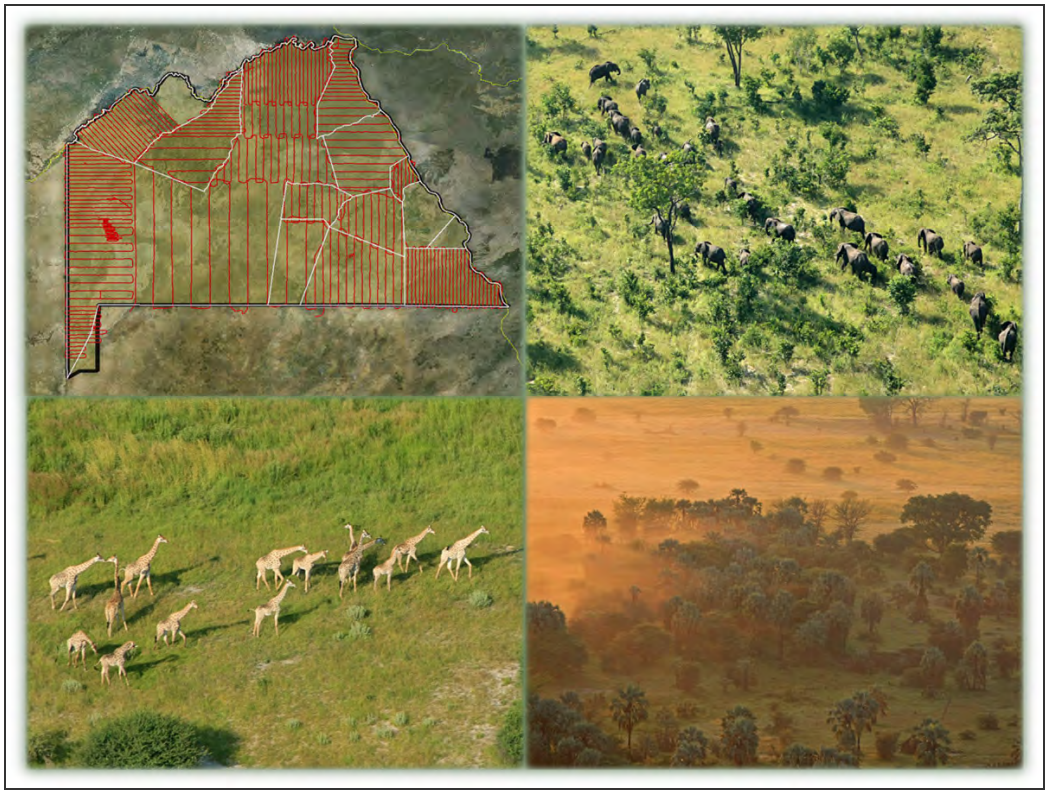
STATUS OF WILDLIFE POPULATIONS AND LAND DEGRADATION IN BOTSWANA'S FOREST RESERVES AND CHOBE DISTRICT



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This survey was conducted jointly by Elephants Without Borders, Forest Conservation Botswana and, the Zoological Society of San Diego.

The opinions expressed in this report are those of the author and do not necessarily represent those of Forest Conservation Botswana, the Zoological Society of San Diego or any of the donors who have helped fund this aerial survey.

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I thank Mr. Mike Holding for flying this aerial survey. I appreciate the assistance of our aerial observers, Ms. Kelly Landen, Mr. Graham Springer, Mr. John Chase and Dr. Larry Patterson. I am grateful to Kelly Landen for her logistical support and administrative assistance.

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Honorable Tshekedi Khama, Minister of Environment, Wildlife and Tourism, is gratefully acknowledged for his commitment and enthusiasm for supporting the presentation of this study's results and recommendations to key stakeholders in Gaborone.

EXECUTIVE SUMMARY

Elephants Without Borders conducted dry (Sept. 2011) and wet (Mar. 2012) season aerial surveys of elephants and wildlife in the Chobe District of northern Botswana to provide recent information on the status of wildlife numbers and their seasonal distribution. The aerial surveys were commissioned by Elephants Without Borders (EWB) and funded largely by Forest Conservation Botswana. A small fixed wing plane was used to fly a stratified sample survey, with parallel transects over the Chobe Distinct a survey area of about 22560 km^2 in extent. It included Chobe National Park (NP), Chobe Forest Reserve (FR), Kasane FR and Extension, Kazuma FR, Sibuyu FR and Maikaelelo FR, and surrounding Wildlife Management Areas (WMAs) in the Chobe District. The principal objective of this survey was to provide relatively precise and accurate estimates of wildlife in the survey area, using a method, which could be repeated. Secondary objectives included mapping the spatial distribution of elephants and other wildlife, distribution of elephant carcasses, baobab trees and large birds. The methods used were suitable for meeting the survey objectives, repeatability and technically robust. Thus this survey provides a baseline for monitoring future trends in the numbers and spatial distribution of wildlife in Chobe. This report provides the results of these two seasonal surveys, in addition to information on the spatial distribution, and abundance of wildlife and trends of elephant numbers. Maps and tables illustrating the distribution, numbers, density and trends of wildlife species in the survey area are provided.

The survey area was divided into 16 strata, which largely conformed to the boundaries of WMAs, FRs and Chobe NP. Within each stratum, transects were parallel and regularly spaced between 2 and 8 km apart. To improve the precision of population estimates, sampling intensity varied between strata, and ranged from 5 – 20 %. The overall sampling intensity was 15 %, a 10 % increase compared to earlier Department of Wildlife and National Parks (DWNP) aerial surveys. Overall mean search effort was 1.4 minutes per km^2.

Aerial surveys often underestimate wildlife numbers, with the degree of underestimation higher for small or cryptic species than for large species. High-resolution digital cameras provided images to compensate for any underestimating or missed animals. The locations of wildlife herds seen during the survey were entered into a GIS to produce maps showing the distribution and herd sizes of principal large herbivores and birds in Chobe District. We adjusted for altitude and photo corrections and used the traditional Jolly's Method II for unequal sized sampling units (Jolly 1969) to calculate population estimates and variance for each species in each stratum.

This survey is the tenth dry season aerial survey of wildlife populations in the Chobe District since 1993. Estimates of elephant numbers in the District, and Chobe NP have remained similar, but do fluctuate according to the timing of dry season surveys. A trend analysis of wildlife estimates from earlier aerial surveys suggests that the estimated numbers of large mammal species remain stable. The 2011 population estimates for wildlife species in the District are generally similar to those of a survey conducted by EWB during 2010 dry season. However, there are large differences in estimates of population size for most species between EWBs and DWNP surveys. The high confidence limits to the DWNP estimates demonstrate that these low intensity surveys (1993 - 2004) might not be satisfactory for estimating wildlife numbers. The significant difference (d = 4.02) in elephant estimates between EWBs 2010 (57457) and 2011 (40517) surveys is most likely attributed to the dispersal of elephants and the timing of surveys.

The estimated population numbers for the principal large herbivores, elephant carcasses and baobabs in Chobe District during the 2011 dry season survey were:

Species	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
Woodland Sp								
Elephant	40517	6745	14891623	7601	19%	32915	48118	1.88
Elephant Bull	4942	757	229263	943	19%	3999	5885	0.23
Elephant Family	35578	5988	13723843	7292	20%	28280	42875	1.64
Elephant Carcass	544	71	10859	205	38%	339	749	0.03
Elephant Bones	1289	198	18165	265	21%	1023	1554	0.06
Buffalo[1]	5474	-	-	-	-	-	-	-
Eland	1237	191	91263	595	48%	642	1832	0.06
Giraffe	1483	198	66345	507	34%	975	1990	0.07
Impala	5616	1043	2368415	3031	54%	2584	8647	0.26
Kudu	524	83	14866	240	46%	284	764	0.02
Roan	287	47	5189	141	49%	145	429	0.01
Sable	2106	374	225992	936	44%	1169	3042	0.10
Tsessebe	341	55	12096	217	64%	124	558	0.02
Warthog	566	104	8858	185	33%	380	751	0.03
Wildebeest	634	80	185682	848	134%	214	1482	0.05
Zebra	6542	1258	2331057	3007	46%	3535	9550	0.30
Wetland Sp								
Hippo	196	36	7300	168	86%	36	364	0.01
Birds								
Ostrich	113	20	2061	89	79%	23	202	0.01
Other Obs								
Baobab tree	702	89	40214	395	56%	306	1097	0.03
Cattle	4815	737	3403259	3648	76%	1167	8463	0.48

[1] Estimates from a partial 'mixed method' total count; more reliable than the strip estimates referred to in Table 18.

The estimated total number of elephant carcasses (1651) in the survey area during the dry season of 2011 represented 3.92 % of the estimated total number of live and dead elephants. The estimate for recent or fresh (category 1) carcasses was 362, representing a carcass ratio of .9 % (which reflects the mortality rate of elephant during the survey year). Elephant carcass estimates for protected (851) and unprotected areas (800) were similar. Most (15.7 %) of the total estimated elephant carcasses occurred in the Phofu stratum within Chobe NP (259), accounting for 41 % of the estimated total number of live and dead elephants, and a mortality rate of 13.32 % in this strata. More than 58 % (952) of the total estimate for all carcass categories were seen in four strata, Phofu, Nogatsaa, Chobe River and Chobe FR.

A total of 306 baobab trees were seen during the survey, of which the majority, (107) were counted in the Chobe FR. Of the trees counted 56 were classified as large, 136 as medium and 114 as small sized tree. Most of the trees (212) appeared to have had less than 10 % damage to them, 56 trees had between 11 - 30 % damage, 12 trees had between 31 – 50 % damage, and 17 trees had greater than 50 % damage. Dead trees (100 % damage, n = 9) accounted for 3 % of the total number seen within the survey area.

A limited wet season survey was flown over the six FR, CH 5 (Northern Plains) and Chobe River stratum. Wildlife densities were considerably lower in strata which included or were close to the Chobe River during the wet season. Most species moved away from the perennial water sources to the interior portions of the District to make use of rain filled pans. Variations in seasonal wildlife estimates can be attributed to the dispersal of large mammals, the Chobe riverfront is not a complete ecological unit but part of a far larger ecosystem in which the FRs and Northern Plains serve as critical wet season ranges for wildlife.

