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**FIXED-WING AERIAL WILDLIFE CENSUS OF THE CAPRIVI RIVER SYSTEMS**  
**A SURVEY OF RIVERS, WETLANDS AND FLOODPLAINS**  
**SEPTEMBER 2009**

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Funded by



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Cover photo credit: Kelly Landen (2009). A pod of 36 hippo rest on a sand bank in the Kavango River.

## EXECUTIVE SUMMARY

This report presents the results of the third fixed-wing aerial wildlife census of the Caprivi River systems in Namibia conducted during September 2009. The purpose of this survey is to provide recent information on the distribution, abundance and trend of wildlife species including comparisons between protected areas and conservancies. The report compares the results of this survey with earlier fixed-wing aerial surveys conducted in September 2007 and August 2004. Maps, tables and bar graphs illustrating the distribution, abundance and trend of wildlife species in various land use categories are presented.

Wildlife numbers were highest in and around formal protected areas. A total of 19,212 head of wildlife were observed during the aerial survey. For wetland species hippo occurred in the greatest numbers (1,291). We recorded two important wetland bird nesting sites each with ~2,000 nesting birds. For woodland species, buffalo occurred in the highest numbers (9,633) followed by elephants (3,450).

Wildlife numbers have increased compared to earlier surveys except for crocodile, reedbuck, and warthog. The rise in wildlife numbers may be attributed to the movement of wildlife within the Caprivi and movements between Botswana and the Caprivi. In addition, community conservation projects (conservancies) may encourage increased wildlife numbers through reduced poaching and game introductions.

Differences between wildlife counts on the three fixed-wing aerial surveys (2004, 2007 and 2009) are illustrated below.

Species	Numbers of Animals Counted on Fixed-wing Aerial Surveys		
	2004	2007	2009
Buffalo	3262	5951	9633
Crocodile	207	243	151
Elephant	860	3062	3450
Hippopotamus	1387	1269	1291
Giraffe	21	1	11
Impala	742	1361	1457
Kudu	98	134	171
Lechwe	738	767	777
Lion	4	10	24
Pelican	498	1924	343
Reedbuck	76	162	105
Roan	0	0	29
Sable	45	102	20
Sitatunga	2	7	19
Tsessebe	25	31	17
Warthog	226	176	173
Wattled Crane	8	24	41
Waterbuck	60	30	131
Wildebeest	6	35	64
Zebra	1084	1653	1689
<b>Total</b>	<b>9349</b>	<b>16942</b>	<b>19596</b>

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# FIXED-WING AERIAL WILDLIFE CENSUS OF THE CAPRIVI RIVER SYSTEMS A SURVEY OF RIVERS, WETLANDS AND FLOODPLAINS

## Introduction

This survey, in September 2009 (Sept09) is the third fixed-wing aerial census of the Caprivi river systems in Namibia. The first survey was conducted in August 2004 (Aug04) (Stander 2004) and the second in September 2007 (Sept07) (Chase 2007). These surveys are confined to the Kavango, Kwando, Linyanti, Chobe and Zambezi rivers and their associated wetlands and floodplains. Hippo and crocodile as well as floodplain ungulates including reedbuck, lechwe, waterbuck, puku and sitatunga were counted. Other large woodland mammals (elephant, buffalo, sable, kudu, zebra and impala) and wetland birds (cranes, pelicans, storks and spur-winged goose) and nesting/breeding sites were also recorded during this survey.

This report presents data from the Sept09 survey and also compares these data with the two previous aerial surveys flown in Aug04 and Sept07. These surveys, help resource managers to determine population estimates as well as evaluate changes in distributions and densities in rivers, wetlands and floodplains. The surveys also provide an opportunity to compare wildlife distribution, abundance and trend between protected areas and conservancies, and compare changes over time. These data provide both parks and conservancies with important information to help them adaptively manage wildlife populations. The survey also contributes to co-management of wildlife across parks and community conservation areas both within Namibia and across international boundaries. This co-management approach recognizes that local level management (conservancies, parks, community forests) is strengthened by conservation monitoring approaches which cross management authority boundaries and which set higher order goals and objectives which are best achieved through collaboration. The conservancies may never carry the same biomass of wildlife as protected areas, but they do aspire to support a larger biomass and diversity than at present. Conservancies are a critical part of the landscape, which provide linkages and corridors for wildlife movement (Chase 2009). At a larger scale the surveys will contribute important data to transfrontier conservation initiatives such as the Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA).

## Study Area

The Caprivi region of Namibia (~18,000 km<sup>2</sup>) is surrounded by Angola, Botswana, Zambia, and Zimbabwe, lying between the Kavango River in the west, and the Zambezi River in the east and Chobe and Linyanti rivers to the south. The Kavango, Kwando, Linyanti and Zambezi rivers are characterized by seasonal flooding and large extensive broad floodplains.

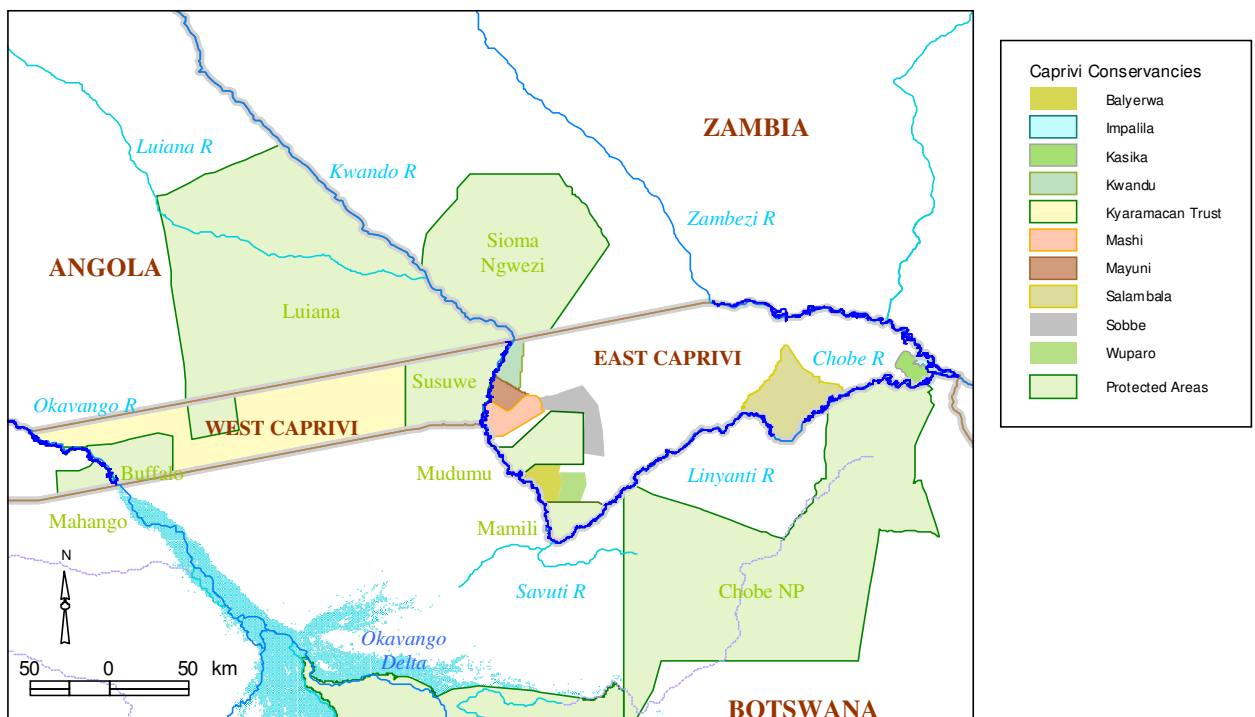
The Kwando River separates the East and West Caprivi. Our survey of wildlife along the rivers in the West Caprivi included the Susuwe segment (east core) of Bwabwata National Park (NP), on the west side of the Kwando River (94 km<sup>2</sup>), and is referred to as



Susuwe in this report. The survey along the Kavango River included parts of west core of Bwabawata NP (Buffalo NP) and the small Mahango NP on the western side of the river (48 km<sup>2</sup>, and is referred to as Mahango/Buffalo) (Figure 1). In the East Caprivi, our survey of the Kwando River included Mudumu NP (65 km<sup>2</sup>), Mamili NP (377 km<sup>2</sup>), and five conservancies (Kwandu, Mayuni, Mashi, Balyerwa and Wuparo), all of which are on the east side of the Kwando River. The conservancies of Salambala, Kasika and Impalila were also included and which adjoin the Linyanti and Chobe rivers respectively (Figure 1).

The Sept09 survey was extended to include Wuparo Conservancy (115 km<sup>2</sup>), Lake Liambezi (298 km<sup>2</sup>) and a larger portion of the Chobe Zambezi floodplains (851 km<sup>2</sup>). These new regions were included due to the high flood waters and rainfall these areas received during the 2008/2009 rainy season (Figure 2).

Figure 1. Conservancies and protected areas in the Caprivi Strip, Namibia.



## Methods

### Fixed-Wing Aerial Survey

The aerial survey was flown over 16 days between 21 September and 05 October 2009 (we did not fly on the 26<sup>th</sup> Sept. and 03<sup>rd</sup> Oct. as we transferred between strata on those days). The survey was conducted during the peak hot-dry season when we expected increased visibility and wildlife to be aggregated near the perennial rivers. To conform to earlier surveys conducted by Stander (2004) and Chase (2007), we delineated the survey area into five strata.

The Aug04 and Sept07 survey strata included the following areas:

1. Kavango – Mahango NP, Babwata West (Buffalo) and their adjacent floodplains from the Botswana border in the south, north as far as the main tar road.
2. Kwando – Babwata East (Susuwe), parts of Kwandu, Mayuni, Mashi, and Balyerwa conservancies and Mudumu NP.
3. Mamili – Mamili NP only.
4. Chobe/Linyanti – the full extent of these rivers extending east of Mamili NP including Salambala conservancy, Chobe NP, and Chobe River ending at the Kazungula Ferry.
5. Zambezi – the international boundary from Katima Mulilo to the Chobe River confluence (Kazungula Ferry) and Chobe Zambezi floodplain between the two rivers.

Within each stratum we delineated areas according to protected area or conservancy to provide species counts for the respective areas (Figure 1). For the Sept09 survey we modified and surveyed larger areas over the Kwando (included Wuparo), Chobe/Linyanti (included Lake Liambezi and Bukalo channel) and Zambezi (included larger areas of Chobe/Zambezi floodplains) strata. This was done for two reasons. First, the Caprivi rivers received record flood levels, hence larger portions of the survey area were flooded compared to the Aug04 and Sept07 surveys (MODIS 2009, Figure 2). Second, the new delineation of strata improves our understanding of wildlife abundance and distribution.

The Sept09 survey strata are defined by the following areas:

1. Kavango – Mahango NP, Babwata West (Buffalo) and their adjacent floodplains from the Botswana border in the south, north as far as the main tar road.
2. Kwando – Babwata East (Susuwe), Kwandu, Mayuni, Mashi, Balyerwa and Wuparo conservancies and Mudumu NP.
3. Mamili – Mamili NP only.
4. Linyanti – the full extent of the Linyanti River eastwards of Mamili to the Ngoma Bridge. The stratum includes Salambala conservancy, Lake Liambezi and Bukalo channel.
5. Chobe – the Chobe River from Ngoma Bridge to the Kazungula Ferry.
6. Zambezi – the international boundary from Katima Mulilo to the Chobe River confluence (Kazungula Ferry). Only observations occurring in Namibia were counted).
7. Chobe/Zambezi floodplain – the floodplains between these two rivers, and Kasika and Impalila conservancies.

For comparative reasons we present data according to the old and new strata (Figure 3a and 3b). The extent of area to survey, which was flooded/under water was determined using satellite imagery (MODIS 2009) and by flying along the periphery of the waterline prior to surveying the area.

Figure 2. MODIS satellite imagery of East Caprivi before (Jan.09) and after the flood (Jun.09).

