BIOGEOGRAPHICAL PRINCIPLES IN HORTICULTURE: CREATING AN ERICA AND FYNBOS GARDEN FOR EDUCATION AND AMENITY

Anthony Hitchcock[1] *& Sally Hey*[2]

ABSTRACT

With more than 780 species, *Erica* is the largest genus in the Core Cape Subregion, once referred to as the Cape Floristic Region (CFR), in South Africa. The redevelopment of the Erica Display Garden at Kirstenbosch National Botanical Garden to fulfil aesthetic, conservation and educational purposes is described. The author draws on decades of field work in the CFR to open a window for botanic garden visitors and schoolchildren who have not had the privilege of experiencing the unique flora of the CFR. An explanation for the extraordinary diversity of the CFR is explored. The challenge of engaging with visitors and at the same time highlighting the diversity of ericas and fynbos while overcoming the difficulties of growing wild species out of their natural and niche habitats is explained. The most effective way to display South African ericas and fynbos is discussed. The use of phytogeographical themes is preferred as a suitable method to display diversity in botanic garden horticulture. Nine planting beds totalling 8,000 m^2 were redeveloped to represent six distinct phytogeographic regions identified in *Plants of the Greater Cape Floristic Region* (Manning & Goldblatt, 2012). Nineteen of the twenty largest families and genera of the Cape flora are also represented in these displays. Interpretation was created to provide information on the defining features of each region. The phytogeographic theme was used to emulate typical natural floristic features of each and to bring the concept of geographically driven plant diversity to the attention of the visiting public and students.

BIOGEOGRAPHY, SPECIES DIVERSITY AND ENDEMISM IN THE CAPE FLORISTIC KINGDOM

Why is the Cape Floristic Region so rich in species and endemics?

The Cape Floristic Region (CFR) is a distinctive phytogeographical unit which was formerly recognised as a floral kingdom of its own (Good, 1974; Goldblatt, 1978; Takhtajan, 1986). More recently, it has been argued that the Cape flora is more appropriately recognised as a floristic region and it is now referred to as the Core Cape Subregion (CCR) (Cox, 2001) (Fig. 1). Floristic links across the southern African winter-rainfall region have led to the region being called the Greater Cape Floristic Region (GCFR) of which the CCR constitutes the most distinctive floristic part (Born *et al*., 2006).

1. Anthony Hitchcock was Nursery, Living Collections and Threatened Species Manager at the South African National Biodiversity Institute, at Kirstenbosch National Botanical Garden. Retired March 2018.
Address: 7 Lysander Way, Meadowridge, Cape Town 7806, South Africa.
Email: anthonyhitch007@gmail.com
2. Sally Hey is Principal Environmental Education Officer at the South African National Biodiversity Institute, at Kirstenbosch National Botanical Garden.
Address: South African National Biodiversity Institute, Kirstenbosch, Cape Town 7735, South Africa.

The land area of the CCR is 90,760 km^2, which is less than 4 per cent of the southern African subcontinent. For its size, the CCR is one of the world's richest areas of plant species diversity. It is richer in species than other floras of temperate regions and most tropical ones (Manning & Goldblatt, 2012). It contains an estimated 9,383 vascular plants of which 9,251 are flowering plants (Manning & Goldblatt, 2012). The levels of endemism are among the highest in the world: 68 per cent of vascular plants are endemic (Cowling, 1992).

Species diversity

The establishment of the cold Benguela Current along the west coast of South Africa in the Miocene, with its cooling and drying effects on the west coast, was probably the single most important impetus for vegetation change in the subcontinent (Manning & Goldblatt, 2012). Summer drought is likely to have become increasingly severe in the west compared with the CCR further east where the warmer Indian Ocean current continues to exert its influence.

The Cape region has a highly dissected, rugged topography, and a diversity of climates. The determinants of the distribution of fynbos communities in the mountains are best described in terms of three major environmental gradients (Campbell, 1983). These are west-to-east gradient; coast-to-interior gradient; and an altitude-aspect gradient. The west-to-east gradient is largely one of decreasing summer-drought intensity and increasing soil fertility (Campbell, 1983). Rainfall in the western CCR occurs predominantly in the winter months, becoming aseasonal, all-year rainfall towards the east. The coast-to-interior gradient is most strongly associated with decreasing rainfall (Campbell, 1983). Local variation in rainfall is pronounced in mountainous areas. Rainfall patterns in the CCR show dramatic variation across the landscape, dropping from 2,000 mm per year on the high mountain ranges immediately facing the coast, to less than 200 mm on the leeward slopes of the interior ranges (Manning & Goldblatt, 2012). The steep mountain gradients contribute to a strong orographic effect. Rainfall, snow and mist-cloud is produced when moist air is lifted as it moves over a mountain range. As the air rises it cools and orographic clouds form and serve as a source of precipitation, most of which falls upwind of the mountain range. The moisture is squeezed out and causes a rain shadow effect on the leeward side of mountain slopes.

Another important environmental factor is the influence of the summer south-east wind and clouds. These clouds normally cap the peaks of the coastal mountain ranges of the CCR, providing much-needed moisture and cooling during the hot summer months. The process whereby precipitation arriving at a location thanks to factors that would normally go unrecorded by a standard rain gauge, for example through the condensation of mist and fog on foliage, is called 'occult precipitation' (Allaby, 2010). Moisture input in the fynbos system is therefore not only limited to precipitation. Additionally, plant groups benefit from an occult event in different ways:

proteas seem to benefit more from transpiration suppression, whereas ericas and restios can absorb moisture directly though their leaves in an occult event (Rogers, 2013).

Ecological gradients are steep because of abrupt differences in soil, altitude, aspect and precipitation. These factors combine to form an unusually large number of local habitats for plants. Sandstone-derived soils are oligotrophic, having characteristically low nutrient status, and many plants present on such soils have low seed-dispersal capabilities, a factor promoting localised distributions. The generally low nutrient status of most of the soils, and subtle differences in nutrient and moisture levels among soil types, represent a major selective force for plant speciation in the CFR (Cowling, 1992).

