Distribution and conservation status of the Endangered pepperbark tree *Warburgia salutaris* (Canellaceae) in Swaziland

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Abstract The Endangered *Warburgia salutaris* (Bertol. f.) Chiov. (Canellaceae), a sought-after medicinal plant in southern Africa, is on the verge of extinction as a result of overexploitation for illegal trade. As part of formulating a conservation strategy for the species in Swaziland we sought to determine its distribution and population status and to revise its national conservation status. Field surveys were conducted in all physiographic regions of Swaziland. Eighteen locations of species presence were found, of which 14 were new records. Three were within protected areas, and seven were in areas worthy of protection. The largest subpopulations occurred in two of the latter areas, Ngudzeni and Sitsatsaweni (351 and 230 individuals, respectively), and one unprotected area, Bulunga (250 individuals). *Warburgia salutaris* has a severely fragmented distribution and an area of occupancy of 192 km². Of 700 mature individuals 38% were ring-barked and 7% felled, and some subpopulations had ring-barked juveniles. This indicates a plausible decline in number of mature individuals. Most localities in unprotected areas are eroded and invaded by alien plants, indicating a decline in habitat quality. Our findings indicate that *W. salutaris* should be categorized as Endangered nationally based on criteria B2ab (iii,v). Although this status implies a lower level of threat than the previous national categorization as Critically Endangered, it does not imply an improved conservation effort in the country, but rather a more accurate assessment based on more data. We have clarified the conservation status of *W. salutaris* in Swaziland, discovered some previously undocumented subpopulations and identified potential conservation interventions. We recommend that this information be used in setting priorities to ensure conservation of the species.

Keywords Africa, medicinal plants, pepperbark tree, protection-worthy area, Swaziland, *Warburgia salutaris*

Warburgia salutaris is a popular medicinal tree in southern Africa, where there is widespread use of medicinal plants (Van Wyk, 2011). Stem bark is the most commonly used part of the tree, and leaves and roots are also used. It is claimed to treat numerous illnesses, including bronchial infections, colds, gastric ulcers, malaria, oral thrush, rheumatism, sinusitis and venereal diseases (Van Wyk, 2011; Maroyi, 2013; Leonard & Viljoen, 2015), and several phytochemical and pharmacological studies attest to its medicinal value (Rabe & van Staden, 2000; Madikane et al., 2007; Mohanlall & Odhav, 2009; Green et al., 2010). However, such popularity makes it a sought-after species, resulting in overharvesting, mainly for illegal trade (Botha et al., 2004). Consequently, it is categorized as Endangered on the IUCN Red List (Hilton-Taylor et al., 1998). In Zimbabwe it is categorized as Extinct in the Wild (Maroyi, 2008) and exists only in cultivated populations (Maroyi, 2012). In South Africa it is categorized as Endangered and is in continual decline (Williams et al., 2008), and in Swaziland it is categorized as Critically Endangered (Dlamini & Dlamini, 2002).

Prior to this study there were only four occurrence records of *W. salutaris* in Swaziland, at Bulunga (Compton, 1976), Malolotja Nature Reserve (Dlamini & Dlamini, 2002), Shewula and Mlawula (Loffler & Loffler, 2005), and no specimens were held in the Swaziland National Herbarium. However, discussions with foresters, traditional healers and local people revealed that subpopulations existed at other locations in the country. We conducted a country-wide survey to map the distribution of the species, estimate its population size, record threats, and revise its conservation status. This was done as part of formulating a conservation strategy to ensure sustainable utilization of the species and maintenance of genetic diversity. Given the widespread use of traditional medicine in Swaziland (Amusan, 2009), such a popular medicinal plant is vulnerable to overexploitation and ultimately extinction.

