

Seeing the food for the trees: An experimental and satellite-tracking study
of foraging success of threatened Cape Vultures in bush encroached areas
of Namibia

***R.E. Simmons^{a*}, P.A. Schultz^a, J.M. Mendelsohn^b L.G. Underhill^c and M.
Diekmann^d***

^a *DST/NRF Centre of Excellence, FitzPatrick Institute, University of Cape Town, Rondebosch 7701,
South Africa*

^b *Raisson. P.O. Box 1405, Windhoek, Namibia*

^c *Animal Demography Unit, Department of Zoology, University of Cape Town, Rondebosch 7701,
South Africa*

^d *Rare and Endangered Species Trust, P.O. Box 178, Otjiwarongo, Namibia*

**Correspondence:* Rob Simmons, DST/NRF Centre of Excellence, FitzPatrick Institute,

University of Cape Town, Rondebosch 7701, South Africa

Tel: +27 21 650 3310

E-mail address: Rob.simmons@uct.ac.za

Running header: bush encroachment effects on threatened vultures

Word count: 6483

Summary

1. Namibia's population of Cape Vultures *Gyps coprotheres* has declined from *c.* 300 birds in 1969 to a low of 11 birds in 2007. Secondary poisoning is assumed to be the most likely agent responsible for this decrease, but bush encroachment of *Acacia* and other trees has also been implicated in contributing to the collapse by reducing carcass availability.
2. We tested the impact of increased tree density on the foraging success of the Cape Vulture in northern Namibia using two methods: (i) measuring the time taken for vultures to locate carcasses experimentally placed in differing levels of tree density and (ii) using PTT/GPS satellite data to find carcasses previously scavenged by Cape Vultures and measuring tree density at those sites.
3. Cape and African white-backed vultures *Gyps africanus* located experimental carcasses more quickly in low density *Acacia* bush than in high density bush. Moreover, as tree density increased, the likelihood of detection decreased to the point where food was never found in habitat with 2600 trees/ha. A total of 24 carcasses (at which vultures had fed 1–7 months prior to the study) was located using the historic satellite data derived from three adult male Cape Vultures.
4. The majority of carcasses (79%) were of wild ungulates and the remainder were livestock. Most of the carcasses (83%) were located in either completely open habitat or low density bush (<1000 trees/ha), while only two (8.3%) were located in dense bush (>2000 trees/ha). Although fence lines and associated tracks comprised only *c.* 1.3% of the farms foraged over, 25% of all carcasses were located there.
5. *Synthesis and application* Because tree densities vary from 3000–10000 trees/ha throughout the vultures' foraging range and this has been increasing for the last 50–60 yr, we suggest that the habitat has become unsuitable for Cape Vultures contributing to their population decline over the same time period. With CO₂ levels leading to

increased bush encroachment worldwide, only active bush clearing is likely to benefit this and other open-country species in these regions.

Key-words: *Acacia* encroachment, *Gyps coprotheres*, globally Vulnerable, foraging success, food experiments, southern Africa, satellite telemetry

Introduction

The Cape Vulture *Gyps coprotheres*, endemic to southern African, is classified as globally Vulnerable (Birdlife International 2004) with a world population estimated at 10 000 birds (Piper 2004). Its main distribution is centred on two core breeding areas in southern Africa: one in Lesotho and south-western South Africa, the other in northern parts including the North West and Limpopo Provinces, southern Zimbabwe and eastern Botswana (Mundy *et al.* 1997). Two outlying populations remain: one in the Western Cape Province of South Africa and the other in north-central Namibia based around the Waterberg Plateau Park (Mundy *et al.* 1997). Within Namibia, it is classified as Critically Endangered (Simmons & Brown in press) due to the decrease in the Waterberg population from an estimated 300 birds in 1969 to 11 in the wild in 2006 (Brown 1985; M. Diekmann unpubl. data). This dramatic decrease of almost 97% is not recent; the population had declined to *c.* 10 birds by 1985, then somewhat recovered with a supplementary feeding scheme in the ensuing years to *c.* 25 adult birds by 1991, but subsequently stagnated (Simmons & Brown 2008). Other Cape Vulture colonies in South Africa have also experienced population declines (Piper 2004).

The Namibian Cape Vulture population is primarily thought to be threatened by direct and indirect poisoning, and habitat unsuitability resulting from bush encroachment (Brown 1985; Bridgeford 2001). Other factors that have been implicated in declines in southern African vultures include improvements in animal husbandry resulting in decreased food availability, land use change, drowning in farm reservoirs, human disturbance at breeding colonies, harvesting for use in traditional medicine and collisions with power lines (Brown 1985; Anderson *et al.* 1999; Benson 2000; Borello & Borello 2002; Hengari *et al.* 2004; Piper 2004). Climate change has also been suggested as a possible threat, stressing the more northerly colonies or birds at north-facing colonies (Simmons & Jenkins 2007, Chaudhry 2007). None of these factors however, have been experimentally tested.

