Leopard *Panthera pardus*

Namibian conservation status	Vulnerable
Global IUCN status	Vulnerable (2016)
Namibian range	Most of the country except the desert coast and far north-central parts
Global range	8,515,900 km² Widespread throughout sub-Saharan Africa and in smaller populations within the Middle East, south-west Asia, south-east Asia and north to the Amur peninsula of the Russian Far East
Population estimate	Namibia: <12,000 mature adults
Population trend	Variable: ▸ Increasing in central Namibia ▸ Decreasing in the north-east and south-west ▸ Data deficient in the north-west, east and south-east
Habitat	Ranges from tropical rainforest to arid savanna, and from alpine mountains to the edges of urban areas. Leopards reach their highest density in riparian zones
Threats	▸ Habitat loss and fragmentation ▸ Retribution killing for livestock predation ▸ Decline in prey ▸ Illegal wildlife trade and poaching ▸ Poorly managed trophy hunting

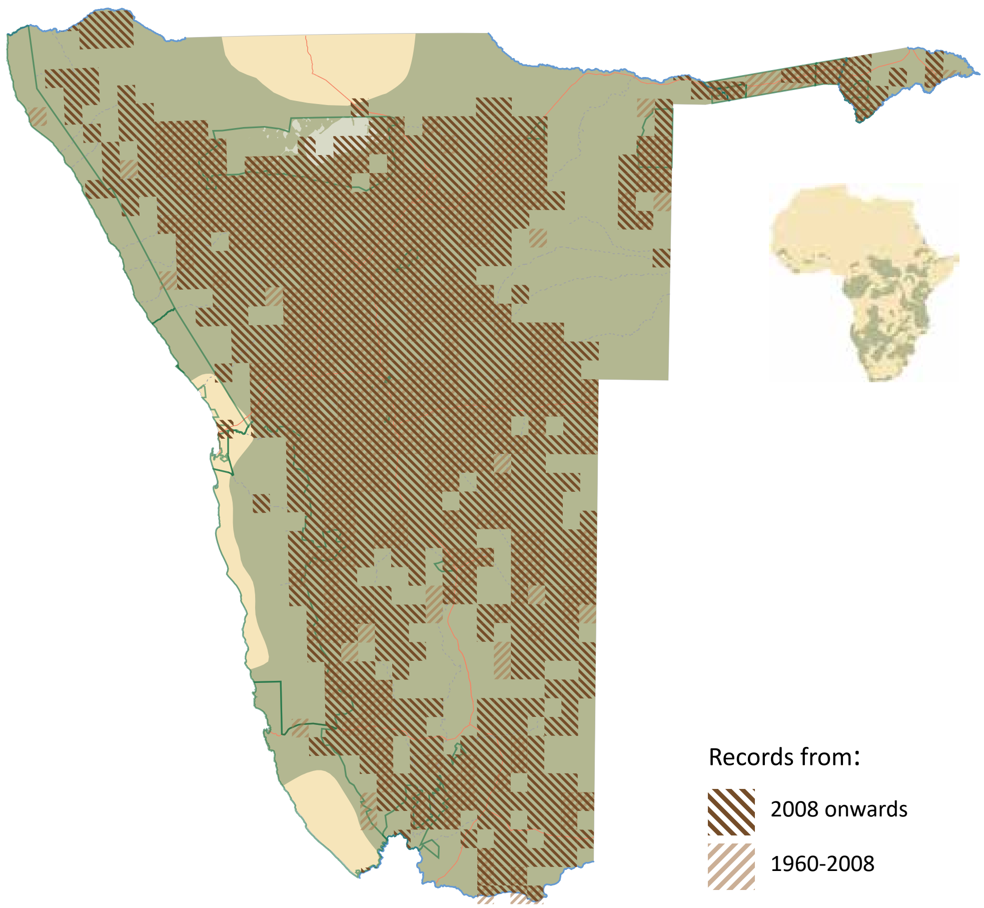
DISTRIBUTION

Based on genetic analyses, nine leopard subspecies are recognised which includes the African leopard *Panthera pardus pardus* (Linnaeus 1758; Miththapala *et al*. 1996; Uphyrkina *et al*. 2001). Leopards historically lived across approximately 35 million km² globally and 20 million km² in Africa, but are now only present in 25% of this area. Leopard distribution now covers 8,515,935 km² in 173 patches from sub-Saharan and North Africa to the Middle East and Asia

Distribution records of leopard, and present estimated area of distribution.

Inset: African distribution of leopard according to IUCN (Stein *et al*. 2016).

The Namibian distribution in the main map is more up to date and does not necessarily agree with the distribution shown in the inset.



(Stein *et al*. 2020, Jacobson *et al*. 2016). The estimated regional range loss for leopards across Africa is 48–67% with regional variations (Stein *et al*. 2020, Jacobson *et al*. 2016). Despite these challenges, the African leopards have the widest distribution, with the least fragmentation and healthy connectivity between populations, of all the cats in sub-Saharan Africa (Henschel *et al*. 2008, Stein *et al*. 2020, Jacobson *et al*. 2016). It also shows the broadest range of genetic variation of all the leopard subspecies (Uphyrkina *et al*. 2001, Castro-Prieto *et al*. 2011b). Leopards inhabit most of Namibia except for the highly populated north-central region, the arid south-east farmlands and the desert coast, and were thought to be absent from 30% of their historic range (Hanssen & Stander 2004, Stein *et al*. 2011a, 2020).

