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South African raptors in urban landscapes: a review

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Globally, but especially in Africa, increasing human populations and anthropogenic land-use change are generally affecting diversity negatively. Urban environments in southern Africa typically comprise a mosaic landscape of anthropogenic infrastructure with some green spaces. These urban cities have a range of fauna that have persisted or increased in population density compared with areas that are more natural. We analysed the occurrence of diurnal and nocturnal raptors using South African Bird Atlas Project (SABAP2) data and reviewed literature. We found 66 raptor species occurred in South African cities. Thirty species had reporting frequencies greater than 10% in at least one of the 11 cities assessed, revealing impressive diversity of the raptor clade in South African cities. Five species were both abundant and widespread, occurring >10% in five or more cities each, of which three belong to the scavenger guild: Black-winged Kite *Elanus caeruleus*, African Fish Eagle *Haliaeetus vocifer*, Common Buzzard *Buteo buteo vulpinus*, Yellow-billed Kite *Milvus aegyptius* and Black Sparrowhawk *Accipiter melanoleucus*. However, only a few of these 66 raptors had been extensively studied in urban areas: the Black Sparrowhawk, African Crowned Eagle *Stephanoaetus coronatus*, Lanner Falcon *Falco biarmicus* and Peregrine Falcon *Falco peregrinus*. This lack of research is specifically severe, given that Africa is hosting a unique and diverse range of raptor species and that numbers and diversity of raptors have declined dramatically over the past decades across the continent. In fact, these four extensively studied species occurred in higher densities in urban areas than rural areas, which indicates that urban areas might create valuable opportunities for urban conservation, not least through public engagement.

Rapaces sud-africains dans les paysages urbains: un bilan

À l›échelle mondiale, mais surtout en Afrique, l›augmentation des populations humaines et les changements anthropiques d›utilisation des terres ont généralement un impact négatif sur la diversité. Les environnements urbains en Afrique australe comprennent généralement un paysage en mosaïque d›infrastructures anthropiques avec quelques espaces verts. Ces villes urbaines ont une diversité de faune qui a persisté ou a augmenté en densité de population par rapport aux zones plus naturelles. Nous avons analysé l›occurrence des rapaces diurnes et nocturnes à l›aide des données du South African Bird Atlas Project (SABAP2) et examiné la littérature. Nous avons trouvé 66 espèces de rapaces présentes dans les villes sud-africaines. Trente espèces avaient des fréquences de déclaration supérieures à 10% dans au moins l'une des 11 villes évaluées, révélant une diversité impressionnante du clade des rapaces dans les villes sud-africaines. Cinq espèces étaient à la fois abondantes et répandues, présentes> 10% dans cinq villes ou plus chacune, dont trois appartiennent à la guilde des charognards: l'Elanion blanc *Elanus caeruleus*, le Pygargue vocifer *Haliaeetus vocifer*, la Buse commune *Buteo buteo vulpinus*, Le Milan à bec jaune *Milvus aegyptius* et l'Epervier noir *Accipiter melanoleucus*. Cependant, seuls quelques-uns de ces 66 rapaces avaient été largement étudiés dans les zones urbaines: l'Epervier noir, l'Aigle couronné *Stephanoaetus coronatus*, le Faucon lanier *Falco biarmicus* et le Faucon pèlerin *Falco peregrinus*. Ce manque de recherche est particulièrement grave, étant donné que l'Afrique abrite une gamme unique et diversifiée d'espèces de rapaces et que le nombre et la diversité des rapaces ont considérablement diminué au cours des dernières décennies à travers le continent. En fait, ces quatre espèces largement étudiées se trouvaient à des densités plus élevées dans les zones urbaines que dans les zones rurales, ce qui indique que les zones urbaines pourraient créer de précieuses opportunités pour la conservation urbaine, notamment grâce à l'engagement du public.

Keywords: anthropogenic land-use change, bird atlas project, citizen science, SABAP2, urbanisation

Introduction

Globally, one of the most significant factors affecting wildlife and human-wildlife interactions is the growth of urban environments (Frank et al. 2019; Soulsbury and White 2016). The human population is now an urban-dwelling majority, which is projected to reach five billion by 2030 (United Nations 2019). Urban growth and land demands are expected to triple, transforming 1.2 million km^2 in the next 30 years (Seto et al. 2012). Specifically, in developing

countries, this human population growth and land-use change are predicted to continue to accelerate (United Nations 2019). The anthropogenic land-use transformation is one of the leading causes of habitat loss and species extinctions (McKinney 2006; Seto et al. 2012; Turvey and Crees 2019).

Africa is experiencing rapid growth, both economically and in terms of human populations (United-Nations 2019), and these changes have considerable impacts on African wildlife (Tilman et al. 2017). Such pressures are likely to increase significantly in the next few decades, because the human population in sub-Saharan Africa is predicted to grow to >2 billion by 2050 (United-Nations 2019). Additionally, Africa, together with Asia, is urbanising faster than any other region in the world. For example, Nigeria is projected to add 212 million urban dwellers by 2050 (Baloye and Palamuleni 2015). This rapid urbanisation poses challenges for sustainable development and public health and it will greatly affect the continent's wildlife (Amar et al. 2018).

Urban ecology is an increasingly relevant and important discipline that endeavours to integrate high-density human populations and wildlife into mutually supportive ecosystems (McKinney 2002; Alberti et al. 2003; Marzluff 2008; Magle et al. 2012; Manfredo et al. 2020). Fundamental changes associated with urbanisation include the occurrence of anthropogenic infrastructure and presence; these are typified by buildings, impervious surfaces, transport and utility networks, artificial lighting, and high human densities (Adams 2006). Abiotic effects of these alterations include the urban heat island, pollution of air, water and soil with exotic anthropogenic chemicals (e.g. plastics, pesticides, heavy metals), as well as increased levels of sound and artificial light at night (Alberti et al. 2003; McCarthy et al. 2010; Dominoni et al. 2013). These changes in the abiotic environment result in impoverished biological richness and diversity compared with surrounding rural and natural landscapes (Chace and Walsh 2006; Beardsley et al. 2009; Reis et al. 2012). For example, a worldwide study on the impact of urbanisation on avian functional diversity showed 20% less functional diversity on average in urban areas than surrounding natural habitats (Sol et al. 2020). However, most research is conducted in the Global North, and conclusions might not always apply to Africa, which is characterised by developing countries with strong socio-economic and socio-cultural gradients, as well as a more tropical climate and different time and pace of urbanisation scenarios (Gupta 2002; Seto et al. 2010; McHale et al. 2013; Chamberlain et al. 2020).

