THE RESTORATION OF *ERICA VERTICILLATA* – A CASE STUDY IN SPECIES AND HABITAT RESTORATION AND IMPLICATIONS FOR THE CAPE FLORA

Anthony Hitchcock[1] & Anthony G. Rebelo[2]

ABSTRACT

The Threatened Species Programme at the South African National Biodiversity Institute, Kirstenbosch National Botanical Garden, is integrated to include both *ex situ* and *in situ* conservation activities. Plant conservation is driven by South Africa's Strategy for Plant Conservation which was developed in response to the Global Strategy for Plant Conservation. This case study examines the conservation of *Erica verticillata* (whorl heath), a flagship for threatened species at Kirstenbosch, and documents the integration of *ex situ* with *in situ* conservation at three areas on the Cape Flats. The whorl heath was thought to be extinct by 1950. Horticulturists have since rediscovered eight clones in botanic gardens worldwide, the Heather Society and commercial growers. *Ex situ* conservation in botanic garden collections and the Millennium Seed Bank has since allowed *in situ* conservation in the critically endangered Cape Flats Sand Fynbos vegetation type. The process of restoring the whorl heath presented many challenges. Initially attempts were hampered by limited available knowledge on suitable niche habitats. Pioneering work carried out at Rondevlei Nature Reserve identified the suitable habitat and this was applied in subsequent *in situ* work at Kenilworth Racecourse Conservation Area and at Tokai Park – the only natural areas remaining in or near this species' historical distribution range. Successful re-establishment of this species depends upon its capacity to recruit after fire, which is an essential ecological process in the fynbos. Many clones have been in cultivation for a long time and are poor seed producers: seed production was first recorded at Rondevlei only after additional clones were planted together. Only one population (Rondevlei) to date has seen a fire and thus has recruited seedlings; however these are competing with vigorous companion plants. The study continues and is currently exploring the role of herbivory in the restoration process. The key lesson learnt to date is the need to include sustainable management of the entire ecosystem in the restoration process and not limit it to single species. Success in restoring a species depends upon a healthy stand of the vegetation type in place, along with pollinators and other key fauna and other natural ecosystem processes. It is recommended that successful re-establishment of a species in fynbos requires the reintroduced population to survive three fire cycles.

INTRODUCTION

The story of *Erica verticillata* P.J. Bergius, the whorl heath (also known as marsh heath and vlei heath), is unique in the annals of plant conservation in South Africa. It was regarded as extinct in the wild in the second half of the 20th century (Adamson & Salter,

1. Anthony Hitchcock is Nursery, Living Collections and Threatened Species Manager at the South African National Biodiversity Institute, at Kirstenbosch National Botanical Garden.
Address: South African National Biodiversity Institute, Kirstenbosch, Cape Town 7735, South Africa.
Email: A.Hitchcock@sanbi.org.za
2. Anthony G. Rebelo works on the Threatened Species Research Programme within Applied Biodiversity Research at the South African National Biodiversity Institute, Kirstenbosch National Botanical Garden.

1950; Oliver & Oliver, 2005) and was listed extinct in 1996 (Hilton-Taylor, 1996a). It used to grow in Cape Flats Sand Fynbos (CFSF) on the Cape Flats of the Cape Peninsula from the Black River to Zeekoeivlei (Oliver & Oliver, 2000). Herbarium records indicate that it grew in a narrow, 3km-wide corridor between the main road and the M5 freeway from the Black River cottages near Mowbray in the north, at Rondebosch, Newlands, Claremont and Kenilworth as far as Wynberg (Fig. 1). A single, isolated record from Kalk Bay (Thompson 170 in PRE) might be suspect. The written record suggests that it may have occurred as far south as Zeekoeivlei (Adamson & Salter, 1950). The rather superficial information on herbarium sheets and in the literature suggests that this species preferred seasonally damp, acid, sandy soils near rivers and wetlands. Agricultural and urban development that occurred as Cape Town expanded here resulted in the destruction of its natural habitat. It is a handsome plant and was regularly sold as a cut flower, being one of the few plant species to flower in profusion during the mid-summer (January–March) months (Gibbs, 2014).

The last herbarium specimen collected from the wild dates back to 1908 and was collected by Dümmer (Dümmer 210 in NBG). More recent herbarium records in South Africa are specimens of plants growing at Kirstenbosch National Botanical Garden (hereafter referred to as 'Kirstenbosch') in 1943 (Henderson 1669 in NBG) and from a cultivated plant growing in the Pretoria district (Repton 5698 in PRE).

It is interesting to note that the whorl heath appears on the Bergvliet Primary School badge (Hilton-Taylor, 1996b) (Fig. 2). After the Second World War an entirely new suburb of Cape Town was established to provide accommodation for ex-servicemen. The Bergvliet Housing Scheme attracted many young families and soon a modern primary school was built in 1949 ready for the first term of 1950. The school chose the whorl heath as the focal point of its badge because it was a very popular plant common in the Bergvliet area until about 1948. After this time it was rarely seen (Bergvliet Primary School, 2013).

In the early 1980s, Deon Kotze, horticulturist with responsibility for *Erica* at Kirstenbosch, began searching remnant patches of CFSF for lost and rare species (Hitchcock, 2003). In 1984, Kirstenbosch scholar David von Well brought back flowering samples and cutting material from *Erica* plants growing at Jan Cilliers Park, also known as Protea Park, in Groenkloof, Pretoria. Collections of fynbos were established in Protea Park during the 1960s by Curator J.E. Repton (Grobler, 2013). *Erica* taxonomist Dr E.G.H. (Ted) Oliver confirmed the material to be the whorl heath. A few years later, a mature stand of this species was discovered by the Kirstenbosch Head Foreman, Mr A. Adonis, growing in a derelict bed behind the Braille Trail (Fig. 3). The Pretoria collection (Fig. 4) was named 'African Phoenix' and the Kirstenbosch collection was given two cultivar names (see Appendix 1) to distinguish the dark pink form, 'Adonis', from the light pink form 'Louisa Bolus' (Fig. 5). The latter cultivar honours Mrs Louisa Bolus, the first Curator of the Bolus Herbarium, who made the first and only wild collection of the whorl heath for Kirstenbosch. She is recorded to have collected seed from the Wynberg Flats on 1 May 1917.

