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Factors determining levels of threat to serpentine endemics

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Abstract

Twenty-nine species endemic to outcrops of serpentine soils of the Barberton Greenstone Belt have been identified. Of these only 11 were previously Red Data Listed, six as Insufficiently Known (K) or Data Deficient (DD). The populations of these endemics are extremely fragmented and many are threatened by afforestation. IUCN criteria were used to re-assess their conservation status. One taxon has been assessed as Critically Endangered, eight as Endangered, 12 as Vulnerable, three as Lower Risk and four as Data Deficient. Additional factors, crucial for setting conservation priorities, are identified.

Keywords: Serpentine; Endemics; Conservation status; IUCN categories

1. Introduction

Over the past 15 years extensive studies have been conducted on the serpentine vegetation in Mpumalanga, South Africa (Morrey et al., 1989, 1992; Williamson, 1994; Hologne, 1994; Balkwill et al., 1997; Williamson et al., 1997). The term 'serpentine' is often applied to ultramafic rocks in general, but in this study it is used in its strict sense and applied to rocks derived from serpentinite. There are about 80 serpentine outcrops in south-eastern Mpumalanga (Fig. 1). These form part of the Barberton Greenstone Belt, which is a triangular geological intrusion extending from Malelane in the east, to Badplaas and Barberton in the south and ending just west of Nelspruit. The outcrops vary in size from 0.1 km^2 to ca. 19 km^2 with a mean size of 2.6 km^2. Some are separated from other outcrops by up to 20 km (Balkwill et al., 1997). The outcrops occur in mountainous areas and are heterogeneous in altitude, slope, soil depth etc. The serpentine vegetation falls within the Mixed Lowveld Bushveld, Sour Lowveld Bushveld and North-eastern Mountain Grassland vegetation types (Low and Rebelo, 1996).

The vegetation of serpentine outcrops is often distinct from the surrounding vegetation, as a result of the presence of high concentrations of heavy metals such as nickel and chromium and high magnesium to calcium ratios (Roberts and Proctor, 1992). To date, 29 species endemic to serpentine soils of the Barberton Greenstone Belt have been identified. Van Wyk and Smith (2001) described the Barberton Centre of Plant Endemism and suggested that the serpentine vegetation contributes significantly to the total endemism and the total number of species of this region. Only nine of the serpentine endemic species were previously listed in the Red Data Lists (Hilton-Taylor, 1996; Victor, 2002), six of these as Insufficiently Known (K) or Data Deficient (DD).

Five endemic species are restricted to single sites and are therefore rare. Serpentine patches are effectively islands surrounded by soils derived from granite, shale and slate, in which serpentine endemics do not grow. Therefore the populations of these endemics are extremely fragmented. Fragmentation has been increased by extensive afforestation of the area. The Barberton Centre of Plant Endemism is the most transformed centre in Mpumalanga at 31% with 22% of its surface area under plantations (Lötter et al., 2002). Only about 6% of its serpentine sites are conserved (Balkwill and Balkwill, 1999) and many remaining sites are threatened by further afforestation and mining. Serpentine ecosystems worldwide are threatened or are being destroyed and therefore a "Resolution" highlighting their unique biology, was endorsed by delegates (including South African representatives) of the First International Conference on Serpentine Ecology. These delegates

Abbreviations: IUCN, World conservation Union.