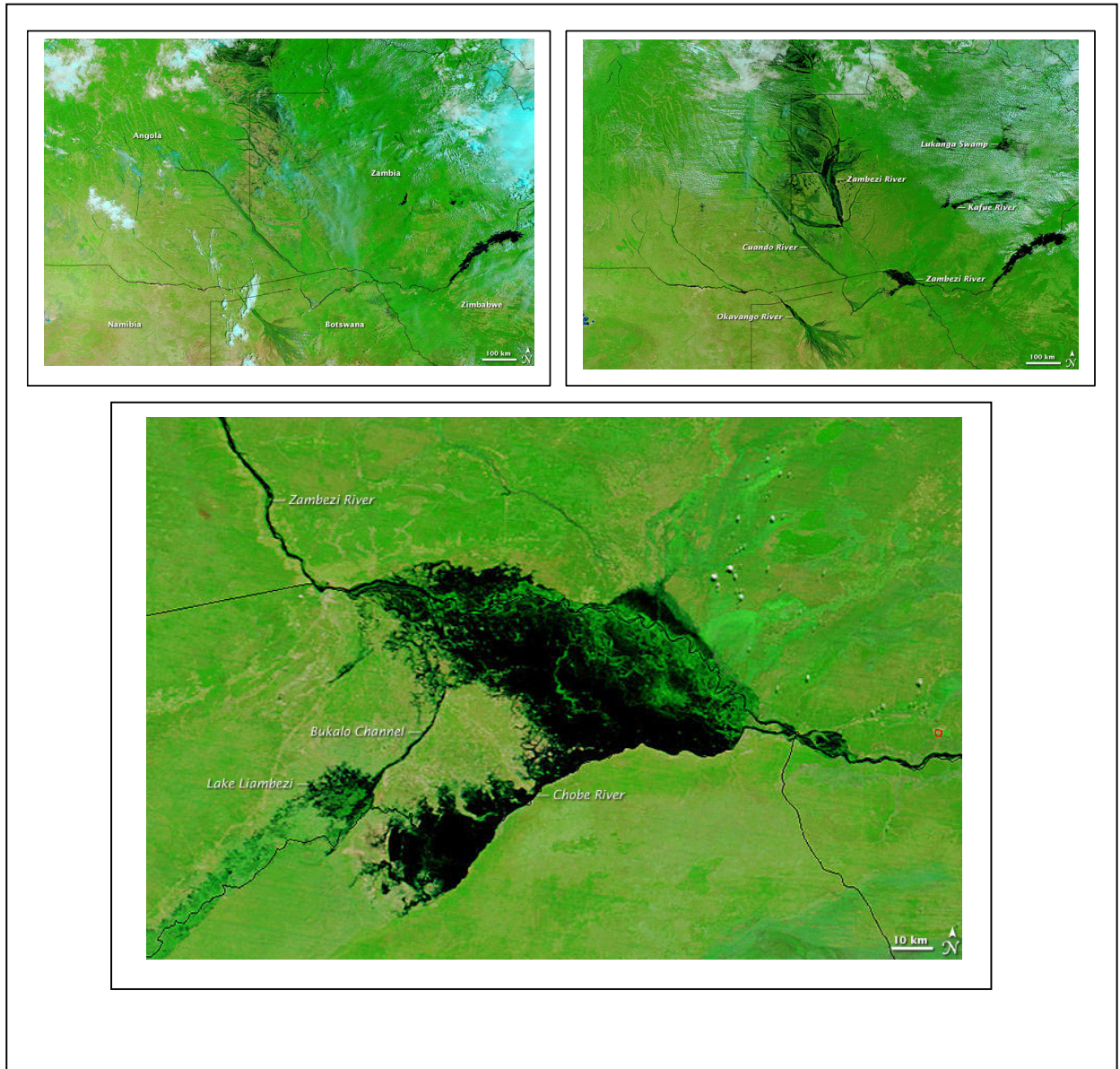
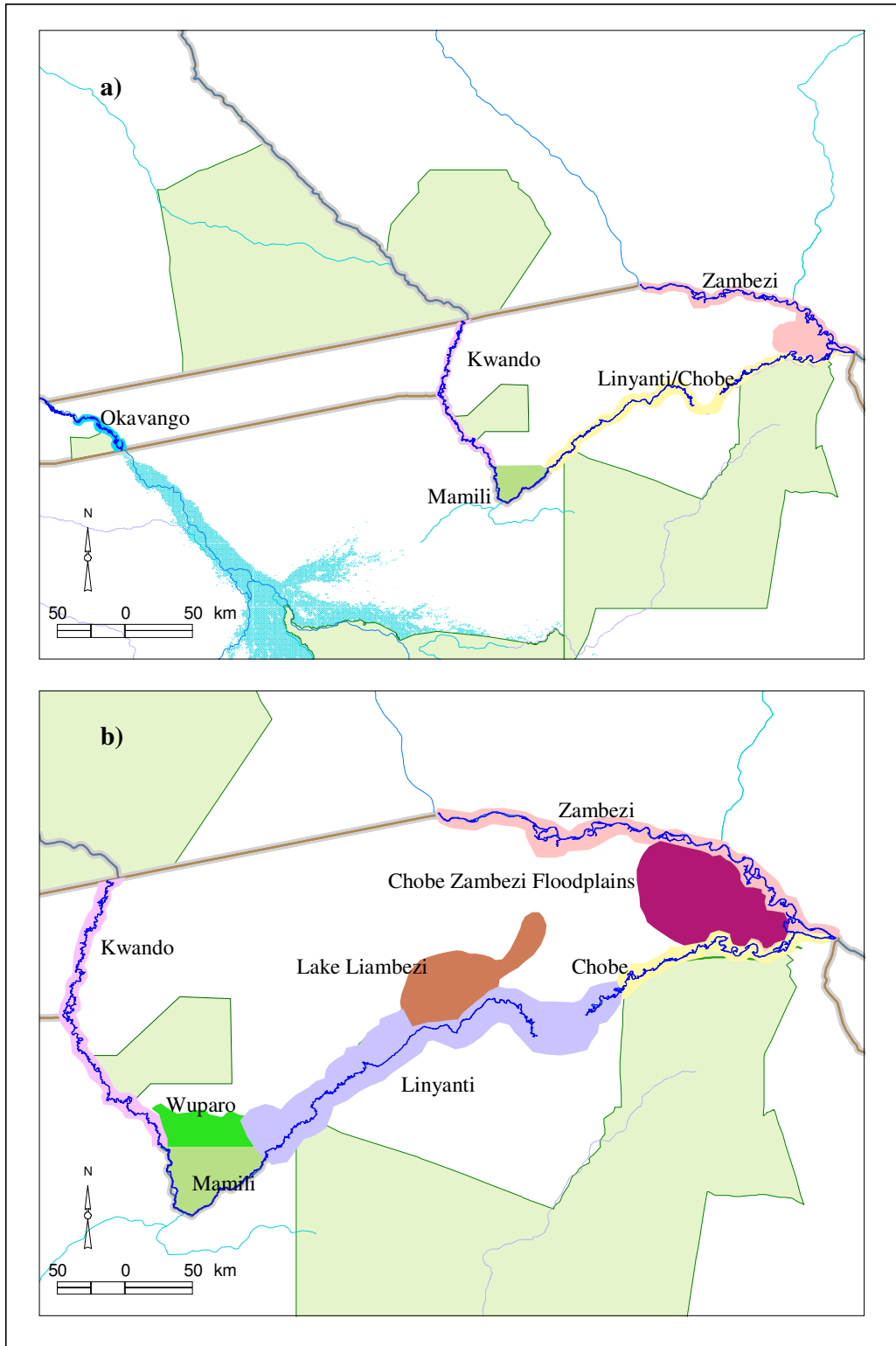


Figure 3. Caprivi river systems aerial survey strata for Sept07 (a) and Sept09 (b).



For this survey, we used the methodology of the Sept07 survey (Chase 2007). We attached two wands to each of the wing struts to delineate a 250 m and 500m interval for recording wildlife observations at an altitude of ~90 m. The interval width was increased to 500 m for the Chobe/Zambezi Floodplains and Lake Liambezi strata which are open, flat and which generally support less wildlife. The survey was flown by means of a total count. We spaced transects 500 m or 1 km apart, providing a 100% sampling coverage. We typically flew transects during morning hours (~0730 - ~1100 hrs); however, the Kavango and Chobe rivers was flown between ~1600 - ~1730 hrs to conform to the Sept07 survey.

Interval widths on each side of the plane were calibrated and confirmed prior to initiating a survey over each stratum. This was done by placing markers at measured distances on the airstrip and conducting flyover tests. After repeated flyovers and photo verification, wands were adjusted to provide the designated interval widths at appropriate flight altitude. The aluminum wands were semi-permanently attached to the struts for the duration of the survey.

Transects were flown at an average speed of 90 knots using a Cessna single engine plane. Height *above ground level* was maintained using a Bendix King radar altimeter. Flight transects were systematically flown along generally east/west axes, corresponding to the perpendicular gradient of major watercourses. For logistical reasons and to conform to previous surveys we flew the eastern half of Mamili NP, Lake Liambezi and Wuparo Conservancy in a north/south orientation.

Prior to flying, all transects were incorporated into a digital map of the survey area with their beginning and end point coordinates. This digital map was created using ArcView 3.2 (ESRI 2002) software and showed observable landmarks and boundaries. All transects were mapped as routes (Mapsource 2007) prior to flying and shown on the digital map with their beginning and end point coordinates. We used GPS receivers (Garmin 12xl, Garmin 176c) and DNR Garmin software (Minnesota Department of Natural Resources, GIS Section) to navigate along transects.

For all strata we used the standard methodology for transect sampling developed by Norton-Griffiths (1978). For the Chobe and Zambezi Rivers the flight path was restricted to the river and backwaters. Observers recorded wildlife species inside and outside the counting interval (Stander 2004). Observers recorded herds when they were as nearly perpendicular to the plane as possible. Additionally, a mark was put on the plane window to help observers keep their eyes at a consistent height to maintain the same sighting angle for each observation. This helped us to keep consistent interval widths for each observation and reduce double counting. Any animals outside of the area delineated by these wands were not counted. For each observation seen within the transect interval, the observer called out the numbers of species. The pilot, data recorder and two observers were able to communicate efficiently through a four-way intercom headset box. With each herd observation, a data recorder entered a waypoint on the GPS. The recorder also kept a written data log for each observation including: the waypoint number and time, altitude from the radar altimeter, and number of individuals observed. The start and end times for

each transect were also recorded. The same three observers were used throughout the survey, one on each side of the plane. Two of the observers had extensive previous aerial survey experience (LSO > 950 hrs RSO > 30 hrs) prior to this project.

To verify herd size and the sighting of herds within the interval defined by the wands, two digital EOS 30D Canon cameras were used. The components of the camera system consisted of two cameras with 20-mm wide-angle lenses, camera backs with time code generators, remote switches and two window camera mounts. A camera was mounted on each side of the plane and the center of the lenses corresponded with the marks on the plane window that were used to help observers keep their eyes at a consistent height for each observation. The cameras provided high-resolution photos so that animals could be more accurately counted during subsequent analyses. Typically, observers took a picture with each wildlife observation > 20 animals. A GPS time code and date were recorded to the second for every frame exposed.

### Boat and Helicopter Survey

To determine the efficacy of our fixed wing aerial survey, we conducted a helicopter count of wetland/aquatic wildlife species along the Kavango River and a boat count on the Chobe River. The helicopter count was flown at an altitude of 200 feet and a speed of 60 knots. The same recording protocol conducted during the fixed wing count was adhered to on the helicopter count. For the boat count, we counted wetland species which were observed from the boat while navigating along the main channel and back waters of the Chobe River.

### Data Analyses

Photo-Interpretation. The number of individuals in the digital image of each herd was counted and compared to the observers' counts. This method verified and/or corrected observers' herd counts and determined whether animals occurred within the counting interval. This method was especially helpful in counting large herds that are difficult to count from the air.

Total Count. The entire area was covered in adjoining transects which were 500 m or 1 km apart, and the total number of animals counted is the total population for the counting area.

## Results

### Sampling Effort

For the 2,719 km<sup>2</sup> survey area, 44 hours were flown totaling 4,878 km (Table 1 and Figure 4). Flight altitude averaged 92 m (range 82-126 m) for wildlife observations.

Table 1. Summary parameters for Caprivi river systems fixed-wing aerial survey, Sept09.

Stratum / Area Surveyed	Transect Spacing (m)	Survey Area km <sup>2</sup> (year)		Total Transect Length (km)	Av Height (ft)	Area Covered (km <sup>2</sup> )	Time Taken (min)	Search Rate (km <sup>2</sup> /min)
Survey Year		2007	2009					
<b>Kavango</b> (Muhango/Buffalo)	500	<b>80</b>	<b>80</b>	162	304	81.16	117	0.69
<b>Kwando</b>	500	<b>370</b>	<b>550</b>	1123	296	562.62	521	1.08
	Susuwe	500	94	94				
	Mudumu	500	65	65				
	Kwandu	500	56	56				
	Mayuni	500	25	25				
	Mashi	500	30	30				
	Balyerwa	500	41	106				
	Wuparo	500	0	115	<i>230</i>	<i>306</i>	<i>115.23</i>	<i>113</i>
	Kwando Botswana	500	59	59				
<b>Mamili</b>	500	<b>377</b>	<b>377</b>	744	293	372.74	386	0.97
<b>Linyanti</b>	500	<b>466</b>	<b>713</b>	1288	298	645.29	552	1.17
	Lake Liambezi	1000	98	298	<i>453</i>	<i>265</i>	<i>226.95</i>	<i>222</i>
	Salambala	500	86	86				
<b>Chobe River</b>	500	<b>54</b>	<b>54</b>	106	301	53.11	49	1.08
	Chobe NP	500	54	54				
<b>Chobe/Zambezi Fplains</b>	1000	<b>361</b>	<b>851</b>	1512	295	757.51	630	1.20
	Kasika	500	311	416				
	Impalila	500	60	78				
<b>Zambezi River</b>	1000	<b>94</b>	<b>94</b>	168	268	84.17	98	0.86
<b>Total</b>		1778	2719	4878		2443.88	2688	0.91

*Not included in total*

### Fixed-Wing Survey Results

We observed 19,212 animals, the highest numbers (6,356) occurred in the Mamili stratum, while the lowest numbers occurred in the Zambezi stratum (101) (Table 2). The most abundant species were buffalo (9,633) and elephant (3,450). The most birds observed on the survey were openbill storks (4,200); on the Kavango River we counted ~ 500 spur-winged goose. Rare bird observations included a flock of 350 black egrets and 30 wattled crane on the Chobe/Zambezi floodplains. Important nesting sites which had several hundred birds (openbill storks, and pelicans) nesting in shrubby vegetation were recorded on Lake Liambezi and the Chobe/Zambezi floodplains. Human activity was recorded by including cattle (31,716), mokoros (1,328) and fishing nets (309) in our observations. The majority of cattle (10,561) and mokoros (787) were observed along the Zambezi River, while the most fishing nets were recorded in the Linyanti Stratum (254, mostly confined to Lake Liambezi) (Table 2 & Figure 5b).

