Leptailurus serval – Serval

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Regional Red List status (2016)	Near Threatened A2c + C2a(i)*†
National Red List status (2004)	Near Threatened
Reasons for change	No change
Global Red List status (2015)	Least Concern
TOPS listing (NEMBA) (2007)	Protected
CITES listing (1977)	Appendix II
Endemic	No

*Watch-list Data †Watch-list Threat

Serval can exist in agricultural landscapes as long as wetlands and natural vegetation are present. Occupancy of Servals decreases with increasing cropland area and pesticide use, but increases with small-scale farming/low intensity of livestock land-use and large-sized wetland patches (Ramesh & Downs 2015b).

Taxonomy

Leptailurus serval (Schreber 1776)

ANIMALIA - CHORDATA - MAMMALIA - CARNIVORA - FELIIDAE - *Leptailurus - serval*

Synonyms: *Caracal serval* (Schreber 1776), *Felis serval* (Smithers 1978)

Common names: Serval (English), Tierboskat (Afrikaans), Letlotse, Lelotswe, Tetekgwe (Sepedi), Phaha, Tlohi, Tholi, Tlodi, Qwako (Sesotho), Indloti, Lindloti (Swati), Ndloti (Tsonga), Tadi, Letlôtse (Tswana), Didingwe, Didinngwe, Dagaladzhie (Venda), Ihlosi, Inhlosi, Ingwenkala, Indlosi (Xhosa), Indlozi (Zulu)

Taxonomic status: Species

Taxonomic notes: A recent molecular phylogenetic study revealed that the Serval is closely related to both the African Golden Cat (*Caracal aurata*) and the Caracal (*Caracal caracal*) (Johnson et al. 2006), diverging from a common ancestor approximately 5.4 million years ago, though distinct enough to be monospecific (O'Brien & Johnson 2007). The Serval taxonomy is currently under review by the IUCN SSC Cat Specialist Group (Thiel 2015). Only one subspecies is recognised from within the assessment region, *L. s. serval* (Meester et al. 1986).

Assessment Rationale

Servals are wetland specialists that historically became regionally extinct in the Eastern Cape Province and most of the Western Cape Province by the 1980s. However, they were successfully reintroduced in several Eastern Cape protected areas in the early 2000s and, although rare, are now regularly seen throughout the province. Natural range expansion is also evident in the Western Cape. Additionally, several range expansions have been documented in the Free State and the eastern Northern Cape, as well as potentially in North West and Lesotho. This may indicate natural recolonisation, as there is no evidence of reintroductions for the North West Province, along man-made corridors (for example, dams and weirs that promote the growth of reeds and other dense vegetation that support their main prey species). Corroborating this, Servals appear to be adaptable to rural agricultural and/or industrial areas where appropriate wetland habitat is conserved or created, and thus areas where prey species thrive. Densities have been found to be similar between farms under various management intensities in the Drakensberg Midlands of KwaZulu-Natal, where density estimates range from 6.2 ± 1.9 to 7.7 ± 1.6 individuals / 100 km^2 using both maximum likelihood and Bayesian methods. However, it remains to be seen whether Serval subpopulations in transformed or degraded landscapes are viable in the long-term, as recent research suggests that the spatial configuration of natural to non-natural wetlands may be important in determining resilience.

Thus, continuing loss and degradation of natural wetlands and associated reed-banks is of major concern. The 1990–2013/14 (24-year period) South African National Land-Cover change report found a 32.8% decline in natural wetlands on a national scale, a combination of both anthropogenic degradation and currently drier conditions. This is almost exactly three generations for Serval (*c*. 25 years). This decline in wetlands is corroborated by general natural habitat loss on a provincial scale. If we infer that natural wetland loss is proportional to population decline for Serval, a Vulnerable A2c listing is appropriate. However, the relationship between natural wetland loss and population trends is unknown, the extent to which natural wetland loss is mitigated by artificial wetland establishment is uncertain, and there is no direct evidence for population decline. Thus, we list as Near Threatened A2c. Long-term monitoring sites should be established to detect any local or regional declines in various subpopulations related to land-use change.

Area of occupancy was calculated by buffering wetlands occurring within the extent of occurrence by 500 m and was estimated to range between 18,789 km^2 (large, natural wetland clusters) and 209,738 km^2 (including small