Herbivore populations in the District appear to be stable. The extent of bush fires during the survey across large areas of the District are a major determinant in the density of plant species, a fire management programme needs to be implemented. Fire frequency in the Maikaelelo and Sibuyu FR is so high that the woodlands have lost their commercial value, and destroying old growth stands of mongongo (*Schinziophyton rautanenii*). The level of deforestation and encroaching human activities for arable fields along the Northern Plains ecotone and Chobe FR ridge are destructive, and will impede wildlife movements. The ecotone along the northern border of Kasane FR and CH 5 (Northern Plains), falls within an important wildlife corridor and should be conserved by incorporating parts of the Northern Plains into Chobe NP or Kasane FR. The allocation of arable fields in the middle of elephant pathways northwest of Kachikau is hindering wildlife access to water which will lead to an inevitable increase in human elephant conflict. Considerable development is taking place within and on the boundaries of FRs; this will have a negative impact on wildlife movements, escalate human wildlife conflicts and is causing high incidents of retaliatory killings of lion, hyena and elephant.

With the District's burgeoning human population (2.5 % annual growth rate) there is a shortage of land, with over 52 % of the District set aside for the Chobe NP, and 18 % designated as FR. There has been growing concern that the large percentage of land (70 %) set aside for conservation needs to offer more diversified investment opportunities. To date, one of the major problems facing Chobe has been a poor effort to implement development programmes within conservation areas (FR specifically) despite repeated recommendations for the sustainable development of such areas. Ecotourism development initiatives have been recommended in a plethora of management plans and policies that appear to have been largely overlooked by decision makers. Tourism operators implied that the management and responsibility for the FR is fragmented, with no-one department showing authority and accountability for the management of the FRs.

While this study provides new information on the status of wildlife in Chobe District, the study merely repeats longstanding recommendations echoed by previous reports to motivate for the sustainable development of Botswana's Forest Reserves. In this case however, the call and urgency to diversify the economic activities within Forest Reserves coincide with increasing concern over tourism congestion along the Chobe riverfront between Kasane – Serondela, rising human wildlife conflicts, poaching of wildlife and overharvesting of natural resources.

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Background

Management decisions for conservation areas and wildlife species require accurate and reliable information about population size, distribution, demography, and habitat use while simultaneously understanding the needs of people who live adjacent to these areas. Obtaining detailed and current data for these parameters in Botswana's Forest Reserves has been hampered by financial constraints. As a consequence, there has been limited information on the status of wildlife populations in Botswana's Forest Reserves (FR), all six of which occur in the Chobe District. Current information on the seasonal distribution and abundance of wildlife together with threats to these FR are needed to guide policy decisions and implement conservation and development projects. The purpose of this study is to present the results of two wildlife aerial surveys flown by Elephants Without Borders (EWB) during the 2011 dry and 2012 wet seasons, providing an updated status report on Chobe District wildlife numbers and distribution. We also use these survey results as part of an analysis of wildlife distribution and abundance in the Chobe District relative to the potential effects of increasing human activities.

Introduction

The Chobe District has become internationally renowned for its large elephant population, specifically; Chobe National Park (NP) is frequented by visitors for its large aggregations of wildlife along the Chobe, Linyanti and Khwai Rivers, while parts of the Park's drier interiors such as Savuti and Nogatsaa have also become popular with tourists for their remoteness. The dry season wildlife concentrations along the Chobe River coincide with increasing visitors (Aug. – Nov.) along parts of the Chobe riverfront. Tourism congestion, mainly between Sedudu Gate and Serondela, has raised concerns within the tourism industry and the possibility of using FR to ease this overcrowding. Tourism overcrowding, human wildlife conflict, concern about wildlife numbers, illegal harvesting and speculative information about the status of wildlife in Botswana's FR prompted this study. Two fixed wing aerial surveys of wildlife in Chobe District were flown. The first survey was conducted during the dry season between August and September 2011 (Sept11) and covered the entire District, while the second survey was flown during the wet season between 1 - 8 March 2012 (Mar12), and covered all the FRs. A ground based strip road count was also conducted along the Chobe River from 22 – 25 May 2012, and a helicopter total count of wildlife on the Savuti Marsh was flown.

Although aerial surveys over the Chobe District have been flown, by the Department of Wildlife and National Parks (DWNP) (1993 – 2006), this is the first independent fixed-wing aerial survey to provide estimates for wildlife populations specifically within Botswana's Forest Reserves (FR) and adjoining areas. The principal objective of this survey was to provide relatively accurate and precise estimates of the numbers of elephants and other large herbivores in the FRs, using a technique that could be executed within a reasonable time and at a reasonable cost. Secondary objectives included determination of the spatial distributions of elephants and large herbivores, and estimation of the number and distribution of elephant carcasses and baobab trees. The methods used were suitable for meeting the survey objectives, repeatable and technically robust. Thus, this survey provides a solid baseline for monitoring future trends in the numbers and spatial distribution of wildlife in the Chobe District and its six Forest Reserves.

Elephants Without Borders received funding from Forest Conservation Botswana (FCB) to conduct these seasonal surveys aimed at providing new and updated estimates on the seasonal distribution and abundance of wildlife species within Chobe NP, the six FR and adjoining areas.

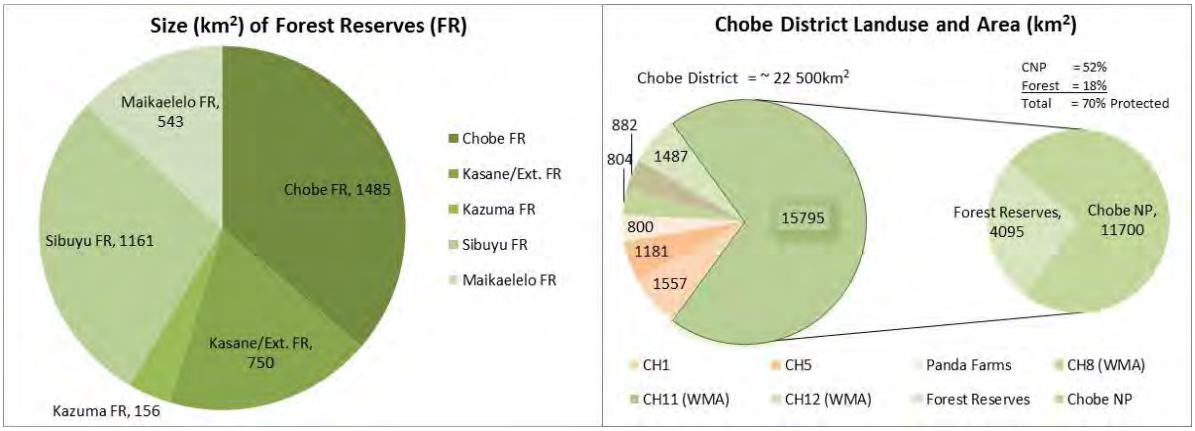
Monitoring large herbivores is central to research and management activities in many conservation areas. Aerial surveys were originally developed to estimate (trends in) population sizes of individual species. However, emphasis is shifting increasingly towards conservation of diversity and communities instead of individual species, as a growing literature shows the importance of herbivore diversity for ecosystem functioning (Joris et al. 2008).

This report presents the results of two aerial surveys and compares wildlife estimates with previous aerial surveys (8) conducted by the DWNP (Chase 2011). The data from this survey provide current information and allow the opportunity to assess wildlife distribution, abundance and trends. At a larger scale, this survey contributes important data to conservation and development initiatives such as the Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA) and highlight the potential of the FRs to serve as tourism sinks in a region experiencing tourism bottlenecks.

Study Area

The Chobe District (22 560 km^2) is bordered to the east by Zimbabwe, and Namibia to the north along the Chobe, Linyanti and Kwando rivers to the north, it also shares a short 800 m border with Zambia along the Zambezi River. All six of Botswana's FR are located within the Chobe District, and comprise of Chobe FR (1545 km^2), Kasane FR (150 km^2, Kasane FR Extension (600 km^2), Kazuma FR (156 km^2), Maikaelelo FR (543 km^2) and Sibuyu FR (1166 km^2) (Figure 1). Four of the FRs surround Chobe National Park (12 890 km^2) and act as important conservation buffer zones. The Chobe Enclave incorporates CH 1 and open to various forms of land use ranging from settlement, farming, hunting and photographic safaris. The Chobe FR (CH 2) is leased to the Chobe Enclave Conservation Trust (CECT) and is the only FR in which large game hunting is permitted (bird shooting is allowed under permit in all FR). The northern Plains area in CH 5 has recently been allocated for multipurpose use. The Pandamatenga Farms include an area approximately and have recently expanded into CH 10. The rest of the District comprises of Wildlife Management Areas, CH 11, which is unused, CH 12 otherwise known as Bottle Pan is mainly used for sport hunting and CH 8, is leased to the Paleka Community Trust where sport hunting is the main economic activity.

Figure 1. The size (km^2) of Forest Reserves relative to other land use in Chobe District.

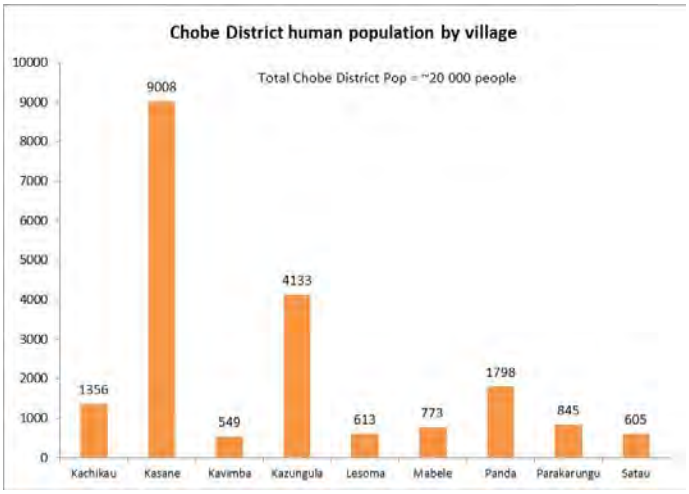


Rainfall is strongly seasonal, occurring mostly from October to April. Rain occurs occasionally in May and September, but it is rare in June through August. Average annual rainfall for northern Botswana is ~ 660 mm. There are six perennial rivers in the study area. The Chobe, and Zambezi (800 m), rivers are the largest rivers that provide abundant water throughout the year. The Khwai, Linyanti, Savuti and Kwando rivers are smaller perennial rivers flanked by seasonally flooded wetlands. These rivers are highly dependent on rainfall in Angola and typically flood during the dry season in northern Botswana. In dry years, only western portions of the Linyanti River may flood, and the Savuti Channel may dry completely. Throughout much of the study area, seasonal pans contain water during the wet season. Typically, water persists in these pans into August; the larger pans can retain water until November when the wet season begins. Yet, little water is available over large portions of the elephant range during the latter part of the dry season except for that available at artificial waterholes.

