Supporting Document

NDF Assessment for *Smaug giganteus* (Sungazer)

Approved by the Scientific Authority of South Africa: (12 February 2015)

Last information update: September 2023

Summary of findings

Smaug giganteus (sungazer) (previously known as *Cordylus giganteus*) is included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In accordance with Article IV of the Convention, an export permit shall only be granted for an Appendix II species when a Scientific Authority of the State of export has advised that such export will not be detrimental to the survival of that species. This NDF for *Smaug giganteus* (sungazer) was compiled through deliberations held at an expert workshop that was convened by the South African National Biodiversity Institute (SANBI) on 2 October 2014 (see list of workshop participants at the end of this document) and amended through various further consultations with experts. A comprehensive review of the relevant scientific literature and reports (see reference list) ensured all available information on the species was considered and captured in this document, current as of September 2023.

Smaug giganteus is endemic to the Highveld grasslands of South Africa and occurs in intact undulating primary grasslands on Karoo sediments in well-drained sites with relatively deep sandy-loam soils. The species occurs south of the Vaal River, and its distribution includes two allopatric populations with around 90% of its distribution located in the Free State and 10% in adjacent southwest Mpumalanga. The species has an extent of occurrence (EOO) of 34 500 km^2, and an area of occupancy (AOO) of 1 149 km^2. The interpreted distribution is 17 978 km^2, of which just under 60% (9 578 km^2) remains untransformed grassland. However, fifty percent of the habitat within the distribution range of the species is irreversibly transformed and highly fragmented. Within the Free State, 47% of the grassland has been destroyed or converted to other land uses and only small remnants of primary grassland still remain within the larger transformed landscape. The current population size is estimated at 677 000 mature individuals. The population has declined as a result of extensive habitat loss and fragmentation, and possibly also due to collection for traditional use and the pet trade, and is assumed to be decreasing through the continued effects of these impacts. A recent study showed a population decline of 32% over a 37-year period. This decline does not correspond with habitat loss over the same time period, as negligible changes in land cover were recorded. It is suspected that the population declines are an indirect result of historical habitat loss, as just under half of the distribution is irreversibly transformed, and colonies persist in islands of suitable habitat within a heavily fragmented landscape. A genetic based population study has found that sungazers occur in five genetically distinct populations across the distribution belonging to three divergent phylogenetic clades. The genetic differentiation of these clades correlate spatially and temporally with geological features that arose during the most recent uplift of the eastern Great Escarpment, ~900 m into the Highveld grasslands, ~2.5-1.8 MYA. It is important therefore, that conservation efforts focus on protecting populations within these clades such that the genetic diversity present within each is preserved. A combination of barriers such as mountains, rivers, and isolation by distance appear to be the primary drivers of population genetic structure, and the effects of human-mediated land cover change do not appear to have yet had an effect on gene flow in the species. This is likely however to be due to a lag effect given the long lifespan of sungazers, since major agricultural development across the distribution of the species equates to only 12 sungazer generations. The genetic effects of habitat loss and fragmentation may only be experienced within the next ~100-200 years. Habitat loss and fragmentation of specifically primary grassland is thus the major quantifiable threat to this species but overharvesting in the form of local traditional use and international pet trade are likely to significantly compound this threat.

The biological characteristics of *S. giganteus* render it highly sensitive to harvesting. Sungazers are long-lived with relatively low reproductive rates. The species is furthermore an extreme specialist with respect to habitat and is closely associated with the perennial grass *Themeda triandra*. They are generalist sit-and-wait predators, mainly feeding on invertebrates of the taxa Coleoptera, Diplopoda, Hemiptera, Hymenoptera, Orthoptera and Lepidoptera, and are highly dependent on their burrows for avoidance of avian, mammalian and reptilian predators and for thermoregulation. Little empirical data are available on the dispersal ability of the species, but the species is presumed to be a poor disperser as sungazers are rarely found more than a metre from a burrow entrance and are only occasionally recorded in unsuitable habitat or killed on roads, despite the presence of adjacent colonies. Sungazers are the first African lizard known to exhibit kin-based sociality, or family living. Juveniles share burrows with either male or female parent, and may receive parental care through protection from conspecifics, burrow sharing and social learning. The complexity of this still relatively unexplored social system may have implications for translocations and captive breeding, both of which have been largely unsuccessful to date. Sungazers will not recolonize previously transformed grassland and are thus highly sensitive to habitat transformation, especially ploughing where burrows are destroyed and colonies inadvertently killed, mining activities, and severe overgrazing. This is an important fact when issuing authorities receive applications to translocate colonies where habitat conversion is planned. The species is however tolerant of well-managed grazing and human activity in the broad vicinity of the colony and individuals readily populate areas adjacent to existing colonies that have been mown or heavily grazed by sheep.

This species has historically been harvested illegally, but there are no data to quantify this harvest. Disappearance of colonies from sites of historical occurrence is largely (anecdotally) attributed to illegal harvesting. The species is listed as 'Endangered' in terms of section 56 of the National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA), specifically the Threatened or Protected Species Regulations (TOPS Regulations), which requires provincial conservation agencies to issue permits for all use activities such as hunting, catching, capturing or killing etc. The species is listed as protected in both the Free State (Schedule 1 of the Free State Nature Conservation Ordinance 8 of 1969) and Mpumalanga (section 4, schedule 2 of the Mpumalanga Nature Conservation Act (Act 10 of 1998)) and all use activities regarding *S. giganteus* are regulated. There are currently no known captive breeding facilities in either province. A parentage study conducted by the National Zoological Gardens on 95 samples collected from a captive breeding facility trading internationally with sungazers could not find any evidence of captive breeding to an F2 generation as there were no indications of founder males and females in the facility. Apart from five (5) sungazers which were born at the SANBI National Zoological Gardens (NZG) (1 born in January 2020, and two sets of two born in January 2023), there are no confirmed records from any other reputable captive breeding operation for the successful breeding of the species in captivity, and there is general consensus that the species is very difficult to breed in captivity (with no formal breeding records anywhere in the world, except at the NZG). It is therefore highly likely that all animals in the pet trade have been illegally harvested from wild populations. Harvesting of sungazers is opportunistic and/or unselective. All current and past harvests from the wild have thus been illegal, except for a few individuals taken for research purposes.

South Africa does not currently have an export quota for sungazers. Sungazers however continue to be exported in large numbers (CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK). Between 1982 and 2022, 1 584 sungazers were exported live from South Africa, with a mean of 58 sungazers exported per year between 1985 and 2014. The trade has increased over the period 2005 and 2014 representing 43% of total recorded live exports. However, since the drafting of the NDF for the species in 2015, export in live specimens from South Africa has declined to only nine specimens exported in total since 2015 (to end of 2022). The export of captive specimens are monitored through the CITES trade database, but there is currently no monitoring of illegal harvest. From a recent study by Zondi (2020), the results estimated that around 442 animals may be harvested annually for traditional medicine purposes within the species geographic distribution. However, the exact number is difficult to ascertain given the opportunistic, illicit and informal nature of the trade.