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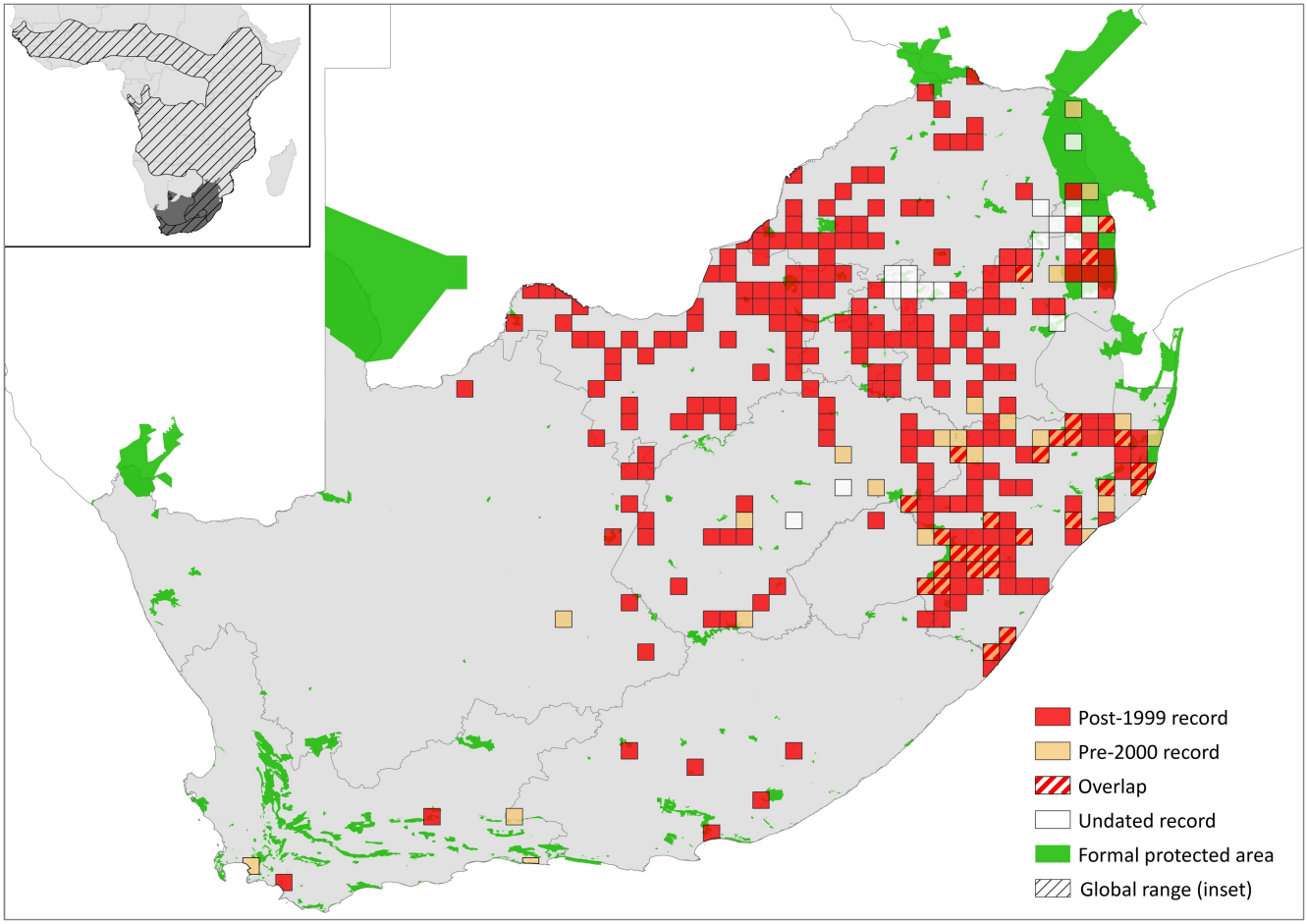

Figure 1. Distribution records for Serval (*Leptailurus serval*) within the assessment region

Table 1. Countries of occurrence within southern Africa

Country	Presence	Origin
Botswana	Extant	Native
Lesotho	Extant	Native
Mozambique	Extant	Native
Namibia	Extant	Native
South Africa	Extant	Native
Swaziland	Extant	Native
Zimbabwe	Extant	Native

waterbodies and artificial wetlands). This yields a current estimated mature population size that most likely ranges between 4,509 and 13,654 individuals (using a 50–70% mature population structure). The 2004 assessment estimated the mature population size at < 2,500 individuals, which is most likely an underestimate. An ongoing decline in mature individuals is suspected from either uses related directly to traditional medicine or cultural regalia (which may represent an emerging threat within the assessment region), or indirectly as collateral in snares laid out for other species or general predator control by farmers and landowners. Given that there is an inferred continuing decline from wetland loss, and a suspected continuing decline in mature individuals from incidental snaring, persecution or illegal trade, Servals would qualify for Vulnerable C2a(i). However, although it is likely that no subpopulation is larger than 1,000 mature individuals, it is uncertain how to define subpopulations in this species given their significant dispersal capacity. Thus we list as Near Threatened C2a(i). We note that further research is needed to more accurately calculate population size and area of occupancy, as well as the net effects of ongoing natural wetland loss versus use of modified habitats. Additionally, the emerging threat of being hunted for cultural regalia, similar to Leopards (*Panthera pardus*), should be monitored and quantified. This species should be reassessed as relevant data become available.

Key interventions include the conservation and restoration of wetlands and riparian/grass vegetation buffer strips around wetlands. We encourage managers and landowners to protect natural or artificial wetlands and waterside vegetation and maintain sufficient ground cover/ vegetation refugia in both farmlands and ranchlands to sustain key resource areas for Servals within an otherwise unsuitable matrix. Although Servals respond well to *ex situ* breeding, reintroduction efforts show mixed success and should be monitored and evaluated more thoroughly to improve best practice. Awareness and education campaigns to end intentional or indirect persecution of Serval should also be continued.

Regional population effects: Dispersal across regions via drainage systems is suspected (*sensu* Hermann et al. 2008). We are unsure whether this dispersal represents significant immigration into the region. It is suspected that South Africa might be a source population as there is possible movement of individuals between South Africa and neighbouring countries. We can expect movements across the Mozambique–South Africa border at several points. Generally other countries tend to be marginal

areas of distribution and no significant rescue effects are suspected.

Distribution

The Serval occurs widely through sub-Saharan Africa, with the exception of tropical rainforests and deserts (Nowell & Jackson 1996). Within recent years there are new records of Servals, implying an expanding population that is recolonising areas, such as Gabon, eastern Central African Republic, southwestern Uganda and central Namibia (Thiel 2015), and within the assessment region, the provinces of the Free State, North West and Northern Cape have been recolonised (Hermann et al. 2008; Power 2014). It is common within wetland habitats of the Drakensberg Midlands, and rare in the lowland wetlands of South Africa (Ramesh & Downs 2013; Ramesh et al. 2016).

In the latter half of the 20th century, the Serval was considered extinct, or near extinct, in many areas of its historical range (Stuart 1985; Smithers 1986; Skinner & Chimimba 2005; Hermann et al. 2008; Thiel 2015), primarily due to accidental persecution as a damage-causing animal and competitive exclusion by other carnivore species (Stuart 1985). For example, it is thought the Serval occurred historically in the eastern Free State (Hunter & Bowland 2013) and as far west as the Cape Peninsula (Skead 2011). Skead (2007) reported that Servals historically occurred along the entire coastal and sub-coastal belt of the Eastern Cape, and that they were nearly extinct in that province in 1987. In the early 2000s, Servals were reintroduced into Shamwari and Kwanwde Private Game Reserves in the Eastern Cape (Hayward et al. 2007). Although they are rare, they are also currently present in the following properties in the Eastern Cape (D. Peinke pers. comm. 2015): Amakhala, Lalibella, Hopewell, Kariega Park, Samara, and Mount Camdeboo. They have also recently been recorded from the Western Cape (Figure 1). With no known reintroductions having taken place, these observations either represent greater sampling effort that revealed an already existing low-density subpopulation or a range expansion from the Eastern Cape or undetected sources in the southern Northern Cape. Such hypotheses need to be researched. It is not impossible too that undisclosed introductions took place from captive facilities.