THE IMPACT OF BUSH ENCROACHMENT

Bush encroachment or bush thickening is the conversion of grassland and woodland savannas to dense thornveld, dominated by *Acacia*, *Dichrostachys* and other invasive species, with minimal grass cover (Bester 1996; Barnard 1998). Factors considered responsible are altered fire regimes and the fencing and overstocking of livestock or wild herbivores resulting in increased grazing pressure (Ward 2005). Once grass is removed as a competitor, woody plants are more likely to establish and thrive. Moreover, this appears to be accelerating under increased CO₂ levels world wide (Hoffman 1997; Bond & Midgley 2000) which facilitates the growth of C₃-dominated (woody) vegetation at the expense of C₄ grasses, and has occurred chiefly since 1950 in southern Africa (Ward 2005). Bush encroachment is typically a problem on

communal (subsistence) farmlands in southern Africa, however, in north-central Namibia it occurs on freehold farmland (Mendelsohn 2006).

The impact of bush encroachment on vultures is largely unknown (Smit 2004) but it has been implicated in limiting cheetah *Acynonix jubatus* hunting success in the same region (Muntifering *et al.* 2006), and recent studies show that it negatively influences biodiversity richness at several levels (spiders, insects, reptiles, small mammals and birds: Seymour & Simmons 2008, Jeltsch *et al.* 2010). Encroachment may have two effects on foraging Cape Vultures. First, it might reduce the visibility of carcasses in dense bush to the point where a carcass is not seen by flying vultures. Second, because of the high wing-loading of the Cape Vulture (112 N/m^2), it is probably unable to manoeuvre within closed woodland or to take off from within it with a full crop, reducing accessibility even if the carcass is visible (Pennycuick, 1972; Brown 1985). This may not be so problematic for the African white-backed vulture given its 47% lighter wing loading (Biggs *et al.* 1979).

Olfaction plays no role in carcass detection in Old World vultures (Houston 1974b; Mundy *et al.* 1992). Visibility within 100 m of a carcass is positively correlated with vulture presence at carcasses in the Caucasus (Gavashelishvili & McGrady 2006). We therefore predicted that, at high tree densities, visibility or accessibility of carcasses would decrease and that, low visibility in severely bush encroached areas would negatively affect the ability of vultures to locate carcasses, reducing foraging success and ultimately fitness.

We undertook experimental carcass placements and predicted that both Cape and African white-backed vultures would find carcasses in dense bush harder to locate, and used satellite tracking data for Cape Vultures alone to determine patterns of natural carcass use.

Materials and Methods

STUDY AREA

This study was centred on the Otjiwarongo district (19°30'–21°S and 16°–18°E) of north-central Namibia (Fig. 1). The region lies within thornveld habitat and is dominated by *Acacia* and *Dichrostachys* tree species (Mendelsohn *et al.* 2002). The topography is generally flat and elevation is *c* 1500 m above sea level (Mendelsohn *et al.* 2002). The region is semi-arid, with 400–450 mm of rainfall annually most of which falls between December and March (Mendelsohn *et al.* 2002). Cattle and game farming is the predominant land use type in this region (Doughton & Diekmann 2006). The Waterberg Plateau Park is a state-protected sandstone plateau with a 150 km-long escarpment that has historically provided Cape Vultures with suitable cliff sites for nesting (Simmons 2002).

CARCASS PLACEMENT IN HABITATS OF DIFFERING TREE DENSITY: EXPERIMENTAL PROTOCOL

A series of experiments was performed in 2007 to determine the impact of bush encroachment on the Cape Vulture's ability to locate carcasses. Animal carcasses of different species (goat, donkey and eland) or offal from the local abattoir were placed in all naturally occurring levels of tree density. Vultures have been fed offal at the REST (Rare and Endangered Species Trust) vulture restaurant since 2002, and have become accustomed to eating this food type. To avoid vultures associating our vehicle with food provisioning, the offal weighing 400–500 kg was either placed out the night

before or at sunrise (before vultures are airborne) on the morning of the experiment. Birds were then observed from just after sunrise with 10×42 binoculars at hides that varied from 35–160 m away from the food (median 75m). Species of vultures present were observed and their numbers counted. Tree density was determined by counting the number of trees in four different height categories (<1 m, 1–2 m, 2–4 m and >4 m) in a circular plot of 6 m radius centred on the carcass (Muntifering *et al.* 2006). Experiments were time-limited and frequently paired: if vultures had not located the food within 24 h (four times), 48 h (twice) or 96 h (once) in dense habitat, the food was moved to an adjacent open patch and the same protocol followed.

Because white-backed vultures often located the carcasses first, presumably due to their numerical dominance in the study area, we have used them as a proxy for the foraging decisions of the Cape Vulture. Their lighter wing loading (76 N/m²: Pennycuik 1972; Biggs *et al.* 1979) makes its foraging decisions a liberal estimate for the decisions that heavier Cape Vultures may make to descend to a carcass.

