Is the present Brackenridgea Nature Reserve large enough to ensure the survival of *Brackenridgea zanguebarica* Oliv.?

Authors:
Milingoni P. Tshisikhawe[1]
Magaretha W. van Rooyen[2]
Jerome Y. Gaugris[2]

Affiliations:
[1]Department of Botany, University of Venda, South Africa

[2]Department of Plant Science, University of Pretoria, South Africa

Correspondence to:
Milingoni Tshisikhawe

Email:
tshisip@univen.ac.za

Postal address:
Private Bag X5050, Thohoyandou 0950, South Africa

Dates:
Received: 01 Feb. 2012
Accepted: 05 July 2013
Published: 04 Sept. 2013

How to cite this article:
Tshisikhawe, M.P., Van Rooyen, M.W. & Gaugris, J.Y., 2013, 'Is the present Brackenridgea Nature Reserve large enough to ensure the survival of *Brackenridgea zanguebarica* Oliv.?', *Koedoe* 55(1), Art. #1072, 5 pages. http://dx.doi.org/10.4102/koedoe.v55i1.1072

Note:
Additional supporting information may be found in the online version of this article as an Online Appendix: http://dx.doi.org/10.4102/koedoe.v55i1.1072-1.

The Brackenridgea Nature Reserve is a 110 ha protected area established by the provincial Limpopo Department of Economic Development, Environment and Tourism as a way of protecting the population of *Brackenridgea zanguebarica*, a species classified as critically endangered in South Africa. In the whole of South Africa, the species is found in only one small area around Thengwe–Mafukani in Venda. It is threatened with extirpation due to high demand for its medicinal bark. This study investigated the adequacy of the reserve to conserve the species using a method established in 2001 by Burgman *et al*. This method involves 12 steps to quantify the risk of the decline or possible extinction of the species and takes current human activities, disturbances and the viability of the population into consideration for setting a conservation target. From the results, it was clear that more area is needed for the current population to survive beyond 50 years. Assuming the status quo, it will require 410 ha to maintain the population, whereas a 50% reduction in human-related activities, such as cultivation, harvesting and livestock grazing, will lower the required potential habitat to 203 ha and a conservation option, which allows for bark harvesting, will require 179 ha.

Conservation implications: The results of this study will have conservation implication on management of viable species population within a nature reserve. It will require managers to take into consideration the reserve size in relation to potential habitats for the development of species under their management.

Introduction

The Brackenridgea Nature Reserve (BNR), or better known as the Mutavhatsindi Nature Reserve, is a protected area established in 1987 by the provincial Limpopo Department of Economic Development, Environment and Tourism in a proactive attempt to protect the population of *Brackenridgea zanguebarica* Oliv. (Ochnaceae), commonly known as yellow peeling plane (English) or mutavhatsindi (Venda). In South Africa, the species is confined to a small area around Thengwe–Mafukani in Venda, but is common in Zimbabwe and Mozambique northwards to Tanzania. It is threatened with extirpation due to its high demand as a magical and medicinal plant species (Netshiungani & Van Wyk 1980; Todd *et al.* 2004) and is currently classified as critically endangered in South Africa (Williams & Raimondo 2008).

The population at Mafukani is facing a serious threat due to the uncontrolled bark harvesting of *B. zanguebarica*. The questions therefore arise as to whether the current Brackenridgea Nature Reserve is adequate to ensure the survival of the species and, if not, in view of the current threats, what would be an adequately sized area to ensure the survival of the species?

Population viability analysis (PVA) is regarded as one of the cornerstones of conservation science and has been used to estimate the minimum viable population for threatened taxa (Beissinger & McCullough 2002; Menges 2000; Pfab & Witkowski 2000). It provides a framework to determine how stochastic events and processes affect the extinction probability of a species. PVA can inform whether the size of a reserve is large enough to conserve a particular species, but data needed for a realistic PVA may take many years to gather (Menges 2000). Furthermore, estimation of extinction risks for a large number of species requires an immense database (Burgman *et al.* 2001; Cabeza & Van Teeffelen 2009) that is seldom available in developing countries. Consequently, conservationists are faced with a problem because they seldom have the time or budget for detailed, long-term population viability analysis and habitat modelling needed for setting ecologically acceptable targets for the size of conservation areas.