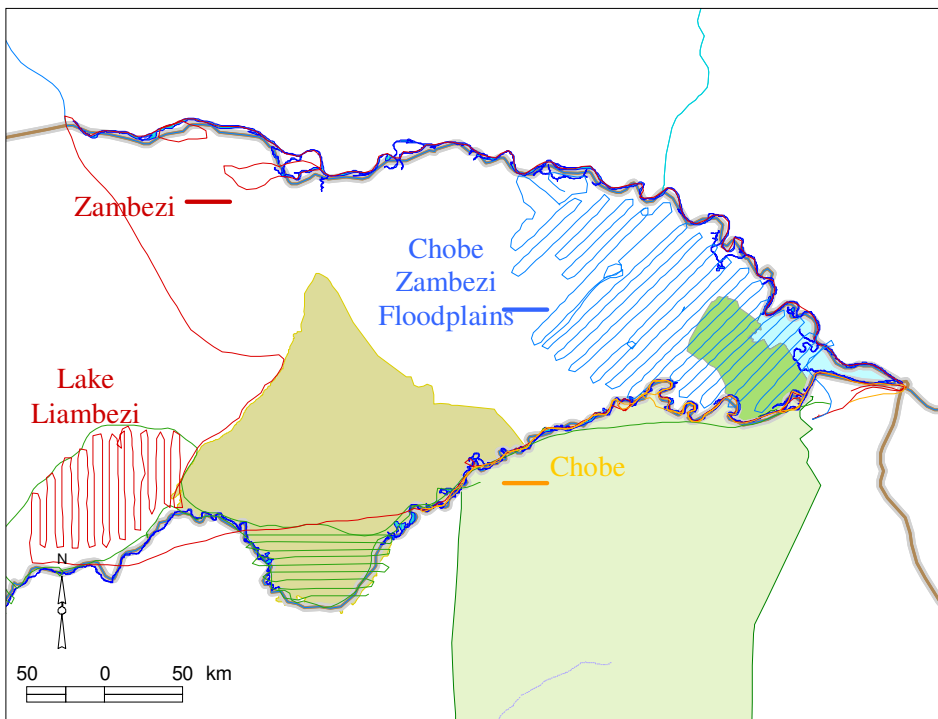
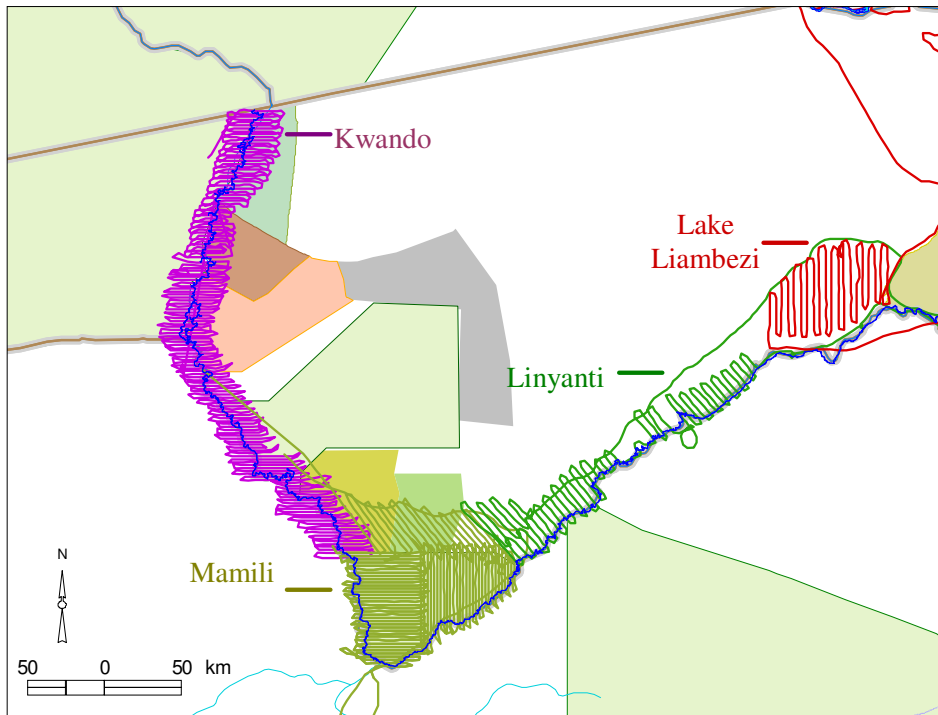
<sup>1</sup> A search rate of 1.5 is considered adequate for large animals, but 1 or less should be aimed at for other animals (Gasaway *et al.* 1986, Craig & Gibson 2002).

Table 2. Wildlife numbers counted in each stratum, Caprivi river systems aerial survey, Sept09.

Survey Strata Sept09								
Observation	Chobe	ChobeZamFplains	Kavango	Kwando	Linyanti	Mamili	Zambezi	Total
<b>Wildlife</b>								
Buffalo	2351	155	519	2276	52	4280		9633
Crocodile	21	15	33	14	3	31	34	151
Elephant	576	118	5	1476	29	1227	19	3450
Giraffe	8		1	2				11
Hippo	210	49	470	252	57	230	23	1291
Impala	271		206	824		156		1457
Kudu	8		71	81		11		171
Lechwe	44	45	169	276	3	240		777
Lion	14					10		24
Reedbuck	3		55	13	7	27		105
Roan			29					29
Sable			13	7				20
Sitatunga				11		8		19
Tsessebe			1	16				17
Warthog	12		18	9		134		173
Waterbuck	107		14	10				131
Wildebeest				64				64
Zebra	1640			49				1689
<b>Subtotal</b>	<b>5265</b>	<b>382</b>	<b>1604</b>	<b>5380</b>	<b>151</b>	<b>6354</b>	<b>76</b>	<b>19212</b>
<b>Birds</b>								
Egret Black		350						350
Open Bill Stork		4200						4200
Ostrich			18	2				20
Pelicans	215				128			343
Wattled Crane		30	9			2		41
<b>Subtotal</b>	<b>215</b>	<b>4580</b>	<b>27</b>	<b>2</b>	<b>128</b>	<b>2</b>		<b>4954</b>
<b>Human Activity</b>								
Cattle		10561	366	3577	10297		6915	31716
Mokoro		322	1	90	175		740	1328
Net		11		34	254		10	309
<b>Subtotal</b>		<b>10894</b>	<b>367</b>	<b>3701</b>	<b>10726</b>		<b>7665</b>	<b>33353</b>
<b>Total</b>	<b>5466</b>	<b>15856</b>	<b>1998</b>	<b>9083</b>	<b>11005</b>	<b>6356</b>	<b>7741</b>	<b>57519</b>



Figure 4. Recorded track logs of flight paths during the Sept09 fixed-wing aerial survey.



## Wildlife Distribution

The distribution of wildlife during the Sept09 survey was largely confined to the protected areas (Figure 5a). However, during the Sept09 survey, we observed more species distributed in the conservancies than on two previous aerial surveys (Aug04 and Sept07). Hippo, lechwe, buffalo and elephant occurred in greater numbers in the conservancies during the Sept09 survey than surveys conducted in Aug04 and Sept07. This may be attributed to the increase in water availability and community conservation initiatives. Hippo have increased in the conservancies by 40%, with the greatest number (71) counted in Balyerwa (Figure 6). The majority of lechwe were distributed in Mamili NP, along the Linyanti River and close to the Botswana border. Along the Chobe River most lechwe occur on Sedudu/Kasika Island.

We counted fewer lechwe in the protected areas on the Sept09 survey. However, we counted the largest numbers in conservancies compared to previous surveys. Lechwe (45) were observed 35 km north of the Chobe River in the Kasika conservancy, but fewer lechwe were observed in Mayuni and Mashu conservancies (Figure 7). The only reedbuck observed in conservancies occurred in Mayuni. Most reedbuck (55) occurred in Mahango NP, on the Kavango River (Figures 8 & 15). Crocodile numbers in the protected areas and conservancies have declined, 79 compared to 120 observed on the Sept07 survey. Crocodile were widely distributed in the Chobe and Zambezi floodplains away from the main river channels (Figure 9). For woodland species buffalo, elephant, impala and Zebra increased on the Sept09 survey. This was the first survey to record 155 buffalo on the Chobe/Zambezi floodplains (Figure 10). A significantly large herd comprising of 789 buffalo were counted in Wuparo. Elephant have doubled in the conservancies with the most numbers (379) occurring in Balyerwa (Figure 11). Impala were distributed in Kwandu and Mashu conservancies (Figure 12). During our Sept09 survey, zebra were primarily observed grazing on the floodplains within Chobe NP. On previous aerial surveys zebra were observed along the Linyanti and Chobe floodplains and occurred in great numbers in the Salambala conservancy (Figure 13).

For the Kavango stratum, many of our wildlife observations were confined to the protected areas of Mahango and Buffalo or West Core of Bwabwata NP (Figure 14 & 15). While we extended the survey area north of the protected areas along the Kavango River to the Angolan border (~51 km) we only observed 5 pods of hippo and 2 crocodile north of the protected areas. The Kyaramacan conservancy on the east side of the river, has encouraged wildlife to disperse north of the tar road in to Angola where we observed elephant, buffalo, kudu and sable while flying along the Namibia/Angola border.

Figure 5. Wildlife sightings (a) and human activity (b) recorded in conservancies and protected areas during aerial survey of Caprivi river systems, Sept09.

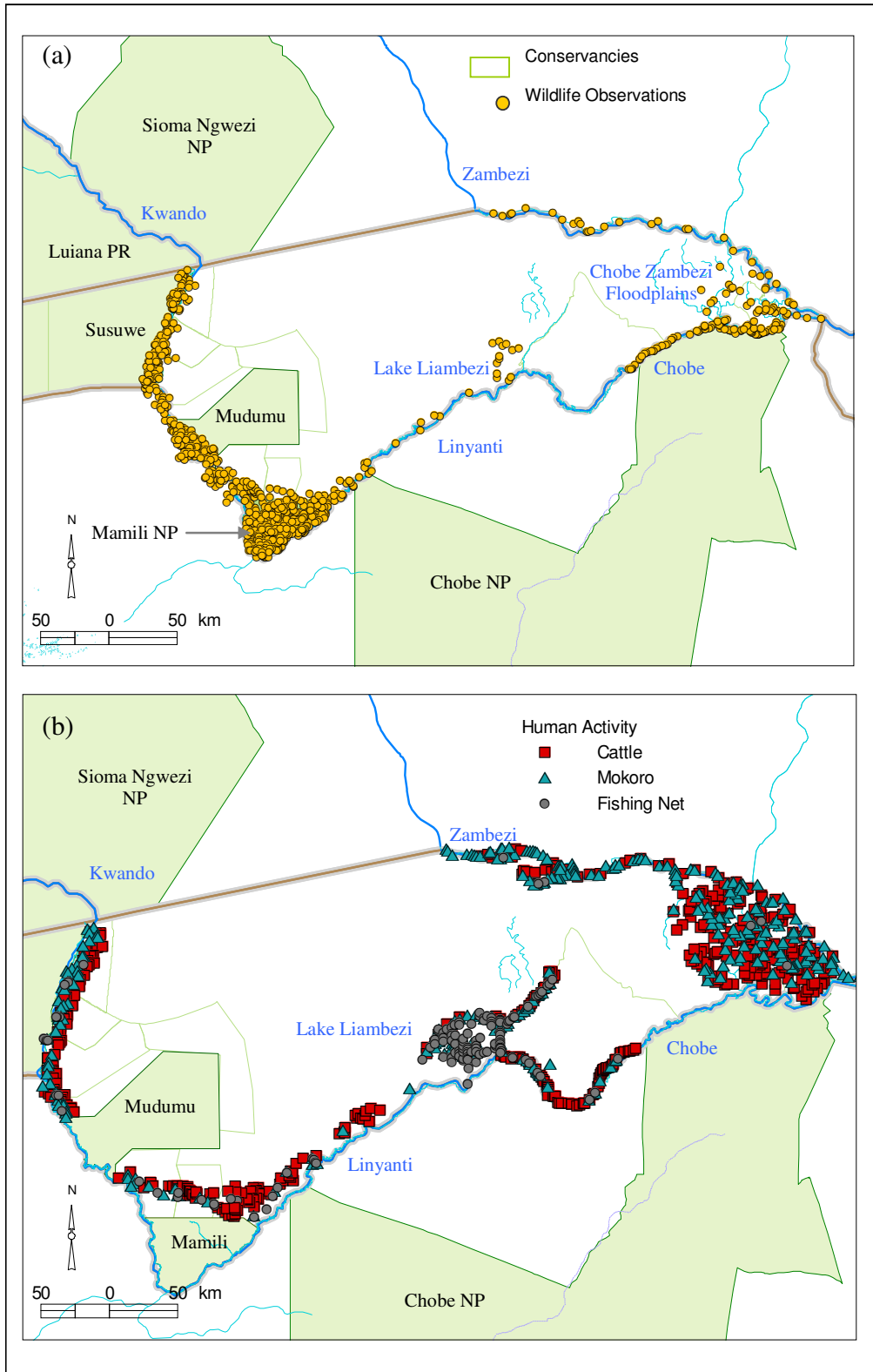
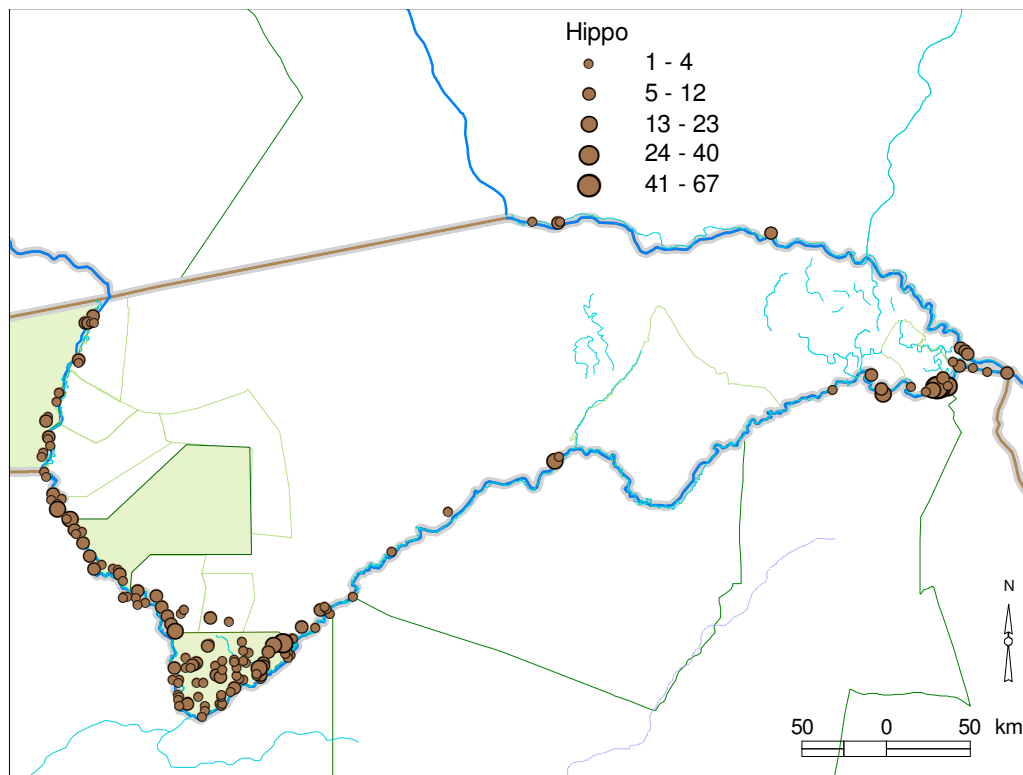


Figure 6. Distribution of hippo during aerial survey of Caprivi river systems, Sept09.



Hippopotamuses were primarily distributed along the major rivers within protected areas. Nearly a third the total numbers counted (409) occur in Mahango NP. Many hippos were also observed great distances away from protected areas. Hippos were distributed near Shile in the Linyanti River, and Wuparo conservancy which were dry on previous surveys. On our survey along the entire length of the Zambezi River in Namibia (~160 km) from Katima Mulilo (Namibia/Zambia border bridge) to the Chobe River confluence (Kazungula Ferry crossing) we counted just 23 hippos. These hippos were primarily observed adjacent to tourism lodges straddling the river. The total number of hippos observed between the Aug04 (1,387), Sept07 (1,269), and Sept09 (1,291) surveys remain similar. Fewer hippos were observed in Mamili, Mudumu and Susuwe. Sixty one hippos on the Kavango occur in an area of high human and cattle density upstream of Mahango NP and a similar number occur in the Balyerwa and Kasika conservancies under the same conditions. Immediately upstream of Mamili NP, on the Linyanti River towards the western boundary of Salmabala is an area of dense human settlement and cattle but we counted 57 hippos in this area. The absence of hippos along the Linyanti may be attributed to the effects of human disturbance or water availability. The Linyanti River in future years may support larger numbers of hippos if the river continues to receive increasing levels of water.

