

# Aerial Survey of Elephants and Other Large Mammals at Yankari Game Reserve, Bauchi State, Nigeria



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## Executive Summary

An aerial survey of Yankari Game Reserve in Nigeria was completed between April 29 and May 2 2011. The aim of the survey was to census the elephant (*Loxodonta africana*) population of the reserve though we also counted other large mammals and documented human encroachment. We employed the total aerial count method and divided the reserve into five counting blocks. Flight paths covering each block followed an east-west direction and their spacing varied from 500m to 2km depending on the density of vegetation on the ground. To maximize chances of locating elephant groups in the dense forest habitat we also flew a number of reconnaissance flights following a generally north-south direction along the Gaji River valley.

At the time of the survey the elephants were distributed along the Gaji River valley as expected. However the presence of extensive areas of closed-canopy forest along the Gaji River meant that large herds may have been missed or under-counted, preventing us from obtaining a reliable estimate of the elephant population at Yankari Game Reserve. Despite this constraint we observed elephant herds on six different occasions. All observations of elephants were made in areas of thick vegetation, precluding exhaustive counts, and all but one of these sightings was made in the far south of the reserve along the Gaji River. Herd sizes ranged from 32 to 82. The similar size of herds seen on different occasions, their relative proximity to each other, and the known fission-fusion behavior of the elephants at Yankari meant that we could not definitively identify unique herds. If each of the six herds recorded were unique, the total elephant count would be 361 individuals, similar to the 348 counted by Omondi and colleagues (2006). However, we cannot place a high degree of confidence in this estimate and can only definitively say that the minimum number of elephants is 82 (the size of the largest herd observed). Only four elephant carcasses, all either old or very old, were observed during the survey and no fresh or recent carcasses were recorded. This is equivalent to a carcass ratio of roughly 1%. However we estimate that there have been at least 50 elephants killed since the last census in 2006, suggesting that the vast proportion of all carcasses were missed.

Though we were unable to reliably estimate the size of the current elephant population, we were able to obtain counts of many of Yankari's other resident wildlife species. Counts of all species were either equivalent to, or greater than, those derived by the previous aerial census in 2006. This would suggest that non-elephant wildlife populations in Yankari have not been significantly reduced by poaching in recent years. However, the fact that none of the populations appears to have grown appreciably in the last decade despite the presence of extensive habitat, suggests that human activities are negatively affecting the reserve's fauna. Both poaching and competition for food from the large numbers of livestock in the reserve need to be controlled if the wildlife populations in Yankari are to be sustainable in the future. Compared to 2006 there was a marked reduction in the numbers of livestock observed within the reserve boundaries. However, livestock were observed inside the reserve at much greater distances from the boundary compared to the previous survey. This encroachment was particularly pronounced in the south-east of the reserve. No farms were seen inside the reserve.

# **Total Aerial Count of Large Mammals in Yankari Game Reserve, Bauchi State, Nigeria**

## **Introduction**

Between April 29 and May 2 2011, we undertook an aerial survey of wildlife and human encroachment at Nigeria's Yankari Game Reserve. The primary goal of the survey was to census Yankari's elephant (*Loxodonta africana*) population, though we also counted other large mammals and documented human encroachment in the reserve. Our survey focused on elephants since Yankari is home to what is likely the last viable population of this species in Nigeria (Blanc et al. 2007). While elephant populations have been declining in Nigeria for some time, the emergence of Nigeria as a hub for the ivory trade in recent years (Blanc et al 2007) has increased the hunting pressure on the country's remaining elephants. A number of conservation organizations (e.g., Wildlife Conservation Society, North Carolina Zoo, MIKE) have therefore made Yankari a priority for elephant conservation in Nigeria and are taking actions to help secure the future of this population. The census follows up on a previous aerial survey in 2006 (Omondi et al 2006) conducted using similar methods.

## **Study Area**

Yankari Game Reserve is located in north-eastern Nigeria in Bauchi State and covers an area of 2,244km<sup>2</sup> (Figure 1). Yankari was created as a game reserve by the British colonial administration in 1956, but in 1991 was upgraded to a National Park and placed under the federal administration of the Nigerian National Parks Service. The Parks Service managed Yankari until 2006, when management responsibility was returned to Bauchi State and Yankari reverted to its former status as a Game Reserve. Historically, Yankari has been one of the most popular tourism destinations in Nigeria, attracting thousands of national and international visitors during its heyday. Unfortunately, a number of factors, particularly chronic instability in the region surrounding Yankari, have resulted in fewer visitors in recent years. Declining number of tourists poses a significant constraint to managing the reserve, since operation of Yankari relies primarily on self-generated income. Despite these challenges, Yankari remains one of the few places in Nigeria where visitors can readily view a range of wildlife species, including elephants.

### *Physical environment and climate*

The reserve consists primarily of rolling hills ranging in altitude between 200m and 500m, though Kariyo Hill in the south-east of the reserve rises to above 600m. In the western extreme of the reserve there is a complex of canyons that form the Tonglong Gorge. Perhaps the defining characteristic of the reserve is the Gaji River valley, which bisects the reserve from north to south. The Gaji, and its tributary the Yuli, are the only perennial rivers in the reserve. Other perennial water sources are limited to five springs which are also located along the Gaji Valley.

