Southern Tanzania

Vulture Monitoring and Conservation

Annual Report
2020

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Executive Summary

Vultures are currently the fastest declining group of birds globally. Prior to the start of our work, little was known about vulture populations in southern Tanzania. The goal of the Southern Tanzania Vulture Program is to conserve southern Tanzania's vulture populations by reducing poisoning and increase our understanding of the population status and threats to vultures to improve conservation efforts. As a wide-ranging species, effective vulture conservation can inform conservation efforts for a range of species. In particular, vultures and carnivores suffer from the similar threat of poisoning and addressing this human-carnivore conflict can help to protect both suites of species. We began working in Ruaha-Katavi landscape in 2013 and expanded our efforts to Selous Game Reserve (now Nyerere National Park) in 2018.

In 2020, we continued population monitoring in both landscapes. However, due to the Covid-19 pandemic, field work activities were halted between April and July, commencing again in August 2020. We conducted two wet season transect surveys, tagged seven vultures, retrieved six units, alerted authorities to a major retaliatory poisoning event and supported a PhD and MSc student.

Monitoring population abundance

We use wet and dry season roadside counts to monitor vulture populations. We have collected seven years of data for Ruaha and Katavi National Park and three years of data for Selous Game Reserve/Nyerere National Park. While we lack historical data, this monitoring gives us information about the trends of vulture populations in southern Tanzania. Analysis of survey trends is in process with a publication expected in 2021. Below are some of the key findings from our work:

- Continued stability in the Ruaha-Katavi vulture population with no significant declines across seven years of survey data.
- Significant differences in counts in Nyerere National Park for 2018, 2019 and 2020 merit further investigation, but given poisoning rates appear to be high, these are reason for concern.
- White-backed vultures are the most common scavenging vulture across all three sites (abundance in Nyerere is 65.7 individuals per 100 km compared to 46.3 in Katavi and 35.0 in Ruaha).
- Southern Tanzania is a population stronghold for several Critically endangered vultures - most notably White-backed, Hooded, and White-headed vultures – when compared with other well studied sites e.g. Masai Mara National Reserve, Kenya.

Satellite telemetry

We began tagging vultures in 2015 and as of December 2020 have tagged 51 vultures in southern Tanzania. At the end of 2020, we had 20 actively tagged vultures in two different landscapes – Ruaha-Katavi and Selous Game Reserve/Nyerere National Park. Movement studies help us to understand vultures' ecological needs as well as identifying core areas of poisoning and poaching activities. In real-time, our telemetry study provides us with information on vulture mortality and poisoning events, disease

outbreaks, and allows the location of carcasses of large mammals to be confirmed. In addition, data from the telemetry study will help us to answer questions about vultures foraging and ranging behavior in southern Tanzania. Below are some of the key findings from our work in 2020.

- Monitored data from 19-28 tagged vultures from three species (White-backed, White-headed and Hooded vultures).
- For active units, four tagged vultures with more than four years of data (4.25 years), three tagged vultures with 2-3 years of data and eight tagged vultures with 1-2 years of data, which will allow for inter-and intra-annual analysis.
- Three confirmed mortalities, two presumed mortalities, and one unclear case occurred. One case of large-scale retaliatory poisoning in Wami Mbiki Game Reserve, and one confirmed from Katavi National Park and one from Lunda Mkwambi Game Controlled Area. Other presumed mortalities were in Ruaha National Park and MBOMIPA Wildlife Management Area, both of which were possibly linked to human activity. In addition, two units fell off and were retrieved from Nyerere and Katavi National Parks.
- Data were used to inform a nation-wide corridor analysis for terrestrial mammals by confirming corridor routes between main protected areas.
- Data have contributed to part of a continent-wide vulture movement study which will provide insights into vulture ranging and foraging ecology across Africa and allow for cross-boundary adaptive management strategies (publication in process, due in 2021).

Student Training

- One PhD student working with NCZ looking at foraging and disease ecology (publications in process, due in 2021).
- One MSc student started at SUA at the end of 2020, working collaboratively with NCZ and the Grumeti Fund, with a thesis focusing on nest surveys in Grumeti and Ikorongo Game Reserve and Ikona Wildlife Management Area.

Communications

- Monthly summaries on tagged birds shared with all key local partners.
- Coordination of a continent-wide study of African vulture movement.
- Coordination of the African Vulture SAFE program within Association of Zoo and Aquariums.
- NCZ, WCS and Tanzania wildlife authorities internationally recognized via the 2020 Association of Zoos and Aquariums (AZA) William G. Conway International Conservation Award of Significant Achievement.

Plans for 2021

- Continued vulture monitoring through roadside counts in all three study sites.

- Further telemetry work – four units in Rungwa/Lukwati-Piti, four units in Ruaha National Park, and three in Nyerere National Park (formerly Selous Game Reserve) with redeployment of currently active units from mortalities or unit drops.
- Continue use of telemetry study for anti-poaching support in partnership with Wildlife Conservation Society and wildlife authorities (Tanzanian National Parks Authority (TANAPA) and Tanzanian Wildlife Management Authority (TAWA).
- Provide support and supervision to two students (PhD and MSc).
- Provide response to poisoning training to Nyerere National Park staff, and explore expansion of training in northern Tanzania, based on connectivity to the north of Selous vulture population, and known historical poisoning cases from Maswa Game Reserve.
- Explore the possibility of integrating vulture nest recognition via machine learning processes into WCS Aviation program's aircraft imaging database.
- Explore with key Tanzanian wildlife institutes the possibility of developing a Tanzania National Action Plan for Vultures.

Vulture Status and Threats

Vultures are currently the fastest declining group of birds globally and recent work suggests that vultures are threatened across all of Africa (Ogada et al., 2016). This resulted in the development of the IUCN's Multi-Species Action Plan for African-Eurasian Vultures in 2017 to use as a framework for conservation practitioners, particularly as transboundary collaborations are necessary for these wide-ranging species.

In East Africa, declines have been severe (Ogada and Keesing, 2010; Virani et al., 2011), and poisoned carrion is the primary cause (Kendall and Virani, 2012). Carbofuran pesticides appear to be widely used for this purpose and efforts to ban these pesticides have been largely unsuccessful (Otieno et al., 2010). While there are multiple sources of poisoning incidents, the primary reason for poisoning in East Africa has generally been considered retaliation against lions, hyenas and other carnivores for livestock predation, which leads to lacing of livestock carcasses with pesticides in efforts to eliminate carnivores, but with grave consequences for vultures as well. In addition, research suggests that poisoning done by ivory poachers is becoming a more prevalent threat to Africa's declining vulture populations (Ogada et al., 2016). This type of poisoning is sometimes called sentinel poisoning. Because vultures can act as an early warning system to rangers for large poached carcasses, poachers have started intentionally poisoning elephant carcasses to reduce vulture populations and, in some cases, also collect vulture parts.

In addition, in 2019 we recorded sentinel poisoning events linked to bushmeat poachers using large snare lines within main protected areas (formerly Selous Game Reserve, now Nyerere National Park). They laced parts of wild ungulate carcasses with pesticides to reduce vulture numbers and in some cases also opportunistically collect vulture parts. Finally, use of vulture parts in muthi and bushmeat trade is well known, particularly in western Africa and South Africa. Two thousand Hooded vultures were poisoned for this reason in 2019 / 2020 in Guiné-Bissau (Henriques et al., 2020). Vulture heads have been recorded at poaching camps in Tanzania as well, first in Maswa Game Reserve, and more recently by our

project in Selous Game Reserve (now Nyerere National Park). We have also heard anecdotally that heads are taken opportunistically across the Ruaha-Katavi landscape. It is unclear if parts are used locally or are part of international trade.

