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Home Range of a Large Forest Eagle in a Suburban Landscape: Crowned Eagles (*Stephanoaetus coronatus*) in the Durban Metropolitan Open Space System, South Africa

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Abstract.—Apex predators are sensitive to human disturbance and persecution, often becoming the first losses in a declining urban wildlife community. A population of Crowned Eagles (*Stephanoaetus coronatus*) within eThekwini municipality, KwaZulu-Natal, South Africa, persists in a green space network called the Durban Metropolitan Open Space System (DMOSS). We used GPS–UHF telemetry to investigate the home range and habitat use of five breeding adult Crowned Eagles for 1 yr. We documented a mean annual home range for four birds of 13 km^2 (Minimum Convex Polygon [MCP] 100%), or 6.3 km^2 (Kernel Density Estimator [KDE], bandwith H_{LSCV} 95%), equating to small home ranges for this large eagle, compared with other large eagles. Habitat use within home ranges and correlation with DMOSS area underscored the importance of retaining forest patches in the urban mosaic landscape to encourage the persistence of this large raptor. Our study highlighted the importance of planning green space in future city expansion and land development. The spatial and habitat associations of Crowned Eagles may be used to inform urban planners who wish to support biodiverse communities that include apex predators in an urban landscape.

Key Words: *Crowned Eagle*; Stephanoaetus coronatus; *Africa*; *habitat selection*; *raptor*; *urban forests*; *urban wildlife*; *utilization distribution*.

ÁREA DE CAMPEO DE UN ÁGUILA FORESTAL GRANDE EN UN PAISAJE SUBURBANO: *STEPHANOAETUS CORONATUS* EN EL SISTEMA DE ESPACIOS VERDES METROPOLITANO DE DURBAN, SUDÁFRICA

Resumen.—Los superdepredadores sensibles a las molestias y a la persecución humana constituyen normalmente las primeras pérdidas en una comunidad de vida silvestre urbana en disminución. Una población de *Stephanoaetus coronatus,* dentro de la municipalidad de eThekwini, KwaZulu-Natal, Sudáfrica, persiste en una red de espacios verdes llamada el Sistema de Espacios Abiertos Metropolitano de Durban (DMOSS, por sus siglas en inglés). Usamos telemetría GPS–UHF para investigar el área de campeo y el uso de hábitat por parte de cinco adultos reproductores de *S. coronatus* durante un año. Documentamos un área de campeo media anual para cuatro aves de 13 km^2 (Mínimo Polígono Convexo [MPC] 100%), o de 6.3 km^2 (Estimador de Densidad de Kernel [KDE], ancho de banda H_{LSCV} 95%). Para *S. coronatus*, especie de gran tamaño, esto equivale a áreas de campeo menores que las áreas de campeo utilizadas por otras grandes águilas. El uso de hábitat dentro de las áreas de campeo y la correlación con el área DMOSS subrayaron la importancia de mantener parches de bosque en el mosaico de paisajes urbanos para alentar la persistencia de este águila. Nuestro estudio destaca la importancia de planificar espacios verdes en la futura expansión de la ciudad y el desarrollo del uso del suelo. El conocimiento sobre las asociaciones espaciales y de hábitat de *S. coronatus* podría usarse para informar a los planificadores urbanos que deseen promover la existencia de comunidades biodiversas que incluyan superdepredadores dentro de un paisaje urbano.

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Global urbanization is rapidly increasing, particularly within Africa and Asia, regions that are urbanizing faster than the rest of the world (United Nations 2015). Generally, urbanization leads to biotic homogenization, as species are filtered due to their limited adaptability to an urban environment (McKinney 2002). Large predators are especially rare in urban landscapes (Chace and Walsh 2006) due to their ecological requirements and their tendency to trigger human–wildlife conflicts (Hager 2009).