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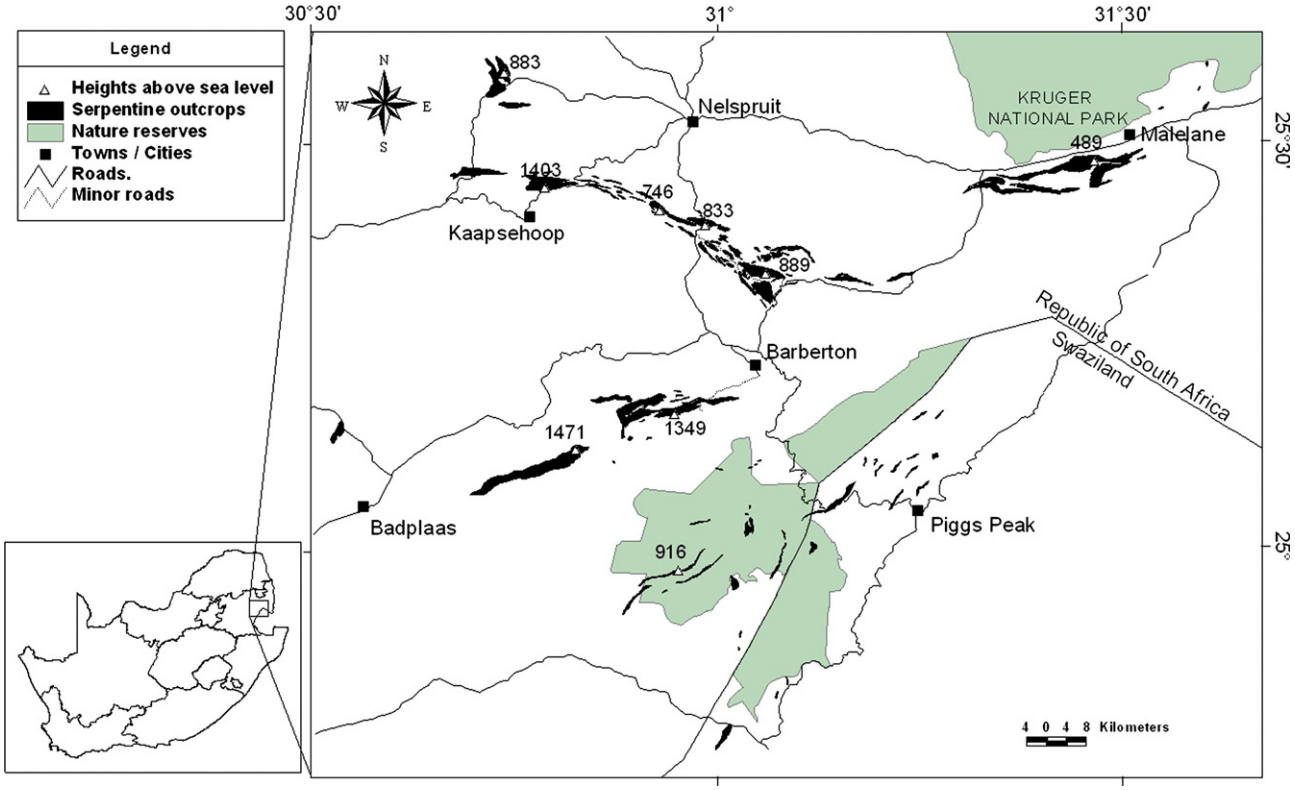

Fig. 1. Map indicating serpentine outcrops of the Barberton Greenstone Belt in Mpumalanga, South Africa.

resolved to support the conservation of the serpentine floras worldwide (Kruckeberg, 1992).

This paper is part of a more extensive study to assess the conservation status of the vegetation of serpentine outcrops in Mpumalanga. The assessment of extinction risk is pivotal in setting conservation priorities for threatened species, being one of many factors that contribute to the setting of priorities (Gärdenfors et al., 2002). The extinction risk of each serpentine endemic is presented and the contributory factors are highlighted.

The current IUCN (2001) criteria that are appropriate for the assessment of these endemics are outlined. Red Data categories are essential as they are used by conservation authorities to set clearly defined priorities for conservation of some areas (Lötter, pers. comm.[1]). However, Red Data Lists do not take into account whether or not species are utilized or whether they are high profile species (Golding, 2001).

Five endemic species have been found to hyperaccumulate nickel and may have uses in the biorecovery of nickel. Hyperaccumulating taxa (especially *Berkheya coddii* Roessl. and *Senecio* sp. aff. *S. coronatus*) are propagated worldwide to determine the mechanisms and evolution of nickel hyperaccumulation (Mesjasz-Przybylowicz et al., 2001a,b) and for phytoremediation and phytomining (Brooks et al., 2001; Angle et al., 2001). Should hyperaccumulation be considered when determining the conservation priorities of serpentine endemics? Does potential use give conservation authorities an additional responsibility to conserve particular species? In addition, taxa such as *B. coddii* and *Berkheya nivea* N.E.Br possess many of the features that characterise most invasive plants (Bromilow, 2001). Away from natural pathogens and competitors these plants have the potential of becoming exotic invaders of serpentine soils in other countries, thus, we question whether there is an additional responsibility to conserve this plant in its natural habitat as a potential source of biological control agents. Currently these factors are not taken into account when determining the conservation status of species using IUCN criteria but could have important implications for the conservation and management of serpentine areas.

