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Red Listed medicinal plants of South Africa: Status, trends, and assessment challenges

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ABSTRACT

In 2009, South Africa completed the IUCN Red List assessments of 20,456 indigenous vascular plant taxa. During that process, medicinal plant species (especially those sold in informal *muthi* markets) were identified so that potential extinction risks posed to these species could be assessed. The present study examines and analyses the recently documented threat statuses of South African ethnomedicinal taxa, including the number of species used, revealing family richness and the degree of endemism, and calculates the Red List Index (RLI) of species survival to measure the relative degree of threat to medicinal species. Approximately 2062 indigenous plant species (10% of the total flora) have been recorded as being used for traditional medicine in South Africa, of which it has been determined that 82 species (0.4% of the total national flora) are threatened with extinction at a national level in the short and medium terms and a further 100 species are of conservation concern (including two species already extinct in the wild). Thirty-two percent of the taxa have been recorded in traditional medicine markets in the provinces of KwaZulu-Natal, Gauteng, Eastern Cape, Mpumalanga and Limpopo. The study also reflects on the challenges associated with Red List evaluations of medicinal species, many of which, based on market reports, are extracted at a seemingly unsustainable rate. In contrast to the majority of species enumerated in the Red List of South African plants, medicinal taxa are often widespread, with large extents of occurrence. Accordingly, the population decline criteria have necessarily been applied to assess threats to their existence, even though accurate figures for numbers of remaining individuals, areas of occupancy, quantities harvested, and regeneration times are often found lacking. Factors leading to susceptibility of plant species to extinction as a result of harvesting pressure are discussed. The current findings reveal a need for greater emphasis on focussed population level research on prioritised medicinal plant species.

1. Introduction

Despite the availability and accessibility of western medicine in the 21st century, a wide range of cultural communities in South Africa still depend on and often prefer traditional medicine (TM) or '*muthi*' as an important component of primary health care. It was estimated that 72% of Black South Africans, even in urban areas, subscribe to traditional health care systems involving the consumption of medicinal plants, and that more than 70,000 tonnes of plant material is consumed in South Africa each year, with at least 134,000 income-earning opportunities generated by the trade in medicinal plants and related products (Mander et al., 2007). Medicinal plants are traded through several large markets throughout South Africa, particularly in the summer-rainfall region (Mander, 1997; Mander, 1998; Botha et al., 2001; Dold and Cocks, 2002; Von Ahlefeldt et al., 2003; Williams, 2003, 2007). Much of the material supplied is obtained mainly from harvesting wild plant resources, leading to concerns over sustainability. Threats to the resource base are further compounded by habitat transformation occurring over parts of the country (Fairbanks et al., 2000), with some vegetation types more adversely affected than others (Mucina and Rutherford, 2006). The rapidly urbanising landscape of Gauteng, for instance, requires medicinal plant users based on the Witwatersrand to source their plants from increasingly further afield (Williams, 2003).

With the population of South Africa continuing to increase (Statistics South Africa, 2007) in the midst of an HIV/AIDS epidemic that requires the extensive herbal treatment of opportunistic infections, the demand for medicinal plant resources is growing apace. A wide range of species are already showing signs of unsustainable harvesting, with the size of the traded components (e.g. bulbs) decreasing, distances to harvesting source increasing (Mander, 1998), supply becoming increasingly irregular and some plants becoming unavailable in certain markets (Te Beest, 2003). There is also documented extirpation at local (e.g. *Warburgia salutaris*) (Gerstner, 1938; Mander, 1998; Botha et al., 2004a) and provincial (e.g. *Siphonochilus aethiopicus*) (Crouch et

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al., 2000) levels. Only one species (*Encephalartos woodii*) is known to be extinct in the wild as a result of over-harvesting for medicine, having been on the brink of extinction at the time of its scientific discovery at the turn of the 19th Century (Crouch et al., 2003a). Unsustainable medicinal plant use in South Africa is, however, not a recent concern. As early as 1946, Father Jacob Gerstner, a Zululand missionary, anticipated the extinctions of "doomed" plant species used for traditional medicine (Gerstner, 1946). He accordingly recommended their cultivation by state nurseries, a relevant suggestion acted on by neither national nor provincial governments of the time. Gerstner (1946) reported witnessing 40 to 50 bags of *Erythrophleum lasianthum* (Fabaceae) being railed to Durban on a single day, presumably to supply *muthi* markets.

There are three large, permanent urban *muthi* markets in South Africa requiring a steady supply of plant material: the Warwick Triangle and Ezimbuzini markets in Durban, and the Faraday market in Johannesburg. Permanent street traders and ephemeral pension day markets, selling medicinal plants, are also present in smaller urban centres throughout the country (Dold and Cocks, 2002; Botha et al., 2004b). In addition to informal street markets are formal *muthi* stores found in almost all urban areas in the region. Less attention has been focussed on *muthi* stores with regard to their contribution to health care services and medicinal plant exploitation, but work in the Eastern Cape and the Witwatersrand shows that a large number of medicinal plant species are traded in these stores (Cocks, 1996; Williams et al., 2001).

The Species Survival Commission of the IUCN devised an objective system of assessing extinction risks based on a set of five quantitative criteria (A–E) with threshold values that delimit the various categories of threat. The IUCN Red List Categories and Criteria Version 3.1 (2001) were used in the assessments of 20,456 indigenous South African vascular plant taxa (Raimondo et al., 2009a; Von Staden et al., 2009a), the first time in the world that a country's entire flora has been assessed. The potential extinction risks posed to plants, including those threatened by harvesting for the medicinal plant trade, were assessed by means of the quantitative criteria, along with other considerations (e.g. habitat loss), to determine their Red List status. Assessing the conservation status of widespread plants, in which category many heavily traded medicinal taxa fit does, however, pose unique challenges. Not only is it difficult to accurately estimate a percentage decline over a set period of time (required if taxa are listed under the population decline Criteria A and/or C), but often species undergoing a continuing decline are abundant and widespread. Accordingly, they do not qualify for the restricted-range Criteria B and/or D. Furthermore, while many medicinal species may be facing a much lower risk of extinction, they still require conservation action to diminish future risks of regional or localised extirpations. In order to meet local conservation concerns for species that are declining but not necessarily in danger of extinction, Victor and Keith (2004) developed additional categories (Critically Rare, Rare and Declining) to flag taxa of conservation concern that would be classified as Least Concern (LC) according to the IUCN system. While these categories are only applied in South Africa, they are pertinent for ethnomedicinal taxa that should be considered in conservation prioritisation processes to ensure that they do not become threatened in the future should deterministic factors (e.g. over-exploitation) in their extinction risks persist.

A challenge for assessing the Red List statuses of medicinal taxa is the availability and accessibility of sufficient quantitative and qualitative data to determine the extent of population decline; however, inferences can be made from observing trends regarding individual plant sizes in *muthi* markets. For instance, Williams et al. (2007a,b) considered market-derived data as a surrogate in an attempt to assess the condition of wild standing stocks. They found statistically significant decreases in the market availability of large bulbs or thick tree bark over time to signal both population decline within a species' area of occupancy, and the reduced occurrence of larger, reproductive individuals. In 1994, for example, *Bowiea volubilis* (Hyacinthaceae) bulbs with a diameter > 15 cm were frequently encountered in Johannesburg *muthi* shops. By 2007, however, 93% of *B. volubilis* bulbs recorded in the Faraday market were <4 cm diameter (Brueton, in preparation). These market data, where available, in conjunction with expert observations, were used in the course of assessing the Red List status of medicinal species known to be traded.

In light of South Africa's significant achievement in assessing the threat statuses of its entire flora, and the unique availability of a complete set of baseline information by which one can fully compare groups of flora, in this paper we analyse and reflect on the recently documented threat and conservation statuses of South African medicinal plants. The objectives were to examine patterns and trends in the taxa used, and to discuss factors leading to the susceptibility of plant species to decline as a result of harvesting pressures. Since medicinal plants are an important resource to the majority of South Africans, the information presented should inform decisions taken by policy makers within the domain of biodiversity conservation and sustainable livelihoods.