There is no confidence in harvest management as the majority of the *S. giganteus* population exists outside of protected areas on private land, which hampers law enforcement efforts. There are no resources available to manage and monitor the harvesting of sungazers outside of protected areas. The lack of management and monitoring of the species and the uncertainty surrounding the extent of the illegal collection of sungazers from the wild is of great concern. Currently, there is no national management plan for the conservation and sustainable use of sungazers in the wild or in captivity, although a Biodiversity Management Plan (BMP) is currently under

development. The captive population is monitored by the Pan African Association of Zoos and Aquaria (PAZAAB) studbook which is managed by the NZG. There are currently no incentives for the conservation of the species or its habitat.

There are only three declared protected areas within the Area of Occupancy (AOO) of *S. giganteus* that have sungazers. Two colonies exist naturally on Sterkfontein Dam Nature Reserve. In the other two reserves sungazers were either introduced (Golden Gate Highlands National Park) or are unviable for long term conservation purposes (Eskom Majuba Power Station Sungazer Reserve). The species no longer occurs in Willem Pretorius Nature Reserve. Even though only a small percentage of the population occurs within state-protected areas, the entire population is protected by national (TOPS regulations) as well as a provincial legislation (Free State and Mpumalanga) through which all use activities relating to *S. giganteus* are regulated. No wild harvesting is allowed but a lack of capacity within the provincial conservation agencies to enforce the legislation leads to no confidence in the effectiveness of these strict protection measures. Strict protection measures are further rendered ineffective as harvesters do not abide by the law and there are no resources to monitor illegal harvests outside of protected areas.

This non-detriment finding undertaken for *S. giganteus* (sungazer) demonstrates that any international or local trade in wild specimens poses a high risk to this species in South Africa and is detrimental to the wild population (Figure 1 & 2). The Scientific Authority is therefore unable to issue a positive NDF for *S. giganteus* at this time and wild specimens of the species may not be exported (except for research or conservation purposes). Due to the uncertainty concerning the captive breeding of this species, exports of captive-bred specimens must not be allowed until scientific evidence for the successful breeding of *S. giganteus* in captivity is provided to the Scientific Authority for evaluation.

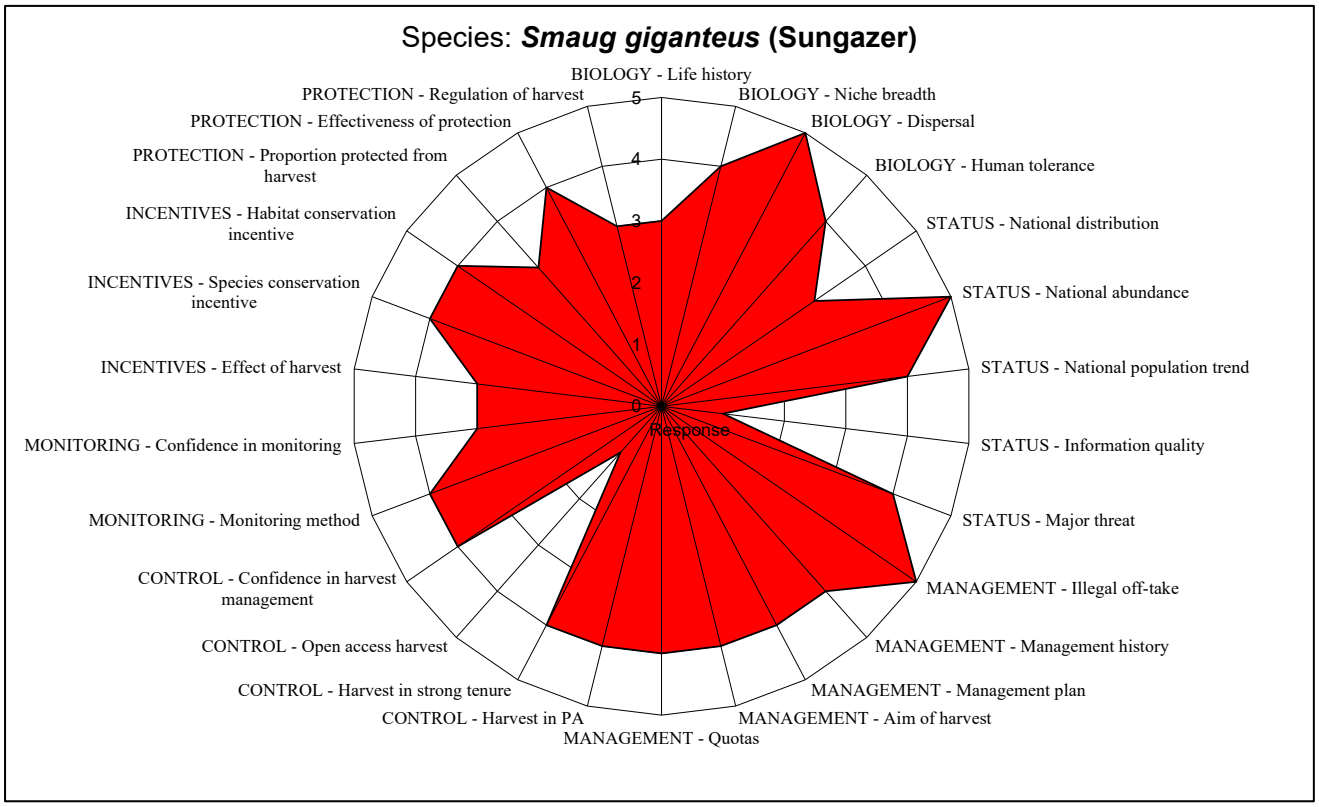

Figure 1: Radar chart summarizing the non-detriment finding (NDF) assessment undertaken for *Smaug giganteus* (sungazer) in South Africa in accordance with the CITES NDF checklist. Explanations of scores given are detailed in Table 1. Higher scores are indicative of higher risks to the species. The extensive shaded area in the radar chart demonstrates an overall high risk to the species.

