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The population status of the Endangered endemic plant *Aloe peglerae*: Area of occupancy, population structure, and past population trends

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ABSTRACT

Aloe peglerae Schönland is a rare succulent plant species, which is endemic to South Africa. The species is currently listed as Endangered and is threatened mainly by illegal collection. The aim of this study was to determine the population status of *Aloe peglerae* in the Magaliesberg Mountain Range, that is, whether the population is declining, stable or increasing. Key population parameters assessed for this study included plant density, population structure, area of occupancy, population size, and rate of past population decline. Nine subpopulations were surveyed in 2009 and 2010 using a distance sampling technique. Also, these data were compared to data collected in 1999 by the Gauteng Department of Agriculture, Conservation and Environment, so as to determine possible population trends. The results showed a decline of 43% in mean population density between 1999 and 2010, suggesting that the population of *Aloe peglerae* in the Magaliesberg is in a state of decline. The application of this technique to plant populations is relatively novel and key recommendations are provided to improve survey design.

1. Introduction

The IUCN Red List Categories and Criteria have been used widely in determining the conservation status of species of conservation concern (Baillie et al., 2004). In order to accurately classify a species, up-to-date information is required on key population parameters such as population size, rate of population decline and extent of occurrence (Baillie et al., 2004). The most important threats to species include habitat loss, fragmentation and degradation, invasive species, overexploitation and climate change (Baillie et al., 2004; Hermy et al., 2007).

Aloe peglerae Schönland is a rare succulent plant species in the family Asphodelaceae, and is currently listed as Endangered (Van Wyk and Smith, 1996; Raimondo et al., 2009). The species is threatened mainly by the uncontrolled illegal collection of plants from wild populations (Pfab and Scholes, 2004). *A. peglerae* is endemic to South Africa, occurring only in the Gauteng and North West Provinces. The species is confined mainly to the Magaliesberg Mountain Range (Magaliesberg), with outlier populations near Krugersdorp and on the Witwatersberg (Pfab and Scholes, 2004). Plants generally grow at an altitude of 1 500 m on north-facing slopes (Scholes, 1988). According to Van Wyk and Smith (1996) *A. peglerae* plants grow as solitary rosettes, rarely forming small groups, with short or absent stems, and leaves curving inwards to form compact heads. Plants of this species are slow growing and have a lifespan of approximately 60 years (Pfab and Scholes, 2004).

An initial survey of the Magaliesberg population of *A. peglerae* was undertaken by the Gauteng Department of Agriculture, Conservation and Environment (GDACE) in 1999, with the aim of determining the impact of illegal plant collection. *A. peglerae* subpopulations were selected at nine sites in the Magaliesberg and surveyed using the line transect sampling technique of distance sampling.

According to Thomas et al. (2002) distance sampling is a widely used group of closely related methods for estimating the density and/or abundance of biological populations. Distance sampling methods have been applied successfully in a very diverse array of taxa including large ungulates (Koenen et al., 2002; Kruger et al., 2008), small mammals (Newey et al., 2003; Stenkewitz et al., 2010), fish (Ensign et al., 1995), birds (Buckland et al., 1993; Thompson, 2002), tortoises (Swann et al., 2002), and butterflies (Brown and Boyce, 1998). Only one study could be found where distance sampling has been used to estimate density in populations of plants (Beasom and Haucke, 1975).

Keith (2000) asserted that the availability of data on the number, size and structure of populations influences the effectiveness of risk assessment, priority setting, recovery planning and management of threatened species. Therefore, the primary objective of this study was to resurvey the nine sites surveyed previously by GDACE using the distance sampling technique applied in 1999. Accurate information on population trends is important in evaluating the conservation status of *A. peglerae*.

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2. Methods

2.1. Study area

This study was confined to the Magaliesberg, which extends from Pretoria, in the north of the Gauteng Province, to a point south of the Pilanesberg in Vlakfontein, North West Province (Carruthers, 1990). The Magaliesberg is situated mainly within the Central Bushveld climate region (Kruger, 2004). The precipitation of this climate region ranges between 500 mm and 750 mm per annum. The rainy season lasts from about November to March, with the peak rainfall in January. The mountain range is associated mainly with the Gold Reef Mountain Bushveld vegetation type (Mucina and Rutherford, 2006).