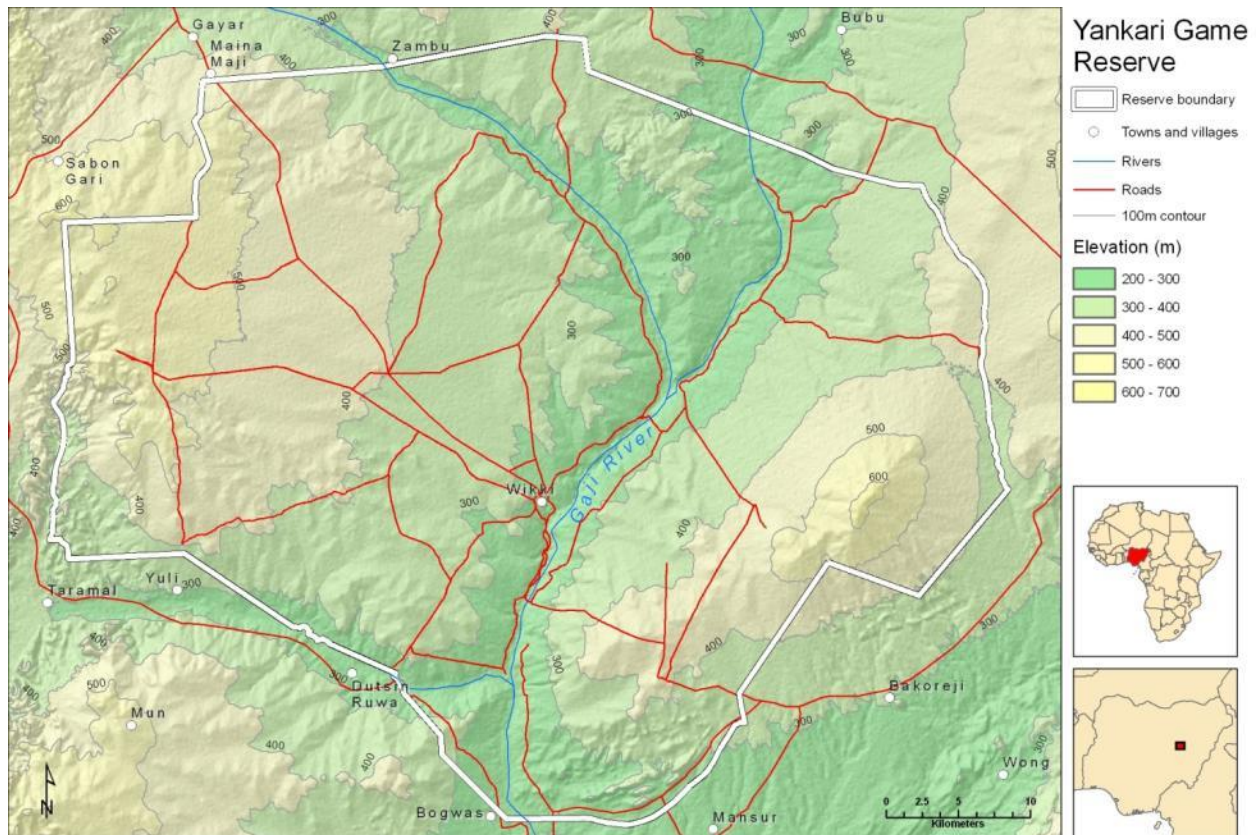


Figure 1. Extent and topography of Yankari Game Reserve in Bauchi State, Nigeria.

The climate at Yankari is strongly seasonal, with little or no rain between November and March and mean temperatures of up to 38°C. The April-October rainy season brings between 600mm and 1,000mm of rain (Green and Amance 1987). The seasonality of rainfall, combined with porous soils and few perennial rivers means that little water is available in the reserve by the middle of the dry season, except in the Gaji valley.

### Vegetation

The dominant vegetation types in Yankari are *Azelia* savanna woodland and combretaceous shrub savanna (Geerling 1973, Green and Amance 1987). The east and west of the reserve consists primarily of these vegetation types. In the rainy season vegetative cover is significant, both from woodland trees and annual and perennial grasses. However in the dry season, aridity and fire (both natural and anthropogenic) result in a major decrease in the availability of green vegetation. Large areas of the reserve have been particularly impacted by fire in recent years and at the time of the survey were extremely dry and bare (Figure 2).

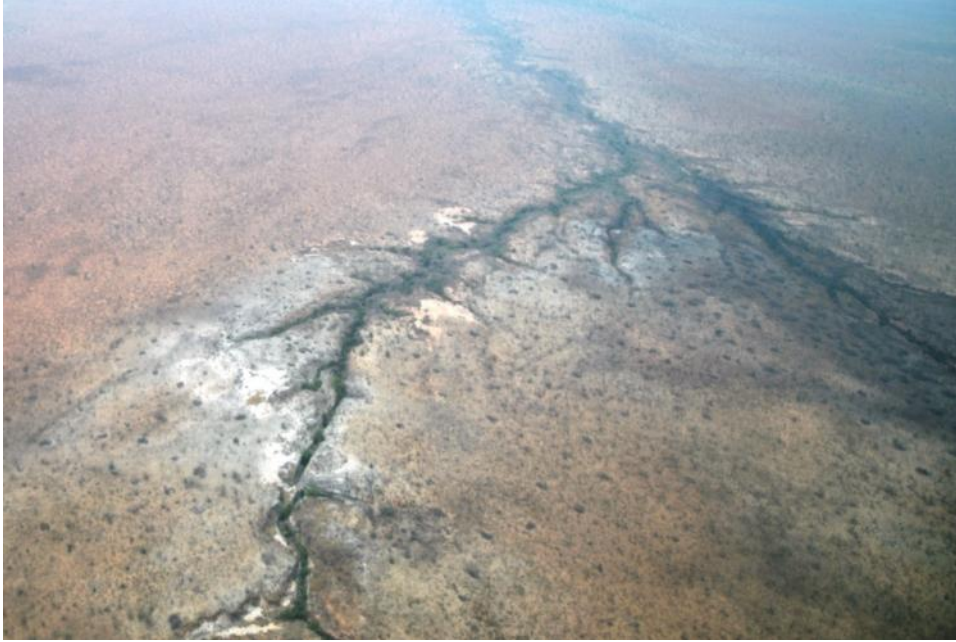


Figure 2. Most of the Reserve was extremely dry at the time of the survey.

The Gaji River Complex, running through the center of the reserve, contains a mosaic of flood plain swamp, swamp forest, savanna woodland, and large areas of gallery forest (Figure 3). This mosaic of different habitat means that the Gaji Valley has the highest levels of plant species richness in the reserve (Abdullahi et al. 2009). During the dry season this vegetation represents an important food source for most of the reserve's wildlife species.



Figure 3. Large areas of closed canopy forest are present along the Gaji River valley even at the height of the dry season.

## *Elephants*

Elephant populations are declining across West Africa and have been doing so for several decades (Blanc et al. 2007). Few large populations remain (e.g., in the “W” Transborder Park), so even moderately sized populations such as that in Yankari are important for the long-term future of elephants in this part of the continent. Yankari’s elephant population has been most recently estimated at 348 individuals following a total aerial count survey by Omondi and colleagues (2006). Prior to this survey, Nicholas (1999) estimated 328 elephants, and Marshall (1985) gave an estimate of 280. While each of these estimates was derived using different methods, they suggest that the Yankari population was relatively stable, or perhaps was slowly increasing in the period from 1985 to 2006. While earlier estimates of the elephant population exist, they are considered unreliable (Green and Amance 1987), so a more comprehensive assessment of the population trend at Yankari is lacking.

The elephant population in Yankari is closely linked to the Gaji River Valley. While the elephants will range away from the river during the rainy season when water and food are available elsewhere in the reserve, during the dry season they rarely move more than a few kilometers from the Gaji. Their distribution along the Gaji varies depending on local availability of food, but the area around the Gaji-Yuli confluence is frequently utilized.

## *Other large mammals*

Yankari contains a wide variety of other large mammal species. Among these are buffalo (*Syncerus caffer*), roan antelope (*Hippotragus equinus*), waterbuck (*Kobus ellipsiprymnus*), western hartebeest (*Alcelaphus buselaphus*), bushbuck (*Tragelaphus scriptus*), oribi (*Ourebia ourebi*), hippopotamus (*Hippopotamus amphibius*), and lion (*Panthera leo*). While some species, such as buffalo and roan antelope appear to be relatively numerous in the reserve, others (such as hippopotamus and lion) are rarely observed and may be approaching extirpation. Several species have been extirpated from Yankari in the last 50 years including giraffe (*Giraffa camelopardalis*), cheetah (*Acinonyx jubatus*) and wild dog (*Lycaon pictus*). Despite these extinctions, Yankari remains the most intact example of savanna fauna in Nigeria.