Importance of vultures in ecosystem health and conservation

Scavengers play a critical role in decomposition and disease control (Sekercioglu, 2006, Sekercioglu et al., 2004), and loss of vultures can have huge effects on the environment and in some cases, lead to major economic losses as well. Loss of vultures in India is estimated to have caused nearly $34 billion in damages (Markandya et al., 2008), partially due to an increase in feral dog populations following vulture declines that precipitated rabies outbreaks in dogs and humans. In addition to healthcare costs, loss of vultures in Africa could have important implications for the tourism industry given the likely rise in rotting carcasses that would arise from their demise becoming an unpleasant nuisance to tourists. In addition, without vultures' efficiency at carcass consumption (as compared to mammalian scavengers), there may be risk of either persistence or increase of harmful diseases within the ecosystem.

Vultures are also important indicators of ecosystem health. Given large range sizes and dependence on high wildlife density, vultures indicate ecosystem health at the landscape scale (Sekercioglu et al., 2004; Markandya et al., 2008; Ogada et al., 2012). Vultures can also be important indicators of poaching activity as they are attracted to large carcasses, such as those of poached elephant and rhino, in large numbers. In addition, because vulture populations are likely to be more sensitive to poisoning than lions, they may prove to be important indicators of conservation success when it comes to mitigating human-predator conflicts. Vulture conservation thus has important ecological and economic ramifications and merits further attention.

Southern Tanzania Vulture Program

Our work has corroborated prior assumptions, such as those outlined in the CMS Multi-Species Action Plan for African-Eurasian Vultures 2017, that Tanzania is a critical country for African vulture conservation. Recent continent-wide estimates for White-headed vultures, combined with our data, highlight southern Tanzania as containing one of the largest remaining populations of this species (Murn et al., 2016). Preliminary findings from continent-wide movement studies also suggest that vultures in southern Tanzania may have particularly small home range sizes, contained primarily within large protected areas, making them easier to conserve. Given the challenges of reducing poisoning across the typically wide range for vulture species, like the White-backed vulture, this may make southern Tanzania one of the best hopes for long-term vulture survival. The importance of African vultures has also been recognized by the Association of Zoos and Aquariums with African vultures becoming a SAFE (Saving Animals from Extinction) program species group in February 2018, under the leadership of North Carolina Zoo.

North Carolina Zoo (NCZ) works across southern Tanzania in two important vulture landscapes encompassing over 150,000km^2, some of the last remaining strongholds for this avian scavenger guild.

Four of the vulture species found in southern Tanzania are now critically endangered, and one endangered (Table 1). Monitoring and understanding the needs and behavior of this population of vultures will be vital for the future of African vultures and needs to be conducted over the long-term. In Asia, rapid declines went unnoticed largely due to the lack of consistent monitoring.

Since 2013, NCZ has worked in the Ruaha-Katavi landscape, partnering with the Wildlife Conservation Society (WCS) and the Tanzania National Parks (TANAPA), and in 2018, initiated further conservation activities in Selous Game Reserve (now also Nyerere National Park), partnering with the Tanzania Wildlife Authority (TAWA) and Frankfurt Zoological Society (FZS). Systematic monitoring of vulture populations is conducted via road surveys for abundance estimates, and via movement studies, which provide important information about foraging ecology and mortality factors, rates, and hotspots. In addition, vulture movement studies offer insights for the conservation of other species, such as location of recent poaching incidents, snare lines, and carnivore poisoning events. Information from vultures can thus help to target the threats to carnivores and other large mammals as well. In 2020, we also started to establish connections with organizations in northern Tanzania in response to the regular movement of the tagged White-backed vultures from Selous/Nyerere, necessitating broadening the network of partnerships for effective conservation.

Table 1 Scavenging vulture species found in southern Tanzania.

Species	IUCN 2015
Hooded vulture *Necrosyrtes monachus*	Critically Endangered
Lappet-faced vulture *Torgos tracheliotos*	Endangered
Ruppell's vulture *Gyps rueppellii*	Critically Endangered
White-backed vulture *Gyps africanus*	Critically Endangered
White-headed vulture *Trigonoceps occipitalis*	Critically Endangered

Program Goal

The goal of the Southern Tanzania Vulture Program is to conserve southern Tanzania's vulture populations by reducing poisoning and improving our understanding of the population status and threats to vultures to improve conservation efforts. In addition, as a landscape species, vulture conservation can help to inform and improve conservation outcomes for other species as well, including carnivores and other large mammals.

Program Objectives

1. Conduct standardized roadside surveys in Ruaha, Katavi, and Nyerere (formerly Selous Game Reserve) National Parks to monitor vulture populations and track changes in vulture abundance over time.
2. Use satellite telemetry to study vulture movement and use this information to establish population ranges and core foraging areas, understand habitat use, discover important breeding sites and determine principle mortality causes and rates. In addition, telemetry data has valuable

real-time monitoring uses, such as identifying wildlife carcasses, as well as bushmeat poaching activities, to inform on-going anti-poaching efforts, and to identify poisoning events. With our partners, these data can help us to address the threats of poisoning and poaching and to target human-carnivore conflict mitigation efforts. Information can also be useful for finding mortalities and disposing of carcasses during disease outbreaks.

3. Train rangers and other partners in appropriate rapid response to poisoning events (knowledge of proper protocols for collection of samples and disposal of carcasses at poisoning events) to deter perpetrators and reduce additional poisoning. Where possible, prepare trainees in proper care of live, poisoned birds for appropriate rehabilitation.
4. Monitor lead levels from tagged vultures to assess the risk of lead exposure and poisoning in southern Tanzania's vulture populations and look for seasonal variation in lead levels that may relate to legal and illegal hunting.
5. Monitor breeding populations and measure occupancy over time using data from roadside surveys, satellite units, tour guide sightings and aerial nest surveys within main protected areas of southern Tanzania.
6. Continue to build partnerships with key stakeholders e.g. protected area authorities and other NGOs particularly working in anti-poaching, carnivore and other large mammal conservation, to allow closer knowledge sharing and collaboration in understanding threats and developing coordinated conservation strategies.

Study Area

The research and monitoring focuses on two main landscapes in southern Tanzania (Figure 1) – the Ruaha-Katavi landscape, a vast area of 100,000km^2, with Ruaha and Katavi National Parks (NP) connected by a network of Game Reserves (GR), Game Controlled Areas (GCA) and Open Areas (OA). Approximately 200 km east from Ruaha National Park, is the greater Selous ecosystem, consisting of over 50,000km^2 encompassing Selous GR / Nyerere and Mikumi NPs.

For vultures, connectivity between the Ruaha-Katavi and Selous landscapes is blocked by the Eastern Arc Mountain ranges (Udzungwa and Rubeho mountains), resulting in two separate southern Tanzanian vulture populations. These overlap with critical stronghold populations of elephants, lions and wild dogs in Ruaha-Rungwa and greater Selous.