The 2019 Namibian Leopard: National Census and Sustainable Hunting Practices study (Richmond-Coggan 2019) found that leopards were present in the north-central region and the south-east farmland (Richmond-Coggan 2019, map), where they were previously thought to be absent, or presence could not be confirmed. A proportion of these new presence records for the south-east are also outside the current IUCN Red List distribution for leopard in Namibia (Stein *et al*. 2020, map).

POPULATION ESTIMATE AND TREND

At the local scale, estimates of leopard population densities vary 300-fold (Jacobson *et al*. 2016). Martin and de Meulenaer (1988) estimated the Namibian population to be 7,745, while Hanssen and Stander (2004) in the Namibia Large Carnivore Atlas estimated it to range between 5,469 and 10,610 animals. The aim of the Atlas was to estimate distribution and population size using data from questionnaires. The 2011 Namibian leopard survey resulted in a national population estimate of 14,154 (CI 13,356–22,706) (Stein *et al*. 2011a).

In the last 20 years, several studies have provided leopard density estimates in Namibia using two main methods: spoor surveys and camera trap surveys. The lowest leopard density in Namibia was recently recorded in the Mudumu North Complex (Hanssen *et al.* 2019) (Table 2.2).

The regions of Erongo, Khomas, Kunene, Otjozondjupa and Omaheke were found to hold the core leopard population (Richmond-Coggan 2019). The density model predicted that Kunene and Khomas Regions have the highest leopard density overall. This was in part due to the Khomas Hochland Plateau and the recent leopard density determined for the Auas Mountains (Table 2.2). The density model predicted that the highest leopard density in the Kunene Region would be in the Kaokoveld up on the Kamanjab Plateau and the escarpment that runs up to the Angolan border. The north-eastern parts of the Erongo Region around the Erongo Mountains and Mount Etjo were also identified as possible areas of high density and Omaruru was confirmed as high density (Table 2.2). The model highlighted that the Otjozondjupa Region has two distinct density areas; the higher density areas cover the freehold farms of the region, while the eastern communal conservancies, namely N#a-Jaqna, Nyae-Nyae and Ondjou Conservancies have lower density than the central and western areas of the region which was confirmed by leopard density studies (Table 2.2). In Omaheke, again, the highest leopard density was predicted by the model to be across the freehold farms in the centre and south of the region, and the lowest densities found in the communal conservancies. The regions of Omusati, Ohangwena, Oshana, Oshikoto, Kavango East and West, ||Kharas, Hardap and Zambezi were all categorised as low density areas by the model and density studies (Table 2.2). One potential variation was in Hardap on the border with Khomas Region where densities were predicted

Table 2.2: Estimates of leopard density from various parts of Namibia.

Location	*Survey Method	Density Estimate (leopards/100km²)	Reference
Khaudum National Park and Nyae Nyae Conservancy	SS	1.5	Stander *et al*. (1997)
Okonjima Farm, Otjiwarongo	RC	5.56	Hanssen & Stander (2000)
Hobatere Concession and West Etosha National Park	SS, GPS	3.85	Stander *et al*. (2001)
Waterberg National Park	CTS	1.0 (SE±0.7, 95% CI 0.8–1.5)	Stein *et al*. (2011b)
Central Namibia (freehold farmland- Waterberg)	CTS	3.6 (SE±3.6, 95% CI 3–8)	Stein *et al*. (2011b)
Northern Namibia (Omaruru)	CTS	3.1	Stein *et al*. (2011a)
Central Namibia (freehold farmland – Auas Mountains)	CTS	2.0	Stein *et al*. (2011a)
Southern Namibia (freehold farmland)	CTS	1.2	Stein *et al*. (2011a)
Bwabwata National Park	SS	1.18 (sand ridges); 2.40 (omurambas)	Funston *et al*. (2014)
Freehold farms bordering the Tsau ||Khaeb (Sperrgebiet) and Namib-Naukluft National Parks	CTS	0.9 (SD±0.41) Northern Area; 0.59 (SD±1.15) Southern Area	Edwards *et al*. (2015)
Mudumu North Complex	CTS	0.6 (SD±0.54)	Hanssen *et al*. (2015)
Okonjima Nature Reserve (private)	CTS	14.5	Noack (2016)
Bwabwata National Park	SS	1.27	Hanssen *et al*. (2017)
Southern section of Khaudum National Park	CTS	1.8 (SD±0.40, 95% CI 1.11–2.50)	Portas *et al*. (2018)
Hoanib River	CTS	1 leopard detected (density not determined)	Portas *et al*. (2018)
Ongava Game Reserve (private)	CTS	2.6–4.6	Stratford *et al*. (2018)
Gondwana Canyon Park (private)	CTS	0.64 (SE±0.36, occupancy derived)	Edwards *et al*. (2018a)
Mudumu Landscape (Mudumu National Park and 3 conservancies)	CTS	0.25 (SD±0.06)	Hanssen *et al*. (2019)
Mudumu North Complex (Mayuni, Sobbe and Mashi Conservancies)	CTS	0.24 (SD±0.08)	Hanssen *et al*. (2019)
Bwabwata National Park (Kwando Core Area)	CTS	0.85 (SD±0.18)	Hanssen *et al*. (2019)
Bwabwata National Park (Multiple use area)	CTS	0.58 (SD±0.21)	Hanssen *et al*. (2019)
Khaudum National Park (North, 2017)	CTS	0.76 (SD±0.31)	Hanssen *et al*. (2019)
Khaudum National Park (South, 2018)	CTS	0.91 (SD±0.25)	Hanssen *et al*. (2019)
Nyae Nyae Conservancy (2017)	CTS	0.58 (SD±0.2)	Hanssen *et al*. (2019)
Nyae Nyae Conservancy (2018)	CTS	2.0 (SD±0.6)	Hanssen *et al*. (2019)
North East Omaruru (freehold farmland)	CTS	3.6 (95% CI 3.03–4.25)	Richmond-Coggan (2019)
Auas Mountains (freehold farmland)	CTS	2.8 (95% CI 1.97–3.68)	Richmond-Coggan (2019)