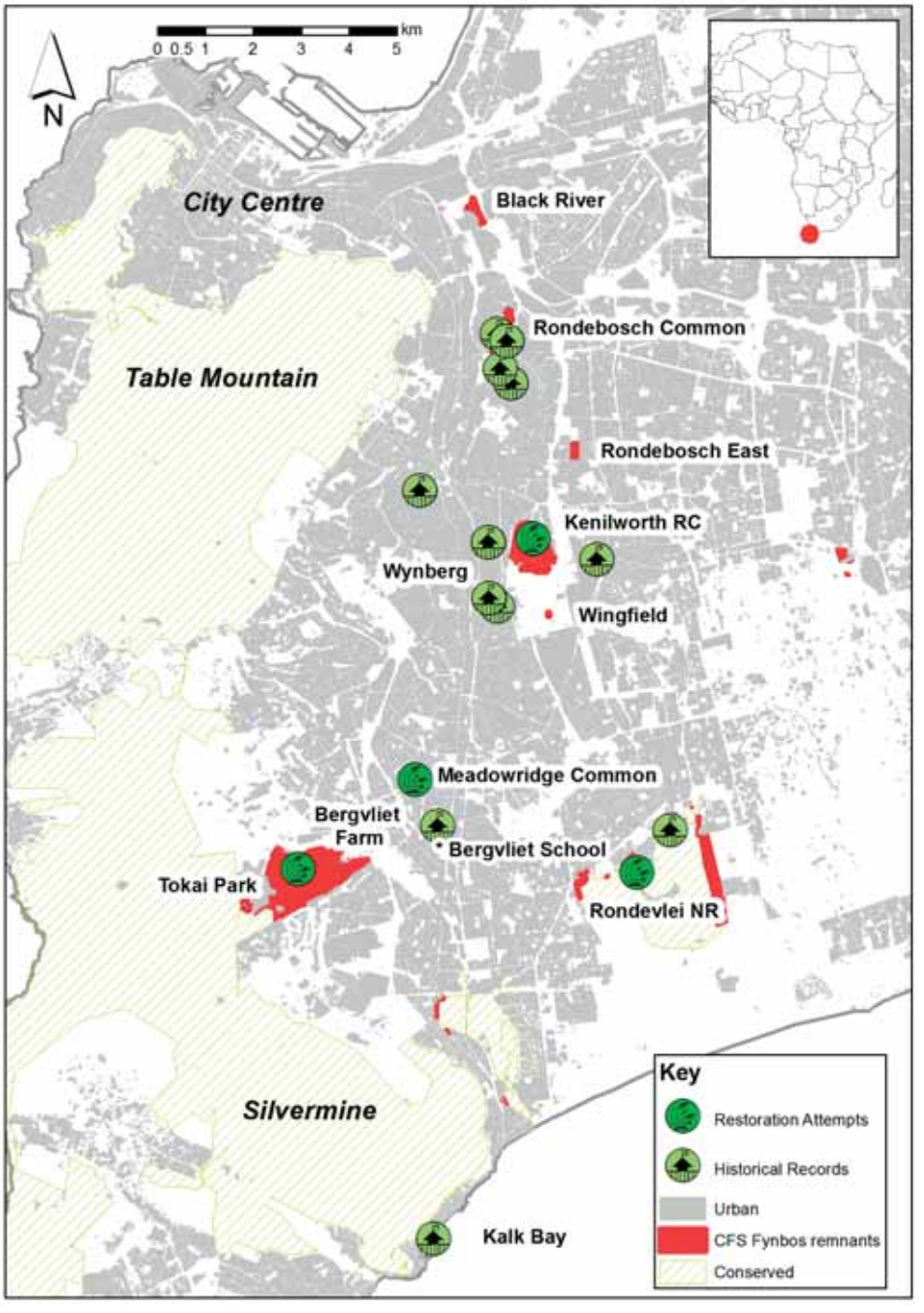

Fig. 1 Map showing the historical distribution and restoration locations for *Erica verticillata* on the Cape Flats, Cape Town. Map drawn by Anthony Rebelo.

Fig. 2 Bergvliet Primary School badge depicting *Erica verticillata.* Reproduced with the permission of Bergvliet Primary School.

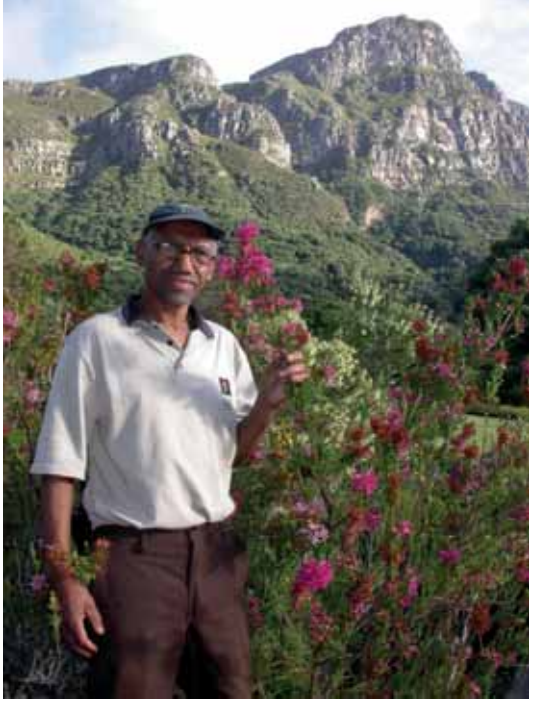

Fig. 3 Kirstenbosch Head Foreman Adonis Adonis with the *Erica verticillata* he discovered on the Kirstenbosch Estate. Photo: Anthony Hitchcock.

Fig. 4 Paintings of *Erica verticillata* forms. 1. 'Adonis' and 'Louisa Bolus', 2. 'Cherise', 3. 'Belvedere', 4. 'Doctor Violet Gray', 5. 'Tresco Abbey', 6. 'Harry Wood', 7. 'African Phoenix'. Paintings by Vicki Thomas reproduced with the kind permission of the artist and the editor of *Flowering Plants of Africa* (2013).