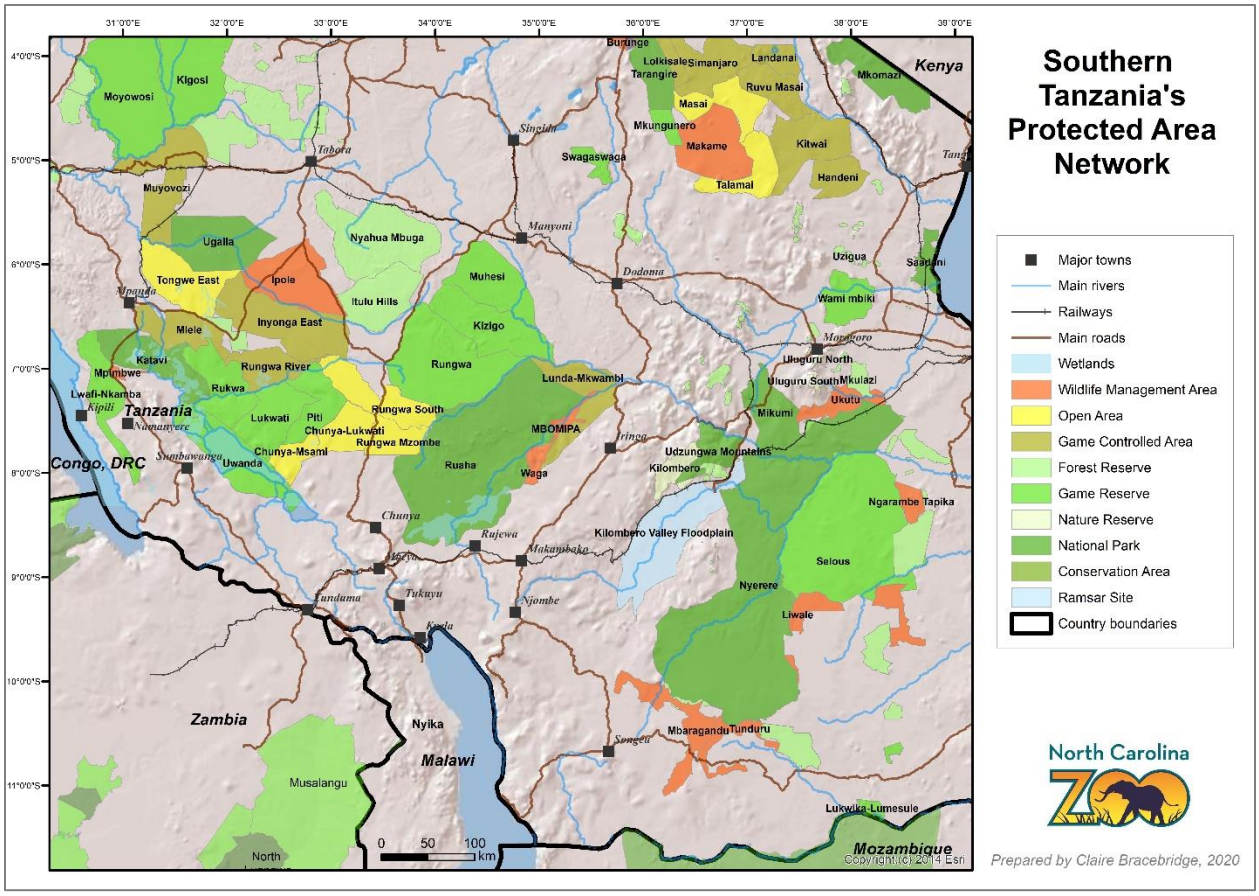

Figure 1 Map of the southern Tanzanian landscape, showing the main protected areas, including Ruaha, Katavi, Mikumi and Nyerere National Parks, the Rungwa-Kizigo-Muhesi, Lukwati-Piti, Rukwa-Lwafi and and Selous Game Reserves.

Vulture Abundance Surveys

Vulture and scavenging raptor (Bateleur and Tawny eagle) abundance was measured using roadside transect counts. Roadside surveys are used as a standardized monitoring tool to track trends in vulture abundance over time, as absolute counts are impossible for these mobile and wide-ranging species. Flying and perched birds were counted along either side of the road. Transects were treated as lines and the distances measured with the vehicle odometer. Transects were driven along main roads and other paths, traveling at 15-50 km/hour, averaging 40 km/hour. Data were collected in CyberTracker on tablets. Transects were chosen to represent a large diversity of habitats and maximize coverage across the protected areas, as well as along roads that are likely to be useable during both the wet and dry seasons. From these data we can calculate encounter rates (number of individuals per species per 100km) which allows us to track trends in populations over time. Due to limitations of field work opportunities because of Covid-19, only two wet season surveys were completed this year in Katavi and Nyerere National Parks. Surveys in Katavi were conducted in February for a total of 3-days and covering

223.9 km, whilst surveys in Nyerere were conducted in March for a total of 3-days and covering 127.5 km. Due to extremely high rainfall, full transects were not possible.

Survey Results

Table 2 presents encounter rates (number of individuals per species per 100km) from the monitoring transects conducted between 2013 and 2020, including average encounter rates across all years.

Ruaha National Park

No surveys were conducted in Ruaha in 2020 due to Covid-19. Whilst there has been some intra-annual and seasonal fluctuations of abundance across the seven years of surveys, the 2019 wet season survey generally demonstrated higher than average abundances for most species. Abundance of White-backed vultures was 45.5 individuals per 100km (vs. an average of 35.0). Four other species had recorded encounter rates higher than the average (Table 2) – Bateleur with an encounter rate of 28.6 (vs. average of 17.5), Lappet-faced vultures at 8.3 (vs. average of 4.0), Tawny eagle 5.6 (vs. 3.8) and Ruppell's vulture 1.1 (vs. 0.2). Two species had lower than average abundance – Hooded vultures had an encounter rate of 3.1 (vs. average of 4.7), whilst White-headed vultures were observed at 1.9 individuals per 100km (vs. 2.7). In general, based on these survey results, the Ruaha population trend is relatively stable.

Katavi National Park

Only a wet season survey was conducted in 2020 in Katavi National Park, and abundance for four vulture species was higher than average. White-backed vultures had an encounter rate of 55.1 individuals per 100km (vs. an average of 46.3), Lappet-faced vultures 5.3 (vs. 2.2), Hooded vultures 4.9 (vs. 2.6) and White-headed vultures 2.2 (vs. 1.8). Ruppell's vultures are present in Katavi, but in smaller numbers than the White-backed vultures as this is at their southern limit. We rarely record them during transect surveys, and therefore data for this species is negligible. Only Bateleur and Tawny eagles had slightly lower abundances than average (Bateleur 11.9 individuals per 100km vs. average of 12.8 and Tawny eagle with an encounter rate of 0.8 vs. 1.2 average). In general, based on these survey results, the Katavi population trend is relatively stable.

Nyerere National Park

Only a wet season survey was conducted in 2020 in Nyerere National Park. While 2020 wet season surveys were comparable to 2019 wet season, numbers across a variety of species are still considerably lower than in 2018. For instance, for White-backed vultures, initial encounter rates in 2018 were over 80 individuals per 100km, this reduced to half of that in the dry season 2018 to around 40 individuals per 100km. Both 2019 and 2020 wet season abundances are around 60 individuals per 100km, with an overall average of 65.7. While three years is too short a time period to be confident of trends, these patterns are worrisome particularly in light of the high levels of poisoning that have been found for this area, and the numbers of White-backed vulture mortalities recorded from these.

