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Review

Conservation and propagation of endangered Proteaceae on the Agulhas plain for sustainable ecotourism development

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Large parts of the Agulhas plain contribute to the commercial cut flower export industry. However, this industry is causing the destruction of many Proteaceae species both endemic and threatened. The Agulhas plain is a large region (34°50′00″S 20°00′09.15″E / 34.833333°S 20.0025417°E) where threatened red data species are not sufficiently valued as many landowners and local communities lack vigilance in the preservation of these species. Flowers are harvested from their natural habitat and trading permits are misused while the lack of authorities inspecting farms is clearly evident. Environmental threats include wine farming, alien invasive plants and wild fires. The occurrence of fires has become one of the biggest threats to the area. Involvement of stakeholders such as conservation, tourism and government departments are important for conservation to succeed. Education and training of farm workers remains undeveloped. Propagation techniques are limited as no red data species are propagated to increase an awareness of these species. There is a lack of guidance and available information in the conservation of the Agulhas plain while the ecotourism potential of the Cape Floral Kingdom (CFK) remains underdeveloped. Current practices which cause the destruction of red data species and the ecotourism potential on the Agulhas plain are assessed in this review.

Key words: Auxin, rooting mediums, cut flowers, flower potted plants, conservation, propagation, red data species sustainable tourism threatened species.

INTRODUCTION

In the Western Cape, the Cape Floral Kingdom (CFK) consists of 330 species of Proteaceae of which some are near extinction (Rebelo, 1995). The United Nations Development Programme (UNDP) views the Agulhas plain as area which has the highest priority for conservation and the largest number of lowland threatened species in South Africa (UNDP, 2003). The area is also known for important vegetation types such as Elim Asteraceous Fynbos, limestone proteoid, restioid fynbos and neutral sand proteoid vegetation types, all of which are highly threatened in the wild (UNDP, 2003). Elim Asteraceous Fynbos contains many endemic Proteaceae species such as *Leucadendron elimense*, *Leucadendron laxum*, *Leucadendron stelligerum* (Mustard et al., 1997). These plant species are classified as endangered plants on the red data List of South African Plants (Hilton-Taylor, 1996). The protea atlas (2008) classifies *L. elimense* and *Leucadendron platyspermum* as vulnerable species. *L. stelligerum* is found in only three populations, totalling 1000 plants in the Voëlvlei area (Rebelo, 1995). According to Mustard et al. (1997) only 5 000 *L. laxum* plants remain in their natural habitat.

The International Union for Conservation of Nature (IUCN) Red Data list of threatened species recorded more than 11 000 plant species which are threatened

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Abbreviations: ABI, Agulhas biodiversity Initiative; **C.A.P.E,** cape action plan for the environment; **CFK,** cape floral kingdom; **EuroGAP,** European good agricultural practice; **FVCT**, flower valley conservation trust; **IAA,** indole-3-acetic acid; **IBA,** indole-3-butyric acid; **IUCN,** international union for conservation of nature; **SAFEC,** south African flower export council; **ppm,** parts per million; **UNDP,** united nations development programme; **WCNCB,** western cape nature conservation board.

with extinction in South Africa (Jeffery, 2003). Leucadendrons on the Agulhas plain are seriously threatened by expanding farm land, uncontrolled veld fires, alien invasive plants and improper cut flower harvesting in the natural habitat (Mustard et al., 1997; Robyn and Littlejohn, 2002). Some species are naturally rare because of reproductive reasons (Paterson-Jones, 2000). Many plant populations will disappear if the destruction of these sensitive habitats continues. This would result in a loss of biodiversity and endemic species (Jamieson, 2001; Robyn and Littlejohn, 2002; Cooper, 2003) and ultimately may affect ecotourism activities in the Western Cape Region.

