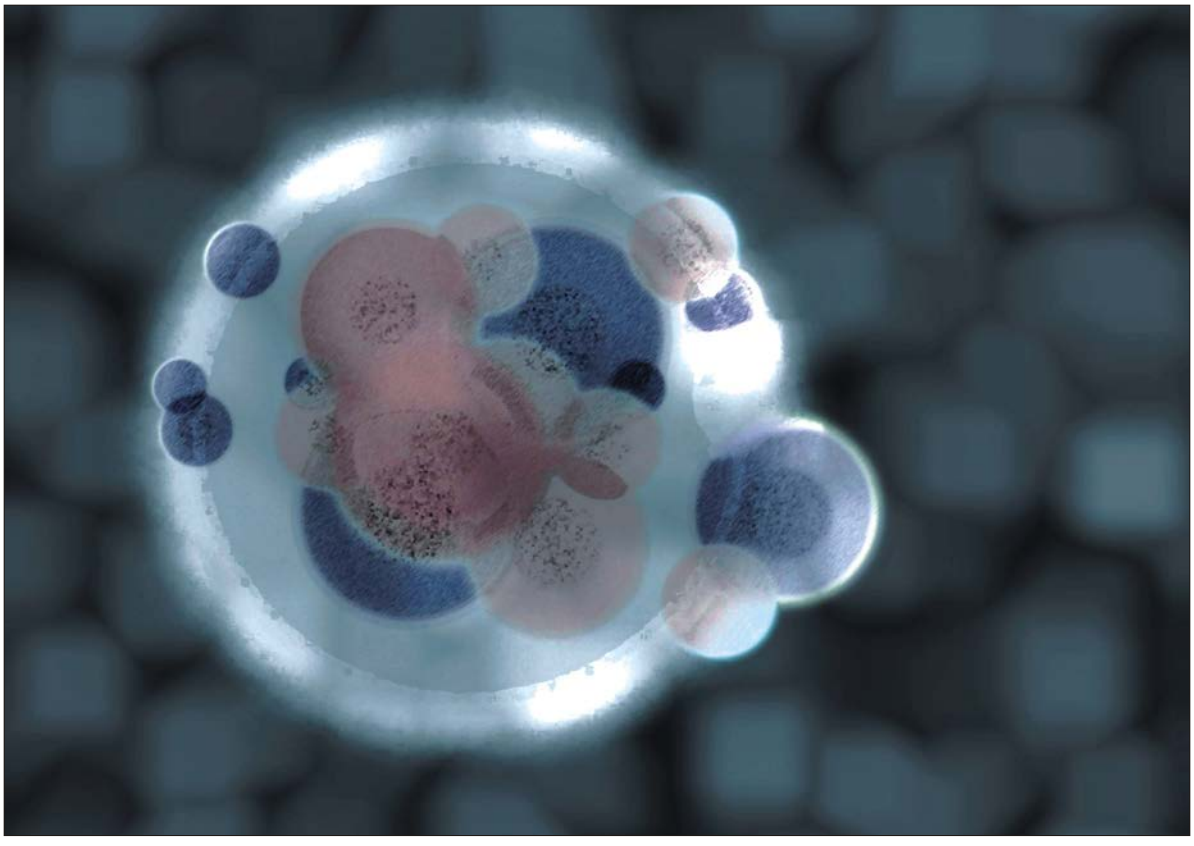

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Research Article
Community's Knowledge on *Euphorbia groenewaldii*: Its Populations, Threats and Conservation in Limpopo Province, South Africa

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Abstract

Background and Objective: *Euphorbia groenewaldii* R.A. Dyer is a Red Data Listed South African plant with a Critically Endangered status. It has a very limited natural distribution with only six known populations, one found on unprotected hills around Dalmada and the rest (n = 5) in Kalkfontein, Masele, Mokgotho, Ngwana-Laka and Ronsma areas of Ga-Mothiba village in the Limpopo Province (South Africa). The current study ascertained community's knowledge on *E. groenewaldii* in this village focusing on the populations, threatening factors and community's conservation ideas. **Materials and Methods:** Data was collected using a semi-structured questionnaire and field observations. **Results:** It was found that all (100%, n = 50) probed participants recognize at least a single population, although none of them were aware of the species conservation status. Despite this, an overwhelming majority (78%, n = 39) of them showed interest in the conservation of the species. Respondents' knowledge of threats varied slightly from one population to another, with no threats reported for Ronsma population. Overall, rainfall scarcity/drought and lack of knowledge regarding the conservation status of the species were common threats perceived by most participants as affecting the remaining four *E. groenewaldii* populations. Threatening factors observed by researchers across all the 5 explored populations were trampling (by both human-beings and livestock) and invasive alien plants. The most salient and pivotal conservation initiatives recommended by most participants for the survival of *E. groenewaldii* were awareness regarding the species' conservation status (96%, n = 48) and remunerated field patrol by local community members (90%, n = 45). **Conclusion:** For successful conservation of explored *E. groenewaldii* populations, local nature conservators must take in to consideration all the conservation strategies recommended by participants during the drafting of the species management plan. Generally, to ensure long-term survival of the investigated plant populations, there is an urgent need to formally protect its habitat and secure all unoccupied areas to allow future expansion.