## *Threats to wildlife*

While Yankari Game Reserve is in many ways the premiere protected area in Nigeria, the reserve is under significant pressure from human activity. Like many protected areas in West Africa, Yankari is an ecological island, surrounded almost completely by human habitation and areas of intense cultivation. Large areas of farm and grazing land abut the boundaries of the reserve. While agricultural encroachment on the reserve itself is minimal, illegal cattle grazing is a significant problem. Livestock are frequently driven into the reserve to graze causing competition with wildlife for food, bringing disease (rinderpest outbreaks have significantly reduced wildlife populations in the past; Namathe and Lamorde 1983; Mohammed et al., 2010), and causing habitat destruction

through the cutting of browse and seasonal bush burning. Poaching in the reserve is also an ongoing problem. Whilst park protection has undoubtedly improved in recent years, and there have been more than 100 poachers arrested since July 2009, levels of poaching remain problematic. It is estimated that as many as 10-20 elephants may be killed by poachers each year yet there has been no recent arrest of any elephant poacher. It is also known that Nigeria is fast becoming a regional centre for the illegal trade in ivory and demand for ivory within the country is high. Yankari rangers are poorly trained and poorly equipped to combat this growing problem, in addition to this there is also a serious shortage of experienced wildlife officers, insufficient patrol vehicles and a lack of functional firearms. These and other threats to the reserve's wildlife and habitat are exacerbated by human population growth in surrounding communities. The area around Yankari has been a destination for migration in recent years, with people from other parts of Nigeria settling here to take advantage of relatively productive soils (Mohammed et al. 2010).

## **Goals of the survey**

The objectives of the 2011 aerial survey were to:

1. Estimate the number of elephants and elephant carcasses in Yankari.
2. Record secondary data on other species.
3. Map the density of elephants, carcasses and other species.
4. Map human activity, including livestock

## **Methods**

### *Survey methods and design*

We employed the total aerial count method (Douglas-Hamilton 1997; Craig 2004) as described by Frederick and colleagues (2010). The reserve was divided into five counting blocks (Figure 4) covering a total of 2,244 km<sup>2</sup> (the total area of the reserve). Areas outside the reserve were not included since the previous survey (Omondi et al., 2006) documented little or no wildlife in these areas. The blocks were designed based on ecological features of the reserve, placing the Gaji River valley at the center of a block in order to have the core elephant habitat comprehensively covered and to minimize the chance of double counting animals. This block design represents an improvement over the design of the previous survey and was recommended by Omondi and colleagues (2006) in their report. Blocks and flight paths were created in ArcGIS 9.3 (ESRI) and exported to GPS receivers for navigation and data collection purposes. Flight paths covering each block followed an east-west direction in order to provide similar lighting conditions for observers on each side of the plane. Spacing of flight paths varied from 500m to 2km depending on the density of vegetation on the ground. Flight path spacing was adjusted during the survey in response to visibility.



In addition to the transects flown to survey the counting blocks we also flew a number of reconnaissance flights. These flights followed a generally north-south direction along the Gaji River Valley and were conducted to maximize chances of locating elephant groups in the thick forested habitat found along the valley. Reconnaissance flights were generally flown at the conclusion of block transects.

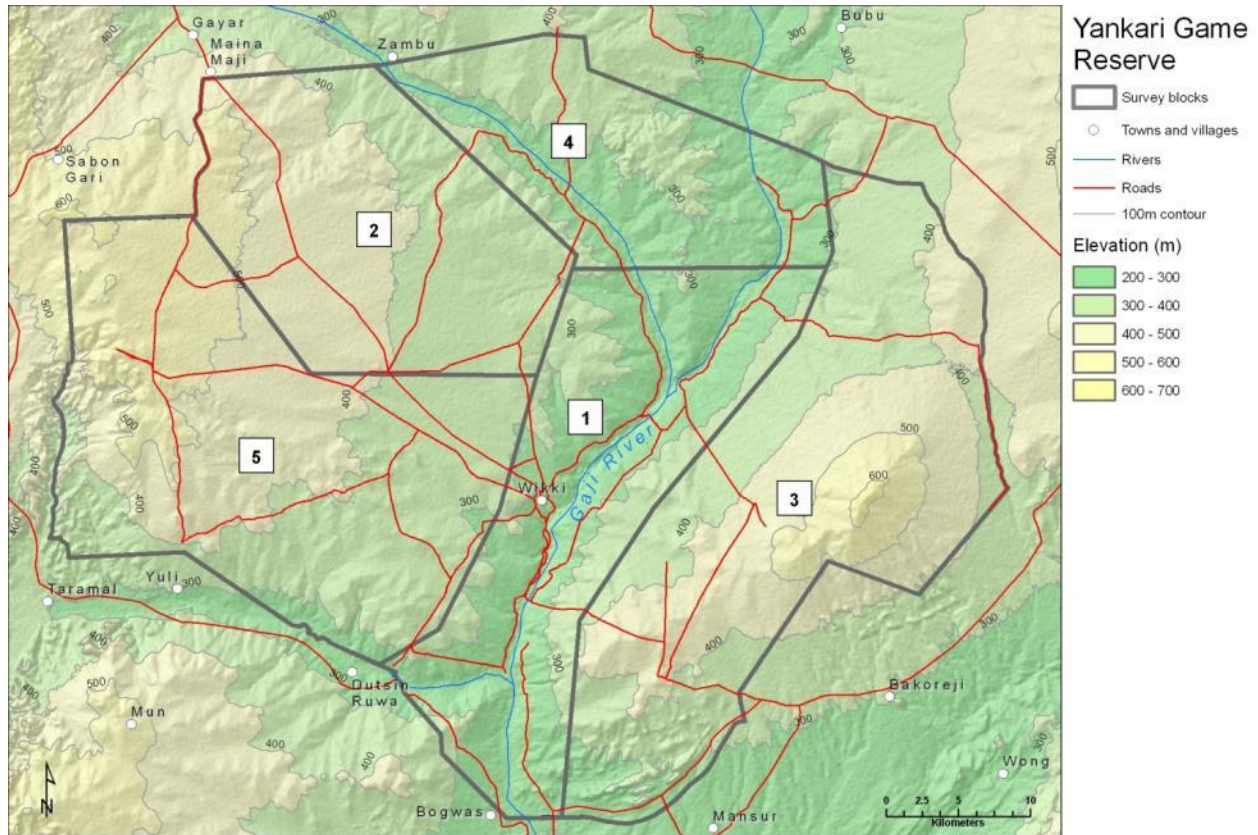


Figure 4. Counting block design for the aerial survey. Core wildlife habitat along the Gaji River was placed at the center of block 1.

### *Flights and data collection*

Flights were conducted between April 29<sup>th</sup> and May 2<sup>nd</sup>, 2011. With the exception of the last day of the survey when only a single morning flight was conducted, two flights per day were conducted (early morning and late afternoon). A Cessna 172 equipped with a Garmin GPS 496 was employed to conduct the survey. The aircraft was fitted with an STOL kit which allowed flying at reduced speed without increasing stall risk. Flights were conducted from Gombe airport, located approximately 60km northeast of the reserve boundary. The same four person crew was used for all flights. The crew consisted of J. Hassan (pilot; Private Fliers), R. Bergl (front seat observer; North Carolina Zoo), G. Nyanganji (rear seat observer; WCS), and J. Umar (rear seat observer; Yankari Game Reserve). The pilot and front seat observer (FSO) were responsible for navigation using the aircraft's GPS and a handheld GPS (Garmin GPMap 62). Rear seat observers (RSOs) were primarily responsible for sighting and counting animals and evidence of human activity. The FSO recorded all observations

and marked associated waypoints in the GPS. A GPS track log was recorded for all flights, with track points marked every 100m.

All mammal species and evidence of human activity observed were recorded on paper data sheets and in a GPS. Animal groups larger than 20 individuals were photographed for later counting. For large herds (e.g., elephants), or those that could not be well-photographed during straight line flight, the aircraft spiraled around the group and additional photographs were taken. Only observations made within the reserve boundaries were recorded. When animal groups larger than 20 individuals were sighted we took high resolution digital photos and conducted counts after the fact on a computer using image analysis software. Digital photos, along with GPS waypoints and track logs were downloaded after every flight. Double counts were identified and eliminated both during flights and subsequent to data downloading by examining waypoints in ArcGIS.

