Paraxerus palliatus – Red Squirrel


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Regional Red List status (2016)	Near Threatened B1,2ab(ii,iii)*†
***P. p. ornatus* Ngoye Forest subpopulation**	**Vulnerable D2*†**
National Red List status (2004)	Near Threatened
P. p. ornatus	Critically Endangered B1,2ab(ii,iv,v)
P. p. tongensis	Endangered B1,2ab(ii,iii,iv,v)
Reasons for change	No change
P. p. ornatus	Non-genuine change: New information
Global Red List status (2016)	Least Concern
P. p. ornatus	Not Evaluated
TOPS listing (NEMBA) (2007)	None
CITES listing	None
Endemic	Edge of range
P. p. ornatus	Yes

*Watch-list Data †Conservation Dependent

While the taxonomy remains to be resolved for this hugely phenotypically variable species, *Paraxerus p. ornatus* only occurs in Ngoye Forest, KwaZulu-Natal Province and represents the southern limit of the species' range (Skinner & Chimimba 2005). The Ngoye Red Squirrel shares its home with several other endemic taxa, such as Woodward's Barbet (*Stactolaema olivacea woodwardi*).

Taxonomy

Paraxerus palliatus (Peters 1852)

Paraxerus palliatus ornatus Ngoye Forest subpopulation (Gray 1864)

ANIMALIA - CHORDATA - MAMMALIA - RODENTIA - SCIURIDAE - *Paraxerus* - *palliatus*

Common names: Red Squirrel, Red Bush Squirrel, Red-bellied Coast Squirrel (English), Rooi Eekhoring (Afrikaans)

Taxonomic status: Species complex

Taxonomic notes: This species is in urgent need of revision as there are large amounts of variation in size and pelage between isolated populations, and at least seven subspecies are currently recognised, some of which may represent valid species (Monadjem et al. 2015). While Meester et al. (1986) listed six subspecies from sub-Saharan Africa, including *P. p. ornatus* (Gray 1864) from Ngoye Forest and *P. p. tongensis* (Roberts, 1931) from Manguzi Forest in KwaZulu-Natal, it is unclear whether these taxa have distinct phenotypes or genotypes (Mugo et al. 1995). Similarly, Thorington Jr. et al. (2012) listed seven subspecies of *P. palliatus* but only listed *P. p. ornatus* as occurring in South Africa (Ngoye Forest, Eshowe District, Zululand). While Viljoen (Viljoen 1980, 1989) suggested a rise to species status for both taxa, which was taken up by Friedmann and Daly (2004), this has not been corroborated by molecular or morphometric research. Thus, given the confusion around the taxonomy due to the lack of genetic evidence and the species' propensity for varied morphology, we assess at the species level, but recognise that *P. p. ornatus* is a distinct form that distinguishes it from the rest of its African range.

Assessment Rationale

The Red Squirrel has a restricted and fragmented range within the assessment region. Although existing at the edge of its range, it is common in suitable habitats and occurs in well-protected forest reserves, such as iSimangaliso Wetland Park, Ongoye Forest Reserve, Mhkuze Game Reserve and Ndumo Game Reserve. Although the northern KwaZulu-Natal forests are largely secure, there is a continuing decline in natural habitat (19.7% loss of natural habitat in KwaZulu-Natal from 1994 to 2011, with an average loss of 1.2% per annum), with the losses mainly occurring in small (< 0.5 ha) forest patches. Additionally, habitat degradation from human encroachment (from 2000 to 2013, there was a 5.6% and 1.1% rate of urban and rural expansion, respectively, in the province), such as fuelwood extraction, may indicate a continuing decline in habitat quality along protected area edges if large canopy gaps are produced. Thus, although habitat loss and degradation are unlikely to be affecting the core protected population, there is still an inferred absolute ongoing decline in suitable habitat. Overall, the estimated extent of occurrence (EOO) is 12,232 km^2 (or 6,511 km^2 if we exclude the Ngoye Forest subpopulation) and the area of occupancy (AOO) (based on remaining forest patches) is 453–721 km^2. Although the species qualifies for Vulnerable B1,2ab(ii,iii), we downlist to Near