Generally, urban areas exhibit a gradient of effects on biodiversity, often highest at the most modified urban core (McDonnell et al. 2009), although modern industrial cities expand in complex and dynamic ways characterised by sprawl developing in fractal patterns (Ramalho and Hobbs 2012), or are a mosaic of habitats, with some natural and green spaces interspersed (Alexander et al. 2019a, 2019b, 2019c; Maseko et al. 2019, 2020). The diversity of indigenous species typically decreases with proximity to the urban core (Kark et al. 2007; Reis et al. 2012). Urban adapters may tolerate some land-use change, while still requiring areas of natural habitats to persist, whereas urban exploiters can effectively use anthropogenic resources to thrive in urban environments. Urban exploiters, or synurban wildlife, are those species that have 'greatly benefited from the availability of anthropogenic resources' (Parker and Nilon 2012). Avian species, such as House Sparrow *Passer domesticus* and Rock Dove *Columba livia*, typify life-history traits that permit the exploitation of anthropogenic resources: cavity-nesting, sociality, tolerance of human proximity, the inclination for dispersal, omnivorous, a capacity for feeding innovations, as well as high fecundity and high adult survival (Chace and Walsh 2006; Ditchkoff et al. 2006; Møller 2009; Hanson et al. 2020; Shivambu et al. 2020). Synurban species make such effective use of anthropogenic resources and opportunities that, despite reduced species richness, the overall biomass in an urban environment can be higher than surrounding natural habitats (McKinney 2006; Kark et al. 2007; Chamberlain et al. 2017; Mackay et al. 2017).

Despite the general trend of degraded biological diversity, some native species benefit from cities, and conservation strategies can be applied in some areas (McKinney 2002; Marzluff 2017; Maseko et al. 2019, 2020; Zungu et al. 2020a, 2020b). For example, in South Africa, some residential estates are managed with the specific goal of conservation, catering for particular requirements of endangered species enclosed within the estate (Grey-Ross et al. 2009; Alexander et al. 2019a, 2019b, 2019c). The availability of reliable resources includes roosting and nesting sites, food availability, and permanent water availability (Chace and Walsh 2006; Waite et al. 2007; Kumar et al. 2019; Singh and Downs 2016a, 2016b; Thabethe and Downs 2018).

Large apex predators are generally excluded from core urban areas (Bateman and Fleming 2012). However, they often have positive ecological influences through top-down regulation of trophic systems, and their absence can negatively influence functional diversity in cities (Faeth et al. 2005; Sol et al. 2020). There is a growing understanding of urban-adapting native mammalian carnivores and avian raptors, which are typically small to medium size, *r*-selected, solitary foragers, diet generalists with a discreet lifestyle that can scavenge and are tolerant to human proximity (Abay et al. 2011; Gehrt et al. 2010; Iossa et al. 2010; Widdows and Downs 2015, 2018; Widdows et al. 2015; Streicher et al. 2021). Beside anthropogenic food and nest resources (Chace and Walsh 2006), they can profit from lower persecution levels (Rutz et al. 2008; Dandy et al. 2011). In addition, proximity refugia exist where some prey species have a greater tolerance for human proximity than their predators (Møller 2008). Therefore, urban areas can provide suitable refugia for predators/raptors. Their presence, however, often trigger human-wildlife conflicts, specifically when livestock or pets are seen at risk (Redpath et al. 2013; Madden et al. 2019; Murgatroyd et al. 2019; Reynolds et al. in press).

Raptors occupy a diversity of habitats, including urban environments (Boal and Dykstra 2018; Kettel et al. 2018). Some of their typical prey species include abundant synurban wildlife like rodents and pigeons, which can attract various Owl, Falcon, and Accipiter species. Small Accipiter, Buzzard, and Kite species are well represented, favouring species that can breed in small fragments of parkland, hunt avian prey in woodland and garden habitats, or exploit refuse areas (Bloom and McCrary 1996;

Salvador et al. 2008; Cava et al. 2012; Boggie and Mannan 2014). Large raptors (>3 kg) are typically excluded from urban areas, but may include urban areas as a part of a larger home range (van Eeden et al. 2017) or if a suitable breeding cliff is situated within an urban area (Padayachee et al. 2020). Large raptors are most commonly from scavenger guilds foraging from urban refuse areas (Galushin 1971; Elliott et al. 2006; Mandel and Bildstein 2007; Gbogbo and Awotwe-Pratt 2008; Chamberlain et al. 2017), and in so doing provide ecological and social benefits (Markandya et al. 2008).

Despite increased urbanisation globally, most research on urban predators until relatively recently was limited to North America and Europe (Magle et al. 2012; Bateman and Fleming 2012; Boal and Dykstra 2018; Kettel et al. 2018). This was the trend for both main urban predator taxa: mammalian carnivores and avian predators (raptors). Thus, there is a clear need for more research on urban predators in Africa, Asia and South America (Magle et al. 2012; Amar et al. 2018).

Two recent reviews in ornithological research that specifically focused on urban raptors (Donázar et al. 2016; Kettel et al. 2018) underline this research gap further. Kettel et al. (2018) did not include a single study from the African continent. Donázar et al. (2016) focussed on ecosystem services and limited their African studies considering only the African vulture decline (Bamford et al. 2009; Ogada et al. 2012, 2015). Furthermore, Donázar et al. (2016) named only a single urban raptor study conducted in South Africa to underline a statement about nest-site availability and potential conflicts with building owners (Altwegg et al. 2014). There is a clear lack of published African urban raptor research, although Africa hosts unique biomes with a diversity of resident and migrating raptor species (Brown et al. 1982; Amar et al. 2018).

Sub-Saharan Africa alone supports breeding populations of >20% of all raptor species globally, while also hosting more than 20 regular Palearctic migratory raptors (Ferguson-Lees and Christie 2001). However, over the past several decades, the numbers and diversity of raptors in many regions have declined dramatically (e.g. Ogada et al. 2016; Garbett 2018). Despite this high relevance, little has been published regarding the urban raptor phenomenon in southern Africa, whereby cities could be urban refugia for some species and could provide valuable urban conservation opportunities. For example, one study from Kampala, Uganda (Chamberlain et al. 2018) shows that generalist scavenger raptors benefit from urban areas across the continent, which is not extensively documented from the urban Global North. Our review aims to highlight the clear research gap on urban raptors, and specifically for South Africa, where comprehensive data from the South African Bird Atlas Project (http://sabap2.adu.org.za/, SABAP2) are available. We review the South African urban raptor research and highlight trends and case studies.

Materials and methods

Our study focusses on avian predators (raptors; orders Accipitriformes, Cathartiformes, Falconiformes, Strigiformes, and Cariamiformes; Iriarte et al. 2019; McClure et al. 2019). We provide a descriptive review of data from the South African Bird Atlas Project 2 (SABAP2; Underhill 2016), of the clades of raptors, in a selection of South African metropolitan areas. SABAP is a citizen science survey, and full protocol checklists involve recording presence and rank order detected of birds in a 'pentad' (5 minutes latitude × 5 minutes longitude), over a given time (minimum 2 h, maximum month). Our review captures full protocol data for the period 1 January 2009 to 1 January 2020 (Figure 1). Our analysis simply reports on the frequency of presence, i.e. the number of cards reporting a presence of a particular species per the number of total cards for that pentad and the 'reporting rate' for that species.

