



Rehabilitation and Restoration Guide for Karoo veld (V4)

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SUMMARY

This document is designed for land managers, consultants and landscapers who wish to revegetate bare ground after construction, improve damaged veld or put Karoo veld back onto transformed urban land. It assists in identification of rehabilitation needs and provides general guidelines for planning, implementing and managing rehabilitation projects in Karoo areas. The guidelines suggest approaches to improving vegetation cover and veld composition, control of invasive alien plants, revegetation techniques for sandy, clayey and rocky surfaces, control of soil erosion, plant species selection, seed storage, seeding and plug planting. The guide also covers the salvage and storage of vegetation biomass and soil prior to engineering projects and damage mitigation during construction or temporary use of land prior to rehabilitation. Photos and sketches illustrate various techniques. We give lists of common plant species suitable for restoration in various parts of the Karoo, further reading, links to additional information sources and contacts for information, Karoo seeds and plants.

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1. Introduction

Rehabilitation aims to make damaged landscapes useful and self-sustaining. Restoration takes a step further and attempts to return damaged landscapes to a condition resembling undamaged landscapes in species composition and functioning. Ideally the restored landscape would be indistinguishable from an undamaged landscape. In arid areas such as the Karoo this is a very slow process taking between decades and centuries. Although the slow recovery might seem disheartening, any interventions you make to conserve water and nutrients on the land through erosion and runoff control, or to bring back the plants that originally held the soil and supported the animals will increase productivity and diversity. It will improve the look of the landscape and increase your connection with the land.

The starting points for veld damage caused by farming, engineering and urban development differ, but all scenarios converge in management designed to trap soil, organic matter and seeds, and sustain cover and biodiversity through ongoing management. This guideline document comprises 6 sections:

1. **Introduction:** here we explain the business and services offered by Renu-Karoo veld Restoration cc, explain what is meant by Karoo vegetation, how it differs from surrounding vegetation types and the patchiness within a vegetation type caused by variations in soil depth, texture or chemistry.
2. **Improving veld cover and composition.** Applicable to those managing natural veld, this section deals with the causes and effects of past vegetation change or loss through ploughing or grazing, and approaches to increasing vegetation cover, and changing veld composition to restore grazing value or biodiversity where veld is dominated by unpalatable, poisonous or invasive alien plants;
3. **Bare ground rehabilitation.** This section is aimed at engineering, mining and urban development projects that remove natural vegetation during construction and later have a legal requirement to return the land to its former potential. It covers **mitigation for planned vegetation and topsoil removal** to facilitate post engineering or mining rehabilitation, **preparation of bare ground for reseed** on various types of soil and topography, **seed procurement and seeding**, techniques for **protecting the rehabilitating site**, and with on-going **site maintenance**.

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4. **Urban restoration**, explaining how bare ground rehabilitation and veld restoration techniques can be used to **bring veld back to gardens in urban areas**.
5. **Evaluating the success of rehabilitation and restoration** efforts.
6. **Appendices** which include:
 - **further reading**
 - **contacts of consultants and businesses** that can assist with information, seeds or plants for rehabilitation projects in the Karoo.
 - **lists of common plant species** suitable for various types of Karoo veld.

1.1 Renu-Karoo

Renu-Karoo veld Restoration was founded in the Karoo village of Prince Albert by ecologists Richard Dean and Sue Milton-Dean in 2008 to provide plants, seeds and consulting services to companies and individuals engaged in efforts to in restoration in the karoo. Our client base includes farmers, engineers, land managers, restoration practitioners, landscapers, horticulturists and private landowners.

Renu-Karoo is registered as a Flora Grower and Seller with CapeNature. We specialize in growing of indigenous Karoo plants which are available at our retail and production nurseries in Prince Albert (Western Cape) and can also be purchased via email and delivered by courier.

Renu-Karoo also grows, collects and supplies bulk seeds of widespread, common grasses and shrubs (Karoo bossies). We collect wild seed and grow some of the seed in genetically diverse populations in seed orchards. We partially clean the seed and sell it by the kilogram. It has not been treated with pesticides and is therefore safe for wildlife. We are one of very few businesses that can supply seeds of Karoo plants in quantities suitable for rehabilitation and restoration projects.

Our services include:

- Consulting on the seeds suitable for various Karoo geographical areas and habitats;
- Advice on site preparation, when to sow the seeds;

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- Growing, selling and contract growing of indigenous plants of Karoo veld, and adjacent vegetation types including Thicket and arid Renosterveld;
- Landscaping and restoration projects using drought hardy plant selections.

1.2 Succulent Karoo, Nama Karoo and neighbouring vegetation types

Vegetation types and veld productivity depend on the long-term **annual rainfall** which increases eastwards from less than 200 mm/year in Namaqualand and the Great Karoo to 400 mm in the Northwest Province, Western Freestate and Eastern Cape and exceeds 600 mm in the grasslands and savannas of much of Limpopo Province and Mpumalanga (**Figure 1**). Rainfall seasonality affects veld composition so that vegetation tends to be shrubby in the winter rainfall areas to the West and grassier in the summer rainfall areas to the North and East. Composition is also influenced by altitude because that affects maximum and minimum temperatures. Regions distinguished by their climate and vegetation are known as “**Biomes**”.

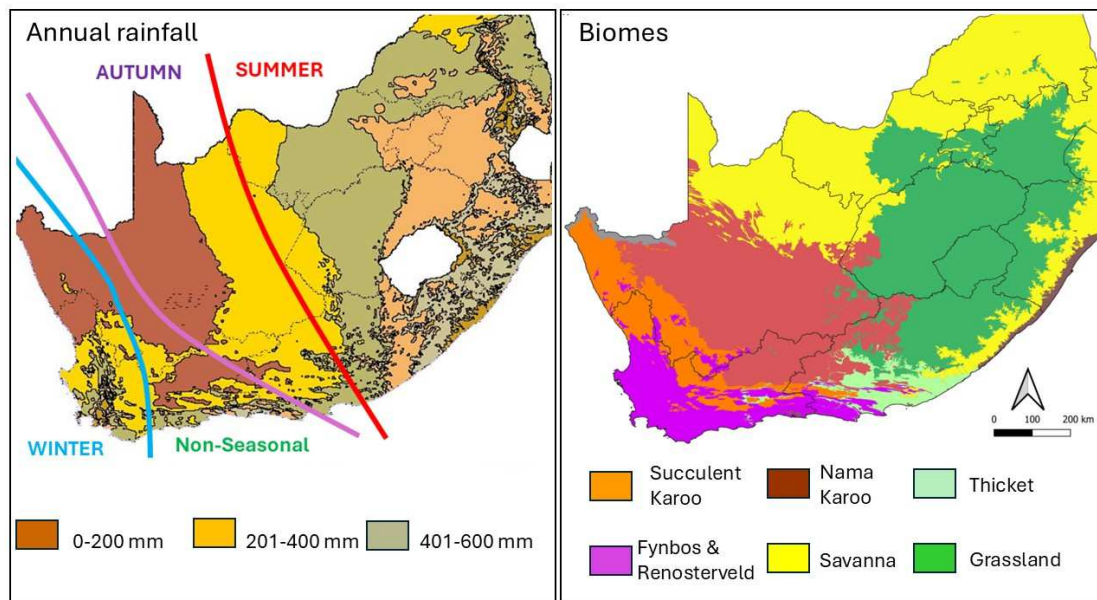


Figure 1. Annual rainfall season and quantity and major biomes of South Africa

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The Karoo region covers about one third of South Africa and is made up of two distinct “Biomes”. The lowland and largely winter-rainfall part of the Karoo to the south and West is known as **Succulent Karoo** (orange in **Figure 1**), and the higher altitude and wetter summer-rainfall Karoo is known as **Nama Karoo** (brown in **Figure 1**). The veld in both Karoo biomes is less than half a meter in height. Trees grow mainly along drainage lines where they can reach ground water.

1.2.1 Succulent Karoo (Figure 2)

As its name implies, Succulent Karoo is dominated by succulents - plants that store water in their leaves or stems. Most succulents are damaged by frost that freezes and kills their leaves, and this limits Succulent Karoo vegetation to the dry and lower altitude areas of Namaqualand, Tankwa, Klein Karoo and the rain shadow lowlands just inland of the Swartberg. The very limited rainfall (< 200 mm/year) in Succulent Karoo results in sparse vegetation and low productivity throughout this biome. Plant diversity on the other hand is very high and the biome includes many rare plants with small distribution ranges. Succulent Karoo merges with Renosterveld to the South and on the Cape Fold Mountain ranges, and with Nama Karoo and Thicket to the East.

1.2.2 Nama Karoo (Figure 3)

found inland and at higher altitudes than Succulent Karoo, Nama Karoo is a mixture of fine leaved and often aromatic Karoo bushes (bossies) and grasses, with a few succulent plants in rocky places where they are protected from frost. The productivity, carrying capacity and grassiness of Nama Karoo for herbivores increases with rainfall from West to East. This vegetation seldom burns but fires are more likely in the wetter eastern Nama Karoo than in the shrubby Western Nama Karoo. Nama Karoo is bounded by Savanna to the North, Grassland to the East and Thicket and Succulent Karoo to the South and West.

1.2.3 Renosterveld (Figure 4)

This shrubby vegetation largely restricted to the Western Cape winter-rainfall area. It occurs on clay soils on the lower and southern slopes of mountains between the higher altitude Fynbos – and the Succulent Karoo of the rain-shadow valleys. Like Fynbos, Renosterveld occasionally experiences hot fires. It has a high plant diversity, especially of bulb plants. Its value as grazing is limited by unpalatable evergreen

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shrubs and limited grass cover. Ploughing, fire exclusion and too frequent burning all reduce diversity.

1.2.4 Thicket (Figure 5)

Thicket grows in frost-free semi-arid areas. In the Klein Karoo it is seen on North-facing warm slopes. It comprises a mix of large succulents, woody shrubs and twiners that bear fleshy fruits. In gaps among the large shrubs there are usually grasses and smaller succulents. Healthy thickets are dense and impenetrable, but may become degraded, open and eroded through excessive browsing by goats and cattle.

1.2.5 Savanna (Figure 6)

Savanna is a open woodland with a grassy understory and is the dominant vegetation of the Northern Parts of South Africa occurring in summer rainfall regions that range from arid (<200 mm/year) to moist (>600 mm/year). Nama Karoo merges into arid savanna on deep sandy soils the Northern Cape and North West Provinces and is typically an open thorn tree woodland of camel thorns with an understory of bushman grasses.

1.2.6 Grassland (Figure 7)

Grassland takes over from Nama Karoo at altitudes over 1000 m above sea level under a rainfall of 400 mm or more. Grasslands support grasses, herbs and bulbs that can survive both grazing and annual dry season (winter) fires.



Figure 2. Succulent Karoo near Prince Albert and a selection of dwarf leaf-succulent plants

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Figure 3. Nama Karoo near Fraserburg showing the typically low shrubland with patches of grass, the rocky koppies and ridges and typical fine-leaves bossies and grasses

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Figure 4. Renosterveld near Barrydale on rolling shale hills under a rainfall of 350 mm. This vegetation type is often dense, waist to shoulder high, with fine-leaved evergreen shrubs, and bulbs and winter-growing grasses that increase after fire.

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Figure 5. Thicket types of the Little Karoo and Eastern Cape comprising of large succulents and thorny shrubs and creepers with grasses and lower succulents in the gaps.

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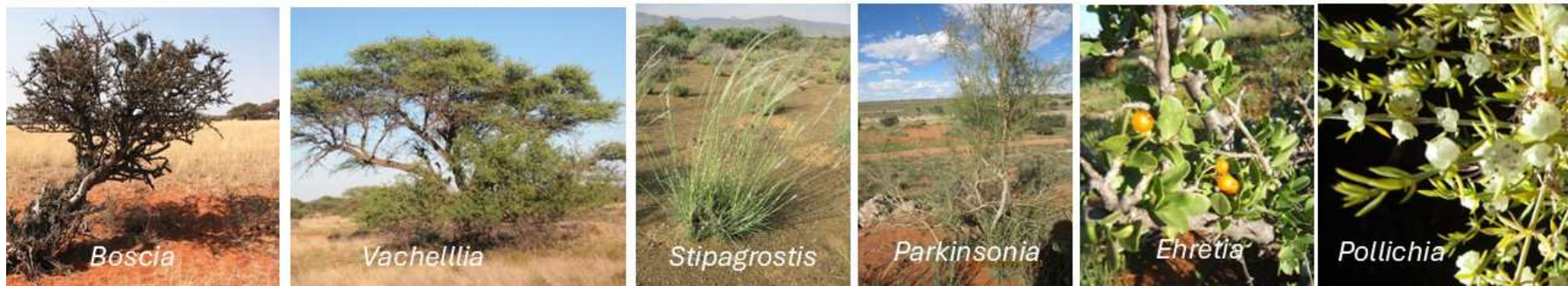


Figure 6. Arid savanna near Kimberley is typical of Northern Cape Kalahari landscapes with scattered trees, fleshy-fruited shrubs beneath the trees and sparse desert grasses.

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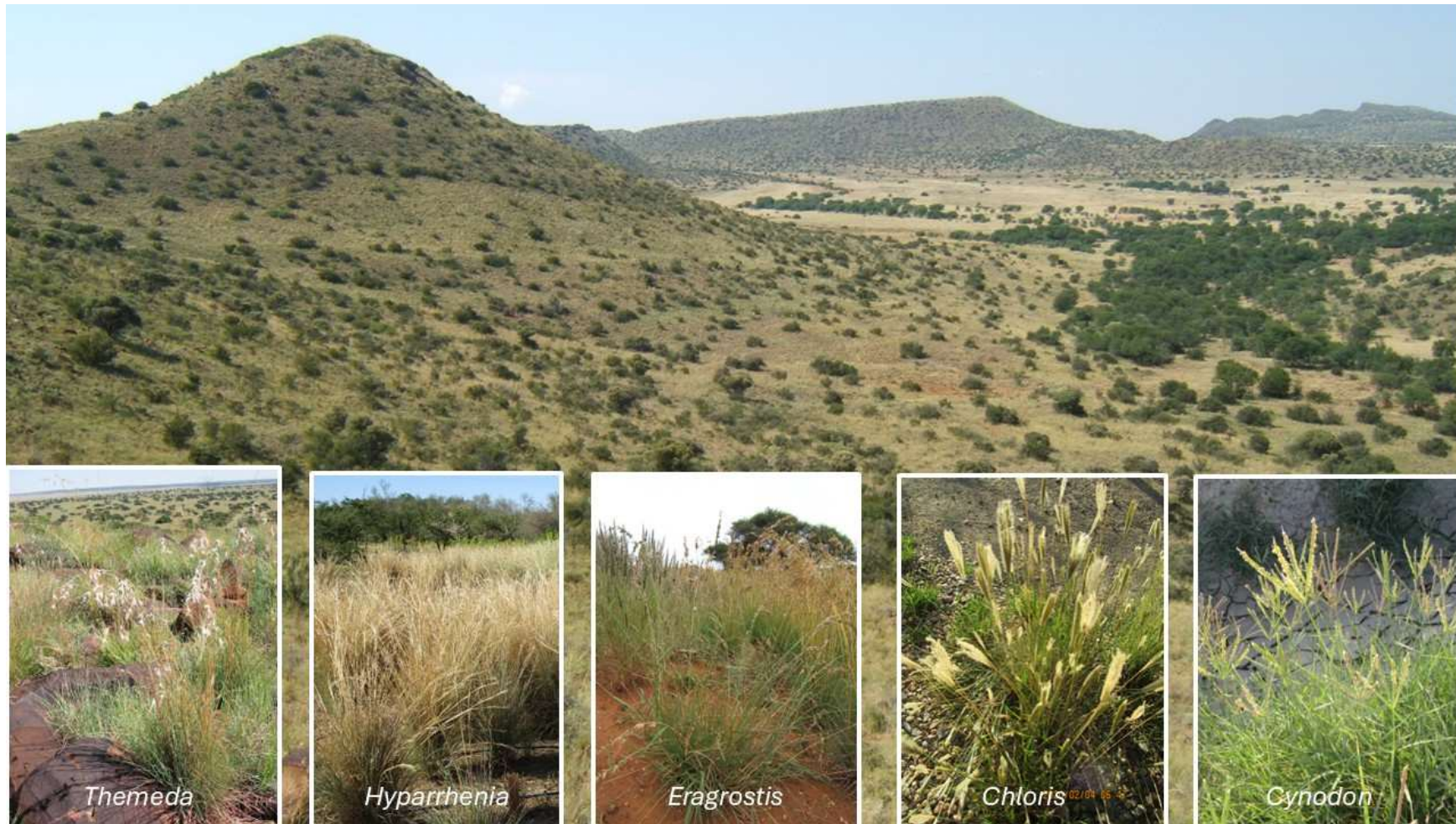


Figure 7. Grassland in the southern Free State includes many kinds of grasses, annuals and bulbs. Clumps of woody shrubs occur on rocky ground and along drainage lines.