THE HEATHER SOCIETY

acting as

INTERNATIONAL CULTIVAR REGISTRATION AUTHORITY

certifies that

***Erica verticillata* 'Louisa Bolus'**

has been registered by

ANTHONY HITCHCOCK

Fig. 5 Registration certificate for *Erica verticillata* 'Louisa Bolus'. The Heather Society International Cultivar Registration Authority.

The search for lost collections of the whorl heath was continued by the first author in 2000 and was an exercise in detective work. The existence of additional collections was revealed with assistance from members of the British and American Heather Societies, botanic gardens, *Erica* growers in Europe and internet searches. Through this process collections were added from the following: Belvedere Palace Garden in Vienna – 'Belvedere'; Tresco Abbey Gardens on the Scilly Isles – 'Tresco Abbey' (Hitchcock, 2007); the private *Erica* collection of 'Doctor Violet Gray' via the British Heather Society – 'Doctor Violet Gray'; Monrovia Nursery in California – 'Cherise'; and the Royal Botanic Gardens, Kew (RBG, Kew) – 'Harry Wood'. Eight confirmed collections have been found to date all of which have been allocated cultivar names by the British Heather Society. Four of these cultivars, 'African Phoenix', 'Adonis', 'Louisa Bolus' and 'Belvedere' have been used in restoration programmes (Hitchcock, 2013; Grobler, 2013).

The whorl heath has become a flagship restoration species at Kirstenbosch and has been re-established to three Cape Flats Sand Fynbos conservation areas within the suburbs of Cape Town. These are Rondevlei in the False Bay Nature Reserve, Kenilworth Racecourse Conservation Area (KRCA) and at the Tokai Section of Table Mountain National Park. These are the only areas within or near the species' natural historical range which are conserved, although Kenilworth is not designated with the status of Reserve.

PROPAGATION

Cuttings

Erica verticillata is one of the easiest ericas to propagate vegetatively. It roots best from late summer to autumn (March–May) at Kirstenbosch, elsewhere it is recommended that cuttings are taken in the active growing season. Heel cuttings selected from thin side shoots from the previous season's growth give the best results, but they will also root from tip cuttings. At Kirstenbosch they are rooted in multi-trays in a medium of equal parts 6mm milled pine bark and polystyrene or perlite chips under mist on heated propagation benches. Rooting is enhanced by using a powder-based rooting hormone for semi-hardwood cuttings or by dipping the base of the cutting for five seconds in 2,000 ppm IBA solution. Rooting takes from three to six weeks. Once well rooted, cuttings are removed from the propagation benches and hardened off away from bottom heat and mist. At this stage they should be fed with diluted (50%) liquid, organic, seaweed-based fertilisers.

Seed

The main challenge has been the poor seed set of these many long in cultivation clones because we believe there is an element of self-sterility and genetic bottle-necking.

Erica verticillata does not readily produce seed unless two or more different clones are in relatively close proximity for intraspecific cross-pollination to take place. The eight surviving collections produce few seeds when compared with most other *Erica* species. *E. verticillata* 'African Phoenix' and 'Adonis' are the best seed producers (Hitchcock, 2013).

The seed is sown in late summer or autumn at Kirstenbosch, but best sown at the beginning of the growing season in other areas. It should be sown fresh and be less than three years old unless preserved under optimal seed storage conditions. Seed is sown in seed trays on a well-drained sandy or peat-based potting mixture of equal parts coarse river sand and well-decomposed pine bark or good quality peat. The potting medium should be acidic, contain no manure and have low levels of phosphate with an optimum pH of 5–6.5. The seed is lightly covered with coarse sand, and then subjected to smoke treatment before the trays are watered. This allows for maximum smoke penetration into the medium containing the seed. Smoke is generated in a drum using dry and semi-dry fynbos plant material and is pumped into a sealed plastic tent stretched over a frame containing the trays of seed. The smoke is allowed to settle onto the medium, leaving a brownish film, after which the trays are removed from the tent. The seed trays are lightly watered, taking care not to disturb the seed. The alternative to applying the trays with smoke is to use the Kirstenbosch Smoke Plus Seed Primer which is a disc impregnated with smoke concentrate (Brown *et al*., 1993).

Erica seed germinates approximately three to four weeks after sowing and produces very small cotyledons. The true leaves appear from the eighth to the twelfth week. Seedlings can be pricked out after they have reached 5mm in height into multi-trays or plugs and a well-drained medium to avoid root rot.

CULTIVATION

Erica verticillata grows best when planted in a well-ventilated, warm, sunny position. It prefers seasonally moist, free-draining, sandy soils, but will grow well in average Mediterranean or warm-temperate garden conditions provided the soils are acidic and the plants are not subjected to frost. Ericas have very fine root systems close to the soil surface which work in symbiotic association with mycorrhizal fungi. Mycorrhizal fungi extend the root system of the host plant which enables increased water and nutrient uptake even in unfavourable, dry conditions. Disturbance of these ericoid roots and associated mycorrhiza may result in the death of the plant.

Pruning is important and may be practised from early in the development of the plant. Pruning will increase branching and the number of flower-bearing stems, and will prolong the life of the plant. Prune after flowering in order not to cut away new buds. Feed with organic liquid fertilisers or sparingly with controlled-release fertilisers low in phosphorus.

Erica verticillata has been known to reach over 20 years of age at Kirstenbosch although it becomes increasingly woody after 10 to 15 years' growth. It has very

few pest problems. Seedlings may suffer from damping-off fungal disease if the seed is sown too thickly, subject to poor ventilation or kept too wet. New growth tips may occasionally be damaged by thrips. These are tiny, slender insects in the order Thysanoptera that puncture and suck on new growth, causing distortion and browning of the tips. Thrip infestations are easily controlled by an appropriate pesticide and then pruning and destroying the infected parts.

CONSERVATION

There has been much debate and some scepticism within the community of botanic gardens and academic, conservation and botanical research organisations over the conservation value of keeping collections of wild species in botanic gardens or by private growers (Cadman, 2016). Our experiences of the whorl heath demonstrate that maintenance of a conservation collection can play an important role in the preservation of a species and may in some cases contribute to conservation programmes, at least for charismatic species.