2.2. Site selection

In 1999 *A. peglerae* subpopulations were selected at nine sites in the Magaliesberg, with sites selected in accordance with their anticipated accessibility or inaccessibility to the public (Table 1). These subpopulations were considered to be a representative sample of the population of *A. peglerae* in the Magaliesberg. In relation to the IUCN Red List categories and criteria subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (Standards and Petitions Working Group, 2006). However it is acknowledged that the subpopulations selected in this study do not fit this definition as genetic exchange is highly likely. The term is used here for convenience to mean a portion of the Magaliesberg population.

2.3. Area of occupancy

The size of the area covered by each subpopulation (area of occupancy) was determined in order to estimate the subpopulation size from density estimates. Area of occupancy is defined as the area within its 'extent of occurrence' which is occupied by a taxon, excluding plants which may be considered as outliers (Standards and Petitions Working Group, 2006). A Global Positioning System (GPS) receiver was used to mark geographical coordinates along the periphery of each subpopulation. The coordinates were imported into the computer software programme ArcMap 9.3 to form area polygons. The area of each polygon was calculated using X-tools, which is an application of ArcMap 9.3.

2.4. Population structure

The method employed by Pfab and Scholes (2004) for classifying the size structure of *A. peglerae* populations was used, where individual plants recorded during the survey were classified into one of the following three classes:

- Seedling (crown diameter < 10 cm);
- Juveniles (crown diameter 10 cm–20 cm); and
- Mature plant (crown diameter > 20 cm).

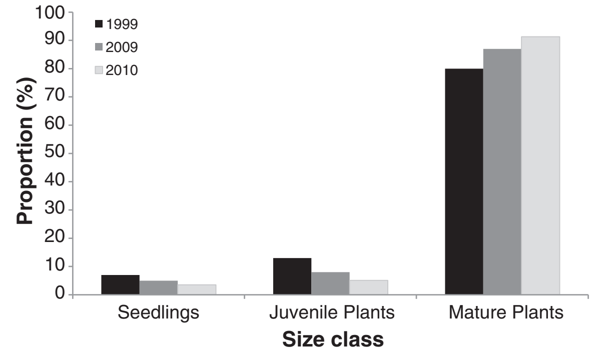

Fig. 1. The population size structure of the *Aloe peglerae* population in the Magaliesberg Mountain Range for the years 1999, 2009 and 2010.

2.5. Plant densities and line transect sampling

The field surveys were conducted during July and August of 2009, followed by a repeat survey during July and August of 2010. This period coincided with the flowering season of *A. peglerae*. The inflorescence is bright red in colour, which visibly contrasted with the late dry season background landscape. This provided the added advantage of improving visibility of plants to the observer.

A GPS receiver was used to locate the starting point of each line transect from the initial survey conducted in 1999. These transects were orientated in a south to north direction. The lengths of each line transect were measured.

One observer walked each line transect, searching for individual plants on either side of the transect line. For each plant detected, perpendicular distances were measured from the transect line to each plant and relevant demographic data such as canopy area and size class (as per 2.4) were collected. Generally, the probability of detecting an object decreases with increasing distance from the line. The key to distance sampling analyses is to fit a detection function to the observed distances and to use this fitted function to estimate the proportion of objects missed by the survey (Thomas et al., 2002). One of the main advantages of distance sampling is that some objects can remain undetected, thus making it suitable for situations in which a complete census is not possible (Buckland et al., 1993).

The distance data were analysed using the software program Distance 6.0. The program consists of a graphical interface that allows users to enter, import and view data, design surveys and run analyses (Thomas et al., 2010). Thomas et al. (2009) provide details of the analysis procedure in Distance 6.0. The Conventional Distance Sampling engine was used for analysis. This engine models detection probability as a function of distance from the line transect and assumes that all objects at zero distance are detected (Thomas et al., 2009).