Agriculture and the keeping of livestock have been identified as the largest cause of habitat destruction (Lombard et al., 1997). On the Agulhas plain, 22.5% of the Asteraceous Fynbos and Renosterveld fertile soils are already covered in cereals, vineyards, pastures and cultivated flowers (UNDP, 2003). Studies on the vegetative propagation of some of the threatened Proteaceae species are lacking (Hartmann et al., 2002; Wu et al., 2007a). Their inception could increase awareness and facilitate rehabilitation of these species in their natural habitats. Future studies should also aim at providing information on the impact of current agricultural practices on sensitive habitats such as those involving Proteaceae and hence alleviating the threat on the biodiversity of these species on the Agulhas Plain.

PROMOTING ECOTOURISM THROUGH PROPER MAINTENANCE OF ENDANGERED PLANT SPECIES

The Agulhas plain has the potential to become a major tourist destination with tourists visiting these sites for its beautiful scenery and large diversity of plant species (Cowling, 1993). In the Western Cape, most of these plant species form part of the CFK which is documented as a world heritage site under exceptional habitat threat (Cowling and Richardson, 1995). Tourist visits to the Western Cape Province are expected to have grown with already 51% of international tourists visiting the area (ABI, 2008). The proximity of the Agulhas plain region to both the garden route and the Cape Peninsula also presents positive ecotourism potential (ABI, 2008). The region has been recognised as having the most distinctive, most diverse and the highest density of endemic flora in the world (Coetzee and Littlejohn, 1994), yet the ecotourism potential in this area remains undeveloped (Cowling and Richardson, 1995), and many parts of the land are threatened with the loss of endemic species which form part of tourist attractions.

Therefore, landowners should realise the value of conserving the remarkable flora of the Agulhas plain for future generations and the possible income benefit derived from ecotourism. This is supported by the fact that many farms on the AP are not sustainable for a variety of crops or livestock and would generate far more wealth in the development of ecotourism activities (Cowling, 1993; Paterson-Jones, 2000; Robyn and Littlejohn, 2002).

The Agulhas plain is a region where conservation, ecotourism and agriculture could work together to maintain a balance of protection, enjoyment and commercial gain of the habitat. An increase in ecotourism on the Agulhas plain is furthermore important in view of the role of extended conservation and job creation. More studies are needed to determine the effect that landowners, habitat destruction and the loss of red data species have on ecotourism development on the Agulhas plain.

Conserving endangered species through correct cut flower practices

The demand for new and interesting flowering plants around the world (Barzilay et al., 1992) has resulted in a strong interest in the diverse biodiversity of South African flora (Milandri et al., 2008). Most Proteaceae such as Leucadendrons are considered speciality flowers due to their unique and naturally bright colours. The export flowers are favoured for their bright yellow colour and attractive cones (Dodd and Bell, 1993; Coetzee and Littlejohn, 1994; Moody, 1995; Paterson-Jones, 2000; Berney, 2000; Jamieson, 2001). Export quantities for Leucadendron flowers increase by 27% in the European winter period (Rabie, 2002, 2003). Some species that are exported include *L. laxum, L. stelligerum* and *L. platyspermum* (Rabie, 2002). These popular flowers continue to be harvested for commercial gains (Robyn and Littlejohn, 2002) and sometimes through incorrect cut flower practices such as over-harvesting and incorrect pruning methods. A total of 80% of Leucadendrons are harvested from low income farm land (Dodd and Bell, 1993; Mustard et al., 1997; McVeigh, 1998; Paterson-Jones, 2000; Robyn and Littlejohn, 2002; ABI, 2008). Over-harvesting of one species such as *L. laxum* from 436 hectares of habitat has caused this species to be listed as endangered in the CFK (Hilton-Taylor, 1996; Mustard et al., 1997; Robyn and Littlejohn, 2002). Over-harvesting threatens many jobs of low-income people as natural habitats are depleted from a reserve of seed required for the next generation of species (Coetzee and Littlejohn, 1994). Because of the demand for *L. laxum*, more farmers should be encouraged to use sustainable cultivation and harvesting techniques, as field harvesting continues to destroy the habitats of many species.