The Crowned Eagle (*Stephanoaetus coronatus*) is associated with forest habitats (Shultz 2002) and open woodlands where tall nesting trees are available (Hockey et al. 2005, Birdlife International 2018). Most of the species' range is in central African primary forests, one of the most threatened of Africa's biomes (Greenpeace International 2007). The species' distribution extends to the Eastern Cape Province, South Africa. Crowned Eagles are listed as Near Threatened (International Union for the Conservation of Nature [IUCN] 2014), and regionally Vulnerable in South Africa (Taylor et al. 2015). Recently, the Crowned Eagle has been studied in an urban-ecology context (McPherson et al. 2016a, 2016b). As the largest forest eagle in Africa (2500–4500 g), the Crowned Eagle preys mainly on medium-sized mammals including monkeys (*Cercopithecidae* spp.), hyrax (*Procaviidae* spp.), and forest antelope (*Bovidae* spp.; Swatridge et al. 2014). Crowned Eagle pairs are thought to maintain a pair bond and occupy a local territory for many consecutive years, sometimes up to a decade (Brown 1972). Shultz (2002) estimated territory size in pristine Taï National Park, Côte d'Ivoire, as 6.5 km^2 ($n = 10$). Other estimates are inferred from the dispersion of nest sites, with inter-nest distances of 1.6, 2.5, and 4.0 km across eastern and southern Africa forests and savannah (Hockey et al. 2005, Swatridge et al. 2014).

In comparison to a territory, which refers to the portion of space and time that is actively defended, the total home range is the complete area of space used by an individual during a defined period (Burt 1943). This may change over years, particularly between life stages such as the juvenile dispersal phase, floating nonbreeding adult phase, and breeding resident phase. The home range of a resident raptor may also include areas where the bird moves for exploration, cuckoldry opportunities, and seasonal changes in behavior (Pérez–García et al. 2012). Historically, and where data are limited, home ranges were often described by a Minimum Convex Polygon (MCP) enclosing the outermost locations in either a 100% or 95% contour, but this method is heavily biased by an emphasis on the extremes of an animal's movements (Laver and Kelly 2005). With greater volume and finer resolution of data, home-range size may be estimated through Kernel Density Estimators (KDE; Worton 1989, Kenward et al. 2001), synonymous to the utilization distribution (UD), which examines where an individual is likely to be given the location data. In a complex landscape, the UD can describe an individual's space choices and habitat associations within the home range.

The city of Durban, in the Indian Ocean Coastal Forest biome of South Africa, hosts a population of Crowned Eagles that nest at mean inter-nest distances of 2.3 km and are closely associated with the Durban Metropolitan Open Space System, DMOSS (McPherson et al. 2016a). Like other tropical forest raptors, Crowned Eagles' territory sizes and population densities have been estimated by nest dispersion; relatively little has been described about individual movements and habitat use. We sought to describe second- and third-order habitat selection (Johnson 1980) and home ranges of breeding Crowned Eagles, and how they persist in this fragmented and human-dominated urban landscape. Knowing the spatial and habitat associations of this raptor may aid urban planners who wish to enhance biodiversity, including apex predators that perform important ecosystem and aesthetic functions in an urban landscape.

METHODS

Study Area. At the time of our study, Durban, South Africa, was a city of approximately 3.4 million people (Statistics South Africa 2011). The greater metropolitan area comprised 2290 km^2 of eThekwini municipal land (eThekwini Municipality 2013). Rising from a small coastal plain to sandstone plateaus to the west up to 650 masl, the landscape is dissected by river valleys and gorges that historically have remained undeveloped. The outer landscape of eThekwini municipality includes rural settlements, sugarcane farmland, and bushland. In 1979, municipal authorities defined and developed the natural assets into the Durban Metropolitan Open Space System (DMOSS) using principals of connectivity, catchment-scale conservation, and functional ecosystems (Roberts 1994). DMOSS comprises a network of human-managed green spaces (parklands, golf courses, sports fields, road and rail buffer strips) and natural habitats (indigenous forests, woodlands, wetlands, and grasslands) within the mosaic of residential habitation, industrial, and commercial activity. Like many cities, Durban exhibits socio-demographic clustering. Informal settlements comprising low-income, low-employment, high-density areas are located generally toward the periphery of the city (Freund 2001, O'Leary 2007). Residents of these areas frequently obtain wood fuel, animals, and medicinal plants from adjacent natural areas (Nesvag 2002, eThekwini Municipality 2007, Statistics South Africa 2011). The highest land-value properties are generally located on borders of the DMOSS reserves (Environmental Branch 1998). Environmentally, these suburbs are characterised by lower housing density, shade and landscape trees, gardens, lawns, and greenbelts. Most Crowned Eagle nests occur in the DMOSS areas adjoining wealthy, formal residential suburbs (McPherson et al. 2016a). To focus on suburban landscapes occupied by Crowned Eagles, we conducted our research within a focal study area of 195 km^2 centered on the western suburbs within the eThekwini metropolitan municipality, where green spaces were most abundant, and where previous observations of Crowned Eagles indicated that nests might be present. This area comprised mainly formal residential zoned (38%) and DMOSS (31%) areas and contained 16 known Crowned Eagle nesting territories (8 pairs/100 km^2 as of March 2015; McPherson et al. 2016a, 2016b). We attempted to capture Crowned Eagles at nests identified in a related study (McPherson 2016a); we captured birds at only five of these nests but provide location data for all nests as context for those we studied.