For other species, abundance in 2020 was higher than average. Hooded vultures had an encounter rate of 10.9 (vs. an average of 4.5), White-headed vultures 5.9 (vs. 3.4) and Ruppell's vultures 1.4 (vs. 0.7) individuals per 100km. Fewer Lappet-faced vultures were recorded at 3.6 (vs. 5.5), but there is variability in sightings for species who are generally found in lower densities. Bateleur were abundant with an encounter rate of 21.3 (vs. 19.7) and no Tawny eagles are observed during the surveys.

Table 1 Encounter rates (number of individuals per species per 100 km) for three monitoring locations in southern Tanzania

RUAHA	2013 Dry	2014 Dry	2015 Dry	2015 Wet	2016 Dry	2016 Wet	2017 Dry	2017 Wet	2018 Dry	2018 Wet	2019 Wet	Average
African White-backed Vulture	35.4	50.9	33.9	52.0	13.6	40.8	31.6	39.4	14.1	27.4	45.5	35.0
Bateleur	14.3	18.9	14.6	18.6	17.0	20.6	19.3	21.0	9.5	10.5	28.6	17.5
Tawny Eagle	5.2	3.7	6.0	1.0	4.8	3.9	2.7	4.8	2.6	1.2	5.6	3.8
White-headed Vulture	3.9	2.3	3.9	4.0	2.8	5.2	2.9	1.9	-	1.5	1.9	2.7
Hooded Vulture	9.8	4.8	5.5	3.5	4.7	4.3	3.3	1.5	7.9	3.9	3.1	4.7
Lappet-faced Vulture	1.7	2.8	5.6	4.0	1.3	8.1	3.3	4.1	1.9	2.7	8.3	4.0
Ruppell's Vulture	-	-	-	-	-	-	-	-	-	0.8	1.1	0.2

KATAVI	2013 Dry	2014 Dry	2015 Dry	2015 Wet	2016 Dry	2017 Dry	2017 Wet	2018 Dry	2018 Wet	2019 Wet	2020 Wet	Average
African White-backed Vulture	47.9	22.7	52.4	54.2	52.3	38.7	82.2	26.5	30.4	47.4	55.1	46.3
Bateleur	21.0	7.4	10.5	12.6	14.4	8.3	10.0	11.9	16.3	16.8	11.9	12.8
Tawny Eagle	1.2	-	-	-	4.0	1.4	1.0	0.4	2.8	1.8	0.8	1.2
White-headed Vulture	1.2	0.5	-	7.1	-	1.0	3.2	0.4	0.8	4.0	2.2	1.8
Hooded Vulture	0.6	4.2	0.4	-	4.2	6.9	3.0	2.0	2.0	-	4.9	2.6
Lappet-faced Vulture	-	4.8	0.9	2.5	0.5	1.9	2.9	1.9	1.0	2.6	5.3	2.2
Ruppell's Vulture	-	-	-	-	-	-	-	0.4	-	-	-	0.0

SELOUS / NYERERE	2018 Dry	2018 Wet	2019 Dry	2019 Wet	2020 Wet	Average
African White-backed Vulture	85.3	81.9	41.9	60.3	58.9	65.7
Bateleur	24.6	27.7	8.6	16.4	21.3	19.7
Tawny Eagle	-	2.7	-	-	-	0.5
White-headed Vulture	4.6	1.2	2.2	3.0	5.9	3.4
Hooded Vulture	7.6	1.2	1.3	1.4	10.9	4.5
Lappet-faced Vulture	9.4	3.3	4.4	6.7	3.6	5.5
Ruppell's Vulture	1.4	0.7	-	-	1.4	0.7

Satellite Telemetry Study

We started the movement study in 2015, and continue to expand the project each year, in terms of numbers of satellite units deployed and location of unit deployment. To date, we have tagged 51 vultures in total from three species (47 White-backed vultures, two Hooded vultures and two White-headed vultures). In 2020, we were able to monitor movement data from up to 25 tagged vultures in any one month, trapped from Ruaha, Katavi and Nyerere National Parks, and Rukwa and Piti Game Reserves. Birds trapped in the Game Reserves have provided valuable additional information about vulture movement and other activities in the central game reserve complex of the Ruaha-Katavi landscape.

The movement study provides critical real-time information about illegal activities and disease outbreaks. Tagged vultures have become an effective tool for finding large carcasses and extensive snare lines as well as poisoning events. This allows data from our work to contribute to anti-poaching efforts underway by partners from Wildlife Conservation Society, Frankfurt Zoological Society, Tanzanian National Parks, and Tanzanian Wildlife Management Authority. Because vultures range across a wider area than carnivores, our data also provide a useful monitoring and evaluation tool for partners addressing human-carnivore conflict, such as Lion Landscapes. Highlighting hotspots of poisoning and poaching activities is a key step in reducing these illegal activities and vultures provide unique insight into the environment in real-time.

In addition, the movement study continues to improve our understanding of vulture ranging and foraging behavior. In 2020, PhD student Natasha Peters continued to analyze our vulture foraging ecology data and their role in disease ecology in greater depth. Our data are also being used as a part of a continent-wide vulture movement study which will provide insights into vulture ranging and foraging ecology across Africa.

Methods

Vultures were trapped using nooses, set up as lines, along carcasses (Watson and Watson, 1985). Noose on noose lines were made of coated wire cord or monofilament, and the noose line was made of parachute cord. Nooses were 10-15 cm in diameter. Noose on noose lines were staked into the ground using tent pegs for added stability. Grass or carrion was used to help hold the nooses upright to increase the chance of a capture. Noose lines consisted of approximately 6-8 nooses. Once a bird was captured, processing took approximately 20 minutes per bird; birds' eyes were covered to reduce stress and the handler restrained both feet and head.

Solar-powered ARGOS/GPS PTT tags (Microwave Telemetry, Inc., Columbia, Maryland, U.S.A.) units (70g for White-backed vultures and 45g for Hooded vultures) were attached as backpacks using Teflon ribbon (Bally Ribbon Mills, Bally, Pennsylvania, U.S.A.). Units are set to take GPS waypoints every hour from 6 AM to 7 PM and at midnight each day for a total of 15 points per day, and to transmit data every day via ARGOS satellites. Units come with a one-year guarantee but could last for several years. At the end of 2020, we had four tagged vultures with more than four years of data (4.25 years), three with 2-3 years of data and eight vultures with 1-2 years of data. Real-time data from these tagged individuals is shared with our partners across the project sites to assist in monitoring and anti-poaching efforts.

Photo 1 Vulture trapping in Piti Game Reserve. Top left, birds perched in trees near trap site; top right,White-backed vultures feeding on the carcass; bottom left, Dr Claire Bracebridge (NCZ) and Msafiri Mgumba (WCS) working together to deploy a satellite unit on a White-backed vulture – here an adult based on underwing color; bottom right, a White-backed vulture with unit visible on its back. Photos @ Claire Bracebridge, NCZ.