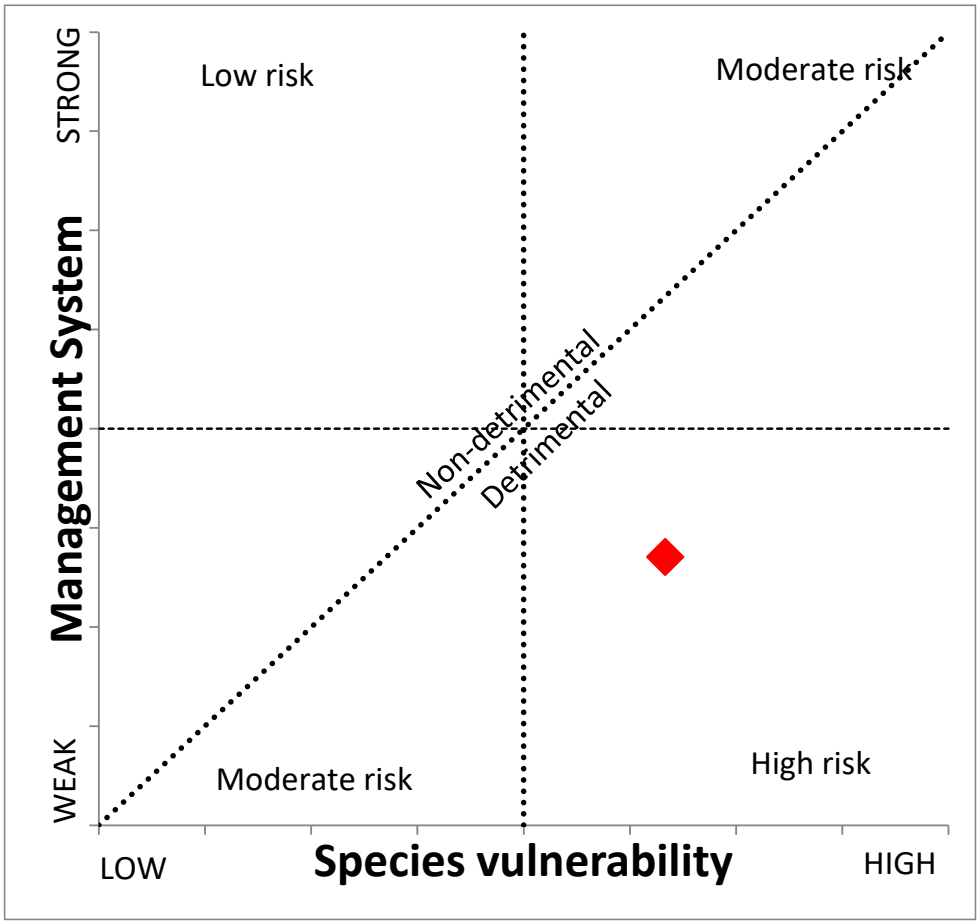

Figure 2: The risk of trading in *Smaug giganteus* (sungazer) by South Africa, as represented by the relationship between species vulnerability (biology and status) and the strength of the management system to which the species is subjected (harvest management, control, monitoring, incentives and protection). The figure demonstrates that the species is assessed as at a high risk and that the current export from the wild population is detrimental to the survival of the species in the wild.

Table 1: Detailed non-detriment finding (NDF) assessment for *Smaug giganteus* (sungazer) by South Africa undertaken in accordance with the CITES NDF checklist. Scores assigned to each question are indicated (bold text in shaded blocks) along with detailed explanations/justifications where relevant. Higher scores are indicative of higher risks to the species.

Biological characteristics		
1. Life history: What is the species' life history?	High reproductive rate, long-lived	1
	High reproductive rate, short-lived	2
	Low reproductive rate, long-lived	**3**
	Low reproductive rate, short-lived	4
	Uncertain	5
Sungazers live in dispersed colonies and are viviparous (give birth to live young). Females produce 1-3 live offspring every 2-3 years. Males and females reach sexual maturity at four to five years of age, at an average snout to vent length (SVL) of 165 mm (Van Wyk, 1992). Growth is relatively slow and lizards may only reach maximum length in their eleventh year (Van Wyk, 1992). The sungazer is a long-lived species with individuals living in the wild estimated to live up to at least 21 years (Stanton-Jones *et al*., 2023). Longevity records for sungazers in captivity show that individuals can live for up to 25 years (HAGR, 2014). Anecdotal observations from various landowners who have kept sungazers in enclosures in a natural environment within the geographic distribution of the species have claimed maximum longevity of 35 years. The slow reproductive rate, age to maturity and long lifespan are typical of a K-selected life history strategy (Van Wyk, 1992). Sungazers are the first African lizard known to exhibit kin-based sociality, or family living (Parusnath, 2020). Juveniles share burrows with either the male or female parent, and may receive parental care through protection from conspecifics, burrow sharing and social learning. The complexity of this still relatively unexplored social system may have implications for translocations and captive breeding, both of which have been largely unsuccessful to date.		
2. Ecological adaptability: To what extent is the species adaptable (habitat, diet, environmental tolerance etc.)?	Extreme generalist	1
	Generalist	2
	Specialist	3
	Extreme specialist	**4**
	Uncertain	5
Sungazers are endemic to the central Highveld grasslands of South Africa and occur in intact undulating primary grasslands on Karoo sediments in well-drained sites with relatively deep sandy-loam soils (Avaelon, Estcourt, Kroonstad and Longland are specific soils preferred) (van Wyk, 1992). Within the interpolated distribution of the species in the Free State, 32% of the natural habitat was transformed to cultivated land prior to 2006, while an additional 5.12% was transformed over the past 10 years (2006-2016) (Viljoen, 2017). They are habitat specialists preferring sites with *Themeda triandra* grass somewhere in the area and are not tolerant of intensive disturbance or transformation (Stanton-Jones, *et al*., 2023). The Extent Of Occurrence (EOO) of *S. giganteus* extends across 31 vegetation types described by Mucina and Rutherford (2006), yet the species occupies only 10 of these vegetation types. The lizards prefer slightly sloping grasslands with soft soil for digging their burrows and do not occur in rocky areas like many other lizard species. Sungazers have a preference for constructing their burrows on northerly-facing slopes and tend to orientate the entrance of their burrows in the same direction to which the land slopes (Stanton-Jones, *et al*., 2023). Although this is likely to have a thermoregulatory advantage, it may also reduce the potential for burrows to flood during rainy seasons (Alexander and Marais, 2007). The sungazer is a generalist sit-and-wait predator, mainly feeding on invertebrates of the taxa *Coleoptera*, *Diplopoda*, *Hemiptera*, *Hymenoptera*, *Orthoptera*, and *Lepidoptera*. They are highly dependent on their burrows for avoidance of abundant avian, mammalian and reptilian predators and for thermoregulation. The burrow systems also appear to be an integral part of their social structure, including offspring raising (Parusnath, 2020).		
3. Dispersal efficiency: How efficient is the species' dispersal mechanism at key life stages?	Very good	1
	Good	2
	Medium	3
	Poor	4
	Uncertain	**5**
Sungazers are presumed to be poor dispersers as they are rarely found more than a metre from a burrow entrance, have been found occupying the same burrow for at least 16 years (Stanton-Jones *et al*., 2023), and are only occasionally recorded in unsuitable habitat or killed on roads, despite the presence of adjacent colonies. However, individuals readily populate areas adjacent to existing colonies that have been mown or heavily grazed by sheep. Individuals readily move between burrows for social interactions such as matings. Sungazer colonies appear to be made up primarily of immediate and extended family members, with only a small portion of animals within a colony being unrelated (Parusnath, 2020). Juveniles stay with a parent		

and/or siblings within a burrow, likely until sexual maturity is reached. It is therefore unlikely that sungazers disperse from their parent colony until at least five years of age.

4. Interaction with humans: Is the species tolerant to human activity other than harvest?	No interaction	1
	Pest / Commensal	2
	Tolerant	3
	Sensitive	**4**
	Uncertain	5

Sungazers are very sensitive to habitat transformation, although they are tolerant of controlled grazing regimes and human activity in the broad vicinity of the colony. The species is restricted to primary grassland and will not recolonize previously transformed land. Once ploughed, primary grassland is replaced with secondary grassland and never recovers to its primary state. Sungazers are particularly susceptible to cultivation and seem unable to repopulate rehabilitated old fields, even where there are colonies in close vicinity. Populations however do occur in areas with moderate levels of grazing, periodic fires, and annual mowing of otherwise natural grassland. There have been reports of colonies near human settlements disappearing, but the cause of their disappearance is unknown. The species is tolerant of handling and sampling (McIntyre, 2006).