In the previous assessment (Friedmann & Daly 2004), it was thought that Servals were restricted to the wetter parts of the country, including the provinces of KwaZulu-Natal, Mpumalanga, Limpopo and the northeastern parts of the North West. However, a number of older records from central South Africa were not included in the species' distribution range (Friedmann & Daly 2004; Skinner & Chimimba 2005), as they were considered to be very rare in this part of the country. These records include four pre-1980 specimens from the eastern Free State (Lynch 1983), four sight records from the northern parts of the Eastern Cape (Lynch 1989), as well as a report that this species occurred within what is now the western part of the North West (Stuart 1981). However, more recent records from the Free State provincial conservation authorities, as well as personal observations, suggest that Servals have re-colonised and bred successfully in the western Free State and the eastern boundary of the Northern Cape (Hermann et al. 2008; Figure 1). These sightings are from vleis or riverine vegetation and suggest that Servals use the drainage lines as corridors for movement through the drylands of the Free State. As such, this is likely to be a genuine range expansion as there is no evidence of any *ad hoc* reintroductions. This expansion was most likely facilitated by the increase in man-made habitats, such as impoundments, weirs and dams, that have enhanced vlei-type habitats favourable to Servals (such as reeds and other dense vegetation that support their main prey species). Reduced threat levels from larger predators or domestic dogs and the adoption of holistic control methods for damage-causing animals or increased landowner tolerance for this species (Hermann et al. 2008) may also have facilitated range expansion. If true, then similar to Greater Cane Rats (*Thryonomys swinderianus*) (van der Merwe & Avenant 2004), Servals may continue to expand their range into other areas of South Africa. Encouragingly, most specimens were collected in the vicinity of perennial and non-perennial rivers or dams, which are the preferred habitats of their main prey species, in landscapes that would otherwise be considered unsuitable for Servals (Hermann et al. 2008).

Similarly, within the North West Province, they have expanded their range westwards by at least double since 1983 (Thorn et al. 2011; Power 2014), but have not been officially confirmed further west than the 25° meridian (Power 2014). In the protected areas, they were most common at Vaalkop Dam Nature Reserve, and, interestingly, the species did not even appear on any earlier checklists at Pilanesberg or Borakalalo (for example, Newbery 1995), although they are present in these areas (Power 2014). Reintroductions to these parks, as well as Madikwe Game Reserve and Kgaswane Mountain Reserve, took place in the 1980s–1990s (van Aarde & Skinner 1986). It is hypothesised that the above average rainfall years that have been experienced since 2000 have led to favourable habitat throughout (for example, dense grass, rejuvenated marshes) (Power 2014). This subsequent increase in both extent of occurrence (EOO) and area of occupancy (AOO), probably due to the creation of artificial water-bodies and a subsequent increase in prey, may indicate continuing recovery from historical persecution and habitat loss (Thorn et al. 2011).

Within KwaZulu-Natal, the population appears stable, especially as densities are comparable across a range of farming intensities (Ramesh & Downs 2013), as long as there are sufficient wetlands with natural vegetation evenly spaced within the landscape (Ramesh et al. 2015a). Although no previous records exist, an individual was seen at the Rooikop waterhole in the dry bed of the Nossob River in the Kgalagadi Transfrontier Park (T. Jackson pers. obs. 1990). They do not occur in the arid parts of the Nama or Succulent Karoo Biomes (Skinner & Chimimba 2005). The species also occurs throughout Swaziland (Monadjem 1998; Skinner & Chimimba 2005), and, although listed as a species predicted to occur in Lesotho lowlands, was not recorded by Lynch (1994). However, they have recently been caught on camera traps in the Lesotho Highlands (A. Jones unpubl. data).

At larger spatial scales, mesocarnivores like Serval are considered generalists, but at finer scales, Servals are habitat specialists in fragmented landscapes (Ramesh et al. 2015a). So they may be locally restricted to smaller areas within their broad distribution range, and conservation planners should integrate these scale considerations into regional management plans. To incorporate the fine-scale habitat selection and wetland spatial configuration into our estimate of AOO, we used

the wetland cluster layer from Driver et al. (2012) to calculate a minimum area of occupancy for Serval across its range. The wetland cluster layer represents clusters of at least three wetlands (within 1 km of each other) embedded within relatively natural areas (50% natural area or more – compared to artificial wetlands). We used maximum Serval home range size (60 km^2; Ramesh et al. 2015a) to buffer current (post-2000) distribution points using the equation:

$$r = \sqrt{\frac{A}{\pi}}$$

where r is the radius distance and A is the home range area, to generate a buffer radius of 4.4 km. This buffer layer was then overlaid onto the wetland clusters (buffered by 500 m) and any clusters containing Serval home ranges were summed. This yielded 10,426–11,144 km^2 of wetland cluster areas overlapping with current Serval records. This is likely to be a significant underestimate in minimum AOO for viable Serval subpopulations as there are false negatives in the Serval distribution data and many occurrence records fall outside of the cluster areas, which indicates Servals can make use of smaller wetland areas. Thus, within the total EOO (9,762,333 km^2), there is an estimated 18,789 km^2 wetland cluster area in total (not clipped to current Serval sightings). Furthermore, summing all buffered wetlands (small waterbodies and artificial waterbodies, not just wetland clusters) within the EOO yields a total AOO of 209,738 km^2 within the Serval's range. These AOO estimates represent a potentially useful baseline of core habitat occupancy for this species. Further research is required to refine these. For example, Ramesh et al. (2015a) use a 20 m buffer from the boundary line of each wetland to define core areas.