The dominant paradigm for speciation in the CFR is that it has been largely allopatric (Rourke 1972; Goldblatt, 1978). Allopatric speciation occurs when biological populations of the same species become geographically isolated from each other to an extent that prevents or interferes with genetic interchange (Biology Dictionary, 2017a).

Alternatively, Linder & Vlok (1991) suggest that sympatric speciation in response to steep ecological gradients is prevalent in the Cape flora. Sympatric speciation occurs when two populations of the same species live in the same geographic location but evolve differently until they can no longer interbreed and are considered to be different species (Biology Dictionary, 2017b). Much of the debate concerning allopatric and sympatric speciation centres on the meaning of the word 'geographical' (Templeton, 1981). Bearing in mind that most fynbos species have short gene dispersal distances (Linder, 1985; Slingsby & Bond, 1985), each distinctive habitat could represent a 'geographic' region without the usual physical barriers associated with allopatric speciation (Linder & Vlok, 1991). Stated thus, conditions are highly conducive to rapid 'sympatric speciation' in an area like the Agulhas Plain.

Edaphic specialisation relates to the physical and chemical conditions of soils which are conducive to sympatric speciation. The high level of edaphic specialisation in the flora indicates that the complex mosaic of edaphic environments in the CCR represents an important selective regime. Populations of edaphically restricted species would be subject to drastic reduction because of fire in the short term (Van Wilgen *et al*., 1992) and climatic change in the long term (Goldblatt, 1978). These processes would result in in the extinction of intermediates (Cowling, 1987) and reduced population sizes of genetically divergent isolates in marginal habitats, such as limestone. The result could be rapid speciation.

Fire is an integral part of the ecology of the CCR. The long-term ecological consequence of the fire regime is the existence of a niche for species that grow rapidly after fire, and which bloom and reproduce in the immediate post-fire years. This suite of species contributes substantially to the overall diversity in the flora. Mature vegetation may be affected in different ways by fire, which may cause local fluctuations in species composition and even the local elimination of some taxa, creating opportunities for diversification and speciation (Manning & Goldblatt, 2012).

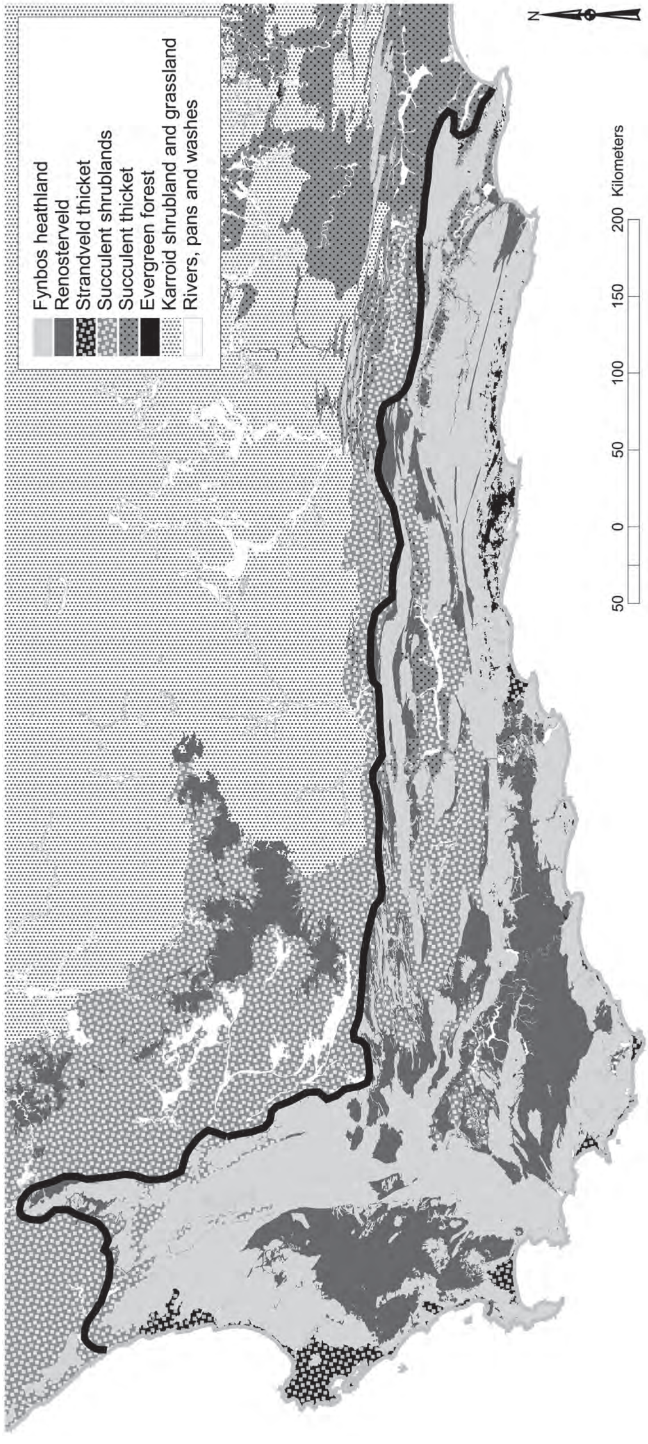

Fig. 1 Main vegetation types in the Core Cape Subregion. Map adapted from Mucina & Rutherford (2006).