National status

5. National distribution: How is the species distributed nationally?	Widespread, contiguous in country	1
	Widespread, fragmented in country	2
	Restricted and fragmented	**3**
	Localized	4
	Uncertain	5

The species is restricted to a limited area of highveld grasslands on the central plateau of South Africa, occurring south of the Vaal River. The distribution includes two allopatric populations with around 90% of its distribution located in the Free State and 10% in adjacent south west Mpumalanga (Figure 3). Within the species' distribution range, 50% of the habitat is irreversibly transformed and very fragmented, while colonies are dispersed and naturally fragmented from a biological perspective. Thus, the species' distribution is both naturally and artificially fragmented. It is difficult to quantify the number of subpopulations as the species occurs in patchily distributed colonies across the distribution. The species has an extent of occurrence (EOO) of 34 500 km^2 and an area of occupancy (AOO) of 1 149 km^2 (Parusnath *et al*., 2017). The interpreted distribution is 17 978 km^2; 16 546 km^2 in the Free State and 1 432 km^2 in Mpumalanga. Just under 60% (9 578 km^2) of the interpreted distribution remains untransformed grassland (Parusnath *et al*., 2017).

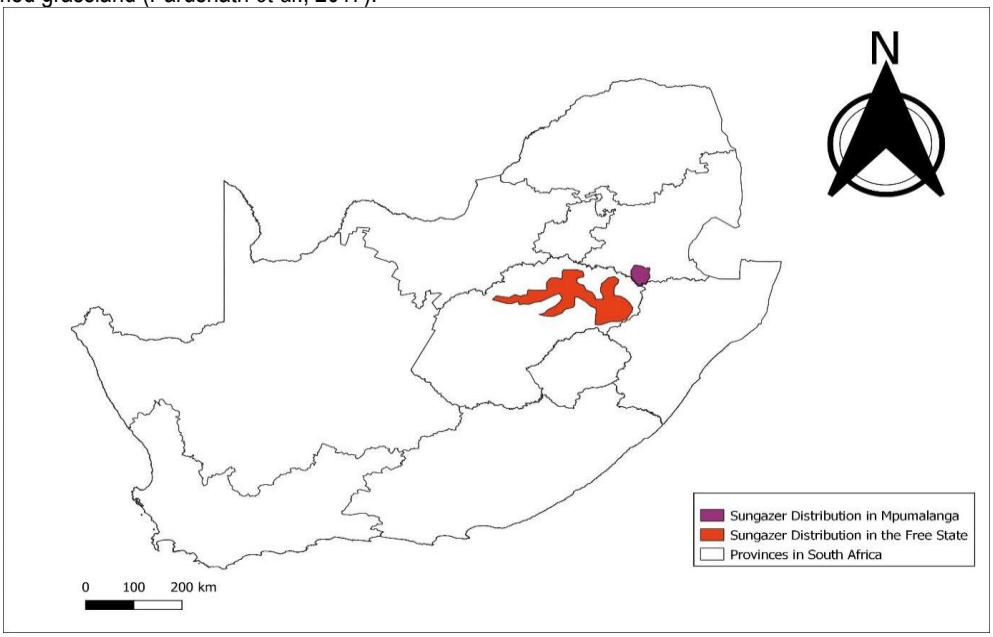

Figure 3: Map of South Africa showing *Smaug giganteus* extent of occurrence (Source: Parusnath *et al*., 2015).

6. National abundance: What is the abundance nationally?	Very abundant	1
	Common	2
	Uncommon	3
	Rare	4

	Uncertain	**5**

Little information currently exists on the sizes of sungazer colonies. Parusnath *et al*., (2017) calculated a mean burrow density (MBD) of 6.14 burrows/ha (range 1-16 burrows/ha). By multiplying the MBD with the AOO, it is estimated that there are 705 000 (SE 100 000) burrows within the distribution of the species. Of these, 605 000 (SE 86 000) are estimated to be occupied. The total current population of sungazers is thus estimated as 1 107 000 individuals (SE 157 000) (Parusnath *et al*., 2017). Population demographics data indicate that 62.4% of a population is made up of mature (sexually reproductive) individuals, and when applied to the total population size, the total mature individual count is 677 000 (SE 96 000) sungazers (Parusnath *et al*., 2017). There is still a high degree of uncertainty around the actual population sizes of the different colonies and national abundance of the species. The species is listed as Vulnerable (A2c) in the Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland (2014) and is at the very least uncommon within its distribution range but a more rigorous assessment of the status of primary grassland within the species' distribution may indicate that the species is rare. The IUCN Red List status was again assessed on 13 June 2017 and published in 2018 and the global status of Vulnerable remains (IUCN Red List).

7. National population trend: What is the recent national population trend?	Increasing	1
	Stable	2
	Reduced, but stable	3
	Reduced and still decreasing	**4**
	Uncertain	5

The sungazer population has declined, likely as a result of extensive habitat fragmentation and distribution wide habitat loss, and possibly also due to collection for traditional use and for the pet trade, and is assumed to be decreasing through the continued effects of these impacts. One-third of sungazer populations have been extirpated within the last four decades (Parusnath *et al*., 2017). The 31.6% decline recorded between 1978 and 2015 translates to a compounded rate of 1.03% per year. Assuming a constant rate of decline, populations have declined by 38.7% over the last 45 years (three generations). While decline was recorded across the distribution, Mpumalanga populations were more than twice as likely to become extirpated, than were Free State populations. The cause of this differential decline is unclear and none of the extirpations recorded in the Parusnath *et al*., (2017) study could be directly linked to habitat loss through recent habitat transformation, as none of these sites had been ploughed since the initial surveys. However, Stanton-Jones *et al*. (2023), assessed the population demographics of four sungazer subpopulations each within different habitat conditions; two were affected by mine tailings dumps, one occurred in a severely overgrazed rangeland, and one occurred in an undisturbed rangeland. The study found that subpopulations occurring in altered habitats (associated with mining and severe overgrazing) had declined by more than 50% over the 12-16 year period between surveys. The findings demonstrate the severe impact that habitat alteration may have on the sungazer population.

It is suspected that the population declines are an indirect result of historical habitat loss, as just under half of the distribution is irreversibly altered, and colonies persist in islands of suitable habitat within a heavily fragmented landscape. A genetic based population study has found that sungazers occur in five genetically distinct populations across the distribution belonging to three divergent phylogenetic clades (Parusnath, 2020). The genetic differentiation of these clades correlate spatially and temporally with geological features that arose during the most recent uplift of the eastern Great Escarpment, ~900 m into the Highveld grasslands, ~2.5-1.8 MYA. It is important therefore, that conservation efforts focus on protecting populations within these clades such that the genetic diversity present within each is preserved. A combination of barriers such as mountains, rivers, and isolation by distance appear to be the primary drivers of population structure, and the effects of human-mediated landcover change do not appear to have yet had an effect on gene flow in the species. This is likely however to be due to a lag effect given the long lifespan of sungazers, since major agricultural development across the distribution of the species equates to only 12 sungazer generations. The genetic effects of habitat loss and fragmentation may only be experienced within the next ~100-200 years. The average sungazer body size (snout-vent-length and mass) in each clade is significantly different, with an increasing size gradient from west to east.