#### *Ground team*

A ground team based at Wikki searched for elephant herds simultaneously with the aerial survey team on a daily basis. On days when elephants were located, the ground team communicated the location of the herd to the aerial team via mobile phone or handheld radio. The aerial team then attempted to locate the herd and conduct an over-flight. The aerial team also communicated elephant sightings to the ground team in order for the ground team to attempt to move elephants out from under canopy cover. The ground team was led by Stephen Haruna (Yankari Game Reserve), John Mshelbwala (Ministry of Environment) and Andrew Dunn (WCS).

## **Results**

#### *Flight summary*

A total of 12.17 hours counting time was flown during block transects (i.e. not including travel time to and from the reserve), with an additional 3.23 hours of counting time flown during reconnaissance flights (Table 1). Survey flights were conducted at 120-150 metres above ground level. Morning counts began between 07:00 and 08:00 and afternoon counts between 14:00 and 17:00. Groundspeed averaged 169km/h for block counts and 188 km/h for reconnaissance flights. A total of 2,666 km was covered during the survey.

	Date	Start Count	End Count	Count Time (hrs)	Distance (km)	Ave. Speed (km/h)
Block 1 N	4/30/2011	7:20	10:22	3.03	511	168
Block 1 S	4/30/2011	14:55	16:54	1.98	348	175
Block 2	4/29/2011	16:52	18:05	1.22	208	171
Block 3	5/1/2011	14:44	17:24	2.67	446	167
Block 4	4/29/2011	8:05	9:23	1.30	223	171
Block 5	5/1/2011	7:28	9:26	1.97	321	163
<b>Total</b>				<b>12.17</b>	<b>2058</b>	<b>169</b>
Recce April 29	4/29/2011	9:23	10:20	0.95	151	159
Recce April 30	4/30/2011	16:54	17:16	0.37	74	202
Recce May 1	5/1/2011	9:26	10:01	0.58	121	207
Recce May 2	5/2/2011	8:26	9:46	1.33	262	197
<b>Total</b>				<b>3.23</b>	<b>608</b>	<b>188</b>

Times and distances do not include travel to and from the reserve

Table 1. Dates, times and average speed of aerial survey flights.

### *Transect flights*

Blocks 2-4 were covered using approximately 2km spacing due to high visibility (Figure 5). The survey was conducted at the height of the dry season, so vegetative cover away from the Gaji valley was minimal. RSOs were able to observe animals as small as patas monkeys. Bad weather during part of the survey prevented us from fully surveying portions of block 2 and 5. A compressed timeline for the survey due to national elections meant that it was not possible to survey these areas on other days. However, based on the previous survey (Omondi et al., 2006), and our own observations, it is unlikely that significant wildlife was present in these unsurveyed areas.

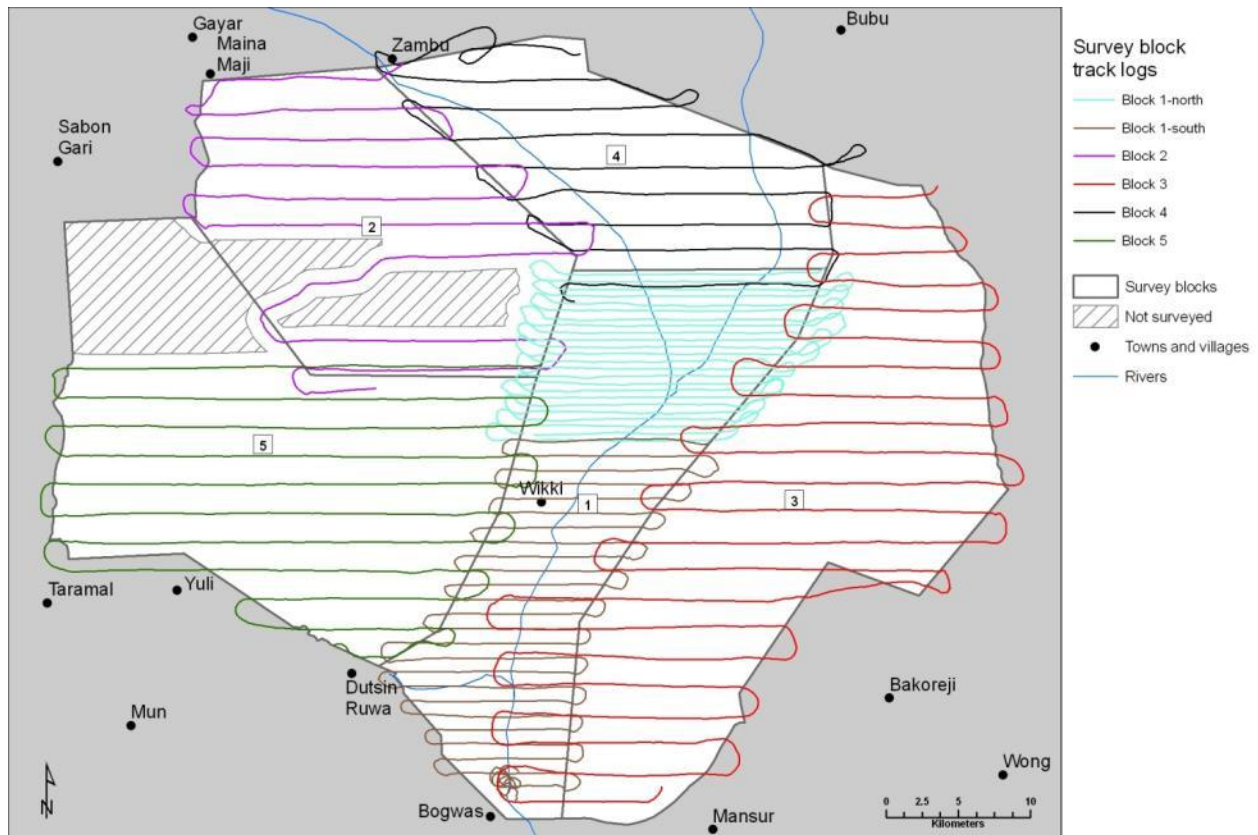


Figure 5. Track logs for transects flown during block counts

Block 1 was initially surveyed using 500m spacing to account for anticipated thick canopy cover along the Gaji River. However, our initial flight over this area demonstrated that canopy cover was dense to the point that even this close spacing did not allow observation of animals under the tree canopy. We therefore revised the spacing to 1 km for the southern portion of the block.

### *Reconnaissance flights*

Four reconnaissance flights were conducted along the Gaji River and its tributaries, both in the morning and afternoon (Figure 6). Counting time during reconnaissance flights ranged between 0.5 hours and 1.5 hours. As with the transect flights, canopy cover along the Gaji River was often too dense to allow observation of animals in some areas of the valley and even in cases where herds could be seen, it is likely that many additional animals were under cover and therefore missed.