2. Materials and methods

2.1. Data collection

Selected outcrops were visited regularly (from 1997 to 2001) to compile detailed checklists of the vegetation and to collect the data needed to assess the conservation status of each endemic. Information was also obtained from publications that report additional localities of some of the endemic species (Dyer, 1983; Balkwill and Balkwill, 1988; Edwards and Getliffe Norris, 1989; Phillips, 1917; Vollesen, 1991; Moffett, 1999). The type of data collected was determined by the definitions of population, subpopulation, extent of occurrence and area of occupancy, outlined in the IUCN documents (1994, 2001). For each

[1] Mervyn Lötter—Mpumalanga Parks Board, Private Bag X11338, Nelspruit, 1200, South Africa.

Table 1
Current and recommended conservation status (according to new IUCN categories and criteria; IUCN, 2001z) of serpentine endemics

Recommended status taxon	Estimated population size	Estimated future decline (%)	Threats and potential threats	Extent of occurrence (EOO) (km^2)	Area of occupancy (AOO) (km^2)	Number of subpopulations	Recommended status	Current status in RDL
Critically endangered								
Brachystelma dyeri	50–100	?	Over collection and afforestation	14.5	3–4	1	CR C2a(ii)	Vu D2[b]
Endangered								
Athrixia sp. nov.	200–250	20–30	Afforestation	20–25	5–7	2–3	EN B1ab(iii,v)+ 2ab(iii,v);C1+ 2a(i)	Not listed
Brachystelma longifolium	100–150	10–15	Afforestation and mining	5–10	1–3	3–4	EN B1ab(v)+ 2ab(v),C1+ 2a(i); D	LR-lc[b]
Cyphia bolusii	100–150	3–7	Afforestation	15–20	3–5	1(2)	EN D[d]	DD[b]
Helichrysum sp. nov.	100–150	0	None known	2–5	1–2	1	EN D	Not listed
Inezia speciosa	200–250	10–20	Afforestation	15–20	2–4	2	EN B1ab(v)+ 2ab(v),C1+ 2a(i)[d]	VuD2[a]
Rhus pygmaea	100–500	5–10	Afforestation	38–40	4–6	5–6	EN D1+2	K[a]
Salpinctium hirsutum	200–250	4–5	Afforestation	15–20	2–3	2	EN C1[d]	K[a]
Senecio sp. aff. *S. anomalochrous*	150–250	5–10	Afforestation	14	50–80 m^2	1–2	EN D	Not listed
Vulnerable								
Aloe thorncroftii	1500–3000	10–20	Afforestation	30–35	5–7	4–7	VU B1ab(v)+ 2ab(v)D2	Vu D2[b]
Asystasia subbiflora	500–1000	5–10	Mining and afforestation	38–40	5–6	5–8	VU D1+2	Not listed
Berkheya nivea	2000–3000	0	Mining	17–20	4–5	4–5	VU D2	Not listed
Berkheya rehmannii var. *rogersiana*	800–1000	5–10	Afforestation	32–35	8–10	10–14	VU D1+2	Not listed
Gladiolus serpenticola	500–1000	5–8	Minor threat of afforestation	26–30	4–5	4–5	VU D1+2	Not listed
Gymnosporia sp. nov.	500–800	5–8	Mining claims	16–20	5–6	3–4	VU D1+2	Not listed
Indigofera crebra	700–1500	10–20	Afforestation	30–40	15–20	6–7	VU D1+2	Not listed
Ozoroa barbertonensis	500–1000	5–10	Afforestation	29–35	4–6	4–5	VU D1+2	DD[c]
Ozoroa sp. nov.	500–1000	5	Afforestation	20–25	3–4	3–4	VU D1	Not listed
Protea curvata	500–1000	5	Sasol pipeline and collection of flowers	16–20	4–5	4–5	VU D1+2	VU (D2)
Sclerochiton triacanthus	250–300	0–5	Mining claims and apparent failure to reproduce sexually	16–20	1–2	2–4	VU D1+2	DD[c]
Senecio sp. aff. *S. coronatus*	500–1000	5	Afforestation	26–30	3–5	4–5	VU D1+2	Not listed
Lower risk taxa								
Berkheya coddii	30000–50000	10–15	Afforestation and over–collection for research and biorecovery	44–45	20–25	10–15	LR-lc	DD[c]
Ocimum sp. nov. (Barberton species)	1000–2000	0	Minor threat of afforestation	27–30	10–15	9–10	LR-nt	Not listed
Sartidia sp. nov.	10000–20000	5–10	Afforestation	30–35	10–15	10–14	LR-lc	Threatened[c]