Conservation efforts at Kirstenbosch have developed from building up *ex situ* collections in containers in the 1970s and 1980s to the integration of *ex situ* and *in situ* conservation since 2000. *Ex situ* conservation alone is not a sustainable way to ensure the survival of a species indefinitely. *Ex situ* containerised collections are limited by the resources available to maintain and curate genetically diverse collections. A collection with limited diversity will reduce further over the years due to lack of recruitment, disease and natural senescence. The answer to the fundamental question "what is a representative genetic sample of a taxon?" depends upon the species and the complexity of its genetic diversity. This is very difficult to do in the Cape Floristic Region where many families consist of large complexes that still challenge taxonomists.

The best way to conserve a species is in its natural habitat where it is subject to natural ecological systems (Hitchcock *et al*., 2012). The Conservation Programme at Kirstenbosch uses an integrated approach including *ex situ* collections of seeds supplied from the Millennium Seed Bank, the cultivation of plants in dedicated threatened species stock beds and containerised collections, and wherever possible, restoration to protected natural habitats (Hitchcock, 2006). Restoration of many threatened species in the Cape Floristic Region is complicated by the fact that most threatened species occur in threatened habitats. Cape Town has 19 vegetation types: 10 of these are critically endangered, 3 are endangered and 4 are vulnerable. There are 450 plant species on the Cape Town Red List: 49 of these are locally extinct and 13 are globally extinct, the greatest number for any city in the world (Holmes *et al*., 2012). The whorl heath occurs in the CFSF vegetation type which is classified as critically endangered. Humans have damaged and destroyed over 85 per cent of CFSF due to urban expansion of the city of Cape Town with more than half of this occurring in the last 50 years, and the vegetation type has over 110 threatened Red List plant species (Raimondo *et al*., 2009).

The South African National Conservation Target for the CFSF vegetation type is 30 per cent (Mucina & Rutherford, 2006) (Fig. 6). The amount left has declined from 16 per cent in 2009 (Stipinovich *et al*., 2009) to 13.4 per cent in 2016 of which only 2 per cent is conserved in nature reserves, while half of this is degraded and in poor condition (Holmes & Pugnalin, 2016). As of 2017, only 11 per cent CFSF remains, of which only 4 per cent can be considered natural vegetation and potentially restorable, with the remainder highly degraded (i.e. unploughed, but there is a legacy effect of alien vegetation having altered the ecosystem quite radically). Alien woody species such as *Acacia* invade fynbos and in most cases form dense, impenetrable stands which dominate and replace the natural vegetation. They drastically change the natural community structure causing the reduction in species diversity and water resources. They increase the fuel loads that result in too many intensely hot fires which are detrimental to the recruitment of many fynbos species. Acacias produce large numbers of hard coated seeds that are long lived and germinate in profusion after fire and outcompete natural vegetation (P. Holmes, pers. comm.).

The remnants of this vegetation type are severely fragmented and most conserved areas – Rondevlei Reserve (9.2ha), Meadowridge Common (6.0ha) and Rondebosch East Common (5.1ha) – are too small to provide viable habitats (Fig. 2). There are only two areas large enough for restoration without intensive management, namely Blaauwberg Nature Reserve (-33.763, 18.477) and Tokai Park. Rondebosch Common and Youngsfield are too transformed and Kenilworth Racecourse Conservation Area is privately owned without any official conservation status. Attempts to establish a conservation management agreement with the racecourse owners have not succeeded to date (Hitchcock *et al*., 2008). The abovementioned status of CFSF illustrates the dire situation when attempting to restore threatened species to their natural, historical habitat.

RESTORATION PROGRAMMES OF *ERICA VERTICILLATA*

The rediscovery of the whorl heath excited interest amongst some conservationists to re-establish it in its natural habitat. Three restoration programmes were conducted at three sites between 1994 and 2008.

Rondevlei Nature Reserve

Dalton Gibbs, Conservation Manager for the City of Cape Town, made the first attempts to reintroduce the whorl heath at Rondevlei Nature Reserve in 1994. The challenge was to discover a suitable place for planting, as so little habitat information was recorded, other than that it occurred “near moist areas”. He planted 20 specimens of the cultivar ‘African Phoenix’ grown in 1kg bags supplied by Kirstenbosch, in a transect starting at the drier sandy areas across a range of habitats ending in the wetland. Only one plant survived in the intermediate, moist area, indicating that this species might prefer the marginal areas between the dry and wet soils. More were planted in 1995, 1997 and

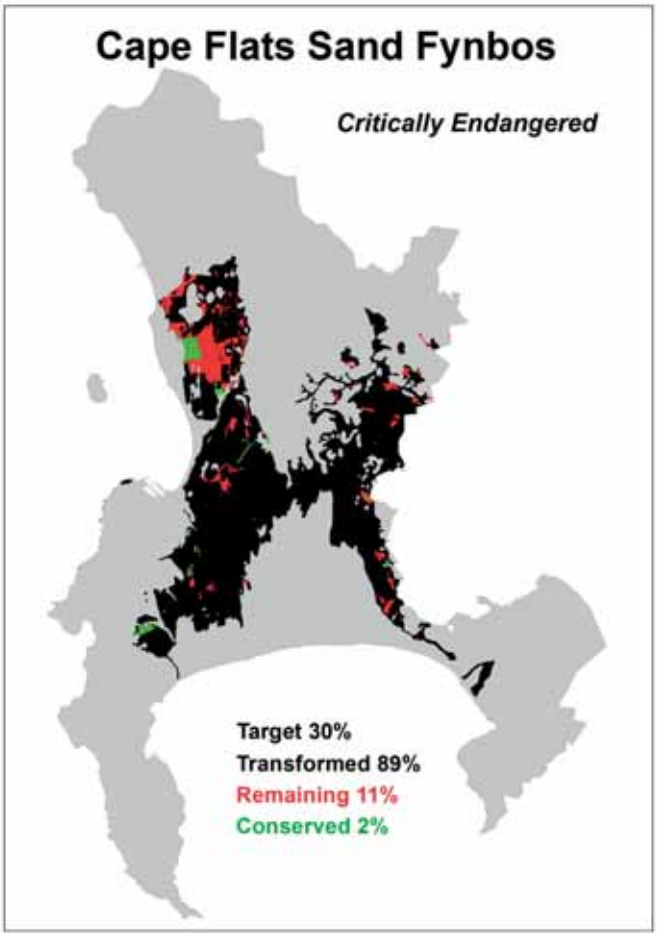

Fig. 6 Map showing the status of Cape Flats Sand Fynbos in 2017. Map drawn by Anthony Rebelo and Amalia Pugnalin.