In response to the general deficiency in time and data, Burgman *et al.* (2001) developed a method for setting conservation targets for plant species when a limited amount of relevant information is available. These authors suggest that by using their method, a reserve system, adequate to conserve a viable population of a species, can be designed.

The present study aims to apply the methodology of Burgman *et al.* (2001) to assess whether the size of the BNR is currently large enough to conserve a viable population of *B. zanguebarica*. Several scenarios were run to investigate different levels of human-induced impact to derive the most promising and realistic target area to conserve the species.

Methods

The study was undertaken in the surrounds of the BNR in the Vhembe District Municipality of the Limpopo Province (Figure 1). The reserve is currently 110 ha in size. The vegetation in and around the reserve is VhaVenda Miombo (Mucina & Rutherford 2006), which is limited to a small area in the upper reaches of the Mbodi River Valley. Several species, amongst which *Brachystegia spiciformis* and *B. zanguebarica*, find their southernmost distribution within this isolated miombo vegetation unit (Mucina & Rutherford 2006). Overall, the vegetation type is heavily degraded by overgrazing, wood-collecting, agriculture and alien invasion (Mucina & Rutherford 2006).

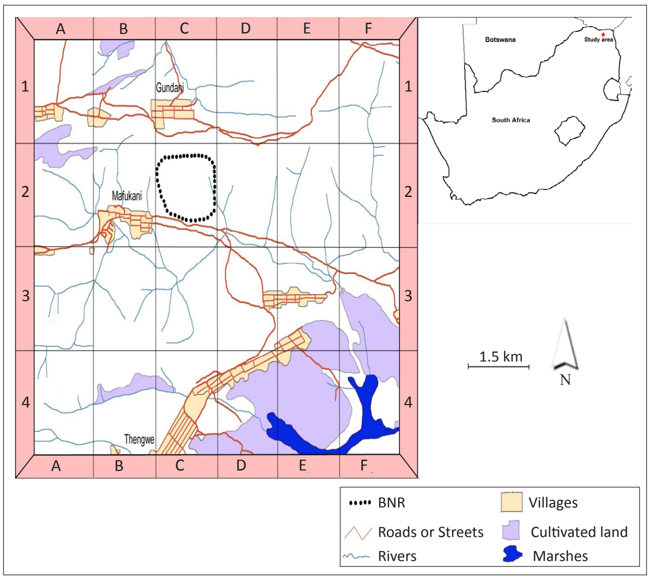
The Mafukani population of *B. zanguebarica* covers an area of approximately 2500 ha (Todd *et al.* 2004). Within the reserve it is a dominant species of the *B. zanguebarica* – *Digitaria sanguinalis* open scrub vegetation, with emergent trees of up to 10 m high (Todd *et al.* 2004).

The method developed by Burgman *et al.* (2001) and modified by Gaugris and Van Rooyen (2010) was used to set conservation goals for *B. zanguebarica*. This method accounts for deterministic and stochastic processes that lead to a decline in a population. The method should ideally be conducted by a panel of experts or people with local knowledge, who guide the decision process and assess the various risks considered. A brief summary of the 12-step method is provided below to guide the reader.

Step 1

The first step was to get a value for *F*, the minimum viable population size likely to persist demographic and environmental influences. This was defined by Burgman *et al.* (2001) as the population size that faces a 0.1% probability of falling below 50 adults in the next 50 years, assuming no detrimental human effects. The *F*-value was obtained by applying the empirical method proposed by Gaugris and Van Rooyen (2010) for practitioners. This was achieved by fitting the exponential function [$y = ae^{b(x)}$] to the graph derived from the *F*-value (y) against life expectancy of known species (x) (Gaugris & Van Rooyen 2010). A life expectancy of 150 years was assumed for *B. zanguebarica*.

The adjusted *F*-value was based on available knowledge regarding the species and environmental factors against the list of 25 ecological factors (Online Appendix Table 1), with each factor having two alternative states: one related to the species resilience and the other one to the species vulnerability (Burgman *et al.* 2001; Gaugris & Van Rooyen 2010). The percentage adjustment needed to the *F*-value



Source: Authors' own creation
Reserve boundary indicated by the black dotted line.
BNR, Brackenridgea Nature Reserve.