Key words: Conservation, *Euphorbia groenewaldii*, Ga-mothiba, Limpopo Province, threats

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Euphorbia groenewaldii R.A. Dyer (Euphorbiaceae) is a spiny succulent dwarf originally discovered in 1936 on stony unprotected hills nearby Polokwane city, capital of Limpopo Province (South Africa), by Dr. F. van der Merwe who named it in honour of his friend, B.H. Groenewald[1]. The plant grows up to 300 mm high and 80 mm wide and it has the main root as well as stem that forms a larger subterranean tuberous body[2]. The stem of *E. groenewaldii* typically crowns the root and is distinguished from it by horizontally extended impressions from which old branches have fallen. Furthermore, it has bluish to greenish branches which rarely comprises of lighter green marks. Moreover, the species has yellow flowers and produce greenish-red fruits containing one or two seeds[3].

Geographically, *E. groenewaldii* has a very limited distribution, with six known subpopulations endemic to two areas namely Dalmada (semi-urban area) and Ga-Mothiba (rural village) both located in the Polokwane municipality of the Limpopo province, South Africa. The plant grows on selected small granite hills and ridges between bands of schist or in gritty red sandy loam soil[4] and it generally enjoy growing on the northern, eastern and western part of the slopes[2].

With regards to the conservation status, *E. groenewaldii* is nationally listed as Critically Endangered (A2ac) on the South African National Red-Data List of plants[5], primarily due to its small area of occupancy and its extent of occurrence. Other justification for categorising this succulent dwarf as Critically Endangered is because it faces an extremely high risk of extinction attributed to the reduction in the number of its mature individuals and its population size, both due to multiple threats[4]. Threats impacting on *E. groenewaldii* population includes, development, illegal harvesting, herbivory, mining activities and trampling[2]. These threatening factors continues to contribute towards the progressive decline of the referred species' populations and this is despite the following conservation initiatives: (i) The protection of *E. groenewaldii* under the local legislation namely Limpopo Environmental Management Act No. 7 of 2003 and National Environmental Management: Biodiversity Act No. 10 of 2004, both which prohibits uprooting, harvesting of species from the wild and trading without a permit, respectively and (ii) The recommendation/ implementation of the species conservation plans by scientists or nature conservators[2,6].

The above is more likely to be attributed to the fact that current conservation efforts or recommendations excluded/does not/did not make a provision to or take into considerations the ideas or perception of the local community adjacent to the *E. groenewaldii* populations as far as the conservation of this species is concerned. It has been reported in various geographical regions[7-10] that conservation plans of any plant species especially those distributed in open access communal lands (such as *E. groenewaldii* found in Ga-Mothiba village) cannot be successful without engaging the local communities. This is because community members located near threatened plant population are the main stakeholder in the conservation or abolishment of the species. Therefore, the present study sought to document the community's knowledge of *E. groenewaldii* population, its threats and conservation ideas/strategies in Ga-Mothiba village. Findings from this study will be incorporated or taken in to consideration when drafting the species conservation plan.

MATERIALS AND METHODS

Study area and population: The present study was conducted in Ga-Mothiba (Fig.1), a rural settlement located in the Polokwane municipality (Capricorn district) of the Limpopo Province, South Africa.

Geographically, Ga-Mothiba is located approximately 7 km east of Dalmada (urban area located outside the Polokwane city, the capital of Limpopo province) and 10 km from the Mankweng Township. However, there is on-going legal battle regarding the geographical demarcation of Ga-Mothiba, with local tribal leader claiming that their land overlap to the Dalmada area. In addition, to this skirmish, there are certain local clans/tribes who are also in a process of legally claiming a portion of land located between Ga-Mothiba and Dalmada (Fig. 1). All these clangs have resulted in an ongoing illegal occupation of this portion of land (Fig. 1).

The study area falls under the traditional leadership of Chief Mothiba and it mainly inhabited by Bapedi people who speak Sepedi language constituting 99.74% of the total population[11]. The referred village was selected due to its proximity to the *E. groenewaldii*, based on the postulation that its inhabitants are potential key stakeholders in both the conservation and destruction of this species. Therefore, members of the community residing closers to the species were considered as target population. According to De Vos[12], target population is a set of elements that the researcher/s focuses on and from which data are obtained or is the totality of persons from which a sample is drawn to study a particular research problem.