Population

The Serval is commonly recorded from most major national parks and reserves within the assessment region. From elsewhere in Africa, the minimum density of Servals in optimal habitat in Ngorongoro Crater was 0.42 animal / km^2 and 0.1 animal / km^2 in Luambe National Park in Zambia (Thiel 2015). Their status outside protected areas is uncertain, but they are inconspicuous and may be common in suitable habitat as they are tolerant of farming practices, provided there is cover and food available (Bowland 1990; Hunter & Bowland 2013; Ramesh & Downs 2013; Thiel 2015). Indeed, Bowland (1990) estimated 8 individuals / 100 km^2 in the Drakensberg foothills, while recently in the same area, a similar density of 6.2 ± 1.9 to 7.7 ± 1.6 individuals / 100 km^2 was recorded on farmland (Ramesh & Downs 2013), which perhaps indicates a stable subpopulation over the past 20 years. Additionally, ongoing work at the Sasol refinery site in Secunda (*c.* 3000 ha), a site with very disturbed artificial wetlands, but affording a good source of rodents, shelter, and protection (from the industry itself as well as persecution, and other predators), shows that there are 45 individuals thus far (based on mark–recapture camera trap survey), which equates to 1.5 individuals / km^2 (Matthews et al. 2014, 2015). This is an unusually high density for a medium-sized felid. There are also indications that the Sasol coal mining site, Syferfontien, (approx. 30 km away from the Secunda site) also has a healthy Serval subpopulation (W. Matthews unpubl. data). This very high density may not be the norm, but does indicate that, where Servals are protected, they can thrive. However, this high density is not the norm for many game reserves, farms and agricultural areas. The occurrence of Servals in farmlands is probably enhanced by the relatively low density of large or competing carnivores such as Caracal and African Wildcat (*Felis silvestris*). Finally, the new records from the western Free State and eastern Northern Cape represent the most western records of Servals in recent years and may represent recolonisation of grassland habitats over the past 20 years in central South Africa (Hermann et al. 2008). Thus, the Serval population may have remained stable over the past two decades (regionally) and may be increasing along the edge of its range (Hermann et al. 2008; Thorn et al. 2011; Power 2014). However, it is difficult to infer a population increase as Servals could simply have been undetected in these areas or have always existed at low density in sub-optimal habitat. Additionally, the recent surge in the use of camera traps in ecological studies may partially explain the increasing number of Serval observations.

Using the minimum and maximum density estimates from the KwaZulu-Natal Midlands (4.3–9.3 individuals / 100 km^2) and the AOO estimates, potential population size ranges from 448–1,747 individuals (using wetland clusters) and 9,018–19,506 individuals (using all buffered wetlands, to account for false negatives in the dataset). This corresponds to a range of 240–1,223 mature individuals using a 50–70% mature population structure for the wetland cluster AOO and 4,509–13,654 for all wetlands within the range. An alternative method of estimating population size, by adjusting the density estimate per vegetation type (*sensu* Mucina & Rutherford 2006) and estimating population size using the proportion of untransformed land across the Serval's range, yields 10,264 ± 812 individuals in total (R.J. Power unpubl. data). This corresponds to 5,538–6,614 mature individuals. In 2004, the mature population size was estimated at around 2,500 individuals using a 50% mature population structure (Friedmann & Daly 2004). Although the current population estimate is far higher, it is not necessarily reflective of population increase but rather better data (and improved methods of data collection) on Serval distribution and density, especially in habitats once presumed to be unsuitable for the species.

This species can subsist away from wetlands, as long as adequate grass cover and/or ecotonal tree cover is available, and artificial wetlands in dam outflows are utilised. These habitats are being increasingly created on low density eco-estates, wildlife ranches, mine buffer zones and agricultural systems. However, where subdivision of farms is taking place, due to inheritance and deeds transfers, habitat quality is often reduced through alien plant invasion and increases in traffic. Nevertheless, the Serval remains a wetland (and moist grassland) specialist and these habitats are the most threatened ecosystem in South Africa (Driver et al. 2012) with an ongoing loss in pristine and functional wetland areas. The extent to which this is compensated for by increasing artificial wetlands remains to be seen. Although Servals make use of such areas, these may not represent resilient and viable long-term habitats, especially as they are vulnerable to changes in management or land-use. Thus, ongoing wetland habitat loss and degradation, combined with a continuing loss of mature individuals to persecution, trade, road collisions or failed reintroductions, indicates that a decline in numbers or loss of core subpopulations cannot be ruled out.

Generation length has been estimated as 8.3 years (Pacifici et al. 2013), which makes the three-generation window 24.8 years.

Current population trend: Possibly declining due to net loss of wetland habitat, and deaths from persecution (snaring and roadkills) in some areas of their range.

Continuing decline in mature individuals: Yes, due to direct or indirect persecution.

Number of mature individuals in population: 4,509–13,654

Number of mature individuals in largest subpopulation: Unknown

Number of subpopulations: Unknown

Severely fragmented: No. They have a broad habitat tolerance and can exist in agricultural landscapes. Although these habitats are fragmented, Servals are able to connect with other subpopulations through corridors such as drainage lines to ameliorate fragmentation effects (Hermann et al. 2008).

