BEST PRACTICE GUIDELINES

for minimising impacts on the flora of the southern Namib

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ISBN 99916-63-77-0

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Cover design and layout by Heike Lorck
Typesetting by Protype
Printed by John Meinert Printing 1999 (Pty) Ltd.

First published in 2005

Published by:

EnviroScience
PO Box 90230
Windhoek
Namibia

and

Namibia Nature Foundation
PO Box 245
Windhoek
Namibia

This publication is supported by the **Critical Ecosystem Partnership Fund (CEPF)**, a joint initiative of **Conservation International**, the **Global Environment Facility**, the **Government of Japan**, **the John D. and Catherine T. MacArthur Foundation** and the **World Bank**. Work that contributed to these guidelines was partially funded by the **Namibian National Biodiversity Programme** (Ministry of Environment and Tourism and Gesellschaft für Technische Zusammenarbeit).

Citation: Burke, A. (2005). Best practice guidelines for minimising impacts on the flora of the southern Namib. EnviroScience and Namibia Nature Foundation, Windhoek, 52 pp.

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Foreword

The southern Namib, and particularly the Sperrgebiet, has been identified as a priority area within one of the world's prime arid-zone biodiversity hotspots, the Succulent Karoo Biome. Wise use of this fragile national asset is vital for Namibia to achieve sustainable development objectives and optimal long-term returns from this region.

Economic developments in the Succulent Karoo put pressure on this natural asset. Many of these developments were initiated many years ago, before wise land-use planning, biodiversity conservation and environmental assessment procedures had been developed. A number of the plants and animals in this region occur nowhere else on earth, and we have a special responsibility for their welfare. We also have a responsibility to maintain the unique character and wilderness of this area, while at the same time developing ways of earning income from the area for local upliftment and national development.

Modern environmental planning and management, and new knowledge on the restoration of disturbed areas offer many tools to achieve economic development, while at the same time protecting and rehabilitating ecologically important areas. This booklet provides simple guidelines in a user-friendly format. It is the first practical guide for environmental management of the Succulent Karoo Biome, and the first of its kind in Namibia. It is my hope that many will read and implement these guidelines and so help make a positive contribution to the wise management and development of Namibia's prime arid-zone biodiversity asset.

Dr Chris Brown
Director, Namibia Nature Foundation
2005

Preface

This booklet is an output of the Southern Namib Restoration Ecology Project of the Namibian National Biodiversity Programme (Ministry of Environment and Tourism). Major developers in the southern Namib supported initial restoration activities, which focussed on plant relocation. Plants that were to be cleared to make way for developments were earmarked for various trials undertaken in Windhoek by the National Botanical Research Institute in collaboration with commercial nurseries, while others were transplanted on site. This booklet summarises the findings of these trials, as well as other restoration initiatives.

It provides guidelines for restoration, but the success of the proposed measures depends on many circumstances – to a large extent on the care taken during their implementation and the environmental conditions at the time. Although I cannot guarantee success, these guidelines will help you to make a difference!

Dr Antje Burke
2005

Acknowledgements

Many people provided input into drafts of this booklet, as well as into the practical work that made these guidelines possible. I would like to thank Henk Dauth, Nicolaas du Plessis, Coleen Mannheimer and Paul Wood for their many practical suggestions. Sarah Frazee, Pauline Lindeque and her staff, the staff of the National Botanical Research Institute, Niko Kisting and Trygve Cooper provided comments on draft versions of this booklet. Nina Marshall, Sue Milton, Karen Esler and Peter Carrick provided a critical review and many useful comments. Carole Roberts, Heike Lorck and Stephan Niemann were important contributors during the final production.

Why should we care?

Plants provide essential goods and services such as food, fodder, oxygen, moisture, shade and medicine. They help to regulate local climatic conditions, capture carbon, stabilise soil, suppress dust and are essential elements of all landscapes giving these a particular character. We could never do without them.

For an arid country, Namibia is exceptionally rich in plant species. In particular, the south-western corner of the country – the southern Namib – is a treasure-box of botanical riches. Some of these riches are protected in conservation areas, such as in the Ai-Ais–Richtersveld Transfrontier Park; the majority is in the Sperrgebiet which will be a multi-use conservation area in the future. These plant riches are also, however, present on farmland adjoining these conservation areas.

Mining, exploration and related service industries, such as, communications, roads and power-line infrastructure linking and feeding the mines, are developments and land uses in the southern Namib that can badly affect the environment.

A treasure-box of botanical riches

Some 1050 plant species occur in the Sperrgebiet alone. That is nearly 25% of the entire flora of Namibia – on just 3% of the country's land surface. This is a remarkable concentration of diversity!

Outside the Sperrgebiet, in addition to mining, exploration and infrastructure, other pressures on the land and vegetation are high. There are demands on resources for clean water, fuel and food, grazing for cattle and browse for goats and sheep, as well as impacts of large irrigation schemes along the Orange River.

So why should we care about protecting and preserving the botanical riches in this area? Bad practices will destroy the essential plant cover and can ruin future options for sustainable living in this area. Not only could it ruin the basic services mentioned above, but probably also a range of useful, yet undiscovered properties that may hide amongst the southern Namib's plant riches. The higher the diversity, the greater the chances that a "wonder drug", the perfect purifier of polluted water or the most durable fibres will be found amongst those riches. The horticultural potential of the attractive succulents that make the southern Namib flora so special, is at present already exploited – unfortunately in the worst sense, mainly illegally and with dire consequences for some plant populations.

As a country, Namibia also wants to make its contribution to maintaining global biodiversity. Because of its unique and varied plant and animal life, this little patch of Succulent Karoo forms part of one of only 25 biodiversity hotspots identified in the world. As a result, all around the world people are paying attention to how we treat this national, natural asset.

A global biodiversity hotspot

Realising that there would probably never be enough money to adequately protect biodiversity on our planet, renowned scientists devised a way of prioritising areas that require the most urgent support. To do this, they looked at plant and animal diversity, those that have a very limited distribution and are restricted to a particular area, and at the threat imposed by habitat loss. The result was a list of 25 global "biodiversity hotspots". Southern Africa's **Succulent Karoo** (of which Namibia holds the northern tip – the southern Namib) is listed as such a hotspot, together with the Guinean rain-forests of West Africa, forests of the tropical Andes, Madagascar and many other hotspots. We can take pride in this.