The vegetation consists predominately of deciduous dry woodland and scattered grassland on either Kalahari sand or shallower clay soils. The vegetation is closely linked to soil characteristics: *Acacia* spp., *Baikiaea* spp., *Combretum* spp., *Lonchocarpus* spp., *Burkea africana*, occurring on Kalahari sands; poorly drained soils support large areas of *Colophospermum mopane* woodland; *Acacia* spp. and *Terminalia* spp. occur primarily on sandy ridges and lacustrine soils; and shallow soils derived from basalt support mixed associations of *Adansonia digitata, Kirkia acuminate* and *Albizia* spp. (Thomas & Shaw, 1991).

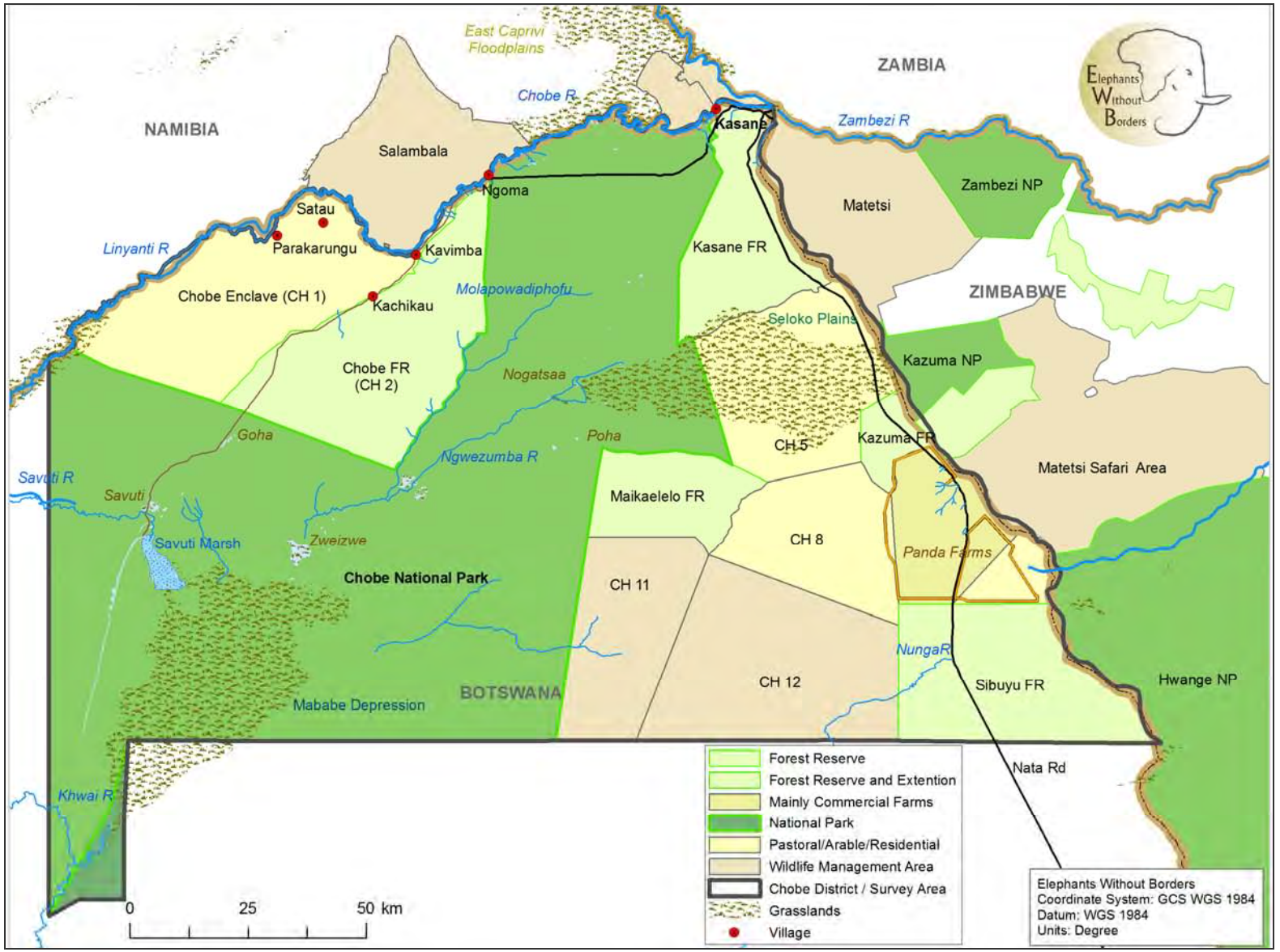
With the District's burgeoning human population (2.5 % annual growth rate) there could be a shortage of land, and when land is allocated in wildlife habitat is could culminate in conflicts (Figure 2).

Figure 2. Chobe District human population in each village (Population Census 2011).



Over 52 % of the District set aside for the Chobe NP, and 18 % designated as FR. There has been growing concern that the large percentage of land (70 %) set aside for conservation needs to offer more diversified investment opportunities (Figure 3).

Figure 3. Chobe District, Forest Reserves, Chobe National Park, and surrounding land use in northern Botswana.



Methods

Fixed-Wing Aerial Survey

Two aerial surveys were flown over the Chobe District. The first was a dry season survey, flown during 26 Aug. - 4 Sept. 2011 (Sept11) and corresponded with the peak dry season when we expected increased visibility and wildlife to be congregated near permanent water. The second survey, 1 - 8 March (Mar12) was flown when water was available throughout the study area in seasonal pans. The areas surveyed differed somewhat between our two surveys. For the Sept11 survey, the entire Chobe District was surveyed, similar to the strata flown by Chase (2011), allowing for direct comparisons between the two dry season surveys. For the Mar12 wet season survey we flew the six FR, the Chobe NP riverfront and CH 5 (Kazuma or more commonly referred to Northern Plains/Seloko area).

Survey Design

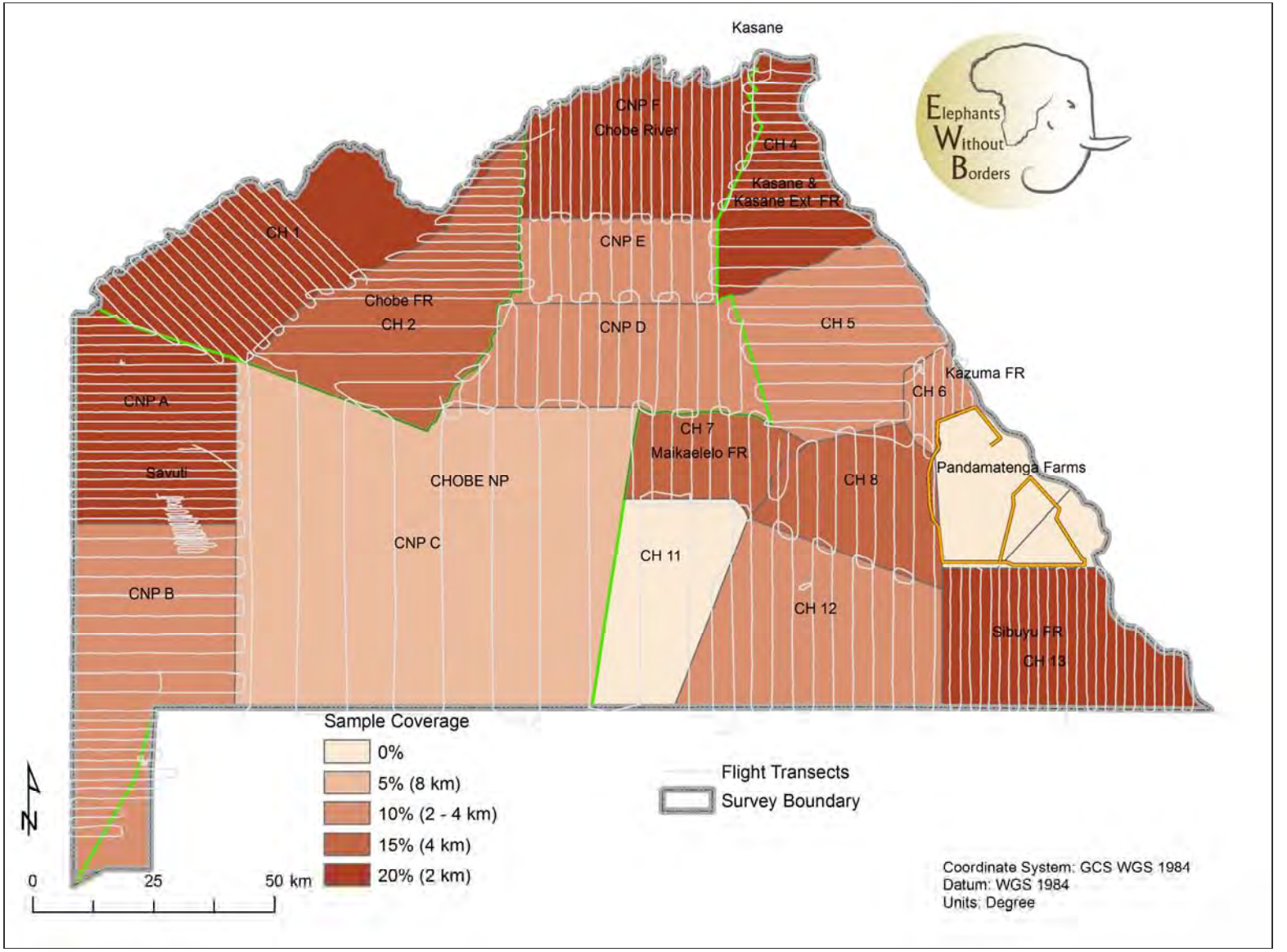
The survey used the standard methodology for strip-transect sampling (Norton-Griffiths 1978), which has been well established for aerial surveys of large African herbivores (Chase & Griffin 2009, Craig & Gibson 2002). This report follows the procedures and methodology used by Chase (2011) for conducting, analyzing and presenting wildlife aerial survey data. For a comprehensive explanation of the survey methodologies refer to this report (Chase 2011).