We selected nine urban centres that represent the largest cities in each of the nine provinces of South Africa (see Figure 1 for the map of South Africa and locations of cities, locations of pentads and urban score). This selection was extended by including Pretoria and Pietermaritzburg, because of their size and connectivity to neighbouring large cities. We attempted to represent an even geographical spread and representation from a variety of biomes (Table 1). We compiled a dataset of raptor detection frequencies for the 11 South African provincial urban cities (from north to south, data are given as area in km^2, population census from 2011 (Statistics South Africa 2011): Polokwane (Limpopo, 147 km², 227 407), Mbombela/Nelspruit (Mpumalanga, 73 km², 58 670), Rustenburg (North West, 1 144 km², 311 901), Johannesburg–Pretoria (Gauteng, 3 357 km², 7 860 781), Kimberley (Northern Cape, 164 km², 225 155), Bloemfontein (Free State, 269 km², 464 591), Durban–Pietermaritzburg (KwaZulu-Natal, 897 km², 2 786 046), Port Elizabeth (Eastern Cape, 341 km², 876 436) and Cape Town (Western Cape, 1 137 km², 3 430 992) (Figure 1).

The relevant urban areas were designated using discrete SABAP2 'pentads (five minutes of latitude, five minutes of longitude)', from aerial photographs, where the 80% majority of each pentad was highly urbanised. Reporting rates of each species may be biased, because of underreporting of cryptic species and unequal distribution of observers and observer locations within the urban areas (Lee and Barnard 2017). However, despite these considerations, some novel insights can be gained from these data, given that they cover a rather understudied region. We assumed no false positives, i.e. that the species was always correctly identified. This was a reasonable assumption, because most observers submitting checklist cards are birders, and SABAP has a vetting system to validate if species are reported out of their normal distribution range.

In addition, we searched the literature for examples of research on South African urban raptors. We used various search engines, including Google Scholar, to find examples of this research as a systematic literature review via Web of Science would not capture so-called 'grey' literature where some of these studies are published. To our knowledge, the last systematic literature review on African raptors was conducted by Amar et al. (2018) and revealed 'only' 555 published studies on 67 diurnal African raptor species, 300 of which were (at least partly) conducted in South Africa or multiple regions, including southern Africa, and only 12 were done in an urban context.

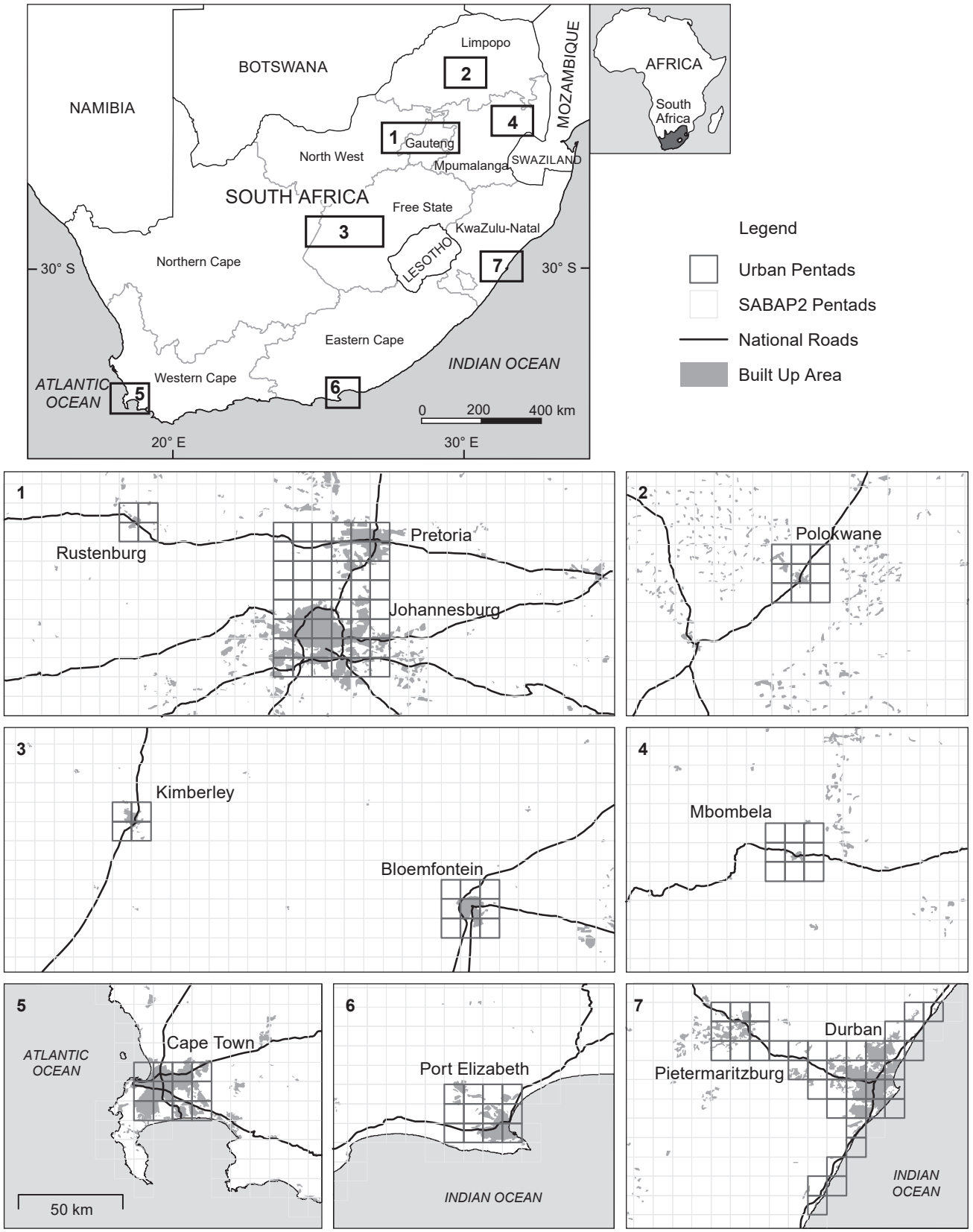

Figure 1: The urban areas of South Africa and the particular pentads that were selected for this review. Insets 1 to 7 are all on the same scale, with the according scale bar displayed in inset 5. The location and extent of each inset is numerically referenced in the regional context map. The shape 'Built Up Areas' was indicative only from South Africa National Topographic Data 1:500 000, Department of Land Affairs, 25 August 1997

Table 1: SABAP summary results for South African **c**ities ranked by geographical location (north-west to south-east) (as per Figure 1), following biome definitions of Mucina and Rutherford (2006)

City	Number of SABAP2 pentads	Number of SABAP2 cards	Species richness	Population rank in ZA	Main biome
Rustenburg	4	298	42		Savanna
Pretoria	18	5 917	48	4	Grassland
Johannesburg	30	10 157	49	1	Grassland
Polokwane	9	734	50		Savanna
Kimberley	4	230	27		Savanna
Bloemfontein	9	1 072	30	9	Grassland
Nelspruit	9	1 632	42		Savanna
Cape Town	12	3 194	27	2	Fynbos
Port Elizabeth	12	1 430	29	5	Albany Thicket
Pietermaritzburg	10	1 907	43	10	Savanna
Durban	32	4 930	37	3	Indian Ocean Coastal Belt
All Total		31 501	66		