FIGURE 1: Grid map of the Mafukani–Thengwe region showing the Brackenridgea Nature Reserve, South Africa.

was derived by calculating the ecological factor score for the species. An all positive score of 25 was assumed to need zero adjustment and an all negative -25 score was assumed to need a 100% adjustment (equal to 2*F*) (Gaugris & Van Rooyen 2010).

Step 2

In step 2, areas experiencing similar sources and intensity of disturbance were identified. For an easy assessment of the area through expert judgement, an area of 6000 ha was mapped into 24 cells of 250 ha each (Figure 1). The disturbance in each of the 24 cells was classified into one of three classes, (1) insignificant, (2) light (human activity disturbances associated with light grazing and resource harvesting) or (3) heavy (disturbances associated with building, cultivation and overgrazing).

Step 3

The potential *B. zanguebarica* habitat per cell was evaluated using knowledge from reconnaissance and fieldwork surveys.

Step 4

This step indicated the potential habitat that was surveyed (ha). The area surveyed in detail to establish a plant density consisted of 110 ha in the BNR.

Step 5

Density of adults trees per ha (D) was established from 16 plots, of 500 m² each, sampled inside the BNR. Although the method allows different density values for the different disturbance regions, it is preferable to use a single density value based on the most undisturbed habitat (Burgman *et al.*

2001), that is the BNR in this instance. Individuals with a stem diameter of ≥ 100 mm were considered as mature as this is the threshold size where plants commence flowering.

Step 6

The preliminary minimum target area (Target area A_0) required for conservation was calculated as:

Target area A_0 = Adjusted F / D (in ha). [Eqn 1]

Step 7

In this step, the proportion of land that remains in 50 years, after yearly disturbance, was estimated (S) in each cell. All activities causing disturbances that may reduce the potential habitat of *B. zanguebarica* species were assessed. It was assumed that these small-scale disturbances (e.g. fire) are reversible and that the species will be able to recover within the 50-year period. The reduction in potential habitat was used to calculate an adjusted target area (A_1) as:

$A_1 = A_0 / S$ (in ha). [Eqn 2]

Step 8

The area expected to be irreversibly damaged in the next 50 years (c_i) was evaluated per cell. The remaining area ($1 - c_i$) was used to refine the adjusted target area (A_2) as:

$A_2 = A_1 / (1 - c_i)$ (in ha). [Eqn 3]

Step 9

Compensation for expected density-reducing human related activities was achieved through adjustment of the target area per block and was expressed as r_i, the estimated proportion of remaining habitat (Burgman *et al.* 2001). The following four human related activities were considered: cultivation, grazing, fencing material and bark harvesting for medicinal material. For each of these activities, a proportion habitat remaining was calculated and the product of these proportions was used for further refinement of the target area (A_3) as:

$A_3 = A_2 / r_i$ (in ha). [Eqn 4]

Four scenarios were assessed in order to determine which scenario could provide the best acceptable management option for *B. zanguebarica*. The four scenarios were as follows: Scenario 1 looked at the current status of the species management, Scenario 2 was when grazing was removed from the management system, Scenario 3 investigated the effect of reducing all the human-related activities by half, whereas Scenario 4 looked at the management system in which all the human-related activities, except bark harvesting, had been removed from the management system.

Step 10

Identification of catastrophic events such as landslides, earthquakes and volcanic eruptions (Burgman *et al.* 2001), that could affect the species' potential habitat was not performed because such events are unexpected in the area.

Step 11

Combining target areas across different regions was also not conducted, because the method was applied on the only population of *B. zanguebarica* that exists within South Africa.

Step 12

The final step entailed an evaluation of the adequacy of current strategies and the setting out of objectives accounting for spatial and species constraints (Burgman *et al.* 2001). The ratio of available to required habitat was calculated for each of the cells.

Results

The study results are described in order, following the abovementioned steps outlined in Burgman *et al.* (2001).

