Protocols for Fynbos Restoration

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Introduction

Cape Flats Sand Fynbos (CFSF) is the most poorly conserved fynbos veld type in South Africa, and has been degraded primarily as a result of invasion by alien plant species and transformation by agriculture and urban development. It is listed as Critically Endangered in the recent National Spatial Biodiversity Assessment (Rouget *et al*. 2005).

Fynbos is a fire-prone ecosystem and many species regenerate from soil-stored seed banks, others from seeds in the canopies of plants such as Leucadendrons and Leucospermums or by sprouting from underground storage organs. The most persistent species in CFSF, soil-stored seed banks are short-lived species; therefore regeneration of a functionally representative community after the clearance of a dense stand of alien vegetation is unlikely from the soil seed bank alone. Therefore the collection of seed and vegetative propagation of long-lived fynbos species must be an essential component of a restoration programme. Subsequent challenges to restoring a fynbos habitat include adaptation to low nutrient levels in the soil and the prominence of molerats and gerbils.

The science of restoration ecology is relatively new and few guidelines are available for a fynbos restoration policy (Holmes *et al*. 2000). A programme has to be initiated that shows people how to restore these degraded landscapes and create a vegetation structure that resembles natural fynbos, thus allowing other indigenous plants and animals to colonise from nearby stands. Over time a more complete natural veld will develop-this is possible within cities where remaining green areas such as rivers, wetlands and green belts can be used as corridors for natural fauna and flora to proliferate.

Site Assessment

The most critical step in restoration is to halt degradation. A successful restoration policy involves three basic criteria. The first is that sufficient habitat must be protected for continued persistence of species. The second is to determine how the vegetation is related to soil type, topography and the soil hydrology characteristics. Thirdly, genetic variation can be considered once these fundamental criteria have been met (Bowles & Whelen 1994). A fundamental phase in restoration is to assess the current and past land-use history of the site, in order to determine the best course of action. When assessing the restoration potential of a site it is important to know which guilds/species may persist in the soil seed bank.

A site that has been heavily invaded with aliens must be cleared immediately, as it has been found that seed bank density is lower the longer a site has been infested (fynbos soil seed banks decline rapidly after four decades). Under thick alien cover, seed banks on the surface are depleted and deeper seeds fail to germinate (Holmes & Foden 2001).

As fynbos is a fire-driven system, the best method to follow is to burn the affected area. Alien stands burn with a much greater intensity than fynbos and may scorch the soil (Holmes *et al*. 2000) and kill rootstocks and geophytes. This can cause the death of seeds to a depth of 4 mm or more, where seed density is highest in the upper 3 mm of soil (Holmes 2002). A fell-and-burn technique has the most detrimental effect on soil seed banks and is not recommended, as it results in an exceptionally intense fire. The fell-remove-and-burn method yields positive results, especially when synchronised with a controlled burn of nearby remnants. Once alien vegetation has been felled and the slash removed, it is advisable to wait for approximately five months for alien seedlings to germinate and then burn. The optimum time of year to have a controlled burn for fynbos is summer or early autumn. The average outside air temperature should be around 26–30°C, with a wind speed of 2–5 km/h and a humidity of 70–80%. Other benefits are the addition of mineral nutrients to the soil and the production of gases (ethylene and ammonia).

The application of carbon-rich mulch such as pine bark or wood chips will aid in the reduction of nitrogen levels in the soil (Cione *et al.* 2002). The reason for this is that aliens and weeds use nitrogen and out-compete fynbos seedlings, which are adapted to very low nutrient levels. Mulch can provide a refuge for small animals and bring back micro-organisms after the fire and, when used in conjunction with a herbicide, it helps to reduce the establishment of weeds. A biodegradable herbicide (active ingredient glyphosate, 0.4 litre/ha at 2% concentration) should be used and applied twice to reduce weed cover significantly. It must be applied on a calm day to prevent spray drift affecting indigenous plants. A direct correlation between reduction in weed cover and reduction in molerat and gerbil activity on sites has been noted and this has minimised seed predation.