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1.3 Patchiness and sensitive habitats

Selecting plant species suitable for the biome is just the first step in choosing seeds or plants suitable for ecological restoration at a particular site. Within every biome there are many vegetation types or units defined by soil type, slope, aspect or drainage. The success of restoration projects depends on matching the techniques and seeds used in restoration to the local soil type and plant community. Some parts of a landscape are far more sensitive to disturbance than others and need to be avoided when planning developments.

1.3.1 Patchiness

At farm landscape scale, vegetation is patchy (**Figure 8**) and varies with soil depth, slope, aspect, stoniness, soil texture and chemistry, and the unequal distribution of water. Vegetation composition differs between cooler South-facing slopes and hotter North-facing slopes. Trees follow drainage lines. Even in dry areas, reed beds may develop in hollows where water collects or around natural springs. Although Karoo soils are generally shallow and stony in the Karoo, deep wind-blown sand may accumulate valleys (**Figure 9**). Fairly flat landscapes may include shallow depressions with clay soils, and in arid Karoo areas pans and valleys tend to have brack mineral-rich, salty soil (**Figure 10**). Landuse such as ploughing and irrigation can change soil structure and chemistry. It is important to take local soil conditions and water distribution into account when planning restoration. The success of a restoration project depends on matching the techniques and seeds used for restoration to the local soil type and plant community.



Figure 8 Landscapes are patchy rather than uniform

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Figure 9 Rocky and sandy soils support different plant species

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Figure 10 Flood plants and bottomlands in the Karoo often have alkaline or saline (brak) silty soils

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1.3.2 Sensitive habitats

Some habitats are rarer or more sensitive to disturbance and more difficult to restore than others. Sensitive habitats in the Karoo include rivers, drainage lines, pans and other **wetlands, some rocky outcrops and gravel and clay patches, and heuweltjies.**

Unusual geology such as quartz or granite outcrops may give rise to isolated stony patches in silty or sandy plains. Quartz patches (**Figure 11**) and clay pans usually support tiny plants in the Karoo and may easily be mistaken for bare ground, kaal kolle or degraded patches of veld. In reality they often support rare plants such as *Lithops* (beeskloutjies), *Conophytum* (knopies), *Argyroderma* and *Gibbeaum* (bababoudtjies) that are found nowhere else in the landscape.



Figure 11. Quartz patch and quartz specialist succulents

Heuweltjies (**Figure 12**) are the soil patches over the colonies of the Southern Harvester Termite. The termite are important for recycling nutrients in Karoo landscapes, and are food for many lizards, birds and mammals such as mongooses, bat-eared fox and aardvark. Their mineral-rich droppings are rich develop limey soil patches that can be seen from the air. Destroyed heuweltjies take centuries to replace.

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Figure 12. Heuweltjies seen from Google Earth and from ground level

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2. Improving veld cover or composition

The problems that most concerns managers of grazing land and nature reserves in the Karoo is loss of grazing capacity. The value of the veld for grazing animals declines when cover is reduced by over grazing, drought or soil erosion (**Figure 13**), or when palatable plants are replaced by poisonous or unpalatable indigenous or invasive species such as mesquite. Bare soil patches and soil erosion may be result from past ploughing or trampling near rivers, waterpoints or in kraals. Much of the Karoo veld was damaged more than a century ago by overgrazing. Problems are often inherited with land, are persistent and can seldom be solved simply by reducing herbivores or changing grazing management.

2.1 Increasing vegetation cover

Heavy grazing, prolonged drought, hail or fire can reduce the value of Karoo veld for grazing of livestock and game, and for biodiversity conservation. The damage may be short lived, as in the case of hail, fire, or once off heavy grazing by mammals or insects. Where poor grazing management was prolonged, or where droughts are exacerbated by climate change, veld recovery may take decades or centuries. Veld resting combined with other interventions can help to restore productivity.

Where vegetation cover is less than expected for the regional annual rainfall.

Figures 14 shows what percentage of vegetation canopy cover to expect for long-term annual rainfall averages between 50 mm and 500 mm. Where vegetation cover falls below the line the grazing capacity is less than its potential and could be improved by a change in grazing management. Veld that rests for longer periods than it is grazed generally has better cover, productivity and biodiversity than veld that is continuously grazed, has little rest, or is ungrazed. Rotational grazing with livestock can be achieved through fencing or herding. Simulating the nomadic movements of wild herbivores to rest the veld is difficult to achieve on small properties. Manipulation of water availability works only for water-dependent herbivore species. Other options are co-management of adjacent properties to create movement corridors, or periodic reduction of herbivores.

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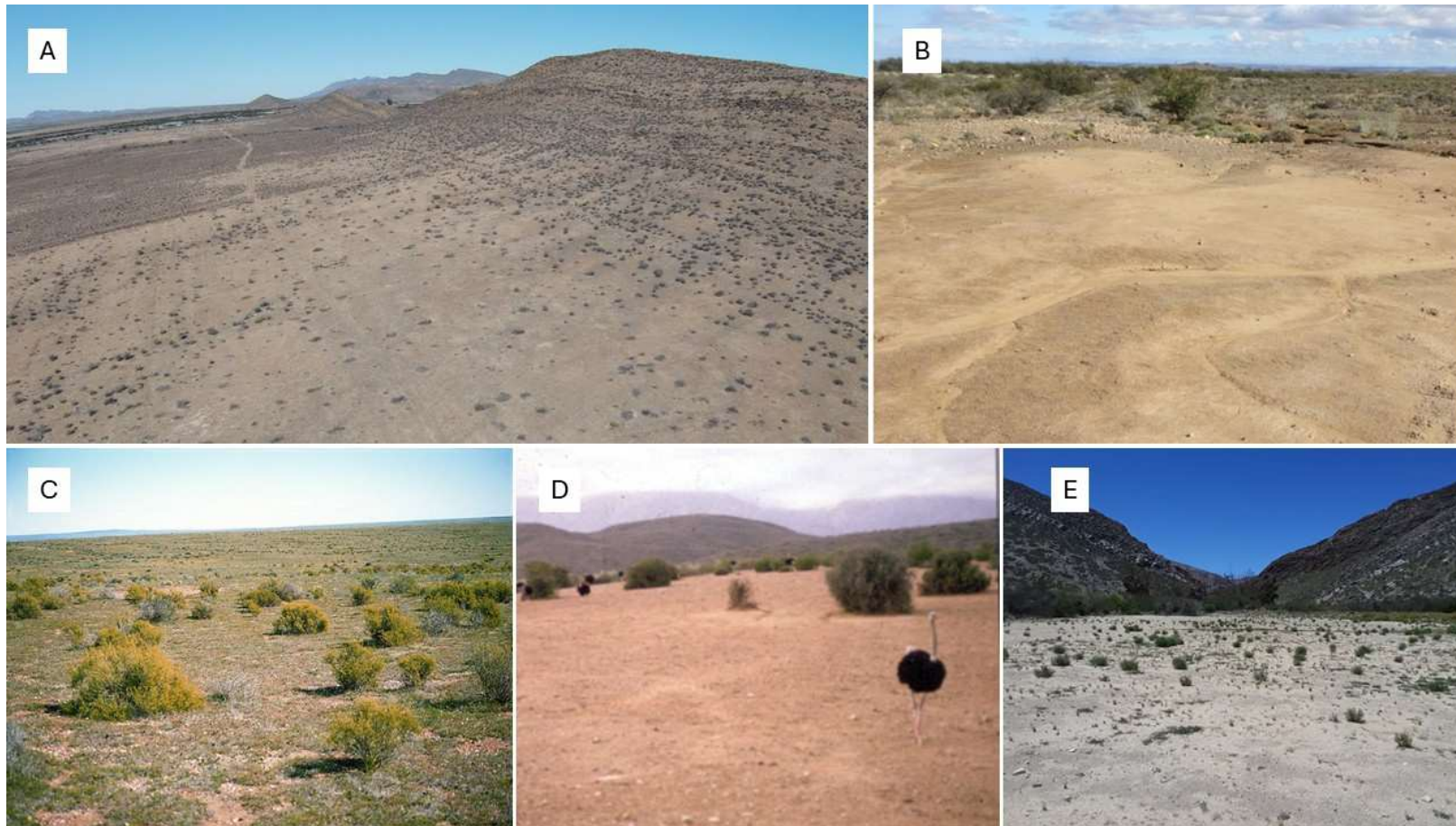


Figure 13. Vegetation loss caused by A. Overgrazing, B. kraaling, C. ploughing, D. and E. ostrich camps.

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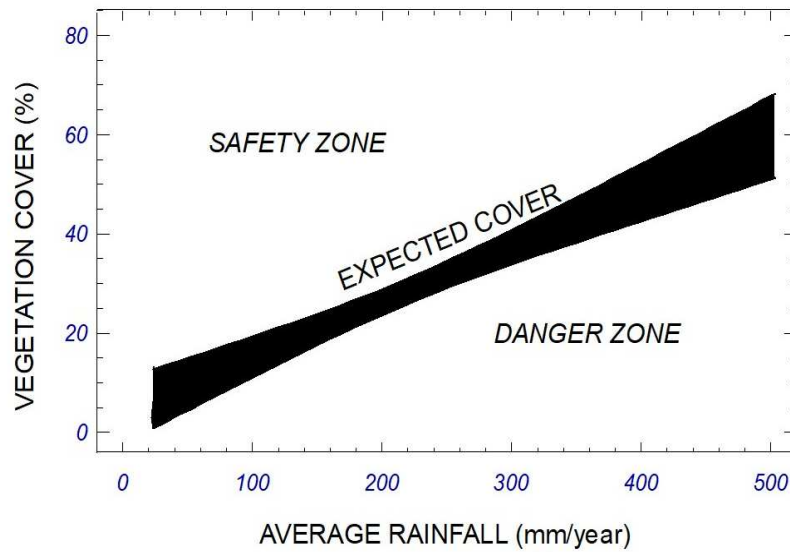


Figure 14. Expected vegetation cover in relation to rainfall. Where vegetation cover is less than expected, some management intervention may be needed

Where veld is very sparse and there are bare patches (kaal kolle) it is advisable to use the rehabilitation methods illustrated in **Section 3** of this guide, namely **3.4** controlling soil erosion, reducing water loss and improving infiltration, **3.5** sowing seeds, and **3.7** protecting the site from sun, wind and herbivores with brush packing (**Figure 15**).



Figure 15. Brush packing on bare ground in natural veld

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2.2 Causes and effects of vegetation loss

Vegetation loss can be caused by ploughing, intensive trampling and grazing such as may be seen in feed lots, kraals and ostrich camps (**Figure 13**), by mining, or by soil erosion caused by abandoned infrastructure such as prospecting roads and broken dams, or by urban development.

Once vegetation has been lost, wind and water erode the lichen crust and the topsoil. Vegetation loss on lowland sites may accelerate runoff, leading to formation of deep gullies (dongas) that gradually creep upslope, undermining plants on the hillsides and further accelerating soil loss. Spontaneous recovery is seldom possible because of the hard texture of subsoil, accelerated water runoff, loss of nutrients and microbes, lack of soil seed traps, and evaporation can increase soil salinity. Before embarking on rehabilitation of bare patches in natural veld it is important to identify the cause of the vegetation loss and to decide whether the factor leading to the loss is still active. It is also necessary to consider the soil depth, slope and soil salinity as these factors will affect rehabilitation approaches.

2.3 Increasing diversity and productivity

Selective grazing can change the composition of Karoo veld to dominance of less palatable species or dominance of highly unpalatable or poisonous plants. In the high cold Karoo areas of the Eastern Karoo, sour grasses and unpalatable shrubs such as renosterbos (*Dicerothamnus rhinocerotis*) and asbos (*Pteronia incana*) become common. In the Central Karoo, spiny plants such as doringkapok (*Eriocephalus ambiguous*), kriedoring (*Lycium* spp) and driedoring (*Rhigozum trichotomum*) come to dominate veld when more acceptable species are grazed out. In lower altitude Karoo poisonous species such as plakkie (*Cotyledon orbiculata*), kraalbos (*Aizoon africanum*), bitterbos (*Chrysocoma ciliata*) and scholtzbos (*Pteronia pallens*) increase in abundance over time.

Invasive alien plants may invade overgrazed and disturbed veld. In high altitude Karoo, alien invaders such as bramble (*Rubus* sp), rose (*Rosa rubiginosa*) and hawthorne (*Cotoneaster* and *Pyracantha*) form thickets that exclude grasses and grazing animals. At lower altitudes alien invaders include various types of cactus such as prickly pear (*Opuntia* spp), torch cactus (*Cylindropuntia* spp), and jointed cactus (*Opuntia aurantiaca*), mesquite (*Prosopis* or *Neltuma* pp), oleander (*Nerium*

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oleander), tamarisk (*Tamarix ramosissima*), Spanish reed (*Arundo donax*) and wattle species (*Acacia mearnsii*, *Acacia pycnantha*), many of which invade water courses, pans and dams. The removal of declared invaders is a legal requirement because they pose a threat to groundwater, surface water and grazing productivity.

Neither veld resting nor high density non-selective grazing is likely to solve the problem of veld dominance by long-lived, unpalatable or thicket-forming plants, particularly if they are poisonous or injurious to herbivores. Partial or total clearing of unpalatable dominant or invasive alien plant species using mechanical, chemical or biological methods is the first step to improving veld composition. In very arid areas where rain suitable for germination is rare, it is unwise to clear very large areas because exposing the soil surface makes it vulnerable to erosion of soil by wind and water. Indigenous poisonous or unpalatable shrubs could be thinned out but should never be completely cleared because, although they are not grazed, they hold the soil, trap seeds, protect seedlings of palatable plants and and mitigate extremely high temperatures at the soil surface during summer.