Figure 7. Distribution of lechwe during aerial survey of Caprivi river systems, Sept09.

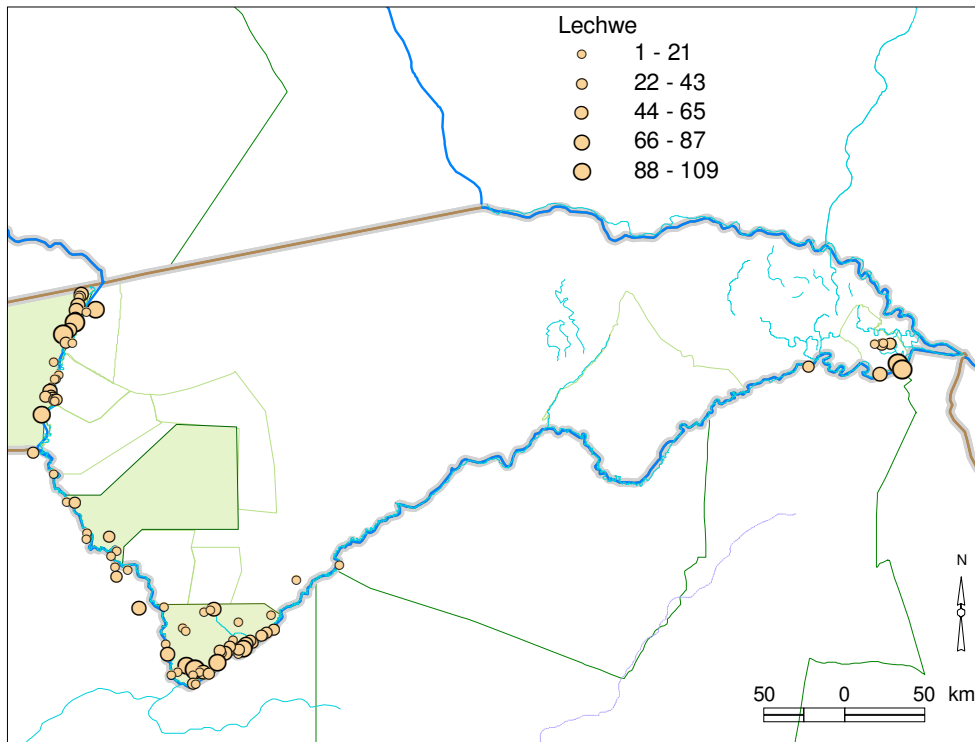


Figure 8. Distribution of reedbuck during aerial survey of Caprivi river systems, Sept09.

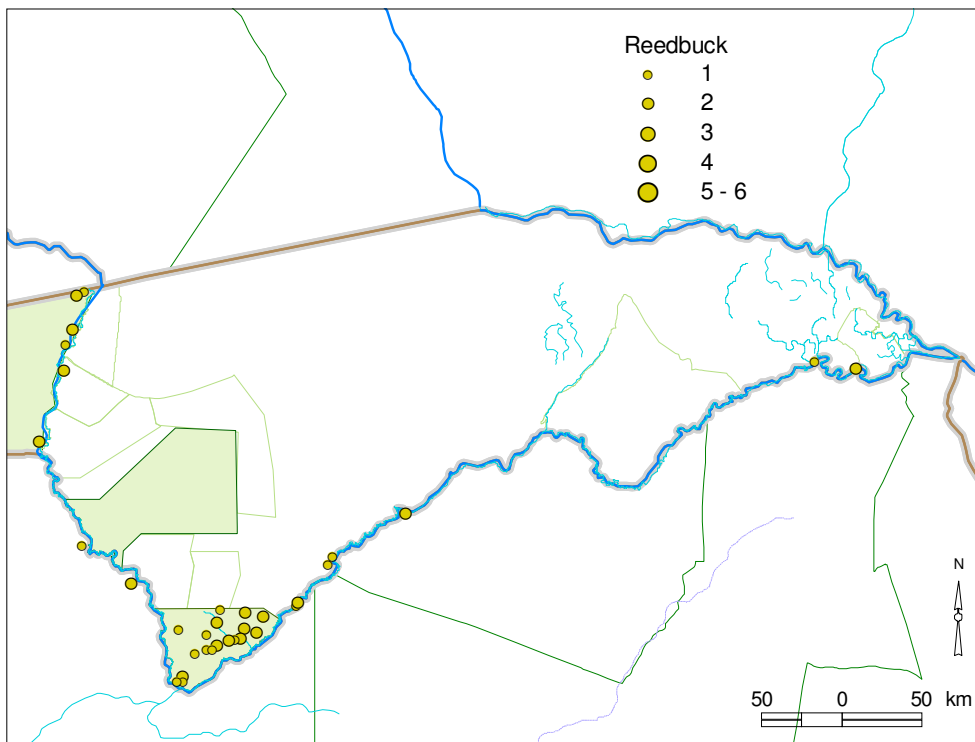
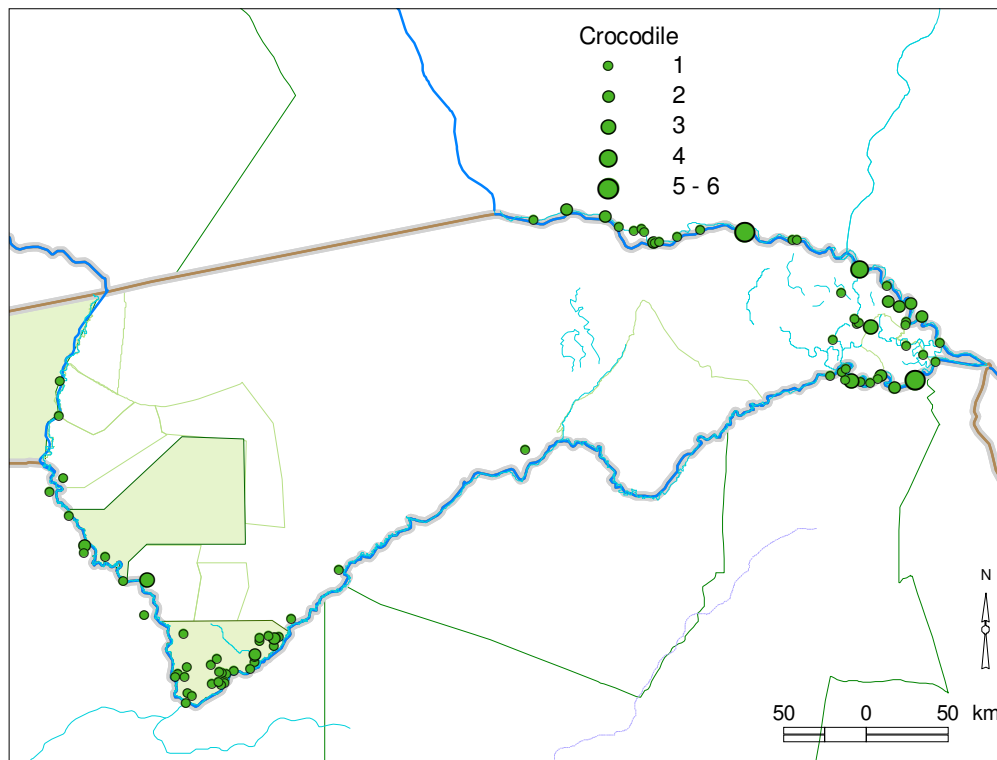


Figure 9. Distribution of crocodile during aerial survey of Caprivi river systems, Sept09.



Lechwe were largely distributed along the major rivers in protected areas, with most herds occurring in Susuwe west of the Kwando River and Mamili NP, along the Linyanti River close to the Botswana border. Along the Chobe River most lechwe occur on Sedudu Island. Lechwe were observed 35 km north of the Chobe River in the Kasika conservancy.

In the East Caprivi, reedbuck occurred mainly along the Linyanti River in Mamili NP. For the Kavango River stratum, most observations for reedbuck occurred on the western side on the river in Mahango NP. Mahango NP is an important refuge for reedbuck populations. Two reedbuck observed in Mayuni were the only observations spotted in conservancies. Three reedbuck were observed along the Linyanti and Chobe rivers respectively.

Crocodile typically occurred along the Linyanti River in Mamili NP. Crocodiles were also distributed away from the major Zambezi and Chobe rivers and observed in the wetlands/floodplains between the two rivers.

Figure 10. Distribution of buffalo during aerial survey of Caprivi river systems, Sept09.

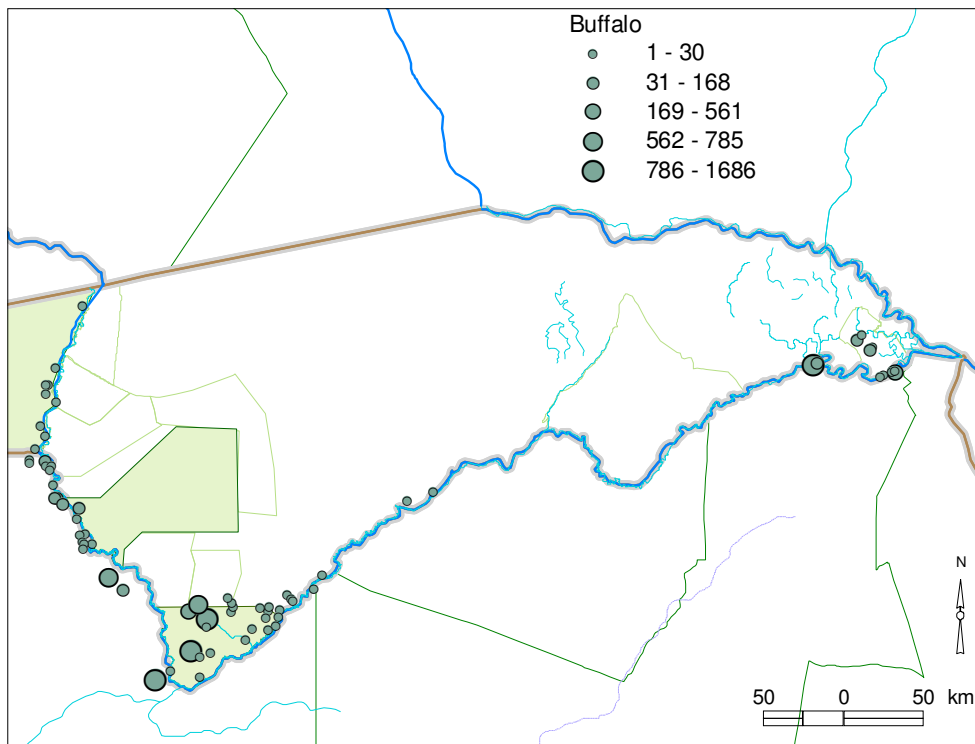


Figure 11. Distribution of elephant during aerial survey of Caprivi river systems, Sept09.

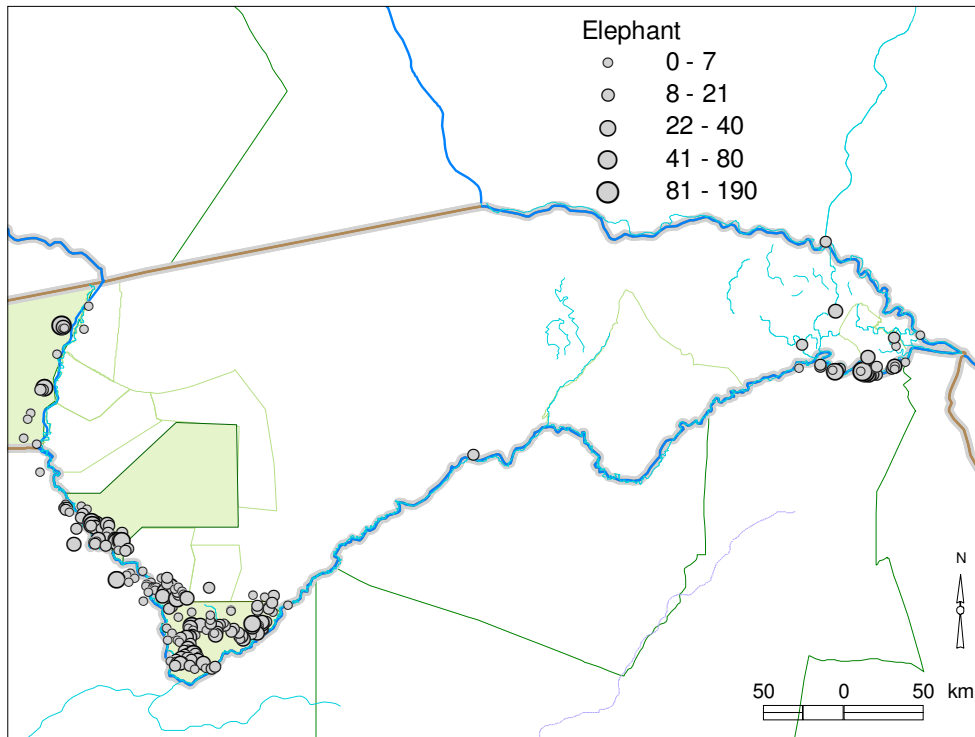


Figure 12. Distribution of impala during aerial survey of Caprivi river systems, Sept09.

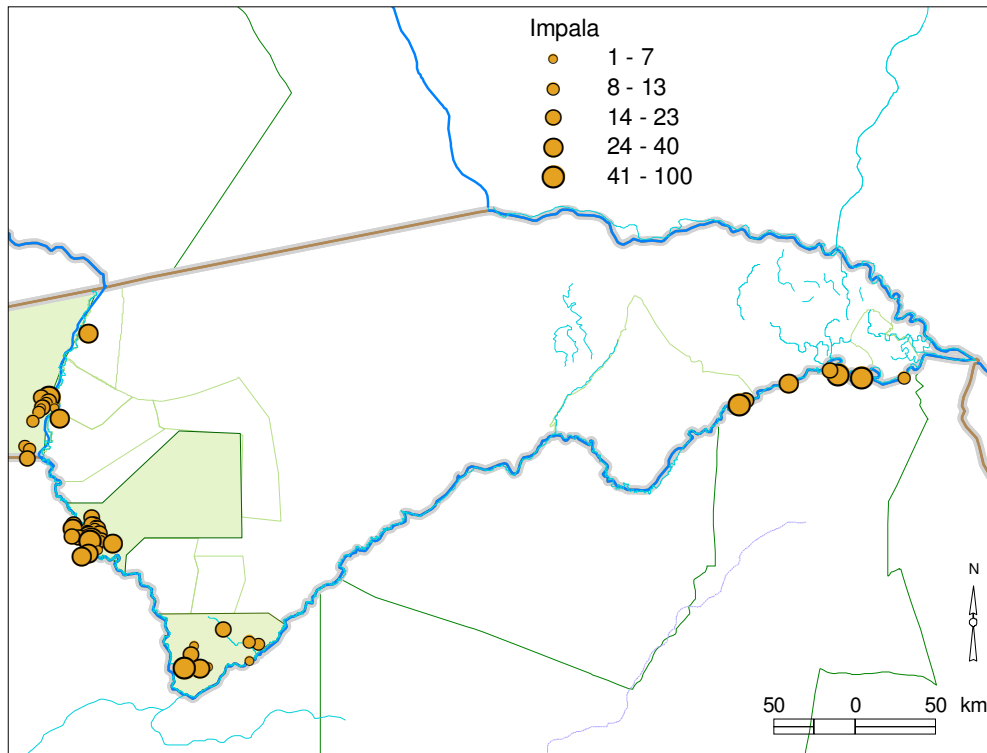


Figure 13. Distribution of zebra during aerial survey of Caprivi river systems, Sept09.