Southern Namib
Sperrgebiet
Orange River

How to use these guidelines

These guidelines are written for environmental planners and practitioners who do not necessarily have a botanical background, and for engineers and contractors working in the southern Namib. The booklet tries to explain some practical aspects of environmental management in the southern Namib in simple terms, hopefully appealing to a wide range of people, who would like to make a positive contribution, but to date have not known how.

It introduces some aspects of environmental management, including ways to minimise impacts and how to reverse these if they cannot be avoided. A major section of the booklet is dedicated to practical steps in restoring habitats, including detailed information on relocating plants. This guide focusses on plants and habitats with the rationale that adequate plant cover and functioning habitats will induce animals to move back to previously disturbed areas.

Important messages are highlighted throughout the text in boxes, like the one below. Background information is provided in shaded textboxes. A quick guide (page 48) provides the most important principles at a glance.

If you read, think about, and implement these messages, you can make a big difference!

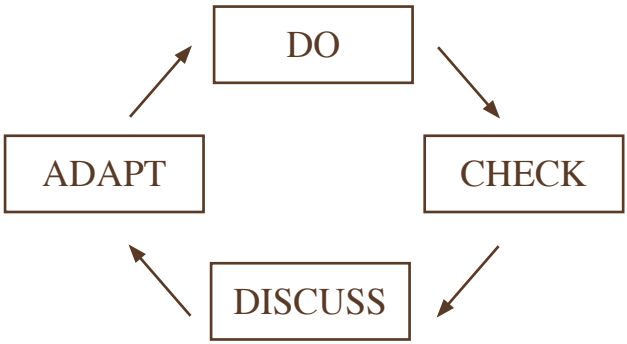
Although most of the practical advice in this booklet is drawn from observations of southern Namib plants and habitats, it can also be applied in other parts of Namibia, and perhaps in other similar drylands elsewhere in the world.

Environmental management

Environmental management is a dynamic task that, in a positive sense, is never finished. This is because proper environmental management implies that you:

- Try to do whatever you can to mitigate impacts, using the latest information available at the time.
- Check how successful your methods are in terms of reducing impacts on the environment.
- Discuss your findings with a wide variety of people (engineers, farmers or others), including those who are not necessarily known to be supporters of conservation.
- Adapt your methods of environmental management to new ideas that may arise from these discussions and that other people have tried and found working elsewhere.

The point is: check what you are doing, discuss, and adapt if it does not go the desired way or if better methods become available.



Minimising impacts on the flora – simple rules

Every plant, no matter how small, has an important role in the southern Namib's web of life. In an ideal world, we should leave them all untouched – which is, of course, not always feasible.

Avoiding impacts is the first choice and always has priority.

Only if there are well-justified reasons, why this is not possible, mitigation (such as, relocating plants) should be considered. Some simple rules to avoid impacts follow.

During **project planning**:

- Assess **all** project alternatives with regard to impacts on the flora, biodiversity and the natural environment.
- Avoid botanically and environmentally sensitive areas.
- Make maximum use of already-disturbed areas.
- If impacts are unavoidable, think about storing topsoil and plants.
- Plan your operations with rehabilitation in mind.

Project alternatives include selecting an alternative location for the main area of development (for example, a different site for a planned power station), as well as alternative positions for infrastructure, and alternative industrial processes. By looking at alternatives, an environmental assessment would identify "no-go" areas during the planning stage of a project. Areas where development would threaten the survival of a species, for example, should thus not be considered at all.

During **construction**:

- Minimise the clearing of vegetation – the more you leave undisturbed, the better the chances that plants will grow back naturally.
- Stay on established roads and tracks, and maintain these to avoid making multiple, parallel tracks.
- Make maximum use of already-disturbed areas for the positions of construction camps and other temporary infrastructure. (Do not only think of the shortest distance to the construction site.)
- In the case of linear infrastructure (such as roads and powerlines), cross sensitive habitats in the shortest way possible to minimise disturbance.
- Clearly demarcate construction corridors and operate only within those demarcated areas.
- Educate all construction staff about environmental obligations – including legal implications and the reasoning behind certain actions.
- Supply commercially obtained firewood, charcoal or gas stoves to construction teams, and prohibit the collection of firewood.
- Regulations against the illegal collection of protected plants (applicable to most plants in the southern Namib) and artefacts, as well as the killing of wildlife, should be strictly enforced.
- If you operate in areas that are infested with invasive alien plants, implement measures to avoid spreading these further.
- Rehabilitate areas that are no longer used or impacted, as soon as construction moves on. Do not leave this task to the very end.

Environmentally sensitive areas

Environmentally sensitive areas are areas that are important habitats for particular plants or animals or for maintaining a healthy environment. These could be areas where wildlife frequently cross the road or have their dens and resting places, where there are water sources, or areas where plant species that are of conservation concern are concentrated. Habitats that are often environmentally sensitive include riverbanks, wetlands, springs and rocky outcrops. Environmentally sensitive areas vary according to region and include additional habitats in different parts of the country. In the southern Namib it is not so easy to label a particular habitat "environmentally sensitive", as range-restricted plants occur on gravel and gypsum plains, rocky surfaces, hills and mountains, and even in the dunes and on sand plains.

During **closure**:

- Optimise the use of infrastructure for future use.
- Remove and dispose of all redundant infrastructure according to accepted waste-management procedures.
- Ensure that waste sites are properly secured.
- Secure all dangerous sites, for example, abandoned pits.
- Specify all rehabilitated sites "out of bounds", so as not to disturb recovery.

Fixing the impact – rehabilitate

If all the ground rules have been followed and the disturbance of natural habitats is unavoidable, there is only one way to help plants to grow back naturally and animals to move back to the disturbed area – rehabilitate.