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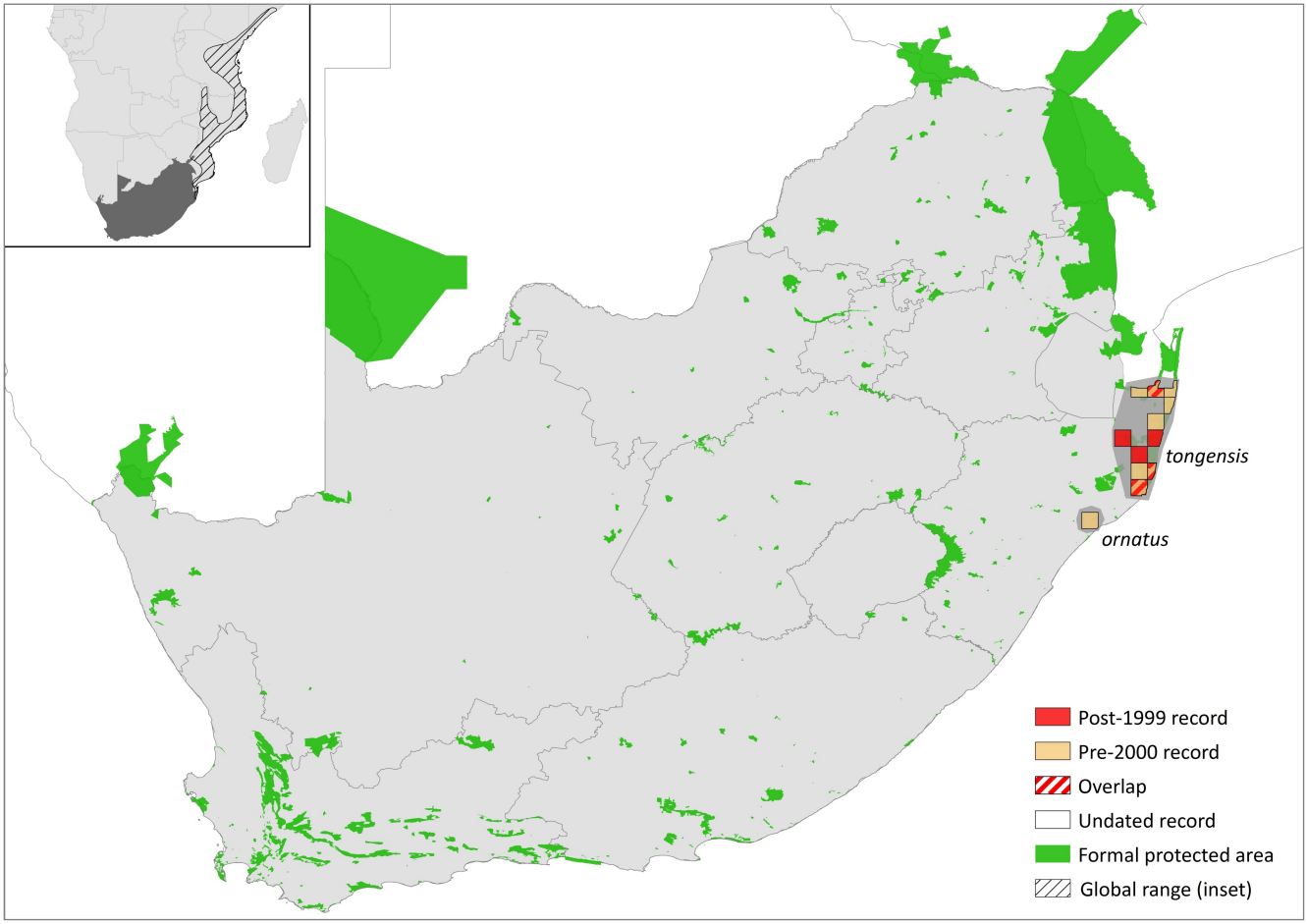

Figure 1. Distribution records for Red Squirrel (*Paraxerus palliatus*) within the assessment region

Table 1. Countries of occurrence within southern Africa

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

Threatened B1,2ab(ii,iii) based on the rescue effect (see below).