8. Quality of information: What type of information is available to describe abundance and trend in the national population?	**Quantitative data, recent**	**1**
	Good local knowledge	2
	Quantitative data, outdated	3
	Anecdotal information	4
	None	5

Recent assessments provided substantiated quantitative trend data, using a rigorous approach to assess 1) population decline, 2) the potential impact of habitat transformation on sungazer subpopulations and 3) habitat decline across the distribution range of the species (Parusnath, 2014; Parusnath, *et al*. 2017; Parusnath, 2020; Stanton-Jones, *et al*., 2023).

	None	1

9. Major threats: What major threat is the species facing (underline following: Habitat loss/ overuse/ invasive species/ other:) and how severe is it?	Limited/Reversible	2
	Substantial	3
	Severe/Irreversible	**4**
	Uncertain	5

Habitat loss of specifically primary grassland has been the major quantifiable threat to this species, but overuse in the form of local (traditional medicine) and international (pet) trade are likely to compound this threat. Approximately 50% of all grasslands in South Africa have been permanently altered, but this figure is likely to be much higher if the loss of primary grassland is considered. Once ploughed, primary grassland is replaced with secondary grassland and never recovers to its primary state. The species is highly dependent on primary grassland. The habitat for the sungazer is further highly fragmented, with small primary grassland patches within a largely altered landscape. The major threat to this species is thus severe and irreversible. It is suspected that the population declines are an indirect result of historical habitat loss, as just under half of the distribution is irreversibly altered, and colonies persist in islands of suitable habitat within a heavily fragmented landscape. However, none of the recently recorded extirpations appeared to be due to habitat loss, as in each case of extirpation, the habitat remained unaltered. Rather, it is likely that extirpations are the result of harvesting and habitat fragmentation (Parusnath *et al*., 2017).

According to the CITES trade database (CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK), approximately 1 584 live sungazers have been exported from South Africa between 1982 and 2022 (Fig. 4). Since the drafting of the fist NDF for the species in 2015, the number of exports from South Africa has declined significantly (Fig. 4). A total of 1 569 live sungazers were exported under permit from South Africa between 1985 and 2014 (x = 58 per year). The period from 2005 to 2014 had the highest number of exports, representing 43% of total export numbers on record. Since 2015 only nine live specimens have been exported from South Africa. The majority of permitted sungazer exports from South Africa over the past three decades were reported to have been captive-bred individuals (70%), while only 6% were reported as wild-caught (Parusnath *et al*., 2017). Seeing that sungazers are notoriously difficult to breed and that there are only a single published case of captive breeding (and only two more recent cases at the SANBI National Zoological Gardens (NZG) captive breeding colony), it is more likely that the vast majority, if not all, captive-bred sungazers are actually wild-caught animals laundered for trade (Loehr *et al*., 2016; Parusnath *et al*., 2017).

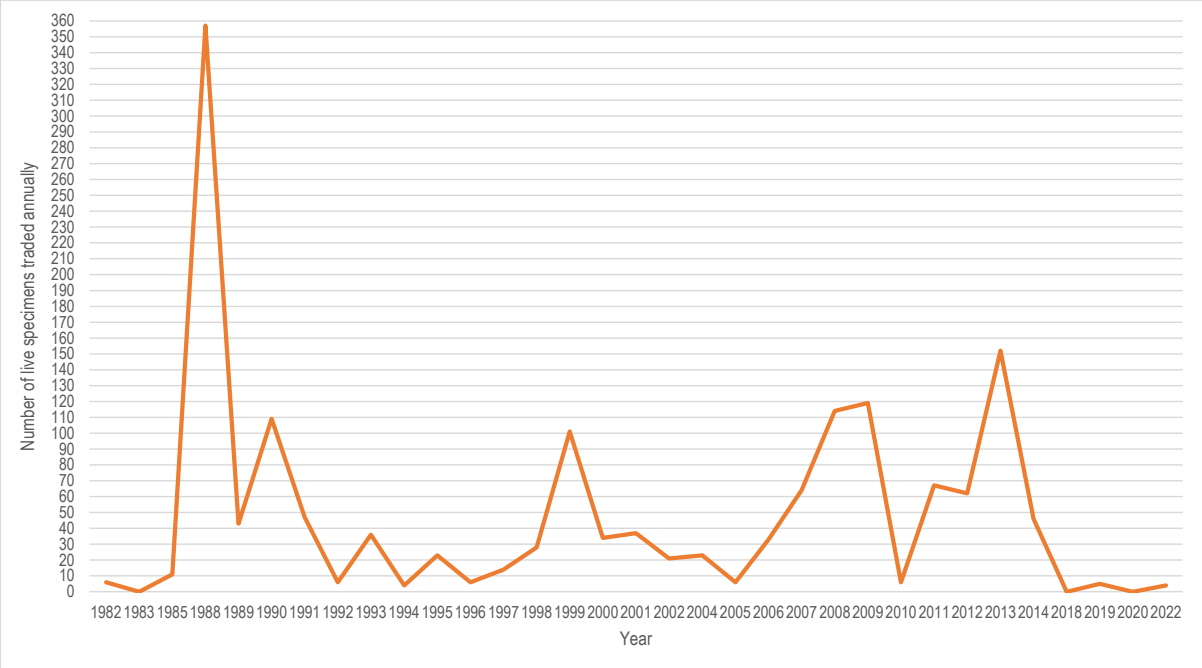

Figure 4: CITES trade data illustration legal trade in live sungazers from South Africa between 1982 and 2022.

From a recent study by Zondi (2020), the results estimated that around 442 animals may be harvested annually for traditional medicinal purposes within the species geographic distribution. However, the exact number is difficult to ascertain given the opportunistic, illicit and informal nature of the trade. At present any removal of sungazers from the wild could be a threat. Translocations in the past have mostly been unsuccessful (Groenewald, 1992).