STATISTICAL ANALYSIS

Statistical analysis was performed using an extension to the Mayfield method that allows explanatory variables to be modelled in this context (LGU submitted). In this approach, the time taken to find a carcass was modelled as an exponential distribution; a logarithmic link function was used to incorporate the explanatory variables into the parameter of the exponential distribution. The RSURVIVAL procedure within the Genstat 8.1 software program (Genstat Committee 2005) was used to construct the models and to test explanatory variables for significance. Within this procedure it is possible to handle truncated experiments in which the carcass had

not been located by the time of termination of the observations. The RUNSTEST procedure in Genstat 8.1 was used to perform the Wald-Wolfowitz runs test (Conover 1971) to test for randomness of the effect of explanatory variables on the detection of carcasses by vultures. Factorial ANOVA, Wilcoxon matched pairs tests and Spearman rank order correlations were run in Statistica version 7 (StatSoft Inc. 2004).

FORAGING SITE ANALYSIS

Six Cape Vultures were fitted with platform transmitter terminal (PTT) satellite transponders in 2004, enabling studies of their movement patterns (Diekmann *et al.* 2004). Hourly observations were made of their foraging ranges, flight speed, foraging height and foraging times (Mendelsohn *et al.* 2005). Three of these birds were excluded from analyses – an immature which had ranged widely through six countries, and two South African birds which were translocated and released but remained near the REST restaurant. The three remaining birds (CV3, CV4 and CV5) were all wild adult males; two were captured and fitted in November 2004 and the other in January 2005 (Diekmann *et al.* 2004). GPS co-ordinates (accurate to 10–15 m), height, speed and bearing were downloaded hourly between 04h00 and 19h00 and stored on the ARGOS system (Mendelsohn *et al.* 2005).

Potential carcass sites utilised 1–7 months prior to the experiments, were determined by analysing the hourly positions of the three vultures indicating where the birds were stationary (speed 0–5 km/hr), typically mid-morning, and away from their preferred roosting sites. These points were then located in the field using a GPS and the area within a 100m radius was examined for evidence of a carcass. Carcasses were located on average 37 m (SD 35, range 0–100 m) from the GPS co-ordinate

provided by the satellite position. In three situations a carcass was not found within a 100 m radius of the GPS co-ordinate, twice the points were unreachable due to dense bush and in another three locations only waterholes were found. Therefore carcasses were found in 80% of the examined sites. A potential bias is that carcasses in dense bush were more difficult to access and locate, hence may be slightly underrepresented in the analysis. Once found, the species, age and sex of the carcass were recorded, and the land use type (e.g. cattle or game farm), tree density and presence of vulture feathers were noted. The minimum distance a Cape Vulture travelled from the previous night's roost site before reaching a carcass was determined by measuring the direct distance between hourly co-ordinates in Arcview v.3.3 geographic information system (GIS) software package (ESRI Inc., Redlands, CA, USA). Minimum convex polygons (MCP) to estimate home ranges were calculated using the Animal Movement extension (Hooge *et al.* 1999).

Results

HABITAT USE

Movements of satellite-tracked Cape Vultures indicated that their preferred foraging habitat was over freehold farmland, and they rarely ventured into the communal areas or to the protected area of Etosha National Park (Fig. 2 and Mendelsohn *et al.* 2005). Thus all carcass experiments were undertaken in freehold farmland which supported mainly cattle and game (ungulate) farms.

CARCASS EXPERIMENTS

Of the 21 experiments undertaken, two were excluded due to a vulture restaurant feed on the same day, biasing the results. Of the remaining 19 experiments, vultures did not locate the food during the time allotted on seven occasions. We subsequently moved them to less dense habitat and the experiment repeated (e.g. an unfound Eland *Tragelaphus oryx* carcass in dense bush of 3300 trees/ha, was moved to an open area after 4 d and located by vultures within two hours). On only one occasion did vultures locate food more than 24 hours after experimental provisioning. The average time taken to locate carcasses was 4.9 h (SD 7.2, range 0.67 h – 25 h).

Carcasses placed in areas of low tree density were found significantly quicker than those in high tree density ($t = 5.17$ $P < 0.001$). As tree density increased, the likelihood of detection decreased, to the point where food was never found by vultures in tree density greater than 2600 trees/ha (Fig. 3). Distance from the REST vulture restaurant (Fig. 4) and the number of days since the last REST feed were not found to influence whether food was located by vultures. (Distance: $t = 1.42$ $P = 0.17$, Last feed: $t = 0.4$ $P = 0.69$). Wald-Wolfowitz runs tests were performed to determine whether the explanatory variables influenced the detection of carcasses by vultures; only tree density was found to have a non-random effect (Tree density: runs= 6 $P < 0.05$; Distance from REST: runs= 9 $P = 0.55$; Last feed: runs= 8 $P = 0.25$).

Tree height has not been taken into account but is also likely to have influenced visibility; when the same analysis was performed with a weighting factor for taller trees it marginally improved the statistical significance

Distance to African white-backed Vulture breeding colonies was not deemed an important factor because they were scattered throughout the study area. Also many experiments were paired (with different outcomes) effectively controlling for any proximity bias to such colonies.

Cape Vultures were only present at five of the experiments (mean number of Cape Vultures 0.82 ± 1.08) making interpretation about their ability to land and take off in areas of dense bush difficult. From this small sample tree density was not significantly related to the presence or absence of Cape Vultures at located carcasses (runs= 7 $P = 0.65$).