(continued on next page)

Table 1 (*continued*)

Recommended status taxon	Estimated population size	Estimated future decline (%)	Threats and potential threats	Extent of occurrence (EOO) (km^2)	Area of occupancy (AOO) (km^2)	Number of subpopulations	Recommended status	Current status in RDL
Data deficient taxa								
Berkheya sp. nov. aff. *B. seminivea*	?	?	?	?	?	?	DD	Not listed
Cheilanthes sp. nov.	?	?	?	?	?	?	DD	Not listed
Macledium zeyheri subsp. *thyrsiflorum*	?	?	?	?	?	?	DD	Not listed
Dicoma swazilandica	?	?	?	?	?	?	DD	Not listed

##Regional assessment (according to guidelines in Gärdenfors et al., 2002).
[a] (Hilton-Taylor, 1996).
[b] (Victor, 2002).
[c] (SABONET, 2003).
[d] National assessment (according to guidelines in Gärdenfors, 2001).

endemic considered the quantitative data collected included; size of subpopulations on each site, estimated number of mature individuals in the entire population and how many sites are inhabited by the endemic. In addition, note was taken of past events that could have affected these populations and any possible future threats in terms of mining, forestry, farming etc. The data used to assess each taxon are summarized in Table 1.

2.2. Taxon assessment

Each endemic species was assessed with the aid of RAMAS Red list version 2.0, which is recommended for assessors evaluating species for the IUCN Red List Program (Akçakaya and Ferson, 2001). RAMAS allows the user to specify a precautionary attitude or a more evidentiary attitude to risk. This software implements the IUCN threatened species criteria (IUCN, 2001) using all the data collected for each species and its habitat after allowing for explicit incorporation of uncertainties in the input data. Depending on these uncertainties, the resulting classification is often a single IUCN category, accompanied by a range of plausible categories.

3. Results and discussion

3.1. Evaluation of extinction risk (voucher specimens are listed in Appendix A)

Brachystelma dyeri K. and M. Balkwill occurs at only one locality and appears to be restricted to the amphibolite band that occurs in this area. The population is estimated to number less than 50 mature individuals. This taxon has been listed in the Red Data Book (Hilton-Taylor, 1996) as insufficiently known (K). However, this research has revealed that it should be listed as Critically Endangered (CR C2a (ii)), on the basis of its small population size and due to the threats of further afforestation in the area and of collectors of rare plant species.

Athrixia sp. nov. (Balkwill 9052) only occurs at two localities, one of which is extensively planted to pine. *Inezia speciosa* Brusse is considered a local endemic to serpentine as it has also been recorded from the Iron Crown area near Haenertsburg in Limpopo Province. In Mpumalanga this taxon is only known to occur at the same localities as *Athrixia* sp. nov. We estimate that afforestation caused at least a 20–30% decline in these populations. The populations of these taxa consist of less than 250 mature individuals and it is predicted that the presence of pine plantations will result in further decline in the size of the populations due to degradation of the habitat and shading. For these reasons it is recommended that *Athrixia* sp. nov. is listed as globally Endangered and *I. speciosa* as regionally Endangered (Table 1).