Deployment of GPS Telemetry. We used bal-chatri traps ($n = 2$) and noosed horse meat ($n = 3$; Bloom et al. 2007) to capture adult Crowned Eagles near nests when their eaglets were >40 d of age. We used white laboratory rats (*Rattus* spp.) in the bal-chatri traps, which we deployed in clearings on the ground in view of the nest tree. We deployed noosed meat on the ground ($n = 2$), and in the canopy ($n = 1$). All captures, and telemetry devices were permitted by provincial wildlife governance and Animal Ethics permits (SCRP145, 3745/2012, 083/12/Animal, 023/13/Animal). We used custom WW1500AS-AVIAN GPS/UHF transmitters from Wireless Wildlife (Potchefstroom, South Africa). At 95–110 g, the tracking devices were lighter than the 5% maximum recommended load (Kenward 1987: Crowned Eagle body mass 2700–4205 g; transmitter loading averaged 3.2% of body weight, with a maximum of 3.9%). We deployed a trial unit as a pelvic mount on adult female (15F) in December 2012 in the peri-urban (rural–urban interface: Iaquinta and Drescher 2000) northern boundary of the eThekwini municipality. We reconfigured subsequent units with a more robust antenna and deployed them as backpacks (e.g., Bierregaard 2014) on Crowned Eagle individuals (16M, 17M, 18M, and 19F where F = female and M = male) from October through December 2013 within the central urban focal area.

We set telemetry schedules as one location per 2 hr, from 0400–1800 H daily. Locations were recorded with accuracy <30 m, typically 5 m, as stated by the tracking and data-management supplier (F. Botha pers. comm.). We downloaded data from the telemetry units via a vehicle-mounted UHF base station at vantage points within core areas. We obtained a UHF download once per month for most of the project, and then more frequently as batteries of the telemetry devices approached expiration dates. We checked downloaded data for empty fields, inconsistencies, location, and velocity outliers, and truncated affected data. Truncation was minimal and only affected data of nesting females 15F (56 of 3007 locations), and 19F (15 of 3072 locations).

Home Range. We followed recommendations for standardizing animal home-range analysis (Laver and Kelly 2005, Cumming and Cornélis 2012) to better understand the scales of habitat selection, as well as to provide comparable data for past and future raptor UDs. We performed statistical analyses in R version 3.0 (R Core Team 2013). We used the package reproducible home ranges (rhr), an R package for analyses of wildlife telemetry data (Signer and Balkenhol 2015), to test core delineation and a home-range asymptote with KDE bandwidth H_{REF}, and 100% and 95% MCP. We performed home range and spatial analyses in ArcGIS 10.2 ESRI 2011, and KDE estimations for H_{LSCV}, $H_{PLUG\text{-}IN}$, and $H_{USER\text{-}DEFINED}$ (1000) in Geospatial Modelling Environment (GME v 0.7.3) in ArcGIS 10.2 (Beyer 2012), with all variables (Kernel function, smoothing method, contouring method, and least squared cross-validation) set at default as described in Laver and Kelly (2005). We chose a bandwidth of H_{1000} (buffer distance 30 m) as recommended for mobile species in urban landscapes (Walter et al. 2012). In addition to home range from standard 50% and 95% contours, we also reported Core Delineation (H_{REF}, Seaman and Powell 1996).