OTHER SPECIES AS CUES TO CARCASS LOCATION?

Oral tradition suggests that other scavengers often alert vultures to carcasses and act as a “green-light” that carcasses can be safely eaten. This was only partially true in our experiments. Of the 14 experiments in which food was located by scavengers, vultures (typically African white-backed vultures, but in one case a Lappet-faced vulture *Torgos tracheliotus*) were the first to find it in 50% and the first to eat in 36.8% of these experiments. *Milvus* kites were the next most successful in locating food first (29%), black-backed jackals *Canis mesomelas* twice (14%) and a tawny eagle *Aquila rapax* once (7%). On two occasions *Milvus* kites directly preceded the appearance of vultures.

There was no significant correlation between tree density and total numbers of vultures of all species at located carcasses (Spearman’s $R = 0.45$ $P = 0.16$).

In 50% of experiments the number of vultures present ranged between 313 and 361. Poisons or other agents of mortality do not appear to have affected African white-backed Vulture numbers negatively because the number attracted to our experiments was significantly greater than numbers at the nearby Waterberg feeding station during the 1980s (Wilcoxon Matched Pairs Test $Z = 2.93$, $P < 0.005$).

FORAGING SITE ANALYSIS USING SATELLITE TRACKING

A total of 24 carcasses was located by retrospective analysis of the PTT satellite data: nine for male CV3, five for male CV4, and 10 from male CV5. Carcasses up to seven months old were detected (median four months) and were generally still evident in the field; farmers never removed known carcasses. A summary of the foraging site characteristics of the located carcasses (Table 1) indicated that the majority (83%) were located in either completely tree-less habitat (i.e. near waterholes or at vulture feeding station) or in low tree density (<1000 trees/ha). Only two (8.3%) were found in dense bush with >2000 trees/ha. Average tree density at all carcass sites was 788 trees/ha while the highest tree density where any carcass was located was 2650 trees/ha; comparable to the findings of the experimental component.

Fences and the associated open tracks either side appeared to contribute disproportionately to ungulate mortality. First, three of the carcasses were animals whose hooves were caught in fence wire. Second, fence lines, and the *c.* 5 m of tracks either side, comprised only about 1.3% of the area on freehold farms, but in this study contributed 25% of the located carcasses, a si

The three male Cape Vultures flew significantly different distances (Factorial ANOVA: $F_{2,21} = 4.02$ $P < 0.05$) to the located carcasses due to their differing roost or nest positions but averaged a minimum distance of 68.8 km (SD = 29.9, range 22.4–185.7 km) assuming direct flight (Table 2). Time spent foraging varied from 2.3–4.0 h and averaged 2.9 h and average flight speeds were similar for the three birds (Table 2).

FORAGING RANGE AND ESTIMATED BUSH DENSITY

The foraging ranges of the satellite tagged Cape Vultures is intimately known and we can use this to determine where they forage in relation to estimated bush density. Previous work by Bester (1996 and unpubl. data) assessed bush densities in northern sections of Namibia at 1 953 sites. We plotted these and overlaid the known foraging ranges of the Cape Vultures on them (Fig. 5). The results indicate few areas where bush density was less than 3000 trees/ha – above the threshold density at which vultures fail to locate provided carcasses. More open areas farther from the Waterberg cliffs, including the Etosha National Park, were rarely visited and the majority of the habitat foraged over comprised bush at densities of 8000–10000 trees/ha.

Discussion

Cape Vulture colonies in Namibia have gradually disappeared from the landscape over a 40-50 yr period (Sauer 1973; Brown 1985) leaving one colony remaining at the Waterberg Plateau Park. Poisons are known to have killed many birds in Namibia (Brown 1985, 1991; Simmons 1995; Bridgeford 2001) but it remains unknown if

poisoning has led to the demise of the majority of Namibian Cape Vultures. The speculative nature of that conclusion is reinforced by the fact that African white-backed Vulture populations have simultaneously (and curiously) increased around the Waterberg. Comparisons show that on average they were five times more numerous at our experimental feeds relative to the numbers present at the Waterberg vulture restaurant throughout the 1980s (Brown & Jones 1989). A possible explanation is a change in habitat suitability. At the turn of the 20th century the Otjiwarongo area and the plains surrounding the Waterberg plateau was open savanna with isolated tall *Acacia* trees dotting the landscape (Brown 1985; Mendelsohn *et al.* 2002). Presently, the area is a dense sea of *Acacia mellifera* providing a classic example of bush encroachment (Bester 1996; Barnard 1998). The Cape Vulture, as a species that evolved in high mountains with strong orographic winds (Brown & Piper 1988), has a wing-loading 47% higher than the smaller White-backed vulture (Pennycuick 1972), and thus might be expected to fare poorly in a densely-treed savanna.

Impact of tree density on foraging success

Our carcass experiments designed to test whether tree density may impede vultures from locating or descending to food, indicated that vultures took longer to find carcasses placed in dense bush; carcasses in the medium dense bush (>2600 trees/ha) were never found. This was matched by retrospective analysis of foraging sites from the satellite-tagged Cape Vultures: the maximum tree density in which a successfully scavenged carcass was recorded was 2650 trees/ha. This corroborates the oral tradition of Namibian farmers who have lived in this region for decades who state that vultures frequently do not find carcasses in thick bush.