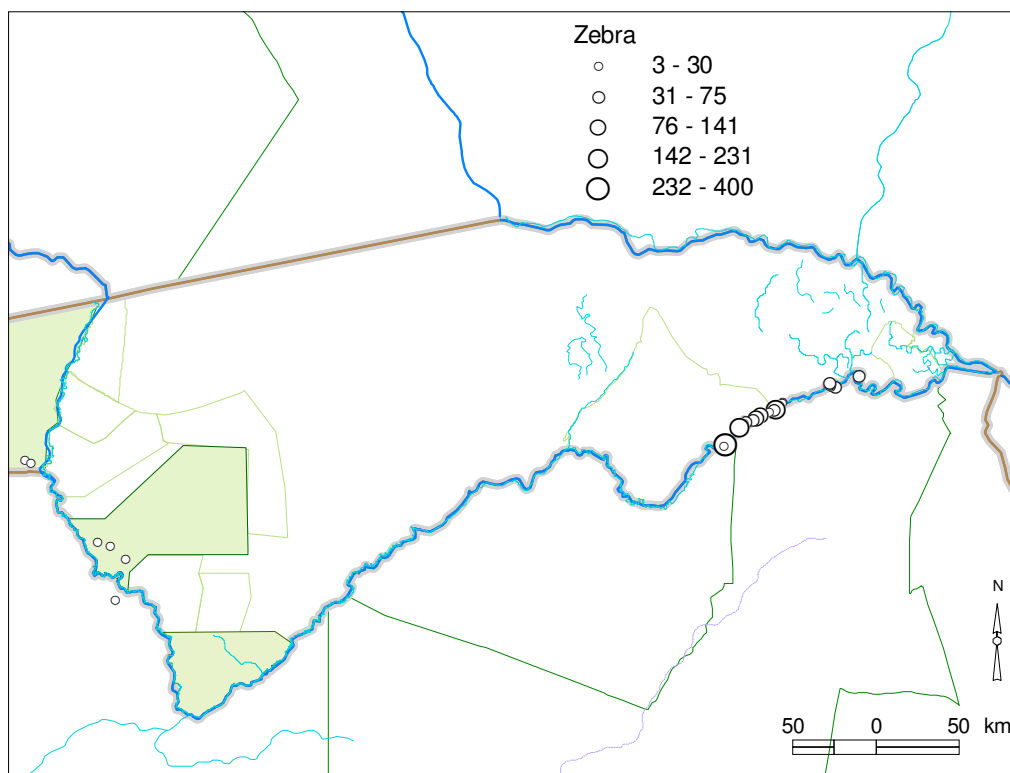




Figure 14. Distribution of woodland species during aerial survey of Kavango River, Sept09.

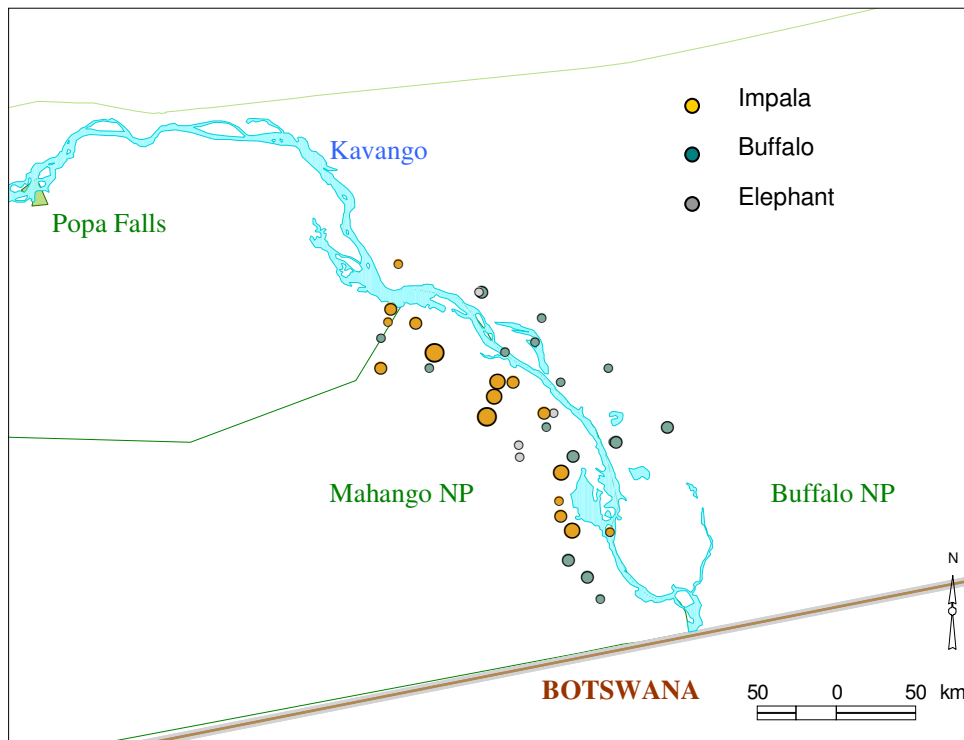
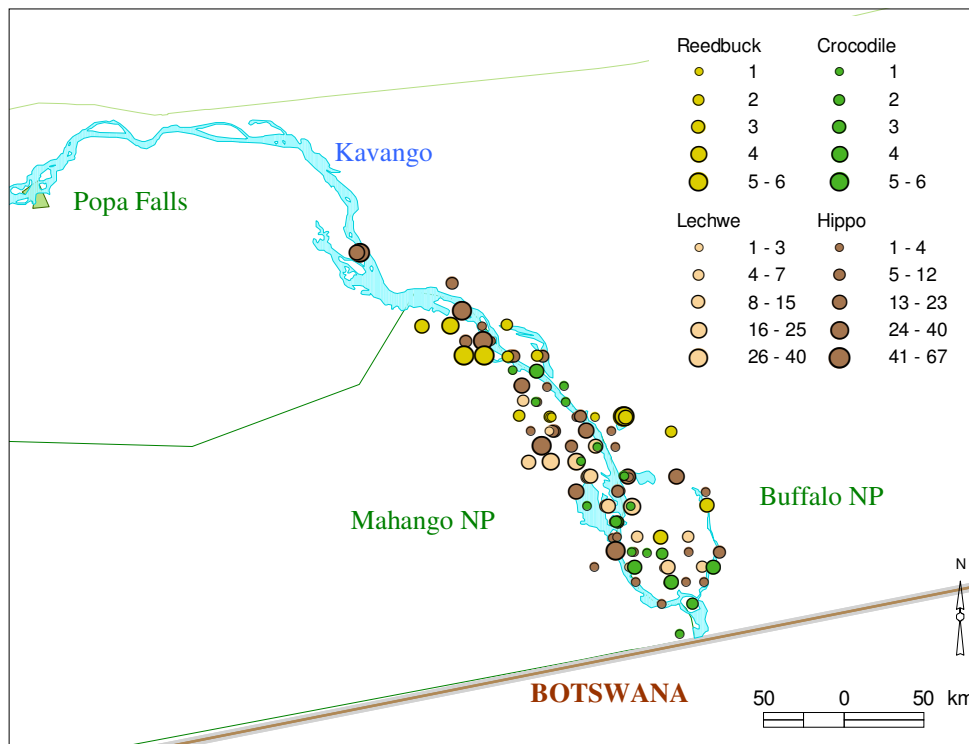


Figure 15. Distribution of water/floodplain species during aerial survey of Kavango River, Sept09.



## Herd Observations and Abundance

The greatest numbers of wildlife species observed occurred in the protected areas (Table 3). We observed 26 hippo pods in communal conservancies compared to 153 herd observations in protected areas. The largest lechwe herd observations for conservancies occurred in the Kasika conservancy (6), while Mamili had the largest lechwe herd observations (40) for a protected area.

Elephant and buffalo herds largely occurred along the major perennial rivers and adjacent floodplains in protected areas. Within the protected areas the most elephant herds (108) were observed in Mamili NP. The total number of elephant herds observed in protected areas numbered 184, compared to 42 elephant herds observed in conservancies. The 42 elephant herd observations in conservancies is over double the number observed on the Sept07 survey (16).

A total of 19,596 head of wildlife/bird species were observed during the aerial survey (Table 4). For wetland species hippo occurred in greatest numbers (1,291), further we recorded two important wetland bird nesting sites which have not be recorded on previous surveys of the Caprivi river systems. For woodland species, buffalo occurred in the highest numbers (9,633) of which 45% occurred in Mamili NP (4,282). Elephants (3,450) were the second highest recorded numbers, with a considerable rise in their numbers in Mudumu NP. The highest Zebra numbers occurred in Chobe NP (1,689). Mudumu had the highest count for impala (433)

The number of animals counted per square kilometer increased for many of the stratum between the three aerial surveys (Figure 16,17,18). The Kavango stratum continues to support the highest densities of wildlife species. Similar to the Aug04 survey we observed larger numbers of wildlife species in the protected areas compared to conservancies (Figure 17). Except for hippo, we recorded generally greater or similar densities for all species, in both protected and communal conservancies (Figure 17) when compared to the Aug04 and Sept07 aerial surveys.

Within the communal conservancies, the density of wetland species was similar on the Sept09 survey compared to the Aug04, Sept07 survey. While we observed more hippo in protected areas (940 vs 920), the number of hippo is still lower than the Sept07 survey (940 vs 1,056). In communal conservancies hippo increased between the Sept07 survey and the Sept09 survey (137 vs 91). The density of lechwe, reedbuck and crocodile increased in conservancies compared to previous surveys.

We extended our flight transects over the Chobe/Linyanti stratum to include Lake Liambezi. Although the lake was full of water, wildlife numbers were low and we counted two reedbuck and 1 crocodile. The lake is surrounded by human settlement and has the potential to support a greater diversity of birdlife. The Lake is an important habitat for wetland birds which use the region for breeding purposes, as we observed one large nesting site with several hundred open bill storks and pelicans.

Table 3. Herd observations (Obs) and mean (Av.) herd sizes in protected areas and conservancies on two aerial surveys of Caprivi river systems, Sept07 (2007) and Sept09 (2009).