In previous research we identified three biologically relevant periods in the Crowned Eagle year for subsampling in our study area (McPherson et al. 2016a, 2016b). These were (1) Nesting (N; September–December), a warming period with increasing rain, (2) Post-nesting or post-fledge (P; January–April), a period of hot, humid weather, and (3) Dry season (D; May–August), which is cooler. Crowned Eagle parental roles are defined by sex: females prepare the nest, incubate, and protect the young, while males forage for the breeding pair and the offspring. During the post-nesting period, food-dependant offspring require that both adults forage and deliver food to the nest area, or adults with a failed breeding attempt have a quiet period. During the dry season, the young-of-the-year become less food-dependant and begin pre-dispersal forays. Late in the dry season, the resident pair shows increasing interest in nest-building and courtship.

Habitat Selection. We generated 15 land-cover classes based on KwaZulu-Natal land cover data from 2005 and 2008 provided by GeoTerraImage 2008. These were open water, riparian, grassland, horticulture, urban park, woodland (<70% closed canopy), dense bush (70–100% closed canopy), indigenous forest (closed canopy of Coastal Belt and Scarp forest species), exotic forest (dominated by *Eucalyptus* or *Pinus* spp.), industrial and commercial zones, informal residential, formal residential, rural residential, roads, and railroad buffer strips (McPherson et al. 2016a). We checked recent habitat changes with ground-truthing visits and aerial imagery (eThekwini Municipality 2013) and updated habitat categories where necessary. We calculated habitat selection coefficients with Bonferroni's confidence intervals ($\alpha = 0.05$) on telemetry data joined to habitat types ($k = 14$, Byers et al. 1984). To increase data volume within the mosaic landscape, we tested two sets of pooled eagle location data (the three males during the post-fledge period, and the full year of data for males 17M and 18M) against the 14 habitat types. Females were excluded due to their central bias and truncation at the immediate nesting area. We calculated selection of DMOSS areas with Pearson χ^2, and we used the KDE H_{1000} bandwidth to quantify patch size and number of selected