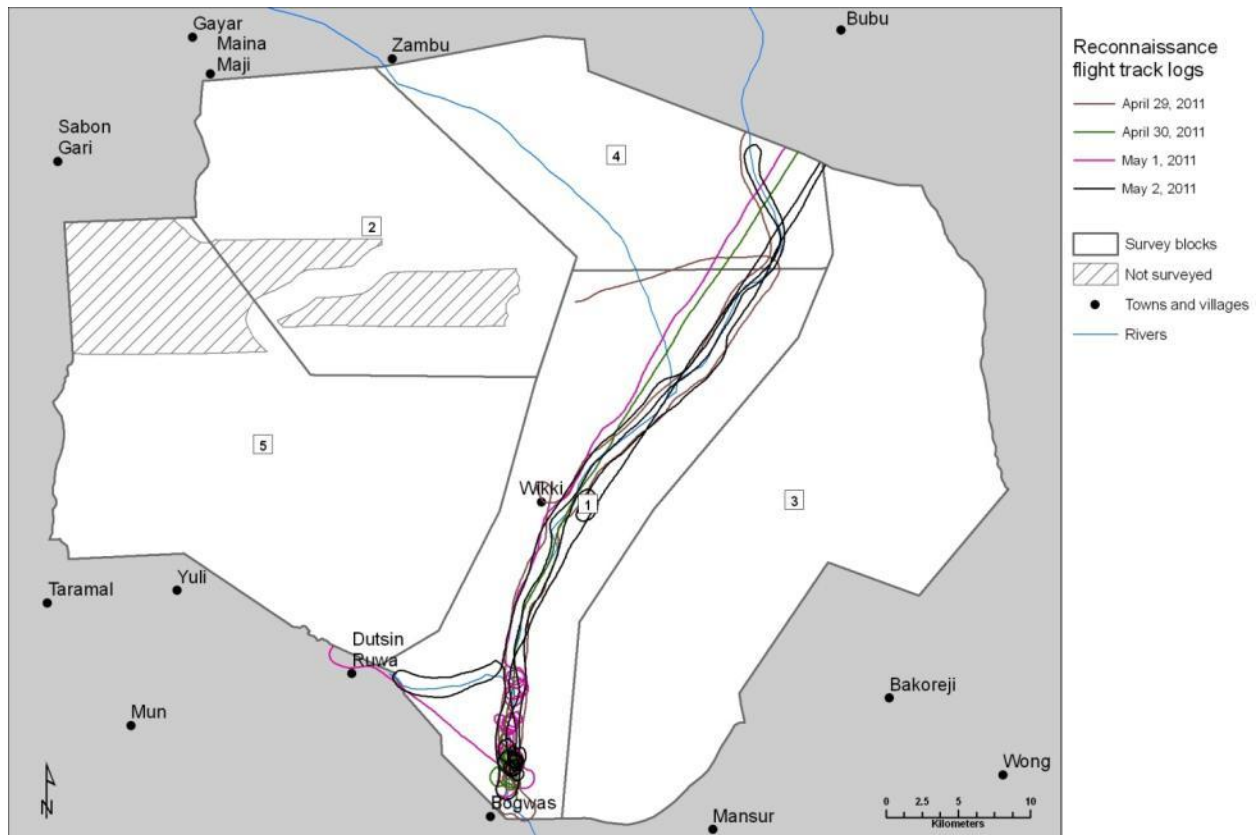


Figure 6. Track logs for reconnaissance flights.

### *Wildlife numbers and distribution*

All of the known large mammal species in Yankari were observed during the survey with the exception of hippopotamus and lion (Table 2). However, we excluded some species from total count calculations (e.g., warthogs, baboons), since total counts were unlikely to have been accurate and they are not species of conservation concern.

	Buffalo	Bushbuck	Duiker <sup>2</sup>	Elephant	Elephant carcass	Hartebeest	Roan antelope	Waterbuck
Block 1	174	6	10	326	4	41	86	29
Block 2							16	
Block 3		1	1			1	6	
Block 4			3			5		
Block 5			3	35 <sup>3</sup>		22	63	
Total	174 <sup>1</sup>	7	17	361 <sup>4</sup>	4	69	171	29

<sup>1</sup>two sightings of 23 and 25 buffalo could not be definitively identified as the same or different groups

<sup>2</sup>it was not always possible to differentiate between duiker and oribi; the totals for both species are presented together

<sup>3</sup>identified by ground team based on dung

<sup>4</sup>it was not possible to determine whether all elephants sighted represented the same or different groups

Table 2. Total counts of all large mammal species observed during the aerial survey.

The greatest concentration of sightings was along the Gaji valley, though both roan antelope and hartebeest were observed considerable distances from the river (Figure 7). While counts of all species were low in comparison to savanna ecosystems in East Africa, numbers of animals observed were either comparable to, or greater than, those

estimated during the last aerial survey of the reserve (Omondi et al., 2006). The number of buffalo (between 150 and 174) is considerably greater than the number observed in the 2006 survey and more similar to Nicholas's (1999) estimate of 148. Similarly, we counted 171 roan antelope, an increase of almost 100 individuals from the 2006 survey. Waterbuck numbers were low, but this species rarely moves away from the Gaji River (Geerling 1973) and is thus difficult to spot from the air.

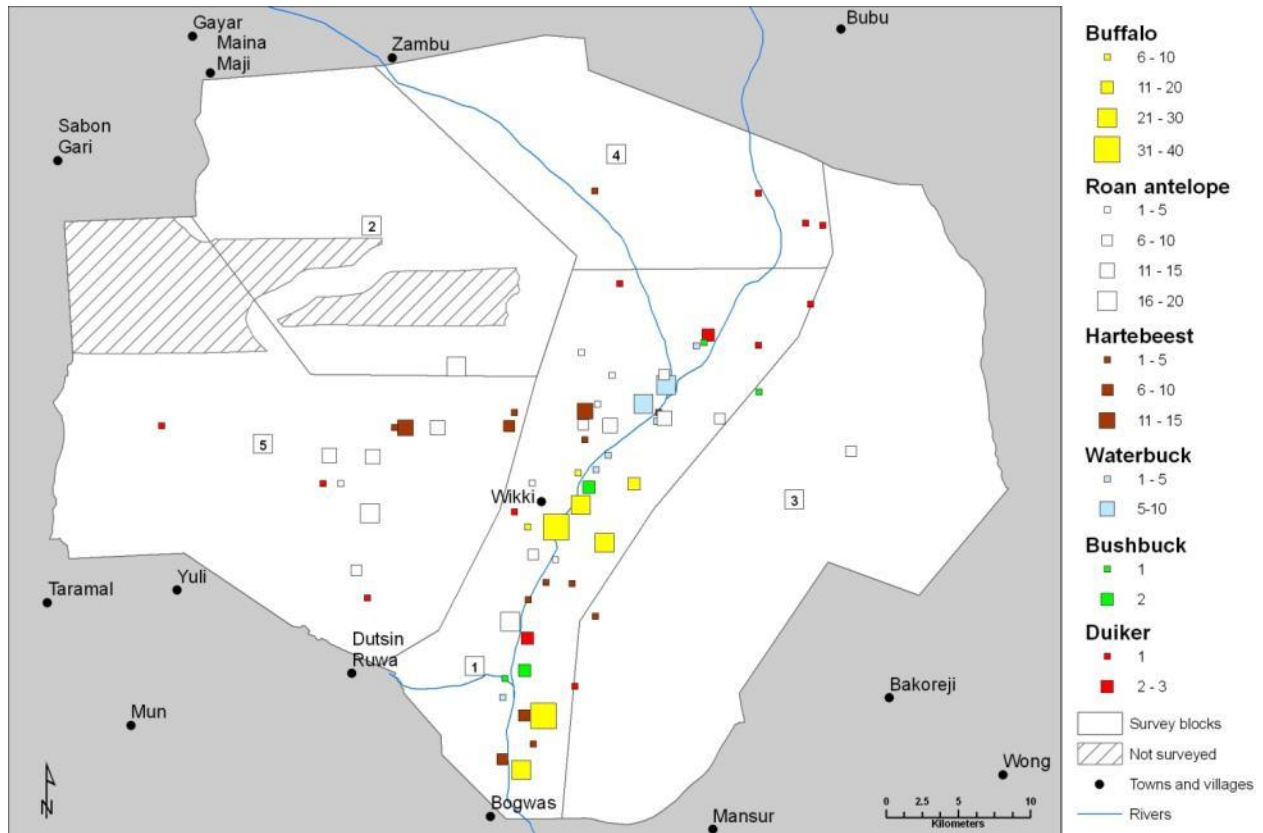


Figure 7. Distribution and size of large mammal herds (excluding elephants) observed during the survey.

