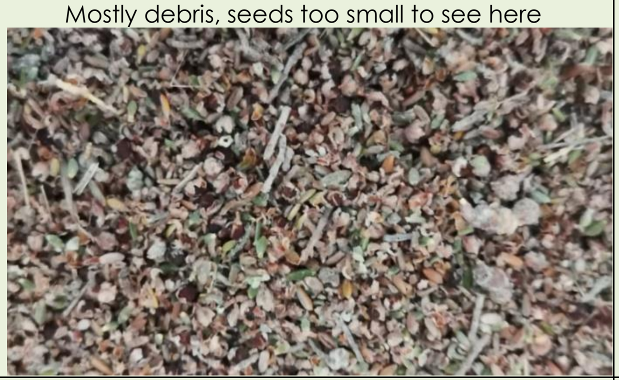
GENUS SPECIES	COLLECT SEED												REGENERA -TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Albuca flaccida										X	X	X	resprouter	geophyte				H and/or S	No
Amphithalea ericifolia										X	X	?	seeder	shrub				H and/or S	H & S
Annesorhiza macrocarpa	X	X											resprouter	shrub				H	No
Anthospermum aethiopicum										X	X	X	seeder	ericoid shrub	Y	Male (left) female (right) 		H and/or S	No

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Arctotheca calendula								X	X				seeder	annual				H	S
Argyrolobium velutinum											X	X	resprouter	forb				H	H & S
Aspalathus ternata	?										X	X	seeder	ericoid shrub				H and/or S	H & S
Asparagus aethiopicum											X		resprouter	scrambler				H	?
Babiana ringens											X		resprouter	geophyte				H	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Babiana villosula										X			resprouter	geophyte	Y			H and/or S	S
Baeometra uniflora										X	X	X	resprouter	geophyte				H and/or S	?
Bobartia indica											X	X	resprouter	geophyte				H	S
Chasmanthe aethiopica										X			resprouter	geophyte				H	S
Chrysocoma coma-aurea										X	X		seeder	ericoid shrub				H	S
Cliffortia polygonifolia	X									X	X	X	seeder	ericoid shrub	Y		Debris-seed mix	S	?

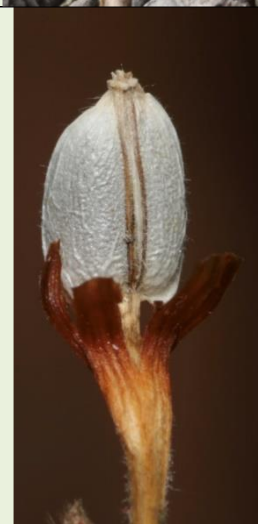
GENUS SPECIES	COLLECT SEED												REGENERA -TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
																			
Cliffortia sp. cf falcata										X	X		seeder	ericoid shrub				S	?
Clutia sp.											X								?
Conicosia pugionifolius	X										X	X	seeder	succulent				Grinder or secateurs to open capsules	S
Dimorphotheca pluvialis									X	X			seeder	annual			Seed from disc floret (left) and ray floret (right) 	H and/or S	S
Diosma oppositifolia									X	X	X	X	resprouter	ericoid shrub				H and/or S	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Elegia tectorum												X	seeder	restioid			Mostly debris, seed too small to see here 	H and/or S	S
Erepsia cf. ramosa		X											seeder	succulent			Debris (most capsules crushed), seeds (small, dark) not visible here 	Grinder or secateurs to open capsules	S
Erica cerinthoides	?										X	X	resprouter	ericoid shrub				H and/or S	S
Erica cf. axillaris		X											seeder	ericoid shrub				H and/or S	S
Erica ferrea	X							X	X			X	seeder	ericoid shrub			Mostly debris, seeds too small to see here 	H and/or S	S
Erica mammosa	X										X	X	resprouter	ericoid shrub	Y		Mostly debris, seeds too small to see here	H and/or S	S

GENUS SPECIES	COLLECT SEED												REGENERA -TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
																			
Erica plumosa									X	X	X		seeder	ericoid shrub			Mostly debris, seeds too small to see here 	H and/or S	S
Ferraria uncinata												X	resprouter	geophyte				H	S
Gladiolus carinatus										X	X		resprouter	geophyte				H	S
Gymnodiscus capillaris										X			seeder	annual				H and/or S	S
Helichrysum dasyanthum										X	X		seeder	shrub			Mostly debris, seeds not visible here	H and/or S	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
																			