Although molecular research is needed to resolve the taxonomy of this potential species complex, the Ngoye Forest subpopulation is suspected to be a source of genetic diversity and warrants special attention. The Ngoye Forest subpopulation is restricted to one location with an AOO of 31–35 km^2 and an estimated total number of mature individuals of 13,392–15,120. Although there has been no net decline in the area under formal protection, excessive fires, leading to increased patchiness of the forest, specifically on the forest periphery and extending outwards of the formally protected area, have occurred within recent years. This indiscriminate burning is resulting in increased alien plant infestation and habitat transformation, which may reduce the available habitat for the Ngoye Forest subpopulation. Ngoye Red Squirrels are rare or absent in such areas and further research is needed to determine whether such degradation is causing subpopulation decline, the results of which will require reassessment as the subpopulation may qualify for Critically Endangered B1,2ab(iii). Recent research suggests that current levels of fuelwood harvesting do not affect canopy structure, but increased harvesting levels will threaten the forest structure. Thus, we list as Vulnerable D2, with the proviso that wood harvesting and fire levels should be closely monitored and managed. As such, this subpopulation remains conservation dependent.

Interventions for this species include protected area expansion to connect forest fragments and enforcement on regulation to prevent disturbances and degradation inside existing forests. If *P. p. tongensis* is proved to be restricted to Maputaland then it will need reassessment. We recommend molecular research to resolve the complicated taxonomy of this potential species complex within the assessment region.

Regional population effects: Dispersal is possible through the northern border of KwaZulu-Natal into Mozambique, particularly through the Lubombo Transfrontier Conservation and Resource Area. Habitat is largely connected in these areas, especially as the species is an adequate disperser and can use secondary habitats. The species is also very common throughout the rest of its range. For example, it is abundant in Maputo Elephant Reserve and throughout the iSimangaliso Wetland Park. However, the Ngoye subpopulation may be isolated from the rest of the species, but not enough is known about its dispersal ability.

Distribution

This species is widely distributed along the coastal forests of southern and eastern Africa (Monadjem et al. 2015), ranging from southern Somalia in the north, southwards to KwaZulu-Natal in South Africa, being found as far south along the coast as Lake Saint Lucia, with an isolated subpopulation in the Ngoye Forest (Viljoen 1989), which marks the southern limit. Within this range, their occurrence is patchy and discontinuous due to the fragmented nature of remaining forest where deforestation has previously occurred (Lawes et al. 2004; Skinner & Chimimba 2005). Within the assessment region, it occurs in evergreen coastal forests (Mugo et al. 1995; Skinner & Chimimba 2005), such as sand and scarp forests, exclusively in KwaZulu-Natal, and is common and widespread in the secure habitats of the northeastern regions and Maputaland (Figure 1). It appears not to occur in Swaziland (Monadjem 1998), despite potentially similar and connected habitat being found in the Lubombo region.

The potential subspecies are relict populations from habitats that were once connected to larger tracts of forests that continued northwards into Mozambique (Mugo et al. 1995). The Ngoye Red Squirrel, *P. p. ornatus*, is an Afromontane relic, isolated from other subpopulations for at least 6,000 years and is distinct morphologically. It may be a separate species but molecular work is needed to confirm this. However, Ongoye Forest Reserve is certainly a key protected area for this species as a reservoir of genetic diversity. Although the subspecies *P. p. tongensis* has been recognised (Meester et al. 1986), with the type specimen coming from Manguzi Forest, and assessed separately before (Friedmann & Daly 2004), there is no evidence for its taxonomic uniqueness and it is not considered to be a Maputaland endemic in this assessment, until further taxonomic research has occurred.

The extent of the occurrence (EOO) for the species is 6,511–12,232 km^2 while the combined area of occupancy (AOO), based on remaining natural forest habitat (GeoTerraImage 2015), is between 641–721 km^2. This is based on all natural forest within (or intersecting) the range, and not just patches for which there are records. It does not include nearby forests outside of the EOO, because, despite the adequate dispersal abilities of the species (Viljoen 1986), rates of colonisation of forest fragments within KwaZulu-Natal are low (Lawes et al. 2000a), which means that patches of forest for which there are no records for the species are probably unoccupied in reality (true negatives). Similarly, as *P. p. ornatus* is restricted to Ngoye Forest (which includes Ongoye, Dengweni, Ezigwayini and Impeleshu Nature Reserves and the respective extensions falling within the Mzimela Traditional Council area), its AOO is calculated as 31–35 km^2. The AOO for confirmed present forest patches (excluding Ongoye Nature Reserve) is 453–509 km^2.