For bush density to negatively influence Cape Vulture foraging success and hence their population numbers, large tracts must be shown to be unsuitable and show high bush encroachment values – rather than the foraging range to be merely a mosaic of low and high density bush. Qualitative reports suggest that ground level visibility in farmlands surrounding the Waterberg Plateau Park decreased from around 85% in the 1940s to less than 10% in the mid 1980s (Brown 1985). Quantitative data from B. Bester (unpubl. data), support this suggestion, indicating that the majority of the area covered by foraging vultures in 2007, is densely encroached with bush density values ranging from 3000 – 10 000 bushes/ha (Fig. 5).

It would appear obvious therefore that bush encroachment has now made virtually the entire foraging range unsuitable and disadvantages the foraging success of vultures in the Waterberg area. This can account therefore, for both the continuous decrease in Cape Vulture numbers since 1960 when bush encroachment became problematic in southern Africa (Bond & Midgley 2000; Ward 2005) and the finding that a disproportionate number of carcasses were located in open areas along fences, which comprise less than 2% of the farmland. This suggests reliance on a rare (and artificial) habitat type within a tree-carpeted landscape. Studies of vulture sightings in central and northern Botswana and Israel have also shown that most vulture species peak in abundance at the interface between protected and grazing land (Bahat 1995; Herremans & Herremans-Tonnoeyr 2000). This was interpreted by the authors that vultures benefit from the security of breeding and roosting inside conservation areas and feeding on livestock outside. An alternative is that many vulture species are scavenging along fence lines where both visibility (due to accompanying tracks either side) and herbivore mortality (due to cheetah and other carnivores ambushing prey there) may be greater.

Bush encroachment also provides a partial explanation of the difference in population trends of the two species (Cape Vulture decreasing, white-backed vulture increasing) given the 47% higher wing loading and presumed lower manoeuvrability of the larger Cape Vulture in densely treed habitat. This suggestion implies that vultures are less capable of reaching known carcasses rather than not seeing them. There are three substantial reasons why we believe visibility is less important than accessibility. First, vultures have exceptional eyesight (Mundy *et al.* 1992); secondly Mendelsohn & Diekmann (2007) reported that individual Cape Vultures forage c. 100 m lower over heavily bush-encroached areas than over open ground (mean altitude 433 m), implying closer searching; and thirdly, vultures can make use of low-flying scavengers such as the Bateleur *Terathopius ecaudatus* and *Milvus* kites and mammalian scavengers such as the jackal, in the detection of carcasses (Mundy *et al.* 1992). That they rarely needed to in this study implies they were able to detect with ease any carcasses that were available. We suggest, therefore, that Cape Vultures are more likely find carcasses inaccessible than they are missing them visually. Predation risk may also play a role given the number of carnivores occurring in these areas which may be a greater threat in dense bush.

Prey type and potential contributors to mortality

The carcasses located from the satellite tracking data indicate that Cape Vultures of the Waterberg rely more on game than domestic livestock for food. This is in contrast with the global tendency of vulture populations to become increasingly reliant on domestic livestock as a major food source (Robertson & Boshoff 1986; Mundy *et al.* 1992; Shobrak 1999; Yosef & Bahat 2000; Camina 2004). In the comparison of prey

species of the Namibian Waterberg colony to South African colonies (Robertson & Boshoff 1986) it is likely that high densities of large herbivores which reach a minimum of 0.6 oryx and kudu/km² in north-central Namibia (MET 1999; Mendelsohn *et al.* 2002) are responsible for this discrepancy rather than different food preferences between the two colonies. High numbers of kudu (Marker *et al.* 1996) could indicate that bush encroachment has benefited browsing species and hence has increased prey density.

Conservation solutions

From 1994 to the present and coincident with the first satellite tracking of wild birds, rehabilitated Cape Vultures from South Africa were housed then released by REST at the Waterberg (Diekmann *et al.* 2004). The re-introductions are designed to bolster the dwindling resident populations while simultaneously providing them with a clean source of protein (Diekmann *et al.* 2004). That this may produce a dependence on vulture restaurants is not a long term sustainable solution without the clearing of large sections of their now bush encroached foraging range. Healthy large herbivore populations mean that food is plentiful but the extent of the bush encroachment and its negative influence on food detectability by Cape Vultures hampers their ability to reach carcasses and is probably the main factor reducing their populations since the 1940s. One long-term solution to increase Cape Vulture numbers is to decrease the bush encroachment across the landscape, beginning with areas close to known roosting or breeding sites. Given the increasing CO₂-related enhancement of bushy areas across many landscapes (Bond & Midgley 2000), the extent of bush encroachment is predicted to increase in the future. There is little doubt that human

intervention is required to create vulture-friendly habitat around the Waterberg. Given its effect on biodiversity and farming practices in Namibia (Barnard 1998; Meik *et al.* 2002, Jeltsch *et al.* 2010) literature is now openly available to farmers and landowners to do this (<http://chameleon.polytechnic.edu.na/wiki/doku.php> 2008).