It is therefore of great importance to investigate the harvesting practices of cut flower producers to determine at what level red data species are destroyed and which measures could be proposed for future conservation of the habitat.

Environmental to the conservation and propagation of endangered Proteaceae

The habitats of many indigenous species such as those

involving Proteaceae have been replaced by commercial vineyards. The Agulhas plain produces high quality wines as the environmental conditions are conducive for vine growing (Hughes, 2002). These farming practices could pose further threats to the environment in which several members of Proteaceae family could struggle to survive. The impact of these new wine farms on the Agulhas plain species remains unknown and the effect of further expansion of this farming practice remain uncertain and needs to be validated.

The Agulhas plain consists of small pockets of broken up land where small scale dairy farming is practiced (Mustard et al., 1997). Close to half of the cattle farms on the Agulhas plain rely on natural habitat grazing, with cattle often grazing along wetlands (ABI, 2008). Many of these areas contain sensitive, endemic plant species, such as *L. laxum*. This type of grazing could further add pressure on the natural habitat of threatened species which could result in their extinction. The need for appropriate conservation measures by farmers is important to protect these sensitive habitats.

The spread of alien invasive species have been recorded as the second biggest threat to biodiversity on the Agulhas plain, with more than 40% of the area being infested and 14.7% of the natural habitat being already lost to alien species (Turpie, 2004; ABI, 2008) such as Mediterranean pine and Australian *acacia* plant species (Mustard et al., 1997). These species have changed the soil pH and nutrient levels (ABI, 2008). Soil types have also become affected by layers of pine needles and leaf mulch, which prevent the germination of natural vegetation species (UNDP, 2003). The removal of alien species has always been problematic and costly (Coetzee and Littlejohn, 1994; De Villiers, 2002). For sustainable conservation of endangered plant species, measures to eradicate alien invasive species are important in reclaiming natural habitats.

The Agulhas Plain is largely affected by seasonal wild veld fires during the dry summer months (Seydack et al., 2007). Unnecessary and irresponsible burning of the natural habitat is a further threat which reduces the biodiversity. Poor fire management control systems (ABI, 2008) along with irresponsible burning in the habitat are dually responsible for the loss of many plant populations. Burnt landscapes can take years to recover and result in a loss of revenue from tourist's visits to the area. This occurrence was seen during the 2006 fires on the Agulhas plain which destroyed ecotourist establishments and in excess of 40 thousand hectares of land. The result of this fire left many local people without employment for two to three years.

Such occurrences of unplanned burning can have a large negative impact on post-fire regeneration and cause the further extinction of species (Cowling and Richardson, 1995; Coetzee and Littlejohn, 1994). The impact of fire on the biodiversity of species is complex. For instance, fire can reduce the seed production output of species through damage caused by the heat of the burning plant material but also assist in germination of seed (Brown and Duncan, 2006).

On the Agulhas plain the existence of sensitive and threatened plant populations and their impeding environmental destruction has not been sufficiently publicised or brought to the attention of the landowners. The question should be asked whether threatened plant populations should not be made more visible by being marked by conservation authorities in their habitat, so service providers can be made aware of their locations? This suggestion would require concerted effort and co-operation between conservation authorities and municipal / provincial administration. The marking of threatened populations can also benefit tourists visiting the area. Ecotourism could provide nature lovers with the challenge to follow marked red data species trails to explore discover and enjoy these remarkable plant species in their natural habitat. To date there have been few studies on the causes of destruction of red data species on the Agulhas plain. More studies targeting these aspects are recommended.

Strategic propagation of threatened red data species

Plant species in nature will continue to survive provided conservation and horticultural efforts are made to maintain them (Jeffery, 2003). Informal interviews with farmers indicated that a lack of propagation techniques for threatened species exists. Many farmers practice basic propagation skills and some have developed and practise their own methods on an ad hoc basis. Many commercial growers are often reluctant to share techniques due to commercial competitiveness as their propagation information is not shared with other growers who may require the information (Laubscher, 1999).