Results

In 2020, we successfully deployed a total of seven satellite units on White-backed vultures, including five new units and two redeployments (Table 7). Due to delays in activities because of Covid-19, we still have four more new units and seven retrieved units to deploy (due to mortalities and units falling off) in 2021.

Mortality of tagged vultures is always very sad but provides us with further valuable information about areas of high risk to vultures. In 2020, we had three confirmed mortalities, one confirmed as retaliatory poisoning linked to carnivore-livestock conflict in Wami Mbiki Game Reserve. A second confirmed mortality was just four months after the bird was tagged and whilst the exact cause of death was not clear, there is no evidence to suggest this mortality was linked with human activity. The bird was feeding at a giraffe carcass in the presence of lions – occasionally vultures can become casualties as they compete for food. We were not able to confirm the cause of death of the third mortality, the Hooded vulture was found alone and on checking points visited in the two days prior to death, there were no

obvious signs of human activity, however the search was one month after the bird died as the area was very remote and inaccessible.

We also had two presumed mortalities, one where the unit was retrieved from a poacher's camp, but the bird was not found, and a second where the unit activity sensor indicated a mortality, but neither unit nor bird was retrieved. The area was occupied by pastoralists and we suspect human intervention. A third unit was retrieved, but it is unclear if the unit fell off during competition while feeding at a large carcass or if the bird died – no sign of the bird was found. Two units fell off with the unit successfully retrieved. There was no sign of the bird and no reason to think there had been an associated mortality, as the last transmissions indicated normal movement patterns by the bird (as indicated by the activity sensor and distance data). Incredibly, a unit that stopped transmitting in November 2019, started again a year later and was successfully retrieved!

In total, at the end of 2020, we had 20 active transmitters on 19 White-backed vultures and one White-headed vulture (Table 3).

Table 2 Information on satellite unit tagged vultures across 2020

Category	Subcategory	Ruaha-Katavi	Greater Selous	Total
Current # tagged birds (Dec 2020)	WBV	9	10	19
	WHV	1	0	1
	HV	0	0	0
	Subtotal	***11***	***10***	***20***
Mortality	Confirmed poisoning	0	1	1
	Confirmed mortality, unknown cause	2	0	2
	Presumed mortality; unit retrieved, no bird	1	0	1
	Presumed mortality; no unit retrieved, no bird	1	0	1
	Subtotal	***3***	***1***	***5***
Unit issues	Unit transmission stopped, unknown if bird death	1	0	1
	Unit comes off	1	1	2
	Subtotal	***2***	***1***	***3***
Known nests	WBV	2	0	2
	WHV	1	0	1
	HV	0	0	0
	Subtotal	***3***	***0***	***3***

** HV – Hooded vulture; WBV – White-backed vulture; WHV – White-headed vulture.*

Range, habitat and connectivity

The two main southern Tanzania vulture populations, Ruaha-Katavi and Selous-Nyerere-Mikumi, remain separate with no east-west movement or connection (Figure 2). However, there was a striking northwards trajectory of most vultures from Selous-Nyerere during the wet season early in 2020. Given the particularly heavy rains experienced, this movement pattern may have been a seasonal response, which was not recorded in previous years. However, most of the White-backed vultures were only tagged in November 2019, so we have yet to see the pattern of behavior for early 2021. The birds increased use of Nyerere National Park/Selous Game Reserve as the dry season commenced, but with regular forays

into northern Tanzania. Tarangire National Park and the Serengeti-Mara ecosystem were used regularly, as well as Tsavo National Park in southern Kenya. Occasional visits were also made to Saadani National Park on the coast of Tanzania.

In Ruaha-Katavi, the movement patterns of the birds tagged in Ruaha were predictably within the confines of the Ruaha-Rungwa protected area network, as has been the case since the outset of the movement project in 2015. Four birds tagged in the central game reserve complex (Rukwa and Lukwati-Piti) focused their movement patterns in this area and have provided extremely valuable and complimentary data to those birds tagged in, and whose movement patterns focus on, Ruaha (Figure 2).

In addition, this year one White-backed vulture, tagged in Katavi National Park in August 2019, travelled to the Serengeti at the end of May 2020 and foraged in the Serengeti-Mara system until September 2020. The time in the north coincided with the dry season wildebeest migration with plentiful food sources due to high mortality. During this time, the bird overlapped with White-backed vultures tagged from Nyerere National Park, showing the first connection between these southern populations since our study started. However, movement from the Ruaha-Katavi landscape to northern Tanzania remains a very rare occurrence when compared with the continuous north-south movement of the Nyerere-Selous birds. The latter tend to use regular corridor routes linking Nyerere-Selous-Mikumi to Wami Mbiki Game Reserve, a key resting and foraging area prior to traveling via the Masai Steppe to the Tarangire-Simanjiro ecosystem or into Kenya.

At the national scale, our vulture movement data were shared with TAWIRI and the USAID-funded PROTECT program, to inform a nation-wide corridor analysis for terrestrial mammals, and these data helped to confirm active corridor routes between main protected areas, thereby informing and supporting conservation of other wide-ranging species such as elephants.

In general, these southern Tanzanian populations of vultures have a much smaller range size than has been found in other areas, such as South Africa and Kenya. Vultures remained largely within the protected area network, where there are high densities of elephant, other ungulate and carnivore populations, and this will assist in the success of the conservation of these populations.