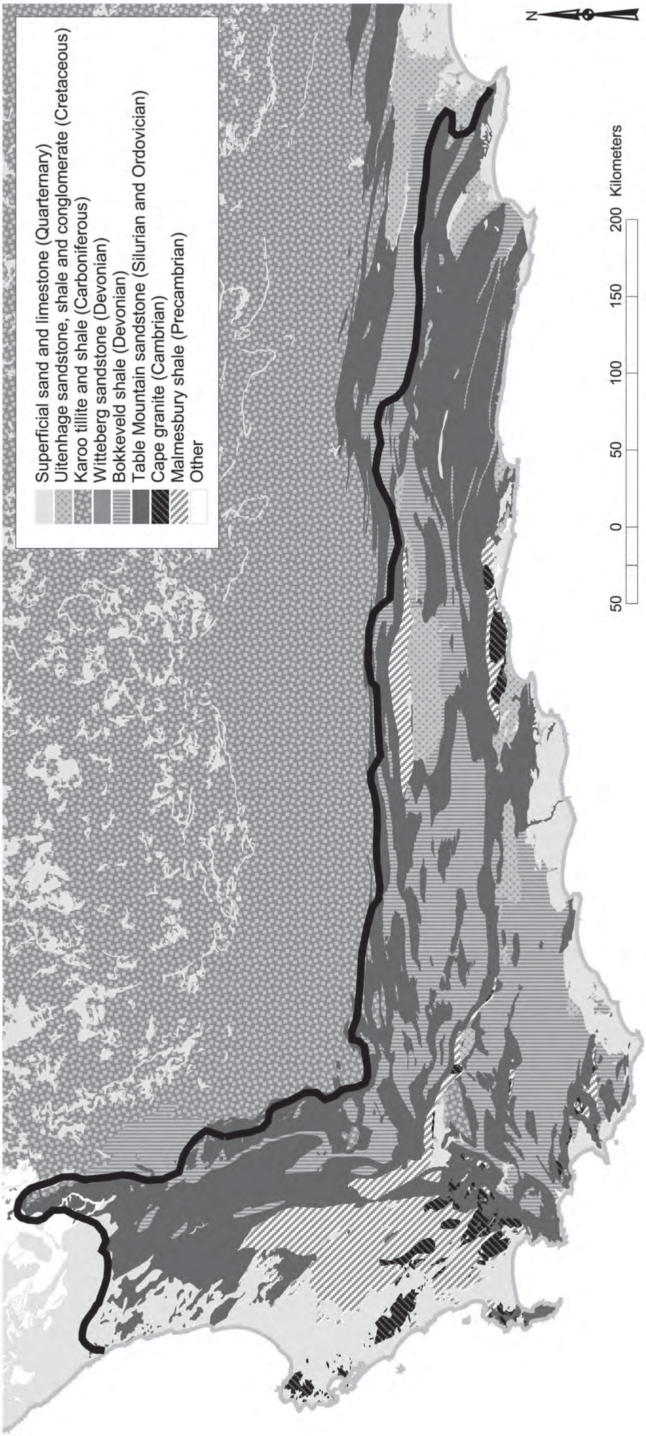

Fig. 2 Altitude in the Core Cape Subregion.

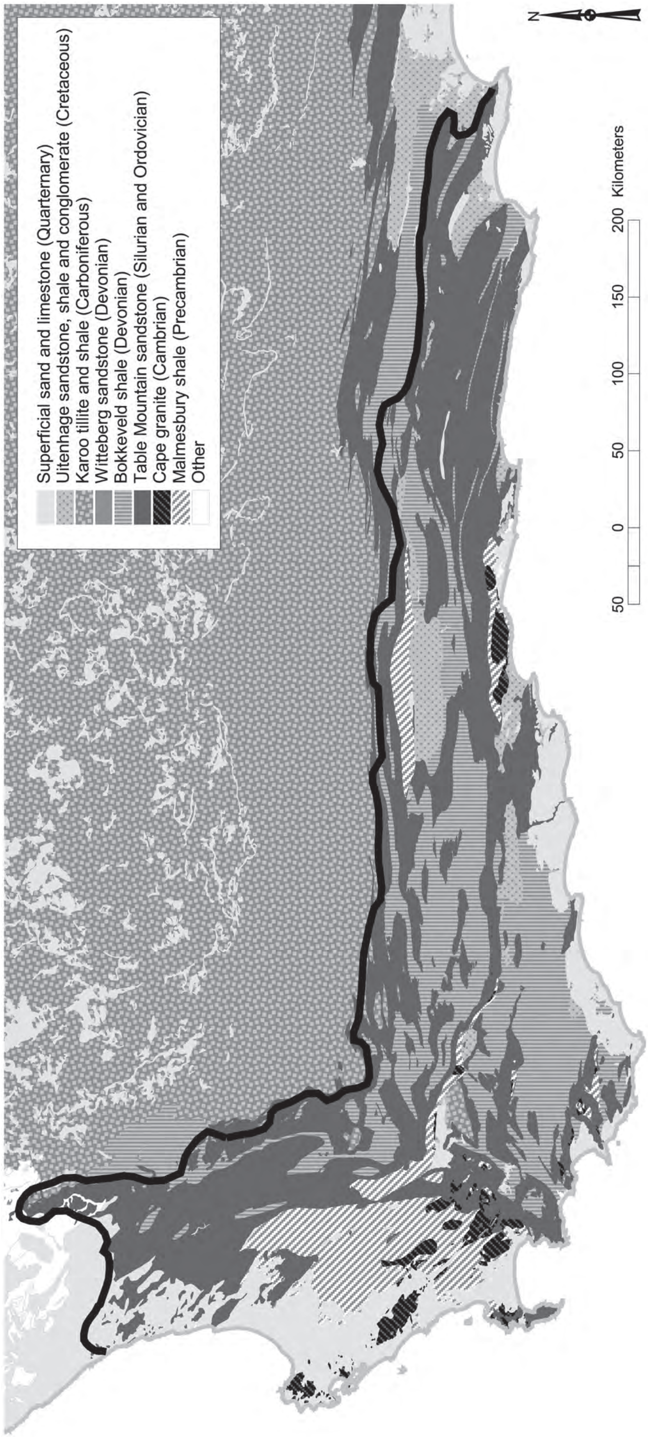

Fig. 3 Main geological formations in the Core Cape Subregion.