Each analysis was assigned a unique name and a set of inputs and results associated with it. The software provides an easy step-by-step procedure whereby the user selects options, in the interface, such as the type of survey used (line or point), the number of observers,

Table 1
Summarised profile of the nine sample sites in the Magaliesberg Mountain Range.

Sample site	Altitude (metres)	Topographical position	Land use/activities	Land ownership
Site 1	1655	Crest	Private nature reserve	Private
Site 2	1567	Upper mid-slope	Camping and hiking	Private
Site 3	1477	Upper mid-slope	Open access	Public land
Site 4	1515	Crest	Hiking	Private
Site 5	1667	Crest	Private nature reserve	Private
Site 6	1638	Crest	Private nature reserve	Private
Site 7	1636	Crest	Hiking and mountain climbing	Private
Site 8	1541	Crest	Game and livestock farm	Private
Site 9	1635	Upper mid-slope	Conservancy	Private

Table 2
Plant density estimates for subpopulations of *Aloe peglerae* surveyed in 1999 using the line transect sampling technique. LCL: Lower Confidence Limit, UCL: Upper Confidence Limits and CV: Coefficient of Variation. Estimates of population size are not included as the area occupied by each subpopulation was not measured in 1999.

Sample site	Plants ha^{-1}	LCL	UCL	CV (%)
Site 1	119	86	163	16
Site 2	33	24	44	15
Site 3	157	115	215	16
Site 4	60	43	84	17
Site 5	131	91	189	19
Site 6	54	38	76	17
Site 7	188	140	252	15
Site 8	129	92	182	17
Site 9	36	22	57	24

Table 3
Plant density estimates for subpopulations of *Aloe peglerae* surveyed in 2009 using the line transect sampling technique. LCL: Lower Confidence Limit, UCL: Upper Confidence Limits, CV: Coefficient of Variation, AO: Area of Occupancy and N: total subpopulation size.

Sample site	Plants ha^{-1}	LCL	UCL	CV (%)	AO (ha)	N	N LCL	N UCL
Site 1	58	44	76	14	26	1507	1140	1993
Site 2	36	25	52	18	15	525	367	750
Site 3	114	80	163	18	7	784	551	1116
Site 4	25	16	39	16	9	231	147	364
Site 5	61	43	86	17	30	1838	1303	2593
Site 6	38	27	55	18	60	2280	1595	3259
Site 7	117	84	163	17	67	7759	5554	10,839
Site 8	62	45	84	16	63	3872	2830	5297
Site 9	54	41	72	14	60	3268	2485	4297

measurement type (perpendicular or radial distance), observations (clusters or single observations) and the measurement units. It also includes options such as data truncation and transformation of ungrouped data into interval data.

The analysis entailed a reiterative process of testing various data filter options and model-expansion combinations. The model-expansion combination of half-normal cosine was found to be appropriate for analysing the distance data. This combination consistently provided reliable estimates of density without showing errors in the analysis results. Data extrapolation was also performed for sites 1 and 2 where the total number of observations was low. The procedure entailed manipulating the field data to increase the number of observations and was conducted during the data preparation phase prior to importation of the data for analysis.

The Distance 6.0 software program provided a summary of results for each analysis, which included the following: number of parameters used, Akaike Information Criterion (AIC), estimate of density and respective confidence limits, Coefficient of Variation (CV), estimate of population size and respective confidence limits, and the probability of detection (Buckland et al., 1993). The student *t*-test was then used to test for statistically significant differences in the mean plant densities at the nine sites between the three survey periods.

3. Results and discussion

3.1. Area of occupancy and population structure

Estimates of the area of occupancy ranged in size from 7 ha in Site 3 to 67 ha in Site 7 (Table 3). Though the sample data used to determine subpopulation size structure varied between sites, in terms of the total number of observations, the subpopulations exhibited similar size structure. Thus the sample data were pooled to represent the size structure for *A. peglerae* in the Magaliesberg. Overall, the population size structure was found to be predominantly comprised of mature plants, followed by juvenile plants and seedlings (Fig. 1). This size structure did not change since the first survey in 1999 (Fig. 1). Scholes (1988) showed that *A. peglerae* exhibited low recruitment and low mortality, as well as a slow growth habit. This means that although recruitment is low, established mature plants can persist for long periods, and thus have a chance to reproduce. Continued long term monitoring of the population demography will contribute to a clearer understanding of the population dynamics of *A. peglerae*.