Harvest management		
	None	1
	Small	2

10. Illegal off-take or trade: How significant is the national problem of illegal or unmanaged off-take or trade?	Medium	3
	Large	4
	Uncertain	**5**

Though the effect of illegal trade has not been quantified, sungazers are used ubiquitously across their distribution range in traditional medicine and are also regularly exported for the international pet trade. According to the CITES trade database (CITES Trade Database, UNEP World Conservation Monitoring Centre, Cambridge, UK), approximately 1 584 live sungazers have been exported from South Africa between 1982 and 2022 (Fig. 4). Since the drafting of the fist NDF for the species in 2015, the number of exports from South Africa has declined significantly (Fig. 4). A total of 1 569 live sungazers were exported under permit from South Africa between 1985 and 2014 (x = 58 per year). The period from 2005 to 2014 had the highest number of exports, representing 43% of total export numbers on record. Since 2015 only nine live specimens have been exported from South Africa. The majority of permitted sungazer exports from South Africa over the past three decades (1985-2014) were reported to have been captive-bred individuals (70%), while only 6% were reported as wild-caught (Parusnath *et al*., 2017). Given that (1) neither the Free State nor Mpumalanga has ever issued a permit to harvest the species, (2) that (excepting the recent births in 2020 and 2023) there have been no other confirmed records of successful breeding of sungazers in a registered captive breeding programme (Loehr *et al*., 2016), and (3) there is a general consensus that the species is very difficult to breed in captivity (van Wyk, 1992), it is highly likely that all sungazers in the pet trade have been illegally harvested from wild populations. A multitude of articles on the captive husbandry of the sungazer and new listings on the European Studbook over the past decade are testament to the thriving trade of the species (Donovan, 1997; Fogel, 2000; Langwerf, 2001; McKeown, 2001; Zwartepoorte, 2003; Zwartepoorte, 2006; Schwier, 2007; Gilchrist, 2009; Gilchrist, 2010a; Gilchrist, 2010b; Zwartepoorte, 2010; Gilchrist, 2013). In addition, according to the CITES trade database, a number of countries have been exporting live sungazers with either no CITES records of imports of the species into the country, or exports occurring prior to imports into the country. For example, there has been no recorded imports of the species into Congo, but in 2013 10 wild caught live specimens of unknown origin were exported to Korea for zoological purpose. Similarly, in 1990, the USA exported 17 live specimens to Japan indicating the origin of the specimens as Lesotho, however, there is no records of Lesotho importing the species from any other country and since the species is endemic to South Africa, the specimens could not have been sourced locally within Lesotho.

In February 2023 sungazers were confiscated from a POSTNET package which was destined for KwaZulu Natal (https://www.news24.com/fin24/climate_future/environment/cobra-lizards-found-in-postnet-parcel-in-alleged-smuggling-bid-20230216). Another article reports that in July 2023 a man from the Gauteng province was found guilty and fined R500 000 for illegally exporting sungazers to Germany and Mexico. His wife received a suspended jail sentence.

Newspaper articles illustrate localised use of *Smaug giganteus*, while anecdotal reports of illegal removal of sungazers have been received from farmers. Approximately 20 people have been convicted in the Free State courts over the past ten years in relation to the *S. giganteus* traditional medicine trade. The selling of *S. giganteus* in traditional medicine markets across the country has also been confirmed; however the scale of the trade has not been quantified.

Due to the regulation of traditional healers, the quantity of sungazers in traditional muthi markets has declined. Although the trade has not stopped, it has decreased significantly. While authorities receive information regarding the illegal harvesting, the alleged perpetrators are seldom found in possession of sungazers. In 2023, only one sungazer was found alive in a harvester's possession. Confiscated sungazers are in most cases taken for rehabilitation. Most illegal harvesters are teenagers. It is further reported that two pet shops in the Free State allegedly sell *S. giganteus*. This species can however easily be confused with other cordylid lizards and unconfirmed reports must therefore be treated with some caution.

Zondi (2020) mentions that the illegal harvest of sungazers for traditional medicinal use in rural areas does not seem to be as extensive as anticipated. Moreover, traditional medicine practitioners mentioned that they usually prescribe small volumes of sungazer material when preparing these concoctions. The commercial trade of the species in large markets in cities is of concern due to the large numbers of registered traditional healers. Therefore, the estimated number of sungazers harvested illegally may potentially be an underestimate, but not a significant underestimate due to the rarity of sungazers observed in the urban traditional medicine markets.

11. Management history: What is the history of harvest?	Managed harvest: ongoing with adaptive framework	1
	Managed harvest: ongoing but informal	2
	Managed harvest: new	3
	Unmanaged harvest: ongoing or new	**4**
	Uncertain	5

Smaug giganteus has been harvested for many years, but there are limited data to quantify the illegal harvest of the species. However, a recent study estimated that approximately 442 animals per year are harvested by 89 traditional medicine practitioners within the species distribution (interviewed for the study) (Zondi, 2020). The absence of the species on several

farms where populations were previously recorded has been confirmed to be due to illegal harvesting on the property and/or high levels of disturbance associated with human settlements or human activity in close vicinity to colonies.

All activities regarding *S. giganteus* are regulated. The species is listed as endangered on the current Threatened or Protected species list (section 56 of the National Environmental Management: Biodiversity Act No. 10 (NEMBA) of 2004), and is a protected species in both the Free State (Schedule 1 of the Free State Nature Conservation Ordinance (Act 8 of 1969)) and Mpumalanga (section 4, schedule 2 of the Mpumalanga Nature Conservation Act (Act 10 of 1998)). Neither the Free State nor Mpumalanga issue permits for the collection of *S. giganteus* from the wild. There are currently no registered breeding facilities in either province.

A parentage study conducted by the SANBI NZG on 95 samples collected from a captive breeding facility in KwaZulu-Natal claiming to have captive bred sungazers and who traded internationally with sungazers could not find any evidence of captive breeding to an F2 generation as there were no indication of founder males and females in the facility (Dalton, Roelofse and Kotze, 2015). Many zoos and individuals have thus far been unable to successfully breed sungazers in captivity (Loehr *et al*., 2016) (excepting a birth recorded at the SANBI NZG in 2020, and two birthing events in 2023). A single successful case of captive breeding is documented by Bert Langewerf in 2001. Langewerf reported this case in Reptile Magazine, June 2001. This report, however, has subsequently been questioned, since Langewerf had collected these animals from the wild in South Africa and the offspring may have been the product of a wild mating, since sungazers have a long (8-9 months) gestation period.

During February 2017, the SANBI NZG placed a group consisting of one male and seven females into an outside camp measuring 85 m^2. The camp simulates the animal's natural environment. During March 2017, three more females were moved to the camp. In August 2019, an additional male was added to the group. The lizards inhabit ten burrows that were partially dug for them and that was modified to their liking by themselves. Courtship and mating behaviour were observed and photographed on numerous occasions. On 17 January 2020, a female with unique ID 917446 gave birth to one offspring. This female (ID no 917446) came to the SANBI NZG on 12/11/2016 and gave birth to the young three years and two months after the SANBI NZG received her. This group is well cared for and is exposed to minimal human disturbance. In January, a further four sungazers were born in captivity to two separate females with unique ID numbers 916904 (donated to the institution in 2014) and 917432 (donated to the institution in 2016). Each female gave birth to two offspring. However, no scientific evidence for the successful breeding of *S. giganteus* in captivity has as yet been provided to the Scientific Authority for evaluation.

12. Management plan or equivalent: Is there a management plan related to the harvest of the species?	Approved and co-ordinated local and national management plans	1
	Approved national/state/provincial management plan(s)	2
	Approved local management plan	3
	No approved plan: informal unplanned management	**4**
	Uncertain	5

A draft Biodiversity Management Plan has been compiled for the species and actions such as awareness activities and research are underway and in some cases already completed. A regional studbook for specimens of *S. giganteus* currently in collections has been established and is monitored by the Pan African Association of Zoos and Aquaria (PAAZA). Within Mpumalanga two documents (Newbery *et al*., (1983) and Newbery and Jacobsen, (1994)) regarding the management of sungazer populations in the previously named Transvaal exist, but neither of these documents was ever implemented by Transvaal Provincial Administration or the current Mpumalanga Tourism and Parks Agency.