Figs 1, 2 & 3 are reproduced from Manning & Goldblatt (2012) with the kind permission of the South African National Biodiversity Institute (SANBI).

Endemism

Levels of endemism in the CFR are among the highest in the world. A centre or area of endemism is delimited by the more or less coincident distribution of taxa that occur nowhere else (Cowling, 1992).

Edaphic specialisation has been very important in the evolution of endemics in the CFR (Cowling, 1992). The Cape region consists of a mosaic of sandstone and shale substrata with local areas of limestone and granite substrata. Restriction of endemic species to peculiar or isolated substrata (serpentine, limestone, laterite, quartzite and calcareous sands) is a widespread phenomenon in the endemic-rich areas such as the CFR. Most endemics are edaphic specialists indicating the importance of soil type as a selection force with certain substrata such as limestones, which are found in the Agulhas Plain and harbour a disproportionally high number of endemics (Cowling, 1992). Taxonomically, endemics are not random assemblages with respect to biological attributes – families such as Ericaceae, Proteaceae and Rutaceae are significantly over-represented among endemics. An endemic is most likely, but not always, a dwarf to low, non-sprouting shrub with soil stored, ant dispersed seed and/or microsymbiont-mediated nutrient uptake. The possession of some of these traits, though adaptive at organism level, may incidentally cause lineage turnover and the multiplication of species. Also contributing to the diversity has been a relatively stable geological history since the end of the Miocene that saw the establishment of a semi-arid and extreme seasonal climate at the south-western part of southern Africa.

Species richness in the Cape flora therefore seems to be the result of this complex mosaic of diverse habitats and steep ecological gradients set against a background of relatively stable climate and geomorphology since the late Cenozoic. This has fostered active speciation and the evolution of new taxa, as well as the accumulation and persistence of existing taxa (Manning & Goldblatt, 2012).

The evolution of the flora in the CCR is a dynamic and ongoing process. The flora cannot be regarded as static but rather continually evolving, exhibiting its adaptive responses to the environment. Therefore, plant families such as Ericaceae express great diversity, challenging taxonomists to classify them. Many ericas express remarkable diversity resulting in separation into subspecies, varieties and forms. To accommodate these, they are often grouped into 'complexes' such as in the case of *Erica discolor* (Oliver & Oliver, 2005), *E. abietina* and *E. plukenetii* (Oliver & Oliver, 2002). This is also true of many other species in the CCR. By choosing to plant these groups according to their phytogeography the opportunity to display this diversity in the different phytogeographic regions is created.

REJUVENATION OF THE ERICA GARDEN AT KIRSTENBOSCH NATIONAL BOTANICAL GARDEN

Kirstenbosch National Botanical Garden (referred to as 'Kirstenbosch') is located at the centre of the CCR. Kirstenbosch therefore naturally focuses much attention on curating

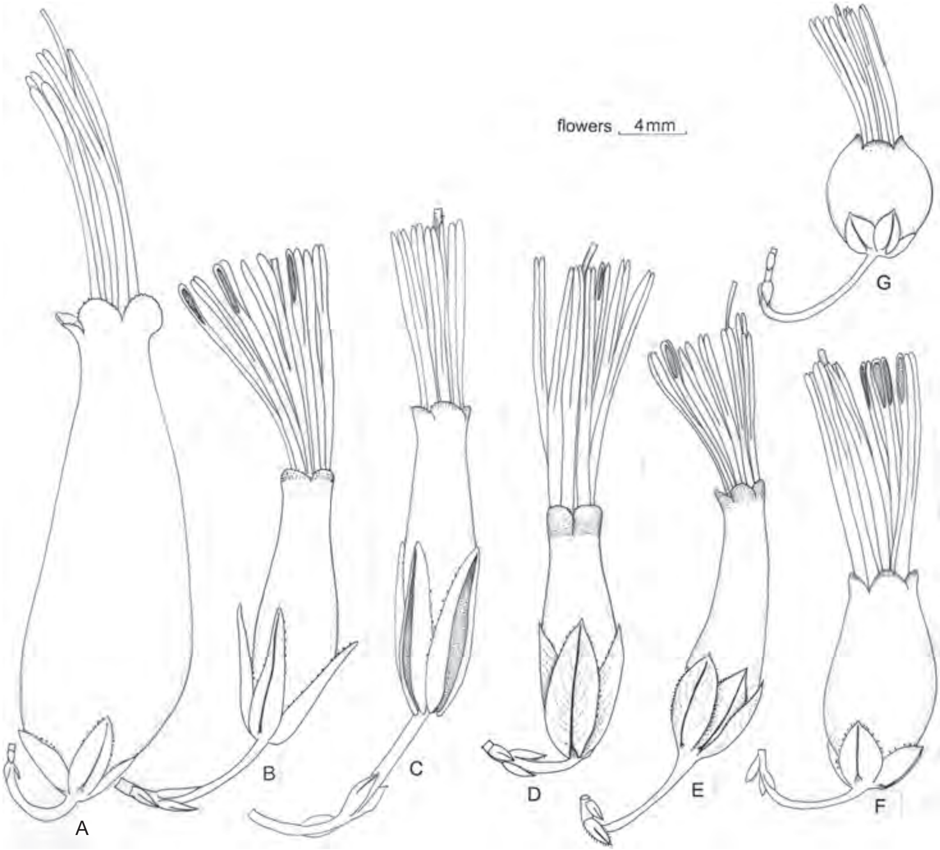

Fig. 4 *Erica plukenetii* complex illustrating diversity in Erica. A & B: subsp. *plukenetii*: A: Oliver 5953, Kamiesberg; B: Rxcroft 1949, Bainskloof; C: subsp. *penicellata*, Oliver 4226, Stanford; D: subsp. *lineata*, Oliver 8749, Pearly Beach, Carruther's Hill; E: subsp. *bredensis*, Marsh 1468, Cape Infanta; F & G: subsp. *breviflora*, F, Taylor 11670, Cederberg; G: Rourke 653, Boboskloot. Scale bar; A–G 4 mm. Drawings by I. Oliver. Reproduced with the kind permission of SANBI.

the classic fynbos families including Proteaceae, Ericaceae, Restionaceae and winter-rainfall geophytes which are dominated by the Iridaceae. Large garden sections are dedicated to the former three families; however, the geophytes are mostly restricted to pot collections in the Kirstenbosch Millennium Collections Nursery to safeguard them from ravaging porcupines and moles. The present erica collection was developed in the 1970s and expanded in the 1980s, but unfortunately fell into disrepair in the latter half of the 1990s when there was no horticulturist curating it. In 2002, Anthony Hitchcock was appointed Nursery Manager with curation of the erica collection as part of his responsibilities.