2. Methods

2.1. Species used and Red List assessments

In order to determine the number of threatened medicinal plants and their conservation status, a list of plant species cited as being used and/or traded for traditional medicine was compiled. The primary source of this information was Arnold et al. (2002) and the references cited therein, including tertiary literature reports such as Watt and Breyer-Brandwijk (1962) and Hutchings et al. (1996). However, Arnold et al. (2002) list plants that occur in southern Africa and that have been cited as being used for traditional medicine anywhere else, though most of them have been employed in the subregion. Since this paper is about South African ethnomedicinals only, the plants were checked against the references and only species that occur in South Africa and that were cited as being used/traded in South Africa were retained from the original Arnold et al. (2002) checklist. A further comprehensive literature search was conducted through published material to justify our decision on what species to retain. More than 140 species were further added to our checklist of medicinal plants from the following references: Anonymous (c.1994), Brandt et al. (1995), Crouch and Hutchings (1999), Crouch and Krynauw (1999), Crouch et al. (2005a,b), Cousins et al. (2012), Dold and Cocks (2000, 2001, 2002), Dzerefos and Witkowski (2001), Hanekom (1967), Kamatou et al. (2008), Kroon (1999), Lourens et al. (2008), Loxton, Venn and Associates (1994), Makgakga (1995), Makunga et al. (2008), Matsiliza (1997), McGraw et al. (2008), More et al. (2008), Netshiungani (1981), Newton (1993), Pooley (1993, 1998), Scott-Shaw (1999), Smith and Crouch (1995), Sobiecki (2002), Van Vuuren (2008), Van Wyk (2008), Van Wyk et al. (1997), Veale et al. (1992), Verschaeve and Van Staden (2008), Von Ahlefeldt et al. (2003), Williams (2003, 2007). The species list is, however, not static and papers published subsequent to this research will add to our knowledge on the number of species used and traded for traditional medicine in South Africa. For example, Moeng and Potgieter (2011) listed two species not captured in our list as being sold in shops and markets in the Limpopo Province. For the purpose of this paper, however, new species recorded in literature published after February 2010 were not taken into consideration.

Not all plant species that are used for traditional medicine are commercially traded and threatened by destructive and unsustainable harvesting practices. Hence, when the conservation statuses of ethnomedicinals were assessed according to the IUCN Red List categories and criteria, a distinction was made between plant species recorded in trade in the medicinal markets of KwaZulu-Natal, Gauteng, Eastern Cape, Mpumalanga and Limpopo Provinces, and those plant species that were cited as being used only but have yet to be identified in the markets. Special attention was also paid to the most heavily traded species, since the likelihood of these plants being threatened by the medicinal plant trade is high (Williams, 2007). Given that many heavily traded medicinal taxa

are widespread and do not qualify under the restricted-range Criteria B and D, an extensive literature search and a workshop with eight ethnobotanists was conducted to try and obtain information to support a listing under the population decline Criteria A and C (Von Staden et al., 2009b). The detailed information obtained during this process sets the medicinal plant assessments apart from the conservation assessments of other South African plants (Von Staden et al., 2009b).

The information collected to support a threat assessment based on population decline as a result of harvesting for the informal plant trade includes: observed losses of individuals or subpopulations over time; the extent of the decline in the distribution range, mainly inferred through information on past and present distributions; relative abundance (e.g. locally frequent, or uncommon in the field); the quantities of plant material traded (Cunningham, 1988; Mander, 1998; Williams, 2007; Williams et al., 2007a); the type of harvesting (i.e. destructive vs. non-destructive); life cycle characteristics (e.g. reproductive capabilities and growth rate); and popularity in the *muthi* markets (Cunningham, 1988; Mander, 1998; Williams, 2007). In addition, information on suspected levels of population decline due to trade was estimated and extrapolated from observed losses of subpopulations, as observed by fieldworkers. These data were also sourced from ethnobotanists during the course of the expert Red Listing medicinal plant workshop (Von Staden et al., 2009b); participants reported on observed changes with time in the abundance, availability and size of individual plants and plant parts. While the expert workshop for ethnomedicinals looked mainly at popular plants (which were invariably those in trade), post-workshop research elucidated further non-trade related threats to some species e.g. habitat loss to commercial agriculture for *Stangeria eriopus*. These were taken into account in the assessments of the relevant species. Since harvesting is usually not a threat to non-traded medicinal taxa, evaluations of the threats to these species were mostly reliant on information contributed by many other knowledgeable botanists who assisted with the Red Listing process.

The assessment of the conservation status of medicinal plant species was carried out using the IUCN Red List Criteria Version 3.1 (2001). There are five broad criteria (A to E) based on quantitative thresholds that are used to assess the probabilities of extinction. If a species does not meet any of the criteria, it is classified as Least Concern (LC). Taxa can be classified into one of the three categories of threat, i.e. Critically Endangered (CR), Endangered (EN) or Vulnerable (VU); or else they are placed into Near Threatened (NT), Data Deficient (DD), Extinct (EX) or Extinct in the wild (EW). For Criterion A, the taxon must show a population reduction (measured as a percentage) over a set time period. Taxa qualifying under Criterion B would have a limited geographic range or restricted area of occupancy and at the same time meet two of the following three subcriteria: a continuing decline; a severely fragmented population or fewer than a threshold number of locations; extreme fluctuations in specified population parameters. Taxa with small global populations would qualify for a category of threat under Criterion C if the total population size is less than a threshold number of mature individuals and there is either a continuing decline over a set period or a continuing decline in numbers of mature individuals combined with small or single subpopulations and/or extreme fluctuations in the number of mature individuals. Taxa with very small and/or very restricted populations, and that are potentially subject to threatening processes, would qualify under Criterion D. Where a quantitative analysis indicates a probability of extinction in the wild to be at least 10% within 100 years, a taxon would qualify for a category of threat under Criterion E. For further more detailed explanation and definitions, refer to IUCN (2001). A species classified as LC can additionally be flagged as being of conservation concern either as Rare, Critically Rare or Declining (Victor and Keith, 2004; Von Staden et al., 2009c).

The Red List assessments for the medicinal taxa analysed in this paper are correct as of February 2010. Subsequent changes to the status of seven medicinal species (one status upgrade and six downgrades) were found when the updated Red List of South African plants version 2012.1 (SANBI, 2012) was announced in May 2012. However, we have not accordingly adjusted the figures and analyses since most changes affect species that are not threatened. Status changes are indicated in the footnotes of Appendix A.

2.2. Red List Index

To evaluate the overall extinction risks to medicinal plant species as a group, we calculated the IUCN Red List Index (RLI) of species survival (Butchart, 2008). The RLI uses information from the Red List to monitor trends in the proportion of species expected to remain extant or to become extinct in the near future (Butchart, 2008), and can be used to explore trends resulting from the impact of specific threats (e.g. unsustainable use) to groups of species (Bubb et al., 2009). While the index is usually calculated as a trend that requires all species in the group to have been assessed for the Red List at least twice (Bubb et al., 2009), RLI values can also be calculated at a single point and the values indicate the relative degree of threat to species in a group at that point in time (S.H.M. Butchart, pers. comm., 2011).

Guidance on the national and regional uses of RLIs is described in Bubb et al. (2009) and Butchart (2008). For the purposes of this study, the RLI was calculated by: A) multiplying the number of species in each Red List category by a category weight (Extinct in the Wild = 5; Critically Endangered = 4; Endangered = 3; Vulnerable = 2; Near Threatened = 1; Least Concern = 0) (Data Deficient and NE taxa are excluded from the analyses since the calculation requires species to have been assessed); B) summing the product of the category scores, and dividing this by the sum of the maximum possible product (i.e. the number of species multiplied by the maximum weight, i.e. 5); and then C) subtracting this value from 1 (Bubb et al., 2009). Since the category of Declining was developed specifically for the South African plant conservation context (Victor and Keith, 2004; Von Staden et al., 2009c) and is not a status recognised at the global level, all Declining species, for the purposes of the RLI, were treated as Least Concern. RLI values closer to 1 indicate that most species are categorised as Least Concern and are expected to remain extant in the near future without additional conservation action, whereas RLI values closer to zero indicate that a high proportion of species have become extinct or are highly threatened (Bubb et al., 2009; Butchart, 2008). Since 80% of South Africa's flora was assessed for the first time in 2009 (Raimondo et al., 2009a), it was not possible to derive RLI values for most species from the previous South African Red List Assessment (Victor, 2002); hence, temporal trends in the extinction risks to South African medicinal plants could not be measured. The RLI was calculated for the entire list of medicinal plants (n = 2000 species; EW, CR, EN, VU, NT and LC species only), and then the data were divided into two subgroups and compared accordingly, namely species that are traded (n = 647 species) versus species that are not known to be traded (n = 1353 species).

It is important to note that, with the exception of endemic species, the Red List statuses used in the calculation of the RLIs for the medicinal plants are all, by default, national assessments because the South African Red List assessments apply only to the section of the global population that occurs within South Africa's borders (Von Staden et al., 2009c). For endemic species, however, the national status is the same as the global status. Hence, when interpreting the RLI values in this paper at a national level, it cannot be assumed that the levels of threat to a group of species are indicative of the survival expectancies at a global level, since the proportion of more widespread non-endemic species must also be considered.

In addition to the RLI, we examined threats at plant family level and calculated the percentage of medicinal species within broad threat categories that were endemic or not endemic to South Africa and the FSA (Flora of Southern Africa) region.