* CTS=Camera Trap Survey; RC=Radio collars; SS= spoor survey; GPS=GPS collars

by the model to be higher due to the Rehoboth Plateau and the Naukluft Mountains (part of Namib-Naukluft National Park).

In southern Namibia there are several large private reserves which were previously farmland with limited carnivore presence but due to their protected status, are now a refuge for multiple carnivores, including leopard. Leopards have been photographed along the western edge of the Nubib Mountains, in the sand and gravel plains further west and the dunes beyond (M Tindall pers. comm. 2018). The dune habitat is considered to be marginal due to its limited resources, however, the assumption is that the resource rich areas already have territorial males and therefore subadults are being pushed out to the margins (M Tindall pers. comm. 2018). Leopard presence is increasing in the southern, western and northern areas of Gondwana Canyon Park due to the mountainous habitat and the distance from the eastern farmland where they are persecuted (Q Hartung pers. comm. 2018). After 15 years the leopard population in the park is considered to be stable as a result of the increased game numbers and fence removal (Q Hartung pers. comm. 2018). A leopard population has recently been identified in the Oana Nature Reserve in the far south of Namibia (V Nesticky pers. comm. 2018).

Considering the density estimates of various studies (Table 2.2) the Namibian leopard population is estimated at 11,733 (RMSE 5,949) which is lower than the 2011 population estimate (Richmond-Coggan 2019). This is due to a combination of the re-classification of the density categories and changes in the leopard density in some areas of Namibia (Richmond-Coggan 2019). However, it is important to recognise that the leopard population varies countrywide: in the centre and north of Namibia across freehold farms, between 2011 and 2019, there has been an increase in leopard density by up to 40% (Richmond-Coggan 2019). Yet, leopard densities in the national parks and communal conservancies remain low (Table 2.2). Relative to other leopard densities recorded in South Africa, both inside (7.51–18.8 leopards/100 km², Balme *et al.* 2010, Owen *et al.* 2010) and outside (2.49 leopards/100 km², Balme *et al.* 2010) national parks, Namibia's leopard densities are still very low overall. However, it is important to recognise that Namibia when compared to South Africa is an arid and semi-arid country with low productivity which will impact both prey availability and distribution this in turn will influence leopard densities.

ECOLOGY

Leopards are highly adaptable and can be found across numerous habitats and climatic zones, including; mountains, rocks, bushveld, woodlands, desert and semi-desert, forest,

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from sea-level to 2,000 m, and in areas which receive less than 100 mm of rain to areas receiving above 1,200 mm (Stein *et al*. 2020). It has been determined that leopard resource use is governed by three key factors: avoidance of anthropogenic disturbance, such as roads and people; selection of prey-rich areas, such as river beds, protected areas and patches of recent rainfall; and selection of rocky areas with adequate vegetative cover to increase hunting success and minimise kleptoparasitism (theft of their kills by other carnivores) (Pitman *et al*. 2017a).

In Namibia leopards have been captured on camera in the Auas Mountains at an elevation of 2091m (Richmond-Coggan 2019) and in the Hoanib River north- east of the Skeleton Coast Park (Portas *et al.* 2018). The habitat suitability for leopard in Namibia showed that land ownership type (freehold, communal, national parks), the amount of rainfall during the wet season and landcover such as vegetation were some of the key variables that influenced leopard occurrence (Richmond-Coggan 2019). Their adaptability can be seen in the Namib Desert, where vegetation on the banks of watercourses provides cover, which is a contributing factor to leopard presence in the area (Mills & Hes 1997). Significantly sized dry river beds have been highlighted by the habitat and density models as potential areas of importance to leopards, for example the Omatako dry river bed, and other eastward-flowing river beds such as the Nossob (Richmond-Coggan 2019). In Hobatere and western Etosha, leopards showed a strong preference towards kopje (53%) and mountainous (25%) habitat (Stander *et al*. 2001). As opportunistic carnivores, they can be found in semi-urban and suburban environments, for example in Mumbai (Braczkowski *et al.* 2018) and Johannesburg (Kuhn 2014). In Namibia, multiple sightings of leopard have been recorded in suburban areas of Windhoek, such as Olympia and Avis.