2.4 Reducing unpalatable indigenous plants

Methods used to reduce the densities of unpalatable plants such as driedoring in Bushmanland, scholtzbos and kraalbos in the Succulent Karoo, and renosterbos and wiregrass in the Upper Karoo have included brush cutting, ripping, knife-rollers, ploughing, manual removal, herbicide, fire and trampling (see Carrick et al. 2022, additional reading, **Figure 16**). Outcomes are not always favourable and sometimes lead to even higher densities of unpalatable plants, particularly where there are insufficient seeds of other grasses and shrubs to fill the gaps or where rainfall fails.

- Ploughing and use of a knife roller successfully reduce kraalbos and renosterbos (*Dicerothermnus rhinocerotis*) on old crop lands to make way for reseeded palatable grasses and shrubs to establish.
- Mechanical and manual uprooting of strips of scholtzbos (*Pteronia pallens*) resulted in more diverse veld.
- Woody plants such as sweet thorn (*Vachellia/Acacia karroo*) can be reduced in density by occasional intense fire, followed by goat browsing.
- Densities of woody plants such as swarthaak (*Acacia/Senegalia mellifera*) and driedoring (*Rhigozum obovatum*) can be reduced by granular or spray

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herbicide application but herbicides are non-selective and may reduce cover and biodiversity.

2.5 Getting rid of invasive alien plants

Invasive alien plants can be controlled using physical, chemical or biological approaches.

2.5.1 *Mechanical and manual clearing*

some, or all, of a problem plants can be physically removed, either by hand or using machinery. Seedlings can be pulled out by hand and saplings can be levered out of the ground using a “tree popper”. Larger woody plants can be killed by ringbarking which involved using a machete to remove the bark around the circumference of the stem so that no carbohydrates reach the roots. This method is effective for large trees that do not make root suckers (mesquite, acacia, pine, wattle), but not for poplars. It is not practical for small or thorny shrubs. For spiny, deep-rooted and multi-stemmed shrubs a mechanical digger is an efficient way of removing plants in areas where mechanical access is unlikely to cause soil erosion (**Figure 17**).

2.5.2 *Chemical control of invasive alien plants*

A wide range of herbicides have been registered for killing of indigenous and alien woody plants and cactus species. Many of these such as Turbidor® and Confront ® are broad spectrum systemic plant killers and should be applied as directly and conservatively as possible. The detailed instructions on herbicide labels explain how best to apply the herbicide. Methods range from stem injection (for cactus species) to bark and cut stump applications using a paint brush, to spray application. Spraying is most wasteful and risky for the operator, adjacent non-target plants and for ecosystems – particularly aquatic ecosystems (**Figure 18**).

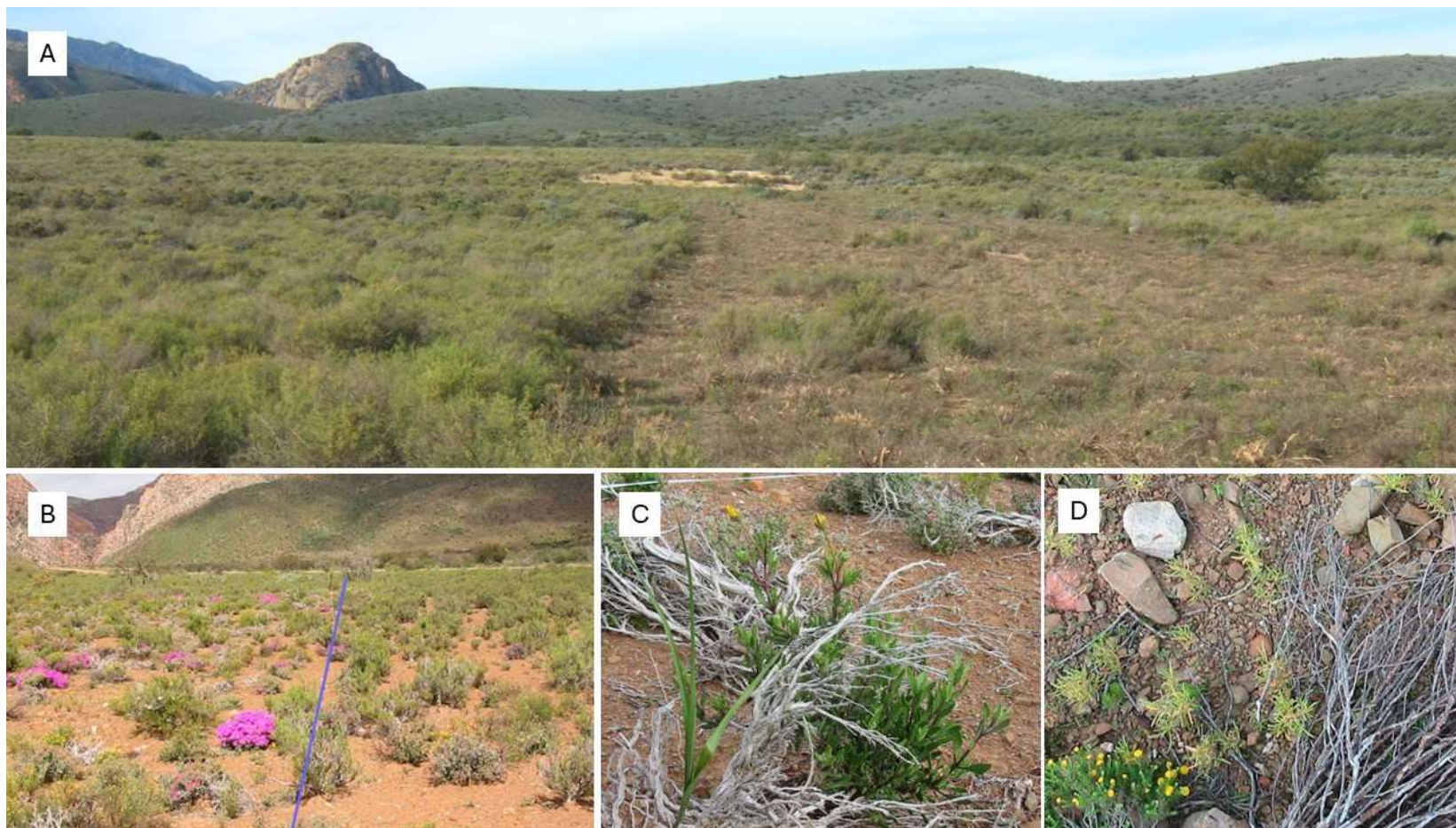


Figure 16. Methods used to reduce the densities of unpalatable indigenous plants: A. brushcutting of kraalbos on old crop lands, and B. increased diversity on left of photos caused by ripping out 50% of schotzbos on overgrazed veld, C. palatable bietou growing under dead schotzbos, and D. increase in unpalatable kraalbos caused by ripping to attempt to reduce this bush.

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Figure 17. A. Ringbarking, B. felling, C. pulling using a tree popper, D. mechanical removal using a digger with a forklift attachment.

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2.5.3 *Biological control of invasive alien plants*

Biological control agents are species-specific insects or pathogens imported from the home range of the pest plant (**Figure 19**). By feeding on the seeds or vegetative plants of the invading plant they reduce its growth rate and its ability to reproduce and spread. In some case, for example in the case of cochineal and mealy bug on cactus, the biocontrol agents become very abundant and kill the plants. They cannot damage indigenous plants because their life cycles are linked to only one species of food plant. Biocontrol agents are available for the following invasive alien plants:

Mesquite (*Prosopis* sp.) seed eating beetles

Prickly Pear (*Opuntia ficus-indica*) cochineal or *Cactoblastis* moth

Toukaktus (*Harrisia martini*) Queen of the nigh mealy bug

Boxing glove cactus (*Cylindropuntia fulgida*) cochineal

Eastern prickly-pear (*Opuntia humifusa*/ *O. caespitosa*, *O. stricta*) cochineal.

Small pieces of the infected plant species can be placed on or near the weed target plant and this is usually sufficient to enable the biocontrol agent to spread into the invasive alien species population. Each of the above cactus species has a species specific control to it is important to obtain the correct cochineal species from Rhodes University Centre for Biocontrol, Kariega/Uitenhage mass-rearing facility (contact Ruth Scholtz on 073 673 8234 and Email: scholtzruth4@gmail.com).

2.6 Post-clearing rehabilitation

Partial or total clearing of indigenous or alien invasive plants leaves bare ground, soil disturbance and soil erosion by wind and water. Rehabilitation of bare ground involves site preparation (**Section 3.4**), reseeding (**Section 3.5**), site protection (**Section 3.7**) and ongoing sustainable management and maintenance (**Section 3.8**).

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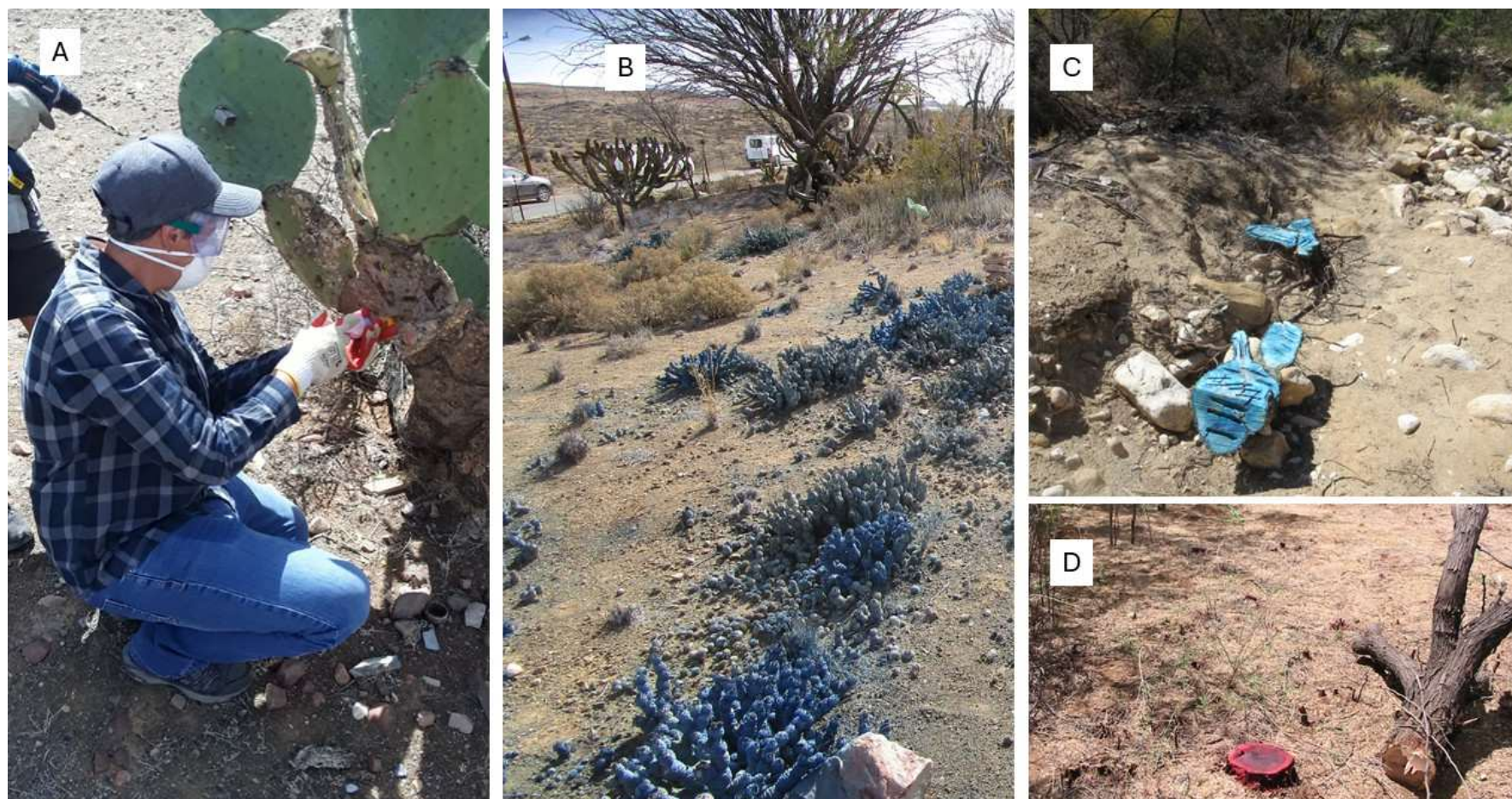


Figure 18. use of herbicide to remove invasive alien plants. A. stem injection into holes drilled into cactus, B. herbicide spray applied to pineapple cactus clumps, C. and D. stump-painting of herbicide used on felled mesquite and tamarisk.

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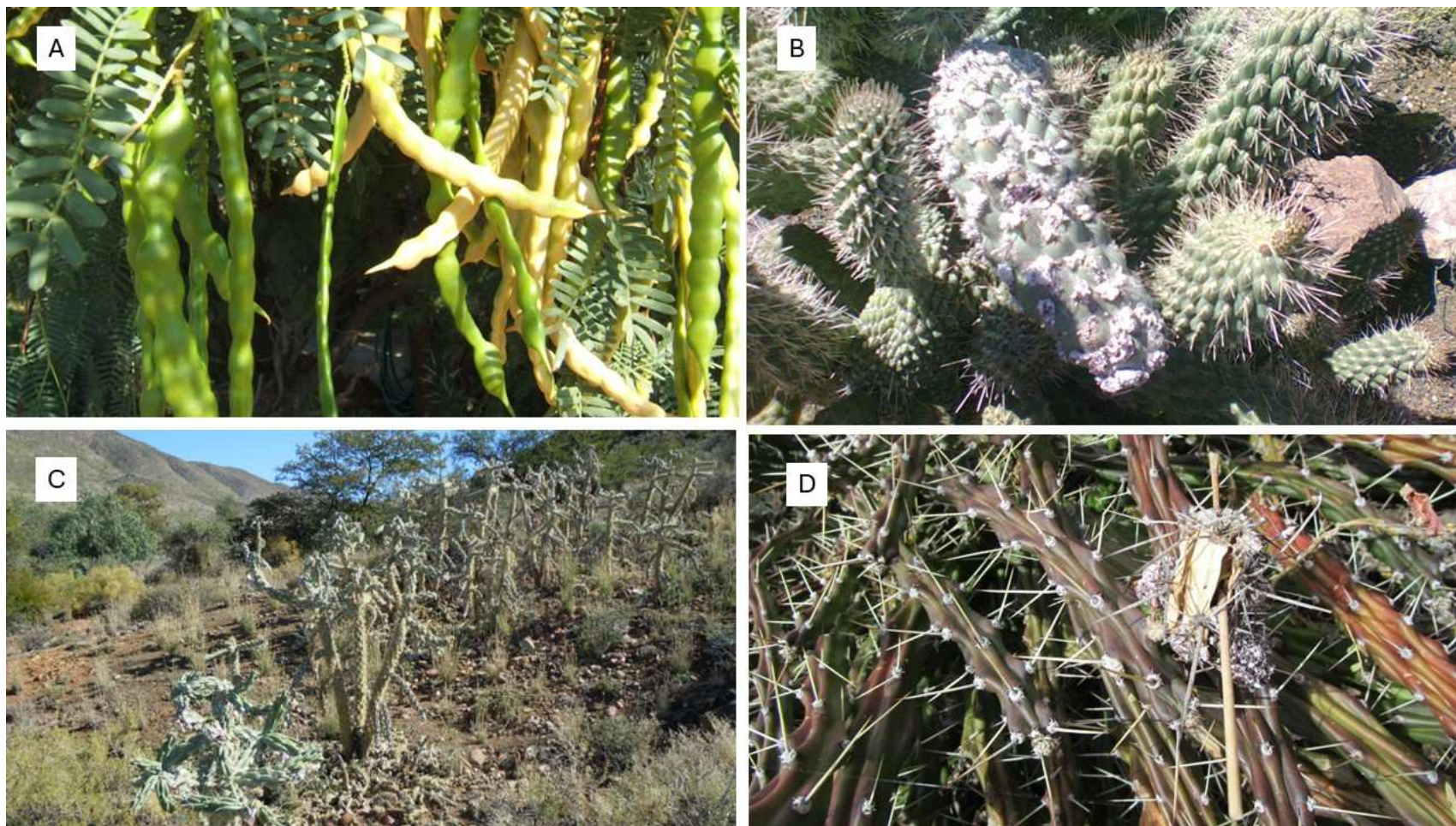


Figure 19. A. mesquite pods with seed feeding beetles, B. boxing glove cactus with cochineal, C. cactus killed by cochineal, D. introduction of mealy bug to Harrisia.