Bush clearing has already been recommended for another threatened carnivore in this region – the cheetah *Acinonyx jubatus* (Muntifering *et al.* 2006). This species is locally common because of a lack of mammalian competitors and high prey densities, but bush encroachment is considered to hamper the hunting success of this species too because line of sight to prey is impeded (Muntifering *et al.* 2006). It has not escaped our notice that while the opening of bush-thickened areas can benefit both carnivores, it may create a double-benefit for vultures if cheetah bring down more prey and leave the remains of their prey (chiefly kudu: Muntifering *et al.* 2006) in newly cleared areas.

We conclude that increased tree density in the form of bush encroachment reduces foraging success of African white-backed and Cape Vultures in their main foraging range in northern Namibia, and this on-going trend, exacerbated by increasing CO₂ levels world-wide, has coincided with the long term decline in the Cape (but not African white-backed) vulture populations. Reducing this bush thickening through active intervention may assist the survival of this, and other threatened carnivores, in southern Africa.

Acknowledgements

This project was funded by the NRF and the University of Cape Town Research Committee, and logistically supported by the Rare and Endangered Species Trust (REST) of Namibia and the Animal Demography Unit. Joerg Diekmann, Chris Brown, REST volunteers and farm workers helped with fieldwork and data collection. The Cheetah Conservation Fund and the farmers of the Otjiwarongo

district generously provided free access to their land and some carcasses. In particular we would like to thank Petou Malan, Fanie and Renee Gildenhuys, Wilhelm and Sabine Diekmann and Fritz and Anita Diekmann for their hospitality and use of their land for the experiments. Wesland Meat provided offal for the experiments. Nick Lindenberg provided GIS advice. We thank Phoebe Barnard and Jeff Muntifering for discussion and advice and David Houston for previous reviews.

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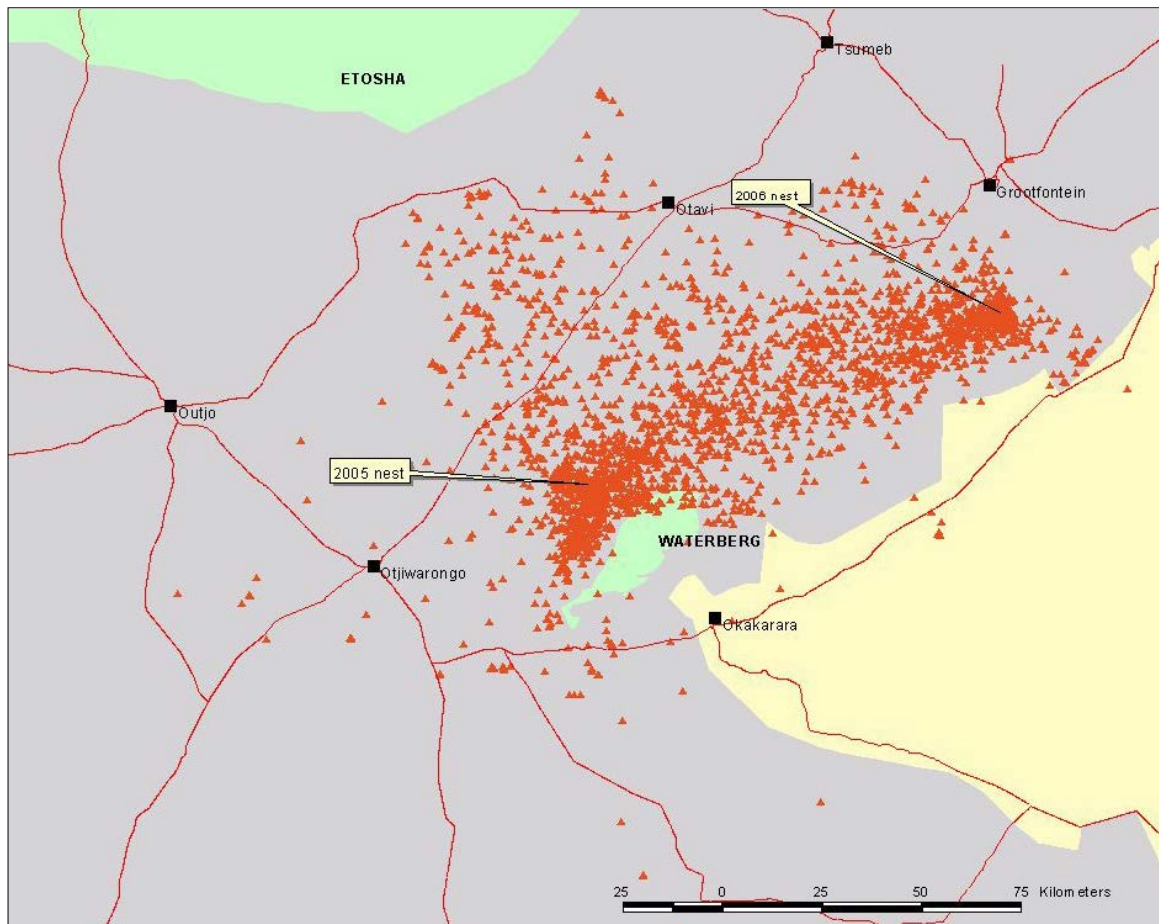
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Table 1. Summary of carcass species, habitat type and type of land use enterprise that carcasses were located in as determined from the satellite data analysis of Cape Vulture foraging sites.