Leopards are sexually dimorphic, solitary and territorial (Voigt *et al*. 2018). Male territories normally encompass two to five female territories (Mills & Hes 1997, Hayward *et al*. 2006a). The degree of range overlap both between and within sexes can vary substantially (Stander *et al*. 1997, Marker & Dickman 2005a, Devens *et al.* 2018). Males aged between 11–13 years start to become displaced when they lose territory to younger, neighbouring males and will then remain on the boundaries between territories (N de Woronin Britz pers. comm. 2018). Dispersing males can move into the territory of young territorial males which are still establishing themselves, kill and eat their cubs (N de Woronin Britz pers. comm. 2018).

Leopard territories in Namibia vary considerably in size and are directly related to prey abundance (Stander *et al.* 1997, Marker & Dickman 2005a). In Namibia adult male home ranges vary between 18.5 km² in a private reserve to 451.2 km² in the north-east; those of adult females range from 9.2 km² in a private reserve to 224 km² in the Hobatere Concession (Table 2.3). Overall, home ranges in the arid and semi-arid areas of Namibia's western-central region are substantially larger compared to those in the central and eastern regions of Namibia, as both prey and leopard density influence male and female home ranges sizes (Table 2.3).

Male territorial boundaries are defined by natural features such as rivers, hills, dams and man-made structures such as roads (Simcharoen *et al.* 2008, Steyn & Funston 2009, Naankuse Foundation 2018). A ten-year study using VHF/GPS collars has shown that over the course of a male's

Table 2.3: Home range size of leopards in various parts of Namibia

Location	Survey Method	Home Range Analysis Method	Home Range		Reference
			Adult Male	Adult Female	
North-eastern Namibia	Radio Collars	Convex Polygon and Grid Cell	451.2 km² (range 210–1,164 km², n=6)	188.4 km² (range 183–194 km², n=3)	Stander *et al.* (1997)
Okonjima Farm, Otjiwarongo	Radio Collars	Kernel (95%)	100.2 km² (range 71.4–221.5 km², n=6)	72 km² (range 70.8–73.2 km², n=2)	Hanssen & Stander (2000)
Hobatere Concession and West Etosha National Park	Radio Collars	Kernel (95%)	94.9 km² (n=1)	202 km² (range 84.5–339.8 km², n=5)	Stander *et al.* (2001)
Waterberg Conservancy	Radio Collars	Minimum Convex Polygon (95%)	229 km² (SD±95, n=3)	179 km² (SD±148, n=4)	Marker & Dickman (2005a)
Central Namibia	VHF/GPS Collars	Kernel (95%)	109 km² (n=1)	49.5 km² (range 46–53 km², n=2)	Stein *et al.* (2011b)
Okonjima Nature Reserve – closed private reserve	VHF Collars/ Camera Traps	Minimum Convex Polygon (100%)	18.3 km² (SD±10.1 km², n=11)	9.2 km² (SD±4.3 km², n=13)	Noack (2016)
Hardap, Khomas, Erongo, Otjozondjupa and Oshikoto	GPS Collars	Minimum Convex Polygon (100%)	150 km² (range 70–240 km², n=25)	110 km² (range 21–200 km², n=17)	Naankuse Foundation (2018)
Ongava Game Reserve	GPS Collars	Minimum Convex Polygon (100%)	190.6 km² (n=1)	96.9 km² (n=1)	Stratford *et al.* (2018)

lifespan, its territory size varied significantly (5–6 years 29 km², 6–7 years 60 km², 7–8 years 90 km², 8–10 years 120 km², 11 years 90 km², 12 years 60 km², 13 years 29 km²) (N de Woronin Britz pers. comm. 2018). During this time of expansion and contraction the number of females within the male's territory rose and fell, from one (male 5–6 years) to four (male 8–10 years) and then back to one (13 years) (N de Woronin Britz pers. comm. 2018).

Cubs are dependent on their mother from birth to 1.5–2 years (Bailey 1993). Female leopards become sexually mature between 2.5 to 3 years old, whilst males reach sexual maturity between 2.5 and 4 years old (Bailey 1993, Balme & Hunter 2004). The sex ratio at birth is assumed to be 50:50 (Clutton-Brock 2016), however, males seem to have a higher mortality rate than females once reaching adulthood, therefore, in the adult population there are usually more females than males (Nowell & Jackson 1996a, Portas *et al.* 2018). In central Namibia, there was found to be a two-year breeding cycle, which resulted in a temporary increase in the leopard density in the area every two to three years for a short duration. Of the 32 cubs born to 8 different female leopards over a ten-year period, only 25% of the cubs reached dispersal age (N de Woronin Britz pers. comm. 2018). The reasons for cub mortality were dispersing males (73%) followed by lions (9%), warthog (5%) and reasons unknown (13%) (N de Woronin Britz pers. comm. 2018).

Leopards are opportunistic ambush hunters that prefer ungulates with a body mass of between 10 and 40 kg (Hayward *et al*. 2006a; Clements *et al*. 2014). Leopards have one of the broadest diets and the highest number of prey species (92) of all the large African carnivores (Hayward *et al*. 2006a). However, leopards may select smaller bodied prey to balance the trade-offs between kleptoparasitic losses and the energy required to kill larger prey (Balme *et al.* 2017). Prey selection changes throughout the lifespan of an individual leopard, and they specialise in certain prey types depending on the habitat and density of prey species (N de Woronin Britz pers. comm. 2018). Livestock such as cattle calves, sheep and goats fall within the preferred weight range and are preyed on.