Preparation of Plant Material

Post-burn recruitment is mainly ephemerals and short-lived species, and the reintroduction of the longer-lived shrubs and graminoids by sowing or planting is therefore required to prevent the development of a dense herbaceous layer (Holmes 2005). Geophytes are relatively persistent in response to invasion, and can survive for many years, dormant in the soil. After fire, most bulbs emerge, flower and set seed before being overgrown by other vegetation. To speed up restoration processes and to improve the probability of establishing a fully functioning ecosystem, serotinous shrubs such as members of the Proteaceae and Ericaceae should be reintroduced.

A short-term goal within a nursery is to ensure that the vigour of a population is maintained. As rare and endangered taxa often exist as relatively small populations, they are subject to population bottlenecks. Therefore a maximum of 18 months to two years in the nursery is recommended to prevent inbreeding depression. A further challenge is hybridisation, as a consequence of contact between populations that have long been isolated from one another.

Seeds harvested from the restoration site by the Millennium Seed Bank must be sown in a nursery one year before burning. Seeds are sown in trays and treated to break dormancy, the flat 16cm seed trays filled with washed river sand are placed in a tent (Figure 1). Fynbos plant material is burnt in a drum and the smoke is pumped into the tent (Figure 2). The trays are removed after three hours, watered and transferred to benches in a nursery with a clear roof. This enables diurnal temperatures to fluctuate while protecting the soil from rain damage; the trays are kept moist by hand-watering. Ideal germination cues for fynbos seeds are 10°C/20°C. Seedlings are transferred into plug trays and grown under shade cloth for eight months to a year.

Vegetative plant material is collected at the optimal time per species, and stem and tip cuttings are then rooted in a sterile bark and polystyrene mix, under mist with bottom heat (Figure 3). The rooting process takes up to four weeks; the plants are then hardened off for three weeks in an open nursery. They are transplanted into small bags containing a sterilised fynbos medium and moved under an open-sided frame with a shade cloth roof where they are grown on for a year.

Reintroduction

Recognition of the layout and pattern at the site is crucial when reintroducing. Reintroductions must be planned in accordance with natural processes. In the Cape, the *bergwind* (hot, dry wind from the interior of the country) precedes rain-bearing fronts and planting should therefore take place only after this wind has ceased to blow.

Smoke-treated seeds sown at the site, take root among other established indigenous vegetation, not on bare soil (Pierce & Moll 1994). This allows nature to initiate succession; 'missing species' can then be planted. This improves the chances of incorporating rare and endangered species at the restored site. Seed selected and inter-seeded should be from multiple vegetation layers. Sowing is done in late autumn and the seed is gently raked into the soil or a light cover of mulch is applied.

Plantings grow better in areas where there is little competition from grasses and aliens; plugs should be planted approximately 18cm apart for best results (Figure 4). Young plants are planted in slight depressions to promote water catchment and protection from wind. Only the critically rare species are given water in extreme weather conditions, watering is done every second day for the first week and then weekly for the

next month, to ensure establishment. Seed, seedlings and plants are planted in a random pattern to mirror the natural site.

The hottest and driest period in the Cape is late summer (Dec. 25˚C/17 mm, Jan. 26˚C/15 mm, Feb. 27˚C/17 mm). If plants and seedlings survive their first season, a successful restoration is on its way.

Monitoring

Records of timing, location and methods are kept, from initiation of the project to completion. They help to keep track of methods that worked so that mistakes are not repeated, and are used for reporting to stakeholders, providing closer collaboration and communication between partners. It is important that the programme is properly co-ordinated and that records are kept safe, accessible and understandable to those involved in restoration.

Conclusion

Not all restorations start from the same point, although the goal of preserving the evolutionary potential of an ecosystem remains the same. It is imperative that before any restoration begins, the cause of the deterioration and transformation of the site must first be removed. The duration and extent of alien stands should be considered when planning clearance and restoration operations. If a site has been densely invaded (30 years or more), it is unlikely that indigenous soil seed banks would have survived and post-fire sowing and planting should be considered. Collection of seed and plant material must be planned a minimum of nine months before any work begins on site; a wider range of guilds can then be collected. Once restored, a minimum of eight years must pass before burning to allow seed banks to replenish. It is hardly an exaggeration to say that the fate of a species lies in the recognition that conservation and restoration are just different ways of doing the same dance.

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Figure 1: Smoke treatment tent and drum.

Figure 2: Fynbos fuel in smoke drum.

Figure 3: Mist unit at Kirstenbosch

Figure 4:Planting Erica verticillata *after a burn*