Habitats and Ecology

In sub-Saharan Africa, Servals are mostly found in and around marshland, well-watered savannah and long-grass environments, and are particularly associated with reed-beds and other riparian vegetation types (Thiel 2015). Servals can penetrate dense forest along waterways and through grassy patches and are able to tolerate agricultural areas to some extent provided cover is available (Hunter & Bowland 2013; Ramesh & Downs 2013). However, they have quite specific habitat requirements, so may be locally restricted to smaller areas within their broad distribution range (Sunquist & Sunquist 2002). Key vegetation types are thus wetlands, grasslands (with a preference for long, rank grass), and indigenous vegetation that can provide cover and allow dispersal. These can be natural or man-made, although more research needs to be done on the ideal configuration of the latter wetlands (Ramesh et al. 2015a). So far the status and response of Servals in mosaic agricultural landscapes is uncertain, particularly their movement patterns and land use in response to habitat fragmentation. For example, they exhibit lower occupancy rates in cropland but increased occupancy with higher human abundance (Ramesh & Downs 2015b). Indeed, the species could be described as being semi-synanthropic due to the strong positive association with human activities. However, they are likely to be sensitive to fragmentation due to habitat specialisation, mainly preference for wetlands and its associated rodents. In an ongoing collaring study (Ramesh & Downs 2013), it was found that native wetland with a higher percentage of less disturbed, large-sized patches (core area) positively explained landscape use by Servals where nearly 80% of the GPS fixes concentrated only on remnant wetland habitats. Servals also avoided or used less cropland (Ramesh et al. 2015a). This is mainly due to the conversion of wetlands and their associated habitat for farming, residential development and commercial purposes that have led to many small disconnected patches of human-altered landscapes (Ramesh & Downs 2013).

Servals specialise on small mammals, in particular rodents, with birds being of secondary importance (Hunter & Bowland 2013). Small mammals (especially Vlei Rats *Otomys* species and Striped Mice *Rhabdomys pumilio*), birds, reptiles, fish, and rarely invertebrates, are also preyed upon (Smithers 1978; Bowland 1990; Skinner & Chimimba 2005; Ramesh & Downs 2015a). They are predominantly nocturnal (Skinner & Chimimba 2005), but increasing evidence points to crepuscular behaviour (S. Laurence unpubl. data).

Radio-tracked individuals on the Magaliesberg plateau of the North West's Kgaswane Mountain Reserve had home

Photo 1. Serval (*Leptailurus serval*) existing within the buffer habitats at the Secunda industrial site, Mpumalanga Province (Wayne Matthews)

range sizes between 2.1–2.7 km² (van Aarde & Skinner 1986). In Mount Currie Nature Reserve, reintroduced Serval had home ranges ranging from 2.9–9.4 km² (Perrin 2002). In the KwaZulu-Natal Drakensberg foothills, home-ranges varied from 15–30 km² (Bowland 1990). While in 2014, the average home range of collared Servals ranged from 5–60 km² in the farmland of KwaZulu-Natal (Ramesh et al. 2015a). As expected with felids, male ranges were much bigger than females. In Secunda, Mpumalanga, where there is a relatively high population density, home ranges are estimated at 1–2 km² (W. Matthews, unpubl. data).

Ecosystem and cultural services: As a predator of rodents and birds, Servals may play a functional role in agricultural landscapes in controlling the numbers of pest species (Thiel 2015; Ramesh & Downs 2015b). It is alleged that the Forestry Department, Mpumalanga, reintroduced Serval to control rodents that feed on the newly sprouting *Pinus* sp. seedlings but no documentary proof has been published for its effectiveness. However, camera trap data do provide evidence of Servals foraging in plantations (S. Laurence unpubl. data).

The Serval can be used as an umbrella species for savannah biotopes, and as an indicator for the highly endangered humid savannah biotope (Thiel 2015).

Use and Trade

Servals are utilised in the traditional medicine trade and skins used for traditional regalia. Trade in West Africa and South Africa appears to be primarily for ceremonial or medicinal purposes, but also for bushmeat. The impacts of this are unknown, but probably low; in North West only one skin has been confiscated in 7 years (R.J. Power unpubl. data). There are also incidents of local communities capturing Serval for traditional medicine or ritual use in the Midlands, KwaZulu-Natal (T. Ramesh unpubl. data), probably as for Leopard skin. They are sometimes mistakenly persecuted as a damage-causing animal (Hermann et al. 2008; Power 2014), although the overall level of persecution may be decreasing owing to increased knowledge and awareness of the species. An increased demand for this species as a hunting trophy by local and overseas hunters is suspected, although the CITES trade database documents a stable trend (Table 3), at an average of 46 ± 9 Serval trophies exported between 2002 and 2012. Although trophy hunting may cause local population declines, it is not expected to impact the overall population negatively given the species propensity for recolonisation and reintroduction. Illegal hunting is, however, suspected to be high. Additionally, there is an international market for hybridised Servals in the pet trade where they are marketed as the "Savannah Cat" in the United States, which is a likely market for captive-bred Servals, if they are not sold locally for reintroduction efforts.

Table 3. Serval (*Leptailurus serval*) trophy hunt exports registered on the CITES trade database

Year	Number of Serval trophies exported from South Africa
2002	37
2003	41
2004	47
2005	60
2006	50
2007	62
2008	47
2009	39
2010	39
2011	43
2012	36

Threats

The major threat to Serval is loss and degradation of wetland and associated grassland. Wetlands generally harbour high rodent densities compared with other habitat types, and form the core areas of Serval home ranges (Bowland 1990; Ramesh et al. 2015a; Thiel 2015). Of secondary importance is the degradation and loss of grasslands through several factors including annual burning followed by over-grazing by livestock, intensive wildlife/livestock farming leading to reduced abundance of small mammals and cover, and transformation with changing land-use, increased anthropogenic structures (roads, buildings) and invasive alien plants. Thus, while Ramesh and Downs (2013) found Serval density similar across a range of farmland management intensities, the continued loss of core wetland area may ultimately threaten a viable Serval population, especially if there is resistance to movement through hostile habitat such as open cropland (Ramesh et al. 2015a). Within agricultural landscapes, Servals selected areas with minimal disturbance and a high proportion of natural habitat

Table 2. Use and trade summary for the Serval (*Leptailurus serval*)

Category	Applicable?	Rationale	Proportion of total harvest	Trend
Subsistence use	Yes	Used for cultural regalia or traditional medicine.	Unknown	Unknown, probably stable.
Commercial use	Yes	Pet trade and *ex situ* conservation breeding.	Unknown	Unknown
Harvest from wild population	Yes	Captured for the pet trade.	Unknown	Unknown
Harvest from ranched population	No	-	-	-
Harvest from captive population	Yes	*Ex situ* conservation breeding.	Minority	Unknown