On the Agulhas plain, propagation of red data species is mainly done by seeds. In this method, seed propagation can be natural whereby plants regenerate themselves in the natural habitat (Hartmann et al., 2002). Alternatively, seeds can also be used by flower producers to establish cut flower fields in their natural habitat (Robyn and Littlejohn, 2002). Unfortunately many seeds sown that have been introduced from other areas to an existing habitat have had a major impact on that environment. These foreign plant species, with new genes can change the biodiversity of an existing habitat irreversibly (Littlejohn, 2002) through genetic changes within species of that habitat.

Vegetative propagation techniques on the other hand would ensure faster rooting of higher quality plant products (Robyn and Littlejohn, 2002). Such plants also flower a year earlier than seed grown plants (Reinten et al., 2002) and have the potential to maintain the unique characteristics of the species (Brown and Duncan, 2006) and flower at predictable times (Reinten et al., 2002). An increase in the propagation of threatened species throug

through vegetative means could benefit ecotourism where new plants could be replanted in the natural habitat where species are threatened, especially after fires (Robyn and Littlejohn, 2002). In addition, plants can also be grown for commercial plantations or for selling to other growers and farmers. The demand for Proteaceae such as *L. laxum* has increased to more than 23673 flower stems per annum (Middlemann, 2004). This growing market has created a further need for the improvement of propagation and cultivation techniques. Advanced techniques could also increase royalties and the sale of patented cultivars for future export purposes (Robyn and Littlejohn, 2002). Literature on propagation techniques of many species remains limited (Laubscher, 1999). Studies on the vegetative propagation of red data species are important to identify and expand the vegetative propagation possibilities of species such as *L. laxum* which has not been previously documented.

Auxin treatments in vegetative propagation of difficult to root red data species

Proteaceae species are generally propagated vegetatively from 150 mm stem cuttings (SAFEC, 2002; Reinten et al., 2002). Cuttings should be taken during dry weather from semi-hardwood stems after shoot elongation (Aug-Nov), rinsed with a fungicide before planting and sprayed weekly with a fungicide (Ofori et al., 1996; Newton et al., 1992; Reinten et al., 2002; SAFEC, 2002). Limited studies have been found on document that influences the different concentrations of auxin on rooting Proteaceae (Perez-Frances, 1995). Most members of this family are categorised as difficult to root plants and may require special auxin treatments and special environmental conditions to facilitate their propagation (Hartmann et al., 2002; Wu et al., 2007a). Auxins have proved to stimulate root and shoot growth in some difficult to root plant species (Baraldi et al., 1993; Wu and du Toit, 2004; Wu et al., 2007a, b).

Auxins play an important role in speeding up the percentage of uniform rooting and in increasing rooting percentages of cuttings (Dodd and Bell, 1993; Hartmann et al., 2002; Fogaça and Fett-Neto, 2005). It is uncertain what specific concentrations of Indole-3-butyric acid (IBA) or Indole-3-acetic acid (IAA) would be successful in rooting some Proteaceae species. An increase in root numbers using IBA has been reported in plants such as Olive, *Dorycnium* spp, *Shorea leprosula*, *Leucospermum patersonii,* and *Protea obtusifolia* (Wiesman and Lavee, 1995; Rodríguez Pérez, 1992; Aminah et al., 1995; Alegre et al., 1998). The auxin accumulation in shoots has been successful in vegetative propagation, however IBA applications could also inhibit rooting, or act together with other compounds to control plant functions such as root formation (Jones and Hatfield, 1976; Zimmerman, 1984; Volper et al., 1995; Hartmann et al., 2002; Reinten et al., 2002; Rout, 2006). Higher levels of auxin than those found in plant cells could result in cell death (Hartmann and Kester, 1983; Hartmann et al., 2002). IBA is one form of auxin that is effective in the rooting of a large number of plant species (Hartmann et al., 2002). In some woody species aryl esters and aryl amid of IBA are similar or more effective than acid formulations in root initiation (Hartmann et al., 2002).