1998 (Hitchcock, 2003). These established well, reaching maturity and attracting a number of pollinators, including *Cinnyris chalybeus* subsp. *chalybeus* (southern double-collared sunbird), Lepidoptera: Sphingidae (hawk moths) and *Xylocopa* spp. (carpenter bees). Despite this, they did not produce seed, and it was inferred that the clone 'African Phoenix' was self-sterile. In 2001, two more clones, 'Adonis' and 'Louisa Bolus', were planted at pollination distance to each other to enable seed production. These additional clones were successful in setting viable seed. Seed was collected and germinated in the Rondevlei nursery in 2005 (Wilman, pers. comm.) (Fig. 7).

An important day in the history of whorl heath was 27 March 2013, when the first ecological fire – a prescribed burn – was put through the population. At this stage 150 plants were still alive (Gibbs, 2014). The fire behaviour observed at Rondevlei suggests that this species has an unexpected strategy of suppressing fire and a complementary flowering strategy to ensure survival. When fire passes through the population, the

Fig. 7 *Erica verticillata* in flower at Rondevlei Nature Reserve. Photo: Alice Notten.

plants burst into flame as the leaves torch up and then, unexpectedly, the fire subsides, leaving behind relatively unscathed plants. The fire incinerates the flammable leaves, but burnt skeletons of branches appear to be fire-resistant, remaining intact, unlike the companion species which are burnt to the ground (Fig. 8). The dead plants clearly mark out where the ericas once stood, perhaps providing semi-shade and wind protection for the seedlings. It is also suggested that restricting the seed to the original distribution is essential to this species which has particular ectonal habitat requirements (Gibbs, 2014).

We believe that the flowering strategy of *Erica verticillata* is as follows. It flowers from mid-summer to early autumn (January to April) which is the fire season in fynbos. Successive whorls of flowers are produced. Only when the first set of flowers has matured does it produce the next set. Fires normally occur in late summer by which time the first seed capsules have matured, while the second set is still flowering. The seed is retained in protective capsules, which open within a few hours of the fire, scattering seeds beneath the skeletal parent plant. It has been observed that recruiting seedlings survive better where they are given protection from the elements by nurse plants. In the absence of fire the seeds are released when ripe at the end of summer.

The first record of post-fire recruitment of the species from seed was observed in 2015 (Fig. 8) (Gibbs, pers. comm., 2015). The seedlings had to contend with vigorous regrowth from competing plants such as *Stenotaphrum secundatum* (H. Walter) Kuntze (Buffalo Grass) and *Psoralea pinnata* L. (Fountain Bush). It is difficult to be sure, but it appears that seedlings might have been overwhelmed by competing plants. This

Fig. 8.1 (top left) *Erica verticillata* on fire in controlled burn at Rondevlei Nature Reserve, March 2014.
Fig. 8.2 (top right) *Erica verticillata* post fire with plant structure intact.
Fig. 8.3 (bottom left) *Erica verticillata* burnt capsules opening at Rondevlei, March 2013.
Fig. 8.4 (bottom right) First record of *Erica verticillata* seedling recruiting after fire in the restoration project. Photos: Dalton Gibbs.

demonstrates that a functioning ecosystem is critical to the success of restoration programmes, and the role of herbivory in controlling competition at Rondevlei is being studied through a pilot project to reintroduce eland (*Tragelaphus oryx*) (*Cape Times*, 2015) (Fig. 9). This project started in 2016 and initial observations are positive: eland are selective in what they browse, feeding on grass and woody vegetation, but ignoring the *Erica* plants (*Cape Times*, 2015).

Kenilworth Racecourse Conservation Area

The site is regarded as the best and least disturbed example of CFSF remaining on the southern suburbs of Cape Town (www.krca.co.za). In 2004, 100 plants comprising 3 clones, 50 'African Phoenix', 25 'Adonis' and 25 'Louisa Bolus', were planted within 100m of each other at Kenilworth Racecourse Conservation Area (KRCA) in a seasonally wet depression (Fig. 10). Young whorl heath plants in 1kg bags, which had been propagated from cuttings, were planted in mature vegetation to protect them from the summer heat and wind. Eighty per cent of these plants survived and have flowered profusely every year since (Fig. 11). Seedling recruitment has been observed in open patches near the parent plants. Cape Nature organised a controlled burn in an adjacent section of the KRCA in March 2005. A second population was established in a moist area adjacent to the east. Plants grown in 50cc re-usable plastic Unigrow® propagation plugs, and also in 1kg bags, were planted in mid-winter, June 2005 (Hitchcock, 2006).

Fig. 9 Eland reintroduced to Rondevlei Nature Reserve as a primary herbivore to control the vegetation. Photo: Dalton Gibbs.

The plants from plugs all died during the summer, probably because they were too exposed to the desiccating summer winds and heat. Thirty per cent of the plants grown in 1kg bags planted amongst grasses survived. It is surmised that the plants in bags survived better because they were protected by re-sprouting grasses that were growing *in situ*. It has been observed that 'nurse plants' shelter young plants from the strong summer wind and by partially shading the plants, keeping them cooler and in better condition. It is speculated that plants grown in plugs do not have sufficient root mass to support the young plants through the first summer whereas those in larger containers have a larger root mass to sustain them. This is based on monitoring other young plants in restoration where 1kg container plants survived better than those planted from plugs, although the surviving plug-grown plants outperformed the plants grown in 1kg bags in the long term.

Tokai Park

This site, which has been under pine plantations for the past 100 years, is now being managed to protect and conserve its endangered vegetation type CFSF which accounts for 20 per cent of the remaining world CFSF. It is also connected to the mountain reserve which has granite and sandstone fynbos.