Brachystelma longifolium (Schltr.) N.E.Br. and *Rhus pygmaea* Moffett occur at three, possibly four localities, but the total area of occupancy of each taxon is less than 1 km^2 and there are only 50–100 mature individuals in the entire population of each species. One sub-population of *B. longifolium* is in an area planted to pine and another is very near a large mine. The largest sub-population of *R. pygmaea* occurs in a forestry area near a sawmill where there is also informal human habitation. *B. longifolium* is listed as Rare (Hilton-Taylor, 1996) using the old categories. Based on the new criteria and new information, it is recommended that *B. longifolium* and *R. pygmaea* be placed on the Red Data list as Endangered (Table 1).

Helichrysum sp. nov. and *Senecio* sp. aff. *S. anomalochrous* (Balkwill 6869) were assessed as Endangered (D) based on the small number of mature individuals (<150 and <250 respectively) that occur at only 1 location in each case. No threats have been recorded for *Helichrysum* sp. nov., but the population of *S.* sp. aff. *S. anomalochrous* is in an area undergoing extensive afforestation and is severely threatened by extensive planting of alien species of *Pinus* and *Eucalyptus*.

Aloe thorncroftii Pole Evans was listed as Vulnerable (Hilton-Taylor, 1996) and recently this taxon was reassessed as Least Concern because of the large numbers of mature individuals in each subpopulation (Smith et al., 2000). However, the area of occupancy of this species is about 5 km^2 at only four or five localities and a catastrophic event at any one of these localities could result in a significant decline of the population. In addition, these populations occur in areas of extensive afforestation and an increase of planting and environmental degradation associated with sylviculture threatens them. This threat includes altered burning regimes and a massive increase in weeds associated with the disturbance. It is recommended that this threat be considered in the assessment and therefore it is listed as Vulnerable (B1ab(v)+2ab(v) D2). Continued

monitoring by Mpumalanga Parks Board (the statutory authority responsible for nature conservation in the province) will determine if there is any decline or increase in the size of the population, requiring a reassessment.

The individual areas of occupancy for the entire populations of *Asystasia subbiflora* C.B.Cl., *Gladiolus serpenticola* Goldblatt, *Gymnosporia* sp. nov. (Williamson 945), *Indigofera crebra* N. E.Br., *Ozoroa barbertonensis* Retief, *Ozoroa* sp. nov. (Balkwill 7840) and *Sclerochiton triacanthus* Meeuse are less than 2 km^2. Each taxon is known from two to five localities and their populations are estimated to consist of 500–1000 mature individuals. *S. triacanthus* has only been recorded at two localities and the largest population could be threatened by existing mining claims. Despite numerous attempts to collect flowering or fruiting material of this population, it has never been observed to be reproducing sexually. At present the populations of *S. triacanthus* are stable and this taxon has been assessed as Vulnerable (D1 + 2), but this could be reclassified as Endangered if further populations are not found and mining operations begin.

Most of the populations of *G. serpenticola* and *Gymnosporia* sp. nov. and a subpopulation of *A. subbiflora* and *O. barbertonensis* occur on land to be incorporated into the Barberton Nature Reserve. Many of the subpopulations of *A. subbiflora*, *I. crebra*, *O. barbertonensis* and *Ozoroa* sp. nov. could be threatened in the future by the forestry industry. Due to the small areas occupied by these taxa and the low numbers of mature individuals in these populations they have been assessed as Vulnerable (Table 1).

Berkheya rehmannii Thell. var. *rogersiana* Thell. and *Senecio* sp. aff. *S. coronatus* (Balkwill, Balkwill and Williamson 6566) were assessed as Vu D1 + 2 and *B. nivea* as Vu D2 based on small numbers of mature individuals (≤ 1000) and/or small area of occupancy (<20 km^2). The smallest subpopulation of *B. nivea* is in the Barberton Nature Reserve whereas the largest occurs on State land with existing mining claims, which will be incorporated into this reserve in the future (Stalmans, pers. comm.[2]). Many populations of *B. rehmannii* Thell. var. *rogersiana* Thell. and *Senecio* sp. aff. *S. coronatus* occur in areas undergoing extensive afforestation and are severely threatened.