Minimum viable population size

Based on a life expectancy of 150 years for *B. zanguebarica*, an F-value of 1071 was derived by applying the empirical method of Gaugris and Van Rooyen (2010). The ecological factor score of 6 (Online Appendix Table 1) necessitated an adjustment of 38% for an adjusted F of 1478.

Identification of populations with similar disturbance

Only three cells showed an insignificant disturbance level, whereas nine cells showed a light disturbance level and 12 showed a heavy disturbance level (Online Appendix Table 2a).

Potential habitat

Six cells exhibited quality habitat for *B. zanguebarica* and small proportions of suitable habitat were found in another five cells (Online Appendix Table 2a).

Potential habitat surveyed

The potential habitat surveyed for a density estimate amounted to 110 ha in the BNR.

Density of mature individuals

The mean density of mature *B. zanguebarica* individuals across all transects within the reserve was 61 individuals per ha.

Minimum target area

The minimum target area or raw area for *B. zanguebarica* (A_0 = Adjusted F/Density), assuming no threats, was 24 ha.

Proportion of land lost

Over the projected 50-year period, the calculation for proportion of land lost would need to include all small-scale activities that affect the population of *B. zanguebarica*. For the BNR, this increased the adjusted target area ($A_1 = A_0 / S$) to 43 ha (Online Appendix Table 2a).

Proportion irreversibly damaged in 50 years

The refinement of the adjusted target area [$A_2 = A_1 / (1 - c_i)$] through irreversible damage in the next 50 years (c_i) brought about a further increase in the target area to 112 ha. It was found that the main cause of these irreversible losses of habitat in the region was human settlement expansion.

Compensation

Four scenarios of expected density-reducing human-related activities (cultivation, grazing, fencing material and bark harvesting for medicinal material) were assessed. Scenario 1 assessed the current status of the area and revealed that 410 ha will be needed in order to maintain a viable population of *B. zanguebarica* (Online Appendix Tables 2a and 2b, cells with suitable habitat). Scenario 2 was to prohibit livestock grazing from the area. It was found that removing grazing from the area can reduce the amount of land needed to conserve the species from 410 ha to 298 ha (Online Appendix Table 2c, cells with suitable habitat). Under Scenario 3, the local communities were allowed to carry on with their activities, but at a reduced rate. By reducing all four human activities (cultivation, grazing, building and harvesting) by half, an area of 203 ha would be needed to conserve *B. zanguebarica* (Online Appendix Table 2d, cells with suitable habitat). Finally, Scenario 4 assessed a scenario of removing cultivation, grazing, harvesting for fencing material, but retaining bark harvesting for medicinal purposes and found that this approach would require an area of 179 ha for a viable population of *B. zanguebarica* (Online Appendix Table 2e, cells with suitable habitat).

Assessment of catastrophes

As stated above, catastrophic events were not considered as the area has no historical records of any such catastrophes and none are anticipated for the foreseen 50-year period of evaluation.

Combination of targets

Combining target areas was not conducted in this study because there are no other populations of *B. zanguebarica* within South Africa.

Evaluation of current strategies

From the ratio of available-to-required habitat calculated in Step 12, it was evident that cells C2, C3, D2 and E2 were the most promising for the conservation of the species. The BNR can therefore be expanded to the east along the ridgeline to obtain the required 179 ha for conservation under Scenario 4. The reserve could also be expanded to the south, but would then have to cross the road (Figure 1).

Discussion

When evaluating rare taxa, it is important to understand the distribution, biology and threats in order to devise efficient strategies for their protection (Lozano & Schwartz 2005; Rodgers *et al.* 2010; Wessels, Freitag & Van Jaarsveld 1999). Understanding the dynamics of the resource base is important to develop a sound management system for resource harvesting (Ghimire, Mckey & Aumeeruddy-Thomas 2005; Obiri, Lawes & Mukolwe 2002).

Although the Burgman *et al*. (2001) method relies heavily on expert opinion, it nevertheless provided a framework to systematically quantify the risk of decline or possible extinction of *B. zanguebarica*, taking into consideration current human activities, disturbances and the viability of the population. The method illustrated the effect of different land-use options on the size of the conservation target.