Fig. 10 Anthony Hitchcock (back) and Dalton Gibbs planting plugs of *Erica verticillata* in burn area at Kenilworth Racecourse. Photo: Trevor Adams.

Fig. 11 *Erica verticillata* first generation restored to Kenilworth Racecourse Conservation Area. Photo: Alice Notten.

Most of the restoration at Tokai is passive, relying on natural regeneration after both the felling of the pines and a restorative fire to flush the seed bank. However, several species designated as Extinct or Critically Endangered (Raimondo *et al*., 2009) have been reintroduced. This is the case of *Erica verticillata* for which a reintroduction programme began in 2004 managed by Kirstenbosch, South African National Parks and the Millennium Seed Bank Project.

The first planting took place in the Soetvlei wetland which was recovering after clearing (Hitchcock & September, 2016). The plants grew well, but were being chewed down to ground level by *Otomys irroratus* (African vlei rat) and swamped by vigorous wetland plants, such as *Cyperus* spp. (Sedges). We identified a new site higher on the slope where competing plants were less likely to swamp the young ericas. The area was also more exposed, which we hoped would allow predators such as raptors to control the rodents. Further rodent control involved the relocation of snake species *Pseudaspis cana* (mole snakes) and *Bitis arietans* (puff adders) which had been rescued from adjacent residences and stables. The ericas established splendidly, with the aid of predators or not, and have become a feature admired by visitors to Tokai Park (Fig. 12).

The most extensive planting to date of 5,000 plants of whorl heath was planned along the Prinskasteel wetlands in 2008 (Figs 13 & 14). The wetlands are bordered by pine plantations, but there was enough natural area to make an experimental planting along the southern fringe of the wetlands stretching for 200m (September, 2010). Three clones, ‘Adonis’, ‘Belvedere’ and ‘African Phoenix’, were selected as the best seed

Fig. 12 Anthony Hitchcock celebrating first-generation *Erica verticillata* restored to Soetvlei wetland. Photo: Wendy Hitchcock.

Fig. 13 *Erica verticillata* first-generation restored, Prinskasteel, Tokai Park, 2011. Photo: Anthony Hitchcock.

Fig. 14 *Erica verticillata* grown in Unigrow® plugs for restoration at Tokai. Photo: Anthony Hitchcock.

Fig. 15 *Erica verticillata* planting, Prinskasteel, Tokai, July 2009. Photo: Anthony Hitchcock.

Fig. 16 Transects set up for planting at Tokai, July 2009. Photo: Anthony Hitchcock.

producers (Grobler, 2013). Sunbirds are common in the area so we hoped that they would pollinate and result in the formation of a significant seed bank.

This mass planting was done in 65 batches with 5m between them, each comprising 15, 10 and 15 plants of the 3 clones respectively, in rows 1m apart (Figs 15 & 16). The rows were perpendicular to the vlei edge from the water's edge into the dry areas. The restoration of the whorl erica in the wetlands was more successful than anticipated despite the gradient. There was one instance of careless herbicide application when subcontractors controlling invasive *Rubus* also sprayed some of the ericas, killing 20 per cent of plants – the total mortality was 40 per cent. This, together with other challenges such as fire belts being cut through the restoration stands, highlights the need for coordinated management, efficient communication and knowledgeable supervision. The plants survived best in the marginal zone between dry and wet, but grew to be larger and more robust on the wetter end. Plants which were further from the wetland were smaller, and most of the plants in the driest zone died. The vigorous plants in the wet marshy areas did less well, being overwhelmed by wetland species. 'Belvedere' did not do as well as the other two clones, being smaller and less robust when planted.

The experiment showed that despite the fact that some sedges outcompeted the whorl heath in the wettest habitat, and aliens did so in others, the restoration was still comprehensive and extensive over the area. The variety of pollinators visiting the ericas

was astounding, with far more pollinators than just the birds which were expected. Apart from *Anthobaphes violacea* (orange-breasted sunbird) and *Cinnyris chalybeus* (southern doublecollar sunbird) (Fig. 17), other visitors noted included wasps (Hymenoptera), carpenter bees, Cape honeybees (*Apis mellifera* subsp. *capensis*), hawk moths and some small beetles.

Subsequently, plantings have been made along the Prinskasteel canal, and in two other wetlands at Tokai, with the whorl heath establishing far better than most other species attempted, perhaps because wetlands buffer against the summer droughts (which have been particularly severe recently) better than the drier sands typical of sand fynbos. This is corroborated by the fact that a planting outside of the wetlands was a total failure.

Restoration at Tokai is a finely balanced process and the public were asked to keep out of the restoration areas to allow the recovery process to develop with as little human impact as possible. However, promoting awareness is critical and the public must be informed. This is in line with Target 14 of the GSPC: "The importance of plant diversity and the need for its conservation incorporated into communication, educational and public-awareness programmes" (Convention on Biological Diversity, 2010; Raimondo, 2015). SANParks and the Friends of Tokai Park (a public volunteer group affiliated to the Wildlife Society of South Africa (WESSA)) selected an area

Fig. 17 Orange-breasted sunbird pollinating *Erica verticillata*. Photo: Alice Notten.

between two of the entrances where some of the threatened species could be planted to showcase the restoration work at Tokai. Funding was provided by the Old Mutual Two Oceans Marathon via the Table Mountain Park Honorary Rangers. The area is called the Tokai Restoration Trail and includes interpretation boards explaining the restoration process, reasons and the management plans. The trail was designed by a local landscape architect and includes pathways and a boardwalk over the wet areas. A range of CFSF species are planted, ten of which have threatened status: Extinct in the Wild, Critically Endangered, Endangered and Vulnerable. The trail was planted by Tokai Park staff, Friends of Tokai Park, Kirstenbosch National Botanic Garden and Millennium Seed Bank staff, and was opened by Park Manager Paddy Gordon in September 2013 (Fig. 18).