Before going further, some terminology needs some explanation. **Rehabilitation** is a general term referring to all the measures that are used to repair damaged environments. These measures include removing infrastructure, cleaning up pollution or even planting pastures. **Restoration** takes rehabilitation one step further and refers to the process of reinstating the habitats, environmental conditions, and plants and animals that were there before the disturbance. Hence, restoration is also a type of rehabilitation. Habitat restoration should be the final goal in all areas of conservation importance, where the final land use (for example, tourism or conservation) depends on the integrity and natural state of the environment. This certainly applies to the southern Namib.

To make it easier for plants to recolonise and animals to move back to disturbed areas, restore the habitat.

If we provide the right conditions, nature will help itself and plants and animals will come back naturally to a previously disturbed area, even if the process takes a long time.

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (Society for Ecological Restoration 2002).

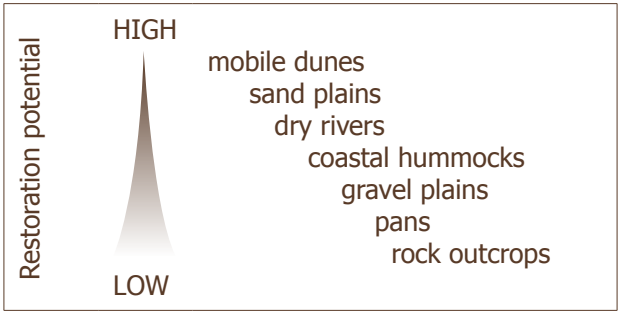
Habitat restoration is a type of ecological restoration. It is based on the principle that if the basic elements and functions of a habitat are restored (such as suitable soil, appropriate drainage conditions, plant cover), nature will do the rest and animals will recolonise these restored areas naturally. The first step in ecological restoration is to restore plant cover – the focus of this booklet.

Restoration of different habitats

The type of restoration measures that are appropriate in a particular area will depend on the habitat and environmental conditions. For example, measures that are used in sandy areas may not be as effective on gravel plains and vice versa. However, there are some basic guidelines to follow.

The nature of the habitat which is to be restored plays a fundamental role in the success of any restoration effort, regardless of the method (such as landscaping, transplanting, replanting or seeding) used.

Some types of habitats are notoriously difficult to restore, others are relatively easy to work with. For the main habitats in the southern Namib, the diagram below illustrates the restoration potential.



Rock outcrops are areas with rocky surfaces, such as small hills, inselbergs or even mountain slopes. In the southern Namib these habitats have the highest numbers of sensitive plant species. They are also the most difficult – if not impossible – habitats to restore. Avoiding impacts on rock outcrops is critical.

Landscaping blasted or otherwise mangled koppies or mountain slopes is a real challenge. The only practical solution is usually to keep them out of sight.

Relocation of plants on rocky outcrops is a difficult task and can only be undertaken for selected species, such as some crassulas and small mesembs. Appropriate action has to be determined on a case-by-case basis, and rock outcrops should only be disturbed under exceptional circumstances.

Pans are usually bare of vegetation, but have salt crusts on the surface which are very difficult to restore. As with rock outcrops, impacts should be avoided at all costs.

Gravel plains are level areas with a stone cover, often with underlying gypsum in the coastal areas. They form a diverse group of habitats, with transitions to sandy areas and the nature of the stone cover varying greatly. Depending on their characteristics, gravel plains are difficult, to moderately difficult, to restore.

Gravel plain habitats are moderately suited for plant relocation.
The types and number of plants affected will determine whether this should be attempted.

Coastal hummocks are large piles of sand, often several metres high, which build up underneath shrubs in the beach areas. Although these are in naturally dynamic, wind-impacted areas, they do not seem to re-establish easily once disturbed.

Dry rivers are usually sandy, experience regular, natural disturbance and, hence, are easier to restore. They occasionally harbour plants suitable for relocation.

Sand plains are habitats with a thick cover of sand. They include vegetated dunes, areas of small hummocks along the coast away from the beaches, as well as the sand plains inland. Sand plains are relatively easy to landscape and ideal habitats for plant relocation. They have a substrate that is easy to dig, they support many species that tolerate relocation and their soil is easily stabilised.

Mobile dunes reshape themselves and usually only require some initial landscaping to redevelop their natural form. They are usually devoid of plants.

Understanding the forces of wind and water in a particular area and how they shape landforms is critical in restoring habitats.

Wind and water are important forces in the southern Namib that need to be kept in mind. It is important to understand in which manner the wind shapes landforms, and distributes soil and seeds in a particular area. In terms of water, whether or not fog or rain occurs, how much and how often, as well as the characteristics of its runoff, are other important factors.

Planning with rehabilitation in mind

Much would be achieved, if project engineers and planners think ahead to what the area should look like once their project is finished. Nowadays, everybody accepts that infrastructure and pollution has to be removed, but to shape the landscape in a more natural way is not always considered. Even less common is the preparation of an altered landscape and habitat to make it easier for plants and animals to recolonise the disturbed area.

There are many things that one should keep in mind, for example:

- What will the material that ends up as the final surface cover be composed of?
- Will it have different chemical or physical properties to the surrounding natural substrate?
- If so, is it possible to avoid this and perhaps spread some other material on top?
- How will the new landforms fit into the natural landscape?
- Will the shapes, contours and the colours of the material blend in?
- Will the new landforms, for example, steep slopes be prone to erosion?
- Could soil and plant material be "rescued", stored and used for rehabilitation later?

Project planners can make a very positive contribution if they think ahead with rehabilitation in mind.

To undertake **rehabilitation**:

- Remove all selected infrastructure and waste.
- Clean up all pollution, including polluted soil.
- Restore the habitat so that plants can recolonise it.
- If topsoil storage proved feasible, spread the topsoil on disturbed areas.
- Replant areas with the original plant species, if the areas will take a long time to recover without assistance.

One principle of restoration is to create conditions that help plants from nearby to gain a foothold in the disturbed area. The most successful model, usually, is to prepare the disturbed site similar to the nearby, undisturbed area, provided that they were similar with respect to habitat and vegetation before the disturbance took place. It would, for example, not make sense to try to create grassland pastures, where before there was succulent shrubland.