From this study, it is evident that the current reserve is inadequate to ensure a viable population of the species and that additional land will have to be set aside. The size of the additional land will depend on the land use. A conservation land use (Scenario 4) will require a total of 179 ha. If the human-related activities are reduced by 50% (Scenario 3), then a total of 203 ha will be needed; however, if only grazing is prohibited (Scenario 2) then a total of 298 ha will be needed. If the human-related activities are allowed to continue unabated the total area needed to conserve the species increases to 410 ha.

Amongst the scenarios assessed, Scenario 4 corresponds to the current conservation option within the BNR where harvesting is occurring, but no cultivation, grazing or other harvesting activities are allowed. Selecting this option would necessitate another 69 ha to be incorporated into the reserve. An area adjoining the reserve (D2) should be selected to avoid the need for corridors between conservation areas. By selecting an area where no cultivation is practiced this would imply that 69 ha of grazing land will have to be sacrificed for the enlargement of the reserve. The use of *B. zanguebarica* for fences will have to be prohibited entirely, but the controlled harvesting for medicinal purposes can continue because of the high demand for the bark. Furthermore, the enlargement of the reserve would be supported by the fact that the Vhembe region, in which the BNR is situated, is a UNESCO-declared biosphere reserve.

Should increasing the size of the reserve not be a viable option, then human-related activities will need to be reduced in the area surrounding the reserve. However, the challenge will arise in the monitoring of the level of utilisation, which is to be reduced by half from the current level in Scenario 3. Prohibiting only grazing (Scenario 2) might be a more realistic option, because this can be more easily monitored than bark harvesting. However, in this case the size of the additional area will have to be almost doubled. Excluding herbivores from an area has the further advantage that it reduces trampling and promotes seedling establishment and the amount of dead plant material that acts as protective mulch (Angassa & Oba 2010).

Although the creation of a protected area facilitates the conservation of medicinal plant species by restricting access and extractive use (McGeoch, Gordon & Schmitt 2008), it has also been found that whenever the economic value of a natural resource carries more weight than the cultural value, traditional management of such a resource can fail to guarantee its sustainability (Saidi & Tshipala-Ramatshimbila 2006). Strict control over the volume of bark harvested will have to be exercised and measures will have to be put in place to prevent illegal bark harvesting.

Conclusion

The study revealed that the current reserve size is not sufficient for conservation of a viable population of *B. zanguebarica*. The study identified potential areas, which can be utilised for the expansion of the reserve. It also identified the size of the area to be set aside under different management options. The most promising option appears to enlarge the reserve by adding at least 70 ha of adjacent land. The conservation of a viable *B. zanguebarica* population can only be achieved through a reduction of human activities that have a negative impact on the population dynamics of the species and by strict control over the volume of bark harvested.

Acknowledgements

The authors gratefully acknowledge the assistance of Mr Magwede Khathutshelo and Mr Siaga Moses with data collection. Staff members at the Brackenridgea Nature Reserve, especially Mr Rasivhaga, Mr Maluta, and Mr Manenshe are thanked for their unconditional support. Dr Nethengwe from the Department of Geography at the University of Venda is also acknowledged for helping out with geographic information system during the production of the area map.

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

M.P.T. (University of Venda) was the project leader who carried out the experiments, analysis and preparation of the manuscript. M.W.v.R. (University of Pretoria) designed the experiments, analysed the data and proofread the manuscript. J.Y.G. (University of Pretoria) provided most of the calculations during data analysis and also helped in proofreading of the manuscript.

References

Angassa, A. & Oba, G., 2010, 'Effects of grazing pressure, age of enclosures and seasonality on bush cover dynamics and vegetation composition in southern Ethiopia', *Journal of Arid Environments* 74, 111–120. http://dx.doi.org/10.1016/j.jaridenv.2009.07.015

Beissinger, S.R. & McCullough, D.R., 2002, *Population viability analysis*, The University of Chicago Press, Chicago.