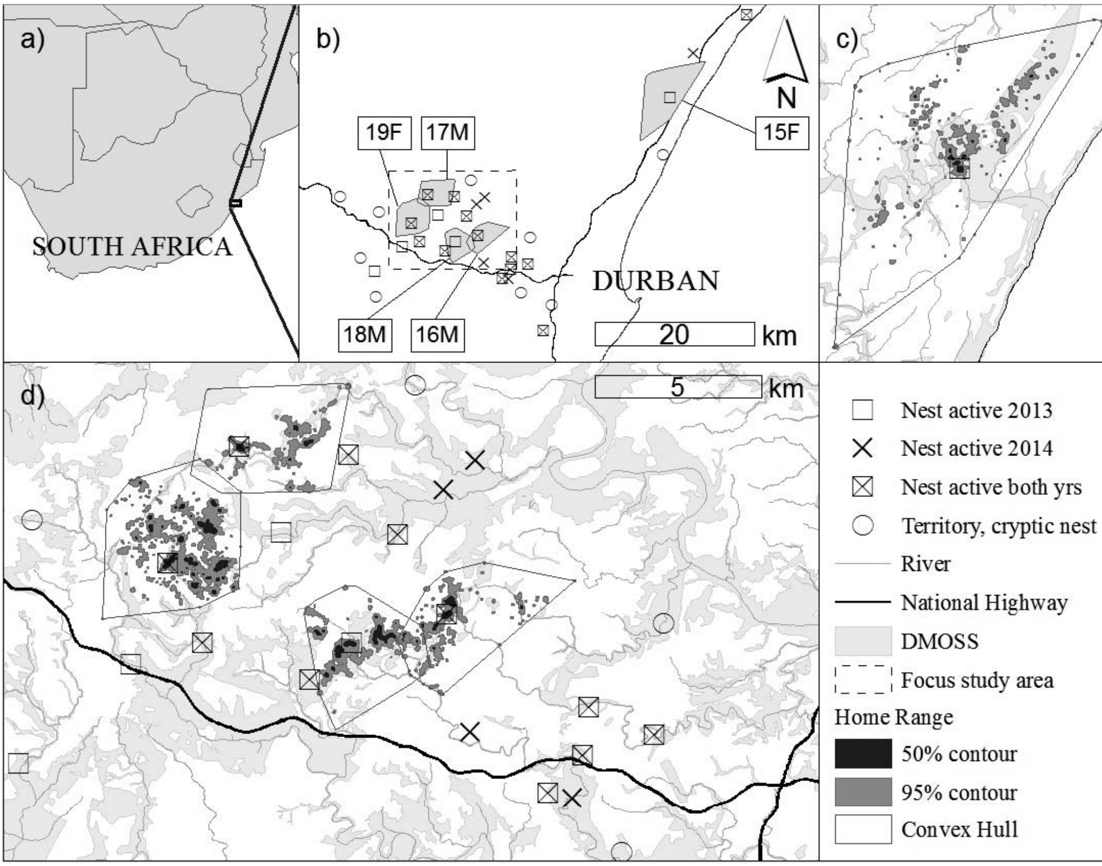

Figure 1. Crowned Eagle home ranges in the urban study area (a) regional location, (b) location of telemetered Crowned Eagles within the Durban municipality showing their 100% Minimum Convex Polygons (MCP, convex hull) in relation to each other and the known Crowned Eagle nest sites in the area, (c) MCP and Utilization Distribution Kernel Density Estimators (50% and 95% KDE H_{1000}) for Crowned Eagle 15F in the Durban north peri-urban landscape, and (d) MCP and Utilization Distribution Kernel Density Estimators (50% and 95% KDE H_{1000}) for the suburban Crowned Eagles in the focal study area.

habitats within the home range. We calculated all habitat areas in ArcGIS with the projection Transverse Mercator Lo31, and raster grid resolution set at 5 m^2. Values refer to mean ± SD, and tests were considered significant at $\alpha = 0.05$.

RESULTS

Telemetry Longevity. All Crowned Eagles monitored held a territory continuously for the duration of our study. Females 15F and 19F successfully raised young in 2013. Their ranges during the nesting period were 0.09 km^2 and 0.05 km^2, respectively. We tracked four adult Crowned Eagles (15F, 19F, 17M, 18M) for an entire year and the adult 16 M for the post-fledge period only; thus, because each year was divided into three periods, we obtained 13 subset periods. Three adults (17M, 18M, and 19F) had dependent offspring when we tracked them during the post-fledge and dry periods. Crowned Eagle 16M died due to collision with a residential wall at nautical dawn on 15 February 2014, an event witnessed by the home's resident. The body was recovered, still warm, from below the wall, and a necropsy revealed a broken neck and cranial haematoma with no abrasion marks from the harness or transmitter placement.

Home Range. Mean annual Crowned Eagle home-range size was 13.18 ± 2.25 km^2 (MCP 100%; Fig. 1) within the focal study area, but the eagles we tracked used only 2.55 ± 1.08 km^2 (according to the KDE 95% H_{1000}) of natural forest and bush habitat within this home range. Crowned Eagles in the urban landscape moved up to 3.5 km from the