Results

We found 31 501 SABAP2 cards from the selected urban pentads in South Africa, with a total raptor species richness of 66 across all selected cities (Table 1). These raptor species included generalist and specialist species of a range of body masses (Table 2) and included most raptor species occurring in southern Africa. However, most of these raptor species had not been studied in urban habitats (Table 2). The few that have been extensively studied in urban areas of South Africa included the Black Sparrowhawk *Accipiter melanoleucus*, African Crowned Eagle *Stephanoaetus coronatus*, Lanner Falcon *Falco biarmicus* and Peregrine Falcon *Falco peregrinus* (Table 2; Figure 2). These 66 species of diurnal (83.3%) and nocturnal (16.7%) raptors were recorded in urban centres of South Africa at least once, with 30 species having a reporting frequency of at least 10% (in at least one of the cities) (Table 3). The species composition of urban raptors varied greatly among regions (Table 3), reflecting different climates and biomes across the country. Five species were widespread urban adapters, reported in frequencies greater than 10% in five or more of the 11 cities: Black-winged Kite *Elanus caeruleus*, African Fish Eagle *Haliaeetus vocifer*, Common Buzzard *Buteo buteo vulpinus* sub spp., Yellow-billed Kite *Milvus aegyptius* and Black Sparrowhawk.

Three large predatory raptors occurred as residents in South African cities: African Fish Eagle, African Crowned Eagle, and Verreaux's Eagle *Aquila verreauxii*. The African Fish Eagle was reported in all eleven cities. The Verreaux's Eagle was reported in Rustenburg (16%), Johannesburg (14%), Pretoria (3%) and with very occasional sightings in Cape Town (<1%). The African Crowned Eagle occurred in four main eastern cities: Durban (31%), Pietermaritzburg (12%), Port Elizabeth (5%) and Mbombela/Nelspruit (4%). With this occurrence, the African Crowned Eagle was the second most frequently reported raptor in Durban after the Yellow-billed Kite. The African Crowned Eagle is furthermore of conservation concern (currently listed as Near Threatened following the IUCN criteria), with a regional status of Vulnerable in South Africa (Taylor et al. 2015). It appears to be the only endangered raptor in South Africa with a significant urban breeding population. All other endangered species are transient (Lappet-faced Vulture *Torgos tracheliotos*, Secretarybird *Sagittarius serpentarius*, Martial Eagle *Polemaetus bellicosus*, Cape Vulture *Gyps coprotheres*, African White-backed Vulture *G. africanus*, Black Harrier *Circus maurus*, Tawny Eagle *Aquila rapax*), summer visitors/non-breeders (Red-footed Falcon *Falco vespertinus*, Pallid Harrier *Circus macrourus*) or isolated cases (Table 2 in bolded italics).

The raptor communities are otherwise variable across the different cities; perhaps because of the biomes, climatic variables, and city grey-to-green ratios. For example, Durban has been largely influenced by its variable topography, creating natural habitat refugia in the abundant kloofs and gorges that cut through the hinterland. In the 1970s, a green space systems development began to protect these natural habitats and combat climate change and water quality issues, known as the Durban Metropolitan Open Space System (DMOSS) (Roberts 1994). Furthermore, as suburbia developed on the grassland plateaus, planting garden shade trees and suppressing and controlling the previous annual grassland fire management resulted in the landscape's widespread afforestation (Bill Howells, Ezemvelo KZN Wildlife [Natal Parks Board], pers. comm.). Johannesburg is located in the grassland biome, but was also shown to support populations of *Accipiter* hawks (Table 3) that associate with woodlands and forests, such as Ovambo Sparrowhawk *Accipiter ovampensis*, Black Sparrowhawk, and Little Sparrowhawk *Accipiter minullus*. Johannesburg is often cited as the largest synthetic urban forest, with ~10 million trees (Symes et al. 2017; Jombo et al. 2020).

In our study, Bloemfontein and Kimberley represent a suite of cities and towns (such as Ladysmith, Himeville and Estcourt in KwaZulu-Natal), that host large communal roosts of the overwintering Amur Falcon *Falco amurensis* and Lesser Kestrel *Falco naumanni*. These species disperse to the surrounding grasslands feeding on insects and rodents, and then congregate nightly in a chosen stand of large trees within an urban area, often by a busy roadside and lit by streetlights (Authors, pers. obs.).

Table 2: A summary of the 66 diurnal and nocturnal raptors (in alphabetical order following their scientific name) reported in South African urban areas from SABAP2 data in the present study and their conservation status (IUCN: *NT* near threatened, *VU* vulnerable, *EN* endangered, *CR* critically endangered). Rarities are displayed in ***bold italics*** (here classified as reported from only one city and/or less than five atlas cards). However, also, most other species are poorly studied in urban areas

	Scientific name	Common name	Urban South African references	IUCN status
Diurnal	*Accipiter badius*	Shikra		*LC*
	Accipiter melanoleucus	Black Sparrowhawk	Malan and Robinson 1999; Curtis et al. 2005; 2007; Amar et al. 2013; Martin et al. 2014a; 2014b; Katzenberger et al. 2015; Sumasgutner et al. 2016a; 2016b, 2018, 2019; Rose et al. 2017; Suri et al. 2017a; Tate and Amar 2017; Tate et al. 2017; van Velden et al. 2017; Wreford et al. 2017; Little and Navarro 2019; Nebel et al. 2020; McCarren et al. 2021	*LC*
	Accipiter minullus	Little Sparrowhawk		*LC*
	Accipiter ovampensis	Ovambo Sparrowhawk		*LC*
	Accipiter rufiventris	Red-breasted Sparrowhawk	Little and Navarro 2019	*LC*
	Accipiter tachiro	African Goshawk	Little and Navarro 2019	*LC*
	Aquila rapax	Tawny Eagle		*VU*
	Aquila spilogaster	African Hawk-eagle		*LC*
	Aquila verreauxii	Verreaux's Eagle	Symes and Kruger 2012; Padayachee et al. 2020	*LC*
	Aviceda cuculoides	African Cuckoo-hawk		*LC*
	Buteo buteo	Common (Steppe) Buzzard		*LC*
	Buteo rufofuscus	Jackal Buzzard		*LC*
	Buteo trizonatus	Forest Buzzard		*LC*
	Clanga pomarina	Lesser Spotted Eagle		*LC*
	Circaetus cinereus	Brown Snake Eagle		*LC*
	Circaetus fasciolatus	***Southern Banded Snake Eagle***		*NT*
	Circaetus pectoralis	Black-chested Snake Eagle		*LC*
	Circus aeruginosus	Western Marsh Harrier		*LC*
	Circus macrourus	Pallid Harrier		*NT*
	Circus maurus	Black Harrier		*VU*
	Circus pygargus	Montagu's Harrier		*LC*
	Circus ranivorus	African Marsh Harrier		*LC*
	Elanus caeruleus	Black-winged Kite		*LC*
	Falco amurensis	Amur Falcon		*LC*
	Falco biarmicus	Lanner Falcon	Jenkins 1994, 2000a, 2000b	*LC*
	Falco naumanni	Lesser Kestrel		*LC*
	Falco peregrinus	Peregrine Falcon	Jenkins 1994, 2000a, 2000b; Jenkins and Benn 1998; Altwegg et al. 2014; Sumasgutner et al. 2020	*LC*
	Falco rupicoloides	Greater Kestrel		*LC*
	Falco rupicolus	Rock Kestrel	Jenkins and van Zyl 2005	*LC*
	Falco subbuteo	Eurasian Hobby		*LC*
	Falco vespertinus	Red-footed Falcon		*NT*
	Gypohierax angolensis	Palm-nut Vulture		*LC*
	Gyps africanus	African White-backed Vulture	Bamford et al. 2009; Naidoo et al. 2011	*CR*
	Gyps coprotheres	Cape Vulture	Naidoo et al. 2011, 2017	*EN*
	Haliaeetus vocifer	African Fish Eagle		*LC*
	Hieraaetus ayresii	Ayres's Hawk-eagle		*LC*
	Hieraaetus pennatus	Booted Eagle		*LC*
	Hieraaetus wahlbergi	Wahlberg's Eagle		*LC*
	Kaupifalco monogrammicus	Lizard Buzzard		*LC*
	Lophaetus occipitalis	Long-Crested Eagle	Maphalala et al. 2020.	*LC*
	Macheiramphus alcinus	Bat Hawk		*LC*
	Melierax canorus	Southern Pale Chanting Goshawk		*LC*
	Micronisus gabar	Gabar Goshawk		*LC*
	Milvus aegyptius	Yellow billed kite		*LC*
	Milvus migrans	Black Kite		*LC*
	Necrosyrtes monachus	***Hooded Vulture***		*CR*