Estimating the total number of elephants proved exceedingly challenging. For the duration of the survey, the only elephants observed were in thick vegetation along the Gaji River. Even in relatively open areas (e.g., Figure 8), counting herds accurately was very difficult. In closed canopy areas (see Figure 3) it is possible that significant



Figure 8. Elephants in one of the more open areas in the Gaji River valley.

numbers of elephants were missed. At least one herd recorded by the ground team, and by tourists, was not seen by the aerial survey team. We observed elephant herds on six different occasions. All but one of these sightings was made in the far south of the reserve along the Gaji River (Figure 9). Herd sizes ranged from 32 to 82. The similar size of groups seen on different occasions, their relative proximity to each other, and the known fission-fusion behavior of the elephants at Yankari meant that we could not definitively identify unique groups. If each of the groups were unique, the total elephant count would be 361 individuals, similar to the 348 counted by Omondi and colleagues (2006). However, we cannot place a high degree of confidence in this estimate and can only definitively say that the minimum number of elephants is 82 (the size of the largest herd observed).

Only four elephant carcasses were observed during the survey. These were all either old or very old (using the categories described by Craig 2005) and no fresh or recent carcasses were recorded. This is equivalent to a carcass ratio of roughly 1%. However we estimate that there have been at least 50 elephants killed since the last census in 2006, suggesting that the vast proportion of all carcasses were missed. It would have been extremely difficult to sight carcasses in the gallery forests of the Gaji Valley.

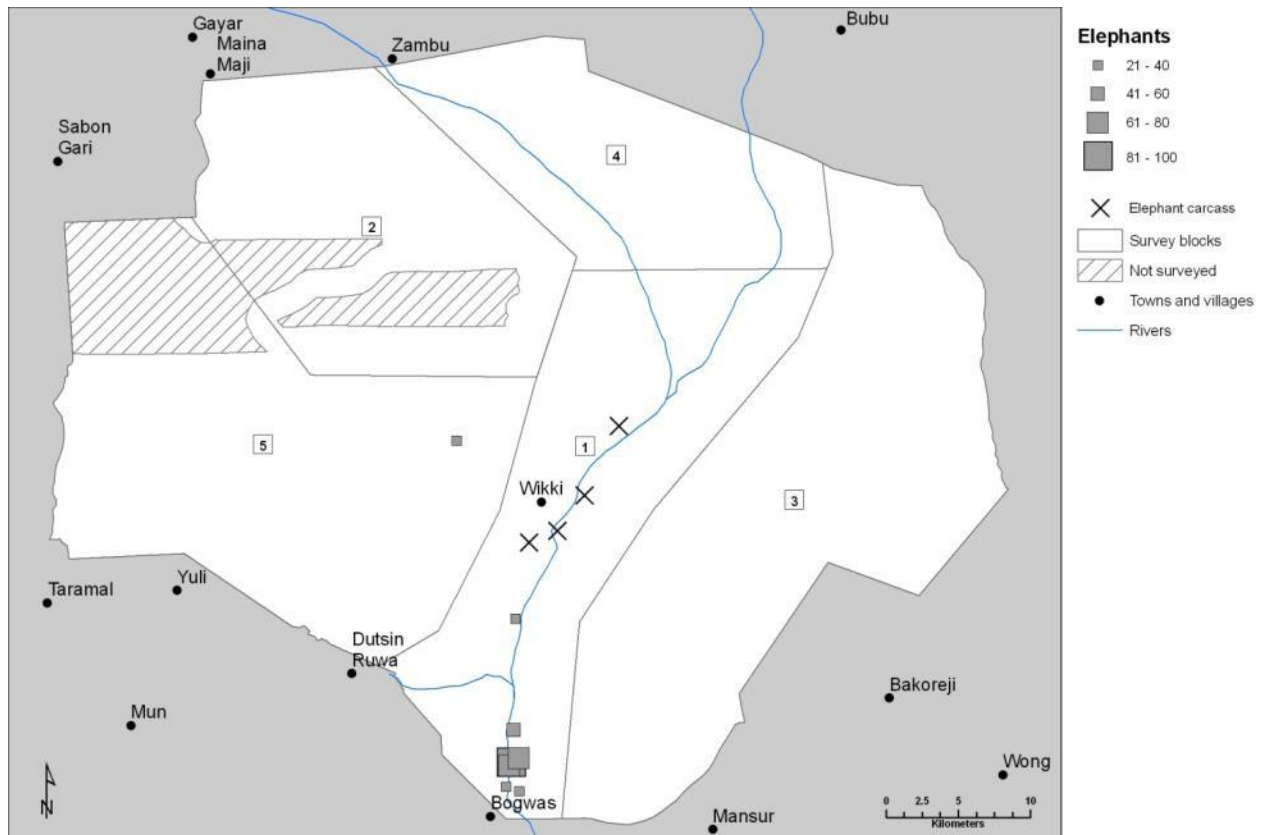


Figure 8. Elephant herds and elephant carcasses sighted during the survey.

### *Human activity*

Significant human activity was observed during the survey. Over 3,000 cattle and 900 sheep/goats were sighted within the reserve boundaries (Table 3). Livestock were observed primarily in the north-west and south-east of the reserve (Figure 9). The total numbers of livestock observed were considerably less than in the last aerial survey (Omondi et al., 2006), but the distribution and extent of penetration into the reserve has changed markedly. We observed few livestock in the south-west of the reserve (the area of greatest incursion in 2006), but increased grazing activity in other areas, particularly the south-east.

	Camps	Cattle	Farms	Sheep/goats
Block 1		656	3	50
Block 2	1	425		551
Block 3		1581		240
Block 4	1	60		60
Block 5	1	292	3	
Perimeter	2	8	3	20
<b>Total</b>	<b>5</b>	<b>3022</b>	<b>9</b>	<b>921</b>

Table 3. Levels of human activity in the reserve and on its perimeter.