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3. Bare ground rehabilitation

Engineering, development and mining projects usually entail the clearing of one or more areas for vehicle parking and storage of materials (laydown areas), and the construction of temporary roads. There is a legal requirement that damaged areas are revegetated with indigenous plants on the completion of a development or before closure of a mine or prospecting area.

Damaged land includes areas that have been completely cleared to use for storage or parking (laydowns), temporary roads, or surface mines including roadside borrow pits used to excavate material for maintaining gravel roads. Areas of bare ground generated by engineering projects are generally large (over one hectare in area) and have soil that has been compacted by vehicles or contaminated with fuel, lubricants or cement. Temporary roads used to access projects such as wind farms, prospecting sites, mines and borrow pits may be on steep gradients and rocky ground.

Rehabilitation of bare ground in arid areas is challenging because of the harsh physical conditions including lack of water, high temperatures, and wind that increases evaporation and destabilizes soil and germinating seeds. Success can be improved by salvaging organic material and topsoil and storing this safely until rehabilitation is carried out, and by managing sites to minimize pollution and damage to surrounding areas.

3.1 Avoiding sensitive habitats and collateral damage

Before the footprint of a development site or mine – whether large or small – is established, an ecologist should identify sensitive habitats including the wetlands (drainage lines, flood plains, pans, natural springs), quartz patches, rock outcrops and heuweltjies (see Section 1.3.2). These habitats must be demarcated and designated as “no-go” areas. According to the National Environmental Management Act (NEMA) and the National Water Act (NWA), no development may take place within 32 meters of a wetland. Avoiding damage to sensitive habitats protects water resources and rare plants and animals, as well as processes such as nutrient cycling essential for maintaining functioning ecosystems.

Once the area for the development has been selected, the footprint of the development should be clearly demarcated with fencing or hazard tape. All

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development activities, whether building, mining, materials storage, offices and ablution facilities, should take place within the demarcated area. No activities or damage should take place in surrounding natural vegetation. In the case of large developments (>1 ha) it is possible that islands of natural vegetation could be conserved within the development area as a source to facilitate vegetation recovery after closure. These should be demarcated as no-go areas within the development site.

Damage planning and containment conserves adjacent habitat and seed sources, and contributes to the post-development recovery of damaged areas.

3.2 Salvage and storage

Record plant species in the area to be cleared and in the surrounding area, preferably when the vegetation is green and growing so that species that lose leaves or bulbs and annuals that disappear during drought, can be identified. Information on the preclearing vegetation of the site can be used in selecting species for use in restoration.

If practical, leave islands of natural vegetation within the demarcated area and designate the as No-go areas. Islands of vegetation are seed sources that attract wildlife and facilitate the return of plant species during rehabilitation (**Figure 20**). Retain long-lived, slow-growing trees: Large specimens of ghwarrie (*Euclea undulata*) or witgat (*Boscia* spp), doppruim (*Pappea capensis*), and Karoo boerboon (*Schotia afra*) are many centuries old and are impossible to replace within a human lifespan. These heritage trees provide shelter for plants and food and nest sites for animals and character to the landscape. (**Figure 21**).

Salvage bulbs and succulent plants from the site and replant them in matching adjacent areas or store them temporarily at a specialist plant nursery. These can be replanted at the conclusion the project. Collect seeds from the demarcated site before clearing and store the seeds as described in **Section 3.6.2**.

Scrape the vegetation off the surface and store dead plant material in windrows for use in rehabilitation. Even dead plants are valuable as a source of seeds, mulch and plant nutrients. If storage space is limited the vegetation can be mulched.

Remove 100 to 200 mm of topsoil and surface rocks. The surface soil contains seeds and microbes needed for vegetation recovery. Rocks provide animal refuges, traps for seed and shade during habitat recovery. Store the topsoil in low berms

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(<2.0 m high) upslope of the cleared area, in a position where it will not be driven on, washed away by flooding or polluted by fuel spills or building materials (**Figure 22**). Do not place cover the topsoil berm with subsoil or any construction materials.

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Figure 20. Islands of natural vegetation retained on a construction site and in a borrow pit

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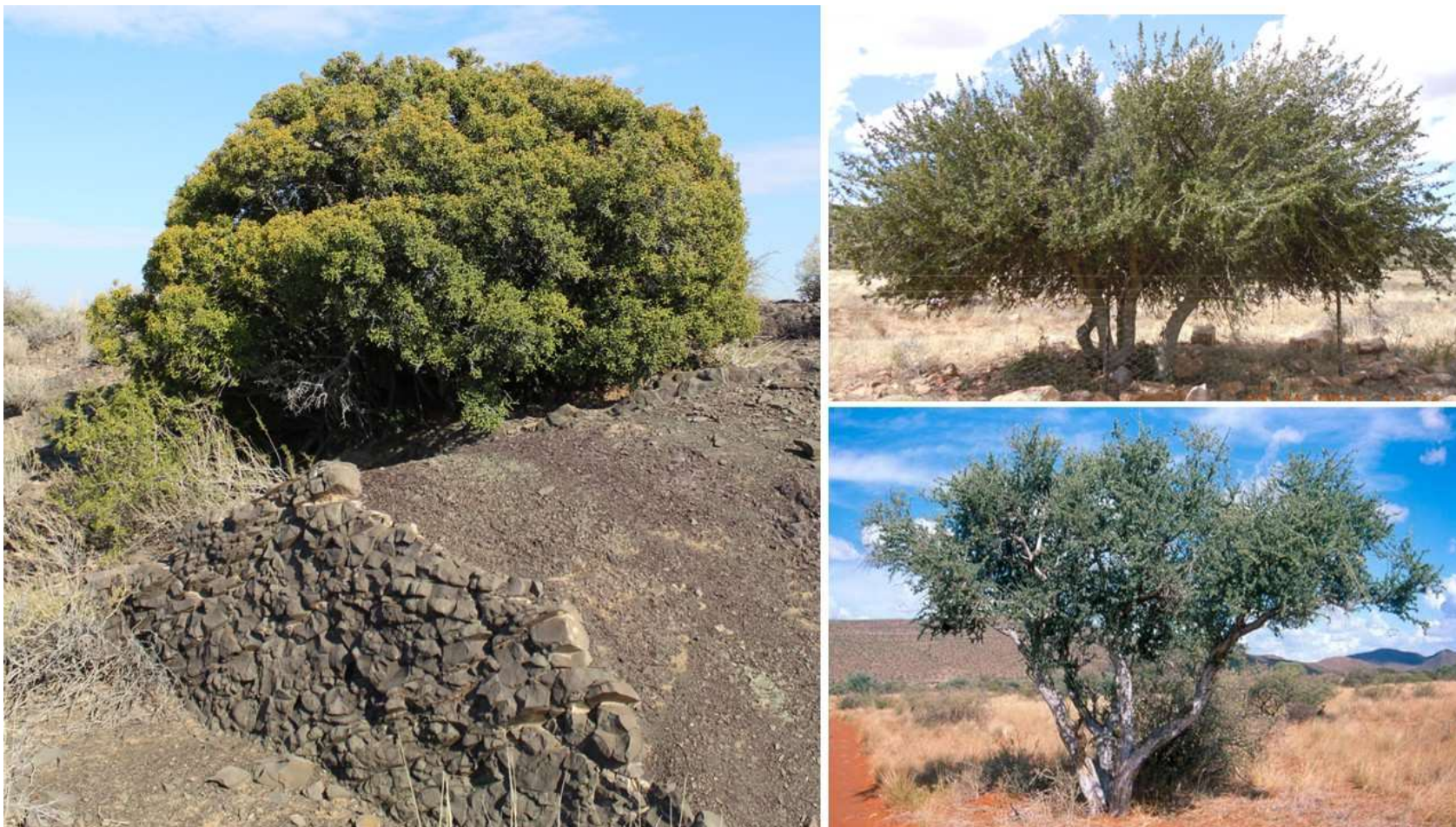


Figure 21. Left: Old ghwarrie, dop pruim and witgat trees should not be removed from laydown and borrow pit sites or urban developments.

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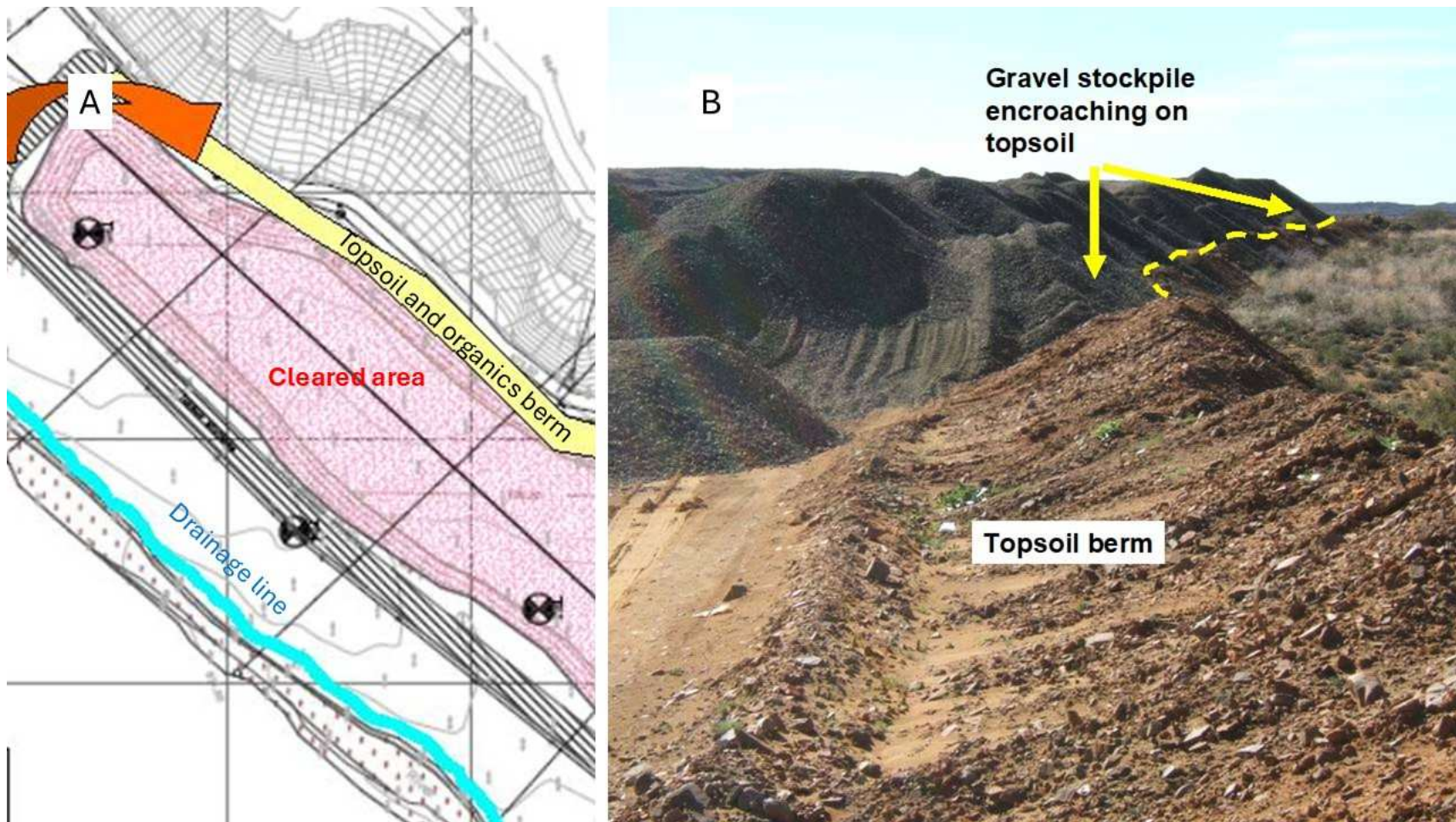


Figure 22. Preferred position for topsoil storage relative to a cleared area and a drainage line, B. Gravel dumped on stored topsoil reduces the value of the topsoil.

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3.3 Damage limitation

Recovery of vegetation on laydowns, borrow pits and other cleared utility areas can be inhibited by pollution caused by spillage of contaminated water, fuel, lubricants, pesticides, detergents, cement, paint and other hazardous materials onto the site (**Figure 23**).

To prevent pollution of laydown, parking and machinery workshop areas management should:

- store all hazardous substances in secure storage containers within fenced areas.
- Install drip pans, a thin concrete slab or a facility with PVC lining in storage areas to catch spills.
- Provide drip pans for machinery, pumps, generators and vehicles stored or serviced on site.
- Spills should be cleaned up immediately and the polluted soil disposing of at a licensed facility.
- Provide bins for hazardous waste and remove these regularly from the site.
- Do not burn solid waste on site
- Remove all concrete slabs and structures from the site before rehabilitation.



Figure 23. Pollution caused by a diesel spill from a bunker.

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3.4 Reshaping and water management

After all pollutants and structures have been removed from a laydown, temporary office site, or borrowpit depression, the site should be reshaped to avoid flooding, inundation and accelerated soil erosion and to facilitate plant establishment.

- Shape the walls of a depression at a shallow enough angle (not steeper than 1:3) to hold soil and plants;
- Prevent flooding of borrowpits and other excavations by building a berm (0.3m high) around the upslope edges of excavations or borrow pits to divert water away from the depression and into the nearest small drainage line. Karoo vegetation will not establish on areas that are occasionally under water.
- Build water diversion berms also prevent rill erosion cutting back up the slope above a depression (see **Section 3.4**).
- Rip any compacted surfaces;
- Spread stored topsoil over the entire cleared and ripped site (**Figure 24**).
- Distribute salvaged stones, large rocks and dead plant material over the topsoil to create a rough surface that will reduce wind speed, partly shade the soil and facilitate water infiltration. Rocks, organic debris and uneven surfaces shelter establishing plants and provide habitat for animals.

Once the site has been shaped to reduce risks of flooding, inundation and soil erosion, follow the steps described under site preparation (**Section 3.5**), reseeding (**Section 3.6**), site protection (**Section 3.10**) and ongoing sustainable management and maintenance (**Section 3.11**).



*Figure 24. Borrow pits A. before rehabilitation showing salvaged plant remains.
B. one year after ripping, spreading of topsoil and seeding.*

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3.5 Site preparation for rehabilitation

Preparation of a site before restoration work is important for the vegetation recovery, because sowing seed or planting plugs on a smooth, compacted surface, on exposed wind-blown sand, or down slope in the path of soil erosion is destined to failure.