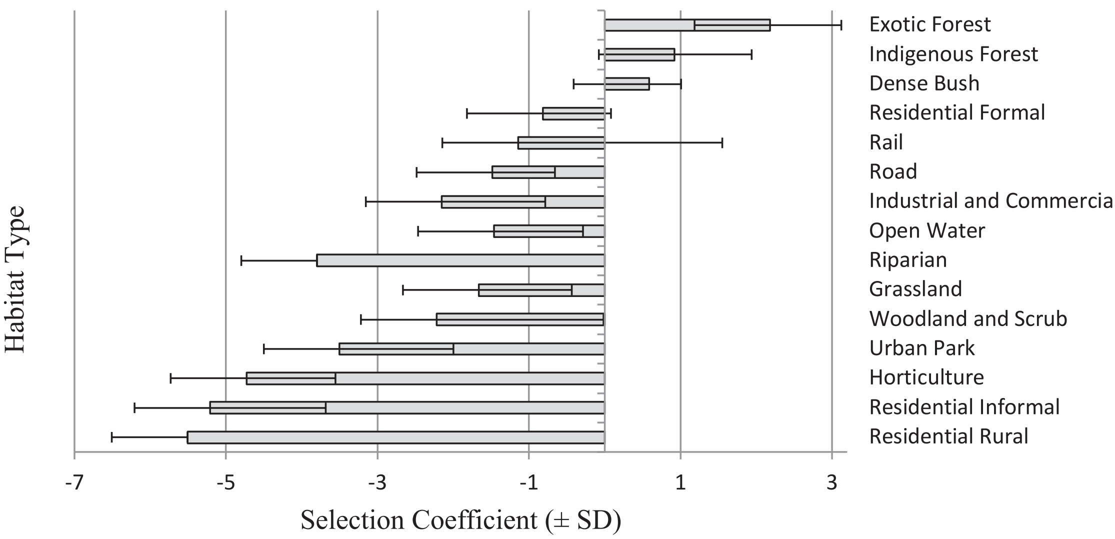

Figure 2. Habitat selection coefficient (± SD) of Crowned Eagle males ($n = 4$, with 3822 locations total) during the post-fledge period within the focal study area (195 km^2).

core of the territory, with little overlap between neighbouring tracked pairs. The peri-urban individual (15F), in contrast, used a similar KDE utilization of 2.34 km^2 of forest fragments within a much larger home range of 38.43 km^2 (MCP 100%).

Habitat Selection. The core delineation (95.2%, range 93.3–97.3%) of Crowned Eagles' home range illustrated the spatially conservative habits of Crowned Eagles in the urban landscape. Across the landscape, only three habitats showed positive selection coefficients by all four birds in the urban landscape (exotic forest, indigenous forest, and dense bush), and bird 16M also selected railroad buffer strips. The remaining 10 habitat types had negative selection coefficients for all the Crowned Eagles we tracked (Fig. 2). However, Bonferroni confidence intervals of habitat selection were not significant in any cases ($k = 15$). The mean size of each patch of forest was 0.64 km^2, with 3–8 patches of indigenous forest (mean = 5) and 2–6 patches of exotic forest (mean = 4) per territory. Most (81%) natural green spaces of all types were within DMOSS boundaries, and the correlation of use of DMOSS areas by Crowned Eagles was highly significant for all individuals (Pearson $\chi^2 = 2631$, $P < 0.001$). Interestingly, small patches (<1 ha) of the exotic *Eucalyptus saligna* were the most selected habitat, likely due to the bias toward these areas as nesting sites (McPherson et al. 2016a).

DISCUSSION

In Durban's suburban landscape, the Crowned Eagle population nested at a density of 8 pairs/100 km^2, with inter-nest distances averaging 2.3 km (range 1.4–7.2; McPherson et al. 2016a; S. McPherson unpubl. data). This density was comparable to that in natural landscapes both regionally and in the wider species' range (Shultz 2002, Swatridge et al. 2014), despite the fact that cities are characterized by a patchy mosaic of natural habitats and highly modified anthropogenic areas. In our study, individuals intensively used small areas of natural forest and bush habitat within a wider home range. When examining the UDs of Crowned Eagles, we found apparent habitat selection; however, the Bonferroni confidence intervals were not significant perhaps because of the high number of habitat categories, of which several made up very small proportions of the urban landscape. The mean UD of the KDE H_{LSCV} was comparable to estimates of whole-territory size in pristine West African rainforest (6.5 km^2, Shultz 2002).