3. Results and discussion

3.1. Patterns and trends in the Red List of South African medicinal plants

There are over 3400 plant species in southern Africa that are used for medicinal purposes (Arnold et al., 2002); of these, 2062 taxa have specifically been cited as used and/or traded in South Africa (10.1% of the total national flora). Furthermore, 32% of South Africa's plant ethnomedicines have been recorded in *muthi* markets in KwaZulu-Natal, Gauteng, Eastern Cape, Mpumalanga and Limpopo (Table 1). Overall, 9.2% were assessed according to threats driven by harvesting for the traditional medicine trade (Table 1). Although the Red List is not static and the threat statuses of some species will change in future to reflect both population and plant use dynamics, there are currently two medicinal plant species Extinct in the Wild and 82 species (4% of the medicinal flora, 0.4% of the national flora) threatened with extinction at a national level (Table 1; Fig. 1). Fourteen species are Critically Endangered, 19 Endangered and 49 Vulnerable (Table 1). A further 100 species are of conservation concern, of which 37 (1.8%) are Near Threatened, 36 Declining, four are Data Deficient (DD) as they are suspected to be threatened but insufficient information is available to place them in a category of threat, and 21 species are either Rare or Critically Rare. The 37 Near Threatened and 36 Declining species (the latter representing 69% of the total number of 52 Declining species assessed in South Africa) are not currently facing a high risk of extinction, but may very well do so in the near future if threats persist. Taxa that are threatened and of conservation concern account for 8.8% of the assessed species (Fig. 1); hence the majority of ethnomedicinals were assessed as Least Concern (88.4%). Appendix A lists the species that are threatened and/or of conservation concern.

Fifty percent or more of the taxa within each threatened category or category of conservation concern have been recorded in the *muthi* markets, especially the Declining (94%), Near Threatened (81%) and Vulnerable (74%) taxa (Table 1); furthermore, 68% of the 82 threatened medicinal species are traded. Hence, traded species are more threatened than non-traded species and persistent commercial exploitation could result in the future upgrading of the Red List statuses of several species that are currently at risk. Less threatened by the traditional medicine trade, however, are Least Concern taxa and only 29% of the 1822 taxa have been recorded in the markets. Threats posed by the traditional medicine trade were specifically used in the assessments of 9.2% of the total number of ethnomedicinal species (Table 1, column 6); within each Red List category, the percentage of species recorded in trade and the percentage of species assessed based on their class as a traded medicinal are similar, except for LC species where the majority of species are not traded (Table 1, cf. columns 4 and 6). For example, of the 49 Vulnerable taxa (Table 1), 36 were recorded in the markets and the Red List assessments of 35 of these were based on population decline information derived and inferred from ethnobotanical literature and market data. Taxa not evaluated according to threats posed by harvesting for the TM trade were thus evaluated according to other factors that pose a more significant threat to their persistence in the wild.

As has been previously stated, a challenge with assessing medicinal plants according to IUCN criteria is that they are typically widespread, occur in hundreds of locations, and therefore do not qualify for listing under the restricted-range Criteria B and D. To verify this observation, we analysed the proportion of threatened and Near Threatened taxa that were listed according to Criteria B and D versus Criteria A and C for 119 medicinal and 2762 South African plants assessed in 2009 (derived from Raimondo et al., 2009a). Currently on the IUCN Red List, 80% of plants assessed in the last 10 years are listed based on the range estimate criteria B and D2 (Rivers et al., 2011). In South Africa, the percentage is similar, viz. 81% (Table 2). For medicinal species, however, we found that of the 119 threatened and Near Threatened taxa, 44% were listed according to Criteria A and/or C, 41% were listed according to Criteria B and/or D, and 14% were listed according to B with A and/or C (Table 2) — hence, 55% of all medicinal taxa are listed based on range as risk factor. However, when one looks more closely at the species recorded in the *muthi* markets that were assessed according to the risks posed by the trade, we find that 53% were listed according to the population decline criteria and only 31% could be listed according to the restricted-range criteria (Table 2). Threatened and Near Threatened medicinal species that were *not* recorded in the *muthi* markets were usually listed according to Criteria B and/or D (67%) compared to Criteria A and/or C (18%) (Table 2). Hence, use and harvesting pose less of a conservation threat to non-traded medicinals relative to their current limited distribution range. The impact on specific taxa by local communities in antiquity is for the most part indiscernible, although early ethnographers have alluded occasionally to plant extinction events as a result of unsustainable utilisation (Dicke, 1926).

Obtaining information to support population decline is not as easy as calculating the Extent of Occurrence (EOO, the quantitative criterion B1). Population decline data is seldom found in publications, hence the knowledge of experts was vital in accomplishing the medicinal plant assessments. Had this knowledge not been obtained, then it would have been near-impossible to assign a threat status to the majority of popularly traded medicinal plants, since their widespread distributions would have placed them outside of the quantitative thresholds for listing as threatened or Near Threatened according to B1.

Table 1
Classification of medicinal plant species in South Africa according to IUCN Red List categories of threat[a].

National Red List status category[b]	Total no. species	No. recorded in trade	% recorded in trade	No. assessed as a traded medicinal	% assessed as a traded medicinal
EW	2				
CR	14	7	50.0%	7	50.0%
EN	19	13	68.4%	12	63.2%
VU	49	36	73.5%	35	71.4%
NT	37	30	81.1%	26	70.3%
Declining	36	34	94.4%	33	91.7%
Rare	21	5	23.8%	0	0
DDD	4	3	75.0%	1	25.0%
LC	1822	521	28.6%	70	3.8%
DDT	17	6	35.3%	5	29.4%
NE	41	1	2.4%		
Total	2062	656	31.8%	189	9.2%

[a] Data are correct as of February 2010; for the most recent statuses see http://redlist.sanbi.org.

[b] Abbreviations: EW = Extinct in the Wild; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; Declining = LC species declining; Rare = LC species considered Critically Rare or Rare; LC = Least Concern; DDD = Data Deficient–Insufficient Information; DDT = Data Deficient–Taxonomically Uncertain; NE = Not Evaluated.

3.2. Endemism

Overall, levels of endemism are low across South Africa's 2062 medicinal species (27% endemic, Fig. 2), reflecting generally widespread distributions, whereas the majority of threatened (CR, EN, VU) and Near Threatened medicinal species are endemic (68% and 57% respectively) (Fig. 2). By contrast, 72% of LC species and only 18% of threatened species are not endemic. Accordingly, medicinal plant species endemic to South Africa and the FSA region are more likely to be threatened.

3.3. Plant family trends

The 2062 taxa used for traditional medicine are from 171 families, the largest of which is the Asteraceae (12.5% of the total number of South African species; for context of scale, the size of the family in this country is provided) (Table 3; Appendix B). The next largest family is the Fabaceae (7.7%) followed by Apocynaceae (5.0%) and Asphodelaceae (4.0%) (Table 3). The eight families with 50 or more medicinal plant species contain 41% of the total number of species used. The first three

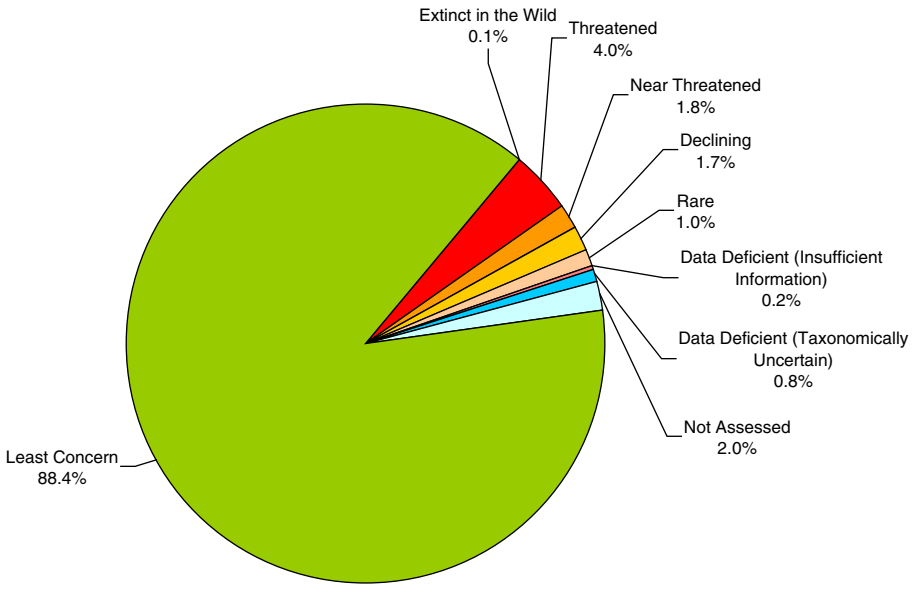

Fig. 1. Taxa classified according to the South African Red List Categories as a proportion of the total number of plants used for traditional medicine in South Africa. 'Threatened' includes the IUCN categories Critically Endangered, Endangered and Vulnerable.

families listed in Table 3 were shown by Douwes et al. (2008) to be better represented in the ethnomedicinal flora than in the overall flora of the subregion. Based on regression analyses it has been possible to identify families that are exceptionally well utilised relative to their overall prevalence in the flora (Douwes et al., 2008), and further in the marketplace (Williams et al., 2000). Future Red List assessments of the medicinal flora of South Africa can accordingly be directed, in part, on the basis of such findings.