Auxins such as IAA, supplied exogenously to cuttings, have been shown to promote rooting through meristematic cell division in many species (Liu et al., 1996; Liu et al., 1998; De Klerk et al., 1997; Robyn and Littlejohn, 2002; Hartmann et al., 2002; Rout, 2006). Natural occurring IAA in plants may not be adequate to enhance auxin functions (Hartmann et al., 2002:295). Applications of IAA may induce economically viable results in Proteaceae by increasing rooting percentages. The aryl esters of IAA are similar or more effective than acid formulations in root initiation. Several studies have reported correlations between higher IAA concentrations in plant tissues and rooting in different plant species (Hartmann et al., 2002). From the above background, it is clear that the need exists to test auxin application in propagating red data species by establishing the optimum level(s) of IAA necessary to stimulate root development. Information from such studies is likely to provide suitable auxin applications for individual plant species which are necessary to stimulate rooting. These methods are necessary to help farmers and growers to successfully propagate and cultivate red data species such as *L. laxum*.

Influence of rooting mediums in vegetative propagation of difficult to root red data species

A number of studies have shown that selecting the correct rooting medium for different plant species has a profound influence on the rooting of cuttings (Leakey et al., 1990; Ofori et al., 1996; Hartmann et al., 1983). Rooting mediums for Proteaceae should be light with good drainage and also retain sufficient moisture (SAFEC, 2002). Combinations of rooting components such as bark, peat, polystyrene and river sand should be tested to ensure faster, better quality root formation (Brown and Duncan, 2006). Success in bark / polystyrene mediums has been reported in various Proteaceae species (Brown and Duncan, 2006; Reinten et al., 2002). Milled pine bark is a medium widely used and must be of good quality (Owings, 1996). However, past studies have shown that pine bark is very rich in phenolic compounds, alkaloids and cyanogenic glycosides (Machrafi and Prevost, 2006) which can also have an inhibitory effect on the growth of plants (Still et al., 1976; Rice, 1984; Siqueria et al., 1991). Good quality shredded milled pine bark is recommended for pH control (Owings, 1996) or can be substituted with a coarse grade peat moss to enhance the water holding capacity of the growing medium (Lamb, 1972; Hartmann et al., 2002; Reinten et al., 2002). Matkin (2008) also suggested using a medium of pine bark / peat as a good

combination for rooting. An average pH of 6.5-7 is recommended for rooting Proteaceae (SAFEC, 2002).

Aeration and good water holding capacity are necessary characteristics for a rooting medium to positively favour the rooting physiology in different plant species (Grange and Loach, 1983; Reinten et al., 2002; Hartmann et al., 2002; SAFEC, 2002). Good aeration is essential for some Proteaceae species which are slower to root and the cuttings therefore require a longer period in the medium which must be of good quality. Polystyrene improves aeration, whereas washed river sand provides coarseness and drainage (Hartmann et al., 2002). A medium with a good air to water ratio such as bark and polystyrene is key to successful rooting (Leakey et al., 1990; Matkin, 2008). Adequate drainage should be provided to prevent *Phytophtora* fungal infection of roots (Reinten et al., 2002; SAFEC, 2002). Studies are needed to test the suitability of rooting mediums for individual red data species. Information from such studies is likely to provide improved rooting mediums which will stimulate better rooting of difficult to root red data species such as those found on the Agulhas plain.