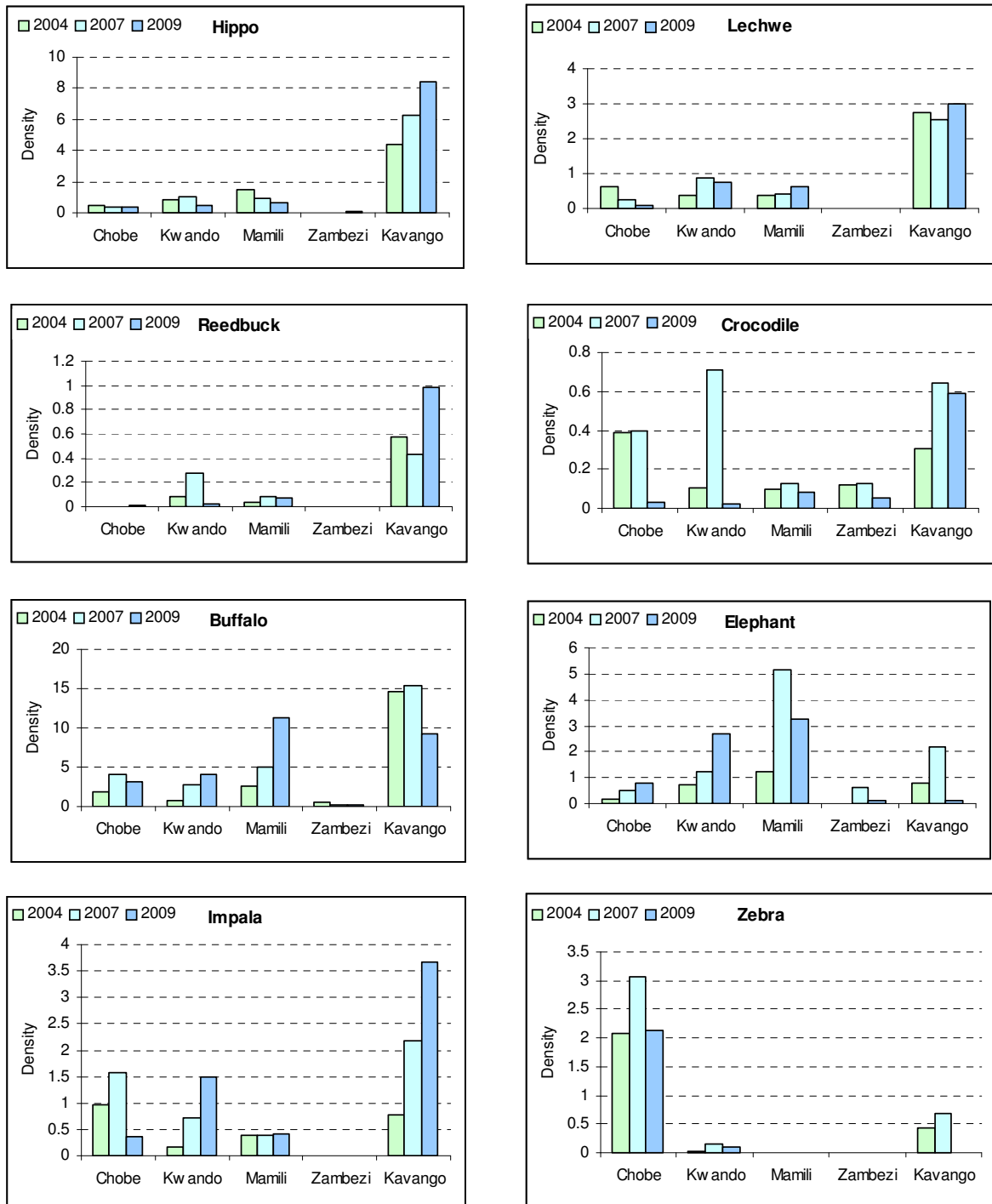
Species	Water/floodplain species															
	Hippo				Lechwe				ReedBuck				Crocodile			
	2007		2009		2007		2009		2007		2009		2007		2009	
Year	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs
<b>Protected Area</b>																
Mahango/Buffalo	7	54	8	53	6	24	11	16	3	13	3	19	2	20	1.5	21
Susuwe	6	11	4.5	14	4	58	8	25	2	41	2	5	1	1	1	1
Mudumu	4	26	4	7	4	5	2	4	4	1			1	5	1	2
Mamili	4	93	3.5	65	5	29	6	40	2	17	2	18	1	38	1	29
Chobe NP	6	10		14	34	4	14.5	3			1.5	2	2	29	1.75	12
<b>SubTotal</b>	<b>5.4</b>	<b>194</b>	<b>5</b>	<b>153</b>	<b>10.6</b>	<b>120</b>	<b>8.3</b>	<b>88</b>	<b>2.75</b>	<b>72</b>	<b>2.13</b>	<b>44</b>	<b>1.4</b>	<b>93</b>		<b>65</b>
<b>Conservancies</b>																
Kwandu	5	3	2.5	3	3	9	7.6	3	1	8			1	4		
Mayuni					3	4	3	1	2	2	2	1	1	1	1	1
Mashi	1	3			4	4	1	1	2	3			1		1	2
Balyerwa	6	4	5	14									1	2		
Wuparo			4.5	2												
Salambala	6	1											1	1		
Kasika	3	4	8	1	4	1	7.5	6					1	8	1.6	3
Impalila	7	5	7	6									1	11	1	1
ChobeZamFloodp															1.3	7
<b>SubTotal</b>	<b>4.667</b>	<b>20</b>	<b>5.4</b>	<b>26</b>	<b>3.5</b>	<b>18</b>	<b>4.775</b>	<b>11</b>	<b>1.667</b>	<b>13</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>27</b>	<b>1.18</b>	<b>14</b>
<b>Total</b>		<b>214</b>		<b>179</b>		<b>138</b>		<b>99</b>		<b>85</b>		<b>45</b>		<b>0</b>		<b>120</b>
Species	Other common species															
	Buffalo				Elephant				Impala				Zebra			
	2007		2009		2007		2009		2007		2009		2007		2009	
Year	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs	Av.	Obs
<b>Protected Area</b>																
Mahango/Buffalo	32	27	32	16	5	25	1	4	8	19	13	15	13	3	6	2
Susuwe	89	10	5	8	22	4	20	14	12	9	14	14				2
Mudumu	59	2	79	2	10	21	18	36	15	2	21	20	6	10	9	4
Mamili	127	15	238	18	9	226	12	108	13	11	12	13				
Chobe NP	252	8	335	7	14	7	26	22	58	13	39	7	51	7	112	13
<b>SubTotal</b>	<b>111.8</b>	<b>62</b>	<b>138</b>	<b>51</b>	<b>12</b>	<b>283</b>	<b>15.4</b>	<b>184</b>	<b>21.2</b>	<b>54</b>	<b>19.8</b>	<b>69</b>	<b>23.3</b>	<b>20</b>	<b>42.3</b>	<b>21</b>
<b>Conservancies</b>																
Kwandu							2	2	8	1	35	1				
Mayuni			3	1												
Mashi			1.5	2	2						30	1				
Balyerwa					5	5	12	31								
Wuparo			263	3			10	1								
Salambala									27	2			48	11	30	6
Kasika	22	4			31	10	13	6								
Impalila	40	1			14	1										
ChobeZamFloodp			38	4				2								
<b>SubTotal</b>	<b>31</b>	<b>5</b>	<b>76.4</b>	<b>10</b>	<b>13</b>	<b>16</b>	<b>9.25</b>	<b>42</b>	<b>17.5</b>	<b>3</b>	<b>32.5</b>	<b>2</b>	<b>48</b>	<b>11</b>	<b>30</b>	<b>6</b>
<b>Total</b>		<b>67</b>		<b>61</b>		<b>299</b>		<b>226</b>		<b>57</b>	<b>23</b>	<b>71</b>		<b>31</b>		<b>27</b>

Table 4. Total number of wildlife species counted in five strata<sup>1</sup> on three aerial surveys (2004, 2007 and 2009) of the Caprivi river systems, Namibia.

Species	Survey Stratum and Species Counted															Total		
	Linyanti/Chobe			Kwando			Mamili			Zambezi			Kavango					
Survey Year	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009
Buffalo	918	2043	2403	304	1040	2276	993	1902	4280	232	105	155	815	861	519	3262	5951	9633
Crocodile	58	60	25	40	40	14	37	48	31	55	59	48	17	36	33	207	243	151
Elephant	73	259	617	267	453	1476	473	1935	1227	4	293	125	43	122	5	860	3062	3450
Hippo	255	173	287	308	389	252	560	344	230	17	12	52	247	351	470	1387	1269	1291
Giraffe	8	1	8			2	13								1	21	1	11
Impala	485	801	271	64	262	824	150	142	156				43	156	206	742	1361	1457
Kudu	4	14	8	6	12	81	31	27	11				57	81	71	98	134	171
Lechwe	314	134	77	132	331	276	137	156	240	1	4	15	154	142	169	738	767	777
Lion	4	8	14					2	10							4	10	24
Pelican	498	1919	343					5								498	1924	343
Reedbuck		3	10	29	102	13	15	33	27				32	24	55	76	162	105
Roan															29	0	0	29
Sable					22	7							45	80	13	45	102	20
Sitatunga				2	5	11		2	8							2	7	19
Tsessebe				4	31	16							21		1	25	31	17
Warthog	18	8	12	17	30	9	182	123	134				9	15	18	226	176	173
Wattled Crane				6				13	2				2	11	9	8	24	41
Waterbuck	53	27	107	7	3	10									14	60	30	131
Wildebeest		14			21	64							6			6	35	64
Zebra	1047	1558	1640	13	57	49							24	38		1084	1653	1689
Total	3735	7022	5822	1199	2798	5380	2591	4732	6356	309	473	425	1515	1917	1613	9349	16942	19596

<sup>1</sup> Strata derived according to the first 2004 aerial survey (Stander 2004).

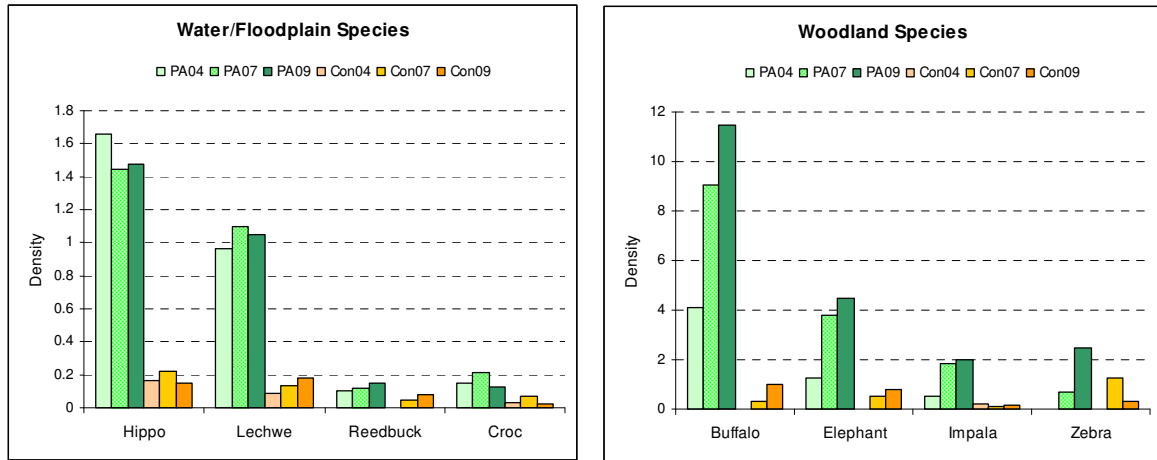
Figure 16. Density (km<sup>2</sup>) of wildlife species by strata and differences between the Aug04 (2004), Sept07 (2007) and Sept09 (2009) aerial surveys.



<sup>1</sup> Chobe, Kwando and Zambezi strata for the 2009 aerial surveys were larger than the previous two surveys.

<sup>2</sup> Chobe Stratum includes the Linyanti River.

Figure 17. Density (km<sup>2</sup>) of water/floodplain and woodland species between protected areas (PA) and conservancies (Con) on three aerial surveys (Aug04, Sept07 and Sept09).



Survey coverage for the conservancy areas was increased for the Sept09 survey to include newly flooded areas in the conservancies (Figure 2). Despite this increase in survey area, densities have remained relatively unchanged or increased in the conservancies.

While it would be possible to fit a trend line to the three aerial surveys counts, but this would be unreliable, as three points are the minimum needed and other statistical assumptions of line fitting (e.g. that precision remains constant) are not met (Craig & Gibson 2002). Many of our species have increased faster than is possible through natural population growth and this suggests that there have been variations in wildlife movements, dispersal, improvements in sighting conditions, and availability of water. Further, aerial surveys of wildlife in the region have shown that population levels can fluctuate in response to climatic conditions, human and environmental disturbances and that the intensity of the response can vary in time and space (Chase & Griffin 2009).

Table 5. Number of wildlife species counted and density (km<sup>2</sup>) between three aerial surveys in protected areas and conservancies.

Protected Area	Area (km <sup>2</sup> ) 2007	Area (km <sup>2</sup> ) 2009	Water/Floodplain Species																										
			Hippo						Lechwe						ReedBuck						Crocodile								
			Numbers			Density			Numbers			Density			Numbers			Density			Numbers			Density					
			2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009			
Mahango/Buffer	48	48	187	351	409	3.90	7.31	8.52	155	142	169	3.23	2.96	3.52	29	24	55	0.60	0.50	1.15	23	35	33	0.479	0.729	0.688			
Susuwe	94	94	91	67	62	0.97	0.71	0.66	62	245	206	0.66	2.61	2.19	20	63	8	0.21	0.67	0.09	6	1	1	0.064	0.011	0.011			
Mudumu	65	65	34	97	29	0.52	1.49	0.45	3	22	13	0.05	0.34	0.20	2	4		0.03	0.06	0.00	2	5	31	0.031	0.077	0.477			
Mamili	377	377	560	344	230	1.49	0.91	0.61	137	156	240	0.36	0.41	0.64	15	33	27	0.04	0.09	0.07	37	48	10	0.098	0.127	0.027			
Chobe NP	54	54	184	61	210	3.41	1.13	3.89	258	134	44	4.78	2.48	0.81			3			0.06	27	48	21	0.5	0.889	0.389			
Sub Total	638	638	1056	920	940	1.66	1.44	1.47	615	699	672	0.96	1.10	1.05	66	124	93	0.10	0.19	0.15	95	137	96	0.149	0.215	0.15			
<b>Conservancies</b>																													
Kwandu	56	56	8	14	8	0.14	0.25	0.14	16	25	23	0.29	0.45	0.41		11			0.20			8	5		0.143	0.089			
Mayuni	25	25	42			1.68			20	12	4	0.80	0.48	0.16		3	2		0.12	0.08		1	1		0.04	0.04			
Mashi	30	30	18	3		0.60	0.10		1	14	1	0.03	0.47	0.03	1	7		0.03	0.23		4		3	0.133		0.1			
Balyerwa	41	106		22	71		0.54	0.67														2				0.049			
Wuparo	0	115			9			0.08																					
Salambala	86	86	1	6		0.01	0.07															1	1		0.012	0.012			
Kasika	105	416		13	8		0.12	0.02		4	45		0.04	0.43								9	5		0.086	0.048			
Impalila	70	78		33	41		0.47	0.59														12	1		0.171	0.014			
Undesignated <sup>1</sup>		1145			214						32						10						62						
Sub Total	413	912	69	91	137	0.17	0.22	0.15	37	55	73	0.09	0.13	0.18	1	21	2		0.05	0.08		13	30	10	0.031	0.073	0.011		
<b>Woodland Species</b>																													
Protected Area	Area (km <sup>2</sup> ) 2007	Area (km <sup>2</sup> ) 2009	Woodland Species																										
			Buffalo						Elephant						Impala						Zebra								
			Numbers			Density			Numbers			Density			Numbers			Density			Numbers			Density					
			2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009	2004	2007	2009			
Mahango/Buffer	48	48	214	861	519	4.46	17.94	10.81	25	122	5	0.52	2.54	0.10	46	156	191	0.96	3.25	3.98			38	12		0.792	0.25		
Susuwe	94	94	735	886	43	7.82	9.43	0.46	18	89	283	0.19	0.95	3.01	5	105	202	0.05	1.12	2.15									
Mudumu	65	65	15	117	158	0.23	1.80	2.43	240	180	647	3.69	2.77	9.95	38	29	433	0.58	0.45	6.66		57	37		0.87	0.569			
Mamili	377	377	993	1902	4282	2.63	5.05	11.36	473	1935	1227	1.25	5.13	3.25	150	142	156	0.40	0.38	0.41									
Chobe NP	54	54	660	2019	2351	12.22	37.39	43.54	44	99	576	0.81	1.83	10.67	112	748	271	2.07	13.85	5.02			355	1462		6.574	27.07		
Sub Total	638	638	2617	5785	7353	4.10	9.07	11.53	800	2425	2738	1.25	3.80	4.29	351	1180	1253	0.55	1.85	1.96			450	1511		0.705	2.368		
<b>Conservancies</b>																													
Kwandu	56	56									3			0.05			35			0.625									
Mayuni	25	25			3			0.12							3			0.12											
Mashi	30	30			3			0.1		2				0.07			30			1									
Balyerwa	41	106								26	379		0.63	3.58															
Wuparo	0	115			789			6.861			10																		
Salambala	86	86											0.00		77	53		0.8953	0.6163				527	178		6.128	2.07		
Kasika	105	416			89			0.85		171	75		1.63	0.71															
Impalila	70	78			40			0.57			14		0.20																
Undesignated		1145			229						113																		
Sub Total	413	912			129	795		0.31	0.872		213	580		0.52	0.64	80	53	65	0.1937	0.1283	0.071		527	178		1.3	0.195		

<sup>1</sup> Includes communal lands not designated as conservancies. These areas have not been included in density estimation.

Figure 18. Density (km<sup>2</sup>) of wildlife species, in community conservancies and differences between the Aug04 (2004), Sept07 (2007) and Sept09 (2009) aerial surveys.