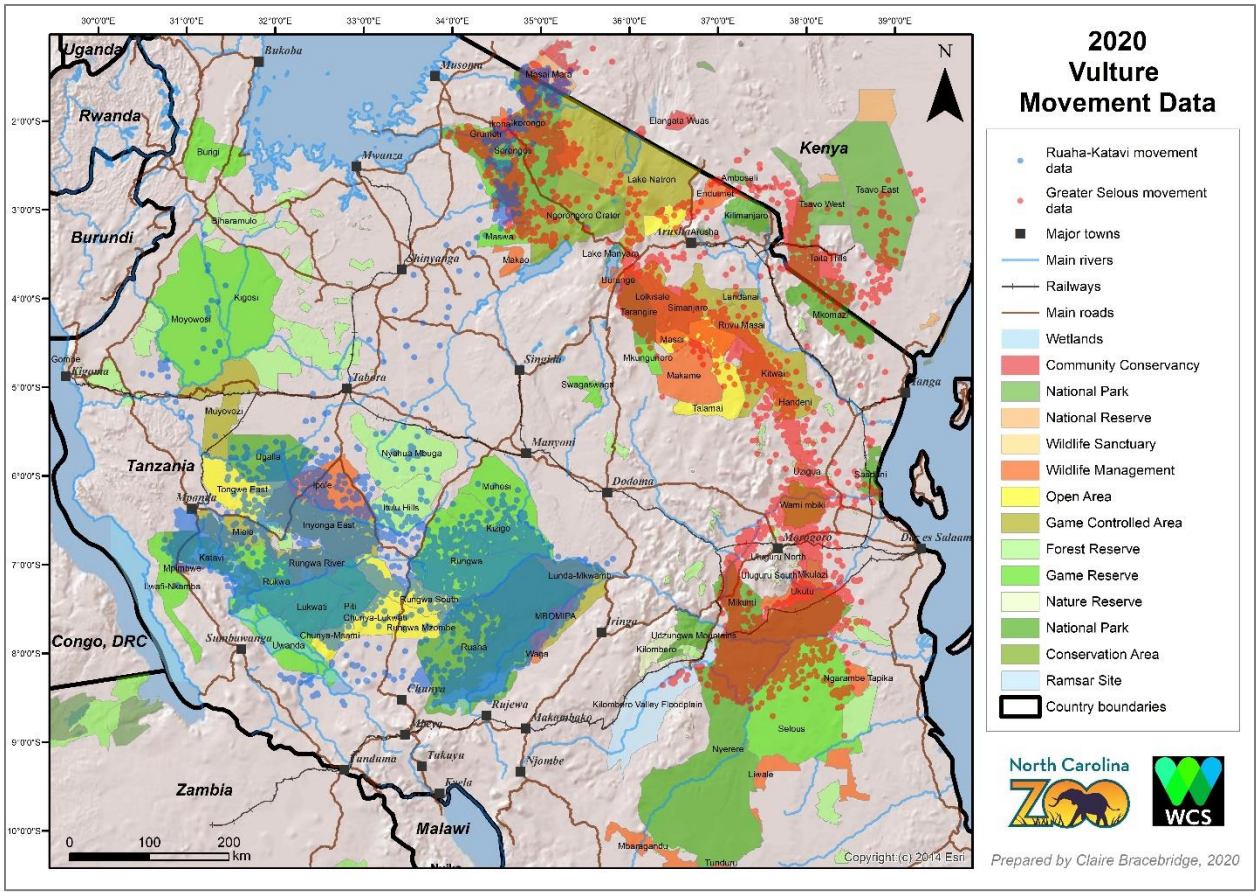

Figure 1 Movement data from January to December 2020 for a total of 16 tagged individuals in the Ruaha-Katavi landscape (blue circles) and 12 White-backed vultures tagged in Selous in southern Tanzania (red circles).

We now have 50 months of data for four White-backed vultures tagged in Ruaha in October 2016, an exceptional spatio-temporal dataset. Most satellite units do not last this long. A few notable statistics from these birds – an adult male has bred three times during this period, using the same nesting location in Ruaha. As a result, his home range (95% kernel density estimate [KDE]) of 6,244 km^2 is small, with the nest at the core of the range. In contrast, an adult female, who interestingly has never been recorded breeding, had one of the longest monthly distances travelled at 5,047 km and a large home range (95% KDE) of 81,054 km^2. Two birds were immature when tagged and have yet to breed. One individual also travels long monthly distances (longest recorded was 4,959 km), but his home range is much smaller at 18,001 km^2. All these data, together with the other tagged birds, are currently being analyzed by a PhD student, to understand space use and behavioral decision-making of White-backed vultures primarily for foraging and feeding, allowing us to assess preferred use areas in relation to protection status and poisoning risk.

Breeding

To date, it has been challenging to obtain meaningful information on nesting densities within the landscapes in which we work due to high tree cover, large areas of the study, use of palm trees for nests which makes nests difficult to detect, and limited aerial surveys. Since the inception of the study, we have

collected information on nests during transects, from tagged vultures, from tour guides, and where possible from aerial surveillance, but still have only a limited number of records. Based on movement data from the tagged birds, three vultures bred this year. Two were White-backed vultures in Ruaha, both recorded breeding previously, whilst one was the White-headed vulture, also recorded breeding last year in Katavi.

For cliff-nesting vultures, such as Ruppell's vultures, counts of nests along known breeding colony cliffs can provide accurate information about population trends and density because the breeding behaviors are concentrated in a small, consistently used area. Use of similar techniques for tree nesting species are considerably more challenging as birds can move nests from year to year, making it unclear if changes in nest density are due to movement or actual declines. This is a particular challenge in the large remote landscapes that we work in in southern Tanzania. For this reason, we have focused our efforts on roadside surveys which allow us to get comparable estimates of population numbers over time for several tree-nesting vulture species at once. However, in northern Tanzania, the Grumeti Fund manages 12,000km^2 of protected area buffering the northern edge of the Serengeti, consisting of Grumeti and Ikorongo GRs and Ikona WMA. Aerial surveys of riparian habitat have been conducted between 2013 and 2019 and provides information on White-backed vulture nests, showing some declines in the number of active nests over time. NCZ and Grumeti Fund are collaborating to fund and support a Tanzanian Masters student to conduct a ground survey of vulture nests in the ecosystem in 2021-2022, assessing status of breeding success, investigating why declines might be occurring and to assess population trends by both nest densities and road survey counts, which will be established as part of the study.

For vast areas such as the Ruaha-Katavi landscape, with improved technology, one possible method to obtain some indication of number of nests and breeding population across the wider landscape, is to utilize camera images recorded from aircraft. Large scale surveys are conducted in Ruaha National Park and Selous Game Reserve/Nyerere National Park by the Tanzanian Wildlife Research Institute for mammalian counts, and WCS is exploring with TAWIRI and others, whether there is an opportunity that machine learning could be trained to recognize nests from aerial imagery. We will continue to pursue this potential new avenue of research in 2021, which has exciting potential but also significant challenges.

Carcass detection

Information from tagged vultures has been useful for discovering and documenting giraffe mortalities, which are of concern as a skin disease outbreak in giraffe may be increasing their susceptibility to lion predation - a NCZ project was initiated in 2019 to investigate this. The tagged vultures have also been able to provide vital information about several other wildlife species of concern. Bird mortalities can also alert to poisoning events when carcasses are laced with pesticides. We have discovered retaliatory, sentinel and belief-based driven poisonings across southern Tanzania. Working closely with WCS, aerial surveillance has been able to detect carcasses in remote and inaccessible locations, which are immediately reported in confidence with partner wildlife authorities. Simple monthly movement summary maps are also shared with relevant partners.

Threats

Given that the vulture populations remain largely within protected area networks, we assume lower risks of poisoning and other persecution. In 2019, we had no confirmed mortalities in Ruaha-Katavi, however in 2020, we had several mortalities that are likely linked to illegal human activities, which is of concern, as this may be an increasing trend linked to increased incursions of cattle into protected areas. In Selous/Nyerere, where we have had several poisoning events, we had no confirmed mortalities in 2020, but we did discover a mass poisoning event in Wami Mbiki Game Reserve linked to carnivore-livestock conflict (Photo 3). Over 50 vultures were killed. This is an important area of use for vultures but experiences a lot of human pressure on the eastern side. Given that the area has been upgraded to a game reserve, we hope this will afford it more protection.

Photo 2 Retaliatory poisoning incident in Wami Mbiki Game Reserve. Top left, dead White-backed vulture found with satellite unit still attached; top right, samples taken by NCZ expert; bottom left, stacked dead vultures moved away from main poison site to a more closed area of woodland by perpetrators to reduce detection of the poisoning event, and bottom right, logs piled over the top of the carcasses by our team to prevent secondary poisoning. Photos @ Claire Bracebridge, NCZ.

Mortality rates

We reviewed data from all our 51 tagged vultures and calculated mortality rates by dividing the number of bird mortalities by the number of active units in each time period. For annual mortality rates, the maximum number of units active in the given the time period was used as the 'population' of active units. Table 4 represents the summarized annual mortality rates.

Overall mortality rate for the entire telemetry study is 31.4%, with mortality rate for Ruaha-Katavi at 33.3% and 28.6% for Greater Selous. However, in general, mortality has been more consistent in Greater Selous, with the confirmed mortalities being large scale poisoning events and over the comparatively shorter timeframe of 2.5 years (versus Ruaha-Katavi's five years). In Ruaha-Katavi the cause of death is largely unknown and most birds were found individually.