3.5.1 *Control wind speed and sand blast*

In coastal areas with loose sandy soils and strong prevailing winds, rehabilitation relies on reduction of wind speed during the first five years of vegetation recovery after mining. Nets should be 0.75 m in height and 5 to 6 m apart, and placed at right angles to the direction of the prevailing wind (**Figure 25**).



Figure 25. Wind netting at Namaqua Sands mineral sands mine on the coast of Namaqualand in Succulent Karoo

3.5.2 *Limit soil erosion upslope*

Reducing erosion and slowing down runoff upslope of a restoration site is essential for seedling establishment. Dongas (gully erosion) accelerate runoff, drying out the soil and removing organic matter and topsoil. Dongas should be tackled at the top ends of the gullies (upslope head cut), where erosion is creeping uphill. Runoff in dongas can be slowed down and silt trapped using natural materials available on site

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to build brush fences, and plant litter to pack areas between the fences (**Figure 26 A & B**).

Contour trenching and fencing can also be used to reduce rapid runoff from bare hillsides (**Figure 27**). Take care to avoid channeling water and causing more gullies or dongas to form.

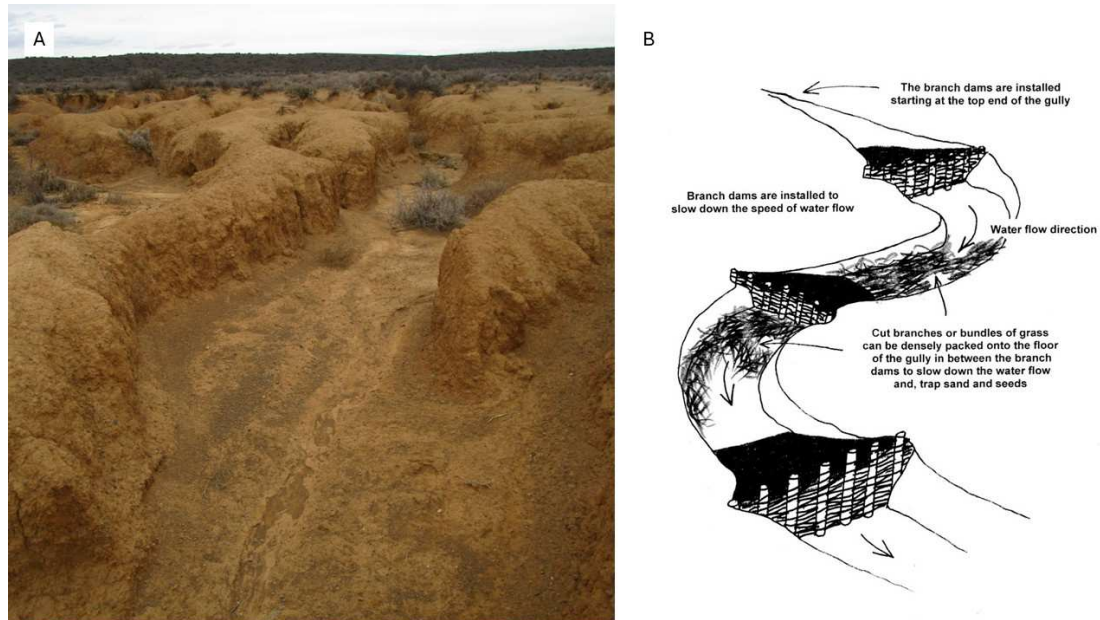


Figure 26. A. Dongas in fine bottomland soil in the Nama Karoo. B. illustration showing the use of brush fencing to slow water and trap silt in gullies (Coetzee 2022).

For more detailed information on control of soil erosion consult Coetzee and Stroebeel (2015) <https://restory.co.za/2022/03/10/guidelines-for-practical-soil-erosion-control-in-rural-africa/>

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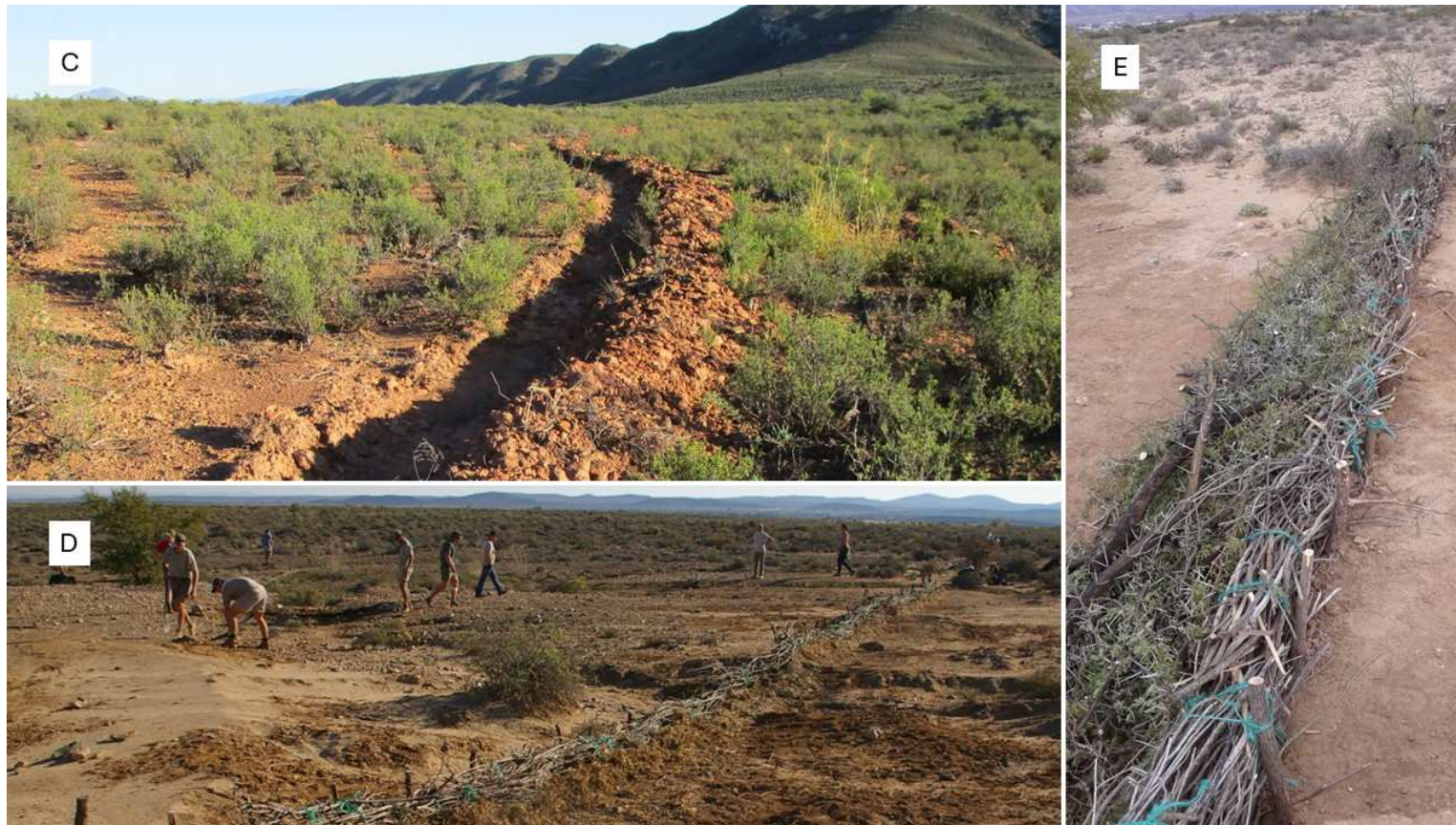


Figure 27. A. Contour trenching near Barrydale the Little Karoo, B. & C. Brush fencing can be added to contour furrows to retain soil and organic matter

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3.5.3 Stabilize steep embankments

Slopes steeper than 1:3 are unstable and a challenge to revegetate. However, engineering works sometimes include very steep embankments that need to be stabilized with natural vegetation. Embankments can be stabilized with built box structure, soil saver nets and cloth and bags of soil and stone known as “Potch sausages”. These meter-long wire mesh tubes are flexible and heavy and can be molded to the slope (**Figure 28**). They retain soil and organic matter and provide a foothold for sown and naturally-dispersed seeds (**Figure 29**).



Figure 28. with stone-filled wire mesh “Potch sausages” provide stable sites for seed germination on a steep embankment.



Figure 29. Seedlings germinating on a slope stabilized with stone-filled wire mesh “Potch sausages”

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3.5.4 *Reduce runoff and increase infiltration*

Sheet erosion on almost flat surfaces is often caused by accelerated runoff of water over bare ground towards gullies. Sheet erosion undermines plants causing further loss in cover. Bare soil caused by past or recent loss of vegetation is an inhospitable environment for seedling establishment. On sandy, silty or loamy soils, the seed bed can be prepared by ripping or making hollows using a dyker plough (*hap ploeg*) or digging hollows by hand (**Figure 30**).

- Rip the compacted surface along the contours on sandy or loamy soil to improve rainwater infiltration in areas accessible to a tractor (**Figure 30A**). Make sure that the rip lines do not run down slope and lead to more runoff and soil erosion. Ripping results in a rough surface that improves infiltration and prevents seeds being blown away. Do not use ripping on clay soils.
- Use hand-dug hollows on loamy or sandy soil in areas inaccessible to machinery (**Figure 30 B & C**). The soil removed from the hollow should be piled on the down-slope lip of the hollow to make a small dam. Orientate the hollows so that runoff water during rainfall will be caught and collected in the hollows. Use smaller dams (<0.1 m wide) on steeper slopes so that rapid runoff does not build up such high volumes of water that it breaks the dams with resulting rill erosion. Hollows on flat areas can be larger (2 m wide, 0.2 m deep).
- Do not use ripping or deep hollows on clay and rocky ground where waterlogging and poor drainage of water after rain can inundate and drown germinating seedlings (**Figure 30 D & E**). As saturated clay at the bottom of the hollows dries out it cracks and shrinks, peeling back from the soil surface and uprooting new seedlings. This problem can be mitigated by adding mulch to hollows on fine-textured soils.

Well-constructed hollows on deep soil continue to trap water, seeds and organic matter over five or more years. The plants that grow in the hollows attract antelope, hares and rodents which in turn bring more seeds and nutrients to the hollows in their droppings. Patches of vegetation on the rehabilitation sites gradually expand and increase in diversity (**Figure 30F**).



Figure 30 A. Ripping, and B.-E. hollows for trapping water on bare ground. B. loamy soil, Outdshoorn, C. silty soil, Sutherland, D. inundated hollows on rocky ground, Prince Albert, E. saline clay near Loxton.

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Figure 30F. Steenbok browsing plants in a five-year old rehabilitation hollow.

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3.6 Reseeding and planting

Seeding with the appropriate mix of locally-collected or purchased Karoo seeds is needed to improve veld composition and where there are large patches (>50 m diameter) of bare ground. Seeding is generally done immediately before or after brush-packing (**see Section 3.8**). In wetter parts of the Karoo to the northeast (>350 mm) or in the winter rainfall areas where rainfall season is predictable, it is possible to plant out small plants (plugs) for faster vegetation establishment.

3.6.1 Sourcing seeds and plugs for restoration

It is important that the seeds used in rehabilitation are locally indigenous, representative of the vegetation and suitable for the soil type. A biome such as Succulent Karoo includes many finer vegetation units defined by geographical area, position on a slope and soil type. A few different vegetation types can converge on a single property when the landscape includes north- and south-facing hill slopes and valleys or shallow and deep soils. At farm scale, a single vegetation is made up of various subtypes determined by soil and drainage (**Figure 31**).

The success of restoration work depends on matching the plants to the soil and local conditions. If possible, collect seeds from the surrounding natural vegetation during the months before the restoration project. Store these in a cool, dark, dry and rodent-free room until they are needed. On bare ground you will need about 10 kg of seeds per hectare and about half this amount for partly vegetated areas. If locally collected seed is insufficient, seed can be bought from specialist Karoo seed suppliers such as Renu-Karoo veld Restoration in the Central Karoo (www.renu-karoo.co.za), and Vula Environmental Services in Namaqualand (<https://vulaservices.com/about-vula-environmental-services/>). **Appendix 1** lists a few of the most common plants in each major Karoo vegetation type for which seed may be available from specialist suppliers.

When sourcing appropriate seeds for rehabilitation, give the supplier as much information as possible, including co-ordinates of site, size of area to be seeded, soil type, previous landuse that might have affected soil chemistry (e.g. irrigation with borehole water), existing vegetation if any, intended landuse.

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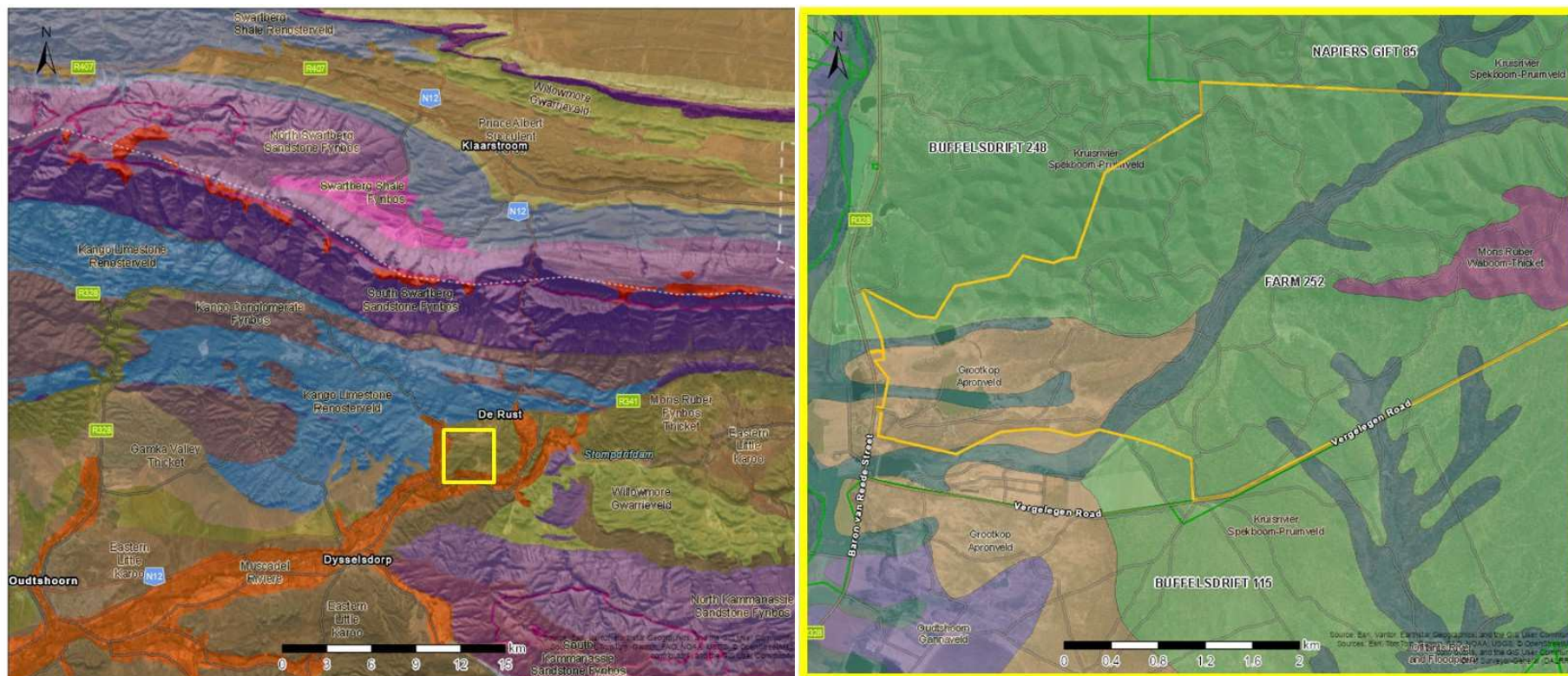


Figure 31. Vegetation complexity in the Succulent Karoo at a scale of 50 km (6 km). The yellow square shown in the upper map is enlarged below to show plant communities at a farm scale.