Table 2: (cont.)

	Scientific name	Common name	Urban South African references	IUCN status
	Pandion haliaetus	Western Osprey		*LC*
	Pernis apivorus	European Honey buzzard		*LC*
	Polemaetus bellicosus	Martial Eagle		*VU*
	Polihierax semitorquatus	***Pygmy Falcon***		*LC*
	Polyboroides typus	African Harrier-hawk		*LC*
	Sagittarius serpentarius	Secretarybird		*EN*
	Stephanoaetus coronatus	African Crowned Eagle	Malan et al. 2016; McPherson et al. 2016a, 2016b, 2017, 2019; van der Meer et al. 2018; Muller et al. 2020.	*NT*
	Terathopius ecaudatus	***Bateleur***		*EN*
	Torgos tracheliotos	Lappet-faced Vulture		*EN*
Nocturnal	*Asio capensis*	Marsh Owl		*LC*
	Bubo africanus	Spotted Eagle Owl	Kopij et al. 2014	*LC*
	Bubo capensis	Cape Eagle Owl		*LC*
	Bubo lacteus	Verreaux's Eagle Owl		*LC*
	Glaucidium perlatum	Pearl-spotted Owlet		*LC*
	Otus senegalensis	African Scops Owl		*LC*
	Ptilopsis granti	Southern White-faced Owl		*LC*
	Scotopelia peli	***Pel's Fishing Owl***		*LC*
	Strix woodfordii	African Wood Owl		*LC*
	Tyto alba	Western Barn Owl	Kopij et al. 2014	*LC*
	Tyto capensis	African Grass Owl		*LC*

Figure 2: Selected examples of urban raptors in South Africa; (a) African Crowned Eagle *Stephanoaetus coronatus* nest with a perched adult beside it in a backyard in Durban, © M Graf and C Sonvilla, (b) Spotted Eagle Owl *Bubo africanus* on the Cape Peninsula, © R Mousley, (c) Peregrine Falcon *Falco peregrinus* perched above Cape Town, © C Cohen, and (d) Black Sparrowhawk *Accipiter melanoleucus* delivering pigeon prey to a nest in a Eucalyptus tree (nest camera), © Black Sparrowhawk Project

Table 3: Frequency of presence for 20 most reported raptor species for each of the largest cities in the nine provinces in South Africa (with the addition of Pretoria and Pietermaritzburg; from SABAP2 full protocol cards, data obtained from 1 January 2009 to 1 January 2020). Reporting rates of at least 10% are highlighted in bold

Johannesburg		Pretoria		Durban		Pietermaritzburg		Cape Town	
Black-shouldered (Winged) Kite	0.56	Black-shouldered (Winged) Kite	0.63	Yellow-billed Kite	0.63	Yellow-billed Kite	0.59	Black-shouldered (Winged) Kite	0.40
Ovambo Sparrowhawk	0.21	African Fish Eagle	0.23	African Crowned (Crowned) Eagle	0.31	Long-crested Eagle	0.57	Jackal Buzzard	0.30
Black Sparrowhawk (Goshawk)	0.16	Steppe (Common) Buzzard	0.11	African Fish Eagle	0.31	African Fish Eagle	0.35	Rock Kestrel	0.28
Spotted Eagle-Owl	0.15	Black-chested (Breasted) Snake-Eagle	0.10	African Goshawk (incl. Red-chested)	0.28	Steppe (Common) Buzzard	0.30	Black Sparrowhawk (Goshawk)	0.28
Steppe (Common) Buzzard	0.15	Ovambo Sparrowhawk	0.10	Black Sparrowhawk (Goshawk)	0.21	Jackal Buzzard	0.27	African Marsh-Harrier	0.25
Verreaux's (Black) Eagle	0.14	Little Sparrowhawk	0.9	Long-crested Eagle	0.18	Black Sparrowhawk (Goshawk)	0.20	Yellow-billed Kite	0.24
Little Sparrowhawk	0.10	Amur (Eastern Red-footed) Falcon (Kestrel)	0.8	African Harrier-Hawk (Gymnogene)	0.13	African Harrier-Hawk (Gymnogene)	0.18	Peregrine Falcon	0.20
Long-crested Eagle	0.9	African Harrier-Hawk (Gymnogene)	0.7	Steppe (Common) Buzzard	0.12	African Crowned (Crowned) Eagle	0.12	Spotted Eagle-Owl	0.19
African Fish Eagle	0.8	Black Sparrowhawk (Goshawk)	0.7	Lanner Falcon	0.9	Black-shouldered (Winged) Kite	0.11	Steppe (Common) Buzzard	0.18
Yellow-billed Kite	0.6	Spotted Eagle-Owl	0.6	Little Sparrowhawk	0.5	African Goshawk (incl. Red-chested)	0.9	African Goshawk (incl. Red-chested)	0.18
Marsh Owl	0.5	Greater Kestrel	0.6	Jackal Buzzard	0.4	African Marsh-Harrier	0.9	African Fish Eagle	0.18
Peregrine Falcon	0.4	Marsh Owl	0.5	Spotted Eagle-Owl	0.4	Lanner Falcon	0.9	African Harrier-Hawk (Gymnogene)	0.12
Amur (Eastern Red-footed) Falcon (Kestrel)	0.4	Yellow-billed Kite	0.4	Osprey	0.4	Wahlberg's Eagle	0.6	Forest Buzzard	0.9
African Harrier-Hawk (Gymnogene)	0.4	Secretarybird	0.4	Wahlberg's Eagle	0.3	Peregrine Falcon	0.4	Booted Eagle	0.8
Barn Owl	0.3	Barn Owl	0.3	African Wood-Owl	0.3	Little Sparrowhawk	0.3	Rufous-chested (Red-breasted) Sparrowhawk	0.7
European Honey-buzzard	0.2	Cape Vulture (Griffon)	0.3	Peregrine Falcon	0.1	Spotted Eagle-Owl	0.3	Lanner Falcon	0.2
Eurasian Hobby	0.2	Verreaux's (Black) Eagle	0.3	Martial Eagle	0.1	Martial Eagle	0.2	European Honey-buzzard	0.1
Lanner Falcon	0.2	Long-crested Eagle	0.3	Black-shouldered (Winged) Kite	0.1	African Wood-Owl	0.2	African Wood-Owl	0.1
Gabar Goshawk	0.1	Lanner Falcon	0.3	Palm-nut Vulture	0.1	Barn Owl	0.2	Barn Owl	0.1
Greater Kestrel	0.1	European Honey-buzzard	0.2	Black-chested (Breasted) Snake-Eagle	0.1	Brown Snake-Eagle	0.1	Verreaux's (Black) Eagle	0.00