In 2002, the Erica Garden was a disorderly mess dominated by senescent plant material. Most of the plantings were without provenance, and many hybrids had emerged, which compromised and devalued the collection. Asteraceae pioneer species such as *Metalasia densa*, *Euryops virgineus* and other opportunistic species dominated the beds at the expense of the erica display. There was an urgent need to redevelop and revitalise the section, but no clarity on how to achieve this. Several ideas were considered with the aim of redeveloping the Erica Garden into an attractive and sustainable display and adding value by being more educational and meaningful to visitors of all ages. Botanic gardens are different from parks; they combine display with education and conservation. All these factors had to be considered when deciding on the best way to display South African ericas.

Landscape theme

Option one was to tap into the inspiration of famous Brazilian landscape architect Roberto Burle Marx (1909–1994), who used strong colour and textural themes in bold landscapes. Famous for organising plants in harmony with aesthetic principles and displaying large groups of the same specimens, his designs were nature-based and he was interested in the effect of each plant's character on the whole garden. Skilled in utilising the sculptural form of plants, Burle Marx truly had a painter's eye and a superb sense of colour and form, coupled with an ability to see the garden both as an aesthetic experiment and as part of the ecology. Burle Marx's style, based on cohesive mass displays of a few species in bold, sweeping colour palettes, does not, however, suit landscaping and gardening with the temperamental, species-rich and diverse fynbos flora. Unfortunately, many of the most attractive and desirable fynbos species are difficult to propagate and grow in gardens (Hitchcock, 2016).

Pollination theme

Another option considered was to plant beds displaying the diverse pollination systems in the genus. South African ericas, unlike European heathers, have a uniquely wide range of flower shapes, colours and colour combinations. These range from long tubular flowers, many with bright colour combinations, to short tubes, bottle, cup, globe and urn shapes, to name just a few. Many of the shorter bottle-shaped or ampullaceous flowers have constricted openings requiring the long proboscis of a hovering fly, butterfly or moth to extract nectar. Some species have a profusion of small flowers with exposed, sticky stigmas that capture pollen carried on the wind. Ericas have formed associations with animals over millions of years to ensure pollination in return for food in the form of nectar or pollen. One species, *Erica recurvata*, is pollinated by a rodent. These associations have resulted in the development of a glorious range of flowers in many sizes, shapes, colours and combinations. It would have been very attractive to display the plants according to the different pollination groups; however, many of the species which exhibit these features are difficult to grow and Kirstenbosch does not have the required conditions or all the specialist pollinators (Hitchcock, 2016).

Phytogeographic theme

The third option for a coherent display was the phytogeographic system. This one was chosen for the redevelopment project because fynbos plant families, and particularly South African ericas, lend themselves to displays featuring the complex diversity associated with the fynbos biome.

The concept of phytogeographic planting is dedicated to the inspirational work of Dr Ernst van Jaarsveld, who curated the xerophytic collection at Kirstenbosch from 1978 until 2015. He is famous as a naturalist and for his knowledge and extensive field work on the South African flora. His knowledge extends to fauna and to the geology and ecology of natural systems. Van Jaarsveld designed the Kirstenbosch Conservatory xerophytic display along phytogeographic principles and even collected soils and rocks from each system to landscape sections to look as natural as possible.

Van Jaarsveld's work inspired the decision to display ericas and fynbos companion plants phytogeographically, highlighting regional floristic differences and focusing on species distribution, endemism and variations within species. The publication *Plants of the Greater Cape Floristic Region 1: The Core Cape Flora* (Manning & Goldblatt, 2012) provided further inspiration.

The six phytogeographic centres are Northwest (NW); Southwest (SW); Karoo Mountain (KM); Langeberg (LB); Agulhas Plain (AP); and Southeast (SE). Endemic species are in many cases limited to these centres because of geographic isolation and a range of microclimates.

The beauty of this system is that it broadly defines the type of vegetation found in each region. Therefore, the NW includes the dry woody vegetation typical of that area. The SE is characterised by a much softer, taller vegetation and more extensive indigenous forest supported by a more temperate climate with aseasonal rain that is more evenly spread throughout the year. Manning & Goldblatt (2012) provide diagnostic descriptions and distribution ranges of each species. *Erica blenna*, for example, is listed as LB, which means it is endemic to the Langeberg, whereas *E. mammosa* is listed as occurring in the NW, SW and AP. This system identifies the species that are widespread and those that are confined to very narrow distributions because of soils, climate and topography.

Classification on a phytogeographic basis with reference to centres of endemism is a superb tool with which to showcase the unique diversity of fynbos and Ericaceae. Not only does it afford the opportunity to highlight endemism, which is so prevalent in fynbos, but it also shows the vegetation from each region and how, in many cases, the same species occur as different ecotypes from one region to another (Hitchcock, 2016).

Forms and varieties

Fynbos and ericas provide many examples of ecotypes that can be used to show the remarkable diversity within the Cape flora. An ecotype may be defined as a distinct population of organisms within a species that has adapted genetically to its local habitat (Dictionary of Botany, 2001–2003). For example, some organisms may be able to tolerate different conditions of temperature or light intensity from other members of the same species, which may result in changes in their morphology or physiology. However, they are able to reproduce with other ecotypes of the same species and produce fertile offspring. These ecotypes may be sufficiently distinct to be given subspecific names, in which case they may be termed ecospecies.