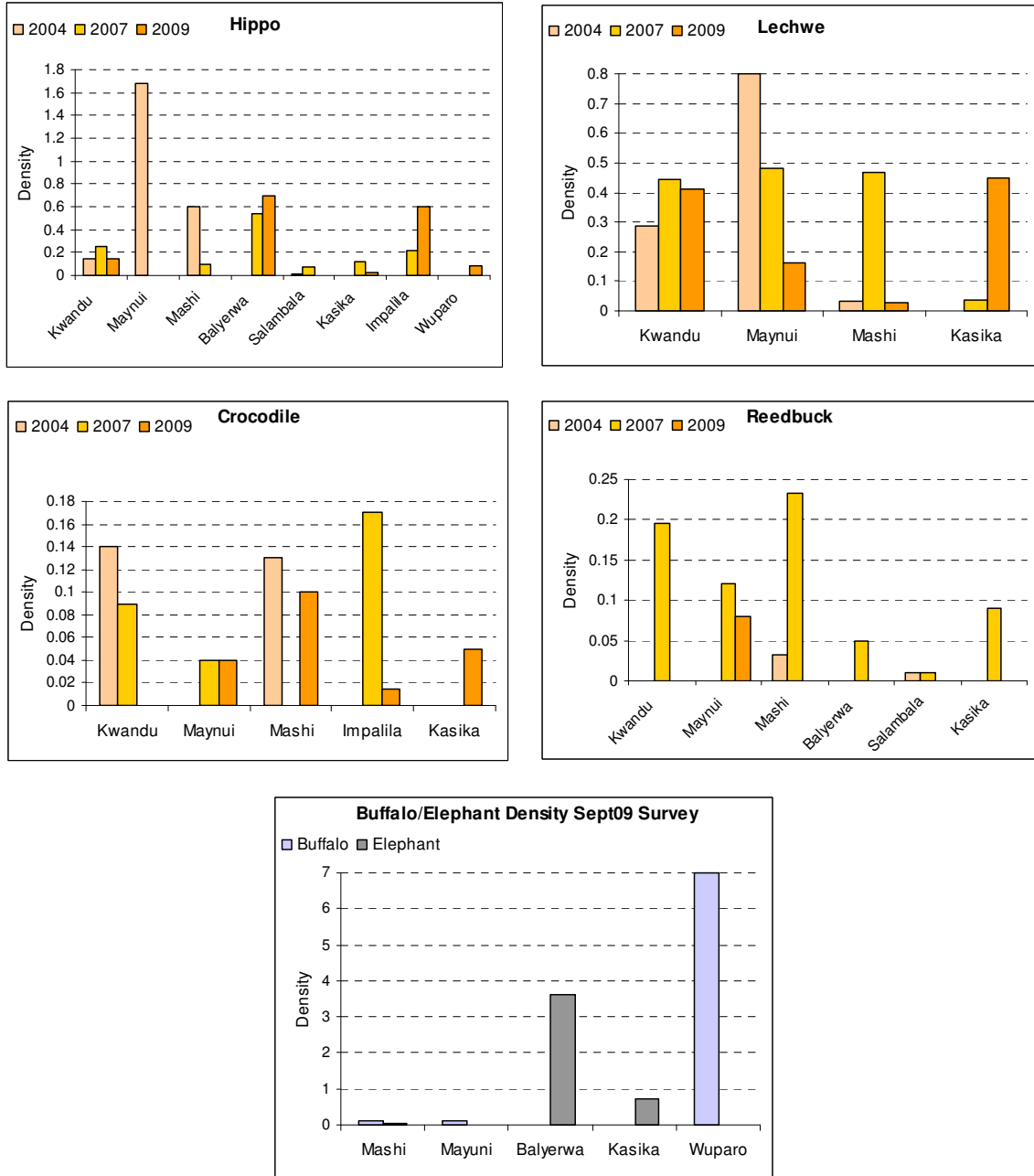
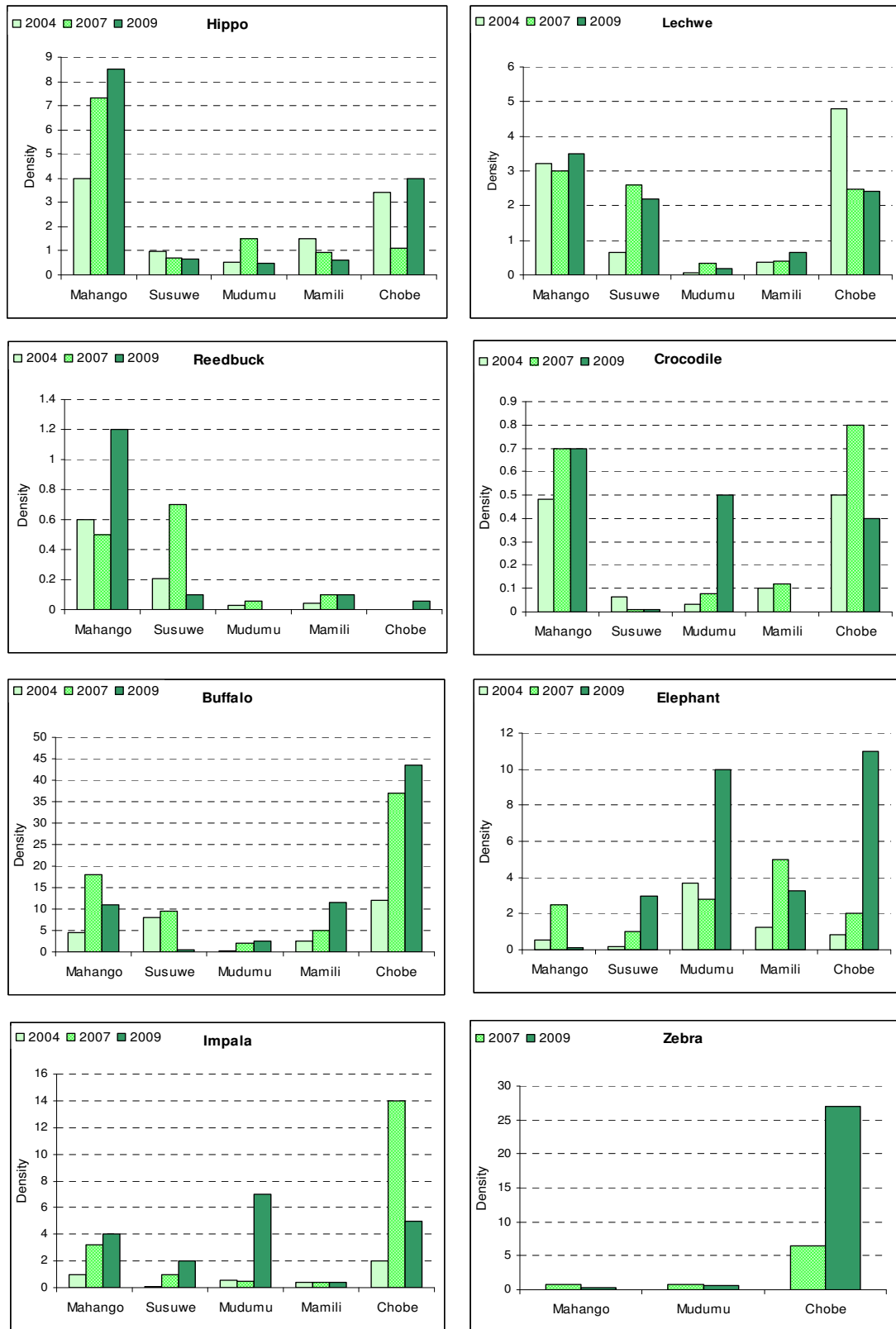




Figure 19. Density (km<sup>2</sup>) of wildlife species, in protected areas and differences between the Aug04 (2004), Sept07 (2007) and Sept09 (2009) aerial surveys.



## Boat and Helicopter Survey

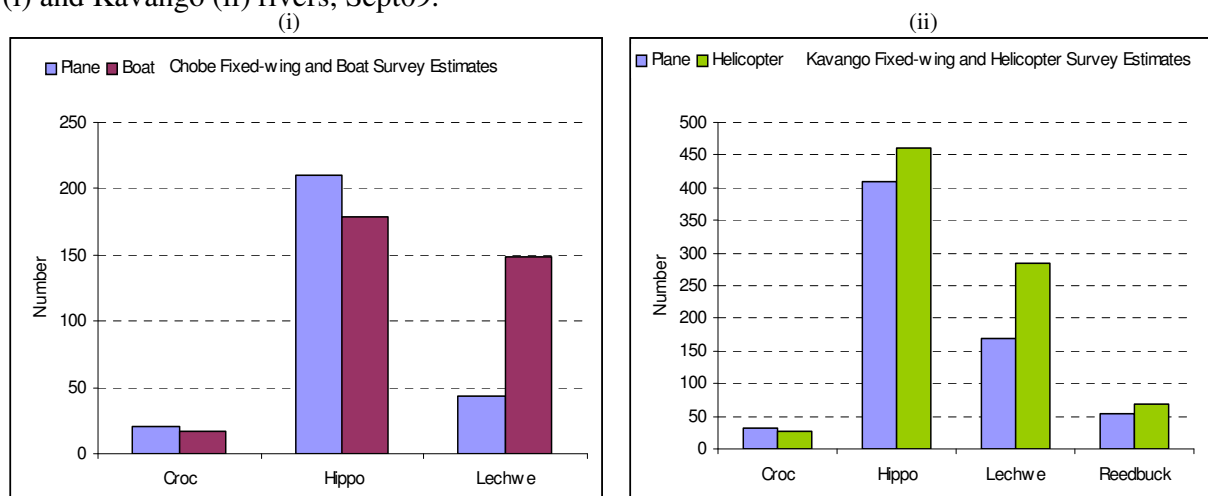
A helicopter (Bell Jet Ranger) and boat were used to count crocodile, hippo, lechwe and reedbuck along the Kavango River (Northern boundary of Mahango and Buffalo NP to the Botswana border) and Chobe River (Chobe NP, Chobe Safari Lodge to Savanna Lodge) respectively. Helicopters are more accurate and the preferred aircraft used for total count aerial surveys but they are expensive compared to fixed wing surveys (Brockett 2002). We conducted helicopter and boat counts to compare wildlife abundance estimates to the fixed wing counts. The comparison would help determine the reliability of estimating wildlife species confined to the Caprivi river systems from a fixed wing aircraft.

The boat survey along the Chobe River yielded lower estimates than the aerial survey for all species except lechwe (Table 6, Figure 20). We counted 70% more lechwe on the boat count (149) compared to the fixed wing survey (44). The helicopter survey yielded similar numbers to the fixed wing aerial count for all species except lechwe. The variances of underestimation in the aerial survey conform to the general accepted principal that aerial surveys underestimate wildlife abundance by 20%.

Table 6. Counts from fixed-wing, boat and helicopter surveys along the Chobe and Kavango rivers, Sept09.

	Chobe River		Difference (%)	Kavango River		Difference (%)
	Fixed Wing	Boat		Fixed Wing	Helicopter	
Crocodile	21	17	< 4 (19)	33	28	< 5 (15)
Hippo	210	179	< 31 (17)	409	462	> 53 (11)
Lechwe	44	149	> 105 (70)	169	285	> 116 (40)
Reedbuck				55	69	> 14 (20)

Figure 20. Differences in counts from fixed-wing, boat and helicopter surveys along the Chobe (i) and Kavango (ii) rivers, Sept09.



## Cattle, Mokoro and Fishing Net Observations

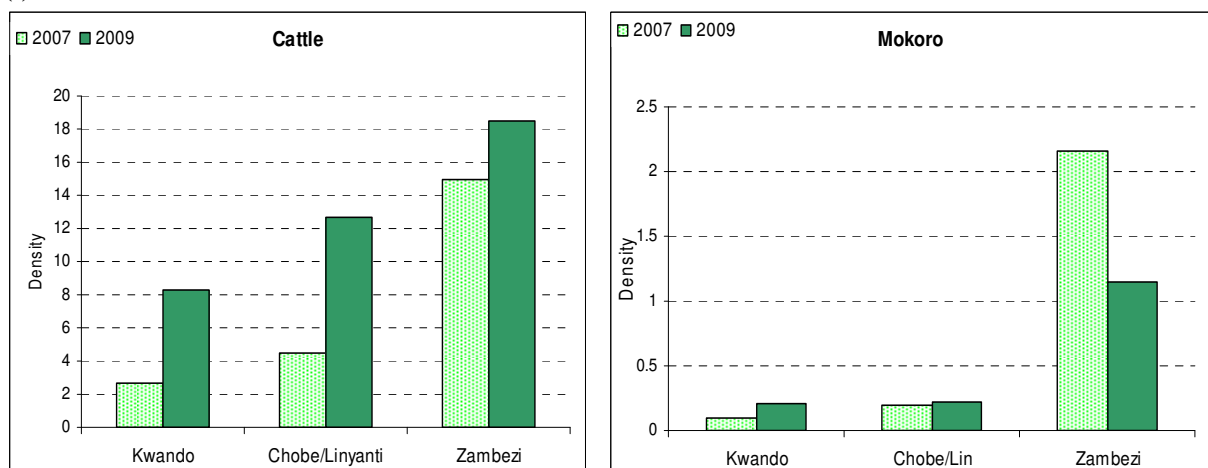
In addition to wildlife species we counted cattle, mokoro and fishing nets. These observations are a relatively good measure of human activity and allow us to better understand the distribution of wildlife. Where these activities occur in high density it may be assumed that less wildlife will be observed and that wildlife may never re-establish in these human dominated landscapes. For the entire survey area we counted 31,716 cattle. For the Zambezi Stratum, we observed 1,062 mokoros (Table 7 & Figure 21), while Lake Liambezi had the most fishing nets (222).

Table 7. Cattle and mokoros density ( $\text{km}^2$ ) and numbers observed in each stratum on two fixed-wing aerial surveys, Sept2007 and Sept2009.