Table 4. Threats to the Serval (*Leptailurus serval*) ranked in order of severity with corresponding evidence (based on IUCN threat categories, with regional context)

Rank	Threat description	Evidence in the scientific literature	Data quality	Scale of study	Current trend
1	*2.1.3 Annual & Perennial Non-timber Crops*: wetland/grassland loss and degradation from agricultural expansion. Current stresses *1.1 Ecosystem Conversion* and *1.2 Ecosystem Degradation*: filling in, draining or degrading of wetlands.	GeoTerraImage 2015	Indirect (remote sensing)	National	Ongoing
		Jewitt et al. 2015	Indirect (remote sensing)	Regional	
2	*2.2.2 Wood & Pulp Plantations*: wetland/grassland loss and degradation from *Eucalyptus* and pine plantations. Current stresses *1.1 Ecosystem Conversion* and *1.2 Ecosystem Degradation*: filling in, draining or degrading of wetlands.	GeoTerraImage 2015	Indirect (remote sensing)	National	Ongoing
		Jewitt et al. 2015	Indirect (remote sensing)	Regional	
3	*2.3.3 Livestock Farming & Ranching*: wetland/grassland loss and degradation from agricultural expansion. Current stresses *1.1 Ecosystem Conversion* and *1.2 Ecosystem Degradation*: filling in, draining or overgrazing of wetlands.	GeoTerraImage 2015	Indirect (remote sensing)	National	Ongoing
		Jewitt et al. 2015	Indirect (remote sensing)	Regional	
4	*5.1.1 Hunting & Collecting Terrestrial Animals*: hunting for cultural regalia and/or traditional medicine and bushmeat.	G. Balme unpubl. data	Empirical	National	Ongoing
5	*5.1.2 Hunting & Collecting Terrestrial Animals*: incidental mortality in snares or traps laid out for other animals; sport hunting with dogs.	Ramesh et al. 2015a	Empirical	Regional	Ongoing
6	*7.2.2* and *7.2.3 Abstraction of Surface Water*: wetland draining from industrial and agricultural processes.	GeoTerraImage 2015	Indirect (remote sensing)	National	Ongoing
7	*4.1 Roads & Railroads*: mortality from vehicle collisions.	Ramesh et al. 2015a	Empirical	Regional	Ongoing
8	*1.1 Housing & Urban Areas*: wetland/grassland loss from residential expansion. Current stress *2.1 Species Mortality*: increased hunting rates.	GeoTerraImage 2015	Indirect (remote sensing)	National	Ongoing
		Ramesh et al. 2015a	Empirical	Regional	
9	*9.3.3 Agricultural & Forestry Effluents*: pesticides reducing prey base in agricultural landscapes.	Ramesh & Downs 2015b	Indirect (correlational)	Regional	Ongoing
10	*5.1.3 Persecution/Control*: direct persecution for poultry predation.	-	Anecdotal	-	Unknown
11	*8.1.2 Invasive Non-Native/Alien Species/Diseases*: deliberate hybridisation with feral cats in USA.	Eckermann-Ross 2014	Indirect	Global	Unknown
		Davis et al. 2015	Indirect	Global	
12	*2.1.2 Small-holder Farming* and *2.3.2 Small-holder Grazing, Ranching or Farming*: wetland loss and degradation from small-scale agricultural practices.	Ramesh & Downs 2013	Empirical	Regional	Unknown
		Ramesh & Downs 2015	Empirical	Regional	

(Ramesh et al. 2015a), thus highlighting that only landscapes with a mosaic of modified to natural habitats will be suitable and emphasises the importance of undisturbed habitats. Similarly, Serval occupancy decreased with increased pesticide use on farmlands (Ramesh & Downs 2015b).

Other threats within the assessment region include road mortalities, accidental persecution by farmers intent on killing other damage-causing carnivores (Power 2014), and incidental snaring as part of the bushmeat trade. Although Servals are non-target animals (and indeed may even be beneficial to crop farmers due to their predilection for rodents), many die in traps set out for carnivores such as Black-backed Jackal (*Canis mesomelas*), which are considered a problem animal or pest on these farmlands. Many also die getting trapped in snares targeted to kill ungulates for meat. For example, Ramesh et al. (2015a) found that nearly 40% of the collared Servals (N = 17) in the KwaZulu-Natal Midlands died due to snaring, roadkill and possibly rodent poisoning. Many un-collared individuals (10 between 2012 and 2013) were found dead on roads, which is corroborated on a national basis (W. Collinson unpubl. data). An average collared individual's age was 3–4 years, which indicates high mortality and low survival rate (Ramesh et al. 2015a). Additionally, Serval occasionally prey on poultry, which may lead to direct persecution. Similarly to Leopards, the trade in Serval skins for ceremonial traditions is an

important threat (G. Balme unpubl. data), and also contributes to a suspected ongoing decline in mature individuals. Trade in Serval pelts for ceremonial or medicinal purposes is widespread throughout Africa (Thiel 2015), and pelts are often worn as a substitute for Leopard pelts.

Hybridisation with feral cats may be a minor threat within the assessment region, although this is not as severe as other species, such as African Wildcat. Hybridisation with the African Wildcat has been documented in captivity (Skinner & Chimimba 2005). Deliberate hybridisation with the feral cat has resulted in a newly registered breed, the "Savannah Cat" (Eckermann-Ross 2014), and facilitated by the fact that many small felids are susceptible to domestication (Cameron-Beaumont et al. 2002). However, the males tend to become sterile after a few generations (Davis et al. 2015). The "Savannah Cat" is even registered with the International Cat Association as a breed, and is subject to various regulations depending on the state or province in the United States and Canada respectively. There has, however, been no indication of any threat as yet.