What is special about topsoil?

Topsoil, the top 10 cm of the soil, contains the majority of the living soil organisms and organic material, as well as the seeds of plants. The living components – which include fungi, insects and microbes – ensure that nutrients are broken down and available to the plants, and retain water in the soil. Seed stores are essential to ensure that new plants can germinate.

If you have fresh topsoil and a disturbed area nearby, do not seal the topsoil under concrete or similar material, but collect it and spread it on an area undergoing rehabilitation.

Common problems during rehabilitation that require some intervention are:

- compacted soil
- unsuitable physical and chemical conditions of the soil (for example, salts that have been brought up from deep in the ground during earth-moving) and
- changes in the flow (amount and direction) of runoff water.

These problems have to be addressed using appropriate measures, and in some cases may require a specialist's advice.

Compacted soil – depending on the severity of compaction – can be loosened manually with rakes, or with machinery such as those used for tilling in agriculture.

If it is suspected that **soil conditions** are a problem, a soil test should be carried out, and appropriate treatments suggested by soil scientists should be used.

Clearing vegetation and changes in the **flow of runoff water** could result in erosion. Erosion should be stemmed by providing surface cover, redirecting flow and slowing the flow of water.

Topsoil must be fresh to be effective

Fresh topsoil is one of the most valuable commodities for restoration. The emphasis, however, is on "fresh". Although appropriate storage times will vary according to environmental conditions at the site, particularly the climate, storing topsoil for years is under most circumstances not advisable. Studies in other parts of the Succulent Karoo have shown that after six months most of the seed bank – the seeds stored in the soil – are no longer viable, and the soil conditions of the stored soil have deteriorated. We expect that this may also be true for the southern Namib. However, if it is feasible to remove topsoil from areas that are going to be cleared and sealed, for example, with concrete, it can then be spread on other areas undergoing rehabilitation – perhaps with a temporary, short-term storage. This would be an excellent course of action.

Restoring plant cover

One of the most important goals in restoration is to recreate the plant cover and, ideally, the composition of the vegetation that was there before the disturbance.

The previous section elaborated on ways to prepare the landscape so that plants and animals will recolonise the area naturally; this is called passive restoration. Yet in many instances, such as in the arid southern Namib, this would take much too long and active management to hasten the establishment and growth of plants is needed.

Around the globe, replanting mined areas is an established practice, however, very little of this is done in developing countries and even less-so in arid environments. Visions of expansive, commercial nurseries, sophisticated irrigation systems and countless well-trained landscapers and horticulturists usually keep developers from thinking about such endeavours.

Fortunately, restoration does not require extreme sophistication. The southern Namib is home to many obliging plants, for example, succulents and bulbs, which store water in their leaves, stems or roots, and can be relocated and transplanted elsewhere without a problem.

Every plant earmarked to be bulldozed or covered, is an extremely valuable asset for restoration.

At present there are no local commercial stocks from which indigenous plants can be purchased. Developers (such as mining companies) will have to generate their own stock of planting material. This stock could, for example, come from elsewhere in a mine that is earmarked for clearing, which would destroy the plants in any case.

Even with very basic facilities (cardboard boxes and a dry, aired storing room) plants can be stored temporarily. With more sophisticated facilities and staff, they could even be propagated. A reasonable stock of planting material can be built up this way.

Only under exceptional circumstances should plants be removed from undisturbed, natural habitat and used for replanting disturbed areas (see box below). As survival rates are mixed and usually many protected species are affected, removing plants from undisturbed areas cannot be universally recommended and should be assessed on a case-by-case basis.

For many once-off tracks, such as those made during exploration activities, manually raking to loosen the compacted soil, will be adequate. Just make sure that the next vehicle does not drive over the rehabilitated track and reinforce it again!

Track rehabilitation in the Obib Valley

Ambase Exploration's track rehabilitation programme in the eastern Sperrgebiet provides an exceptional example of rehabilitation. To rehabilitate tracks in this wilderness area, the exploration company employed a dedicated rehabilitation team that followed the drill rigs, trucks and vehicles that created a network of tracks during their systematic drilling programme. Armed with shovels, rakes and some watering cans, the rehabilitation team raked the tracks, lifted plants from the surrounding area (trying to avoid protected species) and replanted them in the rehabilitated tracks. With a keen eye and sense for their environment, plant composition, spacing and ground covering (such as, stones and branches) were modelled according to the surrounding habitat. The visual recovery of the tracks was remarkable, but even under these conditions the survival rates of plants were mixed.

There are two basic methods that can be used to actively restore plant cover – replanting and seeding. Both require an adequate stock of material to be feasible. Some ways of generating **stocks of live plants** have been described (page 21), and more detail on how it could be done and with which material is explained below under "plant relocation" (page 24).

Using **seeding** to restore plant cover has the advantage of requiring less storage room for seed stocks; in addition, small amounts of seed can be collected from undisturbed areas.

Guidelines for building up seed collections

- Contact the Plant Genetic Resources Institute to obtain permits and advice regarding drying periods and storage conditions.
- Prepare a reference specimen for each species. Press two specimens. Attach a completed standard data form from the National Botanical Research Institute (NBRI). Keep one specimen and send one to the NBRI.
- Collect capsules and seeds in paper or material bags (not plastic).
- Attach label with reference number (corresponding to your pressed reference specimen). Place a copy of the label inside the bag, as well.
- Ensure that locality and habitat are well described using, for example, GPS coordinates.
- If collections are also to be stored at the gene-bank (Plant Genetic Resources Institute), a gene-bank collection sheet must also be filled in.
- Dry and store seeds in a dry, aired room according to guidelines provided by Plant Genetic Resources Institute.

Plant relocation

While plant relocation should be promoted wherever possible, there are some basic rules to follow.

Before going ahead with plant relocation contact the relevant authorities. These institutions will not only issue permits, but may also give some practical advice on how to relocate the plants. While this may seem like placing bureaucratic hurdles in the way of a well-intentioned cause, there are good reasons for it: (1) it enables the authorities to prosecute illegal collectors who are lifting plants not for rehabilitation but for personal gain; and (2) it provides an avenue for sharing information, as feed-back is usually requested from people who obtain permits for relocation.