3.2. Population trends

Density estimates for the 1999 survey ranged between 33 plants ha^{-1} in Site 2 and 188 plants ha^{-1} in Site 7 (Table 2). Overall the mean plant density in 1999 was 101 plants ha^{-1} (SD 56.4) with an average CV of 17% (SD 2.8). It is interesting to note that the density of *A. peglerae* plants was lowest at sites considered by GDACE in 1999 to be highly accessible to the public (sites 4, 6 and 9, inclusive of a site accessible by cable car and another accessible by a service road for telecommunication towers) (Table 2, Fig. 2). Site 2, also a site with a low density of *A. peglerae* plants (Table 2, Fig. 2), was considered in 1999 to have low public access, however this site is open to hikers and campers (Table 1). This observation accords with the suggestion of Pfab and Scholes (2004) that low levels of incidental removal of plants in accessible areas of the Magaliesberg are sufficient to impact detrimentally on populations of *A. peglerae*.

Plant densities obtained from the 2009 field survey ranged between 25 plants ha^{-1} in Site 4 and 117 plants ha^{-1} in Site 7 (Table 3). Overall the mean plant density in 2009 was 63 Plants ha^{-1} (SD 32.4) with a

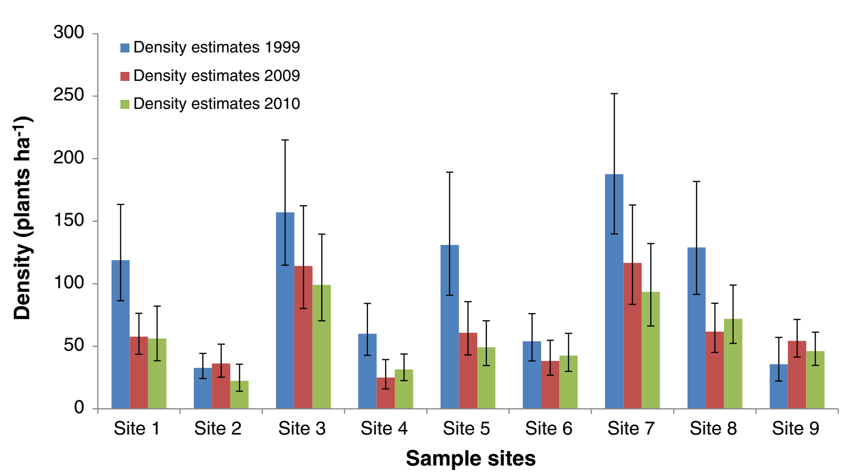

Fig. 2. Plant density estimates for subpopulations of *Aloe peglerae* surveyed in 1999, 2009 and 2010. The error bars show 95% confidence intervals.

Table 4
Plant density estimates for subpopulations of *Aloe peglerae* surveyed in 2010 using the line transect sampling technique. LCL: Lower Confidence Limit, UCL: Upper Confidence Limits, CV: Coefficient of Variation and N: total subpopulation size.

Sample site	Plants ha^{-1}	LCL	UCL	CV (%)	N	N LCL	N UCL
Site 1	56	39	82	19	1466	1003	2143
Site 2	22	14	36	23	323	203	516
Site 3	99	70	140	17	681	483	959
Site 4	32	23	44	17	291	209	406
Site 5	49	35	70	18	1491	1044	2129
Site 6	43	29	60	18	2531	1782	3594
Site 7	94	66	132	17	6224	4407	8792
Site 8	72	52	99	16	4516	3284	6210
Site 9	46	35	61	14	2772	2088	3680

mean CV of 16% (SD 1.6). Again, the density of *A. peglerae* plants was lowest at the high public access sites 2, 4, 6 and 9 (Table 3, Fig. 2). The estimates of total population size (N) were based on the size of the area occupied by each subpopulation. These estimates ranged between 231 plants in Site 4 and 7759 plants in Site 7.