The many forms of *Erica cerinthoides* are a superb example. These range from a compact, densely leafed form from the Cape Peninsula, to a large-flowered, intermediate form from near Albertinia, to a larger, 3.5 m tall, woody form from the western Outeniqua Mountains. These are three of the numerous ecotypes of this species. Many other fynbos species exhibit significant ecotype variation which can be displayed. Two of the best examples of these are the *Agathosma ovata* (false buchu) (Rutaceae) and *Protea cynaroides* (king protea).

IMPLEMENTATION

The phytogeographic theme was applied to nine erica beds labelled K1 to K9. An entire bed, sometimes two, was allocated to each phytogeographic centre. The SW was allocated two beds (K8 & K9), due to the species richness of that region. Two beds (K3 & K6) closest to the nursery stream were allocated to feature the SE region because they are cooler and near water with shade trees nearby, which is an environment better suited to the flora from that region. Rocky, drier and sunny beds were selected for the harsher, drier climates of the NW (K1) and KM (K2) regions. The Cape Peninsula is noted for its exceptional plant species richness. It was therefore decided to deviate from the phytogeographic categories of Manning & Goldblatt (2012) by displaying Cape Peninsula flora in bed K7. Currently about 2,285 vascular plant species are known to be indigenous to the Cape Peninsula, which means that the Peninsula has the greatest concentration of plant species per unit area within the CFR (Helme & Trinder-Smith, 2006). This includes 112 *Erica* species of which 39 are endemic (Forshaw *et al*., 2012; Helme & Trinder-Smith, 2006).

Planting the Erica and Fynbos Garden

In 2004, the Erica Garden beds were cleared of all old plant material as there were few or no plants with reliable provenance left. A front-end loader was used to accelerate the process and in no time the old material had been removed, and the soil turned and cleared of stumps and old roots. The naturally weathered quarzitic display rocks were reset, compost was dug in and the beds were left to settle before planting.

The garden was constructed to demonstrate the appearance of fynbos in each geographic region. The aim was to bring a bit of nature into the garden for the many people who do not have the opportunity to get into the wild areas of South Africa. In addition, it was decided to expand the display to include the four main elements of fynbos and other interesting and unique fynbos endemics. Mixing fynbos species with *Erica* species is a good way to display the natural vegetation and helps to limit the spread of disease amongst susceptible species. *Erica* and other fynbos species are susceptible to root-borne and other diseases, which can be limited by maintaining distance between individuals and interplanting with less susceptible species (Hitchcock, 2016).

Some *Erica* species grow in dense stands, while others are isolated in niche habitats amongst rocks or mixed with companion species in open fields. Where possible the more robust *Erica* species were planted in large stands to create vivid displays. Others were planted singly or in small groups in suitable niche habitats next to or between rocks and boulders with suitable accompanying fynbos species (Hitchcock, 2016) (Fig. 5).

Each bed features the major fynbos groups: Ericaceae, Proteaceae, Restionaceae and winter rainfall geophytes such as Iridaceae. Nineteen of the twenty largest families in the Cape flora are represented in the beds. Other families have been planted for their horticultural value and the character they give to the display. These include Rutaceae, Asteraceae, Aizoaceae, Asphodelaceae, Geraniaceae and Fabaceae.

Some of the garden beds are wide and plants displayed in the middle of these beds cannot be properly viewed and appreciated without walking into the beds. For this reason, narrow stone paths were laid down in some beds to allow visitor access to the middle areas and in this way increase the display potential of the bed (Fig. 6). Larger structural and textural species such as Proteaceae and stands of larger species in

Fig. 5 Agulhas Plain phytogeographic garden bed featuring blue-flowered vulnerable endemic *Lobelia valida* in mixed planting. Photo: A. Notten.

Fig. 6 Southeast phytogeographic garden bed featuring mixed planting including endangered *Leucospermum glabrum* and *Mimetes cucullatus*. Photo: A. Hitchcock.

Restionaceae were planted in the middle of the beds to provide body and structure to the beds while smaller and more interesting species were planted closer to the access paths (Hitchcock, 2016).

Flagship and iconic species

The phytogeographic approach provides an opportunity to display flagship *Erica* and fynbos species representative of each region. The selection of flagship species is a subjective exercise and the species selected are mostly, but not necessarily, exclusive to the region. The principal considerations were ease of cultivation and maintenance, endemism, attractiveness, form and threatened status. Often a species with a combination of these attributes was selected. For example, *Widdringtonia cedarbergensis* is a beautiful, structural tree endemic to the NW and it is listed as Critically Endangered (SANBI, 2017). *Erica blenna* var. *grandiflora* is endemic to the LB, is very attractive and has an unusual orange, lantern-shaped flower. Examples of some featured flagship iconic species are listed below.

The SW flagships include *Erica viscaria* var. *longifolia*, *E. nana*, *E. perspicua*, *Leucospermum cordifolium*, *L. bolusii* and *L. oleifolium*.

The AP bed features *Erica regia* var. *regia*, *Acmadenia heterophylla*, *Leucospermum praecox*, *Thamnochortus insignis* and *Lobelia valida*.

The NW bed displays *Leucospermum reflexum* var. *luteum*, *L. catherinae*, *Erica verecunda*, *E. totta*, *E. lateralis*, *E. haematosiphon* and *Widdringtonia cedarbergensis.*

The KM features *Protea aristata*, *Helichrysum splendidum*, *Leucospermum erubescens*, *Mimetes chrysanthus* and *Erica diaphana.*

The SE features *Erica densifolia*, *E. scabruiscula*, *E. unicolor* subsp. *mutica*, *E. glandulosa*, *E. diaphana*, *Leucospermum glabrum*, *Protea neriifolia*, *P. aurea* var. *aurea* and *Widdringtonia schwartzii.*

LB distinctive species include *Erica cruenta*, *E. blenna* var. *grandiflora*, *E. baueri* subsp. *baueri*, *Adenandra fragrans* and *Leucospermum formosum.*

Cape Peninsula flagship species include *Erica halicacaba*, *E. verticillata*, *E. urna-viridis*, *E. baccans*, *E. abietina*, *Mimetes fimbriifolius* and *Aloe commixta* (Fig. 7).