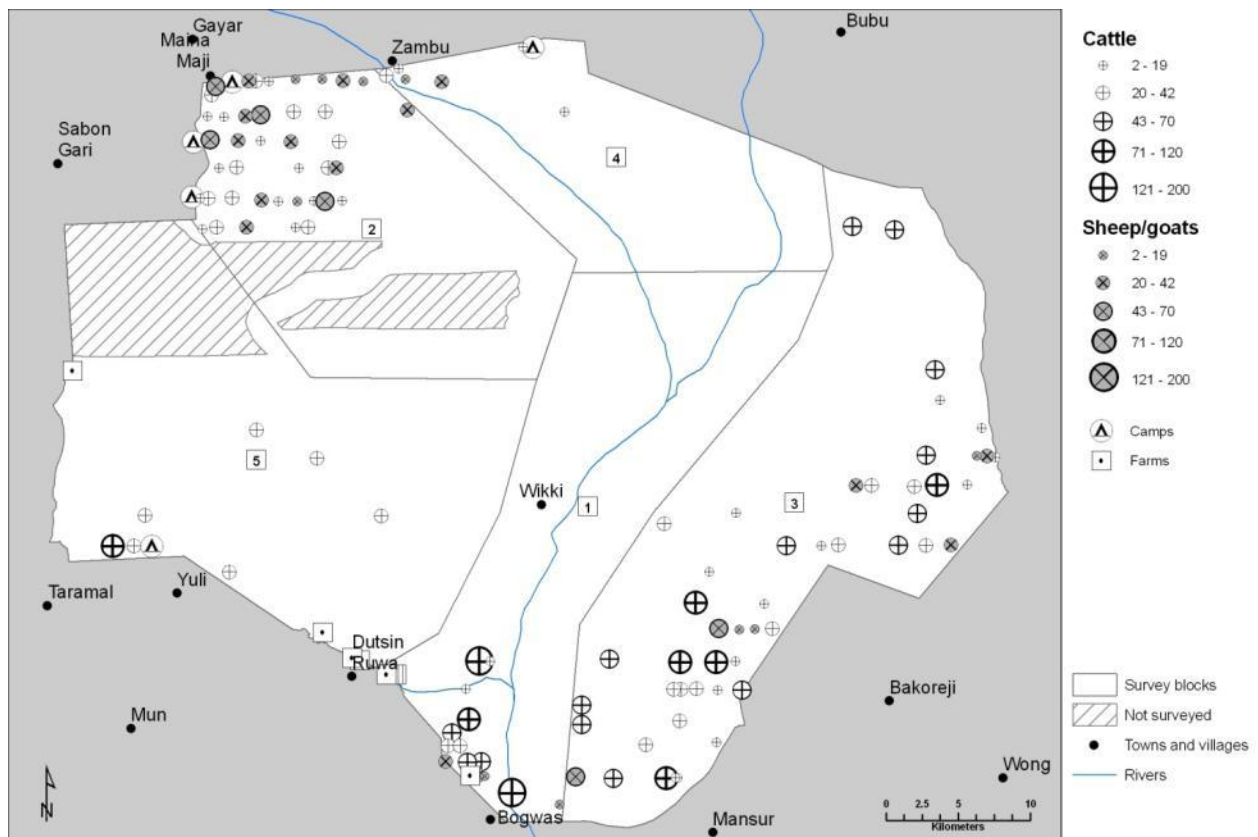


Figure 9. Distribution of human activity observed during the survey.

While considerable livestock encroachment was observed, agricultural encroachment on the reserve was limited. Both farms and camps were only observed on the perimeter of the reserve. In the case of camps, several were located just outside the boundary of the reserve, but were very clearly linked to cattle grazing within the reserve itself.

The boundaries of the reserve can be seen very clearly from the air (Figure 10). This demonstrates both that the reserve boundaries are generally respected and understood (at least in terms of clearance of land for farms), but also that the reserve is indeed an “ecological island” almost completely surrounded by areas of intense cultivation and human occupation.



Figure 10. The boundary of Yankari Game Reserve (left of frame) can be clearly seen from the air for much of the reserve's perimeter.

## Discussion

### *Yankari's elephant population*

The distribution of elephants at the time of our survey unfortunately prevented us from obtaining a reliable estimate of the elephant population at Yankari Game Reserve. All observations of elephants were made in areas of thick vegetation, precluding exhaustive counts. The presence of extensive areas of closed-canopy forest along the Gaji River meant that large herds may have been present that went unobserved. Omondi et al. (2006) had a similar experience during the previous aerial census, only observing elephants on two occasions, despite over 18 hours of counting time over the reserve. These difficulties suggest that an aerial survey over a short period of time may not be the best method by which to census elephants (or some other wildlife species like waterbuck or bushbuck) at Yankari. The heavy canopy cover and unpredictable movements of the elephants conspire to make aerial observation of elephant herds extremely difficult. More reliable options for censusing elephants include: regular and sustained tracking of elephants on foot (so that they can be counted when aggregated and crossing an open area such as a road); re-establishment of the power-chute program in order to have a more regular aerial presence and to conduct over-flights (and photography) of elephant herds when they are known to be in open areas; a dung count survey (e.g., Boafo et al. 2009); or a capture-recapture survey using genetic data derived from fecal samples (e.g., Eggert et al 2003). Each of these options has its own challenges and would incur expenses similar to those of the current aerial survey in terms of equipment, man power or laboratory analysis. If future aerial surveys are

conducted, timing them to coincide with the early rainy season (when forage and water are available away from the river valley, but before vegetative cover becomes too extensive) may produce better results.

### *Other mammals*

Though we were not able to estimate the size of the elephant population, we were able to obtain counts of many of Yankari's other resident wildlife species. Counts of all species were either equivalent to, or greater than, those derived by the previous census (Omondi et al., 2006). Since the counts we obtained are similar to those of Nicholas (1999) we are confident that these results are accurate and suggest that non-elephant wildlife populations in Yankari have not been significantly reduced by poaching in recent years. There are several methodological reasons why our counts may differ from those of Omondi. The 2006 survey was flown at considerably greater speed than the current survey (an average of 220 km/hour versus 173 km/hour). Sighting animals at this speed is more difficult. Additionally, as pointed out by Omondi and colleagues, the block design for the 2006 survey was sub-optimal, placing the Gaji River valley at the boundary between counting blocks rather than at the center of a block as was done in the current survey. This design, combined with the fact that we flew more closely spaced transects over the Gaji block, makes it possible that we were able to sight wildlife more readily than during the 2006 survey. Though wildlife populations do not appear to have reduced significantly, there is no cause for complacency. Previous estimates of the carrying capacity of Yankari for large mammal species are considerably larger than the current population (Green and Amance 1987). This suggests that hunting pressure is having an impact by preventing population growth.

### *Human activity*

In addition to differences in mammal numbers, there was a marked difference in the intensity and distribution of human activity in the current survey as compared to the survey of 2006. The numbers of livestock and farmlands observed were significantly lower in the current study, as was the extent of farmland within the reserve boundaries. However, the extent of incursion of cattle into the reserve was far greater, particularly in the south-east of the reserve. The extent of livestock incursion may be due to the timing of our survey versus that of Omondi and colleagues (2006). Since our survey was conducted at the height of the dry season it is possible that grazing areas for livestock in the areas surrounding Yankari were limited. This may have encouraged herders to drive cattle and other livestock into the reserve where food is relatively more abundant. In contrast, the 2006 survey was conducted during the rainy season when more grazing areas would have been available outside the reserve.

Comparison with the 2006 census is complicated by several factors. First, Omondi and colleagues do not differentiate between human activity observed inside and outside the reserve. Significant human activity was observed in areas far outside the reserve

boundary in their study. The fact that Omondi and colleagues used an incorrect boundary for the reserve to plan their survey and analyze their data further complicates comparisons (Figure 11). Much of the area identified in 2006 as lost habitat due to farming is actually outside the reserve. The lower levels of farming that we observed do not, therefore mean a reduction in farm encroachment, but rather reflect a more accurate definition of the reserve boundaries.