Protea curvata N.E.Br was previously classified as Vulnerable (D2) (Hilton-Taylor, 1996). This classification suggests that there is little or no threat to this species. One of the largest populations occurs on State land, which is under the management of Mpumalanga Parks Board and will be incorporated into the Barberton Reserve in the future. The other populations are on private land, but development in these areas is unlikely due to their low agricultural and afforestation potential. Therefore the recommendation is that the classification of Vulnerable (D2) remains.

The extent of occurrence (EOO) of *B. coddii*, a hyperaccumulator of nickel, is less than 100 km^2 (Table 1) and thus applying a precautionary attitude would suggest this taxon be listed as threatened. However, category B cannot be applied further as there are more than 10 subpopulations and *B. coddii* can also not be categorized as threatened under criterion D due to the large number of individuals in each subpopulation (Table 1). In addition, at least half of the sites where *B. coddii* is found occur in conservation areas. Therefore the status of this taxon is Least Concern (LC). However, this status could change to threatened as some of the populations occur in areas undergoing afforestation.

Ocimum sp. nov. and *Sartidia* sp. nov. occur at more than 8 localities and at each of these sites large numbers have been found and many of these subpopulations occur within conservation areas such as the Songimvelo Game Reserve. It is recommended that these taxa are listed as Least Concern, however, their status could be changed to threatened if afforestation expands in areas outside the reserve boundaries.

Cyphia bolusii Phill. and *Salpinctium hirsutum* T.J.Edwards appear to be local endemics, as in Swaziland they occur off serpentine, but in Mpumalanga they have only been found on serpentine outcrops. *C. bolusii* only occurs at one locality in Mpumalanga and at this serpentine outcrop there has been some afforestation and a major road has been built through it. Both these events caused a decline in the numbers of this taxon, although the exact number cannot be determined. It is thought to only occur at one locality in Swaziland. This cannot be confirmed at present and thus it has been decided to assess this taxon on a national basis using the guidelines outlined by Gärdenfors (2001). The national status was thus determined to be Endangered (Table 1). *S. hirsutum* occurs at a minimum of two sites in Mpumalanga, with less than 250 mature individuals. Swaziland sub-populations could not be assessed and it was therefore also classified as nationally Endangered (Table 1).

An evaluation of *Berkheya* sp. nov. aff. *B. seminivea*, *Macledium zeyheri* (Sond.) S.Ortiz subsp. *thyrsiflorum* (Klatt) N.C. Netnou, *Dicoma swazilandica* S.Ortiz, Rodr. Oubiña and Pulgar and *Cheilanthes* sp. nov. is not possible at present due to insufficient data. Each taxon occurs in less than five localities, which would place each in a threatened category. Due to the lack of information these taxa should be listed as Data Deficient until they can be reassessed.

It is difficult to apply the IUCN criteria to serpentine endemics as in most cases the sub-populations are restricted to few outcrops, which results in extreme fragmentation. More than half of the serpentine endemics assessed here have less than five subpopulations and the rest have less than 16 subpopulations. In many instances subpopulations have large numbers of individuals (*B. coddii*, *B. nivea* and *Sartidia* sp. nov.) (Table 1), but areas of occupancy are very small. It is then difficult to make a decision based on these criteria. Due to this inconsistency when the data were entered into RAMAS, the outcome would be a list of plausible categories but a specific status with criteria could not be achieved at the recommended Burden of Proof (50%). Applying the threat data was also difficult, as these populations have not been studied long enough to determine by what percentage the populations have declined and the percentage future decline was thus predicted.

Categories A and E (describing the rate at which the populations are declining and probability of extinction) were not used in any of the assessments as no quantitative data were available for the taxa considered here. The distribution size and the

[2] Mark Stalmans—International Conservation Services, P.O. Box 19139, Nelspruit, 1200.

numbers of mature individuals of each taxon, together with any threats recorded were used to calculate the extent of occurrence and/or the area of occupancy and to estimate any decline in distribution or population size. These data were used to apply Criteria B and/or C. Criterion D (describing very small or restricted populations) was the most appropriate criterion in most assessments, where there was little or no evidence of threats to the taxa.

In summary, seven taxa, which were insufficiently known (K) (Hilton-Taylor, 1996), have been reassessed and placed in appropriate categories (Table 1). Eighteen serpentine endemics have been assessed for the first time and 11 of these have been categorised as threatened (Table 1). Most of these are assessed as Vulnerable (37%) or Endangered (29%). Only one taxon is Critically Endangered, representing 3.7% of the taxa.