Crowned Eagles in this suburban system had small home ranges compared with other larger tropical forest eagles, most of which are naturally or artificially rare and are difficult to study. In the Neotropics, the minimum inter-nest distance of Harpy Eagles (*Harpia harpyja*) is 4.1 km (range 2.6–6.2 km) in one study (Vargas and Vargas 2011), but a perhaps more typical density for this species was 1–3 pairs/100 km^2, similar to that of Crested Eagles (*Morphnus guianensis*; Galetti et al. 1997). In the Indo-Malayan tropics, the critically endangered Philippine Eagle (*Pithecophaga jefferyi*) occurs in scattered and depressed populations, with 1 pair/133 km^2, each pair using approximately 68 km^2 of forest within each home range (Bueser et al. 2003). In these tropical regions, slightly smaller (2–4 kg) forest hawk-eagles appear to occur at maximum densities of 6.5 and 9.3 pairs/100 km^2 for Black Hawk-Eagles (*Spizaetus tyrannus*, Thiollay 2007), and Ornate Hawk-Eagles (*Spizaetus ornatus*, Whitacre

Table 1. Summary of Utilization Distribution parameters, including several bandwidth treatments for Kernel Density Estimators and Minimum Convex Polygon home-range estimates of tracked Crowned Eagles. Sequential asymptote calculations of string and bootstrap were 24.10.5 in the reproducible home range (rhr) package for analyses of wildlife telemetry data (Signer and Balkenhol 2015).

		Core Delineation		Home-range Size (km^2)						
				Kernel Density Estimator					Minimum Convex Polygon	
Period and Bird	No. of Locations	Isopleth	Area at Delineation (km^2)	50% H_{REF}	95% H_{REF}	95% H_{LSCV}	95% $H_{PLUG-IN}$	95% $H_{1\ 000}$	95%	100%
Full year										
15F	3007	97.25	16.79	0.91	13.92	11.40	3.91	2.34	19.68	38.34
16M										
17M	2731	93.26	8.46	2.36	10.23	9.20	6.40	4.05		15.92
18M	3331	96.04	4.97	0.82	5.51	4.50	2.72	2.03	5.26	10.40
19F	3072	96.28	6.5	0.89	5.87	5.30	1.90	1.57	5.91	13.23
Mean ± SD			6.64	1.36 ± 0.71	7.20 ± 2.15	6.33 ± 2.05	3.67 ± 1.96	2.55 ± 1.08		13.18 ± 2.25
Nesting period (September–December)										
15F	969	99.8	0.07	0.04	0.12	0.08	0.04	0.09	0.11	0.64
16M										
17M	797	93.8	7.43	1.65	7.93	7.94	4.97	1.99	6.44	12.24
18M	964	96.2	4.74	0.84	4.34	3.78	2.30	1.38	3.84	7.13
19F	935	99.7	0.46	0.02	0.66	0.05	0.10	0.05	0.02	0.13
Male mean				1.25	6.14	5.86	3.63	1.68	5.14	9.69
Female mean				0.03	0.39	0.07	0.07	0.07	0.07	0.10
Post-fledge period (January–April)										
15F	968	95.24	15.34	2.1	15.05	12.59	4.96	1.60	12.63	25.83
16M	963	96.42	6.75	0.72	5.97	5.71	3.02	1.64	8.62	10.89
17M	960	92.31	8.07	2.21	9.28	9.32	6.85	3.05	7.07	9.82
18M	947	95.58	5.11	1.13	4.94	4.52	2.89	1.65	4.86	5.91
19F	957	89.7	5.2	1.31	6.86	5.86	3.20	1.53	6.53	11.49
Mean ± SD				1.34 ± 0.54	6.76 ± 1.60	6.35 ± 1.79	3.99 ± 1.66	1.96 ± 0.63	6.77 ± 1.34	9.53 ± 2.17
Dry season (May–August)										
15F	966	94.11	21.68	3.54	23.19	20.97	10.99	2.56	23.26	35.17
16M										
17M	974	91.49	9.2	3.07	10.65	10.62	7.45	2.78	9.20	11.98
18M	974	94.95	5.83	1.35	5.84	5.69	3.34	1.75	5.45	9.51
19F	980	88.3	4.59	1.47	6.14	5.89	2.95	1.37	4.64	6.70
Mean ± SD				1.96 ± 0.78	7.54 ± 2.20	7.40 ± 2.28	4.58 ± 2.04	1.67 ± 0.59	6.43 ± 1.99	9.40 ± 2.16

and Burnham 2012), respectively. These data were generally reported from large-scale natural forest areas.