Table 3 Annual mortality rates for confirmed mortalities of vultures

Confirmed mortality									
	All landscapes			Ruaha-Katavi			Greater Selous		
Year	Max # active units	# mortality	Annual mortality (%)	Max # active units	# mortality	Annual mortality (%)	Max # active units	# mortality	Annual mortality (%)
2015	2	2	100.0	2	2	100.0	0	0	N/A
2016	10	1	10.0	10	1	10.0	0	0	N/A
2017	9	0	-	9	0	-	0	0	N/A
2018	25	5	20.0	17	3	17.6	7	2	28.6
2019	29	5	17.2	14	2	14.3	15	3	20.0
2020	28	3	10.7	16	2	12.5	12	1	8.3
All Years	51	16	31.4	30	10	33.3	21	6	28.6

Trapping has been conducted in Ruaha-Katavi since September 2015, and 30 birds have been tagged during the past 64 months, using 23 satellite units. Twenty tagged birds are no longer providing data (Figure 3). Turnover and redeployment of tags is 25.9% across just over five years. Mortality was 100% in the first year of the study in Ruaha-Katavi – we only deployed two units, but both birds died within 3 months and we suspected some low-level poisoning, although we could not collect samples. In 2016 annual mortality was low at 10%, whilst in 2017, we had no mortalities of tagged birds. For the remaining three years of data, annual mortality was 17.6%, 14.3% and 12.5% for years 2018, 2019, and 2020 respectively. Across this timeframe we have also expanded trapping locations and used game reserves, which are often less well-resourced and protected than national parks. However thus far, this does not seem to have increased mortality rates, as assessed by geographical location of mortality events.

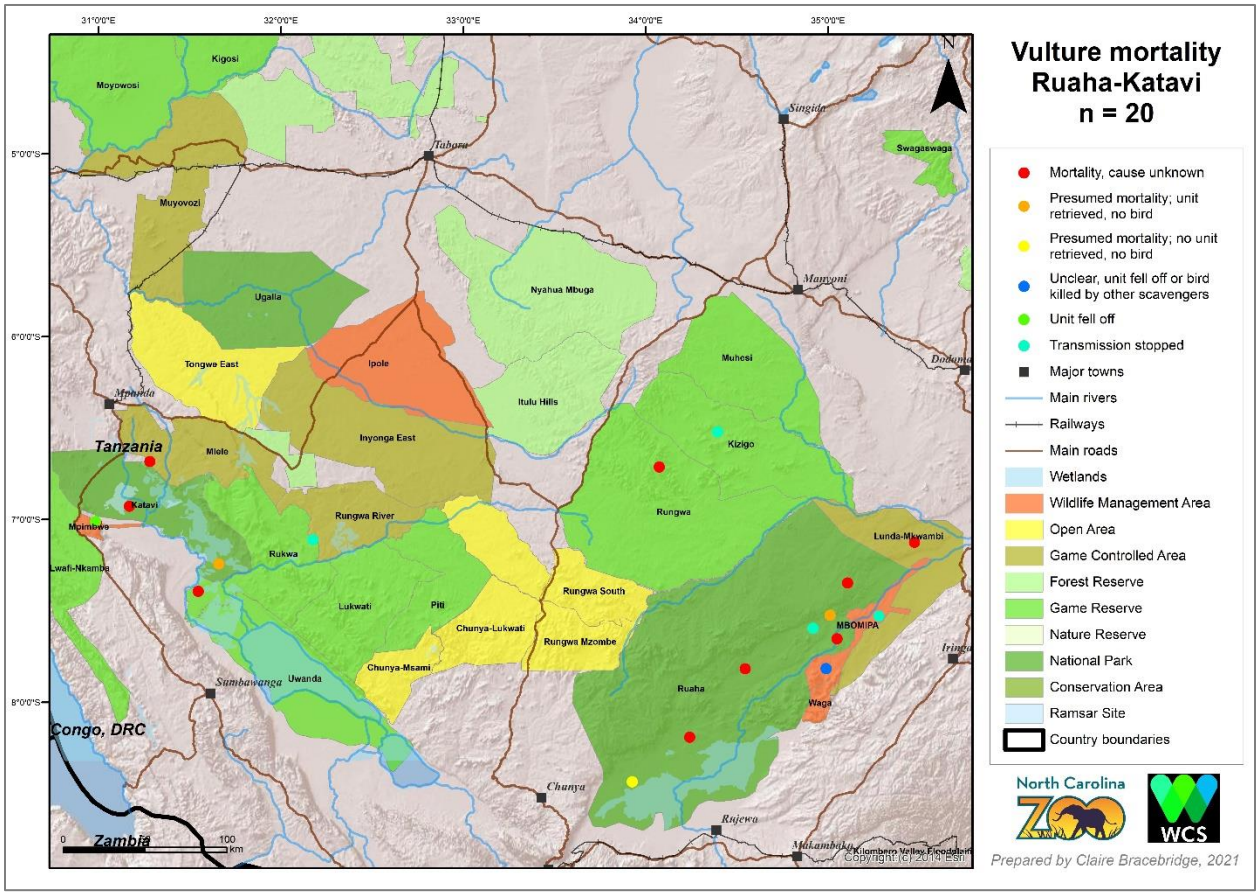

Figure 2 Mortality and unit information for 20 vultures tagged in the Ruaha-Katavi landscape from 2015-2020. One bird's unit stopped transmitting in Botswana and is not shown here.

Trapping has been conducted in Selous since June 2018, and 21 birds have been tagged during the past 31 months, using 14 satellite units. Eleven tagged birds are no longer providing data (Figure 4). Turnover and redeployment of tags is much higher than Ruaha-Katavi at 33.4%, already suggesting some mortality differences between the two landscapes. This is even more concerning given that the Selous movement study has been running for just over 2.5 years versus five years of the Ruaha-Katavi study, with an overall mortality rate of 28.6% and some worrying poisoning events within the protected area. Annual mortality for 2018 was 28.6%, 20% for 2019 and only 8.3% in 2020. Areas of particular concern in the Greater Selous landscape are the Matambwe sector of the newly formed Nyerere National Park, where bushmeat poaching was a problem in 2018 and 2019, whilst Wami Mbiki Game Reserve and the eastern edge of Nyerere NP and Selous GR highlight areas of increasing human-wildlife conflict and retaliatory poisoning events. With higher turnover of units and redeployment to new birds in Selous/Nyerere, movement patterns have changed with the current tagged birds using much more of the northern protected areas of Tanzania (and southern Kenya). It is possible that these use areas (northern circuit national parks are better resourced and protected and have a high level of tourism) have a lower risk of poisoning e.g. Tarangire and Serengeti National Parks, although we also know that Maswa Game Reserve has experienced mass poisoning events in the past.