Table 3: (cont.)

Nelspruit		Port Elizabeth		Bloemfontein		Polokwane		Rustenburg		Kimberley	
African Goshawk (incl. Red-chested)	0.46	Black Sparrowhawk (Goshawk)	0.34	Black-shouldered (Winged) Kite	0.55	Black-shouldered (Winged) Kite	0.61	Black-shouldered (Winged) Kite	0.28	Black-shouldered (Winged) Kite	0.35
Black-shouldered (Winged) Kite	0.30	African Goshawk (incl. Red-chested)	0.29	Lesser Kestrel	0.33	Cape Vulture (Griffon)	0.33	Pearl-spotted Owlet (Owl)	0.20	Southern Pale Chanting Goshawk	0.33
Long-crested Eagle	0.30	Rock Kestrel	0.17	Amur (Eastern Red-footed) Falcon (Kestrel)	0.15	Yellow-billed Kite	0.22	Jackal Buzzard	0.20	Lesser Kestrel	0.23
African Fish Eagle	0.26	Jackal Buzzard	0.16	Steppe (Common) Buzzard	0.13	Gabar Goshawk	0.19	Steppe (Common) Buzzard	0.18	African Fish Eagle	0.17
African Harrier-Hawk (Gymnogene)	0.20	African Marsh-Harrier	0.14	Black Sparrowhawk (Goshawk)	0.11	Black-chested (Breasted) Snake-Eagle	0.17	Verreaux's (Black) Eagle	0.16	Barn Owl	0.17
Spotted Eagle-Owl	0.19	African Fish Eagle	0.13	African Fish Eagle	0.10	Wahlberg's Eagle	0.15	Black-chested (Breasted) Snake-Eagle	0.9	Secretarybird	0.17
Steppe (Common) Buzzard	0.14	Peregrine Falcon	0.12	Gabar Goshawk	0.8	African Fish Eagle	0.14	Wahlberg's Eagle	0.9	White-backed Vulture	0.16
Little Sparrowhawk	0.12	Steppe (Common) Buzzard	0.10	Lanner Falcon	0.6	Steppe (Common) Buzzard	0.13	African Harrier-Hawk (Gymnogene)	0.9	Gabar Goshawk	0.15
African Wood-Owl	0.11	Yellow-billed Kite	0.10	Southern Pale Chanting Goshawk	0.5	Greater Kestrel	0.12	Amur (Eastern Red-footed) Falcon (Kestrel)	0.8	Rock Kestrel	0.11
Barn Owl	0.7	Spotted Eagle-Owl	0.9	Peregrine Falcon	0.4	Lanner Falcon	0.12	Rock Kestrel	0.8	Greater Kestrel	0.8
Lizard Buzzard	0.6	Long-crested Eagle	0.7	Spotted Eagle-Owl	0.4	Pearl-spotted Owlet (Owl)	0.10	African Scops-Owl	0.8	Booted Eagle	0.6
Black Sparrowhawk (Goshawk)	0.6	Forest Buzzard	0.7	Barn Owl	0.4	White-backed Vulture	0.8	Black Sparrowhawk (Goshawk)	0.6	Steppe (Common) Buzzard	0.4
Yellow-billed Kite	0.5	African Harrier-Hawk (Gymnogene)	0.6	African Harrier-Hawk (Gymnogene)	0.4	Amur (Eastern Red-footed) Falcon (Kestrel)	0.8	African Fish Eagle	0.6	Lanner Falcon	0.4
Wahlberg's Eagle	0.5	Black-shouldered (Winged) Kite	0.5	Booted Eagle	0.3	African Harrier-Hawk (Gymnogene)	0.8	Little Sparrowhawk	0.5	Pearl-spotted Owlet (Owl)	0.3
Peregrine Falcon	0.4	Lanner Falcon	0.5	Jackal Buzzard	0.3	Barn Owl	0.6	Spotted Eagle-Owl	0.4	Amur (Eastern Red-footed) Falcon (Kestrel)	0.3
African Crowned (Crowned) Eagle	0.4	African Crowned (Crowned) Eagle	0.5	Secretarybird	0.3	Little Sparrowhawk	0.6	Marsh Owl	0.4	Tawny Eagle	0.3
Brown Snake-Eagle	0.3	Osprey	0.3	Rock Kestrel	0.2	Long-crested Eagle	0.5	Gabar Goshawk	0.4	Peregrine Falcon	0.2
Amur (Eastern Red-footed) Falcon (Kestrel)	0.3	Little Sparrowhawk	0.2	Rufous-chested (Red-breasted) Sparrowhawk	0.1	African Hawk Eagle	0.5	Eurasian Hobby	0.3	Spotted Eagle-Owl	0.2
Jackal Buzzard	0.3	Black Harrier	0.2	Black Harrier	0.1	Secretarybird	0.5	Barn Owl	0.3	Jackal Buzzard	0.1
Bat Hawk	0.3	Booted Eagle	0.2	Red-footed (Western Red-footed) Falcon (Kestrel	0.1	Spotted Eagle-Owl	0.4	Ovambo Sparrowhawk	0.3	Montagu's Harrier	0.1