Helichrysum patulum	X												seeder	shrub				H and/or S	S
Helichrysum revolutum										X			seeder	shrub				H and/or S	S
Heliophila coronopifolia										X	X		seeder	annual				H and/or S	S
Ifloga repens									X	X	X		seeder	ericoid shrub	Y		Mostly debris, seed (small, black, shiny) not visible here 	H and/or S	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Ixia dubia											X		resprouter	geophyte				H and/or S	S
Lachenalia orchioides										X			resprouter	geophyte				H and/or S	No
Lachnaea capitata	**? seed has not yet been collected**												seeder	ericoid shrub					S
Lachnaea grandiflora	**? seed has not yet been collected**												resprouter	ericoid shrub					S
Lachnospermum fasciculatum	X												seeder	ericoid shrub				H and/or S	S
Lampranthus explanatus				X									seeder	succulent				Grinder or secateurs to open capsules	S
Lampranthus reptans												X	seeder	succulent				Grinder or secateurs to open capsules	S
Lapeirousia anceps											X		resprouter	geophyte				H and/or S	S
Lessertia frutescens	X	X									X	X	seeder	forb/ subshrub				H and/or S	H & S
Leucadendron levisanus										X			seeder	proteoid				Shake dry cones in a glass jar, with possible additional hand sorting for	S

GENUS SPECIES	COLLECT SEED												REGENERA -TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
																		few remaining seeds	
Leucadendron salignum	X	X											resprouter	proteoid shrub				Shake dry cones in a glass jar, with possible additional hand sorting for few remaining seeds	S
Leucospermum hypophyllocarpodendron	X												resprouter	proteoid			 	H and/or S	S
Leysera gnaphaloides											X	X	seeder	forb/ subshrub				H	S
Macrostylis villosa											X		resprouter	ericoid shrub				H and/or S	S
Manulea sp. (or Polycarena sp.)										X	X		seeder	annual				H and/or S	S

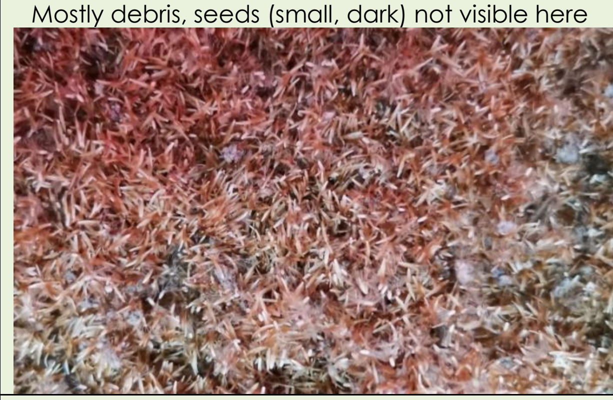
GENUS SPECIES	COLLECT SEED												REGENERA -TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Metalasia densa							X						seeder	ericoid shrub				H and/or S	S
Microdon capitatus	X												seeder	forb/ subshrub			Mostly debris, seeds (small, dark, shiny) not visible here 	H and/or S	S
Moraea fugax										X			resprouter	geophyte				H	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Oncosiphon grandiflorum											X	X	seeder	annual	Y			H	S
Ornithogalum thyrsoides	X												resprouter	geophyte				H and/or S	No
Ornithoglossum viride										X			resprouter	geophyte				H	?
Osteospermum monostrum									X	X			seeder	annual				H	S
Othonna undulosa									X				resprouter	succulent				H	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Passerina corymbosa											X	X	seeder	ericoid shrub	Y			H and/or S	S
Pelargonium capitatum									X	X	X		seeder	forb	Y			H	H & S
Pelargonium myrrhifolium var. coriandrifolium												X	resprouter	geophyte				H	H & S
Pelargonium triste										X	X		resprouter	geophyte				H	H & S
Pentameris pallida											X		seeder	graminoid				H and/or S	S
Pharnaceum lanatum		X											seeder	shrublet				H and/or S	No