Protected species

Certain plant and animal species are protected because they are rare or threatened and vulnerable to exploitation. This is the case for many southern Namib succulents. Many are collector's items and ruthless, illegal collecting has decimated several populations. Protected species in the southern Namib are typically succulents, but there are also lilies and shrubs which are protected. Many trees, such as the camelthorn (*Acacia erioloba*), are protected under forestry legislation in Namibia.

The first step in any plant relocation exercise is to contact the relevant authority to obtain a permit.

How to relocate plants

Over the past few years, despite rather sceptical observers, contributors to the Southern Namib Restoration Ecology Project experimented with a variety of methods for transplanting different types of plants. In all cases a minimal labour force was used and the plants were only watered initially, if at all. Relocation worked for some plants – indeed, very well for many succulents – but appears tricky for others. Some of the findings are outlined below and, where adequate information was available, have been translated into practical guidelines.

Some practical considerations

Whether or not the transplant, relocation or rescue of plants should be attempted, requires some thought. Options need to be discussed with the authorities that issue the permits and the practical aspects of each method need to be considered. For example, plant rescue is only sensible, if there is an organisation or enterprise that can receive the "rescued" plants and provide the necessary after-care. Relocating plants, with interim storage for later restoration, requires adequate storage facilities. Transplanting needs a disturbed area to be rehabilitated. Transplanting into undisturbed, natural habitats should not normally be considered.

What does it mean?

In the context of this booklet:

relocation = removal of plants to a new area for restoration (interim storage in a nursery before finally planting on the site to be restored may be required)

transplanting = planting immediately in a similar nearby area for restoration purposes

plant rescue = removal of species of conservation importance, not necessarily for restoration, but to botanical gardens or nurseries.

The second step in relocating plants is to think carefully about where and how the plants will be stored, and eventually be replanted.

General advice applicable to all southern Namib plants

Roots: During on-site relocation try to move as much of the roots and attached soil as possible with the plant. Do not shake off the soil, as it may contain microorganisms (such as mycorrhizal fungi spores) that are important to the plant.

Soil: Planting into the soil from which they were removed is ideal, but not necessarily required. For potted plants, compost and sand mixtures work well. To ensure adequate drainage, a minimum of two-thirds sand or other very porous material is recommended; the remaining third can be made up of compost or finer-grained soil. Good drainage and aeration is important, so pots should always have a hole in the bottom and adding gravel to the soil will be advantageous.

Timing: Some initial trials showed that the time of year that transplants are carried out can be critical. Although there is no information on many species, generally, transplanting and seeding during the cool winter months when there is also a chance of follow-up rains, is likely to be the best time. To get the timing exactly right, requires observing the plants in question to determine the start of their active period which, for most species, is likely to be the best time to transplant. Transplanting during their resting periods appeared to work for some species, but not many.

Storage and care: This should only be considered, if immediate replanting is not at all feasible. To keep the plants alive during storage requires storage facilities and a good deal of care. Ideally, the plants should be kept in an area with environmental conditions similar to those from which they have been removed. Here, a simple structure with some shade cloth may be sufficient. Depending on the area, some plants may not require shading. However, if the plants are moved from the southern Namib to a higher or summer rainfall area, a proper roof to keep off too much rain, will be required for most species. Some species do not tolerate being moved to a different climatic area, others do.

If potted plants are kept for a few months, they will require watering and fertilising. The right watering and nutrient regime will depend on the type of plant. Again, observing the plants' growth patterns is important and the watering and fertilising regimes will need to be adapted according to their growing periods. Plants from areas where fog has an influence, for example, require light watering (perhaps once a week) all year round. Other species

have distinct resting periods when they should not be watered. Some species do not mind being watered all year round, but they may develop strange growth forms and will then be more difficult to acclimatise to their natural environment when they are replanted.

Fertilising should be considered if plants are kept in the same pot for periods longer than six months. A low-nitrogen, slow-release fertiliser will be appropriate for most species. The most suitable concentration depends on the plant, the nutrients available in the potting soil and the type of fertiliser. Most commercial fertilisers provide some instructions to this effect on the packet.

Replanting: Transplanting fresh material from areas where plants are to be cleared to other on-site areas, is relatively straightforward. Most importantly, the plants should be placed in a similar habitat to that from where they came. That means finding the same soil type, orientation to the sun, surrounding vegetation and similar topography to provide similar shade conditions through the day. Look at the original habitat of each species carefully and let nature be your guide.

Once the right place is found, dig a hole, plant, fill it up with soil again and water (mainly to stabilise the soil). If feasible, continued watering for a few months is likely to increase the chances of success, although it may not necessarily be required.

Plants that have been kept in a nursery will need some preparation to get them accustomed to their natural environment again. Before they are planted, they should be moved into the environment where they are going to be planted. Their watering should be reduced and if they were kept under shade-cloth or a roof, they gradually need to be accustomed to full sunlight again. These plants will most likely require initial watering once planted. All this needs careful planning.

Seed collection: Reseeding with indigenous plants – that is with a seed mix obtained from the vegetation that was present prior to the disturbance – is an appropriate measure for rehabilitation in the southern Namib. Although there is little information on particular species and their germination requirements, many appear to readily colonise disturbed areas. In particular, if no other mitigation measures are considered or feasible, seed collections of all plants to be destroyed should be considered prior to large-scale clearing of vegetation. The Plant Genetic Resources Institute at the NBRI can be contacted for further information and the necessary permit required for most species.

At present reseeding indigenous plants would be a pioneer effort because there are no such restoration efforts from which to learn. The timing of seeding is likely to be important, and the creation of sheltered spots in windy areas.

The natural recruitment of plants in an arid area is very sporadic and often coupled with exceptionally good rainfall. Although distributing seeds on a rehabilitated area may be better than waiting for seeds to blow in naturally, it will probably take several years to show some effect. For quicker results, initial irrigation could be considered, particularly if the rains fail or are very poor during the growing season.