Families that have the highest proportion of threatened and Near Threatened taxa include Zamiaceae (92% of the 24 species used are threatened or Near Threatened), Amaryllidaceae (46% of 42 species), Hyacinthaceae (20% of 44 species), Dioscoreaceae (38% of 8 species) and Lauraceae (43% of 7 species) (Appendix B). In addition, there are five families represented by one species in the medicinal flora and that species is threatened, namely Canellaceae, Cornaceae, Hydrostachyaceae, Stangeriaceae and Zingiberaceae. These five families are also monotypic at the level of family and genus in South Africa (i.e. represented by a single genus and species respectively) and are hence of notable conservation value.

3.4. Red List Index

The Red List Index value for all the medicinal species was found to be 0.974 (n = 2000 species, excluding Data Deficient and NE taxa). This indicates that a high proportion of medicinal taxa are categorised as LC and that 97.4% of the medicinal plants in South Africa are expected to remain extant in the near future without additional conservation intervention, and without considering the impact of climate change, further habitat loss, or negative trends in harvesting patterns. Therefore, in terms of the RLI, only 2.6% of all medicinal taxa are expected to be highly threatened at a national level (this figure differs from the 4% that are actually threatened based on Table 1). However, since only 27% of all medicinals are endemic to South Africa (Fig. 2), the actual proportion of medicinal taxa at risk at a global level will be less than 2.6% (or, <0.3% of the 20,456 indigenous South African flora). Accordingly, although commercial harvesting is a serious concern and is causing significant plant population declines for mainly popular species, the threats posed only affect a very small percentage of plants. However, commercial harvesting is threatening relatively more traded versus non-traded taxa.

Table 2
Criteria used to assess the status of threatened (CR, EN, VU) and Near Threatened (NT) medicinal (traded and not-traded) and non-medicinal South African species.

	Population decline criteria A and/or C	Restricted-range criteria B and/or D	Combination of B and/or D with A and/or C
Traded plants (n = 86)	53% (40% A only)	31% (22% B only)	15%
Non-traded plants (n = 33)	18% (15% A only)	67% (61% B only)	12%
Total medicinals (n = 119)	44% (33% A only)	41% (33% B only)	14%
SA flora (n = 2762)[a]	9.0%	81%	10%

[a] Total number of threatened and Near Threatened plants in South Africa (including 119 medicinal flora) for which criteria A–D were assigned based on the 2009 assessments (Raimondo et al., 2009a). This is not the total number of plants of conservation concern.

To further explore how the exploitation of plants for the traditional medicine trade might be intensifying extinction risks compared to species that are used and have not been recorded in the markets (excluding Data Deficient taxa), two subsets of traded vs. not-traded plants were compared. The RLI values were 0.946 and 0.988 for traded (n = 647 species) and not-traded (n = 1353) species respectively, indicating that proportionally more plants recorded in the markets are likely to be threatened with extinction in the near future compared to species that are not as exploited. Unsustainable use of medicinal plant resources is not, however, the only threat in South Africa driving population decline for many of these species. Hence, the differences in the RLI values cannot be solely attributed to the impact of harvesting for the trade; the results show how traded species are more threatened than not-traded species by threats that *include* unsustainable use. When the national Red List of plants is updated in the future, and if the statuses of plants change, then the RLI can be used to show trends in the proportion of medicinal plants used and/or traded for traditional medicine that are being adversely affected by harvesting.

3.5. Geographic and autecological factors

Geographic and autecological factors, in combination with harvesting and utilisation pressures, play a notable role in the susceptibility of plants to population decline and extinction. Species with inherent characteristics such as slow growth and reproductive rates, long generation times and the production of relatively few propagules are rendered especially vulnerable to harvesting and will be more adversely affected than rapidly

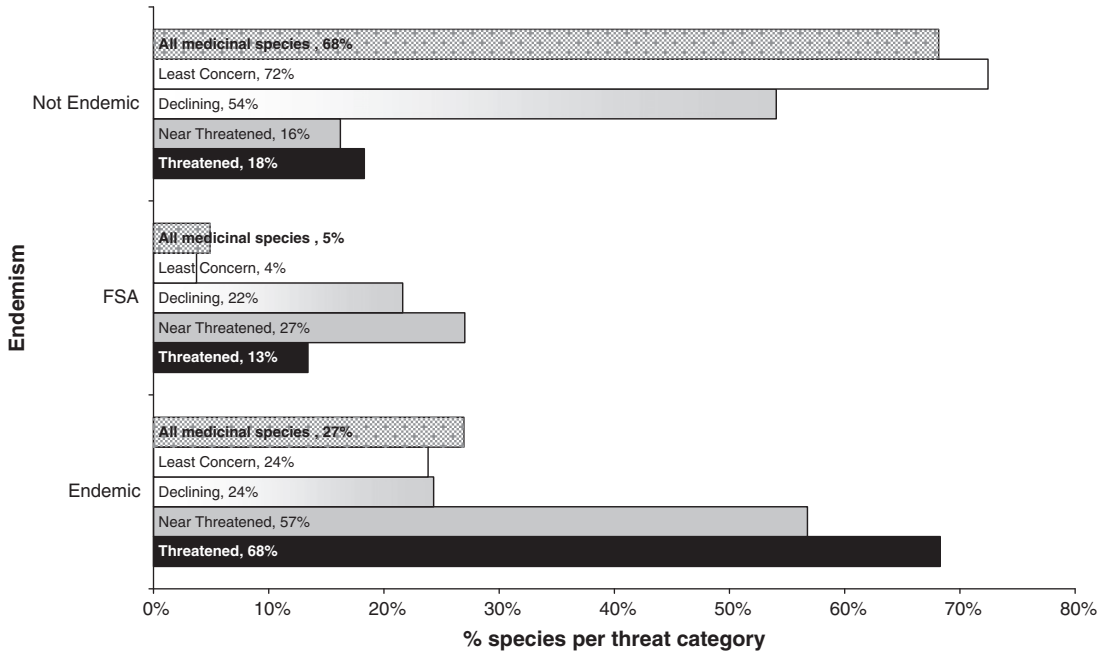

Fig. 2. The percentage of medicinal species per threat category that are endemic to SA, endemic to the FSA region, or not endemic.

regenerating species by whatever destructive harvesting practices are exercised by commercial gatherers. Similarly, endemic species with restricted and fragmented distributions are more likely to be extirpated than widespread taxa. However, for medicinal and other utilised plants, these factors need to be considered in conjunction with the desirability/popularity of the species and the amount of harvesting that takes place, as well as the plant part harvested. For example, trees such as *Albizia adianthifolia* (Fabaceae) (LC) tend to tolerate debarking better than more sensitive species such as *Elaeodendron transvaalense* (Celastraceae) (NT A4d), which exhibits poor bark regrowth capacity (Williams and Geldenhuys, 2004).

As taxa with characteristically restricted range distributions, both the Stangeriaceae and Zamiaceae are inherently susceptible to any pressure in that their extremely slow reproductive rate encumbers recolonisation after harvesting, so even small rates of harvesting can be unsustainable. Even seedlings are extracted when encountered, and traded to be grown around homesteads as *intelezi* (protective charm) plants. Although the predominant pressure on cycad populations (particularly for the rarer species) is related to harvesting for horticultural purposes (Raimondo and Donaldson, 2003), the trade in medicinal plant markets also has had a significant impact on several of the more accessible species (Cousins et al., 2011, 2012).

While restricted geographic distributions are a considered factor in the continued existence of about 55% of threatened and Near Threatened medicinal plants (Table 2), widespread medicinal species are not significantly less at risk of extinction or localised extirpation. We consider two tree species as examples illustrating the complexities of the Red List evaluation process. The endemic Black Stinkwood, *Ocotea bullata* (Lauraceae), for example, has a widespread but somewhat disjunct distribution and an extensive EOO of 659,100 km^2; it was evaluated as EN because of reliable quantitative evidence that the population has declined by 53% in the last three generations or 240 years (Williams et al., 2009), largely due to timber and bark exploitation. In IUCN Red List terms, 'generation time' refers to the average age of mature individuals in a population, and *O. bullata* is an example of a highly desirable medicinal species with a long generation length estimated to be a minimum of 80 years (Medicinal Plant Red List Workshop 14/01/2008, SANBI, Durban). Evidence for this generation time was inferred from a) Sim (1906), who estimated that the mean exploitable age of a tree was 80 years old and that the mean annual increment in stem diameter was 6.35 mm; b) data indicating that mean DBH growth rates vary depending on tree size and position with respect to sunlight (Geldenhuys, 2004), and c) that *Ocotea* has long-lived clonal coppice shoots and that some individual trees could be thousands of years old. However, the older a tree is, the less seed production there is and the greater its susceptibility to the root rot pathogen *Phytophora cinnamomi* (Lubbe and Mostert, 1991). Heavy exploitation of *O. bullata* timber commenced c. 1772 in the Western Cape and extended to Mpumalanga c. 1886 (Fourcade, 1889; Sim, 1906; Phillips, 1931; King, 1939, 1941; Rycroft, 1944; Palmer and Pitman, 1972; McCracken, 1986; Morty and Johnson, 1987). For example, King (1941) estimated that from 1772 to 1938 more than 120,000 m^3 of *O. bullata* was felled in forests between George and Plettenberg Bay — an average of 721 m^3 per annum. If the average stem yielded 0.4 m^3 (Sim, 1906), then an estimate of the total number of trees felled over 167 years is 300,868 — an average of 1802 trees per annum. Many State forests were reduced to a state of complete exhaustion (King, 1939), and in some years commercial exploitation increased to 1255 m^3 per annum (total of 3138 trees from 1889 to 1905) (Sim, 1906). Additionally, there has been detrimental exploitation for bark for the traditional medicine trade, documented from c. 1944 (Rycroft, 1944; Taylor, 1961, 1963; Cooper, 1979; Oatley, 1984; Dally, 1984; Morty and Johnson, 1987; Cunningham, 1988; Mander, 1998; Williams et al., 2000; Geldenhuys, 2004). When supporting information for the destructive timber extraction and bark exploitation was

Table 3
Families with 50 or more of the medicinal plant taxa, ranked according to proportion of medicinals.