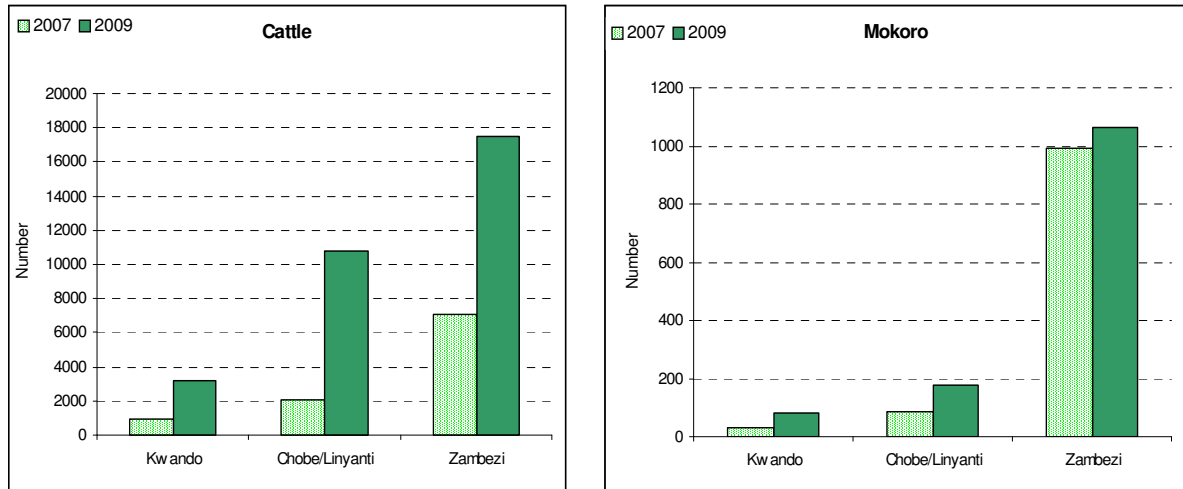
Strata/Area	Observation										
	2009 Survey Area ( $\text{km}^2$ )	Cattle				Mokoro				Fishing Net	
		Numbers		Density		Numbers		Density		Number	Density
	2007	2009	2007	2009	2007	2009	2007	2009	2009	2009	
Kavango	56	366		6.54		1				4	0.07
Kwando	56	445	663	8.00	11.84	15	25	0.30	0.45		
Mayuni	25	146	414	8.85	16.56	2	20	0.08	0.80	5	0.20
Mashi	30	326	775	11.00	25.83	10	16	0.30	0.53	12	0.40
Balyerwa	106	51	264	1.30	2.49	5	18	0.12	0.17	3	0.03
Wuparo	115		736		6.40		3		0.03	7	0.06
<b>Kwando Subtotal</b>	<b>388</b>	<b>968</b>	<b>3218</b>	<b>2.62</b>	<b>8.29</b>	<b>32</b>	<b>82</b>	<b>0.09</b>	<b>0.21</b>	<b>31</b>	<b>0.08</b>
Linyanti River	466	1407	3969	3.02	8.52	6	11	0.01	0.02	1	0.00
Salambala	86	477	4401	5.50	51.17	51	38	0.59	0.44	32	0.37
Lake Liambezi	298	212	2399	2.16	8.05	31	126	0.32	0.42	222	0.74
<b>Chobe/Linyanti Subtotal</b>	<b>850</b>	<b>2096</b>	<b>10769</b>	<b>4.50</b>	<b>12.67</b>	<b>88</b>	<b>175</b>	<b>0.19</b>	<b>0.21</b>	<b>255</b>	<b>0.30</b>
Zambezi River	94	4906	6915	52.19	73.56	820	740	8.72	7.87	10	0.11
Impalila	78	542	830	7.80	10.64	62	78	0.79	1.00		
Kasika	416	1436	1178	4.62	2.83	41	43	0.90	0.10	4	0.01
Zambezi Floodplains	851	172	8553	0.48	10.05	71	201	0.40	0.24	7	0.01
<b>Zambezi Subtotal</b>	<b>945</b>	<b>7056</b>	<b>17476</b>	<b>15.34</b>	<b>18.49</b>	<b>994</b>	<b>1062</b>	<b>2.16</b>	<b>1.12</b>	<b>21</b>	<b>0.02</b>
Undesignated			253				8			2	
<b>Total</b>	<b>2183</b>	<b>10120</b>	<b>31716</b>	<b>5.69</b>	<b>14.53</b>	<b>1114</b>	<b>1327</b>	<b>0.63</b>	<b>0.61</b>	<b>309</b>	<b>0.14</b>

Figure 21. Cattle and mokoro density ( $\text{km}^2$ ) (i) and numbers (ii) in three strata and differences between two fixed-wing aerial surveys, Sept2007 and Sept2009.

(i)



(ii)



## Discussion

### Wildlife Distribution

In 2009, the Zambezi River reached its highest level since 1969, inundating most of the eastern Caprivi. More than 350,000 people lost their livelihoods; more than 55,000 were displaced; and 100 people lost their lives (UNDP 2009). On the 3<sup>rd</sup> Oct. 2009, we flew a reconnaissance flight over the Selinda Spillway, (or Magwagana) and Savuti rivers to determine the extent of water in these rivers and record whether water/wetland species had disbursed into to these newly flooded regions. For this first time in 30 years the Okavango Delta was connected (via the Selinda) to the Kwando-Linyanti and Chobe-Zambezi rivers. Similarly, the Savuti River is flowing for the first time since 1983. When we conducted our survey the water was 8 km east of the Chobe NP cut-line (the water was ~20 km from reaching the Savuti Marsh). These two rivers flow out and into Mamili NP (Kwando/Linyanti wetland). The record high 2009 flood levels and rainfall may have affected wildlife distribution and abundance during this survey and should be taken into account when comparing counts between the three aerial surveys.

On our reconnaissance flight we observed 23 hippo in the Selinda Spillway and 18 hippo in the Savuti River. Chase (2007b) has reported extensively on the repopulation of wildlife in southeast Angola, it is also feasible that hippo in the Susuwe region may have moved north upstream into Luiana Partial Reserve. We counted 71 hippo in Balyerwa conservancy, north of Mamili which had 22 hippo on the Sept07 survey. Further, Chase (this study, Aug. 2009) observed 8 hippo at Kwikamba pan and another 7 hippo at Zwezwe pan, ~70 km from the Linyanti and Chobe Rivers. The wetter conditions (large pans will hold water throughout the year in high rainfall years) may have enticed hippo to move away from the Kwando and Linyanti rivers in the Caprivi, hence the lower numbers recorded on the Sept09 survey (230 vs 344). The most important factor limiting hippo numbers in the Caprivi is competition with cattle for

grazing. Increasing areas of floodplain habitat are being placed under cultivation and, in areas not cultivated, cattle grazing limits carrying capacity for hippo (Martin 2005).

The movements of wildlife in the Caprivi, together with wetter conditions and human disturbance makes it difficult to infer any solid conclusions about wildlife distribution or numbers. The majority of the Caprivi's wildlife populations occur along international boundaries (Kwando, Linyanti, Chobe and Zambezi rivers) and are shared with neighbouring countries (Angola, Botswana and Zambia). The distribution of wildlife is variable and they will continue to move from one bank of the river to the other, disperse to newly flooded regions which are not covered by these aerial surveys or move across international boundaries (Chase 2007, Martin 2005).

While conducting this survey along the Angolan border (north of Susuwe and Kavango River) we observed large herds of buffalo grazing on the floodplains in Angola (outside of our study area). The dispersal of buffalo (and other wildlife) into Angola from Bwabwata NP and Kyaramacan conservancy may account for the lower numbers of buffalo observed in Susuwe and Mahango/Buffalo NPs. Despite these observations outside of our study area we counted nearly 40% more buffalo on the Sept09 survey (9,633) compared to the Sept07 survey (5,951).

#### Herd Observations and Abundance

While we generally recorded fewer herd observations in each area on the Sept09 survey compared to previous surveys we observed larger numbers of animals on the Sept09 survey. We attribute this to species possibly clumping together, as a significant portion of our survey was under water. For the eight major species counted on this survey there were increases in all their numbers except for crocodile, reedbuck and warthog. Hippo group size is an extremely variable parameter. The average group size of hippos both in protected areas and community conservancies was 5 animals, which conforms to the previous surveys (Stander 2004, Chase 2007), but we did observe hippo pods as large as 67 animals. Group size is most likely to be small where hippo are limited in resources or under pressure from human disturbance. Average herd sizes for buffalo in protected areas increased from 112 on the Sept07 survey to 138 on the Sept09 survey, while in the community conservancies herd sizes doubled from 31 to 76 between 2007 and 2009 surveys.

#### Variations in Wildlife Estimates between Aerial Surveys

Wildlife numbers increased by nearly 20% during the Sept09 survey (19,596) compared to the Aug04 survey (17,050). For all species, except crocodile, reedbuck, and warthog we observed more animals than the Sept07. Waterbuck numbers have increased from 31 on the Sept07 survey to 131 counted on the Sept09 survey. Buffalo (155) were observed north of the Kasika conservancy on the Chobe/Zambezi floodplains despite the high density of people and domestic animals. We counted 789 buffalo in the Wuparo conservancy.

Variations in wildlife densities may be attributed to transboundary movements between the Caprivi, Botswana and Angola. The variations in wildlife abundance and distribution are also affected by the availability of water and the large 2009 flood.

#### Differences between Fixed Wing, Boat and Helicopter Surveys

Surveys using fixed wing aircraft are economically feasible, but they tend to underestimate wildlife numbers by 20% (Griffin & Chase, 2004). The differences between the fixed wing, boat and helicopter survey counts were within the range of variation expected from aerial surveys and were surprisingly similar for, crocodile, hippo and reedbuck. This may be due to the experience of our observers and the digital cameras we use to subsequently verify herd sizes. In addition, the boat survey was limited to surveying areas which were deep enough for the boat to access. By October, the water begins to recede and this may have resulted in the survey missing crocodiles which were distributed in shallow waters or floodplains (Figure 9). The similar counts for hippo can be attributed to their large size, making them difficult to miss from the plane when they appear in clear water or on land. The problem in counting hippo from the plane occurs when they are in large pods (>40) (Appendix 1). The greatest variation between the fixed wing survey, boat and helicopter counts occurred for lechwe. The fixed-wing aerial survey underestimated lechwe by ~ 50%. The reasons for this under estimation are unknown but may be attributed to observers missing lechwe when they are resting on the floodplains. Based upon this limited experimental exercise, it would appear that the use of a fixed-wing plane, with experienced aerial observers and digital cameras provide reliable and cost effective counts for wildlife over the Caprivi river systems. Correction factors from the boat and helicopter surveys should be applied with caution until several repetitive counts using these methods have been conducted and which lead to repeatable estimates.

#### Human Activity

Cattle. Cattle numbers have increased considerably between the Sept07 (10,120) and Sept09 (31,716) surveys.

Mokoros. Harvesting and clearing of riparian trees for fuel, construction material, and mokoros should be studied. We observed newly cut mokoros (5%) during the survey easily identifiable by their distinct colour. Harvesting and clearing of riparian trees for construction of mokoros should be studied and perhaps fiberglas mokoros such as the ones introduced to the Okavango delta in Botswana should be promoted over wooden mokoros.

Fishing Nets. In recent years fish have become increasingly threatened by over fishing caused in part by improved modern fishing gear such as gill nets and dragnets. Over 90 percent of the 222 nets in Lake Liambezi were new nets. A study should be undertaken to determine if this system can sustain this level of netting. Many fishing nets we observed were ~2 km long. From our aerial photographs of mokoros, we determined that each mokoro has an average of three nets (which means that there may be as many as

3,186 nets along 161 km of the Zambezi River). Stricter fishing regulations and policing patrols in these systems are urgently required. Some nets we observed on the Chobe River while conducting the boat count were often placed across the entire width of the river. A study on the impact of these nets on biodiversity / aquatic wildlife species, should be conducted urgently.

Important Bird Nesting Sites. Important bird nesting/breeding sites were observed in Lake Liambezi (-17.866 24.308) and Chobe/Zambezi floodplains (-17.703 24.997). Despite virtually no wildlife in these areas, our survey recognises the importance of Lake Liambezi for waterfowl, storks, egrets and pelicans. The number of fishing nets in this region is extreme, and their impact on birds, and fish yields should be given serious consideration. The nest site observed on the lake had approximately 2,000 nesting open bill storks. The Chobe/Zambezi floodplains are also an important wetland bird region, where we counted 300 black egrets, 30 wattled crane and a nesting site of 2,500 open bills storks. These sites were the only nesting sites recorded on the entire survey.

## **Conclusion**

The Sept09 aerial survey recorded the highest numbers of wildlife in the Caprivi region of Namibia when compared to previous aerial surveys. Further, two important bird nesting sites were recorded. Wildlife numbers along the river systems of the Caprivi are increasing. Our Sept09 survey observed 20% more wildlife observations than a survey conducted in Sept07. The increase in wildlife numbers both within the protected and conservancy areas may be attributed to both movement of wildlife within Caprivi and between Botswana, Angola and Caprivi, as well as the effects of local conservation initiatives on wildlife breeding and successful reintroductions.

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## Appendix

Appendix 1. Comparisons between observer and photo corrected observations and timing of aerial surveys.

The survey team had two of the same crew (data recorder/ front seat observer and rear seat left observer) who conducted the Sept07 aerial survey. The right seat observers used on this survey had previous aerial survey experience. Total aerial counts rely on experienced observers. However despite the extensive experience of our observers in counting, observing and estimating wildlife observations, they inherently underestimate herd sizes as such aerial surveys underestimate population densities. Large herds of buffalo, elephant, hippo and flocks of water birds are common along perennial rivers such as the Chobe.

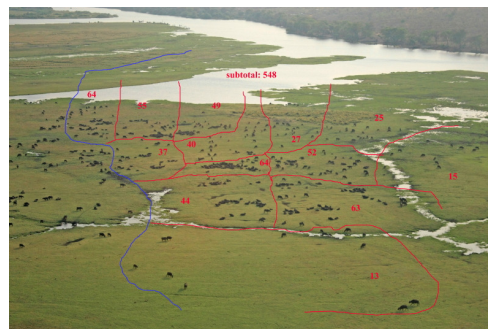
Our results suggest that during our aerial survey of the Caprivi rivers, wetlands and floodplains, our aerial observers were accurate in estimating wildlife numbers and other wildlife observations that were under 50 animals. However, despite their extensive aerial survey experience (950h) when herds exceeded 50 animals the observers underestimated animals, in many instances by as much as 60 %.

Figure 1. Differences in observer estimates of wildlife species and photo verified observations of a herd of buffalo.

Observer estimate 400 buffalo



Photo corrected count 768 buffalo



Despite this survey being a total count, and we suspect we are observing all animals, our simple analysis, boat and helicopter counts suggests that we may be underestimating species when they occur in large numbers or the smaller species such as Impala and lechwe. Therefore, high quality digital images provided by cameras offer us the ability to cross reference observers call-outs and avoid observer biases. Photo verification should be used on future aerial surveys, to improve the precision of the density index and obtain a visibility correction factor.

Figure 2. Fixed wing plane, with especially adapted camera mounts, digital cameras and aluminum wands mounted to the wing struts to delineate a 250 m counting strip width.