Subpopulations of serpentine endemics are severely fragmented and occur at few localities. Therefore they are vulnerable to single events, which could destroy large proportions of the population. These endemics also occur in areas that are largely planted to pine or they are threatened by mining operations. It is recommended that these taxa be placed on the Red Data List in the categories discussed so that conservation authorities and private land owners can be made aware of the value of serpentine outcrops and implement appropriate management actions.

Further assessment is needed to determine the levels of threat of the taxa that have been classified as Data Deficient. *M. zeyheri* subsp. *thyrsiflorum* is recorded from only one locality with a relatively small population and should be placed in a threatened category once data are available.

Additional factors not considered by the IUCN criteria, such as the extensive use of these plants for research and bioremediation and the potential of some serpentine endemics to become invasive weeds, need to be considered when conservation priorities and management plans for serpentine areas are compiled.

Acknowledgments

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Appendix A

Voucher specimens (precise localities have not been included to protect the endangered taxa from unscrupulous collectors of rare plants.)

Aloe thorncroftii Pole Evans

Carolina District, Stolzburg Syncline (2530DD), *Balkwill*, *Williamson and Smith 10075* (J); Barberton District, Barberton (2531CC), *Rogers 20250* (J)

Asystasia subbiflora C.B.Cl.

Barberton District (2530DD), *Balkwill and Cadman* 2590 (J); Barberton District, Queens River Valley (2530DD), *Balkwill and Cadman 2615* (J); Eerstehoek District, Songimvelo Game Reserve (2530DD), *Balkwill 7763* (J); Carolina District, Stolzburg Syncline (2530DD), *Balkwill*, *Williamson and Smith 9873* (J)

Athrixia sp. nov.

Carolina District, Stolzburg Syncline (2530DD), *Balkwill 9052* (J)

Berkheya coddii Roessl.

Carolina District, Stolzburg Syncline (2530DC), *Williamson 406* (J); Barberton District (2530DD), *Balkwill 6884* (J); Barberton District, Queens River Valley (2530DD), *Balkwill*, *Williamson and Smith 10219* (J); Eerstehoek District, Songimvelo Game Reserve (2530DD), *Balkwill*, *Balkwill and Williamson 6693* (J); Barberton District, Songimvelo Game Reserve (2531CC), *Stalmans 2203* (J); Barberton District, Songimvelo Game Reserve (2531CC), *Balkwill*, *Balkwill and Williamson 6646* (J); Kamhlushwa District, Kangwane–Nkomazi west region (2531DC), *Stalmans 2774* (J); Eerstehoek District, Songimvelo Nature Reserve (2630BB), *Stalmans 2359* (J)

Berkheya nivea N.E.Br.

Nelspruit District (2530DB), *Balkwill*, *Williamson and Smith 10016* (J); Barberton District (2531CA), *Stalmans 3005* (J); Swaziland, North West of Mbabane, Malolotja Game Reserve (2631AA), *Balkwill and Balkwill 9328* (J)

Berkheya rehmannii Thell. var. *rogersiana* Thell.

Nelspruit District, Berlin State Forest (2530DB), *Balkwill*, *Williamson and Smith 9786* (J); Barberton District (2530DD), *Williamson and Payet 279a* (J); Swaziland, North West of Mbabane, Malolotja Game Reserve (2631AA), *McCallum and Balkwill 210* (J)

Brachystelma dyeri K. and M. Balkwill

Barberton District (2530DD), *Williamson and Williamson 114* (J)

Brachystelma longifolium (Schltr.) N.E.Br.

Barberton District, Songimvelo Game Reserve (2531CC), *Ellery and Ellery 92/55* (J); Barberton District, Songimvelo Game Reserve (2531CC), *Balkwill and Balkwill 8559* (J); Eerstehoek District, Songimvelo Nature Reserve (2630BB), *Hartley 1469* (J)

Cyphia bolusii Phill.