Family	Number of medicinal species	Percentage of the 2062 taxa in South Africa that are medicinals	Size of the family in the SA flora
Asteraceae	257	12.5%	2236
Fabaceae	159	7.7%	1638
Apocynaceae	104	5.0%	689
Asphodelaceae	83	4.0%	558
Lamiaceae	68	3.3%	264
Euphorbiaceae	65	3.2%	387
Orchidaceae	63	3.1%	487
Malvaceae	50	2.4	332

combined, it was evident that *Ocotea* subpopulations in at least 53% of the quarter-degree squares it once occupied experienced massive declines in tree numbers and density, thereby rendering some of the subpopulations extinct, near-extinct, rare, scarce or fragmented.

By contrast, a tree less widespread in South Africa (*Brackenridgea zanguebarica*, Ochnaceae) has a national EOO of <35 km^2, and the one known subpopulation in South Africa is significantly disjunct from other African subpopulations occurring northwards to Tanzania (Williams and Raimondo, 2009). The species' restricted distribution is exacerbated by persistent harvesting for its roots and the degredative transformation of a large percentage of its remaining habitat, consequently resulting in an 86% population decline between 1990 and 1997 (Todd, 1999; Todd et al., 2004). This rate of decline is far more rapid than that recorded for *O. bullata*, and *B. zanguebarica* accordingly has a national assessment of CR A2ad; B1ab(ii,v).

The geographic proximity of many medicinal plant species (or their potential substitutes) to each other and in relation to traditional users also plays a large role in their susceptibility to harvesting. Arnold et al. (2002) demonstrated that the documented diversity of ethnomedicinal taxa (per quarter degree square) is most concentrated in northern and eastern South Africa, coinciding with the most fertile and densely settled regions of the country (Statistics South Africa, 2004; Keith and Warren, 2007). *B. volubilis* (Hyacinthaceae) provides a good example of just such a species. This bulbous taxon occurs from the Eastern Cape to Limpopo Province of South Africa, northwards through central Africa to Kenya (Bircher et al., 1998), and grows in a wide variety of habitats ranging from exposed screes to well-shaded forest floors, in the summer-rainfall region (Van Jaarsveld, 1992). *B. volubilis* is under severe pressure from medicinal plant harvesting in the majority of its range in South Africa, with an estimated minimum decline of 30% nationally during the past 30 years (Raimondo et al., 2009b). This estimated decline is based on observations of declines of known subpopulations as well as from measured reductions in the sizes of individual bulbs available in the medicinal plant markets. With a broad extent of occurrence of 486,300 km^2 (V.L. Williams, unpublished data), exact data on which historically known subpopulations have disappeared are not available. The species is very popular in trade and was rated by herb traders and rural herbalists in KwaZulu-Natal to be among the top six species that have become difficult to source (Cunningham, 1988). In Mpumalanga, only two subpopulations are known: one has been extirpated, and the other (in a private nature reserve) has experienced a 40% decline over the last decade. Other provinces have observed similar trends, with KwaZulu-Natal estimating a decline of 90% (30% during the past 30 years), and in Gauteng, a minimum 60% population decline in the Suikerbosrand Nature Reserve during the past ten years (Raimondo et al., 2009b). The large-scale and unsustainable extraction from nature reserves as well as privately owned land has resulted in a national Red List status of VU A2ad. The current Red List status, however, remains controversial, as some field workers have noted that it reproduces rapidly and is common in the more remote areas of the country (G. Nichols, pers. comm. cited in Raimondo et al., 2009b). Although in itself not quantitatively supported, this criticism may be justified, especially given that no actual figures supporting the percentage decline predicted are available. Inferences have had to be made from overall field observations, and bulb size reduction in the marketplace. In the absence of sufficient conclusive evidence, the precautionary principle is adhered to, and the species therefore remains in the VU category.

Williams (2010) indicated that there is a trend towards threatened medicinal species being more prevalent in a band along the eastern coastline of South Africa, and less threatened medicinal species occurring from the coast to the interior of the country. For these reasons, species outside of the geographic ranges most commonly exploited by harvesters are considerably less likely to be unsustainably targeted by users. The Northern Cape Bokkeveld endemic *Clivia mirabilis* (Hyacinthaceae) (VU D2), for example, is unlikely to be used as much as other members of the genus, all of which are known to be utilised (Crouch et al., 2003b; Williams, 2005) and are threatened by indiscriminate harvesting practices along the eastern coastline.

Not all species that are popular as medicinal plants and commonly found in the *muthi* markets are threatened with extinction. An example of this is *Elephantorrhiza elephantina* (Fabaceae), a widespread southern African suffrutex occurring in large colonies in grassland and possessing an extensive underground woody rootstock (Brenan, 1970; Schmidt et al., 2002). The species was assessed as Least Concern since there was no evidence to suggest that it is overly threatened by rhizome harvesting despite its popularity in the *muthi* trade (Williams, 2009). *E. elephantina* is heavily harvested, traded and very popular in the Eastern Cape markets (A.P. Dold, pers. comm.) and is fairly common in the Johannesburg and Mpumalanga markets as well (Botha et al., 2001; Williams, 2007). It is believed that the extensive underground stem coppices when damaged and is near-impossible to remove completely (A.P. Dold, pers. comm.), hence lowering the risk of over-exploitation.

4. Conclusions

Medicinal plants are culturally and economically important resources for a large proportion of South Africa's population. Hence, an understanding of their conservation status is important for guiding conservation policy development and action, and contextualizing community-based natural resource management and rural livelihood strategies. Accordingly, we have presented mainly quantitative data that elucidates the state of South Africa's ethnomedicinal taxa in terms of the numbers of species used, the proportion that are traded, and endemic, and threatened. Identified are some of the factors eliciting population declines, and challenges in assessing medicinal species that are mostly widespread compared to similarly threatened non-medicinal plants that tend to be range-restricted. It is hoped that this paper will inform the processes of advising on policy appropriate for the conservation of medicinal plants at national and provincial levels. The data presented are a baseline set against which future quantitative analyses of the conservation status of South Africa's medicinal plants can be compared, on the premise that their status is dynamic. Such comparisons will inform on progress towards achieving specific targets of the 2020 Global Strategy for Plant Conservation (GSPC), most especially Target 2 (an assessment of the conservation status of all known plant species, as far as possible, to guide conservation action) and Target 12 (all wild harvested plant-based products sourced sustainably) (GPPC, 2010).

Factors that influence whether or not taxa will face extinction threats include the size of the distribution range, the relative abundance of mature individuals in the wild and the intensity of the deterministic threat(s). For most medicinally harvested taxa, the extent of their geographic range is less of a factor in predicting risk since most of the species are widespread and the population numbers are still relatively high. However, type of harvesting, popularity and the resultant quantity harvested, as well as inherent life cycle characteristics (autecology) determine the extent of population decline and the sustainability of species use. It is, therefore, anticipated that future Red List updates of ethnomedicinal plants will require further input from experts (as new knowledge becomes available) and the consideration of 'grey' literature sources that are neither peer-reviewed nor mainstreamed. Exactly what proportion of the documented medicinal plant taxa are currently conserved within protected areas is unknown, and baseline monitoring should be promoted to facilitate conservation planning.