This ecological method of display is complex and requires a high level of horticultural input to sustain it. The reason for this is that fynbos species are relatively short-lived and usually survive for even shorter periods in cultivation unless they are given individual attention. The average life expectancy of the Kirstenbosch fynbos display beds is about eight to ten years. The displays also need to be kept in peak condition and cannot be allowed to senesce as would happen in the wild. Fynbos requires fire in natural systems to remove senescent vegetation and to stimulate the new cycle of growth. Due to the

Fig. 7 Cape Peninsula phytogeographic garden bed displaying the endemics *Erica verticillata* (extinct in the wild) and *E. nevillei* (rare). Photo: A. Notten.

absence of fire in the garden, old vegetation is physically removed from the beds. Large numbers of species are required for a phytogeographical display which faithfully represents fynbos. As a result, the propagation plan required to maintain the display and the succession of numerous species with different life cycles is a challenge to horticulturists. Attrition resulting from the effects of disease must also be considered and for some very desirable species it can be as high as 50 per cent. Nevertheless, the effort required to sustain such a display garden is well worth the trouble for its high educational value (Hitchcock, 2016).

EDUCATIONAL VALUE

While this method of displaying plants is complex and requires high maintenance, it has proved to be very useful for educational purposes. Botanic gardens can simply be places of beauty and relaxation but, at Kirstenbosch, the close collaboration between horticulturists and SANBI Biodiversity Education and Empowerment (BEE) staff has meant that the garden plays an increasing role in education. South African school curricula, at all levels, include the topics of biodiversity, conservation and ecology. However, for many schools located in crowded and ecologically degraded environments, the ability to teach such topics is very difficult. Coupled with this, high poverty levels mean that many learners do not have access to areas of natural beauty either on school field trips or in their spare time. To redress some of this inequality, the Kirstenbosch BEE Programme owns a bus dedicated to bringing learners from historically disadvantaged communities to the garden for curriculum-linked lessons.

The development of the Erica Garden at Kirstenbosch provides a unique opportunity to demonstrate how plants grow not in isolation but in communities, and for learners to use these beds to construct meaning through experience and interaction. Since the revitalisation of the Erica and Fynbos Garden in 2002, the fynbos plants have been investigated by learners aged 10 to 18 in Grades 4–12 (Fig. 8). The installation of interpretation boards in 2016 has added the opportunity for deeper research and understanding, especially at the higher grades (Fig. 9). In the financial year 2017–2018, the guided BEE Programme at Kirstenbosch recorded that 7,435 learners used the Erica and Fynbos Garden during their lessons.

INTERPRETATION

Complex natural systems are not easy to grasp without some guidance. Interpretation is a valuable medium through which botanic gardens communicate biodiversity messages. The biggest challenge with the phytogeographic displays was to develop appropriate interpretation for the theme. Interpretation for the Erica and Fynbos Garden was developed in 2016 with financial support from the Botanical Society of South Africa and with guidance from horticultural colleagues, SANBI education staff and garden guides.

Fig. 8 Grade 5 learners work together in groups to observe and describe *Erica cerinthoides*. Photo: SANBI.

The first challenge was to identify the core content relevant to each phytogeographic area. Once this had been decided, it was reworked to develop a template of the key information to illustrate the concept. The information was reduced as much as possible to provide a window into the fynbos world. These drafts were given to the staff and a senior garden guide, Dorothy Malan, who gave valuable input. Finally, graphic designer Kevin Shields designed the boards. Each interpretive board was designed to reflect each phytogeographic region in the CCR and the region corresponding to the Cape Peninsula. Each board is divided into four sections: at the top of the board is a prominent image featuring a typical landscape of the region. Next to it is a close-up of an iconic or flagship *Erica* species. Bottom left is the text section with basic, simplified but essential information describing the essence of the phytogeography. At the bottom right, a map shows the CCR and the location of the phytogeographic region being featured (Fig. 10).

The text includes information about the region and a basic description of the landscape, soils, climate and the nature of the vegetation. The size of the phytogeographic area is given along with statistics on species richness, endemics and finally the number of *Erica* species in the area.

Fig. 9 Grade 9 learners use the interpretation boards to research abiotic factors influencing plant growth on the Cape Peninsula. Photo: SANBI.

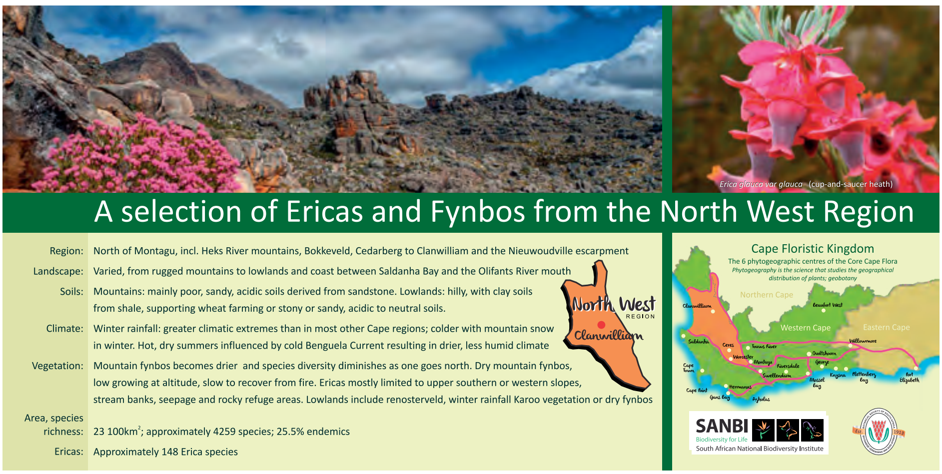

Fig. 10 NW region interpretation panel. There are seven panels, one for each phytogeographic region represented. They all follow this design with appropriate information about the region and the plants that grow there. Panels designed by Kevin Shields.