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Phylica cephalantha										X	X		resprouter	ericoid shrub	Y			Grinder to open capsules, followed by sieving. Possibly some hand sorting required.	H
Phylica imberbis											X		seeder	ericoid shrub				H	H
Phylica plumosa										X	X		seeder	ericoid shrub				H	H
Polycarena sp.(see Manulea)																			
Protea repens		X											seeder	proteoid	Y			H	S
Protea scolymocephala		X											seeder	proteoid	Y			H	S
Restio praeacutus										X			resprouter	restioid				H and/or S	S
Restio duthieae										X			resprouter	restioid				H and/or S	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Restio sieberi										X			resprouter	restioid				H and/or S	S
Romulea rosea											X		resprouter	geophyte				H	S
Salvia africana												X	resprouter	shrub				H and/or S	?
Senecia burchellii									X	X			seeder	forb				H	S
Senecia elegans									X	X			seeder	annual				H	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Senecio foeniculoides	X												seeder	shrub				H	S
Senecio hastatus										X			seeder	forb				H	S
Seriphium plumosum (= Stoebe plumosa)							X	X	X	X			seeder	ericoid shrub			Mostly debris, seeds (small, dark) not visible here 	H and/or S	S
Serruria decipiens	X										X	X	seeder	ericoid/ proteoid				H and/or S	S
Serruria fasciflora	X												seeder	ericoid/ proteoid				H and/or S	S
Serruria trilopha	X									X	X	X	resprouter	ericoid/ proteoid				H and/or S	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Sparaxis bulbifera										X	X		resprouter	geophyte				H	S
Staavia radiata										X	X		resprouter	ericoid shrub		Inflorescences still too fresh here, seed not yet ripe 		H and/or S	S
Staberoha distachyos						X	X	X	X	X	X		seeder	graminoid				H and/or S	S
Thamnchortus bachmannii									X	X			seeder	restioid				H and/or S	H & S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Thamnochortus fruticosus						X	X						seeder	graminoid	Y			H and/or S	H & S
Thamnochortus lucens		X											seeder	restioid				H and/or S	H & S
Thamnochortus punctatus						X							seeder	graminoid	Y		*T. punctatus* mixed with *T. fruticosus* 	H and/or S	H & S
Trichocephalus stipularis										X	X	X	resprouter	ericoid shrub				Grinder to open capsules, followed by sieving. Possibly some hand sorting required.	H
Ursinia anthemoides									X	X	X		seeder	annual				H	S

GENUS SPECIES	COLLECT SEED												REGENERA-TION MODE	GROWTH FORM	LARGE QTY	RIPE SEED IN-FIELD	SEED MIXES: CLEANED / PARTIALLY-CLEANED SEED*	Method of cleaning H=hand sorting S=sieving / other	Treatment pre-sowing H=heat S=smoke **
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC							
Wachendorfia multiflora										X	X	X	resprouter	geophyte				H	S
Wahlenbergia capensis										X			seeder	annual				H and/or S	S
Watsonia meriana	X											X	resprouter	geophyte	Y			H	S
Wiborgia obcordata		X											seeder	shrub				Very difficult to open pods. Possibly cut pods with secateurs.	H & S
Willdenowia arescens										?			seeder	restioid				H	H & S
Willdenowia incurvata										X	X		seeder	restioid				H	H & S

(Photo credits PG, AGR, CD, JvdM, DvE)

Seed cleaning equipment:

Figure 38: Large grinder at the SANBI Seed Room. Capsules are ground through the grinder several times before sieving. The setting on the grinder is small enough to crack open capsules and large enough to avoid damaging the seed. A rolling pin or wine bottle may be used instead but is labour intensive (PG).

Figure 39: Sieves in series are extremely efficient to separate out the debris from the seed – for many species. However, for some species, the debris and seed are of a similar size, or the size of the seed is extremely small, and for the purpose of restoration it is acceptable to use a partially-cleaned seed mix containing a large proportion of debris e.g. *Erica* species, *Passerina*, *Cliffortia* etc (PG).

Figure 40: A wooden mallet is useful for crushing capsules, particularly for a small collection as it is quite physically demanding. A rolling pin or wine bottle may also be used (PG).