Population

Overall, the species is common and abundant throughout northeastern KwaZulu-Natal, such as in Ndumo Game Reserve and iSimangiliso Wetland Park, and throughout the rest of its range. As forest habitat is currently stable, we infer that the population trend is stable. Viljoen (1986) calculated a density of 2.2 mature individuals / ha (or 449 g / ha), which equates to a population size of 97,395–155,015 based on a range of AOO estimates for the species (453–721 km^2). Similarly, the density of *P. p. ornatus* was calculated as 4.3 individuals / ha (again excluding juveniles), which yields a mature population size of 13,392–15,120 for Ngoye Forest. Thus, the population size for this species is estimated to be large, although Viljoen (1986) cautions that juvenile recruitment is low. This direct extrapolation may, however, overestimate the current size for this subpopulation as a result of varying habitat assemblages, created through anthropogenic influence (fire, grazing, wood extraction), within the forest complex and limited number of reported sightings by persons working in the area. Although the core population is suspected to have remained stable since at least the 1990s, due to strong forest protected areas in the region, ongoing habitat loss is inferred to be causing a net decline in the population.

Current population trend: Declining, inferred from ongoing habitat loss in the region although there are secure forest habitats in northeastern KwaZulu-Natal.

Continuing decline in mature individuals: No

Number of mature individuals in population: 97,395

Number of mature individuals in largest subpopulation: Unknown

Number of subpopulations: Unknown

Severely fragmented: Yes. Although they have maximum dispersal distance of c. 1.1 km, many small forest patches exceed this distance or are not viable due to edge effects (Lawes et al. 2000b, 2004).

Habitats and Ecology

This species has been recorded from a variety of habitat types including dry or moist evergreen forests, woodlands, riverine forest and thickets with an understorey of leafy vegetation (Skinner & Chimimba 2005). They do not occur in savannah woodlands unlike Tree Squirrel (*Paraxerus cepapi*). Logging followed by coppice regeneration provides suitable habitat (Skinner & Chimimba 2005), although there is no formal evidence that they utilise secondary habitats within the assessment region. They obtain their moisture from the fleshy fruits they eat or from dripping water on leaves and branches or water trapped in holes on trees (Skinner & Chimimba 2005). They are arboreal and diurnal. Generally solitary, but members of a nesting group will be within vocal contact distance. The female is the focal point of the group, whose males may change from time to time (Skinner & Chimimba 2005). The species has one or two litters annually of one or two young.

Fruit trees are focal points of activity as their diet is comprised primarily of wild fruits, nuts, and berries, with small amounts of roots, leaves, flower buds, bark, lichen and insects. A study from Ongoye Forest Reserve and Mkwankwa forests revealed male home ranges to be 3.2–4.2 ha and females to be 1.2–2.2 ha, with maximum dispersal distance of 1,065–1,142 m and 685–699 m for males and females, respectively (Viljoen 1980). It is a locally abundant and conspicuous species, due largely to its habit of tail-flicking and staccato calling when perturbed (Skinner & Chimimba 2005).

Ecosystem and cultural services: It is possible that it provides seed dispersal services, much like Samango Monkeys (*Cercopithecus albogularis*) (Linden et al. 2015),