Prior to the Sept11 survey, the study area was subdivided into 16 strata[1] (Figure 4). These strata were delineated according to WMA number, protected status (land use), expected distribution and abundance of wildlife from prior surveys, elephant satellite telemetry data, consistency with methods used on previous surveys, and changes in land cover. To reduce sampling bias, we oriented systematic, parallel transects to correspond to the perpendicular gradient of major rivers, drainage valleys, environmental features, watercourses and fence lines. The position of the first transect in each stratum was determined randomly using the DNR Garmin Sampling Extension (Minnesota Department of Natural Resources) in ArcView (ESRI Redlands CA 2002).

In order to maximize the precision of the estimate of the total number of elephant in the area sampled, the sampling intensity varied between strata. In areas designated for high intensity sampling, we spaced transects 2 km apart, providing ~ 20 % sampling coverage, with a strip width of ~ 400 m (i.e. combined width of the two search strips). Transects were spaced between 2 and 4 km apart in areas that we designated for moderate sampling intensity, providing a sampling coverage of ~ 15 %. Transects were spaced 8 km apart in two strata (Chinamaba and CH 11), were the expected density of wildlife is considered low during the dry season, providing a sampling coverage of ~ 5 % (Figure 4).

[1] Stratum - is one 'block' of a sample area which has been partitioned into *blocks/strata* (plural = strata). Most stratum on this survey were defined by the boundaries of WMAs. The results from the strata are then aggregated to make inferences about the population.

Figure 4. Survey stratum and sample coverage during 2011 dry season aerial survey of Chobe District.



Bold lines indicate strata boundaries and labels give strata numbers or names.

Flight Procedures and Observations

For all strata we used the standard methodology for transect sampling developed by Norton-Griffiths (1978).

During the survey observers were instructed to search for elephants, buffalo, eland, gemsbok, giraffe, hartebeest, hippo, impala, kudu, roan, sable, lechwe, tsessebe, warthog, wildebeest and zebra. In the tribal grazing areas, cattle were counted.

Elephants were recorded as being in family groups or bull groups. Family groups were herds in which females and young were present, although the herd may have included elephant bulls. Bull groups were classified as single bulls or herds which contained no females or juveniles. The observers also recorded any elephant carcasses seen. All elephant carcasses noted were classified using two age categories as follows:

Carcass category	Definition
1	**Fresh / Recent** Carcass still had flesh, giving the body a rounded appearance. Vultures were probably present, and the ground still moist. (Likely to have died within the past month). Rot patch and skin still present. Skeleton not scattered. (Likely to have died within the past year).
2	**Old** Clean bones; skin usually absent; vegetation re-grown in rot patch. (Likely to have died more than 1 year ago).

These carcass categories are slightly modified from those used by Douglas-Hamilton & Hillman (1981), and recommended by the CITES programme Monitoring the Illegal Killing of Elephants (MIKE). Where possible, observers also noted the presence and absence of tusks from carcasses. To help determine if carcasses were possibly illegally hunted observers noted if tusks had been chopped or removed. This was done mainly when more than one elephant carcass was observed and in close proximity to each other so not to confuse potentially poached elephants with those hunted legally by sport hunters.

In northern Botswana there has been increasing concern about the impact elephants and fires are having on large trees e.g. baobab and the regeneration of other vulnerable tree species (Chase 2010). To provide current information on the status of baobab trees in the survey area, observers were requested to count baobabs, as well as, assess the level of damage on each tree seen (assumed to have been caused by elephant). This '*damage/impact*' was expressed as a percentage of the tree which had been impacted. The proportion of damage to a tree was categorised into one of five subjective categories: nil (0 - 10 %), light (11 - 30 %), moderate (31 - 50 %), heavy (> 50 %), and dead (100 %) (Knight et al. 1994). Baobab trees were also classified into the following three approximate size categories:

Baobab size	Definition
Small	< 1.5 m in diameter
Medium	between 2.5 - 3 m in diameter.
Large	> 3 m in diameter.

All wildlife species seen during the survey were recorded, although estimates (and assessments) of some were likely to be either inaccurate or imprecise. Estimates of small or cryptic species and those whose behaviour (dive as the plane approaches) or habitat makes them difficult to see from the air can be inaccurate. Examples of these include kudu, lechwe, reedbuck, hippo and impala, among others. Rare species or those that have clumped distributions (such as lechwe, buffalo and zebra, respectively) tend to have imprecise estimates (Craig & Gibson 2002). We tried to address these concerns by stratification of survey effort and aerial photography, which are two technical tools frequently used to improve precision and accuracy of wildlife surveys, respectively.

Strip Width and Calibration

Strip widths were delineated by two parallel aluminum wands connected to custom made brackets, which were attached to each wing strut of the aircraft. The wands could be moved in any direction during the setup phase to delineate a planned 200 m field of view for each strip for recording wildlife observations at an altitude of ~ 91.5 m.

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 (10 m apart) on an airstrip and conducting flyover tests. After repeated flyovers (at ~ 91.5 m) and photo verification, wands were adjusted to provide a designated field of view for each strip interval of ~ 200 m at appropriate flight altitude. The aluminum wands were attached to the struts for the duration of the survey. Transects were typically flown during morning hours (~ 07h00 - ~ 11h30); however, some were flown between 16h00 - 17h30 due logistical constraints.

Data Analysis

Strip Transect Sampling / Fixed-Wing Aerial Survey

Survey strata were largely delineated according to the boundaries of WMAs and protected areas to provide wildlife estimates specific to these areas. Prior to surveying Chobe NP, the survey team conducted reconnaissance flights to determine the density of elephants. Chobe NP was then subdivided into six strata based upon elephant and wildlife sightings on these reconnaissance flights. Two strata (Kasane Forest Reserve and CH 5) were both flown as single strata but subdivided prior to data analysis. The entire survey area, in this report is termed 'Chobe District', the survey area covered the entire part of the Chobe District' and the term is used in reference to the area sampled (22560 km^2).

Following the guidelines developed by Norton-Griffiths (1978) we calculated abundance for individual strata from wildlife counted within the 200 m wide intervals. We adjusted for altitude and photo corrections and used the traditional Jolly's Method II for unequal sized sampling units (Jolly 1969)

to calculate population estimates and variance for each species in each stratum (Appendix 1). Variance estimates for strip transect counts were calculated from observation data collected within the mean combined strip width. The Jolly's Method II 'ratio method' is based on the calculation of the ratio between animals counted and area searched. The population estimate is based on the density of animals per sample unit (transect) rather than number of animals per sample unit.

Entire Survey Area and Strata within it. We calculated population estimates for each stratum and summed these estimates to obtain an estimate for our entire survey area. The upper and lower 95% confidence limits for population estimates for the entire survey area or stratum (within it) were calculated following Dunham et al. (2009) as:

Population estimate $\pm$[t_{v} x Square root of (Sum of Variances for individual strata)]

Where:

$_{v}$ = the degrees of freedom estimated by Satterthwaite's rule (Gasaway et al. 1986)

v was an integer, calculated using the formula:

$$v = \frac{(\text{Sum of Variances for individual strata})^2}{\text{Sum of [Variance for individual stratum)}^2 / (n-1)]}$$

Comparison of observers. For each of the more common species, the total numbers of individuals and groups counted by each observer in all transects was determined. For each observer and each species, the numbers of individual animals and groups that the observer was expected see was calculated. For each species, the observed and expected numbers of animals/groups seen were compared using Chi-square (X^2) one sample statistical tests with 1 degree of freedom (Dunham et al. 2009). Significant differences are reported at $P \leq 0.05$.

Elephant carcasses. Following the method developed by Douglas Hamilton & Burrill (1991), and adapted by Dunham et al. (2009), the elephant carcass 'ratio' (which is a percentage), defined as the ratio of dead elephant (of all categories) to all elephants (dead plus live animals), was calculated.

It is reasonable to assume that all category 1 carcasses represent elephant that may have died during 2011 (within the last year) Dunham et al. (2009). Hence, the category 1 carcass ratio provides an index of elephant mortality (both natural and anthropogenic) during 2010 and was calculated as the estimated number of elephant carcasses in age category 1 as a percentage of the sum of the estimated number of live elephants and the estimated number of carcasses in age category 1.

Photo-interpretation. High-resolution digital photographs taken from cameras mounted on each side of the plane were used to verify the numbers of animals seen by observers to those captured in the photos. This photo interpretation was especially helpful in counting large herds that are difficult to count from the air. In addition, photos helped to verify whether animals occurred within the counting interval (Norton-Griffiths 1978).

Data analysis. Maps illustrating the density, distribution and group sizes of wildlife observations were created using ArcMap (ver.10 ESRI 2010). Photographs were viewed in Adobe Photoshop, colour corrected and dots placed on each counted animal within each counting group. Two sample *t*-tests were

used to compare the sizes of baobab trees and a Rank Correlation test was used to determine the relationship between elephant density and baobab damage east (NG 26) and west (NG 8) of the Southern Buffalo Fence. SYSTAT® 10.2 and Excel® were used for all statistical analyses.

Search Effort

The greater the time spent searching each square kilometer of a transect, the greater the probability that the observer saw animals that occurred within the counting strip. Search effort (in minutes per sq km) for a stratum was defined as the total time spent flying all transects within that stratum, divided by the total area of those same transects (Gasaway et al. 1986).

Aerial surveys inherently underestimate wildlife numbers, with the degree of underestimation greater for small or cryptic species than for larger species. However, population estimates are given for all species, because the estimates provide useful indices of abundance (with measures of precision) that can be used to determine spatial distribution, as well as, temporal trends in population numbers (Dunham et al. 2009). Other than the observations which were corrected by reference to photographs, no other corrections have been applied to any estimates to compensate for any undercounting or missed animals.