MEADOWRIDGE COMMON

The whorl heath and other threatened species such as *Serruria glomerata* (L.) R.Br. (cluster spiderhead) were planted on Meadowridge Common, a small City of Cape Town conservation area about halfway between Tokai Park and KRCA. The Common is less

Fig. 18 Head of Table Mountain Park, Paddy Gordon, opening the Tokai Restoration Trail, September 2013. Photo: Anthony Hitchcock.

than 2km from where the whorl heath used to occur. City conservation staff identified a seasonally wet area and created a habitat suitable for moisture-loving plants. Staff from the City and Millennium Seed Bank staff from Kirstenbosch assisted Friends of the Meadowridge Common on 11 June 2014 to plant 35 'African Phoenix', 25 'Harry Wood' and 35 'Doctor Violet Gray' plants. The introduction was not successful and no plants survived. A reason for this failure could be that the area is not a proper wetland and it dried out in summer. Another reason may be that the year following the planting was a particularly dry one, with rainfall only 60 per cent of the annual mean.

CONSIDERATIONS FOR RESTORATION – LESSONS LEARNED

Fynbos is a fire-adapted vegetation type that requires regular burning for its continuation. In the absence of fire, fynbos is gradually replaced by thicket species and fynbos species die. Fynbos thrives on infertile soils and fire is the mechanism by which nutrients are recycled into the soil from old growth. Fire is a crucial trigger that resets the 'successional clock'. It provides the stimulus for dormant seeds to germinate and the opportunity for many annuals, short-lived perennials and bulbs to grow, flower and set seed during times of abundant nutrients and sunlight. They complete their short life cycles, returning to the soil as larger shrubs overwhelm them, and remain dormant until the next fire. The optimal fire cycle for fynbos is 10–20 years (Kraaij & Van Wilgen, 2014). Shorter fire cycles can wipe out slow-maturing species, while other species start dying when intervals become too long. Restoration of fynbos species needs to include fire in the management protocol.

To determine when the project to restore the whorl heath to the wild may be considered successful is problematic. IUCN Red List rules state that reintroduced plants must produce viable offspring before they can be counted as mature individuals (IUCN Standards and Petitions Subcommittee, 2016). In other words, after two generations, all flowering plants which are producing seed can be counted as mature individuals and used in the population assessments.

Erica verticillata has self-incompatible clones so in this case the viability of the F1 generation has to be checked before assessing the success of the species in the restoration project. In most cases the second natural generation after planting would qualify as a success, but in the case of the whorl heath, a third generation is required in order to ensure that the F1 is fertile and sustainable. In addition, given the threats of recruitment competition from natural and alien species in a habitat recovering from disturbance which includes pine plantations, root disturbance by dune moles, excessive herbivory or lack thereof and variances in climate, it is recommended that successful re-establishment of a species in fynbos requires the reintroduced population to survive three fire cycles.

In order to downlist this species from 'Extinct in the Wild' an assessment will have to be made of the number of plants that exist after three generations; whether the population is stable, declining or increasing; how fragmented the populations are; and the level of conservation protection afforded to the area of restoration.

CONCLUSION

A number of lessons have been learned in the process of restoring the whorl heath. The *ex situ* conservation approach is insufficient and therefore an integrated approach including *in situ* conservation is essential. Restoration of a species on its own is not good enough. A sustainable restoration programme needs to include restoration and sustainable management of the ecosystem, which in this case includes fire. Success in restoring a species depends upon a healthy stand of the vegetation type being in place, along with pollinators and other animals and soil fauna and flora required for maintaining the system. If this is not in place steps must be taken to restore other missing components. Any imbalance in this system, such as an explosion in the population of vlei rats, as happened in Tokai Park, might result in one component becoming a problem rather than having a beneficial influence. The destructive and positive role of herbivory needs to be explored further as this might be a crucial factor in success or failure (*Cape Times*, 2015). Finally, the entire system must be managed holistically, with fire belts and alien control programmes incorporated into areas targeted for species-specific restoration.

Conservation of the rich Cape flora is an enormous challenge, particularly given the increased demand for land and resources, and the effects of climate change. This is especially true of the lowlands where the whorl heath originates. Many other species will not be so lucky and will be lost forever. An example is *E. pyramidalis* Sol. ex Aiton (pyramid heath), which used to grow with the whorl heath but is now extinct in the wild and with no *ex situ* cultivated plants known to exist (Hitchcock, 2007; Raimondo *et al*., 2009). At the time of writing, large numbers of plants are on the brink of extinction on the Cape flats. We will lose these species, and many more, unless these endangered habitats are conserved as a matter of urgency.

The whorl heath therefore plays a crucial role as a flagship species to create an awareness of the general plight of our vanishing flora within the City of Cape Town and beyond.

REFERENCES

ADAMSON, R.S. & SALTER, T.M. (1950). *Flora of the Cape Peninsula*. Juta & Co., Ltd., Cape Town and Johannesburg.

ARGUS (2006). Rondevlei boosts new species thought to be extinct. Fynbos sanctuary plants new attitudes in residents, 16 August, p. 8.

BERGVLIET PRIMARY SCHOOL (2013). History. Available online: http://bergvlietprimary.co.za/index.php/about-us/history (accessed July 2017).

BROWN, N.A.C., KOTZE, G. & BOTHA, P.A. (1993). The promotion of seed germination of Cape Erica species by plant-derived smoke. *Seed Science and Technology*, 21, 573–580.

CADMAN, M. (ed.) (2016). Fynbos Forum Ecosystem Guidelines for Environmental Assessment (2nd edn), Chapter 4, pp. 60–78. Available online: http://biodiversityadvisor.

sanbi.org/wp-content/uploads/2012/04/Ecosystem_Guidelines_Ed2.pdf (accessed July 2017).

CAPE TIMES (2015). Three-year Gantouw Pilot Project will reintroduce eland to the Cape Flats. 23 November, p. 3.

CONVENTION ON BIOLOGICAL DIVERSITY (2010). Updated Global Strategy for Plant Conservation 2011–2020. Available online: www.cbd.int/gspc (accessed June 2017).

GIBBS, D. (2014). Baptism of Fire. *Veld & Flora*, 100(1), 30–32.

GROBLER, A. (ed.) (2013). *Erica verticillata Ericaceae. Flowering Plants of Africa*, 63, 104–119.

HILTON-TAYLOR, C. (1996a). *Red Data List of Southern African Plants. Strelitzia, 4*. National Botanical Institute, Pretoria.