Appendix 2. Restoration Management Plan Template, including Restoration Annual Plan of Operation (RAPO)

Restoration Management Plan Template Example (adapted from City of Cape Town)
Note: instructions/ examples are given in red font

[INSERT RESERVE/ SITE NAME]

Overall Reserve Vision
Copy from Integrated Reserve Management Plan (IRMP)

The Vision of xxx is:
To manage xxx

Restoration Goal

The restoration goal is to reinstate the natural Cape Flats Sand Fynbos vegetation structure and functioning. This will ensure that the conservation integrity of the xxx Nature Reserve (NR) reaches a mostly near-natural state, whereby the long-term ecological integrity of the Cape Flats Sand Fynbos vegetation type is preserved.

The implementation of an effective management plan, with particular reference to veld restoration, fire management and invasive species management, will assist in the long-term contribution that the site makes towards the overall conservation efforts of this Critically Endangered Cape Flats Sand Fynbos vegetation type.

1. General site background

1.1 Location

E.g. Blaauwberg NR (give reference or link to Integrated Reserve Management Plan).
(Map: location of site)

1.2 Ecological Drivers

Refer to the 2016 Fynbos Forum Ecosystem Guidelines (http://biodiversityadvisor.sanbi.org/wp-content/uploads/2012/04/Ecosystem_Guidelines_Ed2.pdf) if unsure. E.g. for Fynbos and Renosterveld ecosystems, an important driver is fire; for Strandveld and Renosterveld ecosystems grazing/ browsing disturbance is important.

Cape Flats Sand Fynbos is a fire-driven ecosystem. However, too frequent fires or alternatively too infrequent fires are contributing factors towards the degradation of this ecosystem. The restoration of identified areas will also aim to restore the major driving force, which is fire, to more natural intervals, as this will assist in the improvement of the vegetation condition.

1.3 Biophysical description

Provide a brief summary of the biophysical setting of the site including vegetation types, soils, topography, climate, specialized habitats (or refer to the IRMP for more information).

(Map: Vegetation map - SANBI national vegetation map: include vegetation subtypes (and plant communities if available) – see link to SANBI BGIS above)

Vegetation type:

Soils, geology and topography:

Climate:

Hydrology:

Specialised habitats:

1.4 Historical land-use

Brief overview of past land uses that may have degraded the biodiversity on site, e.g ploughing, grazing, mowing, soil removal, invasive alien vegetation, introduction of extra-limital species, fire history.

(Map: Historical land-use; veld age map; alien (NBAL or management unit) map - optional)

2. Sites requiring restoration

The habitat condition categories as set (see Appendix x in Restoration Guidelines) were used to map the xx NR in order to inform restoration planning.

Habitat condition assessment took place on xxxx, led by xxx staff/ consultants.

The reserve was delimited into xxx habitat condition areas for the purpose of this Restoration Plan according to the habitat condition scores and mapped.

Cape Flats Sand Fynbos (list these for each vegetation type in Reserve)

- **Natural** (habitat condition score **1**)
    - Reserve Name site (e.g. Blaauwberg F, list all sites for score)
- **Near-natural** (habitat condition score **2**)
    -
- **Degraded** (habitat condition score **3**)
    -
- **Highly degraded** (habitat condition score **4**)
    -
- **Extremely degraded** (habitat condition score 5)
    -
- **Extremely modified** (habitat condition score **6**)
    -

Figure 2: Habitat condition map of xxx Nature Reserve, as surveyed in xxx 2021. Red (2) = near-natural, orange (3) = degraded, and mustard yellow (2) = extremely degraded habitat condition. Letters correspond to datasheets, indicating where habitat condition assessments were completed.