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Seed species selected for rehabilitation should also be suitable for the local soil type. Some plant species are sensitive to soil texture or soil chemistry. Bushman grass species (*Stipagrostis*) succeeds only on loose, sandy soils, whereas Karoo bietou (*Osteospermum sinuatum*) needs fine-textured silty or clayey soils. Plants suitable for saline soils include ganna (*Salsola*, *Caroxylon*), vaal brak (*Atriplex vestita*), spanspekbus (*Manochlamys*), brakbossie (*Exomis*) and some grasses such as vingehoed (*Fingehuthia africana*), vleigras (*Sporobolus fimbriatus*), douvatgras (*Eragrostis obtusa*) and bloubuffel (*Cenchrus ciliaris*). Species for rocky ground include wildegrenaat (*Rhigozum*), slanghoutjie (*Garuleum*), gras-bo-bossie-onder (*Sericocoma*), whereas ankerkaroo (*Pentzia incana*) thrives on silty soils.

Rare and localized species are seldom available from seed suppliers. Plant species with very localized distributions should not be introduced beyond their natural ranges. This applies to many of the vygie (*Mesembryanthemum*) species. Seed capsules of vygie species should be collected in the area around the restoration site rather than bought in. Vygies such as springbokvygie (*Malephora*), and various types of *Ruschia* (steekvy) are important in restoration in the Succulent Karoo because they can establish on bare ground and as they grow they trap seeds of other plants facilitating succession to more diverse veld.

3.6.2 Storing seed

Seeds locally collected or bought in bulk from a supplier should be stored in a cool, dry, dark place free of rodents. Whereas most grass and legume seeds can be stored for up to a decade, seeds of bossies (Karoo shrubs) very rapidly lose viability and should not be stored for more than three years before sowing. It is not advisable to mix insecticides or rodenticides with stored seeds because of the negative effect that poison will have on the fauna (birds, lizards, insects) in the rehabilitation area.

3.6.3 Sowing seed

Seeds of most Karoo plants germinate on the surface or through a covering of soil no deeper than the thickness of the seed. Seeds should not be deeply buried or tilled into the soil. Sowing by hand or by hydroseeding is best done immediately before or after brush packing. Some large seeds and seeds supplied on stalks (for example bushman grass seed that is not easily stripped from the stems) may be unsuitable for

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hydroseeding. The large range in seed sizes and weights makes it difficult to mix seeds species together. Separate sowing of each species may be needed.

The best time to sow seed in winter-rainfall Karoo is autumn (April-May) just before the rainy season. Vygie seeds are enclosed in woody capsules on branch tips and the whole capsules can be collected when dry in spring, stored over summer and sown in autumn onto the soil surface. Autumn is also usually the best season for sowing seed in the Central Karoo, but spring sowing can work in good rain years. In Bushmanland and the Eastern Karoo late summer (Feb-March) and spring (Sept-Oct) sowing is advised.

3.6.4 *Hydrogels and seed coatings*

Some commercially-available seeds are precoated or pelleted with fertilizers, pesticides, adhesives and hydrogels. These coatings are designed to reduce seed damage and enhance germination and seedling growth. We do not advise the use of pesticide-coated seeds in veld rehabilitation because of the harm it may cause to seed predators, soil fauna and the rest of the food chain. It is possible to coat seeds with natural fertilizers such as dung, adhesives (starch, gum) and clay, gypsum or hydrogels to absorb and retain moisture. Seed pelleting methods such as this were developed at the Worcester Veld Reserve in the 1930s and similar mixes are used for arid land restoration in parts of Australia (see reading list **Appendix 1**). Larger pellets (ca. 20 mm) known as seed balls can contain a mixture of seeds. Preliminary trials indicate good initial germination but as for un-pelleted seed, seedling survival depends on follow-up rain.

3.6.5 *Hydro-seeding*

Hydro-seeding involves mixing seed with water, fertilizer, microbes, adhesives and mulch and spraying this onto the soil surface from a tanker with a high-pressure hose. This technique is often used in roadside revegetation of embankments and in large bare areas that need dust control and reseeding. It is more cost effective than hand seeding and the mulch mixture provides a protective germination environment. Despite its wide use in South Africa few studies have compared the outcomes of dry and hydroseeding techniques. In semi-arid areas elsewhere, hydro-seeding has yielded poor results because many plants need protection by other plants “nurse plants” to survive their first few years in hot dry environments. In South Africa hydro-seeding is often combined with soil stabilization methods including the use of “soil

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sausages” and soil blankets or soil-saver hessian sheets that prevent soil loss on bare ground exposed to erosion.

3.7 Irrigation and fertilizer

Irrigation and fertilizer increase plant growth rates, however in arid areas these additions do not always lead to sustainable vegetation cover or promote species diversity.

Rehabilitation trials in the Succulent Karoo that added N2:P3:K2 fertilizer granules to mulched plots and hollows found increased pioneer plant abundance and increased short-term plant growth after rain among the reseeded species, but over the longer term (12 months) survival was poorer in fertilized than unfertilized plots for perennial plants such as Karoo bietou (*Osteospermum sinuatum*). Fertilizers also promoted establishment on non-indigenous annual weeds.

Irrigation using sprayers was compared with non-irrigated areas on a rehabilitating sand mine on the coast of Namaqualand. It was hoped that irrigation would speed up the development of vegetation cover. After a year the irrigated plots had larger plants of a few species and far lower plant diversity and cover than the non-irrigated trial plots.

In general addition of fertilizers and irrigation to rehabilitation sites in the Karoo has not proven successful or cost effective. Karoo plants are adapted for mineral rich but nitrogen poor soils. Adding nitrogen is likely to disadvantage indigenous plants and diverse veld and will lead to their replacement by alien weeds (**see Section 3.10**).

3.8 Planting plugs and saplings

Where irrigation is available it is possible to introduce rooted plants to the rehabilitation site. Planting increases the rate of vegetation development because established plants trap soil, seeds and organic matter moving in the wind. Many Karoo plants need a “nurse plant” to survive long enough to develop deep roots or to tolerate exposure to sun, wind, frost and herbivores.

Small plants (plugs) in trays of 128 or 200 are easy to transport and can be removed from the plug trays with minimal root damage (**Figure 32**). They should be planted out into moist soil after heavy rain or irrigation. Trees such as sweet thorn

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(*Vachelia karroo*) or karee (*Searsia lancea*) and large woody shrubs including kruisbessie (*Grewia robusta*), koeniebos (*Searsia burchellii*), bloubos/jakkalsbessie (*Diospyros* spp) are more successfully established from irrigated plantings of plugs than from seed. Ankerkaroo (*Pentzia incana*) also establishes very well from plug planting.

Addition of hydrogels (water-holding polymers) to planting holes improves survival by retaining water around the roots. However this adds to costs.



Figure 32. A. Trays of ankerkaroo pugs for rehabilitation planting, B. sweet thorn saplings in one-liter bags.

3.9 Site protection

3.9.1 Brush packing

Stones, dung, fallen leaves and twigs in natural veld protect the soil surface and trap water, nutrients and seeds. Brush packing involves covering the soil surface with branches and simulates natural plant litter. Branches lightly shade the soil surface, reduce wind speed and keep the soil moist for longer after rain, protecting germinating seedlings and improving their survival (**Figure 33**). Brush packing also reduces the risk that new seedlings will be trampled or eaten by livestock or wildlife. Brush can be packed in dongas, between erosion fences, in hollows and on open ground. (**Figure 34**). Brush packing is suitable for all types of soil, but it should not be

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so dense that it excludes sunlight (**Figure 35**). Branches should make good contact with the soil and be heavy enough to stay put in windy weather.

Sweet-thorn and other acacias are excellent for bush packing because of the thorns that keep herbivores away from germinating seedlings. Sweet thorn wood is readily eaten by insects, and the disintegrating branches add nutrients to the soil. Any branches can be used, including those of invasive alien plants. However when using branches of invasive plants such as old man salt bush (*Atriplex nummularia*), pink tamarisk (*Tamarix ramossissima*), oleander (*Nerium oleander*), fire thorn (*Pyracantha* sp.) or mesquite (*Prosopis* now called *Neltuma* spp) for brush packing, take care that the branches do not include seeds or pods of alien plant species or the rehabilitation area could be invaded. This would necessitate costly clearing in the future.



Figure 33. Seedlings germinating beneath brush and mulch. Note that brush and mulch should never cover the soil completely. Light needs to reach the seedlings.

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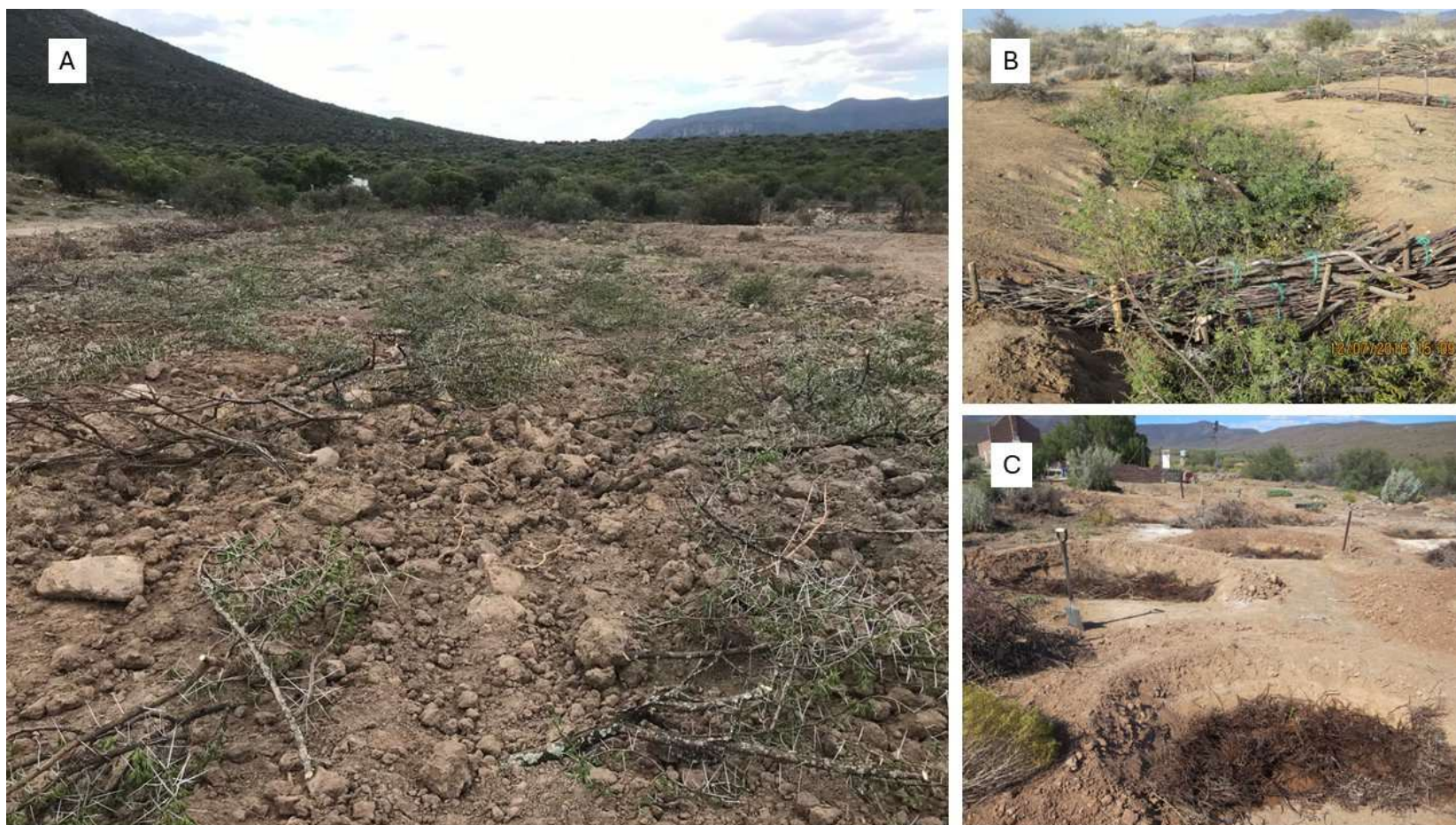


Figure 34 A. Old land ripped and brush packed with sweet thorn branches. B. donga stabilized with fences and brush, D. Hollows packed with brush.

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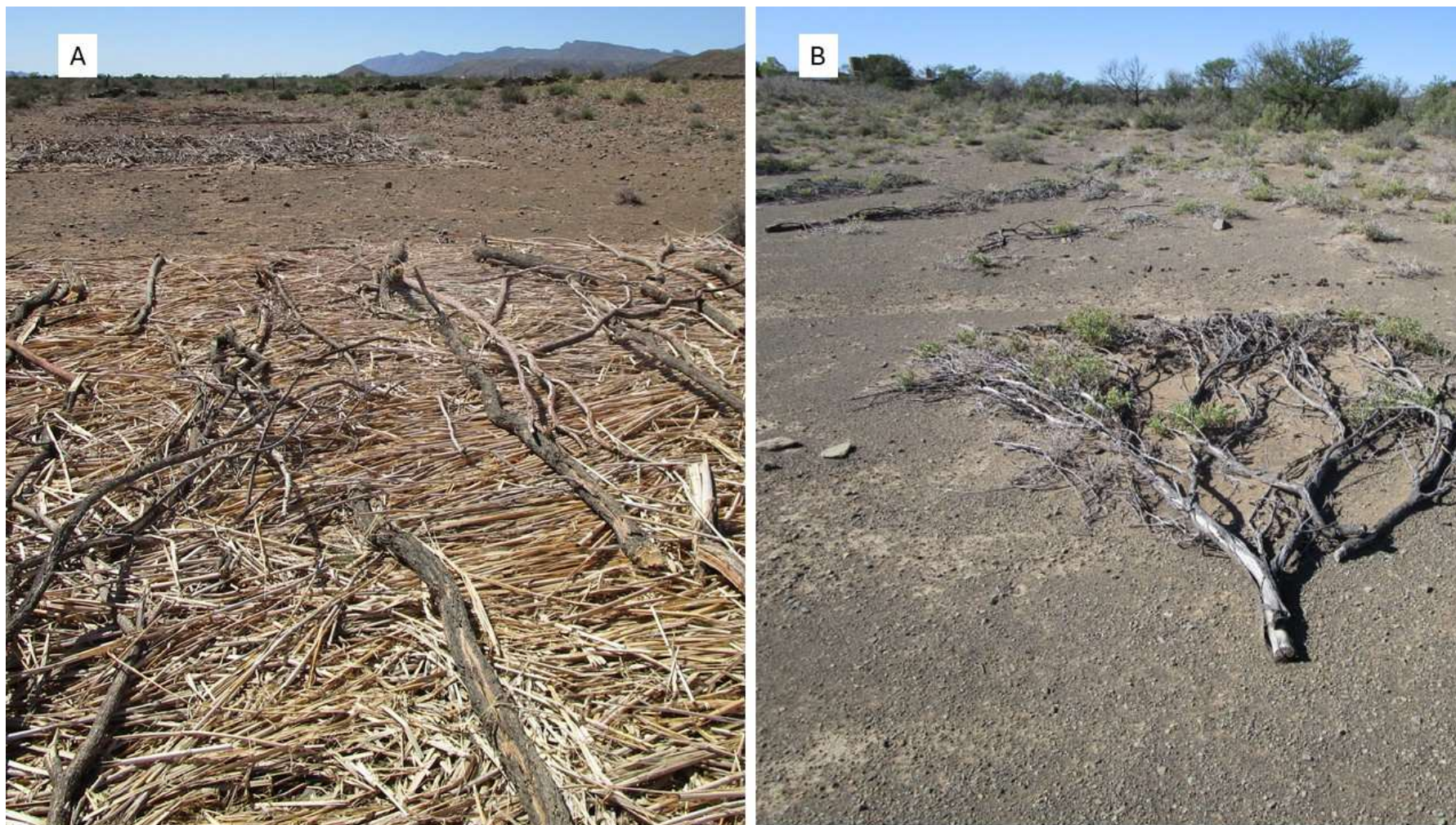


Figure 35 A. Brush packing that is too dense, excludes light and prevents seedling establishment. B. Sparse brush packing can be effective

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3.9.2 *Mulch and other materials*

In areas where no branches are available to protect the germinating seedlings and maintain soil moisture, other materials can be used. These mulch such as reeds, sisal leaves, wood shavings, dung and scattered stones 5 to 20 cm in diameter (**Figure 36**). If you use kraal dung you run the risk of introducing invasive alien plants with dung-dispersed seeds (mesquite, saltbushes) into the rehabilitation area. Never use cactus species for brush packing because the stems take root.