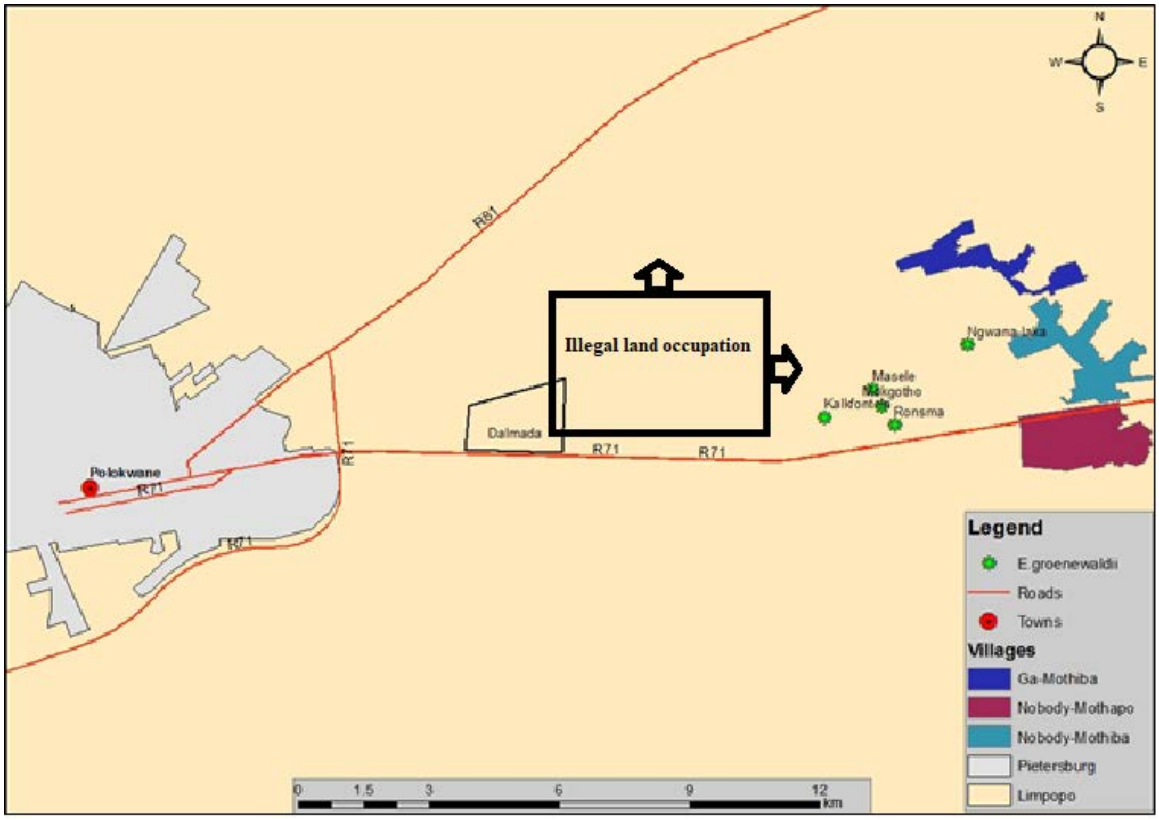

Fig. 1: Study area (Ga-Mothiba village and explored *E. groenewaldii* population)

Description of vegetation and climate: The major vegetation of the study area is Polokwane Plateau Bushveld and the dominant tree species includes *Acacia caffra* (Thunb.) Willd., *Acacia karroo* (Hayne)., *Aloe marlothii* subsp. *marlothii*, *Combretum molle* R.Br. ex G.Don, *Euclea crispa* subsp. *crispa*. *Gymnosporia senegalensis* (Lam.) Loes. and *Ziziphus mucronata* Willd. subsp. *Mucronata*[13]. Common herbs found in the study area comprise of *Hypoxis hemerocallidea* Fisch., C.A.Mey. and Avé-Lall., *Lantana rugosa* Thunb., *Lippia javanica* Burm.f.) Spreng. Momordica balsamina L. and *Solanum panduriforme* E. Mey[13].

The surveyed area falls under the summer rainfall region and has a warm climate[14]. The mean monthly maximum and minimum temperature is 33.2 and 0.6° for October and June, respectively[13]. Most of the rainfall occurs between October and March with the peak period being December or January and the mean annual precipitation for the region is 478 mm. Most precipitation falls between October and March with the peak period being December/January[14].

Survey and data collection: A multipurpose reconnaissance survey was firstly carried-out (January-February, 2016) in Ga-Mothiba village to (i) Ask permission from local tribal office to conduct the current study within the area of their jurisdiction, (ii) Explore and locate different *E. groenewaldii* populations distributed within the study area and (iii) Request community members to take part in this study. The objectives of the project were clearly explained to both tribal leaders and randomly selected community member using their mother tongue (*Sepedi*). Subsequently, members of community (n = 50) who agreed to take-part in this project were requested to sign a consent form.

Data was collected from March-December, 2017 using a semi-structured questionnaire during face-to-face interviews and this was supplemented by field observation in the geographical areas were *E. groenewaldii* populations are found. Questionnaire was generally designed to capture data pertinent to the respondents' biographic profile, (gender, age, educational status and occupation) knowledge of *E. groenewaldii* populations, conservation status and threatening factors of this species as well as the conservation ideas for the species.

Data analysis: Information obtained from this study was analyzed using Microsoft Excel. Descriptive statistics such as percentages and frequencies were used.

RESULTS AND DISCUSSION

Socio-demographic characteristics: Most of the participants in the present study were males (64%, n = 32) and females constituted just 36% (n = 18) of the entire sample. This finding is contrary a local gender composition of Ga-Mothiba rural area which depicted the predominance of females than males[11]. Therefore, higher number of male compared to female in our study might be attributed to a type of sampling technique (e.i., random) employed to select the participants, which favoured more males compared to their female counterparts.