Table 2. Threats to the Red Squirrel (*Paraxerus palliatus*) 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	*2.1.2 Small-holder Farming* and *2.3.2 Small-holder Grazing, Ranching or Farming*: subsistence agricultural expansion leading to forest habitat loss and degradation. Current stress *1.3 Indirect Ecosystem Effects*: fragmentation and isolation of remaining forest patches with limited dispersal between.	Jewitt et al. 2015	Indirect (land cover change from remote sensing)	Regional	Increasing: 19.7% loss of natural habitat in KwaZulu-Natal Province from 1994–2011, with an average loss of 1.2% per annum.
2	*1.1 Housing & Urban Areas*: forest habitat lost to residential and commercial development. Current stress 1.3: fragmentation and isolation of remaining forest patches with limited dispersal between.	GeoTerraImage 2015	Indirect (land cover change from remote sensing)	Regional	Increasing: 5.6% and 1.1% rate of urban and rural expansion in KwaZulu-Natal Province from 2000–2013.
3	*5.3 Logging & Wood Harvesting*: small-scale harvesting of pole-size trees may lead to large canopy gaps and state shifts.	Louw 2010	Indirect	Local	Harvesting of 8 adjacent pole-size trees negatively affects forest dynamics.
4	*7.1.1 Increase in Fire Frequency/Intensity*: excessive wildfires lead to habitat degradation.	-	Anecdotal	-	Possibly increasing with human settlement expansion.

although no formal studies have evaluated this. It has the potential to be a flagship species of KwaZulu-Natal forests and biodiversity stewardship schemes.

Use and Trade

This species is not traded or utilised. There is no evidence for its use as bushmeat.

Threats

The major threats to this species are habitat loss and degradation, although the extent to which these affect the species currently needs research. Although much of its coastal forest habitat has been deforested or degraded historically, it currently occurs in well-protected habitat and, since the 1990s, there has been no real evidence for population decline (Mugo et al. 1995). Furthermore, it is probably not as threatened as ground-dwelling small mammals, such as shrews, because overgrazing and small-scale fuelwood collection will not alter habitat structure as drastically. For example, in a study assessing the impact of human utilisation of woodlands and sand forests in Maputaland, while utilisation decreased averaged stem diameter, the height structure of the forest remained largely unchanged (Gaugris & Van Rooyen 2010). Similarly, in Ongoye Forest Reserve specifically, no instance of canopy tree logging has been recorded (understorey species harvested exclusively at a harvesting pressure of 11.6% of available pole-size trees) and most species harvested for building materials and fuelwood regenerate over small spatial scales, suggesting that the level of harvesting is sustainable (Boudreau et al. 2005), yet this is not the case in adjacent areas within the Ngoye forest complex. A further study concluded that such understorey harvesting at low levels of harvesting (11.6%) does not affect the regeneration of canopy species and will not detrimentally affect the overall species composition of scarp forest (Boudreau & Lawes 2005). Similarly, Louw (2010) found that, while creating small gaps from harvesting pole-sized trees will not affect forest dynamics and species composition, harvesting in excess of eight adjacent trees, and so creating larger gaps, will potentially lead to successional shifts and alternate states in the ecosystem, potentially negatively affecting habitat suitability for the Ngoye Red Squirrel. Thus, harvest management should be regulated accordingly. Other factors that could cause habitat degradation are wildfires and alien plant infestations. For example, over recent years, forest patches have been lost in Ngoye Forest from excessive fires and the Ngoye Red Squirrel has neither been seen in such degraded patches nor the outer-lying eastern forest patches (S. Louw pers. obs. 2016). Furthermore, the protected areas and forest patches extending into the Mzimela Traditional Council area have minimal control, face the same challenges and run the risk of agricultural and residential developments together with their associated infrastructure, and are thus impacted to a greater extent.

Overall, although current rates of habitat loss and degradation appear not to be negatively affecting the population, we take a precautionary purview as an absolute net decline in habitat in the region (see below) and increased levels of harvesting pressure could rapidly affect the species in the near future.