Field surveys were conducted during November 2011–December 2012 in representative areas of all physiographic regions of Swaziland. Five park rangers and 33 local people (traditional healers, herdsmen and plant enthusiasts) assisted with surveys in five protected areas and 15 unprotected areas, respectively. These study sites were identified through discussions with reserve managers and community leaders. As *W. salutaris* is popular and easy to identify, they had no difficulty leading the researchers to its exact locations, and some suggested potential locations beyond their villages,

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TABLE 1 Locations of *Warburgia salutaris* in Swaziland (Fig. 1), with habitat protection status, number of patches per location, and numbers of mature and juvenile individuals.

Location	Protection status	No. of patches	Mature			Juvenile (ring-barked)	Total (mature + juvenile)
			Ring-barked	Felled	Total		
Malolotja Nature Reserve*	Protected	6	0	0	38	40	78
Mhlumeni	Protected	4	0	0	21	46	67
Mlawula Nature Reserve*	Protected	5	0	0	39	6	45
Ekuvinjelweni	Protection-worthy	1	0	0	0	16	16
KaKholwane	Protection-worthy	1	20	4	24	6	30
KaPhunga	Protection-worthy	4	11	15	46	20	66
Mambane	Protection-worthy	1	0	0	10	20	30
Ngudzeni	Protection-worthy	14	27	0	101	250	351
Nyonyane Ranch	Protection-worthy	1	10	3	17	14	31
Sitsatsaweni	Protection-worthy	18	22	15	108	122	230
Bulunga*	Unprotected	19	84	2	155	95 (26)	250
Lomahasha	Unprotected	1	27	13	40	12	52
Mafutseni	Unprotected	2	10	0	10	25	35
Manzini	Unprotected	1	0	0	1	0	1
Nkwene	Unprotected	2	2	0	2	21	23
Shewula*	Unprotected	3	6	0	28	23	51
Sibovini	Unprotected	1	40	0	56	40	96
Timphisini	Unprotected	1	4	0	4	8	12
Total		85	263	52	700	764	1,464

*Previously known locations

which turned out to be correct. Eighteen voucher specimens were collected and deposited in the Swaziland National Herbarium. Geographical coordinates, habitat characteristics, number of individuals (mature and juvenile), and physical damage to the plants were recorded. Semi-structured interviews were conducted with the rangers and local people to ascertain the uses of *W. salutaris*, threats to the species, and its conservation status.

We assessed the extinction risk of *W. salutaris* in Swaziland using IUCN guidelines (IUCN, 2012a,b), applying criterion B, which considers the species' geographical range, number of subpopulations, decline in habitat quality and number of mature individuals. Unlike other criteria, all data required for criterion B were available, facilitating an accurate assessment. A distribution map was plotted using *QGIS v. 2.2.0* (QGIS Development Team, 2014). The area of occupancy (AOO) and extent of occurrence (EOO) were calculated using the *GeoCAT* tool (Bachman et al., 2011).

Eighteen locations of *W. salutaris* were found, 14 of which were new records (Table 1, Fig. 1). The species occurs in small isolated patches, with 1–19 patches per location (Table 1). Three locations (16.5%) were in protected areas, and seven (38.9%) were in unprotected areas worthy of protection, as defined by Roques (2002) based on biological and social importance and threats to biodiversity. Formal protection of these protection-worthy areas would thus conserve at least 55% of the species' locations, provided harvesting was curbed. The largest subpopulations occurred in two protection-worthy areas, Ngudzeni and Sitsatsaweni (351 and 230 individuals, respectively), and in one unprotected area, Bulunga (250 individuals) (Table 1). We conclude that the previously sparse number of records of the species was attributable to lack of research rather than a paucity of the species in Swaziland.

Seven hundred mature individuals were recorded, of which 263 (38%) had been ring-barked and 7% were felled and debarked (Table 1). Juveniles were also ring-barked where mature individuals had been destroyed (Table 1). Such indiscriminate harvesting was observed only in unprotected areas, and all respondents attributed it to illegal trade. The need for supplementary income to alleviate poverty (48%), poor law enforcement (36%), and ignorance of the value of biodiversity (16%) were cited as drivers of the illegal trade. A decline in the number of mature individuals is inevitable if such indiscriminate harvesting persists. Soil erosion and invasive alien plants were prevalent in most of the unprotected areas, indicating a decline in habitat quality, and the occurrence of *W. salutaris* in small isolated subpopulations constitutes a severely fragmented distribution. Thus, despite not being as rare as previously supposed, the species is threatened.