Category:
Habitat condition score:
Vegetation type

- *Historical and current land-use activities*
- *Extent of degradation*
- *Current condition and perceived restoration potential, linked to five habitat condition classes*

Category:
Habitat condition score:
Vegetation type:

- *Historical and current land-use activities*
- *Extent of degradation*
- *Current condition and perceived restoration potential, linked to five habitat condition classes*

Photo of each habitat condition site with date taken and photographer's name

2.1 Prioritization of sites for restoration

Most reserves do not have sufficient budget to restore all sites simultaneously. Here, the sites should be listed in terms of priority for restoration. Cross-reference to alien clearance and ecological burning priorities. Each site should be given a number code on the map for future reference (1 = top priority). Note that it is often more cost-effective to first restore the least degraded sites in order to prevent further degradation, and then to tackle the more degraded sites:

- *Site prioritization*
- *Predicted challenges that may occur to pose a threat to the restoration process.*

2.2 Objectives of restoration interventions

For each priority restoration site, clearly state objectives of restoration (e.g. for old quarry site: source and replace topsoil, re-vegetate with local indigenous species – it will not be feasible in this case to restore full structure and composition – so state how many species of which growth forms must be established). Objectives should be measurable, with clear short to medium time-frames (e.g. 2 or 5 yr), and stated in relation to a reference ecosystem.

- Reduce veld senescence with ecological burning
- Trigger germination of indigenous soil stored seed
- Continue to remove invasive alien species
- Re-introduce local indigenous species to restore structure and functioning
- Promote floral diversity; re-introduce locally extirpated species
- Accurately document management actions applied to restoration sites, including results from areas responding to these actions.

Restorative actions in each of the priority restoration sites are summarised in Table 2.

Table 2. Summary of actions required for restoration of habitat condition categories 1-5

Vegetation Type	Specialised Community	Habitat Condition Category	Actions
e.g. Cape Flats Sand Fynbos	no	2. Near-natural	• Reduce veld senescence with ecological burning • Trigger germination of soil stored seed • Continue to remove invasive alien species

3. Reference Site / Ecosystem

Description and location of site(s) representing closest, non-degraded example of the target vegetation community for each of the restoration sites (reference sites may be different for different habitats being restored).

4. Landscape Scale Integration

Where relevant, describe how the restoration relates to the broader landscape, i.e. what its purpose is at the landscape scale in terms of biodiversity pattern and process (e.g. connectivity for faunal migration; minimum viable population sizes etc.)

5. Stakeholders and collaborators

The proposed restoration activities could be dependent on and affect various different parties, so it is important to identify and involve these key stakeholders or collaborators early in the process in order to ensure a positive working relationship.

The following parties will be conducting and assisting with the restoration process:

- Reserve/ Site manager/ Landowner:
    - xxx

- Landowners from where seed will be collected:
  - xxx
- Staff/ contractors/ volunteers assisting with seed collection:
  - Custodians for Rare and Endangered Wildflowers (CREW)
- Invasive alien plant removal:
  - xxx staff/ contractor
- Stakeholders/ staff/ volunteers assisting with post clearing monitoring:
  - CREW – species verification, collection and compilation of species lists.

The roles and responsibilities of each stakeholder will be incorporated into the Restoration annual plan of operation (RAPO) to facilitate how, what, where and when this will be undertaken.

6. Active restoration interventions to date

Table 3. Historical restoration planting summary for xxx Nature Reserve.

Species	Total planted	Source

7. Operational requirements for Restoration Annual Plan of Operation (RAPO)

The RAPO is aligned to the invasive alien plant and fire management plans and was compiled 12 months (at least) prior to any plant or propagule re-introduction. The RAPO of the site includes the following operational guidelines:
(Map: integrated map showing alien vegetation (NBALs/ management units), veld age and restoration priorities covered in the RAPO)

(The following applies to each restoration site on the reserve, and where different sites on a reserve are not to be restored simultaneously, a separate RAPO will be required at a later stage for the lower priority sites. If any of the stated RAPO management activities do not apply to a site they can be removed)

a. Invasive alien clearance

Goal: To remove and control invasive alien vegetation by the most cost-effective method that simultaneously restores indigenous vegetation cover. Only required in situations where there is no Alien Clearance Subsidiary Plan (ACSP); otherwise refer to the relevant ACSP and NBAL/ management units here

Figure 3: Current (2017) invasive alien species plan for xxx Nature Reserve

The invasive alien species recorded during the habitat condition assessment (Table 3) is not an exhaustive list, but rather those species requiring the most urgent attention.

Table 3. Invasive alien species occurring in xxx Nature Reserve that require the most urgent attention. Letters refer to habitat condition sites assessed (or vegetation type for large reserves).