Selection of ideal rooting environments

An ideal rooting environment is necessary to provide optimum conditions for successful rooting, thereby ensuring the maximum quantity and quality of rooted plants. Bottom heat (20-25ºC) and misting are known to enhance rooting of Proteaceae cuttings (Brown and Duncan, 2006; Reinten et al., 2002). Propagation environments for many threatened Proteaceae species such as *L. laxum* have not been well established. Documentation exists on the rooting period for Proteaceae species which varies between 8 and 12 weeks. However, some species are slower to root and would benefit from extended rooting periods in order to increase rooting percentages (Brown and Duncan, 2006; Kibbler et al., 2004). Facilities to root plants must be cost effective to make production economically viable for growers with limited greenhouse facilities (Laubscher, 1999). Atmospheric air circulation is essential in rooting Proteaceae cuttings (Reinten et al., 2002; SAFEC, 2002). No information has been found on rooting these species under shade house conditions. Cheaper built structures could prove to be more economical for farmers as the cost of construction, maintenance and electricity usage could be reduced. More efficient environmental propagation structures would in turn add value to the rapid multiplication and hence the domestication of plant species which are listed as endangered on the Agulhas plain. Ecotourism could also benefit from guided tours of the propagation facilities on farms informing tourists how these interesting plants are grown. Most farmers have no propagation structures for rooting indigenous plant species. The need exist for the investtigation of suitable structures which will guarantee success in propagation of red data species. Information from such studies is likely to provide guidance on cost effecttive and simpler propagation structures compared with expensive propagation greenhouses.

Conservation strategies: Involvement of all stakeholders

The lack of focus on priorities and the failure to reduce the ongoing degradation of the biodiversity on the Agulhas plain remain causes for concern (Rebelo, 1997; Rouget et al., 2003). The success and development of ecotourism on the Agulhas plain should be based on well planned conservation strategies as this region is recognized as having a biodiversity that has globally significant and irreplaceable vulnerable plant species (UNDP, 2003). Any viable and successful conservation strategies should involve all stakeholders dealing with ecotourism and biodiversity on the Agulhas Plain. Many institutions, including conservation, tourism and government departments have become directly involved in the biodiversity of the CFK (Younge and Fowkes, 2003). For instance, strategies for the Cape Action Plan for the Environment (C.A.P.E.) were formulated to inform landowners of their responsibilities in managing the biodiversity of the region (Lochner et al., 2003). These include the establishment of private and public conservancies (Cooper, 2003). Further efforts to control flower harvesting are supported by Sappex, who encourages the European good agricultural practice (EuroGAP) code of practice with sustainable harvesting (Patterson, 2005). The Flower Valley Conservation Trust (FVCT) is a good example of practicing sustainable harvesting (Privet, 2002; ABI, 2008; Flower Valley, 2008). The Western Cape Nature Conservation Board (WCNCB) should play a major role in conserving the biodiversity and ecotourism on the Agulhas plain, yet informal interviews with farmers for this study revealed a negative attitude towards the WCNCB because of poor management. The WCNCB lacks the capacity to police and control flower harvesting and to protect endangered species (ABI, 2008).

Effective conservation strategies involving all stakeholders are likely to reduce illegal harvesting and lessen the depletion of vulnerable red data species in the wild. Other conservation efforts include the purchasing of land for conservation, the control of alien invasive species and private and government land owners recognizing the commercial potential for ecotourism (Paterson-Jones, 2000). Exploitation of the environment could be minimized if the successful development of ecotourism potential is regulated by the conservation of the natural habitat on the Agulhas plain by all stakeholders.

Conclusion

This review showed that threatened Proteaceae species such as *L. laxum* are continually being destroyed in the wild. The various factors responsible for the loss of

important species which may attract tourists on the Agulhas plain remain uncertain. Further studies are necessary to investigate the management practices of landowners, such as wild flower harvesting, orchard plantings and the control of fire and alien plants to conserve the endangered plant species on the Agulhas plain. In the literature, there is little information on vegetative propagation of red data species. Developing improved propagation techniques of Proteaceae species such as the use of auxin applications, optimum rooting environment and mediums could help advance the growing and replacement of threatened species. Further studies should aim at developing new propagation techniques to advance the replanting of threatened species in the wild.

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