Current habitat trend: Declining. Servals are wetland specialists and, disturbingly, Driver et al. (2012) found that 65% of wetland ecosystem types are threatened (48% critically endangered, 12% endangered and 5% vulnerable), making wetlands the most threatened of all ecosystems. The South African National Land-Cover Change report found a 32.8% decline in natural wetlands nationally from 1990–2013/14, which is a combination of both genuine wetland loss through anthropogenic activities and the generally drier conditions currently than in 1990 (GeoTerraImage 2015). Habitat loss due to land transformation in the surrounding matrix further isolates wetlands from one another and exacerbates the degradation of individual wetlands. Such degradation and fragmentation of natural wetlands from agriculture, residential and commercial development have resulted in small disconnected patches within the assessment region. At provincial levels, natural habitat, which may correlate with wetland loss, is also ongoing. For example, more than 60% of farms in Mpumalanga have either prospecting or mining applications pending (J. Eksteen pers. comm. 2016), and between 2005 and 2011 there was a loss of 7.6% of the natural habitat in KwaZulu-Natal (Jewitt et al. 2015), primarily due to agricultural expansion. Thus, we infer a continuing population decline due to ongoing and extensive natural wetland loss.

Loss of natural wetlands is to some extent compensated by expansion of dam impoundments and "pseudo-wetlands" that create and protect habitat, where access by humans and dogs is limited (Hermann et al. 2008; Power 2014). For example, at the industrial site of Secunda, research is showing that artificial wetlands and associated areas can have a substantial positive effect if Servals are afforded protection on site (W. Matthews unpubl. data). Similarly, despite extensive agriculture in the KwaZulu-Natal Drakensberg Midlands, it is believed to have one of the largest Serval populations outside protected areas and is thus an important area for the conservation of this species (Bowland 1990; Rowe-Rowe 1992; Ramesh & Downs 2013). This is probably related to: (1) appropriate habitat conditions with prey availability, (2) presence of wetland habitats favoured by Servals, (3) the lack of interspecific competition with Black-backed Jackals, (4) low occurrence of competing felids like Caracal and African Wildcat, and (5) absence of large predators. Consequently if wetlands are protected in a mosaic of farmland, the landscape may support the persistence of Serval populations (Ramesh & Downs 2013, 2015a). However, Ramesh and Downs (2015a) found that regions with small-scale livestock farming have a higher likelihood of Serval presence than those with crop and dairy farming as the predominant land use. The latter generally followed conversion of natural wetland, forest and grassland habitats. Serval landscape use increased with increasing wetland core area size (Ramesh et al. 2015a). There is also a concern about the high turnover rate of individuals on farmlands in the Midlands because of snaring, and road kills with few surviving longer than 5 years (T. Ramesh & C. Downs unpubl. data).

Conservation

Effective conservation of Serval populations demands sufficient viable native habitat, particularly wetlands in fragmented landscapes of southern Africa (Ramesh & Downs 2013, 2015a; Ramesh et al. 2015a, 2015b). Wetlands form an island habitat in a mosaic of farmland for several wetland-dependent species; they are reservoirs of small mammal populations that are major dietary components of Servals (Bowland 1990). Consequently if wetlands are protected in a mosaic of farmland, the landscape may support the persistence of Serval subpopulations. Improving the quality of both remaining natural habitats and artificial wetlands is thus a priority intervention. For example, retaining ground cover and rank vegetation by reducing grazing pressure or keeping a buffer of natural vegetation intact around the wetland can reduce the impacts of damaging land-use practices (Bowland & Perrin 1989; Driver et al. 2012), and thus conserve small remnant habitat patches such as shrubby areas and scattered semi-natural grasslands to sustain murid diversity. Restoration of these rich habitat patches is the only means of improving functional connectivity in modified landscapes to facilitate movement between isolated patches (Ramesh et al. 2015a). Conservation managers should thus enhance heterogeneity by protecting diverse habitats including wetlands and other indigenous habitats. The increases in habitat quality could provide source subpopulations for long-distance dispersers to re-colonise fragmented habitats (*sensu* Hermann et al. 2008). Additionally, artificial wetlands, such as industrial sites, that provide protection, prey base and shelter can be integrated into landscape-scale conservation plans. Biodiversity stewardship schemes should also be promoted if landowners possess wetlands close to core protected areas or remaining habitat patches. Protecting such habitats may create further dispersal corridors between patches.

Reintroduction of Servals shows mixed success. Captive-bred Servals are very amenable to reintroductions (van Aarde & Skinner 1986; A. Jones pers. comm. 2015), but it is unclear whether there have been any introductions beyond the known range, though no permit applications have been received (see Power 2014), so it does appear as if natural range expansion has occurred. In North West Province, reintroductions took place in the 1990s and subpopulations are still present in the sites (Power 2014), including Madikwe Game Reserve, and likewise during the 1980s to Kgaswane, so these interventions may have fostered population growth. In KwaZulu-Natal, releases in 2013 in iSimangaliso Wetland Park have been successful thus far, as eight individuals have been recorded in 2014 during camera trap surveys (T. Ramesh unpubl. data).

Table 5. Conservation interventions for the Serval (*Leptailurus serval*) ranked in order of effectiveness with corresponding evidence (based on IUCN action categories, with regional context)