Burgman, M.A., Possingham, H.P., Lynch, J.J., Keith, D.A., Mccarthy, M.A., Hopper, S.D. *et al.*, 2001, 'A method for setting the size of plant conservation target areas', *Conservation Biology* 15, 603–616. http://dx.doi.org/10.1046/j.1523-1739.2001.015003603.x

Cabeza, M. & Van Teeffelen, A.J.A., 2009, 'Strategies of reserve selection', *Encyclopedia of Life Sciences*, John Wiley & Sons, Chichester. http://dx.doi.org/10.1002/9780470015902.a0021224

Gaugris, J.Y. & Van Rooyen, M.W., 2010, 'Evaluating the adequacy of reserves in the Tembe–Tshanini Complex: A case study in Maputaland, South Africa', *Oryx* 44, 399–410. http://dx.doi.org/10.1017/S0030605310000438

Ghimire, S.K., Mckey, D. & Aumeeruddy-Thomas, Y., 2005, 'Conservation of Himalayan medicinal plants: Harvesting patterns and ecology of two threatened species, *Nardostachys grandiflora* DC and *Neopicrorhiza scrophulariiflora* (Pennell) Hong', *Biological Conservation* 124, 463–475. http://dx.doi.org/10.1016/j.biocon.2005.02.005

Lozano, F.D. & Schwartz, M.W., 2005, 'Patterns of rarity and taxonomic group size in plants', *Biological Conservation* 126, 146–154.

McGeoch, L., Gordon, I. & Schmitt, J., 2008, 'Impacts of land use, anthropogenic disturbance, and harvesting on an African medicinal liana', *Biological Conservation* 141, 2218–2229. http://dx.doi.org/10.1016/j.biocon.2008.06.021

Menges, E.S., 2000, 'Population viability analysis in plants: Challenges and opportunities', *Trends in Ecology and Evolution* 15, 51–56. http://dx.doi.org/10.1016/S0169-5347(99)01763-2

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

Netshiungani, E.N. & Van Wyk, A.E., 1980, 'Mutavhatsindi – Mysterious plant from Venda', *Veld and Flora* September, 87–90.

Obiri, J., Lawes, M. & Mukolwe, M., 2002, 'The dynamics and sustainable use of high value tree species of the coastal Pondoland forests of the Eastern Cape Province, South Africa', *Forest Ecology and Management* 166, 131–148. http://dx.doi.org/10.1016/S0378-1127(01)00665-X

Pfab, M.F. & Witkowski, E.T.F., 2000, 'A simple population viability analysis of the critically endangered *Euphorbia clivicola* R.A. Dyer under four management scenarios', *Biological Conservation* 96, 263–270. http://dx.doi.org/10.1016/S0006-3207(00)00088-4

Rodgers, H.M., Glew, L., Honzak, M. & Hudson, M.D., 2010, 'Prioritizing key biodiversity areas in Madagascar by including data on human pressure and ecosystem services', *Landscape and Urban Planning* 96, 48–56. http://dx.doi.org/10.1016/j.landurbplan.2010.02.002

Saidi, T.A. & Tshipala-Ramatshimbila, T.V., 2006, 'Ecology and management of a remnant of *Brachystegia spiciformis* (miombo) woodland in North Eastern Soutpansberg, Limpopo Province', *South African Geographical Journal* 88, 205–212. http://dx.doi.org/10.1080/03736245.2006.9713862

Todd, C.B., Khorommbi, K., Van Der Waal, B.C. & Weisser, P.J., 2004, 'Conservation of woodland biodiversity: A complementary traditional approach and western approach towards protecting *Brackenridgea zanguebarica*', in M.J. Lawes, H.A.C. Eeley, C.M. Shackleton & B.G.S. Geach (eds.), *Indigenous forests and woodlands in South Africa – Policy, people and practice*, pp. 737–750, University of KwaZulu-Natal Press, Durban.

Wessels, K.J., Freitag, S. & Van Jaarsveld, A.S., 1999, 'The use of land facets as biodiversity surrogates during reserve selection at a local scale', *Biological Conservation* 89, 21–38. http://dx.doi.org/10.1016/S0006-3207(98)00133-5

Williams, V.L. & Raimondo, D., 2008, Brackenridgea zanguebarica *Oliv. National Assessment: Red List of South African Plants version 2011.1*, viewed 16 April 2012, from http://redlist.sanbi.org/species.php?species=2924-2