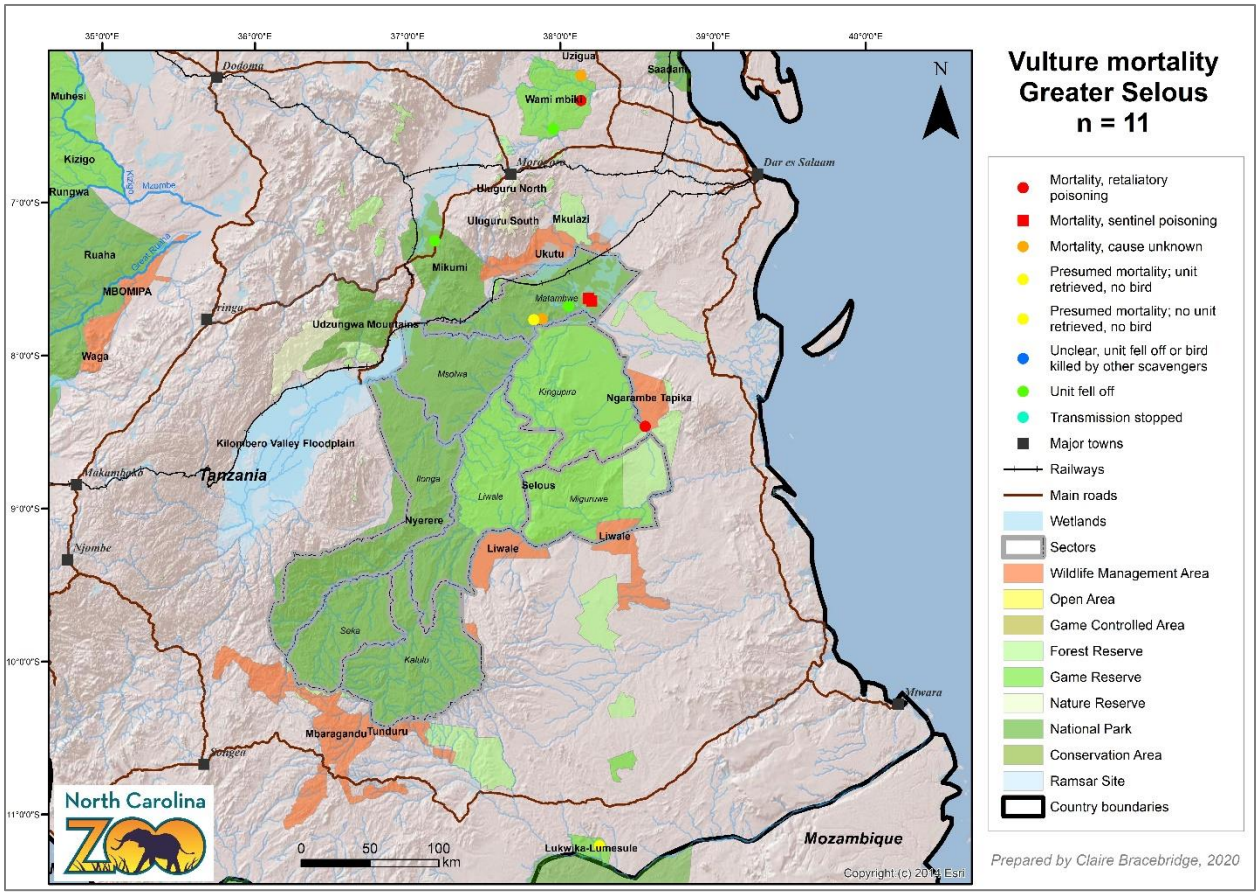

Figure 3 Mortality and unit information for 11 tagged white-backed vultures in the Greater Selous ecosystem from 2018 onwards.

Communications

Monthly summaries of our movement data are shared with our key local partners in both project sites as well as to the Tanzania Wildlife Research Institute, who authorize the research to be conducted in Tanzania.

North Carolina Zoo, together with University College Dublin and the University of Swaziland, have coordinated the ongoing continent-wide study of African vulture movement, which will contribute to conservation efforts across the continent. This paper is in the final stages of co-author review and is expected to be published in 2021.

North Carolina Zoo continues to chair the African Vulture Saving Animals from Extinction (SAFE) program within AZA and is planning to hold a workshop at the November 2021 Pan-African Ornithological Congress in Zimbabwe (postponed from November 2020 due to Covid-19), bringing together practitioners from multiple countries, to develop best practices for response to poisoning events. As part of the SAFE initiative, a short, animated video was developed called *The Key threats faced by African vultures*

(https://m.youtube.com/watch?v=nIYvpGnXM_o). In 2021, we aim to translate this into local languages as an educational tool.

We are extremely pleased to announce that our collaborative vulture project between WCS, NCZ and Tanzania wildlife authorities was internationally recognized via the 2020 Association of Zoos and Aquariums (AZA) William G. Conway International Conservation Award of Significant Achievement. This is testament to the hard work and dedication of many people and the continuing importance and conservation value of this project. Please refer to the news release link below for more information.

https://newsroom.wcs.org/News-Releases/articleType/ArticleView/articleId/15006/WCS-Tanzania-and-North-Carolina-Zoo-Vulture-Conservation-Work-Recognized-by-the-Association-of-Zoos-and-Aquariums.aspx

Conclusions and Future Work

While vultures may not be considered charismatic, they clearly provide important ecosystem services related to waste removal and disease control and act as landscape and sentinel species. As a result, conservation activities directed at vultures also help to protect carnivores and other scavengers. In addition, information from vulture telemetry provides key insights into illegal activities such as poaching, snaring for bushmeat, and poisoning. Vultures act as living drones informing conservation efforts across the landscape.

Abundance of vultures continues to be high in southern Tanzania and appears to be similar to abundances found in southern Kenya. Seven years of data suggest vulture populations are stable for Ruaha and Katavi, but more recent survey work in Selous is worrisome, suggesting substantial declines and significant poisoning levels based on survey efforts as well as a number of tagged bird mortalities. Continued population monitoring is crucial to clearly establish trends in vulture populations in these southern parks. The telemetry study has continued to provide important real-time applications for finding and addressing poisoning and poaching while also improving our understanding of vulture ecology. Both Ruaha-Katavi and Selous/Nyerere are clearly important ecosystems for vultures, particularly the White-backed, White-headed, and Hooded vultures and we must strive to continue addressing the threat of poisoning in these landscapes. Our efforts have already made a difference in diminishing these threats and we will continue to strive towards saving Tanzania's vultures.

Plans for 2021 aim to build on the information we already have, continue monitoring the vulture populations, and explore expansion opportunities into northern Tanzania. Activities include the following:

- Continued vulture monitoring through roadside counts – surveys conducted twice per year (one wet and one dry season) in Ruaha, Katavi and Nyerere
- Further telemetry work – four units in Rungwa / Lukwati-Piti (units purchased by WCS and part of the ongoing WCS-NCZ partnership in Ruaha-Katavi), four in Ruaha and three in Selous/Nyerere
- Explore expansion of response to poisoning training in northern Tanzania (an activity carried over from 2020 due to Covid-19) and training in Nyerere NP and surrounding areas

- Continue important partnerships via the telemetry study for anti-poaching support together with WCS, FZS, and wildlife authorities (TANAPA and TAWA), and expand partnerships to northern Tanzania
- WCS to explore the possibility of integrating vulture nest recognition via machine learning into the work supported by their aviation program
- Explore with key Tanzanian wildlife institutes the concept of developing a Tanzania National Action Plan for Vultures
- Provide continued support and supervision to two (PhD and MSc) students.

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Partnerships

Donors

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