Scientific Name	Common Name	Site	Site	Site
e.g. Acacia saligna	Port Jackson Willow	X	X	X

Pre – Operation: Site Evaluation:

a) Vegetation: Indigenous vegetation cover and condition; invasive alien species present and their perceived re-invasion potential (seed bank), density or coverage, area (ha), growth stage (vegetative, flowering, fruiting); species of concern (rare and threatened); Reserve Management Blocks (NBALs).
b) Terrain: slope, accessibility, mobility
c) Labour: type – skilled / unskilled
d) Method: type – mechanical, chemical, biological, integrated
e) Biophysical conditions: environmental constraints, timing (season)
f) Costs: labour, transportation, maintenance, equipment

During – Operation

a) Monitor clearance process: ensure methods applied correctly (quality control)

Post – Operation

a) Appropriate method for removal of alien slash material (ecological block burn, brush piles, delayed burning or leave to rot)
b) Monitoring: follow-up requirement (regrowth of aliens)
   - indigenous vegetation recovery
   - specific restoration operations to apply (fire, erosion control, re-introductions)

7.2 Fire Management

Fire management should align with the Fire Management Subsidiary Plan (FMSP) – also refer to its check list and plans. Where the FMSP did NOT take restoration requirements into account, it may need to be updated.

Goal: To allow for a natural or managed ecological fire process to promote indigenous vegetation recovery. See Figure 4 for recently mapped fires.

Figure 4. Recently (2010-2021) mapped fires in xxx Nature Reserve.

Pre – Operation: Site Evaluation:

a) Vegetation: indigenous vegetation cover and condition; invasive species present and their perceived re-invasion potential (seed bank), density or coverage, area (ha), growth stage (vegetative, flowering, fruiting); species of concern (rare and threatened); Reserve Management Blocks (NBAL).

b) Terrain: slope, accessibility, mobility.
c) Labour: type – skilled / unskilled,
d) Method: type – brush piles, fire breaks, ecological block burns
e) Administration: permits, FPA letters, first aid kit (logistic personnel – see fire check list)
f) Biophysical conditions: environmental condition, climatic conditions, timing (season)
g) Costs: labour, transportation, maintenance, equipment

During – Operation

a) Equipment: appropriate equipment is available
b) Biophysical conditions: environmental conditions, climatic conditions and timing are to monitored closely prior to the burns
c) Administration: permits, FPA letter, first aid kit (necessary documents must always be in hand; refer to fire check list)

Post – Operation

a) Monitoring of objectives: (note also immediate post-fire assessment e.g. fire debris that may pose a risk, soil erosion risk, that requires additional actions)
    - later post-winter assessment: Indigenous and alien vegetation regrowth
    - specific restoration operations to apply (fire, erosion control and re-introductions).

7.3. Soil Erosion

Goal: To ensure the management of soil erosion risk and rehabilitation of eroded areas

Pre – Operation: Site Evaluation:

a) Vegetation: vegetation type, vegetation cover, veld age, veld history, soil type, area (ha), Reserve Management Blocks (NBAL).
b) Terrain: slope, accessibility, mobility, roads
c) Labour: type – skilled / unskilled
d) Method: type of erosion; (e.g. sheet, rill erosion, donga, head-cut in stream), situation (e.g. path, river, degraded veld) and relevant method (e.g. erosion fences, drainage channels, gabions, mulching, re-vegetation)
e) Biophysical conditions: environmental condition, climatic conditions, timing (season)
f) Costs: labour, transportation, equipment

Post – Operation

a) Monitoring: soil movement
    - regrowth: vegetation cover and condition
    - further restoration operations to apply

7.4. Re-introduction of Plant Species

Goal: To re-introduce plant species historically occurring in the degraded site. Follow restoration guidelines to avoid risk of using unsuitable species or causing hybridization etc.

Refer to Appendix 3 for a list of plant species transplanted on site since xxxx. The localities of re-introduced species need to be revisited, the success of restoration planting recorded, and survival rate evaluated before a planned ecological burn takes place, to contribute to 'lessons learnt' for restoration.