The plant density estimates for the 2010 survey ranged between 22 plants ha^{-1} in Site 2 and 99 plants ha^{-1} in Site 3 (Table 4). Overall the mean plant density in 2010 was 56.9 Plants ha^{-1} (SD 26.4) with a mean CV of 17.7% (SD 2.4). Estimated population sizes ranged from 291 plants in Site 4 to 6224 plants in Site 7.

The results of the 1999 and 2009 field surveys suggested that the subpopulations appeared to be stable to increasing at only two sites, namely Sites 2 and 9. These sites showed a percentage increase in estimated density of 11% and 53%, respectively (Fig. 2). However considering that the plant density is already low at these sites, these increases can be regarded as negligible. Subpopulations at all the other sites showed a decline ranging from 27% for Site 3 to as much as 58% for Site 4 (Fig. 2). The results showed an overall statistically significant decline of 38% in mean plant density, from 100.7 plants ha^{-1} (SD 56.4) in 1999 to 62.8 plants ha^{-1} (SD 32.4) in 2009 ($t = 3.390$, $p < 0.05$) (Fig. 3).

Aloe *peglerae* subpopulations showed a statistically significant decline of 43% between 1999 and 2010 ($t = 3.702$, $p < 0.05$) (Fig. 3). However, the decline of 9% in mean plant density between 2009 and 2010 was found to be statistically non-significant ($p > 0.05$). These results clearly indicate that the population of *A. peglerae* in the Magaliesberg is in a state of continuing decline and support the listing of the species in the IUCN Red List category of Endangered species under the A criterion. However, extrapolating the 38% decline observed over 10 years (1999–2009) to 3 generations (generation length estimated at 30 years), indicates that a Critically Endangered listing under the A criterion may be more appropriate.

Norris (2004) highlighted that diagnosing the causes of population decline is the principle component of virtually all projects aimed at saving threatened species from extinction. The major underlying threat to *A. peglerae* is known to be the illegal collection of mature plants (Pfab and Scholes, 2004). Illegal plant collection and climate change have also been found to be major factors driving declines in populations of other *Aloe* species including *Aloe pillansii* and *Aloe dichotoma* (Duncan et al., 2006; Klopper and Smith, 2007). Further research is needed to understand the nature and extent of illegal collection of *A. peglerae* plants and seeds, and the impact of other potential threats such as the white scale insect infestation on plant leaves. The white scale insect was observed at most sites except for sites 2, 4 and 9. As recruitment within the population is healthy (Fig. 1) with a high percentage of reproductive plants (67% of mature plants flowered in 1999), it is unlikely that the cause of the decline in *A. peglerae* in the Magaliesberg is intrinsic to the population.

The line transect sampling technique provided density estimates with adequate precision, that is, a mean CV below 18%. This level of precision was found to be adequate for the detection of large ungulate population trends over time in the Kruger National Park (Kruger et al., 2008). However, populations that naturally occur at low densities would require increased effort for adequate sampling. The total number of the recorded distance observations and the frequency distribution of the data have a bearing on the resultant estimate of density. Thus, it is important that the distance data be scrutinized when interpreting the calculated density estimates.

An improved survey design would result in more accurate estimates of density, narrower confidence limits and improved levels of precision. An interface of the Distance 6.0 software program can be used to generate a series of parallel line transects for each subpopulation. Thereafter, line transects can be selected at random prior to the survey. This approach would allow for the number of line transects to be increased objectively. Distance sampling does allow for a fixed pre-determined width to be used during a field survey (Thomas et al., 2002). For *A. peglerae*, a width of 60 m can be considered the limit beyond which the likelihood of detecting plants is very low.