Results

Sampling Effort

For the 21552 km^2 dry season survey area, 243 transects ($\overline{X}$ = 26 km), totaling 2583 km were flown in 113 hours over 18 days (Table 12 & Figure 14). Flight altitude averaged 96.5 m (range 81 - 133 m) for wildlife observations. The search rate, (km^2/min) was calculated as the total sample area divided by the total time on transects and averaged 1.4 for the entire survey area. During the wet season only eight strata were flown, these included the six Forest Reserves, the Chobe Riverfront and CH5 area. All strata in the wet season were flown at the same sampling intensity as the dry season, except for Sibuyu FR which was flown at 10 % sampling coverage during the wet season as opposed to 20 % during the dry season.

Estimates

The estimated numbers of elephants, elephant bulls, elephant family groups, elephant carcasses (age category 1 = elephant carcass and, 2 = elephant bones), buffalo, eland, giraffe, gemsbok, hippopotamus, impala, kudu, roan, sable, tsessebe, wildebeest, zebra, ostrich, baobab trees and cattle are given in Tables 13 to 32, respectively. Estimates are given for each stratum, for various land units within the survey area (WMAs, protected areas and district estimates) and for the entire survey area. There may appear to be small arithmetic errors in some tables, but these are rounding errors.

The columns in the abundance estimate tables provide:

- the name of **stratum**,
- the **estimate** of the number of animals of that species in that stratum, in other words the population estimate,
- the number of individuals of that species seen (**No. seen**) inside the search strips during the survey of that stratum,
- the **variance** of the estimate number of animals in that stratum,
- the 95 % confidence interval of the population estimate for that species in the stratum, as a percentage of the population estimate for that stratum (**% CI**),
- the lower 95 % confidence limit of the population estimate (**Lower CL**),
- the upper 95 % confidence limit of the population estimate (**Upper CL**), and
- the **density** (estimate of animals per km^2) was calculated using the stratum area. Density estimates were calculated for those strata in which the animals occurred or where animals were not observed but are known to occur.

The last row of each table gives the same measures of the entire survey area and additional rows give subtotals for various land units within the survey area. If the calculated lower confidence limit (**Lower CL**), was less than the actual number of elephants counted within the strip (**No. seen**), then it is biologically meaningful to replace the calculated lower confidence limit with the number seen (Chase & Griffin 2009, Dunham et al. 2009).

For practical purposes, it can be assumed that the number of a given species in a given stratum lies between the lower and upper confidence limits, with the '**estimate**' providing the best estimate of the number there. For example, from Table 1, one can say that there were between 32915 and 48118 elephant in the Chobe District, with 40517 being the best estimate of the number of elephants within our survey area (Chobe District). For practical purposes, one might say that there were between 33000 and 48000 elephants within Chobe District during the late dry season of 2011, with 40000 being the best estimate of the number of elephants in our survey area.

Buffalo are a particularly difficult species for which to obtain precise population estimates because of their tendency to occur in very large herds, making the estimate dependent on a small number of sightings. Clumping of buffalo (and their mobility) is a major problem for aerial surveys (Patterson *pers. comm*.). Warthog are typically not countable before 09:00.

Low numbers of bushbuck, hyaena, leopard, lion, and waterbuck were seen during the survey, and no attempt has been made to estimate the numbers of these species. While baboon, steenbuck and duiker were seen their numbers have not been estimated.

Table 1. Wildlife estimates and statistics for major wildlife species, elephant carcasses, baobab trees, and cattle during the 2011 dry season aerial survey in Chobe District.

Species	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
Woodland Sp								
Elephant	40517	6745	14891623	7601	19%	32915	48118	1.88
Elephant Bull	4942	766	229263	943	19%	3999	5885	0.23
Elephant Family	35578	5988	13723843	7292	20%	28280	42875	1.64
Elephant Carcass	544	71	10859	205	38%	339	749	0.03
Elephant Bones	1289	198	18165	265	21%	1023	1554	0.06
Buffalo	17370[1]	2611	49072948	13799	79%	3571	31168	2.09
Eland	1237	191	91263	595	48%	642	1832	0.06
Giraffe	1483	198	66345	507	34%	975	1990	0.07
Impala	5616	1043	2368415	3031	54%	2584	8647	0.26
Kudu	524	83	14866	240	46%	284	764	0.02
Roan	287	47	5189	141	49%	145	429	0.01
Sable	2106	374	225992	936	44%	1169	3042	0.10
Tsessebe	341	55	12096	217	64%	124	558	0.02
Warthog	566	104	8858	185	33%	380	751	0.03
Wildebeest	634	80	185682	848	134%	214	1482	0.05
Zebra	6542	1258	2331057	3007	46%	3535	9550	0.30
Wetland Sp								
Hippo	196	36	7300	168	86%	36	364	0.01
Birds								
Ostrich	113	20	2061	89	79%	23	202	0.01
Other Obs								
Baobab tree	702	306	40214	395	56%	306	1097	0.03
Cattle	4815	737	3403259	3648	76%	1167	8463	0.48

[1] Aerial survey strip estimate.

Observations

During the dry season survey 2832 herd observations were recorded (Table 2). The highest number of observations occurred for elephants (948). Using a sex ratio of 2:3 bulls to cows within family groups suggests that there were 14231 bulls in the family herds (Craig & Gibson 2002). This gives an overall sex ratio of 1:2.6. Herd size for the family groups averaged 10 animals and 68 % of elephant observations occurred in groups of 10 animals or less. Average herd size for bull groups was 2.2, 53 % of the bulls seen were solitary, and 19 % were observed in pairs. Zebra (96), giraffe (86), sable (61), and buffalo (51) herds were observed frequently. Buffalo had the largest average herd size (51), although one herd numbered ~ 1483 buffalo. Average herd size for impala and zebra, were 23 and 13 animals respectively (Table 2).

Baobab observations. A total of 306 baobab trees were seen during the survey, of which the majority, (107) were counted in the Chobe FR. Of the trees counted 56 were classified as large, 136 as medium and 114 as small sized tree. Most of the trees (212) appeared to have had less than 10 % damage to them, 56 trees had between 11 - 30 % damage, 12 trees had between 31 – 50 % damage,

and 17 trees had greater than 50 % damage. Dead trees (100 % damage, n = 9) accounted for 2.94 % of the total number seen within the survey area.

Table 2. Numbers seen, groups counted and average group size of animals, baobabs, birds and carcasses seen during the 2011 dry season aerial survey in Chobe District.

Species Observed	Number of individuals seen	Number of groups seen	Average group size	Min. group size	Max. group size	Std. Dev.
Woodland Sp						
Elephants	6752	948	6	1	175	5.85
Elephant families	5986	606	9.8	2	175	9.7
Elephant bulls	766	342	2.2	1	13	1.85
Elephant carcass	51	41	1.2	1	3	0.58
Elephant bones	203	181	1.1	1	4	0.4
Buffalo	2640	51	52	1	500	97.8
Eland	201	44	4.5	1	35	7.6
Gemsbok	15	7	2.1	1	4	1.1
Giraffe	197	86	2.3	1	11	1.8
Impala	1066	46	23	1	300	47
Kudu	83	31	2.6	1	9	1.9
Roan	59	27	2.2	1	12	2.4
Sable	364	61	6	1	32	7
Tsessebe	56	13	4.3	1	11	3
Warthog	121	44	2.7	1	6	1.4
Wildebeest	81	9	9	1	50	15.5
Zebra	1251	96	13	1	150	24.3
Wetland Sp						
Hippopotamus	36	8	4.5	1	15	4.4
Lechwe	9	4	2.25	1	5	1.9
Waterbuck	3	2	1.5	1	2	0.7
Birds						
Ostrich	30	18	1.6	1	8	1.6
Other Obs.						
Cattle	737	20	37	1	100	26.7
Baobab tree	306	147	2.1	1	14	2.3
Total / mean	**21013**	**2832**	**8.4**	**1**	**500**	

Comparison of observers. A comparison of the numbers of animals seen by the two observers (Table 3), suggested that they generally saw similar numbers of herds of animals. The left observer counted more individual animals. It is not possible from the survey results to determine which observer counted most accurately. No Chi-square test was conducted if any expected number was < 3.

The left observer saw more individual animals (except for buffalo) than the right observer. The left observer also saw more herds of wildlife (for all species) than the right observer (Table 3), although for many of these observations the two observers saw approximately similar numbers of herds.

Some species (e.g. buffalo, impala and zebra) often occur in relatively large herds. Furthermore, relatively few groups of these same species are seen during the survey. Hence, some of the differences, while statistically significant, are probably a consequence of chance. However, differences were found for most species, the left observer saw more animals than expected if the observers were of similar efficiency.

Elephant carcasses. Observers counted 51 recent elephant carcasses (i.e. age category 1) during the survey. The majority of elephant carcasses seen were bones and occurred in the age category 2 (n = 203). Douglas-Hamilton et al. (1991) suggest a carcass ratio of 2 – 8 % as being normal for a stable or increasing population. The estimated total number of elephant carcasses (1651) in the survey area during the dry season of 2011 represented 3.92 % of the estimated total number of live and dead elephants. The estimate for recent or fresh (category 1) carcasses was 362, representing a carcass ratio of .9 % (which reflects the mortality rate of elephant during the survey year). Elephant carcass estimates for protected (851) and unprotected areas (800) were similar. Most (15.7 %) of the total estimated elephant carcasses occurred in the Phofu stratum within Chobe NP (259), accounting for 41 % of the estimated total number of live and dead elephants, and a mortality rate of 13.32 % in this strata. More than 58 % (952) of the total estimate for all carcass categories were seen in four strata, Phofu, Nogatsaa, Chobe River and Chobe FR.

Of the 11 fresh elephant carcasses seen during the entire survey 24 occurred in the Phofu-Nogatsaa and CH 5 region, of which observers assumed that 52 % had been killed by poachers. This number is a reliable estimate based upon fresh carcasses which were observed in non-sport hunting concessions, carcasses which appeared to have had their tusks chopped out, and the occurrence of more than one carcass in close proximity to each other. Wildlife officials may have removed tusks from these elephant carcasses, but it is unlikely given the remote areas where carcasses were observed. Nearly a quarter (21 %) of the estimated total number of elephant carcasses occurred in the Chobe Enclave.