Since certain factors (e.g. plant parts removed, harvesting intensity, inherent susceptibility to wound infection, regeneration rates) render some taxa more vulnerable than others to harvesting for medicinal purposes, the IUCN Red List system provides an excellent tool in South Africa for prioritising taxa that are threatened with extinction in the short and medium term. Currently, based on the RLI, less than 2.6% of the medicinal species in South Africa (i.e. <0.3% of the total national indigenous flora) are predicted to be at risk of extinction if no remedial and/or preventative conservation actions are taken. Hence, while medicinal plant

harvesting poses threats to the persistence of socio-economically valuable species, such harvesting is not a significant driver of plant population decline nationally within the context of all (combined) factors threatening South Africa's flora. Readers are referred to Raimondo et al. (2009a) for information on the diversity and scale of such threats. It is important to note, however, that species undergoing decline as a result of unsustainable exploitation to a degree not measureable by the Red List Index (e.g. LC species) may have to undergo substantial changes in population size before their threat status changes sufficiently to reveal the degree of risk to their persistence (Butchart, 2008). Hence, the category of 'Declining' employed in South Africa is a useful means of highlighting which medicinal species are in need of conservation monitoring and intervention. In theory, such action could prevent population declines, ensuring that taxa statuses are not upgraded to threatened or Near Threatened. It thus serves as an 'early warning system' that can inform conservation authorities of which taxa to target.

The harvesting and trade of plant (and animal) material from wild populations for medicinal purposes have been, and remain, a controversial issue, particularly with regard to biodiversity conservation. Socio-economic gains in the short term are often put before long term sustainability of both resources and traditional medicinal practices (Crouch and Smith, 2011). It is our intention that this list of threatened medicinal plant species highlights the importance of conservation management with respect to particular taxa (Appendix A), informing policy development, national and provincial legislation (e.g. TOPS), law enforcement, and most importantly, proactive alternative supply of market-demanded materials through cultivation (Gerstner, 1946; Crouch, 2001; Crouch and Edwards, 2004). Ongoing monitoring of harvesting and trade is required, using techniques comparable to those used historically to quantify these elements, and so allow for the elucidation of trends. Such research should further refine this list and thus re-prioritise species for crucial conservation action.

While it is possible to use market research as a proxy for assessing the condition of medicinal resources in the wild, our current quantitative knowledge of standing stocks is highly deficient both within and outside of theoretically protected areas. For selected species that are currently at high risk, extensive field survey work is needed. In this respect it is necessary to assess and monitor populations (e.g. establishing localities, number of subpopulations, number of mature individuals, genetic diversity, habitat quality, susceptibility to climate change, threats beyond harvesting), and to undertake the autecological research (e.g. generation time, seed viability, pollination ecology, susceptibility to disease post harvesting) that underpins data generation necessary for accurate Red Listing, but which are often difficult to estimate. Management plans for susceptible species are informed by Red Lists, which in turn require quantitative consideration to establish their value limits. The current contribution has thus considered the status, trends, and assessment challenges associated with Red Listing of medicinal plants in South African in support of Target 3 of the GSPC (information, research and associated outputs, and methods necessary to implement the Strategy developed and shared) (GPPC, 2010).

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Appendix A

The medicinal plant species in South Africa that are threatened or are of conservation concern (correct as of September 2012; footnotes indicate status changes since 2009).

Name[a]	Status	Criteria	Family	Recorded in trade
Encephalartos nubimontanus	EW		Zamiaceae	
Encephalartos woodii	EW		Zamiaceae	
Adenium swazicum	CR	A4acd	Apocynaceae	Yes
Agathosma gonaquensis	CR	B1ab(ii,iii,iv,v)	Rutaceae	No
Brackenridgea zanguebarica	CR	A2ad; B1ab(ii,v)	Ochnaceae	Yes
Dioscorea strydomiana	CR	B1ab(v) + 2ab(v); C1	Dioscoreaceae	Yes
Encephalartos cupidus	CR	A2acd; B1ab(ii,iv,v) + 2ab(ii,iv,v)	Zamiaceae	No
Encephalartos dolomiticus	CR	A2d; C1	Zamiaceae	Yes
Encephalartos heenanii	CR	B1ab(ii,iv,v) + 2ab(ii,iv,v)	Zamiaceae	Yes
Encephalartos hirsutus	CR	A4acd; B2ab(iii,iv,v); C1	Zamiaceae	No
Encephalartos laevifolius	CR	A2acde	Zamiaceae	Yes
Encephalartos latifrons	CR	A2ad; B2ab(ii,iii,v); C1 + 2a(i)	Zamiaceae	No
Satyrium rhodanthum	CR	B1ab(i,ii,iii)	Orchidaceae	No
Siphonochilus aethiopicus	CR	A4acd	Zingiberaceae	Yes
Widdringtonia cedarbergensis	CR	A2ab	Cupressaceae	No
Adenia wilmsii	EN	D	Passifloraceae	Yes
Adromischus mammillaris	EN	B1ab(iii) + 2ab(iii)	Crassulaceae	No
Albizia suluensis	EN	B1ab(ii,iii,v) + 2ab(ii,iii,v); C2a(ii)	Fabaceae	Yes
Begonia dregei	EN	C2a(i)	Begoniaceae	Yes
Begonia homonyma	EN	C2a(i)	Begoniaceae	Yes
Cassipourea flanaganii	EN	A4acd; C1 + 2a(i)	Rhizophoraceae	Yes
Cyrtanthus suaveolens	EN	B1ab(i,ii,iii)	Amaryllidaceae	No
Encephalartos eugene-maraisii	EN	A2d; C1	Zamiaceae	No
Encephalartos horridus	EN	A2cd	Zamiaceae	No
Encephalartos lebomboensis	EN	A2acd; B1ab(ii,iii,iv,v) + 2ab(ii,iii,iv,v)	Zamiaceae	Yes
Euphorbia woodii	EN	A4cd	Euphorbiaceae	Yes
Haworthia attenuata var. *attenuata*	EN	A4acd	Asphodelaceae	Yes
Haworthia koelmaniorum var. *macmurtryi*	EN	B1ab(iii,v) + 2ab(iii,v)	Asphodelaceae	Yes
Ledebouria galpinii	EN	B1ab(iii) + 2ab(iii)	Hyacinthaceae	Yes
Leucospermum conocarpodendron subsp. *conocarpodendron*	EN	B1ab(i,ii,iii,iv,v) + 2ab(i,ii,iii,iv,v)	Proteaceae	No
Mondia whitei	EN	A2ad	Apocynaceae	Yes
Ocotea bullata	EN	A2bd	Lauraceae	Yes

Appendix A (*continued*)