Discussion

We found 66 raptor species recorded in urban areas of South Africa. However, only a few of these had been extensively studied (Amar et al. 2018), which is particularly true for urban areas (this review). Despite the typical negative effects of urbanisation, we found examples of raptors reaching higher densities in South African cities than in rural areas. These species were Black Sparrowhawk (Martin et al. 2014a, 2014b; Wreford et al. 2017), African Crowned Eagle (McPherson et al. 2016a, 2016b; 2019), and Peregrine Falcon (Altwegg et al. 2013; Sumasgutner et al. 2020). Potentially African Goshawk *Accipiter tachiro*, African Harrier-hawk *Polyboroides typus*, Spotted Eagle Owl *Bubo africanus*, African Wood Owl *Strix woodfordii*, Palm-nut Vulture *Gypohierax angolensis*, and Yellow-billed Kite (Authors pers. obs.) also may have higher densities in urban areas than surrounding landscapes, but to our knowledge, no comprehensive studies have been done on these species. These raptors tend to be species that require tall trees or synthetic or natural cavities for nesting in suburbia and forage on a range of vertebrate prey. Others show behavioural plasticity in either feeding or breeding. For example, the African Wood Owl feeds on the abundant tropical house gecko (*Hemidactylus mabouia*) attracted to prey at artificial exterior lighting in some South African cities (CT Downs, pers. obs.). African Harrier-hawks regularly breed in exotic palm trees (e.g. *Roystonea regia*) grown in gardens or urban parks in South African cities (B Hoffman, African Raptor Trust, pers. comm.; CT Downs pers. obs.). Elsewhere in Africa, raptors reported in cities tend to be scavenger species, such as Hooded Vultures *Necrosyrtes monachus* and Black Kites *Milvus migrans* in West Africa (Brown 1970; Ssemmanda 2005; Mullié et al. 2017). Scavengers in urban areas are a typical image of the Urban Global South (Reynolds et al. in press), with vultures accumulating at garbage dumps in the New and Old World (Bildstein and Therrien 2018; Chamberlain et al. 2017), and Black Kites reaching previously unseen population densities in Dehli, India (Kumar et al. 2018, 2019).

The primary factor affecting raptors in Africa, including South Africa, is, without a doubt, the rapid human population increase throughout the continent (United Nations 2019). This population explosion has significantly altered landscape functioning and its capacity to support wildlife, including raptors and their prey resources. However, where raptors are not persecuted, some raptor species can make use of abundant resources inside city boundaries, as was evident in our study. These included larger African Eagles, such as African Fish Eagles, African Crowned Eagles, and Verreaux's Eagles.

Generally, species with large home ranges are more sensitive to fragmentation and species that occupy edge and mosaic habitats in natural settings are pre-adapted to urban fragmentation effects, whereas other species show a behavioural capacity to adapt (Evans et al. 2009; Widdows et al. 2015; Widdows and Downs 2015, 2018; Patterson et al. 2018, 2019; Streicher et al. 2020). Some relatively large raptors persist in urban areas of South Africa and likely have reduced home range sizes than conspecifics in non-urban areas (McPherson et al. 2016a, 2016b; 2019; Sumasgutner et al. 2016b). A variety of land-use types exist within a city, each with distinct configurations (Ramalho and Hobbs 2012; Singh and Downs 2016a, 2016b; Alexander et al. 2019a 2019b; Maseko et al. 2020). Green spaces are essential for most wildlife, such as raptors (Beninde et al. 2015; McPherson et al. 2019), and the provision of ecosystem services (Alberti et al. 2003). In addition, lawns, gardens, shade trees, and the provision of food plants, ponds, nest cavities, and supplementary food (e.g. bird feeders) often attract wildlife species to urban areas in South Africa (Downs et al. 2021). Some of these species are in turn, important prey for various raptor species (McPherson et al. 2016a; van der Meer et al. 2018; Suri et al. 2017a). Furthermore, value to wildlife, including raptors, is enhanced by connectivity between highly fragmented green-space habitats and is usually associated with green corridors, roads and watercourses (Suri et al. 2017b; Alexander et al. 2019c).

Many South African raptors species in urban areas benefit from the use of exotic trees as secure nesting sites (Smith 1974; McPherson et al. 2016b). Pine trees are the most frequently used nest tree for urban Black Sparrowhawks (Malan and Robinson 2001; Tarboton 2001). Blue gum *Eucalyptus saligna* was a particularly important nesting tree for the Crowned Eagle in the urban environment, especially small patches of mature trees (McPherson et al. 2016b; Malan and Shultz 2002). Eucalyptus and pine trees are also often chosen by Amur Falcons and Lesser Kestrel roosts (in Ladysmith and Himeville; SC McPherson, pers. obs.). Positive and negative effects of exotic trees are many and varied, including soil ecology, water use, erosion control, forest succession, and honey production. Therefore the ecological impacts and management of exotic trees should be carefully considered (Dickie et al., 2014), especially if the various raptor species are to persist breeding in suburbia (McPherson et al. 2016b; Muller et al. 2020). The removal of exotic trees might also affect African Fish Eagles in the Western Cape of South Africa where eucalyptus trees provide the only suitable nesting sites (Welz and Jenkins 2005).

With large carnivores or raptors, human-wildlife conflicts arise from perceived threats to the safety of humans and domestic animals, which generate the need for management and removal strategies (Bjerke et al. 2003; Luck et al. 2013). In South Africa, human-raptor conflicts occur, as is evident from the number of raptors admitted to rehabilitation centres (Thompson et al. 2013; McPherson et al. pers. obs.) with injuries from shooting or showing signs of targeted or secondary poisoning. Often these are juvenile African Crowned Eagles, which occasionally prey on pet cats and small dogs. However, domestic stock comprised 6% of the identifiable prey at nests and contrary to popular belief, no domestic dogs and few domestic cats (<1%) were delivered to the nest (McPherson et al. 2016a).

Case studies of long-term urban raptor research in South Africa

African Crowned Eagles in Durban Metropole

The African Crowned Eagle is a large predatory raptor and a threatened species of forested areas of sub-Saharan Africa (IUCN 2014). Studies initiated in 2011 to the present have

shown that there is a large, seemingly saturated population of African Crowned Eagles in an urban landscape in the Durban Metropole, KwaZulu-Natal Province, South Africa (McPherson et al. 2016a, b, 2019; van der Meer et al. 2018; Muller et al. 2020). The population of African Crowned Eagles in urban areas was poorly understood before this research. New knowledge was contributed in terms of African Crowned Eagle biology and ecological requirements in this urban landscape (McPherson et al. 2016a, 2016b, 2019; van der Meer et al. 2018; Muller et al. 2020). Successful use of new field techniques, such as camera-traps (McPherson et al. 2016a) and global positioning systems (GPS) telemetry (McPherson et al. 2019) revealed new insights into their urban ecology and behaviour. Human-eagle conflicts were found and they included pet attacks and causes of eagle mortality; accordingly management guidelines were proposed (McPherson, pers. obs).

In the city of Durban alone, 30 pairs of Crowned Eagles form a resident breeding population within the Metropolitan green-space system (McPherson et al. 2016; Muller et al. 2020). Crowned Eagles take advantage of forest patch refugia, alien *Eucalyptus* spp. trees as nesting trees and the abundant and diverse food supply of urban wildlife, including Rock Hyrax *Procavia capensis* as primary prey, Hadeda Ibis *Bostrychia hagedash*, small forest antelopes like duikers (e.g. *Cephalophus* spp., *Sylvicapra* spp. and *Philantomba* spp.) and Bushbuck *Tragelaphus sylvaticus*, as well as small carnivores and Vervet Monkeys *Chlorocebus pygerythrus*. Foraging adaptability of African Crowned Eagles, and potential fluctuations in preferred urban adapting wildlife species, particularly Rock Hyrax and Hadeda Ibis nestlings, may result in prey switching and increased threats to livestock and pet depredations. Unexpectedly the inter-nest distances were small in this human-dominated landscape (McPherson et al. 2016b). Breeding sites were not evenly distributed and were most often associated with natural forest within the DMOSS planning zones. On a finer scale, nest trees were most frequently in large non-native Sydney Blue Gum. African Crowned Eagles showed a strong tendency to avoid informal settlement areas; however, they were tolerant of proximity to established formal settlements and occupied dwellings (McPherson et al. 2016b, 2019). Their relatively small home ranges for a large eagle included shared territorial boundaries (McPherson et al. 2019). Rapid replacement of vacancies at breeding sites suggests a saturated population (McPherson et al. 2016b). Habitat selection within the home range, thresholds of critical habitat, exotic trees, and correlation with DMOSS show the importance of indigenous forest pockets in this urban mosaic landscape (McPherson et al. 2016b, 2019). These urban forests are fragmented, and fragmentation increases the available edge habitats and landscape heterogeneity, potentially enhancing resource availability for African Crowned Eagles in a highly modified landscape (McPherson et al. 2016a, 2016b, 2019).