Table 3. Comparison of numbers of individual animals seen and numbers of herds/groups seen by the left and right observers.

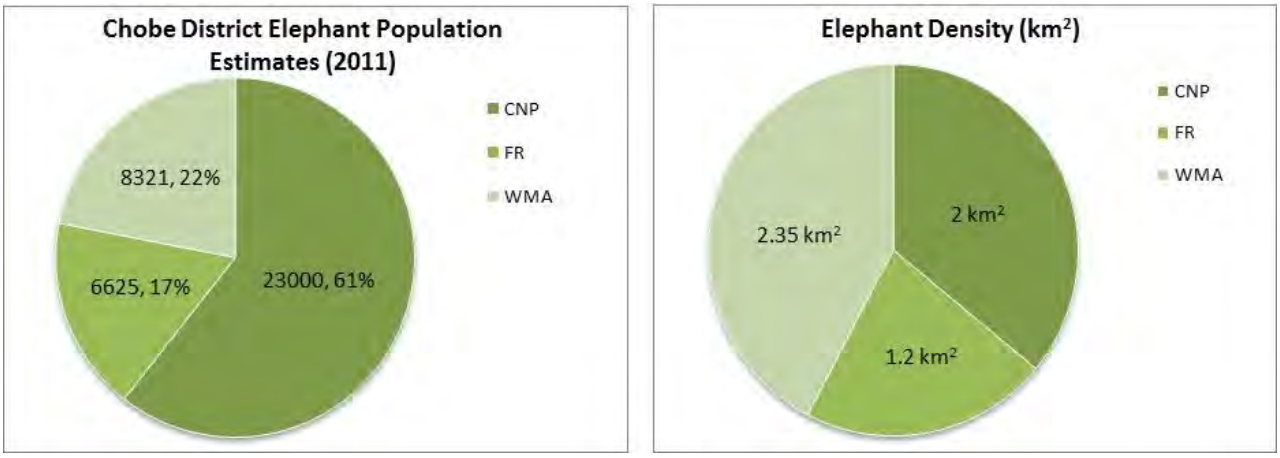
Species	Observed Number of individuals		Expected Number of individuals		Observed Number of herds		Expected Number of herds		Chi-square individuals	*P*	Chi-square herds	*P*
	Left	Right	Left	Right	Left	Right	Left	Right				
Woodland Sp												
Elephant Family	3262	2724	2770	2707	326	280	280	274	-	0.000	7.53	0.006
Elephant Bulls	352	414	354	346	158	184	158	155	13.2	0.000	5.55	0.018
Elephant Carcass	32	19	24	23	26	15	19	19	3.7	0.054	3.28	0.070
Elephant Bones	121	82	94	92	107	74	84	82	8.8	0.000	7.20	0.007
Buffalo	1136	1504	1222	1194	21	30	24	23	-	0.000	2.37	0.124
Eland	121	80	93	91	24	20	20	20	9.7	0.001	0.65	0.420
Gemsbok	10	5	7	7	5	2	3	3	1.8	0.177	1.39	0.240
Giraffe	149	48	91	89	57	29	40	39	-	0.000	9.95	0.001
Impala	894	172	493	482	30	16	21	21	-	0.000		0.030
Kudu	45	38	38	38	19	12	2	2	-	0.286	4.68	0.300
Roan	37	22	27	27	17	10	12	12	4.3	0.038	2.02	0.154
Sable	275	89	168	165	39	22	28	28	-	0.000	5.24	0.022
Tsessebe	18	38	26	25	6	7	28	28	8.8	0.003	0.21	0.643
Warthog	91	30	56	55	34	10	20	20	-	0.000	14.06	0.000
Wildebeest	74	7	37	37	8	1	4	4	-	0.000	5.85	0.015
Zebra	584	667	579	566	57	39	44	43	18.1	0.000	4.01	0.045
Wetland Sp												
Hippo	9	27	17	16	3	5	4	4	10.6	0.001	0.66	0.416
Lechwe	7	2	4	4	3	1	-	-	3.0	0.084		0.000
Birds												
Ostrich	24	6	14	14	14	4	8	8	11.6	0.000	5.97	0.015
Other Obs												
Baobab tree	177	129	142	138	85	62	68	66	9.5	0.002	4.54	0.033
Cattle	357	380	341	333	9	11	9	9	7.3	0.006	0.43	0.512

Wildlife Distributions

The spatial distribution of wildlife is illustrated in Figures 12 to 30. On most maps, the distribution is shown in two ways. First, each stratum is shaded to represent the average density of the given species in that stratum. Secondly, the locations of sightings of groups of the given species, together with an indication of the size of group/herd are depicted by points of varying sizes. It should be remembered that the recorded number of groups of any species was determined by both group density and sampling intensity – which, by design varied between strata (Table 12). The distribution of animals during the 2011 dry season was generally similar to that seen to the previous year's aerial survey (Chase 2011). Most animals were found within 30 km of the major perennial rivers. Wildlife densities were lowest in the dry interiors of south east Chobe NP, and adjoining CH 11 WMA.

Elephants were widely distributed throughout the entire survey area. Most elephants (57 %) occurred outside of Chobe NP (Figure 5). A large number of elephants occurred within 30 km of the Linyanti, Chobe and Savuti rivers, occasional observations were made in the drier interior of the Chobe District (Figure 12). The highest densities of elephants occurred in CH 1 along the now flowing Linyanti River (8 km^2), followed by 7 / km^2 along the Savuti Channel and 4 / km^2 along the Chobe River.

Figure 5. The number and density (km^2) of elephants in Chobe District in relation to protected areas (CNP), forest reserves (FR) and WMAs, dry season 2011.



Buffalo observations mainly occurred along the Chobe and Linyanti rivers and adjoining floodplains, but bachelor herds were seen near seasonal pans which still held water and artificial waterholes (Figure 20). Large herds were observed in the lower Mababe Depression and Savuti Marsh, where recent water flow had created a flush of green vegetation. Eland were primarily seen in the northeast Chobe District and within the grasslands of the Northern Plains (Figure 21). Many eland were observed during the wet season survey within the new fenced area of the Pandamatenga Farms (Appendix 2). Giraffe were observed mainly along the Chobe River, and along the Magwikhwe Sand Ridge, west of Savuti. The deep sand ridge supports mature stands of *acacia erioloba* to which giraffes are partial too (Figure 22). Gemsbok were seen in very low numbers and in small herds, but more often on their own within the Northern Plains area (Table 21). Hippos occurred along the main river channels in the Chobe and Linyanti rivers. Most impala observations occurred along the Chobe River floodplains, along the Khwai River and the Savuti region (Figure 23). Kudu were observed mainly throughout the District, but high numbers are known to occur along the Chobe River (Figure 24).

Roan observations were limited (27), and mainly observed in small groups (3 - 5). Most observations were made in the Linyanti region, the Northern Plains appear to be a critical wet season habitat for these animals (Figure 25). Sable were mostly seen in the northeast parts of the District within the Kasane Forest Reserve and Chobe River stratum (Figure 26). Tsessebe were mainly seen ~ 20 km south of the Chobe River and on the Northern Plains in CH 5 (Figure 27). Wildebeest were rarely observed, and were only seen within the Savuti region and along the Khwai River (Figure 28). Zebra occurred mainly along the Chobe and Linyanti floodplains. Just one herd of zebra were seen on the Savuti Marsh despite this area having water (Figure 29). Ostrich occurred throughout the survey area but at relatively low numbers (Table 30). In the multi-use concessions which allow agriculture, many cattle were observed. Cattle were distributed in the Chobe Enclave and within the Kasane FR and CH 5 areas (Figure 30). Baobab trees occurred throughout the survey area (Figure 31). Important baobab habitat included the Kachikau ridge, the Northern Plains – Kasane FR ecotone and northern Sibuyu FR.

Cattle Distribution

The survey was flown mainly over wildlife conservation areas, but within the six FR, CH 1 and CH 5 WMAs cattle farming (grazing rights in the case of the FR) is permitted under a multiple land use system (Table 31). The Chobe FR and CH 1 areas had an estimated 4815 cattle. The density estimate of 3 cattle / km^2 is misleading, as the density estimate incorporates the entire Chobe FR, and areas where cattle do not occur. Given that cattle mainly occur within 10 km of villages, the density of cattle within 10 km of the Linyanti River (along the Kachikau Rd) increases significantly to approximately 20 cattle / km^2.

A comparison of wildlife density and distribution shows that there is a clear separation between areas of high cattle and high wildlife numbers. Wildlife density within 10 km of the Chobe Enclave villages is low. Where people and livestock are concentrated, wildlife populations are lower.

Trends in Elephant Numbers in Chobe District

In 1993, the DWNP standardized their aerial survey methods. Since then, nine aerial surveys of wildlife in northern Botswana have been flown (DWNP 1993, DWNP 1994, DWNP 1996, DWNP 1999, DWNP 2001, DWNP 2002, DWNP 2003, DWNP 2004, and this survey). Wildlife population estimates for Chobe District and Chobe NP were compared to the DWNP aerial survey estimates. For all stratum the areas covered by the surveys were similar and survey intensity for a few strata varied between the Chase (2010 and 2011) and the DWNP (1993 -2004) surveys. The time series of population estimates for Chobe District and Chobe NP were examined to determine trends over the past 17 years (Table 4 and Figure 6).

Elephant population estimates derived from the nine aerial surveys suggests that Chobe's elephant population increased during the early 1990s. From 2004 however, elephant population estimates in Chobe District and Chobe NP have remained similar or declined. This suggests that the elephant population has remained stable.

Table 4. Calculated growth rates (*r*) and 95% Confidence Intervals (CI) for elephants in Chobe District, Chobe NP, Chobe River and CH 1 and 2 strata, covered by all aerial surveys in Chobe District, 1993 - 2010.