Leopards mostly hunt alone at night by stalking their prey then sprinting for a short distance to capture it (Bertram 1979, Bailey 1993). Leopards regularly kill other carnivores and prey on baboons when larger prey is scarce (Hayward *et al*. 2006a, Jooste *et al*. 2012). As an apex carnivore, they provide ecosystem services such as preying on smaller carnivores such as jackals, which would otherwise grow in numbers. On Namibian farmland, lions and spotted hyaenas have largely been eradicated so leopards mostly cache their carcasses by dragging them under thick bushes rather than up trees. In central Namibia, territorial males were regularly noted to share kills with the territorial females and their offspring in their range (N de Woronin Britz pers. comm. 2018).

THREATS

The major threats to leopard are habitat loss and fragmentation, human-wildlife conflict, prey loss, illegal trade and poaching, and unsustainable trophy hunting (Stein *et al*. 2020, Jacobson *et al.* 2016). Multiple studies in South Africa have found that the removal of problem animals can lead to a major decline in the leopard population, particularly for females with cubs (Ramesh *et al*. 2017b, Williams *et al*. 2017).

The decline in the leopard population across sub-Saharan Africa is the result of widespread habitat loss (21% in 25 years) and prey loss inside African protected areas (Stein *et al*. 2020). The conversion from livestock farming to game ranching, although it offers significant economic advantages, is increasing the level of conflict between valuable game species and carnivores (Lindsey *et al*. 2013c, Pitman *et al*. 2017b). Game ranching practices have become more intensive and involve activities such as removal of problem animals, particularly carnivores, to safeguard profitability. Leopards are generally not constrained by farm fences and move freely across the landscape (Balme & Hunter 2004, Balme *et al*. 2007, Swanepoel *et al*. 2013, Stratford

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et al. 2018). However, a recent study (Ceia-Hasse *et al.* 2017) highlighted that 59% of the leopard's African range is affected by roads and their infrastructure which has a significant impact through direct mortality and by causing a barrier to movement.

Livestock predation by large carnivores is the most widespread cause of conflict and retaliatory killing by people (Woodroffe *et al.* 2005). The leopard exhibits an array of biological and behavioural traits such as opportunistic hunting behaviours, solitary living and a varied diet that renders it a high-impact conflict species (Kissui 2008). Globally, leopards are considered the leading carnivore conflict species, preying on livestock and threatening human safety (Seoraj-Pillai & Pillay 2017, Braczkowski *et al.* 2018). In southern Africa, leopards are shot, snared and poisoned mostly for their impact on livestock farming and less so for illegal wildlife trade (Skinner *et al.* 1977, Henschel *et al.* 2008, Stein *et al.* 2020, Jacobson *et al.* 2016, Ripple *et al.* 2017). Jacobson *et al.* (2016) showed that the retribution killing of leopard for real and perceived livestock loss is the second largest threat to the population today. Namibian freehold landowners echoed this finding, undertaking problem leopard removal based not only on actual loss of livestock and/or game but on the perceived threat to livestock and/or game along with the risk to human safety (Richmond-Coggan 2019).

In Namibia, the majority of the leopard population resides outside of national parks on freehold farmland and communal conservancies. Therefore, it is critically important to recognise that the majority of the national leopard population is under significant anthropogenic pressure, which will impact the population's long-term viability. Across Namibia, leopard removal rates vary depending on the density of the different carnivore species, farm management, type of livestock, landscape, vegetation cover, abundance of free-ranging prey and the level of poaching and livestock theft (Edwards 2015, Richmond-Coggan 2019).

When key prey species for leopard decline due to drought and high levels of poaching, leopards switch to catching livestock which can lead to increased levels of persecution and problem animal removal (Khorozyan *et al.* 2015, Jacobson *et al.* 2016, Rosenblatt *et al.* 2016). For example, when prey biomass drops below 812 kg/km², predation rates on cattle by leopard significantly increase (Khorozyan *et al.* 2015) furthermore, if prey biomass falls to 540 kg/km², cattle, sheep and goats will all be intensively preyed on to optimise a leopard's energy intake (Khorozyan *et al.* 2015). This pattern can be seen in the Hardap and ǁKharas Regions as they have two of the lowest game densities and highest livestock densities (sheep and goats) of all the regions and consequently suffer from the highest predation rates (Richmond-Coggan 2019).

In central Namibia retribution killing of leopards due to cattle loss led to 14% of the population being removed (killed or translocated) from the area over a five-year period (Stein *et al.* 2010). Conflict between leopards and small-stock farmers due to predation has recently been recorded along the Orange River in the far south of Namibia (V Nesticky pers. comm. 2018). The proportion of leopard-associated conflict has been rising since 2008, and from 2015 more than 50% of all carnivore conflict cases have been attributed to leopard (Naankuse Foundation 2018). Over 16 years (2001–2017) in ten regions, across 75 communal conservancies, 5,718 incidents (problem animal removed and/or livestock predation) of human-leopard conflict have been recorded, averaging 336 incidents per year (NACSO 2018). Freehold farmer's loss of 2,836 individual animals (cattle, sheep, goats, horses) between October 2016 and December 2018 led to the removal of 342 problem leopards (64% males, 28% females) (Richmond-Coggan 2019), an 87% increase from 2011 (Stein *et al.* 2011a). This increased removal of males can lead to destabilisation of the population (Balme *et al.* 2010, Davidson *et al.* 2011). The two main removal methods were live cage trapping and shooting however, other known removal methods are; snaring, poisoning, gin traps, hunting with dogs and call-ins using pre-recorded sounds (Richmond-Coggan 2019).