Guidelines for selected plant groups

Information pertaining to the practical aspects of restoration is constantly changing with new insights becoming available all the time. The information presented here is based on observations of a few species representative of particular groups. Although most of the generalisations are expected to be true for most species in a group, this might not necessarily be the case for all the species; further work will help to close the knowledge gaps. Non-succulent shrubs are not covered at all because there is not enough information available. The information presented on the following pages is grouped according to the growth form of the plants and their related species:

Ebracteola derenbergiana

Tufted mesembs are leaf-succulent, perennial plants of the family Mesembryanthemaceae (vygies) with no main stem or woody branches. They are mainly found on sand plains and gravel plains. All tufted mesembs in Namibia are protected.

Transplanting	Ideally suited
Relocating	Suited
Plant rescue	Suited
Storage	Tolerates being out of the soil for a few days
Seeding	The seeds germinate easily.
Vegetative propagation	Feasible with some species, but requires propagation facilities; carefully dividing up older plants is probably a better option than trying to make cuttings.
Comments	Survival rates in Windhoek, as well as on-site, have been good.
Examples	*Cheiridopsis*, *Dracophilus* and *Ebracteola* species

Ruschia spinosa

Shrubby mesembs are leaf-succulent Mesembryanthemaceae (vygies) with a shrubby appearance. They form a very diverse group of plants and grow in very different habitats, from plains to the slopes of mountains. Many shrubby mesembs (for example, *Eberlanzia* species) are protected.

Transplanting	Species on sand plains are suited, but should only be transplanted during the cool winter months.
Relocating	Some species (e.g. *Eberlanzia*) are not suited to be moved elsewhere.
Plant rescue	Same as for transplanting
Storage	No information
Seeding	The seeds of most species germinate readily. Seed collections of mature capsules and storage of entire plants with capsules containing seeds should be tried. Even if the plants do not survive transplanting, their seeds will – and seedlings are likely to emerge after rains. Growing plants from seed is successful in most species.
Vegetative propagation	Not expected to be suitable for most species
Comments	The shrubby mesembs showed very mixed results and a lot more work is required to provide specific guidelines for different species in this group.
Examples	*Amphibolia*, *Aridaria* (brakveldwitvygie), *Drosanthemum* (bergvygie, mountain mesemb), *Eberlanzia*, *Ruschia* (doringvygie) and *Stoeberia* (rooivygie, vaalvye) species

Mesembryanthemum hypertrophicum

Weedy mesembs are annual, short-lived plants of the family Mesembryanthemaceae (vygies), often with large, fleshy leaves and capsules that disintegrate easily. Most grow low, with long branches creeping on the ground. They are often found in disturbed habitats.

Transplanting	Most species not suited
Relocating	Generally not suited, but longer-lived species (e.g. *Phyllobolus*) can do well
Plant rescue	Not suited
Storage	No information, but not expected to survive long storage periods
Seeding	Recommended – collection of capsules and seeding of less-common species is recommended
Vegetative propagation	Dividing up older plants may work with some species (e.g. *Phyllobolus*, *Psilocaulon*)
Comments	None
Examples	*Mesembryanthemum* (ice plant), *Phyllobolus* (vingerkanna) and *Psilocaulon* (asbos, ash bush, grootlidjies, little soap-bush, scorpion mesemb, seepbossie) species

Crassula sericea

Crassulas are usually small, leafy succulents, often creeping or forming small tufts. There are also some larger stem-succulent species (e.g. *Tylecodon*). Most crassulas are found in rocky habitats. The majority, particularly the smaller species, are protected. These all belong to the family Crassulaceae.

Transplanting	Difficult – mainly because of their occurrence in rocky habitats
Relocating	Not very successful with large crassulas (*Tylecodon* and *Cotyledon*), but could be tried with smaller plants
Plant rescue	Should be attempted, as most species are of high conservation value
Storage	No information
Seeding	Feasible with many species, e.g. *Cotyledon orbiculata*
Vegetative propagation	Some creeping crassulas are naturally adapted to grow from parts of plants, and thus suited to vegetative propagation. Cuttings from side branches without flowers or the tips of plants are likely to produce the best results.
Comments	This group requires further transplant and seeding (germination) studies for different species.
Examples	*Adromischus* (kleinplakkie, pig's ear), *Cotyledon* (pig's ear, plakkie), *Crassula* (lizards's tail, louhout, rygbossie, skoenventerbos, sosatiebos) and *Tylecodon* (krimsiektebos) species

Lavrania marlothii

Stapelioids are small, spineless stem succulents, which normally grow no more than 30 cm high. Most have attractive, though rather smelly flowers. They grow in a variety of habitats, often in the shelter of other plants, but are also found in rock crevices and in the shade of rock overhangs. Stapelioids belong to the family Apocynaceae.

Transplanting	Suited
Relocating	Suited
Plant rescue	Ideally suited; removal to Windhoek showed high success rates at the NBRI.
Storage	Small plants need to be planted immediately; larger ones tolerate being out of the soil for some days and often do better if they are left to dry a while.
Seeding	Most species grow readily from seed.
Vegetative propagation	Dividing up mature plants is usually successful.
Comments	Several stapelioids have been relocated in various locations. Feedback from trials in semi-arid shrubland north-east of the southern Namib indicates that they relocate well in those habitats.
Examples	*Lavrania* (*Larryleachia*), *Orbea* and *Stapelia* species

Hoodia gordonii

Hoodias are medium-sized to large, spiny stem succulents. Most species have large, attractive flowers, which are rather smelly to attract flies. All *Hoodia* species are protected. *Hoodia* species belong to the family Apocynaceae.

Transplanting	Difficult, particularly for large plants
Relocating	Not very successful
Plant rescue	Should be attempted, as all species are protected
Storage	Believed to grow better, if left to dry for a while
Seeding	Germination from seeds is very successful.
Vegetative propagation	Propagation from cuttings is very difficult, but dividing up old plants should be tried.
Comments	Transplanting has been attempted in various locations, but proved unsuccessful in semi-arid shrubland outside the southern Namib when undertaken during the dry season.
Examples	*Hoodia alstonii* and *Hoodia gordonii*

Euphorbia melanohydrata

Euphorbias in the southern Namib are a diverse group of stem succulents. They can be small or large, and spiny or spineless, but all have irritating, milky sap. There are also a number of taller, shrubby euphorbias. All euphorbias are listed on Cites, Appendix 2, which means trade in these species is restricted. They belong to the plant family Euphorbiaceae.