The occupations of the interviewees were also probed and accordingly it differed per gender with 22.2% (n = 4) of females having no occupation. As expected, full-time employees in various local companies (75%, n = 24), self-employment comprising mainly of business ventures like bricks factories and accommodation (9.3%, n = 3) as well as cattle rearing (15.6%, n = 5) were the primary jobs for males. The important source of female occupations was baby-sitting (33.3%, n = 6), housekeeping (i.e., clean other people' houses, do laundry and ironing) (16.6%, n = 3) and traditional healing (27.7%, n = 5). Nevertheless, larger proportion of males who are employed on a full-time basis, could be explained from the African traditional stand-point that men are the main economic providers, disciplinarians and protectors within their families[11]. Therefore, they are expected to ensure a steady-flow of income, hence most of them in this study are full-time employees. On the other hand, the types of jobs performed by questioned females in this study are often synonymous with low status jobs, with limited career opportunities[15], perhaps attributed to lack of necessary skills which are prerequisites for better occupations or employment in South Africa. The informal sector activities performed by men and women also tend to be different.

Pedagogically, all participants have completed a certain level of education. Greater proportion of them were educated up to secondary (76%, n = 38) and primary (18%, n = 9) schools with a relatively lesser (6%, n = 3) number of them who attained tertiary education. The limited number of participants who acquired a tertiary schooling is understandable primarily due to high academic financial cost in south Africa. Nevertheless, studies showed that individuals with basic educational skills can easily be capacitated with elementary conservation knowledge and skills that are critical to identify and solve challenges surrounding their natural environment[10,16,17]. Therefore, it acceptable to stated that interviewees in our study are suitable entrants to be capacitated with the basic conservation knowledge of *E. groenewaldii*. This will afford them an opportunity to gain an awareness or sensitivity to the species' habitat and ultimately a set of values and positive attitudes towards the entire populations.

With regards to age, an overwhelming majority of respondents were between 20 and 40 years old, representing 62% (n = 31) of the total sample. Just over a third (34%, n = 17) of the interviewees fell in age brackets of 40-60 years old and very few (4%, n = 2) were over 60 years old. These finding generally showed that participants in the present study are matured adults and perhaps responsible, thus have potential to be utilized as agents to convey and spread the conservation message of *E. groenewaldii* within their families and to the community at large particularly to children since the future survival of this threatened succulent taxa also rest on their attitude. This is because the positive attitude towards conservation of plant species imparted is imperative as it makes individuals differentially sympathetic to arguments used to promote conservation[18].

Community's knowledge of *Euphorbia groenewaldii* and its conservation status: Although, Haffner[1] wrote that *E. groenewaldii* does not have a vernacular name due its rarity status, however, the present study found that the species is prevalently known to an overwhelming of questioned people as "Sekgopha se se tala senyane sa metwa", translating to a small thorny succulent herbaceous plant. This finding came as no shock primarily because the traditional classification of species is basically based on the linguistic description of plants nomenclature[19-22]. However, few participants (27.7%, n = 5) who practiced traditional healing vernacularly called *E. groenewaldii* as "Sekgopha sa maoto" (herb for foot medicine), which allude to the fact the species is extensively harvested and highly valued in the treatment of conditions of the foot and related structures of the leg. In this regard, ethno-therapeutic studies focusing on the application of *E. groenewaldii* will be key in determining both the value and extent of usage of this species as remedy for foot and allied symptoms.

The community's knowledge of *E. groenewaldii* conservation status and populations was investigated. Generally, none of the participants were aware that this succulent plant species is a threatened Red-Data Listed, thus indicating a need to conduct public awareness campaigns in

the studied area about the conservation status of the referred succulent species. It is worth noting that despite lack of knowledge regarding the conservation status of *E. groenewaldii* by sampled community members, their overwhelming majority (78%, n = 39) expressed an interest in conservation of the species. This finding has a positive ramification for future survival of this species as it shows that most of the questioned community members are highly positive towards conserving and protecting it and its habitats. According to Bennett and Dearden[23], conservation success is often predicated on local support for conservation which is strongly influenced by positive perceptions of the local communities and their opinions of management. Nonetheless, just 22% (n = 11) of interviewees stated that the investigated species is "unimportant" to them. According to these participants, they do not see the significant of conserving or participating in the conservation of *E. groenewaldii* because of lack of inequitable benefits, attributed to the lack of knowledge and understanding of what the benefits of conserving this succulent are. Unfortunately, this attitude might have a negative conservation implication. For instance, it may promote negative behavioural intentions by participants towards *E. groenewaldii* conservation. Therefore, it is very fundamental that future community education efforts outline detailed information about the benefits and value of conserving this species.