In Namibia, if a species is deemed to be causing damage to livestock or poses a threat to human life, a permit can be granted by MEFT which allows the hunting of any specially protected game at any time. The reporting structure relies on the accuracy of the kill identification information provided by the landowner, including which species was responsible for the livestock predation. It is important to recognise that when problem leopards are removed there can be misidentification of the specific problem animal at both the individual and species level (Grey *et al.* 2017). Between 2011 and 2019 there has been decline from 50% to 45% in the number of freehold farmers applying for a MEFT problem leopard removal permit. Interviewed freehold landowners who applied for a permit removed 60 leopards/year, whereas those who did not removed 90 leopards/year (Richmond-Coggan 2019). The lack of reporting is a cause for concern as the annual documented figures are not an accurate national representation.

Leopards that are responsible for livestock predation are generally specific individuals, often subadult males or old individuals, that prey at times on juvenile large stock and sometimes on small-stock and poultry (Kumar *et al.* 2017, L Hanssen pers. comm. 2018). Individual leopards can enter nighttime enclosures designed to keep livestock safe due to their climbing capability and agility which enables them to get through small gaps in mesh fencing (L Hanssen pers. comm. 2018). This can make it difficult to secure and protect livestock that is targeted (L Hanssen pers. comm. 2018).

The regions of Kunene, Khomas, Erongo and Otjozondjupa are conflict hot spots due to the level of livestock predation in the freehold farmland and total number of incidences recorded in the communal conservancies (NACSO 2018, Richmond-Coggan 2019). Given that the majority of the leopard population resides in these regions this level of human-leopard conflict is not unexpected.

Jacobson *et al*. (2016) identified the illegal trade in skins and parts across their African range as the fourth most important threat to the leopard. This is not a new threat; in 1977 Skinner *et al*. (1977) recognised that the skin trade was already a reason for the decline in the South African leopard population. In villages and cities in some African countries, skins and canines continue to be traded for use in traditional rituals (Stein *et al*. 2020; Jacobson *et al*. 2016). Preliminary data suggest that 4,500–7,000 leopards are harvested annually as part of the illegal trade in leopard skins for cultural regalia, a practice that is extensive throughout southern Africa (Stein *et al*. 2020).

A recent camera trapping survey in Omaruru, Namibia captured evidence of both brown and spotted hyaenas with wire snares around their necks and prior to the start of the survey a leopard was found dead in a snare (Richmond-Coggan 2019). This demonstrates the indiscriminate impact of the snares used in illegal poaching activities. Landowners in the Omaruru area engaged anti-poaching patrols to mitigate against the illegal activities, however, they report an ever-increasing number of snares being found. The concern is that this situation is indicative of a wider national issue.

Leopards are included in CITES Appendix I. Trade of Leopard Skins and Products (CITES resolution 10.14) is restricted to 2,483 individuals in 11 countries across sub-Saharan Africa (CITES 2018). Namibia has the 4th highest leopard quota within sub-Saharan Africa (CITES 2018). In 1997 the CITES export quota for Namibia was set at 100 individuals; in 2004 this was increased by 150% to 250 (CITES Resolution Conf. 10.14 (Rev.CoP13)). The quota was increased in 2004 as a result of the 7,745 population estimation by Martin and de Meulenaer (1988) from which an annual harvest of 332 animals (4.2% of the population) was calculated and determined to be a safe offtake level. The report by Stein *et al*. (2011a) recommended that the quota of 250, which represented 3–4% of the total adult male population, was to remain, along with the introduction of an intensive monitoring programme.

In Namibia, the highest number of leopard trophy hunts take place in the freehold farmland, followed by communal conservancies, and national parks. The areas shown to have higher leopard density, suitable habitat and prey availability had the greatest trophy hunting success rates (Erongo, Khomas, Kunene, Otjozondjupa) (Richmond-Coggan 2019). On average 39% of the trophy hunts undertaken were successful across Namibia, which is in line with other African countries, but information on why a hunt was unsuccessful is limited (Richmond-Coggan 2019). Since the implementation of Namibia's new TAG system in 2011 the quota of 250 leopards has never been reached, 2017 was the highest at 161 (-35.6%), the average between 2016–18 was 155 (Richmond-Coggan 2019). The implementation of the new regulations has had multiple impacts; firstly the size of the trophy has significantly increased post-2011, and secondly only male leopards can be hunted. The new regulations have resulted in a decline in hunted females from 32% to 0.7% which is a positive outcome. The remaining 0.7% is due to the misidentification by hunters (Richmond-Coggan 2019). Females are a key reproductive unit and are more difficult to replace than adult males (Daly *et al*. 2005), as such their removal can directly impact the population viability.

While the conservation value of regulated trophy hunting is recognised, it is important to note that there is a fine balance between sustainable and unsustainable offtake of leopards. For example, trophy hunting may selectively harvest large individuals with fitness-enhancing traits (Ripple *et al*. 2016). Poor management such as overharvesting, corruption, or lack of reinvestment in conservation and development of local communities, could undermine the rewards from trophy hunting and in turn threaten the species (Lindsey *et al*. 2007).