Name[a]	Status	Criteria	Family	Recorded in trade
Sparaxis grandiflora subsp. *grandiflora*	EN	B1ab(ii,iii,v)	Iridaceae	No
Warburgia salutaris	EN	A2acd	Canellaceae	Yes
Alepidea amatymbica vars	VU	A2d	Apiaceae	Yes
Alepidea macowani	VU	A2ad; B1ab(v)	Apiaceae	Yes
Aloe dichotoma	VU	A3ce	Asphodelaceae	No
Aloe pruinosa	VU	B1ab(ii,iii,v)	Asphodelaceae	Yes
Arctopus dregei	VU	B1ab(i,ii,iii,iv,v)	Apiaceae	No
Argyrolobium longifolium	VU	B1ab(i,iii,v)	Fabaceae	No
Bowiea volubilis subsp. *volubilis*	VU	A2ad	Hyacinthaceae	Yes
Cassipourea gummiflua var. *verticillata*	VU	A4acd	Rhizophoraceae	Yes
Ceropegia cimiciodora	VU	B2ab(ii,iii,v)	Apocynaceae	No
Clivia gardenii	VU	A2abcd; B1ab(ii,iv,v)	Amaryllidaceae	Yes
Clivia miniata var. *miniata*	VU	A2abcd	Amaryllidaceae	Yes
Clivia nobilis	VU	A2cd	Amaryllidaceae	Yes
Clivia robusta	VU	A2cd; B1ab(ii,iii,v)	Amaryllidaceae	Yes
Crinum moorei	VU	A4de	Amaryllidaceae	Yes
Cryptocarya myrtifolia	VU	A2cd	Lauraceae	Yes
Cucumis humifructus	VU	B1ab(ii,v)	Cucurbitaceae	No
Diaphananthe millarii	VU	B1ab(iii,v)	Orchidaceae	No
Dioscorea brownii	VU	D2	Dioscoreaceae	No
Dioscorea sylvatica vars	VU	A2cd	Dioscoreaceae	Yes
Dracosciadium italae	VU	B1ab(i,ii,iii)	Apiaceae	No
Drimia cooperi	VU	A2ad; C2a(i)	Hyacinthaceae	Yes
Encephalartos altensteinii	VU	A2acd; C1	Zamiaceae	Yes
Encephalartos ghellinckii	VU	C1	Zamiaceae	Yes
Encephalartos humilis	VU	A2acd; C1	Zamiaceae	Yes
Encephalartos ngoyanus	VU	A4acd; C1	Zamiaceae	Yes
Encephalartos paucidentatus	VU	A2acd; B1ab(v) + 2ab(v); C1	Zamiaceae	No
Encephalartos senticosus	VU	A2ace; C1	Zamiaceae	Yes
Eriospermum bracteatum	VU	D2	Eriospermaceae	Yes
Eucomis vandermerwei	VU	B1ab(i,ii,iii,iv,v) + 2ab(i,ii,iii,iv,v)	Hyacinthaceae	Yes
Euphorbia franksiae	VU	A2cd	Euphorbiaceae	Yes
Gasteria croucheri	VU	A2d	Asphodelaceae	Yes
Gerrardanthus tomentosus	VU	D1 + 2	Cucurbitaceae	Yes
Haworthia koelmaniorum var. *koelmaniorum*	VU	A2acd; C2a(i)	Asphodelaceae	Yes
Haworthia limifolia vars	VU	A2d	Asphodelaceae	Yes
Hydrostachys polymorpha	VU	D2	Hydrostachyaceae	Yes
Knowltonia bracteata	VU	A2d; B2ab(v)	Ranunculaceae	Yes
Leucadendron procerum	VU	A4c	Proteaceae	No
Ocotea kenyensis	VU	D1	Lauraceae	Yes
Oncosiphon africanum	VU	B1ab(ii,iii,iv,v)	Asteraceae	No
Orbea woodii	VU	B1ab(v)	Apocynaceae	Yes
Pleiospilos bolusii	VU	B1ab(iii,v)	Mesembryanthemaceae	No
Prunus africana	VU	A4acd; C1 + 2a(i)	Rosaceae	Yes
Rhynchosia vendae	VU	B1ab(i,ii,iii,iv,v) + 2ab(i,ii,iii,iv,v)	Fabaceae	Yes
Sceletium expansum	VU	B1ab(ii,iii,iv,v)	Mesembryanthemaceae	Yes
Schlechterina mitostemmatoides	VU	B1ab(ii,iii,v) + 2ab(ii,iii,v)	Passifloraceae	Yes
Stangeria eriopus	VU	A2acd + 4cd	Stangeriaceae	Yes
Steirodiscus tagetes	VU	B1ab(ii,iii,iv,v)	Asteraceae	No
Umtiza listeriana	VU	B1ab(v)	Fabaceae	Yes
Adenia fruticosa subsp. *fruticosa*	NT	A2c; B1ab(iii,v) + 2ab(iii,v)	Passifloraceae	Yes
Alberta magna	NT	B2ab(ii,iii,v)	Rubiaceae	Yes
Aloe linearifolia	NT	A2c; B1ab(ii,iii,iv,v)	Asphodelaceae	Yes
Aloe micracantha	NT	B1ab(ii,iii,iv,v)	Asphodelaceae	No
Aloe thraskii	NT	A2c	Asphodelaceae	Yes
Anemone fanninii	NT	A2d	Ranunculaceae	Yes
Asparagus stipulaceus	NT	B1ab(ii,iii,iv,v)	Asparagaceae	No
Clivia caulescens	NT	A3d	Amaryllidaceae	Yes
Combretum mkuzense	NT	B1ab(ii,iii,iv,v)	Combretaceae	No
Cotyledon orbiculata var. *flanaganii*	NT	D2	Crassulaceae	Yes
Crinum campanulatum	NT	B1a	Amaryllidaceae	Yes
Curtisia dentata	NT	A2d	Cornaceae	Yes
Cyrtanthus mackenii subsp. *cooperi*	NT	A2c	Amaryllidaceae	Yes
Drimia sanguinea	NT	A2d	Hyacinthaceae	Yes
Elaeodendron transvaalense	NT	A4ad	Celastraceae	Yes
Encephalartos caffer	NT	A2	Zamiaceae	Yes
Encephalartos ferox[b]	NT	A4d	Zamiaceae	Yes
Encephalartos friderici-guilielmi[c]	NT	A2d	Zamiaceae	Yes
Encephalartos lehmannii	NT	A2d	Zamiaceae	Yes
Encephalartos longifolius	NT	A2d; B1ab(v)	Zamiaceae	Yes
Encephalartos natalensis	NT	A2ad	Zamiaceae	Yes
Erythrophleum lasianthum	NT	A2cd; B1ab(ii,iii,iv,v) + 2ab(ii,iii,iv,v)	Fabaceae	Yes
Eucomis bicolor	NT	A2d	Hyacinthaceae	Yes
Eucomis pallidiflora subsp. *pole-evansii*	NT	B2ab(v)	Hyacinthaceae	Yes
Euphorbia meloformis subsp. *meloformis*	NT	B1ab(i,ii,iii,iv,v)	Euphorbiaceae	No

(*continued on next page*)

Appendix A (*continued*)

Name[a]	Status	Criteria	Family	Recorded in trade
Gasteria batesiana var. *batesiana*	NT	A2d; B1ab(v)	Asphodelaceae	Yes
Gethyllis ciliaris subsp. *ciliaris*	NT	A2ac; B1ab(ii,iii,iv,v)	Amaryllidaceae	No
Haemanthus deformis	NT	B1ab(v)	Amaryllidaceae	Yes
Haworthia fasciata	NT	B1ab(ii,iii,iv,v)	Asphodelaceae	Yes
Helichrysum cochleariforme	NT	B1ab(ii,iii,iv,v)	Asteraceae	No
Hoodia officinalis subsp. *officinalis*	NT	B1ab(v)	Apocynaceae	Yes
Hoodia pilifera subsp. *pilifera*	NT	B1ab(iii,v)	Apocynaceae	Yes
Lithops lesliei subsp. *burchellii*	NT	D2	Mesembryanthemaceae	Yes
Lithops lesliei subsp. *lesliei*	NT	A4acd	Mesembryanthemaceae	Yes
Merwilla plumbea	NT	A2bd	Hyacinthaceae	Yes
Pelargonium exhibens	NT	D2	Geraniaceae	Yes
Synaptolepis oliveriana	NT	A4d	Thymelaeaceae	Yes
Urginea lydenburgensis	NT	B1ab(v)	Hyacinthaceae	Yes
Vanilla roscheri	NT	D2	Orchidaceae	No
Acridocarpus natalitius vars	Declining		Malpighiaceae	Yes
Adenia gummifera var. *gummifera*	Declining		Passifloraceae	Yes
Agathosma betulina	Declining		Rutaceae	Yes
Agathosma crenulata	Declining		Rutaceae	Yes
Aloe cooperi subsp. *cooperi*	Declining		Asphodelaceae	Yes
Ansellia africana	Declining		Orchidaceae	Yes
Balanites maughamii subsp. *maughamii*	Declining		Balanitaceae	Yes
Boophone disticha	Declining		Amaryllidaceae	Yes
Callilepis leptophylla	Declining		Asteraceae	Yes
Cassipourea malosana	Declining		Rhizophoraceae	Yes
Crinum bulbispermum	Declining		Amaryllidaceae	Yes
Crinum macowanii	Declining		Amaryllidaceae	Yes
Crinum stuhlmannii	Declining		Amaryllidaceae	Yes
Cryptocarya latifolia	Declining		Lauraceae	Yes
Cryptocarya transvaalensis	Declining		Lauraceae	Yes
Cyathea capensis var. *capensis*	Declining		Cyathaceae	Yes
Cyrtanthus obliquus	Declining		Amaryllidaceae	Yes
Dioscorea elephantipes	Declining		Dioscoreaceae	Yes
Drimia altissima	Declining		Hyacinthaceae	Yes
Elaeodendron croceum	Declining		Celastraceae	Yes
Eucomis autumnalis subspp.	Declining		Hyacinthaceae	Yes
Eucomis comosa vars	Declining		Hyacinthaceae	Yes
Eucomis montana	Declining		Hyacinthaceae	Yes
Eulophia speciosa	Declining		Orchidaceae	Yes
Euphorbia bupleurifolia	Declining		Euphorbiaceae	Yes
Gunnera perpensa	Declining		Gunneraceae	Yes
Hypoxis hemerocallidea	Declining		Hypoxidaceae	Yes
Ilex mitis var. *mitis*	Declining		Aquifoliaceae	Yes
Loxostylis alata	Declining		Anacardiaceae	Yes
Newtonia hildebrandtii var. *hildebrandtii*	Declining		Fabaceae	No
Prionium serratum	Declining		Prioniaceae	Yes
Pterocelastrus rostratus	Declining		Celastraceae	Yes
Rapanea melanophloeos	Declining		Myrsinaceae	Yes
Sandersonia aurantiaca	Declining		Colchicaceae	Yes
Asparagus spinescens	Rare		Asparagaceae	No
Brachystelma meyerianum	Rare		Apocynaceae	No
Cephalaria decurrens	Rare		Dipsacaceae	No
Crassula arborescens subsp. *undulatifolia*	Critically Rare		Crassulaceae	No
Crassula sarmentosa var. *integrifolia*	Rare		Crassulaceae	Yes
Disa sanguinea	Rare		Orchidaceae	No
Euphorbia sekukuniensis	Rare		Euphorbiaceae	No
Faurea macnaughtonii	Rare		Proteaceae	Yes
Gasteria bicolor var. *liliputana*	Rare		Asphodelaceae	No
Greyia flanaganii	Rare		Greyiaceae	No
Haemanthus pauculifolius	Rare		Amaryllidaceae	No
Huernia pendula	Rare		Apocynaceae	No
Orbea gerstneri subsp. *gerstneri*	Rare		Apocynaceae	No
Killickia grandiflora	Rare		Lamiaceae	No
Scabiosa transvaalensis	Thr*		Dipsacaceae	No
Tetradenia barberae	Rare		Lamiaceae	No
Thunbergia venosa	Rare		Acanthaceae	Yes
Vitellariopsis dispar	Rare		Sapotaceae	Yes
Acanthosicyos horridus[d]	DDD		Cucurbitaceae	No
Hoodia gordonii	DDD		Apocynaceae	Yes
Isoglossa densa	DDD		Acanthaceae	No
Syringodea flanaganii	DDD		Iridaceae	Yes

[a]Taxa downgraded to LC: *Acacia mellifera* subsp. *detinens* and *Pelargonium sidoides* (previously Declining); *Orbea paradoxa* and *Tritonia gladiolaris* (previously Rare).
[b]Previous assessment: LC.
[c]Previous assessment: VU C1.
[d]Previous assessment: CR PE.