Transplanting	Reasonably to very successful, depending on the species and growth form: ▪ Small- and medium-sized species of shrubby euphorbias (e.g. *Euphorbia cibdela*) transplant well, while larger ones (e.g. *Euphorbia dregeana*) have, so far, not been very successful; smaller individuals are most likely to succeed. ▪ Dwarf stem-succulent euphorbias (e.g. *Euphorbia melanohydrata*) transplant extremely well in sand plain habitats.
Relocating	See transplanting
Plant rescue	Very successful with dwarf stem-succulent species – hence recommended for all dwarf stem succulents (*E. melanohydrata*, *E. namibensis*) and should be attempted with rarer or endemic shrubby euphorbias (e.g. *Euphorbia chersina*, *E. decussata* and *E. ephedroides*)
Storage	No information

Seeding	No information on southern Namib species, but other dwarf stem-succulent euphorbias (e.g. *Euphorbia obesa*) grow readily from seed.
Vegetative propagation	Probably difficult because of the milky sap; dividing up old plants could, however, be tried
Comments	More information on seeding (germination) and relocation trials with different species is needed.
Examples	*Euphorbia cibdela*, *E. melanohydrata* and *E. namibensis*

Pelargonium cortusifolium

Pelargoniums in the southern Namib are stem-succulent, low shrubs of the geranium family (Geraniaceae). Although none is protected, there are some species endemic to the southern Namib and Namibia. They are generally not very abundant, except on outcrops along the coast.

Transplanting	No information
Relocating	Reasonably successful
Plant rescue	Reasonably successful
Storage	No information
Seeding	No information
Vegetative propagation	They grow extremely well from cuttings.
Comments	Information on transplanting success, storing of plants and the feasibility of seeding (germination) is required for the southern Namib species.
Examples	*Pelargonium* species

Sarcocaulon patersonii

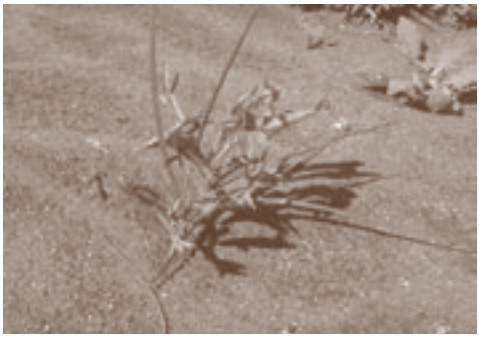
Bushman candles also belong to the geranium family, and are usually spiny stem succulents with a wax covering on their stems and branches. Most have extremely pretty, showy flowers during the growing season, but otherwise look rather hostile. Some species are endemic to the southern Namib.

Transplanting	Suited – particularly good results on sand plains
Relocating	Suited
Plant rescue	Suited – care needs to be taken during packing, not to damage other plants
Storage	Observing plants to determine their active and dormant periods, and hence the appropriate watering regime, appears important, as some (e.g. *Sarcocaulon patersonii*) can have several growing periods during one year. Some of the rarer species appear to require specific soil conditions (e.g. *Sarcocaulon crassicaule*, *S. peniculinum* and *S. inerme*) and may require fertiliser over longer storage periods.
Seeding	No information available
Vegetative propagation	Probably difficult
Comments	Seeding (germination) and vegetative propagation studies are required.
Examples	*Sarcocaulon* (bushman candle, candlebush, kersbos) species

Othonna furcata

Succulent daisies are shrubby leaf or stem succulents, similar to the shrubby mesembs, but not producing woody capsules. They have daisy-like flowers and the seeds often have feathery structures. Most grow no more than half a metre in height. These plants belong to the family Asteraceae.

Transplanting	Recommended – *Othonna cylindrica* showed a high success rate in the eastern Sperrgebiet, despite being transplanted during the hot summer months.
Relocating	So far not very successful, but perhaps not undertaken at the right time of the year.
Plant rescue	See relocating
Storage	The activity of *Othonna* species, which have distinct active and dormant periods, need to be observed carefully, and the watering regime adapted to this.
Seeding	Germinate readily and seed collections and subsequent seeding could be attempted, as these are important plants in the more sparsely vegetated coastal areas. Sowing should be undertaken during the cold winter months.
Vegetative propagation	No information
Comments	The success of seeding during restoration efforts needs to be established.
Examples	*Othonna* and some *Senecio* species



Babiana namaquensis

Bulbs are lily-like plants with underground storage organs (geophytes) and are only present above ground for short periods during the year. Most lilies are extremely attractive and have showy, intricate flowers. There are many southern Namib endemics.

Transplanting	Likely to be worth transplanting, particularly in sand plain habitat
Relocating	Elsewhere in southern Africa, bulbs have been successfully removed, stored and replanted in restoration efforts.
Plant rescue	Ideally suited, because they are naturally adapted for storage
Storage	Well-suited for storage
Seeding	No information on southern Namib species, but related plants (e.g. *Bulbine frutescens*) readily grow from seed
Vegetative propagation	Many bulb species naturally reproduce vegetatively by producing small bulbs.
Comments	Little information on southern Namib species is available and, because of their conservation importance, this group urgently deserves further study.
Examples	*Albuca*, *Bulbine* (snake flower), *Lachenalia* and *Ornithogalum* species

Arctotis fastuosa

Herbs are annual (short-lived) plants that grow from seed each year. They are the most colourful group of plants and an extremely important component of the southern Namib vegetation. There are several protected or endemic species amongst the herbs. Many have wind-dispersed seeds and hence also blow into disturbed sites naturally.