The key to providing effective interpretive information is to keep it simple and to not overload the board with text. Most visitors do not read boards cluttered with information (Hitchcock, 2016).

CONCLUSION

The reality of botanic garden collections is that their sustainability is heavily dependent on the skill, ability and continual dedication of their horticulturists. Thorough knowledge of the flora and the ecosystems in which they survive is important before attempting a phytogeographic system of gardening. This knowledge may only be developed, refined and put into practice after years of practical experimentation. The challenge is ongoing and never-ending when gardening with a flora as rich and diverse as is found in the CCR. The result is well worth the effort for the knowledge that is gained researching and managing a wild and generally poorly known flora and bringing this to the attention of visitors to the botanic garden. The main prize is to have an education department with staff that use this work in integrated curriculum-based learning programmes.

ACKNOWLEDGEMENTS

Thanks go to SANBI for maps of the CCR and to Dr Ernst van Jaarsveld for all I have learned from this exceptional horticulturist. Thanks also to Mr Kevin Shields for designing the interpretation for the Erica and Fynbos Garden.

REFERENCES

ALLABY, M. (2010). *A Dictionary of Ecology* (4th edn). Oxford University Press, Oxford. Available online: http://www.oxfordreference.com (accessed July 2018).

BIOLOGY DICTIONARY (2017a). Allopatric Speciation (definition). Available online: https://biologydictionary.net/allopatric-speciation/ (accessed June 2018).

BIOLOGY DICTIONARY (2017b). Sympatric Speciation (definition). Available online: https://biologydictionary.net/sympatric-speciation/ (accessed April 2018).

BORN, J., LINDER, H.P. & DESMET, P. (2006). The Greater Cape Floristic Region. *Journal of Biogeography*, 34(1): 147–162.

CAMPBELL, B.M. (1983). Montane plant environments in the fynbos biome. *Bothalia*, 14(2): 283–289.

COWLING, R.M. (1987). Fire and its role in coexistence and speciation in Gondwanan shrublands. *South African Journal of Science*, 83(2): 106–112.

COWLING, R.M. (ed.) (1992). *The Ecology of Fynbos*. Oxford University Press, Cape Town.

COX, C.B. (2001). The biogeographic regions reconsidered. *Journal of Biogeography*, 28(4): 511–523.

DICTIONARY OF BOTANY (2001–2003). Ecotype (definition). Available online: http://botanydictionary.org/ecotype.html (accessed October 2018).

FORSHAW, N., OLIVER, E.G.H., VOLK, F. & BOLUS HERBARIUM (2012). Genus Erica: Interactive identification key (Version 3.00) [CD-ROM]. Bolus Herbarium, Cape Town.

GOLDBLATT, P. (1978). An analysis of the flora of southern Africa: Its characteristics, relationships, and origins. *Annals of the Missouri Botanical Garden*, 65: 369–436.

GOOD, R. (1974). *The Geography of Flowering Plants* (4th edn). Longman Green, London.

HELME, N.A. & TRINDER-SMITH, T.H. (2006). The endemic flora of the Cape Peninsula, South Africa. *South African Journal of Botany*, 72(2): 205–210.

HITCHCOCK, A. (2016). The History of the *Erica* Collection at Kirstenbosch: Part 2. *Veld & Flora*, 102(1): 8–13.

LINDER, H.P. (1985). Gene flow, speciation and species diversity patterns in a species rich area: The Cape Flora. In: VRBA, E.S. (ed.) *Species and Speciation*. Transvaal Museum, Pretoria, pp. 53–57.

LINDER, H.P. & VLOK, J. (1991). The morphology, taxonomy and evolution of *Rhodocoma* (Restionaceae). *Plant Systematics and Evolution*, 175(3–4): 139–160.

MANNING, J. & GOLDBLATT, P. (2012). *Plants of the Greater Cape Floristic Region 1: The Core Cape Flora.* Strelitzia 29. South African National Biodiversity Institute, Pretoria. Available online: www.sanbi.org/sites/default/files/documents/documents/strelitzia-29-2012.pdf (accessed March 2018).

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

OLIVER, E.G.H. & OLIVER, I.M. (2002). The genus *Erica* (Ericaceae) in southern Africa: Taxonomic notes 1. *Bothalia*, 32(1): 37–61.

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

ROGERS, A. (2013). Occult moisture inputs in the fynbos: Foliar moisture uptake in Ericaceae, Restionaceae and Proteaceae. Available online: https://open.uct.ac.za/handle/11427/14026 (accessed March 2018).

ROURKE, J. (1972). *Taxonomic studies on* Leucospermum *R.Br.* (*Journal of South African Botany* Supplementary Volume 8). Trustees of the National Botanic Gardens of South Africa, Kirstenbosch.

SANBI (2017). Statistics: Red List of South African Plants version 2017.1. Available online: redlist.sanbi.org (accessed April 2018).

SLINGSBY, P. & BOND, W.J. (1985). The influence of ants on the dispersal distance and seedling recruitment of *Leucospermum conocarpodendron* (L.) Buek (Proteaceae). *South African Journal of Botany*, 51(1): 30–5.

TAKHTAJAN, A. (1986). *Floristic Regions of the World* (translated by T. Crovello). University of California Press, Berkeley, CA.

TEMPLETON, A.R. (1981). Mechanisms of speciation – a population genetics approach. *Annual Review of Ecology and Systematics*, 12(1): 23–48.

VAN WILGEN, B.W., BOND, W.J. & RICHARDSON, D.M. (1992). Ecosystem management. In: COWLING, R.M. (ed.) *The Ecology of Fynbos*. Oxford University Press, Cape Town, pp. 345–371.