The African Crowned Eagle is identified as a special case of a large predatory raptor consistently observed in highly urbanised landscapes in forest biomes. The urban mosaic landscape provides conservation benefits for this threatened species (IUCN 2014). In particular, it highlights the value of the DMOSS (McPherson et al. 2016a, 2016b, 2019; van der Meer et al. 2018; Muller et al. 2020) and wildlife-eagle issues. Other African cities may benefit from adopting DMOSS urban design principles. Additionally, globally, cities in tropical forest biomes can perhaps take valuable information from this system and provides hope that other regions can establish urban forest landscapes suitable for their local threatened forest raptors.

Black Sparrowhawks in Cape Town

This is summarised from Amar et al. 2018. The Black Sparrowhawk population on the Cape Peninsula, including Cape Town, has been since 2000 the focus of an on-going long-term study. The species can be characterised as an urban adapter, exploiting nesting opportunities in alien tree plantations (Sumasgutnert et al. 2016) and the high prey abundance of pigeons and doves (Suri et al. 2017a). Black Sparrowhawks suffer no negative effects of urbanisation in terms of either productivity (Rose et al. 2017), survival (Sumasgutner et al. 2019), senescence (Sumasgutnert et al. 2020) or individual health (Suri et al. 2017a). However, there is potentially a higher infection prevalence with Knemidokoptes mites in urban environments, as recorded in Cape Town and Durban (van Velden et al. 2017). Recent GPS-tracking of urban Black Sparrowhawk revealed relatively small home range sizes for an Accipiter species (Sumasgutner et al. 2016) and limited use of heavily urbanised areas for hunting compared with forested habitats (Tate and Amar 2017).

Population ecology of Cape Peninsula Peregrines

Worldwide, the most widespread and thoroughly urbanised raptor is the Peregrine Falcon, and colonisation of modern urban areas has been extensive and well documented. The colonisation by Peregrine Falcons of a modern city was pioneered by the conservation actions of The Peregrine Fund in the USA (Cade et al. 1994). Artificial eyries on high buildings and towers are fair analogies to natural cliff nesting sites, whereas pigeons, preferred prey of falcons, are one of the most successful suburban birds and provide an abundant, reliable food supply (Bell et al. 1996; DeCandido and Allen 2006). Peregrine Falcons show behavioural plasticity and use artificial lighting for hunting migrating passerines at night (DeCandido and Allen 2006). Currently, Peregrine Falcons breed or winter in cities across America, Europe, India, Asia, Australia and Africa (Dixon et al. 2013; eBird 2020), including contemporary colonisation of the metropolitan district of Cape Town (Jenkins 2010b, 2010a; Pollack 2010).

A study on Peregrine Falcons on the Cape Peninsula has focused on the individual colour-ringed population to monitor survival, recruitment, dispersal, and breeding success in relation to a variety of potential biotic and abiotic drivers (Jenkins 1994, 2000a, 2000b; Jenkins and Benn 1998). The study has now accumulated over three decades of detailed demographic data and has documented a more than five-fold population increase over that time (Sumasgutner et al. 2020). In this system, nest-boxes play an important part in the significant expansion of breeding density, specifically in the core urban areas of Cape Town and they are known to provide a buffering effect against extreme weather events (Altwegg et al. 2014; Sumasgutner et al. 2020).

Future directions

Nocturnal species
Although there are several commercial and NGO initiatives focused on owl and bat box installations in urban areas in South Africa (see https://ecosolutions.co.za/owl-box-project/installation-servicing-and-maintenance, https://www.freemekzn.co.za/project/owl-box-project), there is currently limited available published data on the scale and ecological influence that artificial nest boxes have on nocturnal raptor densities in urban areas. We would encourage additional research and publishing on this clade, particularly regarding their often advertised ability to control urban rodent populations.

Nest-site competition
Unfortunately, most urban raptor studies reviewed were single-species focused. In South Africa, each city comprises interesting and different raptor communities. It would be ideal to see future studies focusing on community-level interactions. For instance, the dynamics between African Fish Eagles, Black Sparrowhawks, African Crowned Eagles (and Egyptian Geese *Alopochen aegyptiaca*, see for example Curtis et al. 2007, Sumasgutner et al. 2016a, Wreford et al. 2017) using, usurping and amending nest locations over long timescales (SC McPherson, unpubl. data).

Intraguild competition
Furthermore, it is speculated by local birders in Durban that the rise in the abundance of Blacks Sparrowhawks has been matched by a decreased abundance in African Goshawks (see also Little and Navarro 2019).

Conclusions

We show that at least 66 raptor species occur in South African cities, some of which are migratory and therefore summer visitors, whereas others are rarely reported. However, even species that occur in high breeding densities have not been extensively studied in these urban areas (except for African Crowned Eagles, Black Sparrowhawks and Peregrine Falcons). Increasingly, the need for incorporating ecosystem services into urban landscapes provides opportunities for green-space to benefit biodiversity and indigenous wildlife. Ecosystem service provision by raptors present in cities is usually only highlighted regarding the predation of 'pest' species (e.g., pigeons and rodents; Shipley 2009). However, enhancing urban green-space maximises indigenous biodiversity and provides conservation value, and can in addition benefit people by enriching their experience and awareness of nature. Furthermore, human-raptor relationships (within the field of nature-society interactions) can trigger positive emotions and make residents more likely to engage in conservation activities. There is increasing evidence that urban green spaces, and their associated animal and plant communities enhance the quality of human lives through psychological and physiological health benefits (e.g. Fuller et al. 2007; Dearborn and Kark 2010; Belaire et al. 2015). Less studied is the fact that birds, specifically raptors, are conspicuous and charismatic animals, whose ubiquitous presence is critical in shaping how people experience nature (Marzluff 2014). Urban wildlife might be a city dweller's only contact with nature, which in itself has value.

In particular, some South African urban raptors benefit from a habitat mosaic, which includes green spaces with tall trees. Others of the species use anthropogenic infrastructure successfully to breed. Some of these raptor species play important roles as top predators. Understanding the habitat use of keystone and apex raptor species can provide urban planners with opportunities to integrate biodiversity in growing South African cities. Raptors are, as such, suitable flagship species for urban conservation.

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