Transplanting	Not suited
Relocating	Not suited
Plant rescue	Not suited
Storage	Ideally suited for seed collections, but not for live plant collections
Seeding	Herbs are ideally suited for seed collections. In the southern Namib this is especially recommended for herbs that have no wind-dispersed seeds, such as members of the foxglove family (Scrophulariaceae), e.g. *Lyperia*, *Manulea* and *Nemesia* species. Where the rapid re-establishment of plant cover is important, seed mixes of the vegetation prior to clearing should be collected.
Vegetative propagation	Not suited
Comments	No results from seeding efforts in restored areas in the southern Namib are available at present.
Examples	*Foveolina*, *Nemesia*, *Senecio* and *Ursinia* species

Stipagrostis ciliata

Grasses are tuft-forming or creeping plants, usually with long, narrow leaves, but without brightly coloured flowers. They are members of the family Poaceae. There are short-lived and perennial grasses in the southern Namib. Both are ideally suited for seed collections. Many, such as *Stipagrostis*, have wind-dispersed seeds which blow into disturbed sites naturally.

Transplanting	No information – should perhaps be tried in areas with perennial grasses, where these form the main constituent of the vegetation, and a rapid restoration of plant cover is desired
Relocating	No information
Plant rescue	Not suitable
Storage	No information
Seeding	Ideally suited; seed collections and subsequent seeding should be undertaken, particularly where the dominant grasses have no wind-dispersed seeds.
Vegetative propagation	Not suitable
Comments	No information on seeding trials in the southern Namib
Examples	*Eragrostis* (love grass) and *Stipagrostis* (bushman grass) species

How can you contribute?

Apply these guidelines wherever possible and adapt to your particular situation. Your successes and failures are very important to others who would also like to help preserve and restore the southern Namib flora. In the spirit of adaptive environmental management these guidelines should be continuously updated. Please provide feedback and liaise with contributors to the Southern Namib Restoration Ecology Project. Their contact details are given on the opposite page.

Please provide feedback!

Please contact or send your information to:

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Glossary

acclimatise: to become accustomed to new climatic or environmental conditions

biodiversity: the diversity of life and its supporting environment

capsule: a dry fruit that releases its seeds when ripe

endemic: plant or animal restricted to a specific area

environmental practitioner: person involved in environmental management on the ground (e.g. conservation officer, environmental scientist)

gene-bank: facility to store seed at the Plant Genetic Resources Institute, a division of the National Botanical Research Institute

GPS: Global Positioning System – a device to measure longitude and latitude

habitat: the environment of an organism

hotspot: a concentration of certain features, usually refers to an area of high diversity or concentration of endemics

hummock: accumulation of sand underneath and in the lee of a plant

inselberg: isolated mountain

koppie: small hill

MET: Ministry of Environment and Tourism

mitigation: moderating impacts through management intervention

NBRI: National Botanical Research Institute of Namibia

perennial: a plant that lives for more than one growing season

plant rescue: removal of plants ahead of clearing to a nursery, for example – in most instances not necessarily for restoration purposes

plant relocation: removal of plants to a new area either nearby or somewhere else with the final goal to use these plants in restoration

propagation: multiplying plants from parent material by natural processes (e.g. cuttings or seed)

recolonising: re-inhabiting a particular area

recruitment: re-growth of plants

reference specimen: a plant sample prepared for permanent storage in a plant collection (herbarium)

rehabilitation: measures to repair damaged ecosystems or make land useful again after disturbance

restoration: measures to reinstate habitats and environmental conditions prior to the disturbance

shrub: woody plants with several stems arising from the base

Sperrgebiet: refers to the south-western corner of Namibia; literally translates to "forbidden territory" from German

southern Namib: the southern part of the Namib Desert which stretches from the Kuiseb River in Namibia to the Olifants River in South Africa

stem succulent: plants that store water in their stems

succulent: plant capable of storing water

Succulent Karoo: arid area in southern Africa characterised by the dominance of succulent dwarf shrubs

topsoil: the upper soil layer (top 10 cm)

transplant: removing a plant and planting in a similar area nearby for restoration purposes, in this context

vegetative propagation: multiplying plant material through cuttings or other plant parts that are not seeds

Quick guide

Important principles and guidelines at one glance:

Check what you are doing, discuss, and adapt if it does not go the desired way or if better methods become available.

Avoiding impacts is the first choice and always has priority.

To make it easier for plants to recolonise and animals to move back to disturbed areas, restore the habitat.

Understanding the forces of wind and water in a particular area and how they shape landforms is critical in restoring habitats.

Project planners can make a very positive contribution if they think ahead with rehabilitation in mind.

If you have fresh topsoil and a disturbed area nearby, do not seal the topsoil under concrete or similar material, but collect and spread it on an area undergoing rehabilitation.

Every plant earmarked to be bulldozed or covered, is an extremely valuable asset for restoration.

The first step in any plant relocation exercise is to contact the relevant authority to obtain a permit.

The second step in relocating plants is to think carefully about where and how the plants will be stored, and eventually be replanted.

Please provide feedback!

Further reading

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The Succulent Karoo Ecosystem Programme

This booklet is part of a series of products of the Succulent Karoo Ecosystem Programme (SKEP) for the Namibia Subregion.

This programme's vision is to effectively conserve and manage biodiversity in the Succulent Karoo ecosystem in Namibia by the State and civil society, through an integrated programme of conservation action and co-management of conservation areas for the sustainable development of the region and for the improvement of people's livelihoods.

SKEP Namibia is housed by the Namibia Nature Foundation (NNF), an institution with a long-standing record and experience in fostering and achieving conservation and development goals throughout Namibia. This programme works in partnership with the Ministry of Environment and Tourism and civil society by offering grants to institutions and individuals for projects which fulfil the overall objectives of the programme. Funding for these activities (and this booklet) is provided by the Critical Ecosystem Partnership Fund.

The main focus of SKEP Namibia is to provide support to the management and development of the Sperrgebiet National Park, and other activities in the interest of this new conservation area.

The objectives of SKEP Namibia are to:

- restore and retain important biodiversity areas which are under the greatest land-use pressure
- engage key industries, create capacity and link biodiversity to job creation, and
- create awareness of the unique value of the Succulent Karoo hotspot.