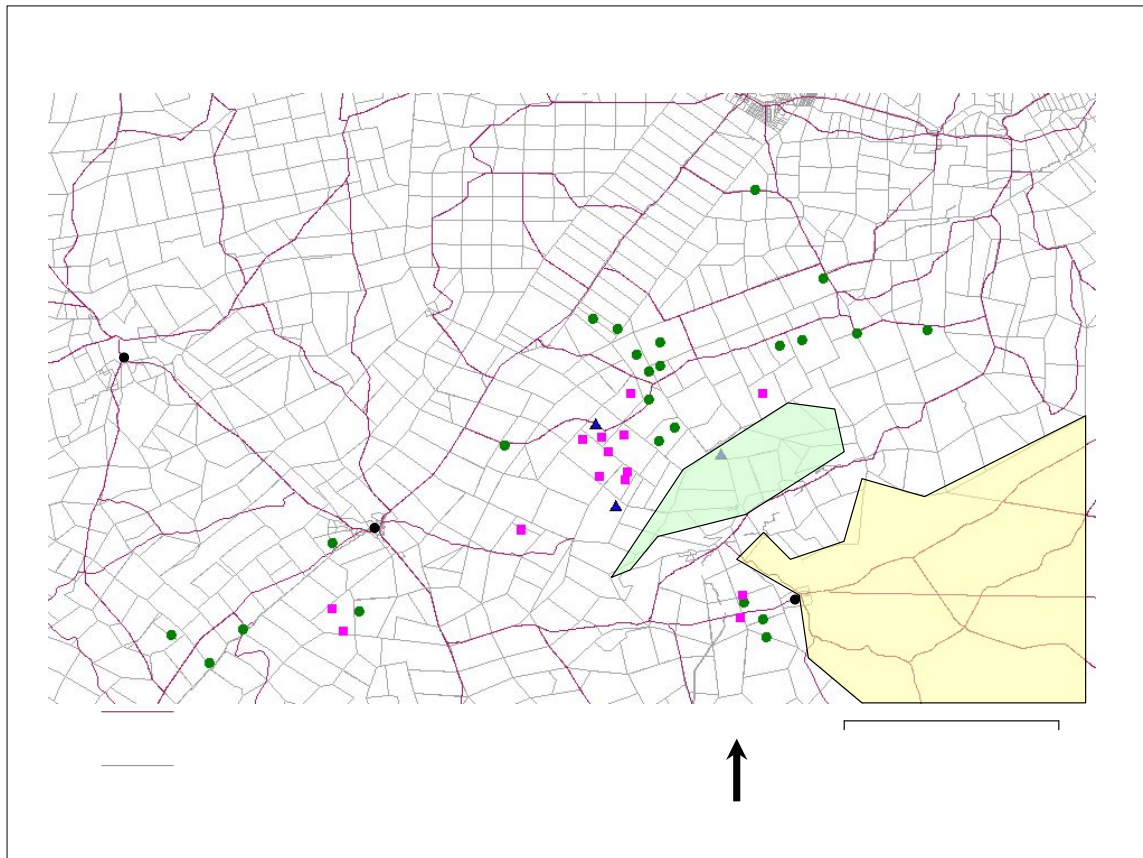
Table 2. Summary of flight characteristics of three Cape Vultures determined from PTT satellite data analysis over the period November 2004 to December 2006.



Minimum Convex Polygon estimate of foraging range

** Average figure from 3 birds because this bird did not breed in 2006

Figure 1. Positions (n = 10 786 data points) for an adult male Cape Vulture (CV4) recorded by satellite telemetry between November 2004 and December 2006. Grey



areas correspond to freehold farmland, beige areas are communal land and green areas the protected areas of Etosha National Park and Waterberg Plateau Park.

Figure 2. The study area encompassing the Otjiwarongo district in north-central Namibia, depicting vulture restaurants, naturally occurring carcasses and experimental sites. White areas with grey borders are freehold farms, the green area corresponds to the Waterberg Plateau Park and to the bottom right is communal land.

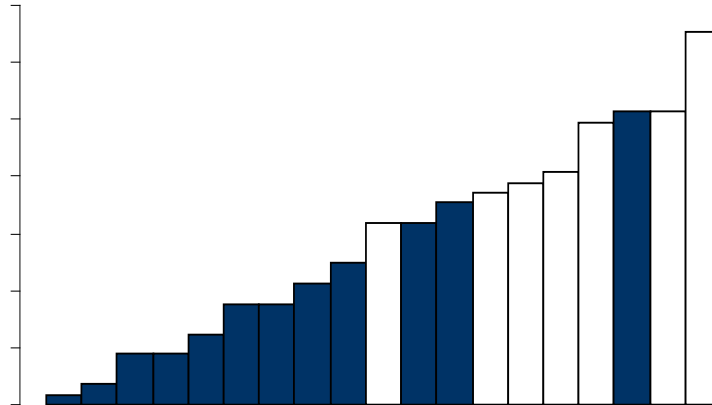


Figure 3. Tree densities at which experimentally provided carcasses were successfully located (solid bars) or unlocated (open bars) by White-backed and Cape vultures near the Waterberg, Namibia.