District / Protected Area	aerial surveys	Std. Error	*r* (95% CI)	*F*	*P*
Chobe NP[a] $_{1993\text{-}2010}$	9	0.02	0.05 (0.01 – 0.1)	7.43	0.03*
Chobe NP $_{2001\text{-}2010}$	5	0.01	-0.02 (-0.08 – 0.04)	-	-
Chobe District $_{1996\text{-}2010}$	7	0.01	0.03 (0.01 – 0.1)	9.27	0.03*
Chobe River $_{1996\text{-}2010}$	7	0.02	-0.01 (-0.05 – 0.02)	0.75	0.42
Chobe River $_{2001\text{-}2010}$	5	0.02	-0.02 (-0.01 – 0.08)	-	-
CH 1 & 2	7	0.01	0.01 (-0.02 – 0.04)	0.96	0.37

[a] Trends were calculated using elephant density (trends using elephant numbers appear in Figures 7-10).
The *F* and *P* values indicate when the slope of the regression line (which represents rate of growth) differs significantly from zero.
* indicates significant trends.

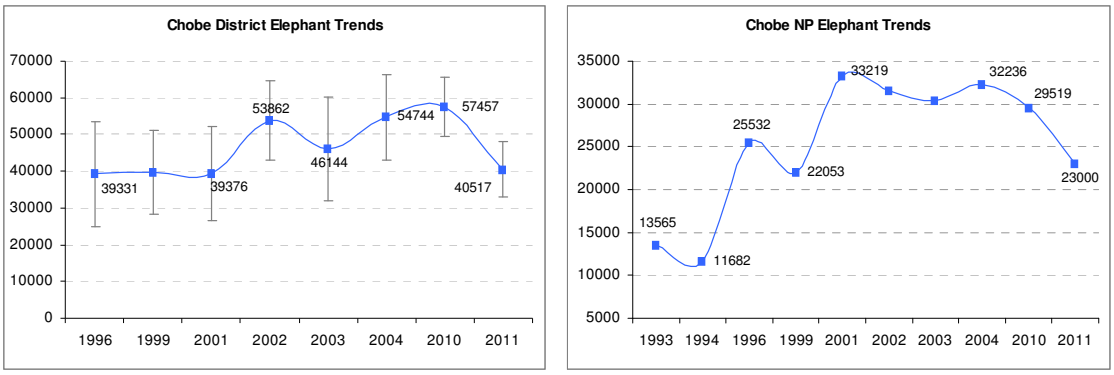
The elephant population in Chobe NP has increased significantly (*P* = 0.03), from 13565 in 1993 to 29519 in 2010. In 1996 the population in Chobe NP nearly doubled, but estimates from four aerial surveys conducted between 2001 and 2011 have remained similar (~ 30000 elephants). The doubling of elephant numbers in Chobe NP in 1990s was mostly likely caused by elephants moving into Chobe NP, this subsequently had an impact on their numbers which appear to have stabilised over a ten year period. Elephant numbers in the Chobe District have been increasing at an annual rate of 3 % per annum from 1993 (Table 4).

Trend statistics (d-test (Norton-Griffiths 1978)) may confidently test for stability (no significant difference), and were used to compare 2010 and 2011 elephant survey estimates (variance estimates are not provided for the DWNP surveys). The absence of a statistically significant trend does not necessarily mean there was no trend (Table 5). For Chobe NP estimates the 95 % Confidence intervals are not provided by DWNP, further it is unclear how DWNP extrapolated estimates for the Park as survey strata over the Park incorporated other land use types. Therefore, estimates specifically for Chobe NP derived from the DWNP aerial surveys should be interpreted with caution.

Table 5. d - test (students *t* test) comparing the 2010 and 2011 aerial survey elephant estimates.

Stratum	**Elephants**		
	Survey Estimates		*d* test
CHOBE (CH) DISTRICT	2010	2011	
CH 1 Chobe Enclave	5815	9003	1.39
CH 2 Chobe Forest Res	7807	4965	**2.06**
CH 4 Kasane Forest Res	1471	542	1.42
CH 5 & 6 N Plains	617	381	0.96
CH 7 Maikaelelo Forest Res	0	78	1.90
CH 8 Community Hunting	0	454	1.82
CH 11	0	0	0.00
CH 12 Bottle Pan	1527	1437	0.11
CH 13 Sibuyu Forest Res	10681	659	**5.24**
FR & WMA Subtotals	27918	17519	**3.00**
Chobe NP (CH 3)			
CNP A (Linyanti-Savute)	11655	9550	1.19
CNP B (Mababe-Khwai)	4498	4100	0.30
CNP C (Chinamba)	5281	2650	0.74
CNP D (Nogatsaa)	1871	1112	0.99
CNP E (Phofu)	951	371	1.66
CNP F (Chobe River)	5283	5215	0.06
CNP NP Subtotals	29539	22998	1.49
Chobe District Totals	57457	40517	**4.04**

Figure 6. Trends in the number of elephants in Chobe District and Chobe NP (1993 – 2011).



Estimates and 95 % CI error bars for Chobe District, CI not provided for Chobe NP by DWMP surveys

The differences in population size from 2010 to 2011 may be the result of movements by elephants across international borders and dispersal across district boundaries, rather than variations in census error or natural population increase through reproduction. There has been some concern expressed about the outlier estimates and consistency of the DWNP counts (Junker et al. 2008).

Trends in Wildlife Numbers

Wildlife population estimates from the DWNP aerial surveys (8) between 1993 and 2004 suggest that in Chobe District animals are increasing or stable with the exception of wildebeest and tsessebe, whose numbers appear to be declining throughout northern Botswana (Chase 2010, & Table 6). The 2010 and 2011 aerial survey estimates for eland, impala, lechwe, sable, tsessebe, warthog and zebra in Chobe District are some of the highest recorded when compared to the DWNP survey estimates. The 2011 wildebeest estimate (634) in Chobe District is low, but this is the highest estimate since 1999 (Table 6).

Trends in wildlife populations in Chobe show high variation even between surveys separated by one or two years. This is probably due to natural fluctuation in numbers because of seasonal dispersal, the timing of dry season aerial surveys, the result of poor application of survey method in some years, and poor calculations (Deloitte & Touche 1992).

Table 6. Wildlife population estimates from ten dry season aerial surveys over Chobe District and Chobe NP, 1993 – 2011.

Species	Wildlife Population Estimates Chobe District & Chobe NP									
Year of survey	1993	1994	1996	1999	2001	2002	2003	2004	2010	2011
Chobe District										
Elephant	-	-	39331	39836	39376	53862	46144	54744	57457	40517
Buffalo	-	-	6645	10658	6903	3874	5304	15976	7409	5474[1]
Eland	-	-	1370	2012	590	2202	1458	691	2374	1237
Giraffe	-	-	1236	1262	978	835	1528	1885	1245	1483
Hippo	-	-	6	40	92	41	103	85	304	196
Impala	-	-	667	936	2079	1784	1154	2532	6630	5616
Kudu	-	-	280	434	155	260	314	813	456	524
Lechwe	-	-	205	62	252	154	355	213	404	-
Ostrich	-	-	478	532	606	535	492	-	376	113
Roan	-	-	550	407	436	308	124	21	395	287
Sable	-	-	1347	1188	1622	1758	1920	1327	2131	2106
Tsessebe	-	-	369	964	232	239	553	32	926	341
Warthog	-	-	113	133	140	299	262	-	1095	566
Wildebeest	-	-	1079	602	192	266	109	152	525	634
Zebra	-	-	7213	2747	2884	4259	6900	2184	7882	6542
Chobe NP										
Elephant	13565	11682	25532	22053	33219	31598	30348	32236	29519	22998
Buffalo	31	736	5319	4903	1788	252	3773	10603	2643	4233[1]
Eland	-	100	239	225	27	166	115	218	1059	438
Giraffe	364	1107	666	850	692	540	999	1044	770	777
Hippo	83	145	6	-	90	-	50	85	246	138
Impala	1697	2008	386	560	1502	1439	868	1645	6051	5298
Kudu	-	497	114	260	123	156	205	434	306	324
Lechwe	52	138	172	63	245	-	362	197	404	
Ostrich	291	43	344	416	173	300	369	-	223	81
Roan	31	195	160	148	144	1533	68	20	140	177
Sable	448	868	951	1119	857	-	1117	116	777	209
Tsessebe	1322	270	253	960	43	103	77	-	462	111
Warthog	104	337	114	63	153	184	170	665	862	322
Wildebeest	-	-	777	-	188	147	-	145	500	634
Zebra	479	1762	2490	1504	1359	338	2121	1151	2472	3874

- Cells donate estimate not provided by DWNP. Whether animals were counted or not seen is unknown. [1] Partial total count estimates.

Complete trend data were not available to calculate d- tests (trend) for the DWNP data (1993 - 2004), as variance estimates were not presented/missing from the dataset provided by DWNP. Long-term trends are difficult to analyse given the variable nature of the DWNP surveys and comparisons in this report will be made only to 2010 data and course comparisons made through the use of graphs to earlier DWNP surveys (Figure 7 & Table 7).

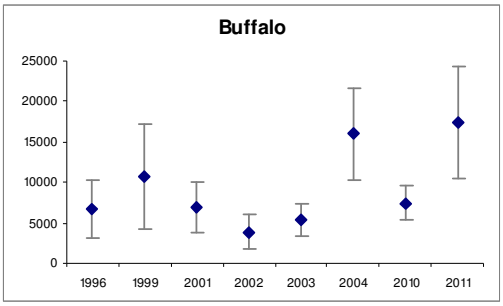
The great differences in estimates of population size for most species between different surveys and the high confidence limits to the estimates demonstrate that the older DWNP surveys are not satisfactory for estimating numbers other than for elephants, particularly if estimates are required for sub-units within the total survey area e.g. specifically the FRs. They also provide data at too crude a level to show anything but gross seasonal distribution patterns of elephants (Deloitte & Touche 1992). The problem with the DWNP surveys is that the sample intensity is very low, generally around 3.5 % to 4 %. Transects are flown approximately 10 km apart. With the low density of animals it is likely that species could be missed in any single block.