3.9.3 *Herbivore exclusion*

Domestic and wild herbivores, including ostrich, may be attracted to germinating seedlings. It is advisable to fence areas undergoing rehabilitation out of the grazing system or to withdraw grazing livestock from camps where rehabilitation work is taking place.



Figure 36. A. Sisal leaf mats and B. wood shavings can be used as alternatives to branches for protecting the soil and seedlings. C. It is important to exclude herbivores including ostrich from rehab sites.

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3.10 Maintaining rehabilitation sites

3.10.1 Weeding

Fast-growing indigenous and alien annual plants, proliferate on disturbed sites in the Karoo after heavy rains and on rehabilitation sites that are irrigated. Some of these are considered as weeds (undesirable plants) because they pose a problem for livestock farmers, but others are likely to die back naturally when the long-lived plants replace them. In winter rainfall areas, particularly on old lands, weeds may include indigenous stinkkruid (*Pentzia pilulifera*) and alien blasiebrak (*Atriplex lindleyi*) and brome grass (*Bromus* spp). In non-seasonal and summer rainfall areas, the annuals rolbos (*Salsola kali*, **Figure 37**), Mexican thistle (*Argemone ochroleuca*), Scotch thistle (*Carduus* sp.) may invade rehabilitation sites. These are short lived and do not usually pose a long-term problem unless they persist in a run of wet years and out-compete perennial grasses and shrubs.

Longer-lived weeds and alien trees such as boetebos (*Xanthium* sp.), fountain grass (*Cenchrus setaceus*) and mesquite (*Neltuma* sp. previously called *Prosopis*) should be weeded out as soon as possible because they pose problems for sheep farming and biodiversity conservation (**Figure 38**).



Figure 37. Rolbos dominated rehabilitation trials in an ostrich camp in the first year.

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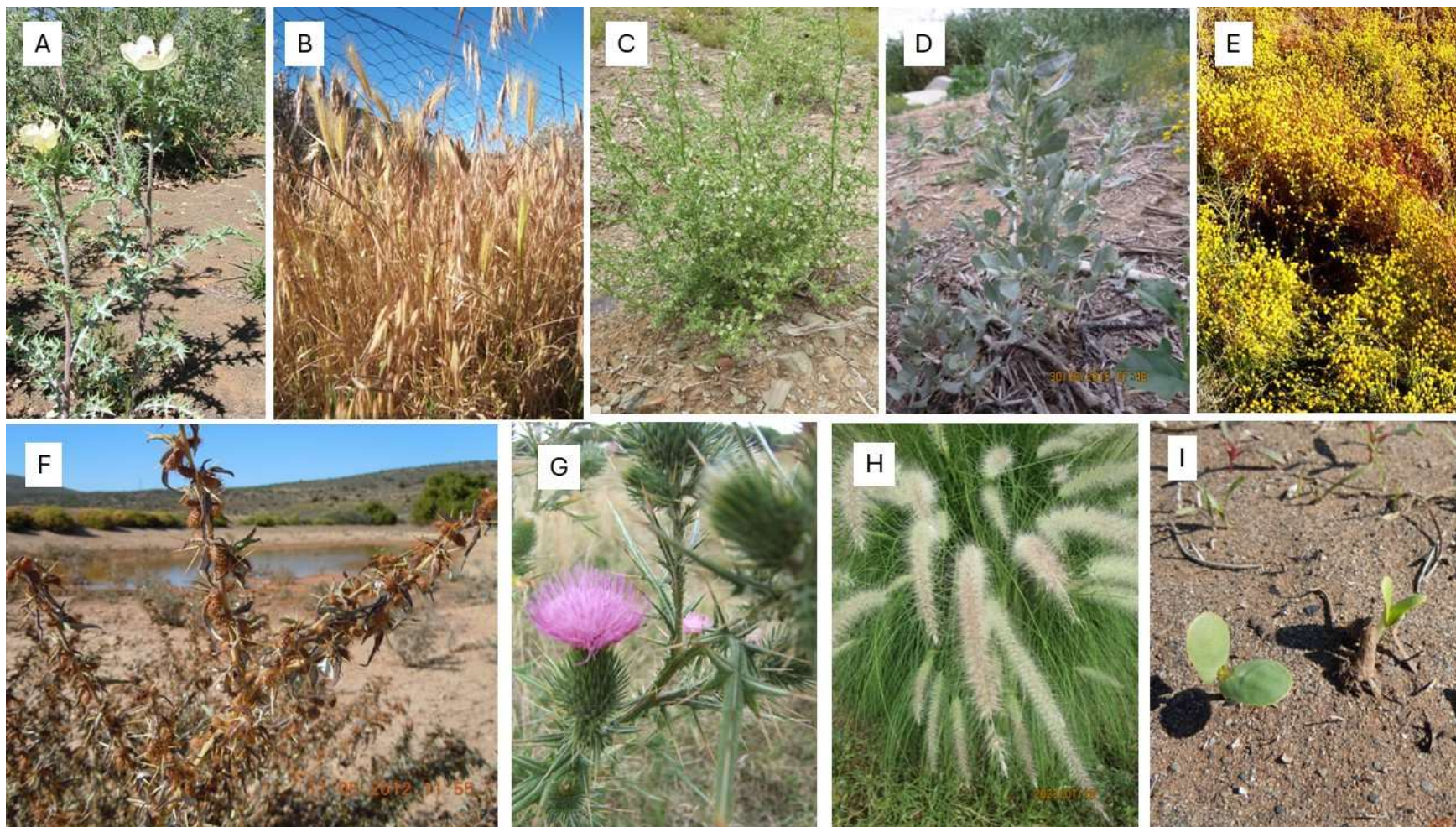


Figure 38. Weeds that may establish on areas undergoing rehabilitation. A. Mexican thistle, B. brome grass, C. rolbos, D. blasiebrak, E. stinkkruid, F. boetebos, G. thistle, H. fountain grass, and I. seedlings of mesquite.

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3.10.2 Soil erosion control

Erosion fences and hollows should be checked annually and repaired where wash-aways or broken water retention dams are causing further erosion damage that could threaten the investment in rehabilitation work (**Figure 39**). Where erosion structures are proving inadequate to slow runoff, additional structures should be added. Rehabilitation work should be seen as a continuous process rather than a once-off effort.



Figure 39. A large-scale fish-scale swale rehabilitation project near Montagu in need of maintenance. Accelerated runoff has broken through the swale dams and is causing on-going soil erosion.

3.10.1 Germination failure

Germination failure and death of germinated seedlings on rehabilitation work occurs where rainfall was inadequate or where the species selected were inappropriate for the local conditions. Seeding should be repeated in the appropriate season in more than one year to achieve the required cover and diversity. It is advisable to collect or buy fresh shrub seeds and to store grass seed for use in repeat seeding. Shrub seeds have shorter shelf lives than grass seeds. Seeding immediately before major predicted rainfall events increases the probability of success.

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4. Urban rehabilitation: bringing veld back

Residential erven in urban areas and eco-estates may still support natural vegetation (undeveloped), may have been previously ploughed for agriculture, previously built on or simply cleared of vegetation and left as bare ground. Restoring these sites to natural or semi-natural vegetation is very satisfying in the Karoo because

- Reconnects the owner to the surrounding Karoo;
- Brings back the lizards, birds and insects originally in the area;
- Develops a water wise and carefree landscape that needs no fertilizer and minimal labour to sustain;
- Is a source of constant interest as the vegetation diversity increases and changes and new bees, mantids, beetles and flies appear every year.

Renu-Karoo veld Restoration has successfully brought the veld back to vacant erven and gardens in very arid areas including Prince Albert, Merweville and the Moordenaars Karoo. Our nursery in Prince Albert grows over 500 species of indigenous plants most of them indigenous in the Karoo and adjacent areas. We also supply seeds of many Karoo species, advice on how to create veld gardens, and a site preparation and landscaping service.

The steps required for returning veld to an urban plot (**Figure 40-42**) vary with landuse history, climate and soil type, but generally involve the following:

- Remove rubble and concrete;
- Prepare the surface of the plot to trap water and protect seeds;
- Add structures that improve the site as shelter for plants and habitat for invertebrates and small animals (large rocks, tree trunks, or a small water feature);
- Compile a list of plants in the surrounding natural vegetation;
- Sow seed and plant plugs and plants in the appropriate season;
- Add thorn branches and mulch to protect the plants from wind and sun;
- For a quicker result arrange for hand watering or install temporary irrigation;
- Weed and maintain the young veld until the plants are strong enough to out-compete weeds;
- Watching the return of wildlife to your veld garden (**Figure 43**).

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Figure 40. Bringing the veld back to the garden: Step 1 – creating germination sites and water traps.

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Figure 41. Bringing the veld back to the garden: Step 2 – adding mulch, texture and seed.

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Figure 42. Bringing the veld back to the garden: Step 3 – adding diversity and removing weeds.

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Figure 43. Bringing the veld back to the garden Step 4: watching wildlife colonize your veld garden (Photos Karin Sternberg).

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5. Measuring restoration achievements

Restoration success can be measured by comparing the rehabilitated or restored veld or ecosystem with a nearby ecosystem in good condition (reference ecosystem). Six characteristics of the environment are usually considered as illustrated in **Figure 44** the “*Ecological Recovery Wheel*”. These are the

- species composition including the plants, animals and soil fauna;
- Structural diversity including horizontal and vertical structure;
- Ecosystem function including recycling of plant litter, recruitment of new plants, recovery after drought;
- External exchanges referring to processes such as pollination and seed dispersal that moves genes around landscapes and habitat connectivity that facilitates animal movements;
- Absence of threats meaning a lack of invasive alien plants, chemical pollution or over-grazing, and
- Physical conditions such as soil permeability, surface roughness, microsites, animal diggings all of which help plant populations to maintain themselves.

Each of these characteristics is scored from 1 (20% similar) to 5 (100% similar) depending on its similarity with the reference or desired condition that restoration is trying to emulate.

Even if one does not wish to formally score a restoration site it is useful to look not only at species composition but also at vegetation structure such as clump formation, the presence of decomposers and recyclers (e.g. termites), new plants, pollinators, weeds, soil erosion and microsites for seedling establishment caused by animal activity (diggings, burrows, dung). Taken together these signs tell you either that the restoration is progressing towards a self-sustaining ecosystem – or that the land needs further maintenance or seeding.

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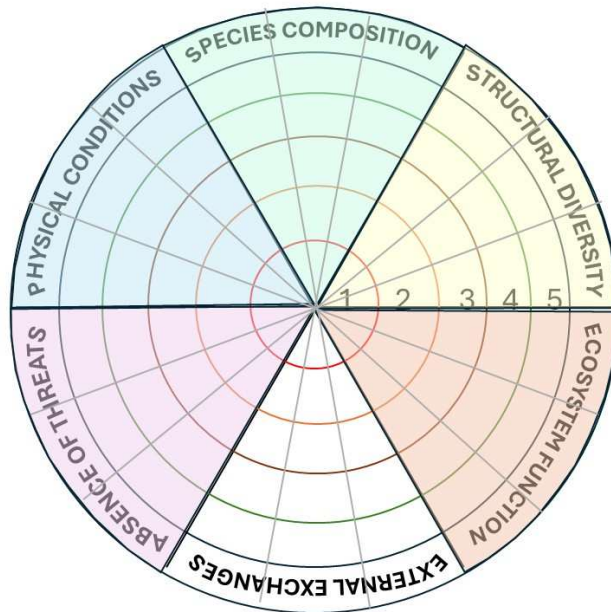


Figure 44. Ecological Recovery Wheel showing aspects to consider when comparing a rehabilitation project with veld in good condition.

Acknowledgements

Dr Peter Carrick of Nurture, restore, Innovate <https://nurturerestoreinnovate.org/> kindly reviewed Version 3 of this guide in March 2026.

Appendices

Appendix 1 Additional reading

General Karoo restoration and management

Carrick PJ, Botha S, Kruger R. 2022. Ekologiese restourasie in Namakwaland – 'n praktiese gids. Nurture, Restore, Innovate. Order from <https://nurturerestoreinnovate.org/namaqualand-book/> or email the author Pcarrick.nri@gmail.com

Coetzee, K. & Stroebel, W. 2015. Soil erosion control and veld rehabilitation for the Gouritz Cluster Biosphere Reserve. Available from https://gouritz.com/wp-content/uploads/2019/02/Soil-Erosion_Soil-erosion-control-and-veld-rehabilitation-guidelines_Coetzee-Stroebel_2015-compressed.pdf

Coetzee, K. 2023. Caring for Natural Rangelands, second improved edition. New Voices Publishing, Cape Town. Hard copy available from the author, email consken@mweb.co.za

Esler, K.J., Milton, S.J. and Dean, W.R.J. 2006. Karoo Veld - Ecology and Management. Briza Press, Pretoria. 224 pages. ISBN 1 875093 52 4

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(English), ISBN 1 875093 55 9. Hand copy Afrikaans edition available from the author renukaroo@gmail.com

Milton, S.J. and Dean, W.R.J. 2021. Anthropogenic impacts and implications for ecological restoration in the Karoo, South Africa. *Anthropocene* 36: Article 100307 <https://doi.org/10.1016/j.ancene.2021.100307>

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Improving veld composition

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Saayman N, Cupido C, Botha H, Swart R. 2017. Possible rehabilitation methods of *Galenia africana*-dominated old lands in the Cederberg Mountains, South Africa, *African Journal of Range & Forage Science*, 34:3, 167-171, <https://DOI:10.2989/10220119.2017.1380077>

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Site preparation

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Milton SJ, Coetzee K 2022 Hollows bring new life to bare patches in Karoo even in drought. *Grassroots* 22(1):10-13. https://wcro.co.za/wp-content/uploads/2023/10/Milton--Coetzee-2022-rehab-hollows-Grassroots-22_1.pdf

Seed collection, storage and seeding

Genis A 2021 Pak eko-herstel nou aan ter wille van oorlewing. *Landbouweekblad* 18 November pp 52-55.