Current habitat trend: Overall, there was a 19.7% loss of natural habitat in KwaZulu-Natal from 1994 to 2011, with an average loss of 1.2% per annum (Jewitt et al. 2015). If this rate of loss continues into the future, there will be an estimated 12% loss of habitat over 10 years. Worryingly, a massive 7.6% of natural habitat was recently lost in KwaZulu-Natal in just six years (2005–2011). Correspondingly, Southern Coastal and Swamp Forest have declined by at least 1–3% between 2000 and 2013 (F. Daniels unpubl. data). More analysis is needed to more accurately estimate rate of forest loss over the past 10 years. Additionally, between 2000 and 2013, there has been a 5.6% and 1.1% rate of urban and rural expansion in KwaZulu-Natal Province respectively (GeoTerraImage 2015), which indicates both a loss of habitat and possibly an increase in human encroachment on forest resources, which we infer as increasing habitat degradation especially if not properly managed. However, a local study in the KwaNibela Peninsula, in the northernmost region of Lake St Lucia, composed of sand and coastal forest, showed that core forest area expanded and open areas contracted slightly from 1937 to 2001 (although both

Table 3. Conservation interventions for the Red Squirrel (*Paraxerus palliatus*) 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	*1.1 Site/Area Protection*: protected area expansion of formally protected areas to link with existing transfrontier conservation areas.	Smith et al. 2008	Indirect	Regional	480 km^2 of corridors could be created.	Ezemvelo KwaZulu-Natal Wildlife protected area expansion strategy
2	*1.2 Resource & Habitat Protection*: biodiversity stewardship expansion to protect remaining forest patches.	-	Anecdotal	-	-	Ezemvelo KwaZulu-Natal Wildlife protected area expansion strategy
3	*3.1.1 Harvest Management*: regulating the harvest of understorey trees in protected forests (*c.* 11% available stems, < 8 adjacent trees).	Boudreau & Lawes 2005	Empirical	Local	Canopy structure intact at 11.6% harvesting pressure.	None
		Louw 2010	Empirical	Local	Forest dynamics intact if < 8 stems harvested adjacently.	

shifted in both directions over the time period), despite being utilised by local communities (Corrigan et al. 2010). However, all cover types have become more fragmented (Corrigan et al. 2010). More research and systematic reviews are needed to determine the net effects of forest land cover change on this species.

Conservation

This species occurs in well protected coastal forest reserves, such as, iSimangaliso Wetland Park, Ongoye Forest Reserve, Mhkuze Game Reserve and Ndumo Game Reserve. Further field studies should document in which unprotected forest patches the species occurs, so as to assess the threat of losing small patches (Lawes et al. 2004), and to inform protected area expansion strategies. For example, a transfrontier conservation area in Maputaland that connects with the existing Lubombo Transfrontier Conservation Area has recently been proposed and would add 480 km^2 of linking corridors between forest habitats and potentially generate US$18.8 million from game ranching (Smith et al. 2008). Such a protected area network would undoubtedly benefit this species. Biodiversity stewardship schemes that protect remaining patches of forest would also help to create corridors.

Conservationists should also work with local communities to regulate the harvesting of pole-sized trees in forests. For example, recent research suggests that small-scale harvesting of understorey trees (around 11% of available stems) should be sustainable and not alter forest structure if fewer than eight trees are harvested adjacently in any one area (Boudreau et al. 2005; Boudreau & Lawes 2005; Louw 2010).

Recommendations for land managers and practitioners:

- Conservation authorities should develop harvesting strategy guidelines for understorey trees and engage with local communities.
- Enforce regulations on developments that potentially impact on the habitat integrity of forests.
- Conservation authorities should control and manage livestock grazing within forest protected areas.
- Conservation authorities and local Fire Protection Associations should monitor the burning regimes adjacent to indigenous forest patches and provide necessary support to burn appropriate fire breaks around such areas.

Research priorities:

- Further field studies are needed to determine the distribution of this species in forest patches within the matrix between protected areas.
- More research and systematic reviews are needed to determine the net effects of forest land cover change on this species.
- Molecular research is necessary to resolve the taxonomy of this potential species complex.

Encouraged citizen actions:

- Report sightings and photograph this species, especially outside protected areas, on virtual museum platforms (for example, iSpot and MammalMAP).

Data Sources and Quality

Table 4. Information and interpretation qualifiers for the Red Squirrel (*Paraxerus palliatus*) assessment

Data sources	Field study (unpublished), Indirect information (literature)
Data quality (max)	Estimated
Data quality (min)	Inferred
Uncertainty resolution	Maximum/minimum values
Risk tolerance	Evidentiary

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Details of the methods used to make this assessment can be found in *Mammal Red List 2016: Introduction and Methodology.*