Therefore, it is critical to recognise a leopard's economic value and the need for careful management of the numbers that are utilised. The positive attitudes of some landowners towards leopards was based upon their potential economic value through either trophy hunting or tourism and this was why they tolerated having leopard on their property (Richmond-Coggan 2019). Landowners simply state that if the leopard loses its economic value, particularly through trophy hunting, then the rate of unreported and indiscriminate removals will rapidly increase in order to protect their livelihood (Swanepoel *et al*. 2015b, Richmond-Coggan 2019). When a territorial male is removed, by any means, from the territory it creates a "vacuum" which is immediately occupied by the dispersal males in the area (Davidson *et al*. 2011). As a male loses territory a female may then be sharing her territory with two males. This can result in infanticide and an unnatural ratio of males to females, causing females to mate with the new neighbouring dispersal male. Infanticide can also lead to females not raising young due to the incursion of new males (Balme *et al*. 2009, Balme *et al*. 2010, Balme & Hunter 2013). All of these interactions will have a significant impact on the long-term viability of the leopard population.

In terms of proactive population management, removals of problem animals are often uncontrolled, unreported and indiscriminate of age, sex and population density. On the other hand, regulated trophy hunting, if managed effectively, is limited to areas which have a leopard population capable of sustainable controlled offtake. Therefore, it is necessary to improve the management of trophy hunting, in tandem with reducing the losses through other causes of mortality, particularly problem animal removal and its subsequent reporting.

CONSERVATION STATUS

Leopards are listed as a CITES Appendix I. species (Trade of Leopard Skins and Products, CITES resolution 10.14) with an allocated trophy hunting quota (CITES 2018). In 2008 the leopard was classified as Near Threatened on the IUCN Red List (Henschel *et al*. 2008). However, due to a global decline of the leopard populations by >30% over the last three leopard generations, the species was reclassified to Vulnerable in 2016 (Stein *et al*. 2020). The perceptions of Namibian landowners are that over the past five years there has been a 64% rise in the leopard population across the freehold farmland (Richmond-Coggan 2019). This rise has been recorded in some areas of the freehold farmland. However, lowering of densities have also occurred in parts of southern Namibia and communal conservancies in the north-east within the same timeframe. Leopard density varies significantly, particularly across different land use types, but overall is still low compared to other African countries (Richmond-Coggan 2019). The core leopard population resides in the freehold farmland and communal conservancies and is under substantial anthropogenic pressures; this is also the area where trophy hunting is at its highest. The scale and distribution of problem animal removal and the subsequent lack of reporting unequivocally represent the most significant pressure on the Namibian leopard population. Collectively these points justify retaining the conservation status as Vulnerable in Namibia.

ACTIONS

Awareness

It is critically important to recognise the role freehold farmers and communal conservancies have in the long-term survival of leopard in Namibia as these landowners are the custodians of the national population. Consequently, leopard conservation would be enhanced by increasing tolerance through education, implementation of conflict mitigation methods, improving financial aids and incentives such as utilising ecotourism, sustainable trophy hunting and wildlife credits schemes.

Management

Namibian landowners feel that they lack control over the official process of dealing with livestock losses, which frequently drives them to retaliatory killing to sort out the problem as quickly as possible, a sentiment shared by South African landowners (Grey *et al*. 2017). This has led to the disconnect between MEFT permit numbers and actual removal figures. As such reporting of problem leopard removal must be prioritised to determine and address conflict hotspots. To do this the official management of retaliatory killing needs to be effective and quick, data collection could be incorporated into regular MEFT management activities such as fence checks and game counts. An increase in efficiency in the system and a clear understanding of the data usage in relation to leopard management will further encourage farmers to report.

To improve coexistence with leopards bettering livestock husbandry should be the first step. Livestock management techniques, such as kraaling livestock in well-constructed enclosures at night and herding the livestock during the day, are some of the best methods to reduce livestock predation from leopards (Balme *et al*. 2009). In the Waterberg Conservancy, farmers who employed at least one out of six livestock husbandry techniques reported 85% less conflict with carnivores (Stein *et al*. 2010). To minimise risk of attacks on juvenile livestock at night, where juveniles are separated from their mothers, enclosures need to be as "leopard-proof" as possible. This would involve using small gauge wire mesh to prevent leopards from getting access, or using roofing sheets to prevent leopards from jumping into enclosures (L Hanssen pers. comm. 2018). Alternatively, juvenile livestock must be accompanied by an adult when in kraals as adults defend their young in cramped enclosures (L Hanssen pers. comm. 2018). On occasion, habitual stock-raiding leopards may need to be removed humanely (L Hanssen pers. comm. 2018). Lethal control strategies should be applied only if all other prevention methods have failed, and they should be careful to correctly target the identified problem individual, otherwise they will be counterproductive (Treves & Naughton-Treves 2005).

In some instances, farmers will trap leopards in metal cages in the hope that they can be translocated (L Hanssen pers. comm. 2018). In Namibia, of a sample of six confirmed conflict leopards that were translocated all six established new home ranges, four of them did not prey further on livestock and reproduced successfully (Weise *et al*. 2015a). Despite this apparent success, translocation is not a long-term solution as the number of suitable translocation sites is limited and information on the release sites must be available to improve chances of success.