Society for Ecological Restoration INTERNATIONAL NETWORK FOR SEED-BASED RESTORATION <https://ser-insr.org/native-seed-film>

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Reddy CM, Rajeswari SV 2025. Hydro-seeding: a restoration technique https://www.researchgate.net/publication/389599566_Hydro-Seeding_A_Revegetation_Technique

Measuring restoration success

Society for Ecological Restoration. A Tool for Assessing Ecosystem Recovery: The 5-Star Recovery System in Action. <https://www.ser.org/page/sernews3113>

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https://cdn.ymaws.com/www.ser.org/resource/resmgr/custompages/publications/ser_publications/recovery_wheel.pdf

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Appendix 2 Where to get advice, seeds, plants and services

Karoo and Renosterveld veld assessment and botanical surveys

Dr Helga van der Merwe helga@saeon.ac.za Succulent and Nama Karoo

Jan Vlok janvlok@mweb.co.za Succulent Karoo, Thicket, Renosterveld

Nick Helm botaneek@iafrica.com Renosterveld, Karoo, Fynbos

Rudi Swart Rudi.Swart@westerncape.gov.za Succulent and Nama Karoo

Simon Todd Simon.Todd@3foxes.co.za Succulent and Nama Karoo, Renosterveld

Dr Sue Milton-Dean renukaroo@gmail.com Succulent and Nama Karoo

Restoration Consultants

Bertus Fourie bertus.renukaroo@gmail.com Renu-Karoo veld Restoration cc
<https://www.renu-karoo.co.za> Karoo veld, urban restoration, landscaping

Chrizzette Neethling cdn@endemicvision.co.za Endemic Vision
<https://www.endemicvision.co.za/> mine restoration arid savanna, restoration assessment, compliance

Deon van Eeden deon@vula.biz Vula Environmental <https://vulaservices.com/>
Namaqualand and West Coast strandveld restoration and landscaping

Jolandi Buck jolandie@gouritz.com Renosterveld, Strandveld, Fynbos

Ken Coetzee consken@mweb.co.za Conservation Management Services
<https://conservationmanagementservices.co.za/> veld restoration, erosion control, arid and semi-arid areas, game management

Dr Peter Carrick pcarrick.nri@gmail.com Nurture, Restore, Innovate
<https://nurturerestoreinnovate.org/> veld and mine restoration Namaqualand

Wallie Stroebeel walliecms@telkomsa.net Conservation Management Services
<https://conservationmanagementservices.co.za/> veld restoration, erosion control, arid and semi-arid areas, game management

Suppliers of Karoo or Renosterveld seed and plants

Renu-Karoo Veld Restoration cc, Prince Albert <https://www.renu-karoo.co.za> contact
Bertus Fourie bertus.renukaroo@gmail.com Nama and Succulent Karoo and some Renosterveld seeds and plants

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Green Inthaba, Wolseley, Western Cape <https://www.greenintaba.co.za/> contact
Johann van Biljoen johann@greenintaba.co.za Riparian systems Western
Cape, Renosterveld seeds and plants

Worcester Veld Reserve (Western Cape Agriculture)
<https://www.elsenburg.com/worcester-veld-reserve-research-farm/> contact
Rudi Swart Rudi.Swart@westerncape.gov.za Succulent Karoo seeds

Hydroseeding companies

Salok Hydrograss <https://salok.co.za/index.html> (Welgemoed, Western Cape)

Hydromulch <https://hydromulch.co.za/contact/> (Gauteng)

Aquamulch <https://www.aquamulch.co.za/hydroseeding/> (Gauteng)

Conservation advice, stewardship, permits

Cape Nature Oudtshoorn:

- Theresa van der Westhuizen (permits) tvdwesthuizen@capenature.co.za;
- Carmen Gagiano (permit queries) cgagiano@capenature.co.za
- Tom Barry (Stewardship queries) tbarry@capenature.co.za

Overberg Conservation Trust <https://overbergrenosterveld.org.za/> conservation,
stewardship and veld restoration in Overberg Renosterveld

Grant Forbes (Conservation Manager Overberg Renosterveld Trust)
grant@overbergrenosterveld.org.za

Gouritz Cluster Biosphere Reserve (GCBR) <https://gouritz.com/> online information on
conservation and restoration in the Gourtiz catchment, assistance with conservation
networking

Endangered Wildlife Trust (EWT) Drylands Focus Area [https://ewt.org/drylands-
strategic-conservation-landscape/](https://ewt.org/drylands-strategic-conservation-landscape/) Co-developing and implementing conservation
management approaches to ensure sustainable conservation impact with a particular
focus on restoration and habitat management for endangered species including
Riverine Rabbit, Dwarf Tortoise, succulent plants and birds of prey.

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Appendix 3. Seed selection by region: These lists are for a few common plant species for which seed is available from Renu-Karoo and a few other suppliers

Appendix 3.1 Succulent Karoo - Rain-shadow valley Karoo (Klein Karoo, Tankwa, Prince Albert, Moordenaars, to Willowmore)

Plant type	Latin name	Common name	Sowing season	Soil	Notes
Grass	<i>Fingerhuthia africana</i>	Vingehoed	any	Silt, clay	Hard pioneer grass
Grass	<i>Stipagrostis obtusa</i>	kortbeenboesmangras	Spring-summer	sand	Short, palatable grass
Bossie	<i>Osteospermum sinuatum</i>	Karoo bietou	autumn	Loam, clay	Palatable deciduous dwarf shrub
Bossie	<i>Garuleum bipinnatum</i>	slanhoutjie	autumn	rock	Palatable, deciduous dwarf shrub, Rocky ridges
Bossie	<i>Limeum aethiopicum</i>	koggelmandervoetkaro	Spring-summer	Rock, loam	Palatable dwarf shrub
Succulent	<i>Tetragonia spicata</i>	kinkelbos	autumn	Rock, silt, loam	Palatable dwarf shrub
Succulent	<i>Ruschia spinosa</i>	steekvy	autumn	rock	Dwarf succulent Good pioneer as plants trap seeds of other plants and shelter seedlings
Shrub	<i>Caroxylon aphyllum</i>	rivierganna	Spring-summer	Deep saline silt	Tall shrub (2 m) valley bottoms

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Appendix 3.2 Succulent Karoo – Namaqualand and knersvlakte

Plant type	Latin name	Common name	Sowing season	Soil	Notes
Grass	<i>Stipagrostis obtusa</i>	kortbeenboesmangras	Spring-summer	sand	Short, palatable grass
Grass	<i>Chaetobromus involucratus</i>	hartbeesgras	autumn	Sand dunes	Mid height hard grass pioneer
Grass	<i>Ehrharta calycina</i>	rooisaadgras	autumn	Loam, clay	palatable
Annual	<i>Lessertia annularis</i>	skaapertjie	autumn	Sand, loam	Palatable legume
Bossie	<i>Osteospermum sinuatum</i>	Karoo bietou	autumn	Loam, clay	Palatable deciduous dwarf shrub
Succulent	<i>Ruschia spinosa</i>	steekvy	autumn	rock	Dwarf succulent Good pioneer as plants trap seeds of other plants and shelter seedlings
Succulent	<i>Tetragonia fruticosa</i>	kinkelbos	autumn	Rock, silt, loam	Palatable dwarf shrub
Shrub	<i>Caroxylon aphyllum</i>	riviervanna	Spring-summer	Deep saline silt	Tall shrub (2 m) valley bottoms
Shrub	<i>Manochlamys albicans</i>	spanspekbos	autumn	Sand and silt	Medium height (1 m), palatable

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Appendix 3.3 Nama Karoo – Gamka lowland

Plant type	Latin name	Common name	Sowing season	Soil	Notes
Grass	<i>Cenchrus ciliaris</i>	Bloubuffel	Spring-summer	River beds	Palatable to larger grazers
Grass	<i>Fingerhuthia africana</i>	Vingehoed	any	Silt, clay	Hard pioneer grass
Grass	<i>Stipagrostis obtusa</i>	kortbeenboesmangras	Spring-summer	sand	Short, palatable grass
Annual	<i>Gazania lichtensteiniana</i>	botterblom	autumn	all	Palatable annual
Bossie	<i>Osteospermum sinuatum</i>	Karoo bietou	autumn	Loam, clay	Palatable deciduous dwarf shrub
Bossie	<i>Garuleum bipinnatum</i>	slanghoutjie	autumn	rock	Palatable, deciduous dwarf shrub, Rocky ridges
Bossie	<i>Eriocephalus ericoides</i>	Karoo kapok	autumn	Rock, loam	Palatable dwarf shrub
Bossie	<i>Limeum aethiopicum</i>	koggelmandervoetkaroo	Spring-summer	Rock, loam	Palatable dwarf shrub
Bossie	<i>Sericocoma avolans</i>	Gras-bo-bossie-onder	Spring-summer	Rock, loam	Palatable dwarf shrub
Succulent	<i>Ruschia spinosa</i>	Steekvy	Autumn	rock	Dwarf succulent Good pioneer as plants trap seeds of other plants and shelter seedlings
Shrub	<i>Rhigozum obovatum</i>	Wildegarnaat/karoo gold	Spring-summer	Rocky ground	Tall shrub (2 m) ridges

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Appendix 3.4 Nama Karoo – Western Upper

Plant type	Latin name	Common name	Sowing season	Soil	Notes
Grass	<i>Fingerhuthia africana</i>	Vingehoed	any	Silt, clay	Hard pioneer
Grass	<i>Themeda triandra</i>	rooigras	Spring-summer	loam	Palatable perennial
Grass	<i>Stipagrostis spp</i>	Bushman grasses	Spring-summer	Loose sand	palatable
Annual	<i>Gazania lichtensteiniana</i>	botterblom	autumn	all	Palatable annual
Bossie	<i>Pteronia glauca</i>	Boegoekaroo	autumn	Loam, silt	palatalbe
Bossie	<i>Pentzia incana</i>	Skaapbossie, anker karoo	any	Silt, loam, clay	Palatable dwarf shrub
Bossie	<i>Dimorphotheca cuneata</i>	Wit bietou, bride's bouquet	autumn	Rock, loam,	Palatable dwarf shrub
Bossie	<i>Eriocephalus ericoides</i>	Karoo kapok	autumn	Rock, loam	Palatable dwarf shrub
Bossie	<i>Limeum aethiopicum</i>	koggelmandervoetkaroo	Spring-summer	Rock, loam	Palatable dwarf shrub
Succulent	<i>Drosanthemum hispidum</i>	Dew vygie	autumn	Rock, loam	Palatable pioneer
Succulent	<i>Ruschia intricata</i>	steekvy	autumn	Sand	Unpalatable spiny
Shrub	<i>Rhigozum obovatum</i>	Wildegrenaat/ karoo gold	Spring-summer	Rocky ground	Tall shrub (2 m) ridges

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Appendix 3.5 Nama Karoo – Eastern Upper

Plant type	Latin name	Common name	Sowing season	Soil	Notes
Grass	<i>Fingerhuthia africana</i>	Vingehoed	any	Silt, clay	Hard pioneer
Grass	<i>Themeda triandra</i>	rooigras	Spring-summer	loam	Palatable perennial
Grass	<i>Hyparrhenia hirta</i>	dekgras	Spring-summer	Loam, rock	Less palatable tall grass
Grass	<i>Digitaria eriantha</i>	Smuts fingergrass, hoenderspoor	Spring-summer	Loam, rock	Palatable perennial
Grass	<i>Chloris virgata</i>	Klossiegras, feather grass	Spring-summer	silt	Palatable pioneer
Bossie	<i>Pentzia incana</i>	Skaapbossie, anker karoo	Any	Silt, loam, clay	Palatable dwarf shrub
Bossie	<i>Felicia filifolia</i>	persdraaibos	Early spring	Rock, loam	Palatable dwarf shrub
Bossie	<i>Eriocephalus ericoides</i>	Karoo kapok	Early spring	Rock, loam	Palatable dwarf shrub
Bossie	<i>Limeum aethiopicum</i>	koggelmandervoetkaroo	Spring-summer	Rock, loam	Palatable dwarf shrub
Shrub	<i>Dicerotheramnus rhinocerotis</i>	renosterbos	Early spring	Loam, silt, rock	Unpalatable tall shrub

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Appendix 3.6 Bushmanland

Plant type	Latin name	Common name	Sowing season	Soil	Notes
Grass	<i>Fingerhuthia africana</i>	Vingehoed	any	Silt, clay	Hard pioneer
Grass	<i>Stipagrostis spp</i>	Bushman grasses	Spring-summer	Loose sand	palatable
Grass	<i>Eragrostis lehmanniana</i>	knietjiegras	all	Sand, silt	Palatable pioneer
Annual	<i>Gazania lichtensteiniana</i>	botterblom	autumn	all	Palatable annual
Bossie	<i>Pteronia glauca</i>	Boegoekaroo	autumn	Loam, silt	palatable
Bossie	<i>Pentzia incana</i>	Skaapbossie, anker karoo	any	Silt, loam, clay	Palatable dwarf shrub
Bossie	<i>Eriocephalus ericoides</i>	Karoo kapok	autumn	Rock, loam	Palatable dwarf shrub
Bossie	<i>Lessertia frutescens</i>	kankerbos	autumn	Sand, loam	Palatable legume
Bossie	<i>Limeum aethiopicum</i>	koggelmandervoetkaroo	Spring-summer	Rock, loam	Palatable dwarf shrub
Succulent	<i>Kleinia longiflora</i>	sjambokbos	autumn	Rock, loam	Unpalatable shrub
Shrub	<i>Caroxylon aphyllum</i>	rivierganna	Spring-summer	Deep saline silt	Tall shrub (2 m) valley bottoms
Shrub	<i>Rhigozum obovatum</i>	Wildegarnaat/ karoo gold	Spring-summer	Rocky ground	Tall shrub (2 m) ridges

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Appendix 3.7 Arid Renosterveld

Plant type	Latin name	Common name	Sowing season	Soil	Notes
Grass	<i>Ehrharta calycina</i>	rooisaadgras	Autumn	Loam	palatable
Grass	<i>Eragrostis curvula</i>	oulandsgras	Autumn	Loam	palatable
Grass	<i>Themeda triandra</i>	rooigras	Spring	Loam	palatable
Shrub	<i>Athanasia spp</i>	kouterbos	Autumn	Loam	unpalatable
Bossie	<i>Dicerotheramnus rhinocerotis</i>	renosterbos	Autumn	Loam	unpalatable
Bossie	<i>Dimorphotheca cuneata</i>	Wit bietou	Autumn	Loam	palatable
Bossie	<i>Euryops spp</i>	harpuis	Autumn	Loam	unpalatable
Bossie	<i>Felicia filifolia</i>	draaibos	Autumn	Loam	palatable
Bossie	<i>Oedera spp</i>		Autumn	Loam	palatable
Bossie	<i>Pentzia dentata</i>		Autumn	Loam	unpalatable
Bossie	<i>Pteronia incana</i>	Asbos, kraakbos	Autumn	Loam	unpalatable
Woody shrub	<i>Searsia longispina</i>	taaibos	Spring	Loam	Palatable for browsers
Woody shrub	<i>Diospyros austroafricana</i>	bloubos	Spring	Loam	Palatable for browsers
Tree	<i>Searsia lancea</i>	karee	Spring	Loam	Palatable for browsers

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