4. Conclusion

Keith (2000) asserted that there is a need for the application of rigorous cost-effective sampling designs, systematic field methods and simple analytical techniques to estimate both the abundance and distribution of plant populations. This is important as the conservation agencies responsible for undertaking long-term monitoring of threatened plant species in South Africa often have limited resources such as manpower, time and finances. Accurate and updated information is crucial

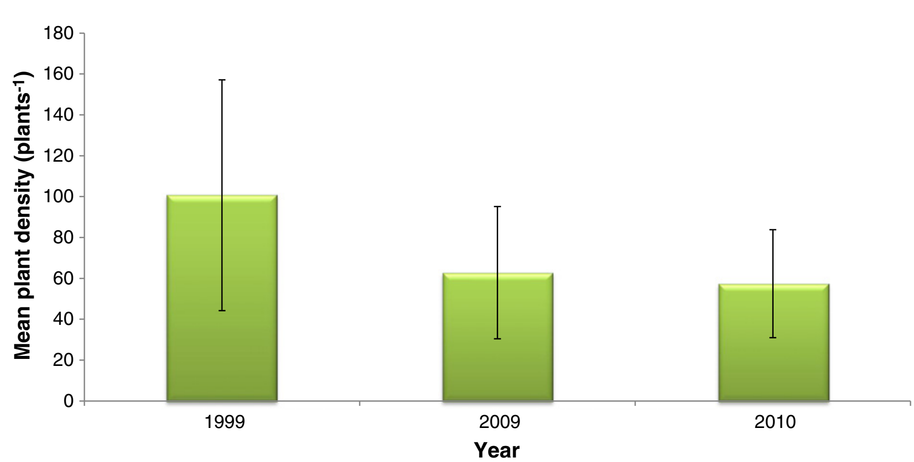

Fig. 3. Mean plant density estimates of the *Aloe peglerae* growing in the Magaliesberg Mountain Range for the years 1999, 2009 and 2010. The error bars show 95% confidence intervals.

in ensuring that species are assigned to the appropriate Red List categories in accordance with the IUCN Red List criteria (Baillie et al., 2004).

The results of this study clearly show that distance sampling can be applied in sampling subpopulations of *A. peglerae*; however it does require some refinement. The technique is highly recommended for the long term monitoring of *A. peglerae* in the Magaliesberg. This will provide insight regarding the population dynamics of the species and will be particularly important to assess the effectiveness of specific conservation interventions. Moreover, the monitoring programme should include observations on the habitat of the species, potential threats and environmental conditions such as changes in the climate. Future work should also focus on providing accurate estimates of the entire geographical extent of *A. peglerae*. Effective conservation of this species will require cooperation and further research between academic institutions, conservation agencies and private landowners. This partnership will ensure that relevant research is prioritized and it will also allow for sharing of resources. Furthermore, *A. peglerae* can be used as a flagship species in generating interest in issues pertaining to threatened plant conservation in the Magaliesberg.

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References

Baillie, J.E.M., Hilton-Taylor, C., Stuart, S.N. (Eds.), 2004. IUCN Red List of Threatened Species: A Global Species Assessment. IUCN, Gland (http://iucn.org/dbtw-wpd/edocs/RL-2004-001.pdf. (Accessed 11/02/2010)).

Beasom, S.L., Haucke, H.H., 1975. A comparison of four distance sampling techniques in South Texas Live Oak Mottes. Journal of Range Management 28 (2), 142–144.

Brown, J.A., Boyce, M.S., 1998. Line transect sampling of Karner blue butterflies (*Lycaeides melissa samuelis*). Environmental and Ecological Statistics 5, 81–91.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., 1993. Distance Sampling: Estimating Abundance of Biological Populations. Chapman and Hall, London.

Carruthers, V., 1990. The Magaliesberg. Protea Book House, Pretoria.

Duncan, J., Hoffman, T., Rohde, R., Powell, E., Hendricks, H., 2006. Long-term population changes in the Giant Quiver Tree, *Aloe pillansii* in the Richtersveld, South Africa. Plant Ecology 185, 73–84.

Ensign, W.E., Angermeier, P.L., Dolloff, A.C., 1995. Use of line transect methods to estimate abundance of benthic stream fishes. Canadian Journal of Fisheries and Aquatic Sciences 52 (1), 213–222.