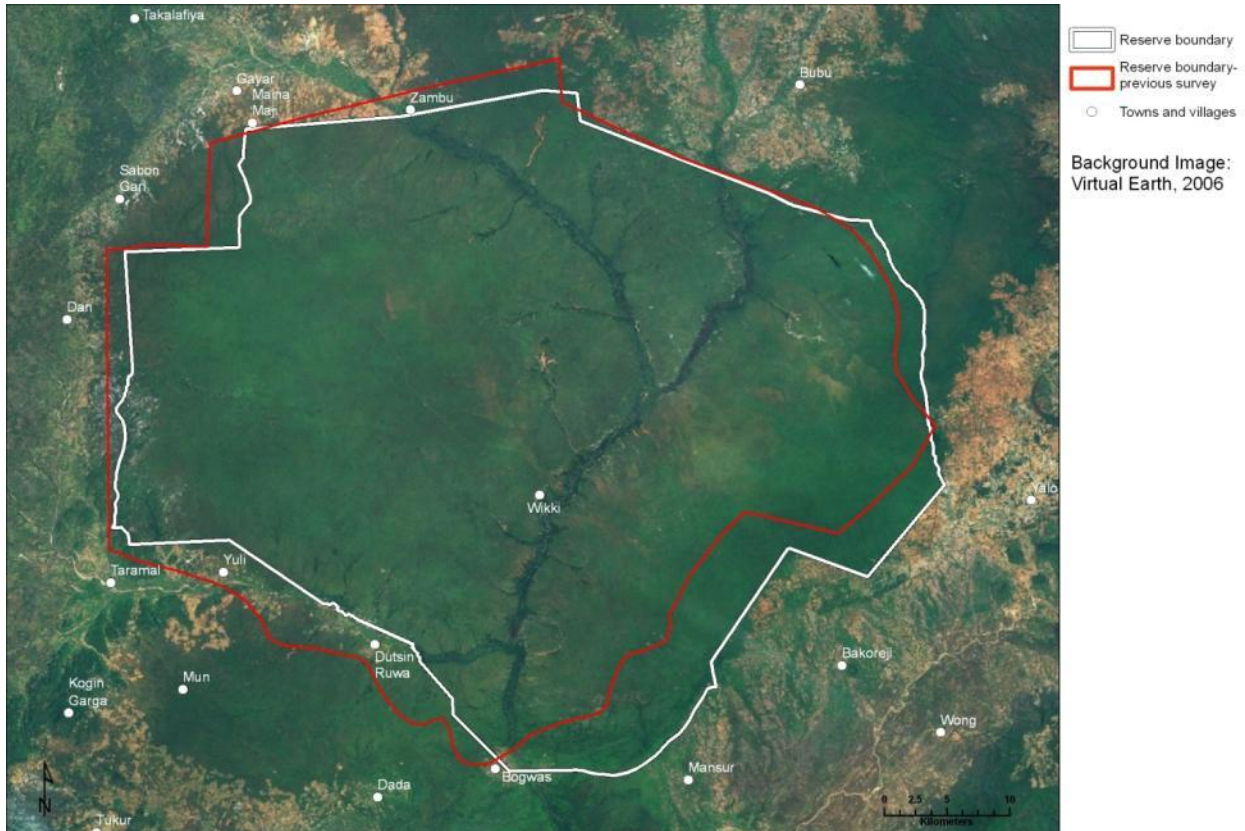


Figure 11. A comparison of the actual boundary of Yankari Game Reserve and the boundary used by Omondi and colleagues during the 2006 aerial survey.

### *Implications for conservation*

Our study shows, for species we were able to count, that wildlife populations at Yankari have been relatively stable in recent years. However, the fact that none of the populations appears to have grown appreciably in the last decade despite the presence of extensive habitat, suggests that human activities are negatively affecting the reserve’s fauna. Both poaching and competition for food from the large numbers of livestock in the reserve need to be controlled if the wildlife populations in Yankari are to be sustainable in the future.

Despite the small population size of most of Yankari’s wildlife species, the reserve represents the best chance Nigeria has to maintain viable populations of elephants, buffalo, roan antelope and other savanna species. As such, Yanakri needs greater

attention and resources from both Bauchi State Government and conservation NGOs. At present, a number of NGOs (e.g., Wildlife Conservation Society, A.P. Leventis Ornithological Research Institute, CITES-MIKE, Nigerian Conservation Foundation, North Carolina Zoo) have varying levels of involvement and cooperation with conservation activities at Yankari. These efforts need to be better coordinated and designed to complement each other. The conservation status of Yankari has improved recently and is not as gloomy as some predict but needs continued, increased and sustained effort, conducted in the context of mutually supportive collaboration, in order for Yankari to function as an effective protected area.

## Recommendations

- Encourage increased financial commitment from Bauchi State Government for the management of Yankari Game Reserve in general and for wildlife protection in particular.
- Existing protection and surveillance efforts in the reserve need to be improved and expanded. Additional vehicles are needed. Rangers need formal training, uniforms, equipment, and functional firearms. Many of the existing rangers are only casual-staff and should be placed on permanent contracts with Bauchi State Government. Patrolling activities need to extend beyond existing roads and tracks and multi-day overnight foot patrols need to be done constantly. Protection activities should specifically target Yankari's elephant herds (see below).
- Given the relatively small population of elephants at Yankari and the growing market for ivory in Nigeria, a daily monitoring program for elephants should be established. As many herds as possible should be accompanied by rangers from dawn to dusk, with rangers camping near the elephants each night. This monitoring program could be aided by the placement of radio-telemetry collars on selected individual elephants to ensure that at least some elephants could be located at any time. Telemetry collars would have additional benefits in terms of tourist viewing of elephants and better prediction of crop raiding.
- Assess options for, and conduct, a follow-up survey to definitively count the elephant population at Yankari.
- Reestablish the powerchute program previously active at Yankari. Use of a powerchute or other ultra-light aircraft, would allow for more frequent counts of elephants and other wildlife and could make a significant contribution to law enforcement activities.
- Illegal livestock grazing within the reserve must be stopped in order to prevent habitat degradation and potential disease transmission. Put in place better safeguards to prevent entry of livestock into the reserve.
- Options to help limit elephant crop raiding should be explored including the possible creation of a buffer zone around the reserve.
- The use of fire to encourage growth of annual grasses needs to be reevaluated. Large areas of the reserve have been badly burnt and currently offer little food for wildlife. Regular and extensive burning significantly damages perennial grasses and woody plants (important food sources for many species, especially elephants; Henshaw 1979), and promotes erosion (Afolayan and Ajayi 1980), causing some authors to suggest that burning should be suspended indefinitely (Abdulahi et al. 2009).

-Review the current management plan for Yankari Game Reserve with all relevant government, NGO and community stakeholders with special emphasis on elephant protection.

-To improve levels of collaboration and trust between stakeholders organize an annual Yankari conference to review threats, prioritize and plan suitable conservation interventions.

-To improve access to all areas of the reserve and thus improve levels of protection open up more patrol tracks in the north-west, the Shaushau triangle, the east and south-east parts of the reserve.

-To improve access to all areas of the reserve and thus improve levels of protection rehabilitate Barkono bridge and Tranofur Bultu bridge to Tunga Kifi. Construct new bridges at Dalamiri, Buri, across Yuli river and south of Dimil spring.

-Liaise with the Federal Ministry of Environment and NESREA to tackle the illegal ivory trade in Nigeria.

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