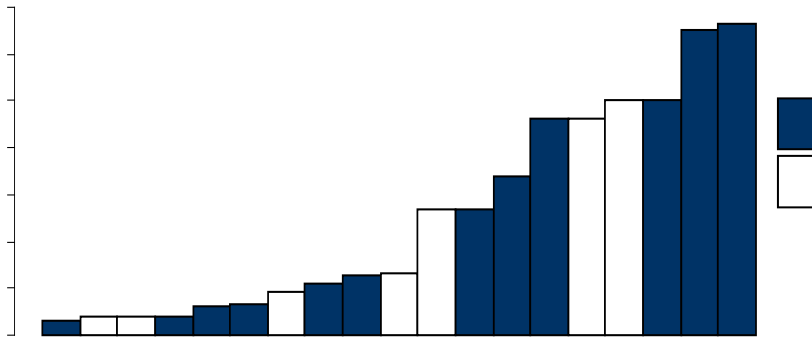


Figure 4. Distance from REST (main vulture restaurant) of successful (solid bars) and unsuccessful (open bars) location of experimentally provisioned carcasses in the Otjiwarongo district of Namibia. The experiments are ordered by increasing distance from REST.

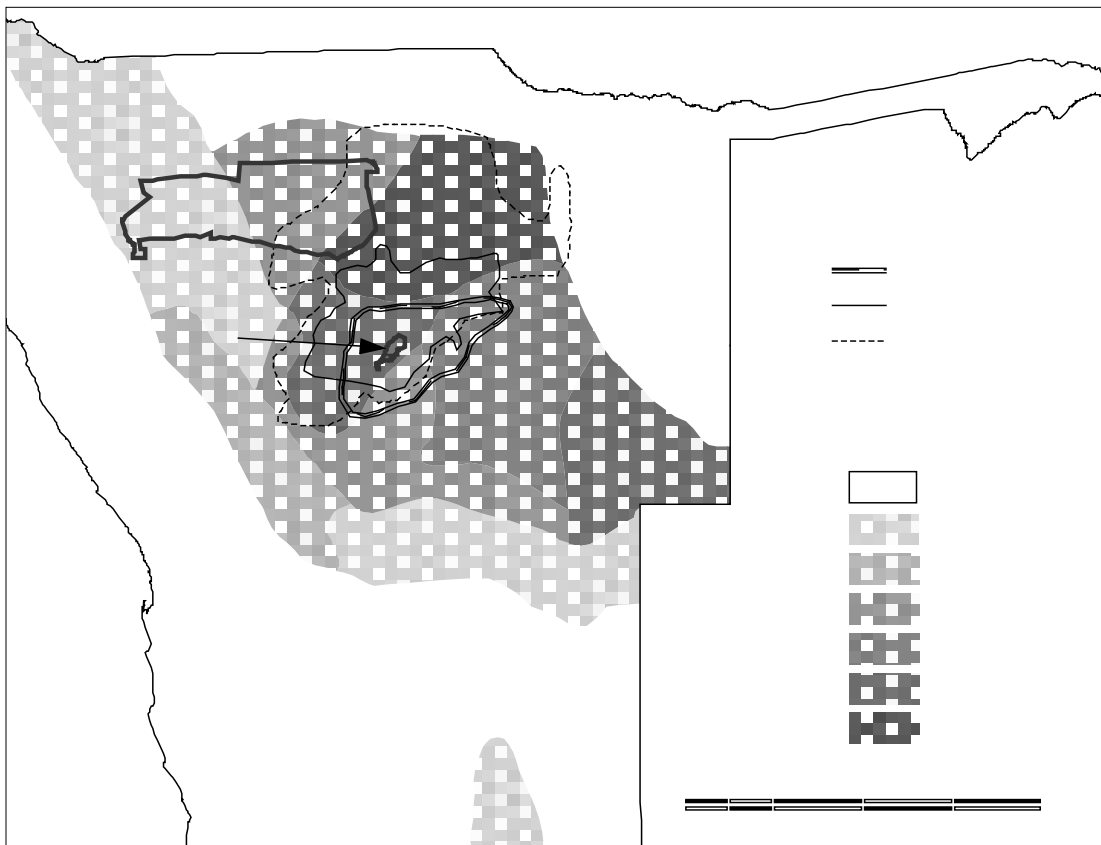


Fig. 5. Estimated bush density in north-central Namibia (after Bester 1996 and unpubl data) in relation to Cape Vulture foraging ranges. Bush encroachment values that are above 2600 tree/ha are generally unsuitable for foraging vultures.