13. Aim of harvest regime in management planning: What is harvest aiming to achieve?	Generate conservation benefit	1
	Population management/control	2
	Maximize economic yield	3
	Opportunistic, unselective harvest, or none	**4**
	Uncertain	5

No permits have been issued by range provinces for the harvesting of sungazers from the wild and as such all past and current harvests are illegal. All activities regarding *S. giganteus* in both the Free State and Mpumalanga provinces are regulated by national and provincial conservation legislation.

14. Quotas: Is the harvest based on a system of quotas?	Ongoing national quota: based on biologically derived local quotas	1
	Ongoing quotas: "cautious" national or local	2
	Untried quota: recent and based on biologically derived local quotas	3

	Market-driven quota(s), arbitrary quota(s), or no quotas	**4**
	Uncertain	5
No quotas are in place, and all past and current harvests are illegal.		
Control of harvest		
15. Harvesting in Protected Areas: What percentage of the legal national harvest occurs in State-controlled Protected Areas?	High	1
	Medium	2
	Low	3
	None	**4**
	Uncertain	5
There are three declared protected areas within the AOO of *S. giganteus*. Two sungazer colonies currently occur on Sterkfontein Dam Nature Reserve. Sungazers on the other two protected areas were either introduced (Golden Gate Highlands National Park; Groenewald, 1992) or are unviable for long term conservation purposes (Eskom Majuba Power Station Sungazer Reserve (Parasnath, 2014). The species no longer occurs in Willem Pretorius Nature Reserve. No legal harvest occurs within any of the protected areas.		
16. Harvesting in areas with strong resource tenure or ownership: What percentage of the legal national harvest occurs outside Protected Areas, in areas with strong local control over resource use?	High	1
	Medium	2
	Low	3
	None	**4**
	Uncertain	5
There is no current legal harvest.		
17. Harvesting in areas with open access: What percentage of the legal national harvest occurs in areas where there is no strong local control, giving *de facto* or actual open access?	**None**	**1**
	Low	2
	Medium	3
	High	4
	Uncertain	5
There is no current legal harvest.		
18. Confidence in harvest management: Do budgetary and other factors allow effective implementation of management plan(s) and harvest controls?	High confidence	1
	Medium confidence	2
	Low confidence	3
	No confidence	**4**
	Uncertain	5
All current harvests are illegal and therefore there is no confidence in harvest management. Law enforcement efforts are hampered by the fact that only a small percentage of the national population occurs within protected areas. There is no control over illegal harvesting and it is difficult to apprehend perpetrators before the theft has occurred. There are extremely limited resources to effectively manage the harvest of this species.		
Monitoring of harvest		
19. Methods used to monitor the harvest: What is the principal method used to monitor the effects of the harvest?	Direct population estimates	1
	Quantitative indices	2
	Qualitative indices	3
	National monitoring of exports	**4**
	No monitoring or uncertain	5
Smaug giganteus is currently listed on Appendix II of CITES and all international exports of specimens are monitored through CITES export permits. The species is listed as endangered in terms of section 56 the National Environmental Management: Biodiversity Act 10 of 2004 – Threatened or Protected Species Regulations (TOPS Regulations) which requires provincial conservation agencies to issue permits for all use activities such as hunting, catching, capturing or killing etc. Harvest of the species is not allowed in Mpumalanga or the Free State and thus monitoring of legal use through a permit system does not take place. All harvesting is thus illegal. There is no monitoring of illegal harvesting from the wild at present and not feasible due to lack of capacity and costs involved and difficulty in locating poached animals and illegal activity (such as collecting animals and being in possession of sungazers). It has been shown from research conducted that it is still happening on an ongoing basis, but in unknown numbers. Parusnath, (2020) has developed a suite of microsatellite genetic markers that can		

be applied as a tool to determine relatedness and verify parentage of sungazers, thus facilities claiming to captive breed sungazers for export can be investigated. These markers also allow for the origin determination of confiscated animals or those already in collections to be identified. This can be very informative in detecting poaching hotspots and where illegal trade is impacting on populations. Although genetic tests are costly, funds are made available through SANBI under the Biodiversity Management Plan to render a service to government and the provinces to combat illegal trade. For any export of sungazers by a private individual, costs are for their own account. In addition, there is some preliminary research into the potential of using stable isotope analyses (carbon & nitrogen) as a means to distinguish between wild caught and captive bred individuals (Hall *et al*., 2019). The methodology is however still in development.

20. Confidence in harvest monitoring: Do budgetary and other factors allow effective harvest monitoring?	High confidence	1
	Medium confidence	2
	Low confidence	**3**
	No confidence	4
	Uncertain	5

There is currently no monitoring of illegal harvest for pet trade and traditional medicinal use. Between 1982 and 2022, 1 584 sungazers were exported live from South Africa, with a mean of 58 sungazers exported per year between 1985 and 2014 (Fig. 4). The trade has increased over the period 2005 and 2014 representing 43% of total recorded live exports. However, since the drafting of the NDF for the species in 2015, export in live specimens from South Africa has declines to only nine specimens exported in total since 2015 (to end of 2022). These individuals were all reported as captive-bred but there is currently no scientific evidence for successful captive breeding of this species. In addition, a study has shown that approximately 442 animals are harvested per year by 89 traditional medicine practitioners within the species' distribution range with the purpose for traditional medicinal use (Zondi 2020).

It is highly likely that all animals in the pet trade as well as traditional medicinal use have been illegally harvested from wild populations. A monitoring programme using the genetic tool will be valuable to establish the origin of these specimens in the pet trade. This can be part of the Biodiversity Management Plan and where SANBI may fund such a programme.

Incentives and benefits from harvesting

21. Utilization compared to other threats: What is the effect of the harvest when taken together with the major threat that has been identified for this species?	Beneficial	1
	Neutral	2
	Harmful	**3**
	Highly negative	4
	Uncertain	5

Harvest of *S. giganteus* in addition to current habitat fragmentation is likely to be harmful given the disappearance of colonies from intact sites of known historical occurrence and anecdotal evidence of harvest (from local landowners) (Parusnath *et al*., 2017). All current harvests are illegal. The natural rate of colony loss is unknown but presumed low. Fragmentation can also cause a decline in genetic variation which may impact on the genetic viability of populations.

22. Incentives for species conservation: At the national level, how much conservation benefit to this species accrues from harvesting?	High	1
	Medium	2
	Low	3
	None	**4**
	Uncertain	5

None.

23. Incentives for habitat conservation: At the national level, how much habitat conservation benefit is derived from harvesting?	High	1
	Medium	2
	Low	3
	None	**4**
	Uncertain	5

None.