Nelspruit District (2530DB), *Balkwill and Balkwill 3982* (J); Eerstehoek District, Songimvelo Game Reserve (2530DD), *Ellery and Ellery 92/120* (J)

Dicoma swazilandica S.Ortiz, Rodr. Oubiña and Pulgar

Eerstehoek District, Songimvelo Nature Reserve (2630BB), *Balkwill and Robinson 6831* (J)

Macledium zeyheri (Sond.) S.Ortiz subsp. *thyrsiflorum* (Klatt) N.C.Netnou

Barberton District, west of Malelane (2531CB) *Williamson and Williamson 263* (J)

Gladiolus serpenticola Goldblatt and Manning

Barberton District (2531CA), *Balkwill, Balkwill, Goyder, Paton and Williamson 10865* (J)

Indigofera crebra N.E.Br.

Barberton District, Queens River Valley (2530DD), *Balkwill, Balkwill and Williamson 6617a* (J); Carolina District (2530DD), *Balkwill, Williamson and Smith 9894* (J); Barberton District, Songimvelo Game Reserve (2531CC), *Germishuizen 5677* (J); Swaziland, North west of Mbabane, Malolotja Game Reserve (2632AA), *McCallum and Balkwill 396* (J); Swaziland, Mbabane District, (2631AC), *McCallum 381* (J)

Ocimum sp. near *O. obovatum* E. Mey. ex Benth.

Barberton District (2530DD), *Balkwill, Williamson and Smith 10208* (J); Eerstehoek District, Songimvelo Game Reserve (2530DD), *Balkwill 7765* (J); Barberton District, Songimvelo Game Reserve (2531CC), *Hartley 1291* (J); Barberton District, Songimvelo Game Reserve (2531CA), *Balkwill and Balkwill 8564* (J); Eerstehoek District, Songimvelo Nature Reserve (2630BB), *Balkwill, Balkwill, Stalmans, Goyder and Paton 10901* (J)

Ozoroa barbertonensis Retief

Barberton District (2530DD), *Balkwill and Balkwill 4001* (J)

Ozoroa sp. nov.

Eerstehoek District, Songimvelo Game Reserve (2530DD), *Stalmans 2856* (J); Barberton District, Songimvelo Game Reserve (2531CC), *Lee 166* (J); Eerstehoek District, Songimvelo Nature Reserve (2630BB), *Masilo E90* (J); Eerstehoek District, Songimvelo Game Reserve (2631AA), *Balkwill, Balkwill and Kidger 8096* (J)

Rhus pygmaea Moffett

Barberton District (2530DD), *Balkwill, Balkwill and Williamson 6596* (J); Barberton District (2531CA), *Williamson 623* (J)

Salpinctium hirsutum Edwards

Nelspruit District, Berlin State Forest (2530DB), *Balkwill, Balkwill and Williamson 6704* (J); Barberton District, Songimvelo Game Reserve (2531CC), *Balkwill, Balkwill and Williamson 6659* (J); Swaziland, Mbabane District (2631AC), *McCallum 445* (J)

Sartidia sp. nov.

Nelspruit District, Berlin State Forest (2530DB), *Balkwill, Balkwill and Williamson 6434* (J); Barberton District (2530DD), *Williamson, Balkwill and Balkwill 53* (J); Eerstehoek District, Songimvelo Game Reserve (2530DD), *Stalmans 2829* (J), Carolina District, Stolzburg Syncline (2530DD), *Balkwill 9043* (J); Barberton District, Songimvelo Game Reserve (2531CC), *Lee 126* (J); Eerstehoek District, Songimvelo Nature Reserve (2630BB), *Balkwill 9148* (J); Eerstehoek District, Songimvelo Game Reserve (2631AA), *Balkwill, Balkwill and Kidger 8097* (J)

Sclerochiton triacanthus Meeuse

Barberton District (2531CC), *Davidson s.n.* (J)

Senecio sp. aff. *S. anomalochrous* Hilliard

Nelspruit District, Berlin State Forest (2530DB), *Balkwill, Balkwill and Williamson 6441* (J)

Senecio sp. aff. *S. coronatus* Hilliard

Nelspruit District, Berlin State Forest (2530DB), *Balkwill, Balkwill and Williamson 6566* (J); Carolina District (2530DD), *Balkwill, Williamson and Smith 9950* (J)

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