Community's knowledge of *Euphorbia groenewaldii* populations: Participants' knowledge of four *E. groenewaldii* populations namely Kalkfontein (KP), Masele (MP), Mokgotho (MKP), Ngwana-Laka new stands (NLP) and Ronsma (RP) were explored. Consequently, none of these populations were known by all respondents. Not surprisingly, NLP was the only one known by higher number of participants (74%, n = 37) representing all the occupations recorded in this study, namely full-time employees in various local companies (79%, n = 19), self-employment and housekeeping (66.6%, n = 2, for each), cattle rearing (60%, n = 3), baby-sitting (100%, n = 6) as well as traditional healing (100%, n = 5). This finding was anticipated for multiple reasons. For instance, there is an ongoing mining/quarrying (sand and stones) activities within this population. Therefore, most of the community members might have visited the mining site more often in search of employment opportunities and accordingly had ample opportunity to observe or notice the diversity of *E. groenewaldii*. It might also be due to the participants' familiarity to the populace' attributed to its close vicinity to their settlement. In fact, a significant proportion of NLP were cleared for human occupation and some of the households even conserved few individual species within their gardens for ornamental purposes. Also, most of the questioned community members disclosed that they pass via the population almost on daily basis in search of the ecosystem goods such as grass for hatching and for making brooms. Likewise, interviewed traditional healers specifically, said that they are aware of the NLP because they harvest *E. groenewaldii* (foot disorders) and other species such *Drimia* spp. (sexually transmitted infections and high blood pressure) occurring in association with it for the utilization as traditional medicines to heal the stated ailments. Cattle headers on the other hand disclosed that they invariably pass via the population with their cattle, with some of them stating that they also graze their cattle right within the population. All the above-mentioned aspects coupled with the fact that *E. groenewaldii* is an evergreen to radish in colour (which makes it unique) succulent with a high aesthetic appeal, make it to be easily noticed by people throughout the year and this can partly elucidate the larger proportion of participants in this study who are aware of NLP. However, the number of anthropogenic activities occurring within this population will negatively affect its survival and swiftly wipe it out. Therefore, the local conservation authorities are advised to prioritize the protection of NLP and keep it under review to evade the elimination of its individuals.

Masele population (MP) was also known by a substantial number of participants (62%, n = 31) representing most the occupations. Plausible explanations for this widespread knowledge of MP amongst the participants, could be linked to the value of habitat (to these participants) wherein population is found coupled with its easy access. According to local cattle headers, there is plenty of palatable grass species and trees occurring in association with *E. groenewaldii* and thus they utilize MP habitat as natural pastures for their cattle. Overall, all participants who are knowledgeable about this population divulged that they harvest several medicinal plants such as *Croton gratissimus* Burch. subsp. *Gratissimus*, *Dicoma anomala* Sond. subsp. *anomala*, *Gymnosporia senegalensis* (Lam.) Exell, *Lippia javanica* (Burm.f.) Spreng., *Monsonia angustifolia* E. Mey. and *Mundulea sericea* (Willd.) A. Chev. on this habitat for self-medication. In addition to this, participants who practice traditional healing explicitly disclosed that they exploit *E. groenewaldii* for the preparation of foot and allied symptoms medications. Apart from its medicinal value, participants also regard the hill housing MP as pivotal source of species such as *Grewia flava* DC, *Pappea capensis* Eckl. and Zeyh., *Vangueria infausta* Burch. and *Ziziphus mucronata* Willd. subsp. *mucronata* which are

exploited for their fruits. Besides meeting the above-mentioned needs, a sizeable proportion of the respondents also collect limestone's for the utilization for body steaming and decoration in the gardens from this hill. Moreover, a smaller proportion (15.1%, n = 5) of participants stressed the importance of the referred hill as crucial site to perform their ancestral rituals. Therefore, most of the participants in the present study might had come across the MP or had recurring opportunities to observe it in pursuits of all the aforesaid ecosystem goods and services.

Not surprisingly, the remaining three populations namely KP, MKP and RP was recognized by few participants (mainly cattle headers), perhaps due to their limited accessibility. Only eight (n = 8) participants were aware of RP. This population is located on a higher hilly area which is almost encircled by privately owned business premises (except on the northern aspect wherein big portion of land is presently unoccupied), all which limit human movement towards it. Generally, the RP was only known by businesses owners (100%, n = 3) and cattle herders (100%, n = 5). This result was expected, for instance, premises belonging to interviewed business owners are located approximately less than 200 m from RP and on the other hand all questioned cattle headers reported grazing their livestock on the hill wherein this population occurs. All these might had allowed respondents greater exposure to RP, hence their knowledge of this population. This study thus, submit that local business owners and cattle headers are imperative partners for the conservation of RP. This is because their knowledge of *E. groenewaldii* gained through almost daily interaction with its ecosystems/habitat may hold clues regarding any illegal activities or negative change occurring within the population.

Similarly, only five (n = 5) participants who are cattle headers disclosed that they know KP and MKP. This finding was expected due to the difficulties in accessing these populations. Both the referred populations occur on higher hills which are difficult to access and climb. In addition to these predicaments, KP is in a fenced area and only cattle herders graze their cattle, which explained why they aware of the population. With regards to MKP, cattle headers reported that they regularly climb the hill where this population occur to monitor the movement of their livestock on the lower hills and through this they become aware of the population.