Appendix B

List of plant families used for traditional medicine in South Africa, the number of species per family, the percentage of the total number of medicinal species used within the family, and the percentage of species threatened and of conservation concern. Proportion of the total medicinal flora in South Africa.

Family	Number of species used per family	% of the total medicinal flora used in South Africa (n = 2062)	% species per family threatened or Near Threatened
Acanthaceae	31	1.5%	
Achariaceae	3	0.1%	
Agapanthaceae	8	0.4%	
Agaricaceae	1	0.05%	
Aizoaceae	4	0.2%	
Alliaceae	10	0.5%	
Amaranthaceae	13	0.6%	
Amaryllidaceae	42	2.0%	26.2%
Anacardiaceae	29	1.4%	
Anemiaceae	1	0.05%	
Annonaceae	8	0.4%	
Anthericaceae	4	0.2%	
Apiaceae	39	1.9%	10.3%
Apocynaceae	104	5.0%	7.7%
Aponogetonaceae	1	0.05%	
Aquifoliaceae	1	0.05%	
Araceae	3	0.1%	
Araliaceae	6	0.3%	
Arecaceae	2	0.1%	
Asparagaceae	24	1.2%	4.2%
Asphodelaceae	83	4.0%	14.5%
Asteraceae	257	12.5%	1.2%
Balanitaceae	2	0.1%	
Balanophoraceae	1	0.05%	
Balsaminaceae	1	0.05%	
Begoniaceae	3	0.1%	66.7%
Behniaceae	1	0.05%	
Bignoniaceae	3	0.1%	
Blechnaceae	1	0.05%	
Boraginaceae	14	0.7%	
Brassicaceae	6	0.3%	
Buddlejaceae	7	0.3%	
Burseraceae	4	0.2%	
Buxaceae	1	0.05%	
Cactaceae	1	0.05%	
Campanulaceae	8	0.4%	
Canellaceae	1	0.05%	100.0%
Capparaceae	19	0.9%	
Caryophyllaceae	15	0.7%	
Celastraceae	20	1.0%	5.0%
Celtidaceae	5	0.2%	
Chenopodiaceae	3	0.1%	
Chrysobalanaceae	2	0.1%	
Clusiaceae	2	0.1%	
Colchicaceae	4	0.2%	
Combretaceae	16	0.8%	6.3%
Commelinaceae	5	0.2%	
Convolvulaceae	17	0.8%	
Cornaceae	1	0.05%	100.0%
Crassulaceae	32	1.6%	6.3%
Cucurbitaceae	24	1.2%	12.5%
Cunoniaceae	1	0.05%	
Cupressaceae	2	0.1%	50.0%
Cyatheaceae	2	0.1%	
Cyperaceae	7	0.3%	
Dennstaedtiaceae	1	0.05%	
Dioscoreaceae	8	0.4%	37.5%
Dipsacaceae	8	0.4%	
Dracaenaceae	4	0.2%	
Dryopteridaceae	3	0.1%	
Ebenaceae	15	0.7%	
Elatinaceae	1	0.05%	
Equisetaceae	1	0.05%	
Eriospermaceae	6	0.3%	16.7%
Euphorbiaceae	65	3.2%	4.6%
Fabaceae	159	7.7%	3.1%
Flacourtiaceae	3	0.1%	
Gentianaceae	10	0.5%	
Geraniaceae	37	1.8%	2.7%
Gesneriaceae	1	0.05%	
Greyiaceae	2	0.1%	
Gunneraceae	1	0.05%	
Haemodoraceae	1	0.05%	
Hernandiaceae	1	0.05%	
Heteropyxidaceae	2	0.1%	
Hyacinthaceae	44	2.1%	20.5%
Hydnoraceae	2	0.1%	
Hydrostachyaceae	1	0.05%	100.0%
Hypericaceae	1	0.05%	
Hypoxidaceae	10	0.5%	
Icacinaceae	5	0.2%	
Iridaceae	41	2.0%	2.4%
Lamiaceae	68	3.3%	
Lauraceae	7	0.3%	42.9%
Lecythidaceae	1	0.05%	
Lentibulariaceae	3	0.1%	
Lessoniaceae	1	0.05%	
Linaceae	2	0.1%	
Lobeliaceae	10	0.5%	
Loranthaceae	2	0.1%	
Lycopodiaceae	4	0.2%	
Lythraceae	1	0.05%	
Maesaceae	2	0.1%	
Malpighiaceae	3	0.1%	
Malvaceae	50	2.4%	
Melastomataceae	2	0.1%	
Meliaceae	6	0.3%	
Melianthaceae	7	0.3%	
Menispermaceae	12	0.6%	
Menyanthaceae	1	0.05%	
Mesembryanthemaceae	22	1.1%	18.2%
Molluginaceae	6	0.3%	
Monimiaceae	1	0.05%	
Moraceae	9	0.4%	
Musaceae	1	0.05%	
Myricaceae	4	0.2%	
Myrothamnaceae	1	0.05%	
Myrsinaceae	2	0.1%	
Myrtaceae	4	0.2%	
Nymphaeaceae	2	0.1%	
Ochnaceae	7	0.3%	14.3%
Olacaceae	2	0.1%	
Oleaceae	8	0.4%	
Orchidaceae	63	3.1%	4.8%
Orobanchaceae	11	0.5%	
Oxalidaceae	4	0.2%	
Passifloraceae	6	0.3%	50.0%
Pedaliaceae	7	0.3%	
Phyllanthaceae	9	0.4%	
Phytolaccaceae	2	0.1%	
Piperaceae	1	0.05%	
Pittosporaceae	1	0.05%	
Plantaginaceae	1	0.05%	
Plumbaginaceae	1	0.05%	
Poaceae	25	1.2%	
Podocarpaceae	3	0.1%	
Polygalaceae	21	1.0%	
Polygonaceae	9	0.4%	
Polypodiaceae	2	0.1%	
Portulacaceae	7	0.3%	
Potamogetonaceae	1	0.05%	
Prioniaceae	1	0.05%	
Proteaceae	13	0.6%	15.4%
Ptaeroxylaceae	1	0.05%	
Pteridaceae	9	0.4%	
Putranjivaceae	1	0.05%	
Ranunculaceae	12	0.6%	16.7%

(continued on next page)

Appendix B (*continued*)

Family	Number of species used per family	% of the total medicinal flora used in South Africa (n = 2062)	% species per family threatened or Near Threatened
Restionaceae	1	0.05%	
Rhamnaceae	8	0.4%	
Rhizophoraceae	6	0.3%	33.3%
Rosaceae	11	0.5%	9.1%
Rubiaceae	46	2.2%	2.2%
Rutaceae	21	1.0%	4.8%
Salicaceae	9	0.4%	
Salvadoraceae	2	0.1%	
Samydaceae	1	0.05%	
Santalaceae	6	0.3%	
Sapindaceae	10	0.5%	
Sapotaceae	9	0.4%	
Scrophulariaceae	24	1.2%	
Selaginellaceae	3	0.1%	
Smilacaeae	1	0.05%	
Solanaceae	14	0.7%	
Stangeriaceae	1	0.05%	100.0%
Strelitziaceae	2	0.1%	
Strychnaceae	7	0.3%	
Tamaricaceae	1	0.05%	
Tecophilaeaceae	1	0.05%	
Theophrastaceae	1	0.05%	
Thymelaeaceae	15	0.7%	13.3%
Typhaceae	1	0.05%	
Urticaceae	5	0.2%	
Valerianaceae	1	0.05%	
Velloziaceae	2	0.1%	
Verbenaceae	5	0.2%	
Violaceae	2	0.1%	
Viscaceae	6	0.3%	
Vitaceae	12	0.6%	
Zamiaceae	24	1.2%	91.7%
Zingiberaceae	1	0.05%	100.0%
Zygophyllaceae	2	0.1%	

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