Hermy, M., Endels, P., Jacquemyn, H., Brys, R., 2007. Conservation of plants. Encyclopedia of Life Sciences. John Wiley & Sons Ltd., Chichester.

Keith, D.A., 2000. Sampling designs, field techniques and analytical methods for systematic plant population surveys. Ecological Management and Restoration 1 (2), 125–139.

Klopper, R., Smith, G., 2007. The genus *Aloe* (Asphodelaceae: Alooideae) in Namaqualand, South Africa. Haseltonia 13, 38–51.

Koenen, K.K.G., Destefano, S., Krausman, P.R., 2002. Using distance sampling to estimate seasonal densities of desert mule deer in semi-desert grassland. Wildlife Society Bulletin 30 (1), 53–63.

Kruger, A.C., 2004. Climate of South Africa: Climate Regions. South African Weather Service, Pretoria.

Kruger, J.M., Reilly, B.K., Whyte, I.J., 2008. Application of distance sampling to estimate population densities of large herbivores in Kruger National Park. Wildlife Research 35 (4), 371–376.

Mucina, L., Rutherford, M.C. (Eds.), 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia, 19. South African National Biodiversity Institute, Pretoria.

Newey, S., Bell, M., Enthoven, S., Thirgood, S., 2003. Can distance sampling and dung plots be used to assess the density of mountain hares *Lepus timidus*? Wildlife Biology 9, 185–192.

Norris, K., 2004. Managing threatened species: the ecological toolbox, evolutionary theory and declining-population paradigm. Journal of Applied Ecology 41, 413–426.

Pfab, M.F., Scholes, M.A., 2004. Is the collection *of Aloe peglerae* from the wild sustainable? An evaluation using stochastic population modeling. Biological Conservation 118, 695–701.

Raimondo, D., Von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D. A., Manyana, P.A. (Eds.), 2009. Red List of South African plants. Strelitzia, 25. South African National Biodiversity Institute, Pretoria, pp. 19–40.

Scholes, M.A., 1988. A population study of *Aloe peglerae* in habitat. South African Journal of Botany 54 (4), 137–139.

Standards and Petitions Working Group, 2006. Guidelines for using the IUCN red list categories and criteria: version 6.1 [Online]. Prepared by the Standards and Petitions Working Group for the IUCN SSC Biodiversity Assessments Sub-Committee in July 2006 (http://app.iucn.org/webfiles/doc/SSC/RedList/RedListGuidelines.pdf (Accessed 26/09/2009)).

Stenkewitz, U., Herrmann, E., Kamler, J.F., 2010. Distance sampling for estimating springhare, Cape hare and steenbok densities in South Africa. Journal of Wildlife Research 40 (1), 87–92.

Swann, D.E., Averill-Murray, R.C., Schwalbe, C.R., 2002. Distance sampling for Sonoran Desert tortoises. The Journal of Wildlife Management 66 (4), 969–975.

Thomas, L., Buckland, S.T., Burnman, K.P., Anderson, D.R., Laake, J.L., Borchers, D.L., Strindberg, S., 2002. Distance sampling. In: El-Shaarawi, A.H., Piegorsch, W.W. (Eds.), Encyclopedia of Environmetrics. John Wiley & Sons Ltd., Chichester.

Thomas, L., Laake, J.L., Rexstad, E., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D. L., Anderson, D.R., Burnham, K.P., Burt, M.L., Hedley, S.L., Pollard, J.H., Bishop, J.R.B., Marques, T.A., 2009. Distance 6.0. Release 2 [Online]. Research Unit for Wildlife population AssessmentUniversity of St. Andrew (http://www.ruwpa.st-and.ac.uk/distance/ (Accessed 26/09/2009)).

Thomas, L., Buckland, S.T., Rexstad, E.A., Laake, J.L., Strindberg, S., Hedley, S.L., Bishop, J.R.B., Marques, T., Burnham, K.P., 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47, 5–14.

Thompson, W.L., 2002. Towards reliable bird surveys: accounting for individuals present but not detected. The Auk 119 (1), 18–25.

Van Wyk, B., Smith, G., 1996. Guide to the Aloes of South Africa. Briza, Pretoria.