Pre – Operation: Site Evaluation:

a) Vegetation: vegetation type, vegetation cover, veld age, veld history, soil type, area (ha), previous restoration, Reserve Management Blocks (NBAL).
b) Terrain: slope, accessibility, mobility
c) Method: collection (seed or propagated plants), re-introduction (seed or planting)
d) Biophysical conditions: environmental condition, climatic conditions, timing (season)
e) Costs: labour, transportation, propagation and seed storage, equipment

Post – Operation

a) Monitoring regrowth: plant species and vegetation cover; establishment of propagated plants (survival rate) in relation to the set objective.

7.5. Faunal considerations

Are the keystone faunal species required for a functional remnant of xx vegetation type still on site? For example: indigenous ants and specialist pollinators. If these are absent this should mentioned here and how this will be managed or mitigated. If unknown, highlight it as a baseline data gap. This may only be required for smaller, more isolated sites.

Are there indigenous or alien fauna species that could threaten the restoration or long term ecological functioning of the site? For example: alien invasive Argentine ant, too many Grysbok, or too many molerats or gerbils?

7.6. Monitoring

Include an appropriate monitoring programme for active restoration interventions. For example:

a) Rootstock: monitor the number of surviving plants per species after the first summer/autumn season and if possible in subsequent years to inform whether methods are appropriate and whether further restoration is required.
b) Seeded areas: record the species and quantities of seeds sown (e.g. weight of semi-cleaned seed) and monitor establishment success over the next two seasons. Plots, transects and/ or fixed point photographs may be used, but some recording of established species is advisable.

Appendix 1. Restoration Annual Plan of Operation (RAPO) Gantt Chart for xxx Nature Reserve (example)

A. Degraded and modified vegetation type areas.

	ACTIVITY	RESPONSIBLE PARTY/ STAKEHOLDER INVOLVED	BUDGET	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUNE
20xx to one year prior to prescribed burn																
1	Ongoing control of alien Kikuyu	Reserve staff	Herbicide costs													
2	Ongoing control of herbaceous weeds	Reserve staff, assisted by xxx	Staff time													
3	Monitor planted species (survival success pre-burn)	Reserve staff, assisted by xxx or CREW	Staff time													
4	Identify source sites for threatened species to be re-introduced	Cons Services & reserve Staff	Staff time													
5	Interim propagation & planting	Nursery facility, assisted by reserve staff	Staff time/ restoration facility													
6	Draw up seed collecting plan	Manager assisted by Cons Services	Staff time													
From pre-burn year onwards																
7	Collect material for propagation; deliver to Nursery facility (repeat next year)	Nursery facility, assisted by reserve & xxx	Staff time/ restoration facility													
8	Collect seed (off-site) one year pre-burn; deliver to Nursery Facility	Nursery facility & reserve staff, assisted by xx	Staff time/ restoration facility													
9	Site preparation: prescribed burn	Manager/ contractor/ staff	Staff time													
10	Pre-treat fynbos seeds: dry heat shock, hot water soak & smoke, depending on species	Nursery facility	Staff time/ restoration facility													
11	Sow seed: broadcast & rake fynbos seeds (repeat next year)	Nursery facility & reserve staff	Staff time/ restoration facility													
12	Harden off rooted material (repeat next year)	Nursery facility	Staff time/ restoration facility													
13	Plant rooted material in clumps (repeat next year)	Nursery facility & reserve staff	Staff time/ restoration facility													
14	Monitor planted species (repeat next year)	Reserve staff, volunteers, CREW	Staff time													

Appendix 2. Site assessment sheet for xxx Nature Reserve

Site	Coordinates		Habitat Condition						Date	Restoration potential			Notes	Priority	General Comments
	S	E	Open water	Irreversibly modified	Heavily modified / Poor	Degraded / Fair	Near-natural / Good	Natural / Good		Low	Medium	High			

Appendix 3. Plant re-introductions to date in xxx Nature Reserve

		Collection Information					Re-Introduction Information					
Species Name	**IUCN status**	**Source population**	**Seed**	**Cutting**	**Season**	**Date collected**	**Seed broadcast**	**Propagate in house**	**Date re-introduced**	**Point of reintroduction**		**Comments (NB monitor establishment)**

Appendix 4. Suggested species for restoring structure and function to degraded and modified areas post-fire in xxx Nature Reserve

NB – other species may be substituted; geophytes optional (not included here); resprouters underlined. Most species respond positively to smoke treatment, so apply this prior to sowing.