Smaller hawks such as *Buteos* and accipiters are more common urban-adapters than large eagles. Smaller territory sizes might account for this. For example, Cooper's Hawks (*Accipiter cooperii*) in Arizona, USA (Mannan and Boal 2000), had home-range sizes of 6.6 km^2, (95% MCP), and adult male Northern Goshawks (*Accipiter gentilis*) in Hamburg, Germany, had home ranges of 8.6 km^2 (Rutz 2006). However African megacities are home to many accipiter species for which urban ecology and tracking studies are lacking. Urban Black Sparrowhawks (*Accipiter melanoleucus*) of Cape Town, South Africa (Tate and Amar 2017), are an exception, as they had much larger home ranges (99.9 $\pm$ 84.1 km^2 [100% MCP], 18.2 $\pm$ 12.8 km^2 [95% KDE]; Sumasgutner et al. 2016) than did urban Crowned Eagles.

Some raptor species benefit from increased heterogeneity and novel habitats and landscapes (Suárez et al. 2000, Pawson et al. 2010). The Crowned Eagle appears to demonstrate this behavioral flexibility. Sustainable urban raptor populations require a main prey species or prey diversity, along with suitable habitat. In Durban, Crowned Eagles feed on rock hyrax (*Procavia capensis*), Hadada Ibis (*Bostrychia hagedash*), small carnivores, and to a lesser extent, vervet monkeys (*Cercopithecus aethiops*; McPherson et al. 2016b, Patterson et al. 2018, Widdows and Downs 2018). Crowned Eagles in Durban avoided human recreational green space, particularly golf courses, sporting grounds, school grounds, and open parks. These parks and recreation areas are apparently suitable for a more limited range of species and offer refugia for some urban adapters (Møller 2008, Ramalho and Hobbs 2012, Chong et al. 2014).

Despite their invasive status and targeted removal programs (Forsyth et al. 2004), small patches of mature *Eucalyptus* trees provide heterogeneity and opportunity for numerous African raptors (Malan and Robinson 2001, Welz and Jenkins 2005). Management of the urban landscape to enhance Crowned Eagle presence should consider afforestation, heterogeneity, and connectivity. In our study, we observed further reduction in size of the patches surrounding nest trees due to girdling or felling of *Eucalyptus*. Replacement trees should be planted if continuous occupation by Crowned Eagles is desired along with the removal of alien trees.

Nesting Crowned Eagles move seldom, and only short distances from the nest tree during the incubation and nestling phases. From 10 d prior to the start of incubation to the time when the young reached 60 d old, the female Crowned Eagles 15F and 19F occupied just 0.05 and 0.09 km^2 (95% KDE), respectively. To reduce the disturbance and potential failure of nesting attempts, the area within 150 m of the nest tree should be afforded full protection from human disturbance from August–January annually.

The home range was largest during the dry (winter) period, a result, perhaps, of limited food availability, and of territorial defense in preparation for the approaching nesting season. While the female was fully occupied with nesting duties, the male's home range was consistently smallest during the nesting period. This might suggest the potential need to defend the territory more actively during breeding. Another reason might be to guard females from extra-pair copulation, as is known from other raptors (Safina 1984). Because resident eagles shift their patterns of use within a home range over long time periods, we recognize the limitation of this 1-yr tracking period. Pérez–García et al. (2012) observed that Bonelli's Eagles' (*Aquila fasciata*) home-range sizes reach an asymptote after 3 yr, and some individuals made occasional far-ranging extra-territorial forays.

Conclusions. The principles adopted in the creation and management of DMOSS green spaces provide insight into planning strategies of tropical megacities globally. The small sample size and demographic variation of the telemetered Crowned Eagles in this study limit the statistical power of our analysis. However, our data suggest that as Durban's peri-urban perimeter expands, connected forest green spaces can provide habitats for the perpetual occupation of Crowned Eagles, and by extension a diversity of indigenous meso-vertebrate prey communities. Our study contributes new data, and is, to the best of our knowledge, the first to estimate space use for urban breeding eagles. However, the high individual variation underscores the importance of multi-year tracking periods and larger samples sizes. Identifying these critical spatial and temporal limitations of such a flagship species can aid landscape planners in developing effective wildlife integration designs for growing urban areas.

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