Threats affecting *Euphorbia groenewaldii*: Participants' knowledge of diverse factors threatening five *E. groenewaldii* populations occurring at Ga-Mothiba region was determined. Generally, participants were aware of the threats contributing to the progressive decline of these populations. However, it was found that respondents' knowledge of threats varied slightly from one population to another, with no threats reported for RP (Table 1). These differences may be attributed to the interviewees level of knowledge regarding the threatening factors to *E. groenewaldii* populations. Overall, threats mentioned by respondents as negatively affecting the rest of the populations comprises of lack of rainfall-shortage/drought (84%, n = 42), habitat degradation such as soil erosion (44%, n = 22), expansion of rural settlement (56%, n = 28), lack of knowledge about the conservation status of species (84%, n = 42), mining/quarrying activity (60%, n = 30) and human induced fire (42%, n = 21). Information pertinent to the degree of these threats (observed/confirmed by researchers in the field) are presented in Table 1. The above-mentioned threatening factors to the investigated population are commonly known to affect plant biodiversity of conservation concern distributed in the communal areas of South Africa[10,24,25] and elsewhere[26,27], rendering them very difficult to find in their natural range. Therefore, one can infer that these factors will ultimately do the same with *E. groenewaldii*, unless they are eliminated.

Expansion of rural settlement (56%, n = 28) and habitat degradation specifically soil erosion (44%, n = 22) were disclosed by questioned community members as threatening NLP only. Indeed, a bigger portion of the following sites of this population, north, north-west, south-east and east is already cleared for human occupation. It also worth highlighting that although participants acknowledged expansion of rural settlement as impacting negatively to the NLP, they were also very pleased with the direction the village is expanding towards and this was regardless of the fact that it encroaches in to the *E. groenewaldii* population. This was because the participants would like to reside towards the city of Polokwane (a direction were the species is distributed) hoping that their village will be given preferences in the near future as far as services such as tar roads, street lights and sewage, amongst the others, are concerned. Other factors mentioned by participants as threat to NLP only included mining/quarrying activity (60%, n = 30) and human induced fire (42%, n = 21). Mining/quarrying activity take place within the boundaries of the population and it is increasingly expanding towards the north-west, north and north-east of the population. It should be stated that the majority of participants who reported mining/quarrying as threat to NLP were also pleased with the activity, primarily because it creates job opportunities for the local residents. Although fire can play a crucial role in the expansion of *E. groenewaldii* population by assisting with the release of more seeds and ultimately new growth/seedling, too much of it can completely destroy the whole plant as reported by participants in the present study. This is highly

Table 1: Threats affecting *Euphorbia groenewaldii* populations found in Ga-Mothiba region

	Populations				
Threats	NLP	MKP	MP	KP	RP
*Business establishment	∞	∞	+ (10-20%)	∞	+ (10-20%)
*Cutting of trees for firewood	+ (50-60%)	∞	∞	∞	∞
#Expansion of rural settlement	+ (30-40%)	∞	∞	∞	∞
#Habitat degradation	+ (30-40%)	∞	∞	∞	∞
#Human induced fire	∞	∞	+ (<10%)	∞	∞
*Invasive alien plants	+ (30-40%)	+ (<10%)	+ (20-30%)	+ (20-30%)	+ (<10%)
#Lack of knowledge of conservation status of spp.	+ (100%)	+ (100%)	+ (100%)	+ (100%)	∞
αLack of rainfall-shortage/drought	+ (30-40%)	+ (30-40%)	+ (30-40%)	+ (30-40%)	∞
#Mining/quarrying activity	+ (30-40%)	∞	∞	∞	∞
*Overgrazing	+ (50-60)	∞	+ (20-30)	∞	∞
Open waste dumping/burning of domestic	+ (30-40)	∞	∞	∞	∞
*Lime stone collection	∞	∞	+ (<10%)	∞	∞
*Rock collection	∞	∞	∞	∞	+ (<10%)
*Tar road	∞	∞	∞	∞	+ (30-40)
*Trampling (human- being and livestock)	+ (50-60)	+ (<10%)	+ (50-60)	+ (<10%)	+ (<10%)
*Unsustainable harvesting	+ (30-40)	∞	+ (<10%)	∞	∞

#: Threat reported by community members and confirmed by researchers, α: Threat reported by community members and not observed by researchers, *: Threat observed by researchers, +: Threat affecting population, ∞: Absent of threat, %: Degree of impact of threat

probable particularly since *E. groenewaldii* is succulent in nature with a high-water content, thus hot fire can destroy the inner cells[28]. However, the participants who stated fire as threat to *E. groenewaldii* acknowledged that they too are also responsible for the deliberately ignition and rationale for this was that fire promote lush growth of grasses for their livestock. Overall, alternative income generating activities, rangelands and land for rural expansion that will satisfy local community will be a key to avoid human induced mining activity, fire and rural growth as threats to the survival of this species.

The rest of the threatening factors namely rainfall scarcity/drought and lack of knowledge of conservation status of *E. groenewaldii* were common threats perceived by participants as affecting the survival of four investigated populations (KP, MKP, MP and NLP). It should be highlighted that apart from the absent of precipitation, all threatening factors stated by participants were observed by researchers during field excursions and are indeed contributing towards the reduction of *E. groenewaldii* diversity. This finding therefore, clearly showed that conservation of this species found in Ga-Mothiba village can only generally be achieved in partnership with local community members since they are knowledgeable about its threats or potential threats but most importantly because their own activities/actions directly or indirectly affect the investigated plant and its ideal natural habitats. However, lack of rainfall as mentioned by participants (to be one of the factors affecting *E. groenewaldii*) might be a consequence of climate change which is a potential threat to all plant biodiversity on planet earth[29]. This postulation is based on the fact that we observed several desiccated and dead individuals (with no observable sign of threat/s) in all the four sampled populations and these observations are some of the footprints of climate change on plant species. Lack of knowledge regarding the conservation status of threatened species by participants indeed might be a primary contributor to *E. groenewaldii* populations. This is because participants stated that if they knew conservation status of this species they would have given much attention to it with respect to the management and conservation including reporting illegal activities and any threat impacting its survival to the relevant authorities.