HILTON-TAYLOR, C. (1996b). Threatened Ericaceae in southern Africa. *Yearbook of the Heather Society*, 7–16.

HITCHCOCK, A. (2003). *Erica verticillata* is brought back from the brink of extinction. *Yearbook of the Heather Society*, 45–50.

HITCHCOCK, A. (2006). Restoration Conservation at Kirstenbosch. *Veld & Flora*, 92(1), 40–44.

HITCHCOCK, A. (2007). The return of *Erica verticillata. Veld & Flora*, 93(1), 14–17.

HITCHCOCK, A. (2013). *Erica verticillata* P.J.Bergius (Ericaceae). *PlantZAfrica*. Available online: http://pza.sanbi.org/erica-verticillata (accessed June 2017).

HITCHCOCK, A., COWELL, C. & REBELO, A. (2012). The lost fynbos of Tokai Park. *Veld & Flora*, 98(1), 30–33.

HITCHCOCK, A., COWELL, C. & STAUCH, M. (2008). Weaving the Golden Circle: Kenilworth Racecourse Conservation Area. *Veld & Flora*, 94(1), 31–35.

HITCHCOCK, A. & SEPTEMBER, J. (2016). Kirstenbosch Threatened Species Programme: Tokai Rehabilitation Project. Unpublished Report.

HOLMES, P. & PUGNALIN, A. (2016). The Biodiversity Network for the City of Cape Town Municipal Area. C Plan & Marxan Analysis: 2016 Methods and Results. Environmental Resource Management Department (ERMD), City of Cape Town, June 2016. Available online: http://resource.capetown.gov.za/documentcentre/Documents/City%20research%20reports%20and%20review/BioNet_Analysis-2016_C-Plan+MARXAN_Method+Results_report_2016-07.pdf (accessed June 2017).

HOLMES, P.M., REBELO, A.G., DORSE, C. & WOOD, J. (2012). Can Cape Town's unique biodiversity be saved? Balancing conservation imperatives and development needs. *Ecology and Society*, 17(2), 28. Available online: http://dx.doi.org/10.5751/ES-04552-170228 (accessed June 2017).

IUCN STANDARDS AND PETITIONS SUBCOMMITTEE (2016). Guidelines for Using the IUCN Red List Categories and Criteria. Version 12. Available online to download: www.iucnredlist.org/documents/RedListGuidelines.pdf (accessed March 2017).

KENILWORTH RACECOURSE CONSERVATION AREA (2006). Available online: www.krca.co.za (accessed June 2017).

KRAAIJ, T. & VAN WILGEN, B. (2014). Drivers, ecology and management of fire in fynbos. In ALLSOPP, N., COLVILLE, J.F. & VERBOOM, G.A. *Fynbos: Ecology, Evolution and Conservation of a Megadiverse Region.* Oxford University Press, Oxford.

MUCINA, L. & RUTHERFORD, M.C. (2006). *The Vegetation Map of South Africa, Lesotho and Swaziland*. SANBI, Pretoria.

OLIVER, E.G.H. & OLIVER, I.M. (2005). The genus *Erica* (Ericaceae) in southern Africa: taxonomic notes 2. *Bothalia*, 35(2), 121–148.

OLIVER, I. & OLIVER, E.G.H. (2000). *Field Guide to the Ericas of the Cape Peninsula*. Protea Atlas Project, National Botanical Institute, Cape Town.

RAIMONDO, D. (ed.) (2015). *South Africa's Strategy for Plant Conservation*. South African National Biodiversity Institute and the Botanical Society of South Africa, Pretoria.

RAIMONDO, D., VON STADEN, L., FODEN, W., VICTOR, J.E., HELME, N.A., TURNER, R.C., KAMUNDI, D.A. & MANYAMA, P.A. (2009). *Red List of South African Plants. Strelitzia 25*. South African National Biodiversity Institute, Pretoria.

SEPTEMBER, J. (2010). A felling tale. Restoring critically endangered lowland fynbos in the Tokai Plantation. *Veld & Flora*, 96(3), 134–135.

STIPINOVICH, A. & HOLMES, P. (2009). City of Cape Town's Biodiversity Network. C-Plan & Marxan Analysis: 2009 Methods and Results. Environmental Resource Management Department (ERMD), City of Cape Town, December 2009. Available online: http://resource.capetown.gov.za/documentcentre/Documents/City%20research%20reports%20and%20review/BioNet_Analysis-2009_Methods+Results_report_2009-12.pdf (accessed June 2016).

APPENDIX

Erica verticillata clones registered by the Heather Society. Charity no. 261407. Address: 84 Kinross Road, Rushington, Totton, Southampton, SO40 9BN, UK for Kirstenbosch National Botanical Garden. All the clones were registered on 4 September 2012 by Anthony Hitchcock.

Erica verticillata **cultivar name**	**Cultivar reg. no.**	**Accession number at Kirstenbosch**	**Origin**
'Adonis'	E.2012:06	273/2012	Kirstenbosch Estate, South Africa. Discovered by foreman Mr A. Adonis probably from original collection by Mrs Louisa Bolus in 1917
'African Phoenix'	E.2012:05	536/1984	Protea Park, Pretoria, South Africa
'Belvedere'	E.2012:07	109/2001	Belvedere Palace Nursery, Vienna, Austria
'Cherise'	E.2012:11	549/2006	Monrovia Nursery, California, USA
'Doctor Violet Gray'	E.2012:09	548/2006	From the collection of Dr Violet Gray, original member of the Heather Society Cape Heaths Group, UK

***Erica verticillata* cultivar name**	**Cultivar reg. no.**	**Accession number at Kirstenbosch**	**Origin**
'Harry Wood'	E.2012:10	657/2006	Harry Wood, Curator of the Fernkloof Nature Reserve, Hermanus, South Africa sent seed to the Royal Botanic Gardens, Kew in 1961. Accession number 1961-9001. Then sent to Kirstenbosch NBG in 2006
'Louisa Bolus'	E.2012:12	272/2012	Kirstenbosch Estate, South Africa. Discovered by foreman Mr A. Adonis probably from original collection by Mrs Louisa Bolus in 1917
'Tresco Abbey'	E.2012:08	543/2006	Tresco Abbey Botanic Garden, UK