Appendix 5. Selection of species to restore composition to near-natural areas in xxx Nature Reserve

Appendix 6. Plant species recorded at xxx Nature Reserve

Species	Date seen	Sighted by	*Threat Status	Alien	**Growth form

*** Threat status:** LC = least concern, NT = near-threatened, VU = vulnerable, EN = endangered, CR = critically endangered.
**** Growth forms:** A = annual forb, B = bulb/geophyte, ES = ericoid shrub, F = perennial forb/subshrub, G = graminoid, LS = leptophyllous shrub, P = parasite, PS = proteoid shrub, TS = thicket shrub, and V = succulent.

Appendix 3. Costs in 2021 ZA Rands of Conducting an Ecological, Dry Season Prescribed Burn Close to the Urban Edge or Built Infrastructure.

COSTS ARE SIMILAR FOR AN AREA BETWEEN 5-50 HECTARES PROVIDED THAT THE SITE IS RELATIVELY FLAT TO ALLOW COMPLETION IN ONE DAY. LANDOWNERS MAY BE ABLE TO SUBSITUTE THEIR OWN WORKERS AND EQUIPMENT TO REDUCE SOME OF THESE COSTS.						
Item		**QTY**	**Each**	**Sub_Total**	**TOTAL**	**Notes**
Planning and Approval:						
FPA Membership	Annual membership fee (averaged)	1	R1 946	R1 946		
Burn plan	Professional Fees @ R500 per hour	8	R500	R4 000		
Neighbour consent	Travel @ R4.20 /km	180	R4	R756		
Permit application	Cost of application			R1 100		
					R7 802	
Site preparations:						
Tractor with brush cutter	Travel cost @ R800 per hour	7	R800	R5 600		
Team of workers	Raking and stacking brush on edges	10	R180	R1 800		Casual workers
Team manager	Oversee and supervise	1	R308	R308		Professional Worker
					R7 708	
Ignition:						
Skid Units	4x4 with mobile tanker unit fitted (per 15 minutes)	120	R236	R28 320		5 x Skid Units for 6 hours (24 x 15-min sessions)
Bravo Units	Specialised 4x4 5 ton trucks (per 15 minutes)	48	R324	R15 552		2 x Braco Units for 6 hours (24 x 15-min sessions)
Whiskey Units	Specialised water tanker 20 ton trucks (per 15 minutes)	24	R486	R11 664		1 x Heavy Water Tanker (24 x 15-min sessions)

Support vehicles	Usually one or two 4x4 or quad bikes for transporting equipment, provisions etc. from IC to front line where needed	48	R77	R3 696		2 x Quad bikes for 6 hours (24 x 15-min sessions)
Incident Commander	Fire boss for the day	1	R2 000	R2 000		Senior Manager
Logistics	Person in charge of logistics	2	R308	R616		Professional Worker
First aider		2	R180	R360		Casual worker
Scribe		1	R180	R180		Casual worker
Team leaders		4	R308	R1 232		Professional Worker
Driver		11	R308	R3 388		Professional Worker
Fire Fighter		35	R180	R6 300		Casual worker
Fuel (litres)	Drip torches, bakkie sakkie etc.	40	R20	R800		
Tools	10%			R7 411		
Admin	20%			R14 822		
					R96 340	
<u>Mop-up (overnight)</u>	6 PM to 6 AM					
Skid Units	4x4 with mobile tanker unit fitted (per 15 minutes)	48	R236	R11 328		1 x Skid Unit for 12 hours (48 x 15-minute sessions)
Fire fighter		2	R180	R360		Casual Worker
Driver		1	R308	R308		Professional Worker
Tools	10%			R1 200		
Admin	20%			R2 399		
					R15 595	
<u>Post-fire monitoring: (48 hours)</u>						
Skid Units	4x4 with mobile tanker unit fitted (per 15 minutes)	8	R236	R1 888		1 x Skid Unit for 2 hours (8 x 15-minute sessions)
Fire fighter		2	R180	R360		Casual Worker
Driver		1	R308	R308		Professional Worker

Tools	10%			R256		
Admin	20%			R511		
					R3 323	
					R130 768	**Total Cost of Ecological Burn**