Threats observed by researchers: A field walk across all the five investigated *E. groenewaldii* populations was conducted to determine the threats and also corroborate the threats mentioned by participants. Overall, it was found that there are number of threats that impact upon the existence of these populations and their habitats. In addition to the threats reported by community members, it was observed and noted that the following threatening factors namely business establishments, cutting of trees for firewood, invasive alien plants, overgrazing, solid waste, stone collection, lime stone collection, trampling (human- being and livestock) and unsustainable harvesting. It should be stated that none of the interviewed community members reported these factors as threat to *E. groenewaldii* populations and one logical reason for this might be their lack of extensive knowledge regarding what is considered "threats" to the plant species of conservation concern. As depicted in Table 1, the aforesaid threats were not observed in all five investigated populations. Threats that were evidenced in all these populations encompass invasive alien plants and trampling by both human-beings and livestock.

Trampled individual species were easily marked by both human and animals foot prints and this impact is expected to continue since some villagers graze their livestock and move them across the populations on daily basis. Although trampling can assist in the transportation/tilling of seeds, our field observation showed that trampled parts of the species were damaged and most of them were greatly exposed to various biotic and a biotic factors. This according to Knowles and Witkowski[30] will make the species susceptible to opportunistic pathogens infestation and ultimately fatality. It should be stated that the vegetation cover in some of trampled areas were destroyed and traces of multiple crisscrossing livestock and human tracks are clearly visible within the population. This exposed some proportion of bare soil to erosion which in turn might trigger nutrient loss and ultimately extrinsic factors such as habitat fragmentation which may slow or prevent the species' recovery or result in the isolation of plant populations.

Invasive alien plants such as *Opuntia ficus-indica* (L.) Mill. and *Cereus jamacaru* DC are also invading or threatening certain areas of all five studied populations albeit they are not prominent yet. However, due to their ability to reproduce offspring in large numbers and at considerable distances from the parent plants[31], *O. ficus-indica* and *C. jamacaru* are more likely to increase and become major threat across the entire geographical range of population. Therefore, they should be exterminated and frequently monitored.

The rest of the threats as evidenced in Table 1 were restricted to particular population/s. Not surprisingly, open waste dumping and burning of domestic only impacted the NLP. This came as no shock because human settlement has already encroached in to the population, thus local community are more likely to litter within the population due to lack of official local landfill and waste management services. According to Ali *et al.*[32], open waste dumping and burning of domestic garbage deteriorate the soil's quality and ultimately decrease plant population expansion and its diversity. Therefore, domestic waste management services in the local villages of Ga-Mothiba located nearby NLP will be a key in solving these threats. Other noticeable threats affecting this population were extensive overgrazing of grasses and other palatable shrubs occurring in associations with *E. groenewaldii*. These accompanied by aridity in study area has resulted in land erosion and formation of boggy areas, both which has the potential to reduce *E. groenewaldii* diversity. Evidence of excavations of this succulent dwarf was also observed and accordingly several dead individuals next to most dug area was noted. Cutting of trees for firewood is widespread and intensive within NLP, chiefly due to the fact that fuel wood serves as primary source of energy (i.e., heating/warming house and daily cooking) for many households adjacent to this population, especially since households currently do not have electricity. The effect of frequent collection or over-collecting of firewood is severe on NLP as many *E. groenewaldii* adults occurring next/around the previously harvested trees shows physical signs of trampling and damage by human-being. This will lead to the rapid decline of the population if the affected individual plant species die[33].

Overgrazing and collection of *E. groenewaldii* was also observed as a threat to MP but the impact was low compared to NLP, perhaps attributed to the fact that the population is located on a rockier area, which makes it not easy for both human-beings and their livestock, to dig and graze palatable species, respectively. Other detrimental threats to MP observed were collection of lime-stone for decoration and body steaming. During field walks within this population, it was found that *E. groenewaldii* occurring in-between most stones were either destroyed or uprooted as the results of stones removals/collections. Another threat to MP population were development although it was not clear as to what sort of business it was. For instance, a big portion of land just less than 20 m away from population (on the eastern aspect) is fenced with a one security/guard house at the main gate/entrance. However, there are rumours in the community that this land will be used as a store-house and processing place for undisclosed minerals to be mined within the population. Should this rumour be true, both the existence and future expansion of MP will be entirely obliterated. Therefore, any activity that might affect this population, to be practiced within the above-referred fenced portion of land should be opposed.