Protection from harvest

24. Proportion strictly protected: What percentage of the species' natural	>15%	1
	5-15%	2
	<5%	**3**

range or population is legally excluded from harvest?	None	4
	Uncertain	5
The majority of the *S. giganteus* population exists outside of protected areas on private land. However, three declared protected areas within the AOO of *S. giganteus* have sungazers. Two colonies exist naturally on Sterkfontein Dam Nature Reserve. In the other two protected areas, sungazers were either introduced (Golden Gate Highlands National Park; Groenewald, 1992), or are unviable for long term conservation purposes (Eskom Majuba Power Station Sungazer Reserve) (Parusnath, 2014). The species no longer occurs in Willem Pretorius Nature Reserve. The species only occurs in a small section within these three conservation areas and all three the reserves occur at the periphery of the species distribution with most suitable habitat occurring beyond reserve boundaries. All use activities relating to the species are regulated within the Free State and Mpumalanga. No harvest is legally permitted in either of these provinces, but enforcement to prevent illegal harvest is considered largely ineffective.		
25. Effectiveness of strict protection measures: Do budgetary and other factors give confidence in the effectiveness of measures taken to afford strict protection?	High confidence	1
	Medium confidence	2
	Low confidence	3
	No confidence	**4**
	Uncertain	5
Two viable sungazer colonies occur on Sterkfontein Dam Nature Reserve. The majority of the *S. giganteus* population, however exists outside of protected areas on private land. There is good legislation in place both on a national (TOPS regulations) as well as a provincial level (Free State and Mpumalanga) where all use activities relating to *S. giganteus* are regulated. No wild harvesting is allowed, but a lack of capacity within the provincial conservation agencies to enforce the legislation leads to no confidence in the effectiveness of these strict protection measures.		
26. Regulation of harvest effort: How effective are any restrictions on harvesting (such as age or size, season or equipment) for preventing overuse?	Very effective	1
	Effective	2
	Ineffective	**3**
	None	4
	Uncertain	5
There is good legislation in place both on a national (TOPS regulations) as well as a provincial level (Free State and Mpumalanga) where all use activities relating to *S. giganteus* are regulated. No wild harvesting is allowed, but a lack of capacity within the provincial conservation agencies render this regulation ineffective.		

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References

Alexander, G. and Marais, J., 2007. A guide to the reptiles of southern Africa. Struik Publishers, Cape Town. 408 pp.

Dalton, D.L., Roelofse, M. and Kotze, A., 2015. Scientific report: Parentage in Sungazers (*Smaug giganteus*). September 2015.

Donovan, P., 1997. The Giant Zonure or Sungazer. *Reptile and Amphibian Hobbyist* 2, 30-34, February.

Fogel, G., 2000. Observations on the Giant Sungazer Lizard, *Cordylus giganteus*, in Captivity. *The Bulletin of the Chicago Herpetological Society* 35, 277-280.

Gilchrist, F., 2009. Studbook Breeding Programme: *Cordylus giganteus*. Annual Report 2009, 1-4.

Gilchrist, F., 2010a. Inbreeding and captive breeding: helping the Sungazer survive. *Practical Reptile Keeping*; April, 48-51.

Gilchrist, F., 2010b. New insights into Sungazers. *Practical Reptile Keeping*; November, 15-20.

Gilchrist, F., 2013. Studbook Breeding Programme: Annual Report 2013, 1-4.

Groenewald, G.H., 1992. The relocation of *Cordylus giganteus* in the Orange Free State, South Africa: Pitfalls and their possible prevention. *The Journal of the Herpetological Association of Africa* 40, 72-77.

Human Ageing Genomic Resources, 2014. Giant spinytail lizard (*Cordylus giganteus*) longevity, ageing, and life history. Available at: http://genomics.senescence.info/species/entry.php?species=Cordylus_giganteus. [Accessed 26 March 2014].

Langwerf, B., 2001. Keeping and breeding Sungazers. *Reptile Magazine* June, 59-65.

Loehr, V.J.T., Parusnath, S. and Gilchrist, F., 2016. Bogus captive breeding of the South African Sungazer lizard *Smaug giganteus*. *Traffic Bulletin* 28(1).

McIntyre, T., 2006. Impact of gold mining on *Cordylus giganteus* and recommendations for conservation and management. Unpublished MSc thesis. University of the Witwatersrand, Johannesburg, South Africa.

McKeown, S., 2001. Digging up Sungazers in South Africa. *Reptile Magazine* June, 48-56.

Mouton, P.L.F.N. and le Fras, N., 2014. *Smaug giganteus* (Smith 1844). Pp 209. In Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J., De Villiers, M.S. (eds). Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. Suricata 1. South African National Biodiversity Institute, Pretoria.

Mucina, L., Rutherford, M.C. and Powrie, L.W., 2006. Vegetation Atlas of South Africa, Lesotho and Swaziland. In: Mucina, L., Rutherford, M.C. (eds.). The Vegetation of South Africa, Lesotho and Swaziland. SANBI, Pretoria.

Newbery, R.E. and Jacobsen, N.H.G., 1994. Conservation plan: *Cordylus giganteus*. Internal report, Transvaal Provincial Administration: Chief Directorate Nature and Environmental Conservation, Pretoria.

Newbery, R.E., Peterson, W. and Jacobsen, N.H.G., 1983. Management proposals: *Cordylus giganteus*. Internal report, Transvaal Nature Conservation Division, Pretoria.

Parusnath, S., 2014. A conservation assessment of the Sungazer (*Smaug giganteus*). MSc thesis, University of the Witwatersrand, Johannesburg.

Parusnath, S., 2020. Population genetics and sociality in the Sungazer (*Smaug giganteus*). Doctoral thesis. University of the Witwatersrand, Johannesburg.

Parusnath, S., Cunningham, M.J., Jansen, R., Little, I., and Alexander, G., 2017. The desolation of Smaug: the human-driven decline of the Sungazer (*Smaug giganteus*). *Journal for Nature Conservation* 36, 48-57.

Schwier, H., 2007. The Giant Girdled Lizard – Extraordinary and Mysterious. *Reptilia Magazine* 52.

Stanton-Jones, W., 2023. Habitat selection by a Threatened lizard, the Sungazer (*Smaug giganteus*): Implications for conservation. Doctoral thesis. University of the Witwatersrand, Johannesburg.

Stanton-Jones, W.K., McIntyre, T., and Alexander, G.J., 2023. Habitat transformation correlates with the decline of sungazer (*Smaug giganteus*) subpopulations. *African Journal of Wildlife Research* 53, 135-146.

Van Wyk, J.H., 1992. Life history and physiological ecology of the lizard, *Cordylus giganteus*. Unpublished PhD thesis. University of Cape Town, Cape Town, South Africa.

Viljoen, R., 2017. Mapping the transformation of the *Smaug giganteus's* (Sungazer) habitat using remotely sensed data and GIS techniques. MSc thesis, UKZN.

Zwartepoorte, H.A., 2003. Studbook Breeding Programme: *Cordylus giganteus*. Annual Report 2003. Zwartepoorte, H.A. 2006. Studbook Breeding Programme: *Cordylus giganteus.* Annual Report 2006.

Zwartepoorte, H.A., 2010. Studbook Breeding Programme: *Cordylus giganteus.* Annual Report 2010.