Rank	Intervention description	Evidence in the scientific literature	Data quality	Scale of evidence	Demonstrated impact	Current conservation projects
1	*2.3 Habitat & Natural Process Restoration*: restore wetlands and grasslands in matrix habitat by maintaining buffer strips and reducing grazing pressure.	-	Anecdotal	-	-	None
2	*1.1 Site/Area Protection*: identify and incorporate key wetland areas into formally protected areas.	-	Anecdotal	-	-	SANParks, provincial conservation agencies
3	*1.2 Resource & Habitat Protection*: engage with landowners to conserve wetland and grassland patches.	-	Anecdotal	-	-	Biodiversity Stewardship initiatives
4	*2.1 Site/Area Management*: set aside natural patches on farmlands or create protected buffer zones on industrial sites.	Matthews et al. 2014, 2015	Empirical	Local	High Serval density on Secunda buffer areas.	Sasol management
5	*3.3.1 Species Reintroduction*: reintroduction into suitable areas from captive stock.	van Aarde & Skinner 1986	Empirical	Local	Captive-bred Serval do persist post-release but show mixed success rates.	Provincial conservation agencies, Private Nature Reserves, Private farmlands
		Hayward et al. 2007	Empirical	Regional		
		Perrin 2002	Empirical	Local		
		Ramesh et al. 2015a	Empirical	Regional		
6	*4.3 Awareness & Communications*: education and awareness to decrease accidental persecution.	-	Anecdotal	-	-	Conservation NGOs
7	*5.1.1 Legislation*: "Savannah Cat" import regulations to prevent hybridisation with local population.	-	Anecdotal	-	-	Department of Environmental Affairs
8	*5.4 Compliance & Enforcement*: increased prosecution of illegal killing of Servals.	-	Anecdotal	-	-	Provincial conservation agencies
9	*6.2 Substitution*: use faux Serval furs to replace authentic skins at cultural/ religious gatherings.	G. Balme unpubl. data	Indirect	Regional	Ratio of fake to authentic skins observed at gatherings increased.	Furs for Life, *Panthera*

Thus, captive-bred animals may repopulate nature reserves well and convert readily to free ranging subpopulations. Similarly, Eastern Cape subpopulations have been restored at Kariega and Great Fish River Game Reserves with limited success (Hayward et al. 2007). However, they have thrived on Shamwari where three were reintroduced in 2001, and 11 were counted in 2005 (Hayward et al. 2007), which suggests some breeding may have taken place. However, there are also cases of unsuccessful reintroductions. For example, Serval recently released into Phinda Game Reserve, KwaZulu-Natal Province did not seem to persist, which may be related to the high number of large predators in the reserve (V. Hugo pers. comm. 2016) or insufficient rodent prey as the coastal grasslands are generally poorer. Similarly, Tembe Elephant Park is another example of low success of reintroduction, and it seems that management priorities of protected areas affect the success of reintroduction (W. Matthews pers. comm. 2015). Servals used to occur in Mkuze Game Reserve historically, but have not been seen for years (T. Bodasing pers. comm. 2016), but two rehabilitated individuals were introduced in February 2014 (T. Bodasing pers. comm. 2015) and monitoring will assess the success of the reintroduction. Of two hand-reared Serval released into Mount Currie Nature Reserve, KwaZulu-Natal in 1998, one remained in the reserve while the other established its core home range in neighbouring farmland (Perrin 2002). Reintroductions have also had low success in Mpumalanga, especially in areas with other more prolific or dominant predators present (J. Eksteen pers. comm. 2015). Radio-tracking data also reveal a high turnover of individuals, which may suggest a high mortality rate post-release (Ramesh et al. 2015a). Thus, while Servals can be reintroduced easily as they respond well to *ex situ* breeding, the factors determining successful reintroductions require analysis before reintroduction can be effectively used as a tool to increase habitat occupancy and supplement existing subpopulations. For example, Perrin (2002) recommends hand-reared Servals are reintroduced to sites > 10 km away from human settlements to avoid habituation and potential mortality.

Strict controls on the importation of hybrid "Savannah Cats" from the USA should be put in place to prevent genetic contamination with the national population. While the males tend to become sterile, the females do not (Davis et al. 2015). Likewise we should monitor exports of this species in the light of potential over-harvest for this purpose. To this end, educational awareness campaigns, are suspected to have decreased persecution of Servals and should be continued to promote Serval conservation and good land management practice. Similarly, reducing the illegal trade in skins by providing faux furs for use at cultural ceremonies may be an effective intervention, such as that currently being implemented by Panthera, an organisation working on the conservation of wild cats (G. Balme unpubl. data).

Recommendations for land managers and practitioners:

- Habitat management to conserve prime habitat. Managers and landowners must avoid draining wetlands and ensure good veld condition as Servals forage away from wetlands too in woodlands with good grass cover. Waterside vegetation and ground cover should be maintained in farmlands and ranchlands to conserve key resource areas for Servals within an otherwise unsuitable matrix.
- Serval subpopulations should be systematically monitored to determine abundance and trends. Due to their specialised habitat requirements at small spatial scales, they may serve as a useful ecosystem indicator of the effect of habitat fragmentation in agricultural landscapes (Ramesh et al. 2015b).
- Monitoring Serval should be introduced as a compliance measure in Environmental Impact Assessment mitigation reports.
- Industrialised sites should incorporate the long-term persistence of Serval and associated habitats into onsite biodiversity management practices. Buffer habitats on mining sites could be modelled based on minimum wetland size and available cover.

Research priorities:

- General survey for population estimates, by estimating densities in both prime and marginal habitat. Some regions, such as Limpopo, have no current information on density and should be targeted for surveys. Long-term monitoring of subpopulations in protected areas and farmlands will also reveal the resilience and population trends of Serval subpopulations.
- Efficacy of local community-based eco-awareness to mitigate hunting and persecution of Serval (for example, snaring, use of hunting dogs and road kill).
- Long-term monitoring of translocated/reintroduced individuals, as well as released animals from rescue centres, at least until they have reproduced (one to two years). There are currently very few data on whether captive releases or reintroductions have been successful or not. These should be done using radio-, GPS-Cell or satellite telemetry collars.
- Role as controller of agricultural pests.
- Basic systematic distribution data of Serval across southern Africa should be collected through structured questionnaire surveys. This will highlight key areas that will need to be studied further.

Encouraged citizen actions:

- Report sightings on virtual museum platforms (for example, iSpot and MammalMAP), especially outside protected areas.
- Create conservancies to enhance Serval dispersal and persistence.
- Do not purchase or import hybrid "Savannah Cats" from the USA.
- Report snaring or road kill incidents to provincial conservation agencies or conservation NGOs.

Data Sources and Quality

Table 6. Information and interpretation qualifiers for the Serval (*Leptailurus serval*) assessment

Data sources	Field study (literature), indirect information (literature, unpublished)
Data quality (max)	Estimated
Data quality (min)	Suspected
Uncertainty resolution	Best estimate
Risk tolerance	Precautionary

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