Threats observed in numerous areas across RP were collection of rocks (perhaps for building of houses). For instance, evidence of removal of rocks has left some permanent excavations within population. Type of businesses such as accommodation (on the western site), sand and building materials factory (north-west), bricks and "atchaar" productions (eastern site) and constructed tar road (northern site) found adjacent to the eastern boundary of population are also threats. This is because the future expansion of RP will be effectively and greatly affected. It is therefore, imperative that local tribal leaders be requested not to allocate business slots at the north and north-eastern sites of this population as these are the only ranges that can allow future expansion of populace.

Overall, KP and MKP was the least impacted/threatened amongst the five studied populations, likely because they are less accessible to human-beings and domestic animals.

Community perception about the conservation activities: An assessment of local people's knowledge and perceptions, can produce useful information that could be incorporated into the decision-making process as well as management of threatened species[10,25]. Thus, local community perspectives regarding potential management solutions or strategies that might contribute to the conservation of explored *E. groenewaldii* populations was sought. It is encouraging to note that an overwhelming majority (96%, n = 48) of the respondents suggested a high level of local support for the species' conservation initiative and just 4% (n = 2) of them could not suggested any strategy to the species conservation or solution to any of the threats identified. Generally, awareness regarding the conservation of the investigated species were stated by the majority (96%, n = 48) of participants as the best strategy for its protection. Indeed, the success of biological conservation initiatives of a threatened species is not solely reliant on the collection of ecological information but equally on the community or public based conservation programmes/educations and their adherence[34,35]. This is because community members who are knowledgeable about the conservation can play a vital role in addressing the loss of plant diversity. Furthermore, they are more likely to willingly contribute towards in both the monitoring and preservation of the entire floral population. It is therefore, critical that local nature conservator and traditional leaders partner in creating awareness as well as campaigns amid community members for the protection of *E. groenewaldii* populations. The next most suggested conservation idea by participants (90%, n = 45) were a paid field patrol (by government) conducted by local community members, involving movement through the species' habitat at regular intervals looking out for any signs of threat of any kind. According to these participants', employment of local community members as patrol officers is more likely to decrease illegal activities occurrence within the population. This is because locals are acquainted with people within their community and are more likely to be respected in the society as opposed to the outsiders. Therefore as part of conservation strategy of investigated *E. groenewaldii* populations, we plea the Limpopo Department of Economic Development, Environment and Tourism (LEDET) together with the Polokwane municipality to cogitate appointing some community members from Ga-Mothiba village specifically as *E. groenewaldii* field patrollers. This will go a long way in contributing towards the current and future survival of the species entire population.

Additional conservation strategies of *E. groenewaldii* proposed by questioned community members included restriction from entering the population (76%, n = 38), fencing of the areas were species occurs (66%, n = 33), cultivation of species in other areas (42%, n = 21), active management structures of the populations involving government and local community (30%, n = 15), establishment of local *E. groenewaldii* gardens for harvesting (both for medicinal utilization and trading) (24%, n = 12) as well as development and promotion of the species' habit as a tourism destination (including development of ethno-tourism enterprise or centre show casing local talent (i.e., songs, dance and foods, amid the others) (18%, n = 9). According to participants, the latter will encourage people participate in the conservation of species as they will be benefitting from it via tourism. Overall, participants' keen perception towards conservation activities revealed that they are highly positive towards protecting *E. groenewaldii* populations and this is evidenced by the above-mentioned conservation ideas they put forth. Therefore, local nature conservators must take these ideas in to considerations during the drafting of the species management plan. Acknowledgment and integrations of the participant' conservation ideas should be viewed as a strategic approach of engaging with local communities, involving them more closely in the management and creating positive relationships with them as far as investigated *E. groenewaldii* populations are concerned. Furthermore, it will afford the local nature conservators an opportunity to craft more holistic and culturally/locally appropriate strategies for the conservation of this species. Consideration and implementation of community idea in the management and conservation of threatened species can also build a local sense of ownership over decisions and thus community members will ensure that their fellow residents respect and follow the idea.

CONCLUSION AND FUTURE RECOMMENDATIONS

The present study revealed that people residing nearby *E. groenewaldii* populations are unaware of the conservation status of this species. Thus, educational campaigns aimed at filling this gap in knowledge is urgently needed in all villages neighbouring the referred populations. The local nature conservation authority must take in to considerations most of the conservation ideas suggested by the interviewed villagers of Ga-Mothiba for the protection of *E. groenewaldii* populations during the species management plans. In addition to addressing various threats affecting this populations, we recommend that the local government should urgently purchase/secure available unoccupied lands in all aspects of five studied populations to allow their future expansion. An ongoing quarrying/mining activities within NLP

should be stopped with immediate effect. Overall, land use planners and conservationists from local government should assist the tribal leaders of Ga-Mothiba village in planning rural expansion in such as a manner that will not encroach in to the populations or affect the population's future expansion.

SIGNIFICANCE STATEMENT

This study indicated that people residing nearby the investigated *E. groenewaldii* populations are unaware of the conservation status of this species. Furthermore, our study revealed that these populations are under severe threats from anthropogenic factors. However, most people expressed great interest in the conservation of the referred populations and suggested some imperative conservation ideas that might aid in its current and future survival. Generally, the present study provides useful data that can be used by the Limpopo Department of Economic Development, Environment and Tourism to conserve *E. groenewaldii* populations.

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