Some farmers reduce their losses by keeping their livestock away from waterholes to avoid opportunistic predation when leopards go to drink and by synchronising calving periods with the wild game. For example, farmers in southern Namibia experienced lower losses of cattle in comparison to small-stock, partly because cattle show anti-predator behaviour by avoiding water points during peak carnivore activity times (Edwards 2015). The frequency and severity of livestock predation by leopards depends on the availability of natural prey (Ray *et al*. 2005b). It therefore helps if a farm has a healthy density of free-ranging antelopes as available wild prey to diminish predation on livestock. Large guarding dogs (at least two animals) should be placed and always kept with the livestock as they can also dissuade leopards.

A landscape approach to leopard trophy hunting could be created through leopard management zones across freehold farms. The freehold conservancies have demonstrated that it is possible to establish landscape management zones of mixed farm types and it is recommended that these zones are re-established as part of a stratified monitoring system for Namibia's leopards, as called for by IUCN (2018). These management zones would be responsible for monitoring and management of their natural resources, including leopard and their prey species. Information gathered through the monitoring would include; population density and structure, environmental variables and problem animal removals. As these management zones would be spread across the known areas of leopard presence in Namibia they have the potential to acquire ongoing information on the local leopard population. This vital information would feed into the national adaptive management plan to inform effective decision making on the long-term conservation of the leopard.

Tourism can also provide an economically viable, non-consumptive use of leopards (Lindsey *et al*. 2007). In a survey out of all African wildlife the leopard came out as one of the highest ranked in terms of key species that tourists wanted to see (Di Minin *et al*. 2012). Income generation through tourism was stated as one of the key reasons that freehold landowners wanted to have leopard present on their property (Richmond-Coggan 2019). Since most leopards in Namibia live outside of national parks, such economic value is critical to ensure the long-term conservation of the species. For example, land use in the broader pro-Namib area is shifting away from farming and moving towards tourism, this change in land use has also led to a decline in human-leopard conflict (M Tindall pers. comm. 2018). However, areas of Namibia that are not easily accessible lack the opportunity to generate income from tourism, therefore legal consumptive use of leopards through trophy hunting could be a means of generating revenue in those areas (Balme *et al.* 2010).

Research

Since 2000, there have been 22 scientific journal articles containing data on the African leopard density across its geographical range (Jacobson *et al*. 2016). There is consensus within the conservation community that further research on leopards across Namibia is needed. As described above the density, territory size and distribution

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of leopard varies greatly across Namibia due to variations in habitat, persecution levels and prey availability. Acquiring further information on leopard densities regionally will also improve our ability to model the national population and its geographical variations. Understanding the impact of these variables on a national scale is critically important to understanding the leopard in Namibia as a whole. As problem leopard removal is a significant threat to the national population understanding which mitigation tools provide the most effective solution relative to cost in reducing the levels of leopard-livestock conflict and widely deploying these tools must be made a priority. The prolific use of snares in illegal bushmeat poaching highlights a real need for a more comprehensive understanding on the impact of this activity on leopards and other carnivores directly and indirectly due to the removal of wild prey, particularly in the freehold farmland.

It has already been identified that the core leopard population of Namibia, trophy hunting of leopard, and problem leopard removal predominantly occurs in the freehold farmland and the Kunene communal conservancies. Long-term leopard density monitoring across these areas must be made a priority as data is currently limited for this important leopard area. As well as farmers employing the most effective livestock husbandry techniques in order to significantly reduce the number of problem leopard removals nationally. Leopard presence records have now been established in the east and south-east of Namibia and therefore this area warrants further investigation to understand the structure of the resident population. Landowners on the south-east Botswana border have noted the transboundary movement of leopard and other carnivores onto their properties. Further research into the relationship between the Transfrontier Park and freehold farms is needed to understand leopard population dynamics in this area. Leopards in the Oana Nature Reserve and the broader area of the Orange River are also an understudied population; ongoing research there will provide valuable new information.

Building a Namibian leopard DNA database would provide multiple benefits for leopard conservation both nationally and internationally. DNA can provide useful data for answering questions on conservation and population genetics of wide-ranging species such as the leopard. DNA can also be used for DNA-based assignment tests, from which it is possible to infer geographic origins of DNA samples from seized illegal leopard products such as skins which helps to identify trade routes and poaching hotspots for leopards at a subcontinent scale, as has been the case in India (Mondol *et al*. 2015). The importance of understanding the genetic diversity of the Namibian leopard population has already been recognised. A genetic sample collection protocol was developed and incorporated into the post trophy hunt permit requirements which was implemented at the start of the 2019 hunt season (Richmond-Coggan 2019). The implementation of DNA collection as part of the trophy hunting permit requirements could be seen as phase 1. Phase 2 therefore, would be the inclusion of DNA collection as part of the problem animal removal permit requirements. This would substantially increase the sample size and geographical spread of leopard DNA collected on an annual basis.

Presence data recently collected for leopard across Namibia was, in part, was through a citizen science initiative which requested participants to submit their leopard photographs from private camera traps and key farm information. This initiative contributed to the expansion of the known leopard distribution as well as engaging people in leopard conservation efforts as such the continuation of this type of inclusive initiative is highly recommended.

The economic benefits that the leopard brings to Namibia, through both consumptive use and non-consumptive use, is important to multiple sectors. Incorporating this information into the long-term monitoring of the leopard population will enable pro-active management of the species to occur. This in turn will ensure the permanency of leopards across Namibia.

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