The AOO and EOO were calculated to be 192 and 10,436.62 km^2, respectively. Although the EOO falls below the threshold for the Vulnerable category, the AOO corresponds to the Endangered category. Considering the ongoing decline in number of mature individuals and habitat quality, the severely fragmented distribution, and the EOO

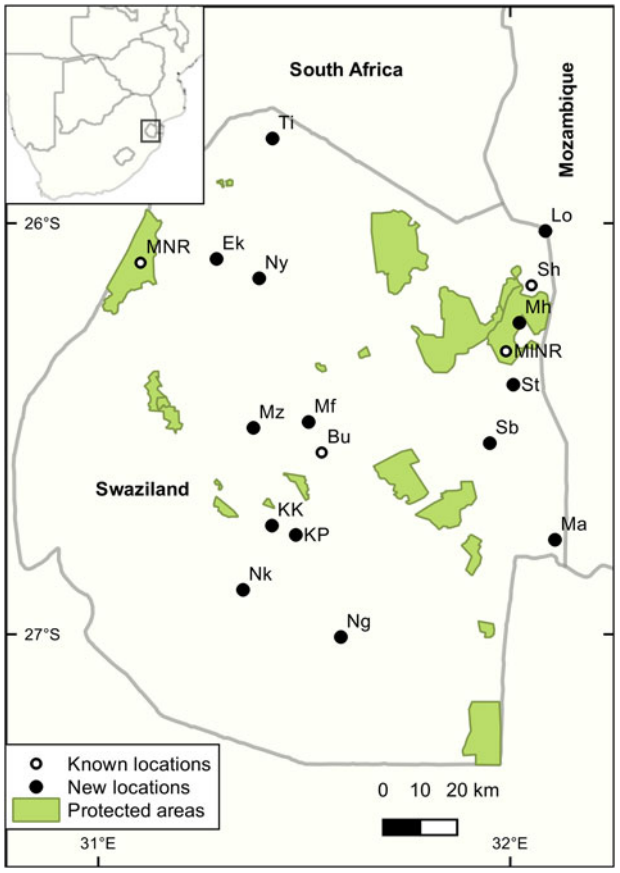

FIG. 1 Distribution of locations of *Warburgia salutaris* in Swaziland. Bu, Bulunga; Ek, Ekuvinjelweni; KK, KaKholwane; KP, KaPhunga; Lo, Lomahasha; Ma, Mambane; Mf, Mafutseni; Mh, Mhlumeni; MlNR, Mlawula Nature Reserve; MNR, Malolotja Nature Reserve; Mz, Manzini; Ng, Ngudzeni; Nk, Nkwene; Ny, Nyonyane Ranch; Sb, Sibovini; Sh, Shewula; St, Sitsatsaweni; Ti, Timphisini.

of < 500 km^2, *W. salutaris*, in Swaziland, meets the criteria for categorization as Endangered (EN B2ab (iii,v)). Although this represents a decreased extinction risk compared to the previous national assessment by Dlamini & Dlamini (2002), it does not imply an improvement in conservation efforts but rather a more accurate assessment based on more data.

Potential interventions cited in the interviews were improved law enforcement to curb illegal trade (61% of respondents), cultivating the species to relieve the pressure on wild populations (22%), and raising awareness about the value of biodiversity among community members (17%). This study has clarified the conservation status of *W. salutaris* in Swaziland and identified previously undocumented wild subpopulations. We recommend that this information be used in setting priorities for conservation of the species, and in updating the global status of the species on the IUCN Red List (IUCN, 2015). We will share our findings with conservation authorities in Swaziland to help guide conservation planning.

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Biographical sketches

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