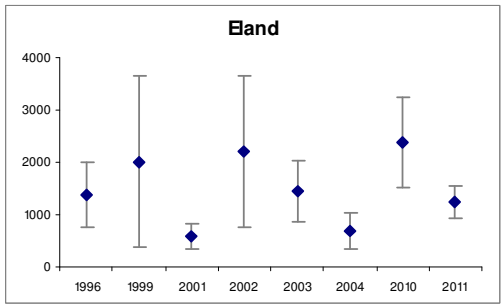
The 2011 dry season estimate of 40500 elephants in the Chobe District is ~17000 lower when compared to aerial survey estimates between 2002 – 2010. There was a statistical significance between the 2010 and the 2011 estimate (d = 4.04). This variation could be attributed to cross border elephant movements between Botswana and Zimbabwe. The estimates for elephants in the Sibuyu FR along the Zimbabwe border differ by nearly 10000 animals between the two surveys.

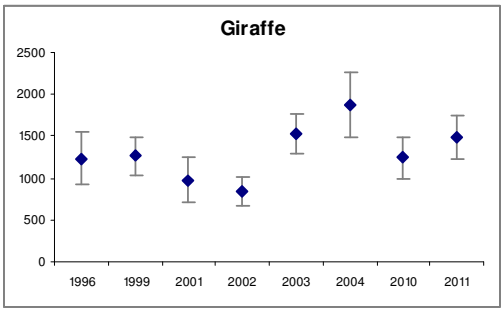
Table 7. Two dry season (2010 and 2011) strip aerial survey estimates of wildlife, with d-test comparisons between 2010 and 2011 aerial surveys.

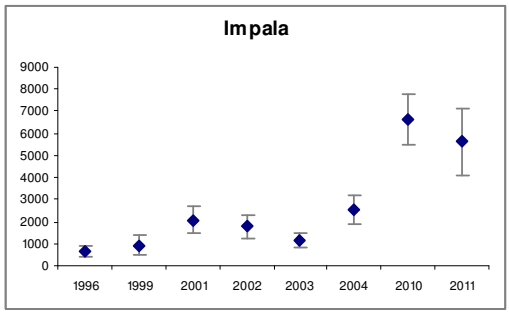
Year of survey	2010			2011			*d* test
	No. Seen	Est.	95% CL	No. Seen	Est.	95% CL	
Chobe District							
Elephant	8319	57457	8018	6745	40517	7601	**4.04**
Buffalo	1245	7409	4224	2611	17370	13799	1.36
Eland	306	2374	1722	191	1237	595	1.23
Giraffe	155	1245	505	198	1483	507	0.65
Hippo	63	304	212	36	196	36	1.00
Impala	1187	6630	2353	1043	5616	3031	0.52
Kudu	64	456	277	524	524	240	0.37
Lechwe	87	404	289	32	160	50	1.67
Ostrich	43	376	184	20	113	89	**2.52**
Roan	57	395	301	47	287	141	0.64
Sable	362	2131	789	374	2106	936	0.04
Tsessebe	104	926	1003	55	341	217	1.12
Warthog	149	1095	385	104	566	185	**2.44**
Wildebeest	78	525	471	80	634	600	0.22
Zebra	1419	7882	4040	1258	6542	3007	0.52
Chobe NP							
Elephant	4654	29539	6228	3791	22988	6119	1.49
Buffalo	2643	564	1823	1990	13861	13553	1.86
Eland	147	1059	1329	89	438	399	0.89
Giraffe	102	770	320	95	777	418	0.03
Hippo	52	246	202	25	138	155	0.84
Impala	1103	6051	2289	1002	5298	3029	0.39
Kudu	48	306	204	50	324	217	0.12
Lechwe	87	404	289	34	124	-	-
Ostrich	21	223	110	14	81	87	**2.10**
Roan	26	140	76	28	177	108	0.55
Sable	154	777	370	209	1025	722	0.61
Tsessebe	55	462	496	21	111	90	1.38
Warthog	118	862	370	57	322	144	2.70
Wildebeest	75	500	474	80	634	854	0.27
Zebra	533	2472	1842	803	3874	2859	0.83

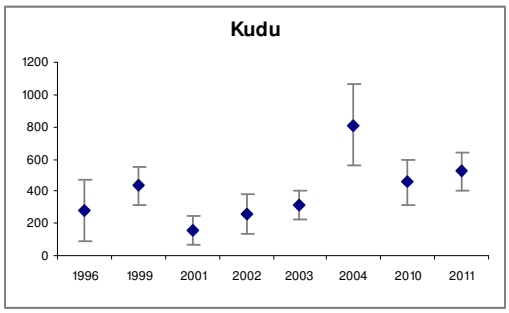
Figure 7. Summary trend analyses for selected wildlife species in Chobe District, based upon dry season aerial surveys (10) flown between 1993 and 2011.

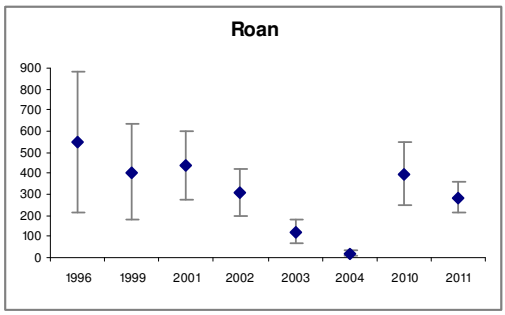


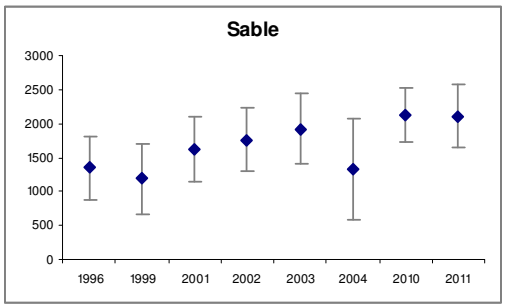


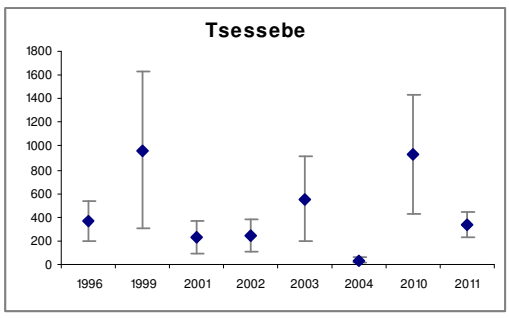


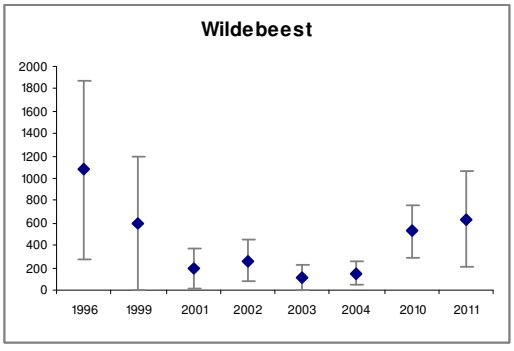












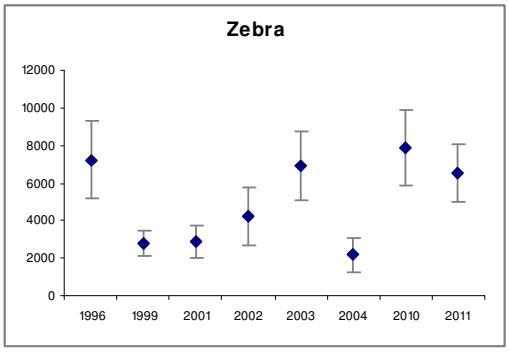
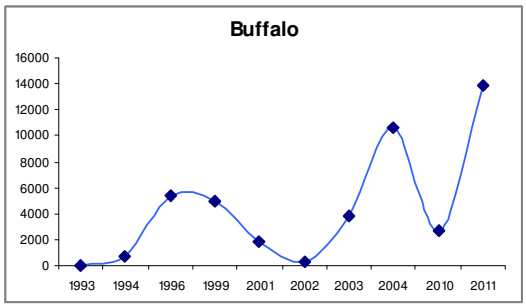
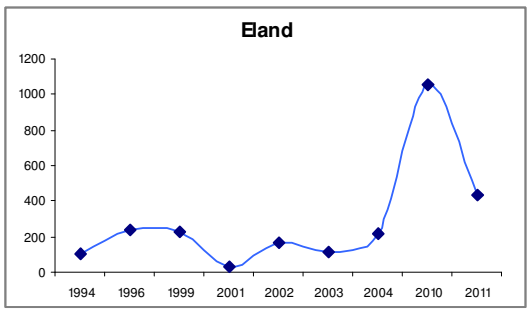
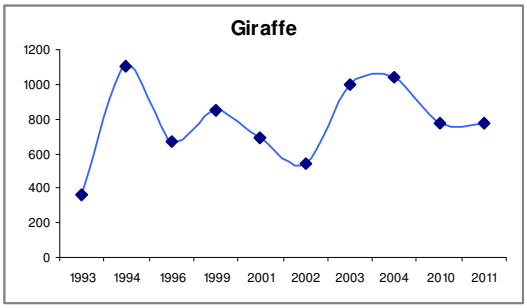
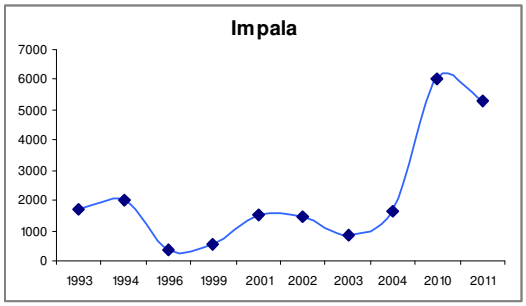


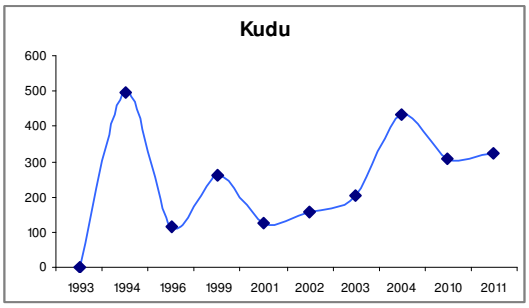
Figure 8. Summary trend analyses for selected wildlife species in Chobe NP, based upon dry season aerial surveys (10) flown between 1993 and 2011.

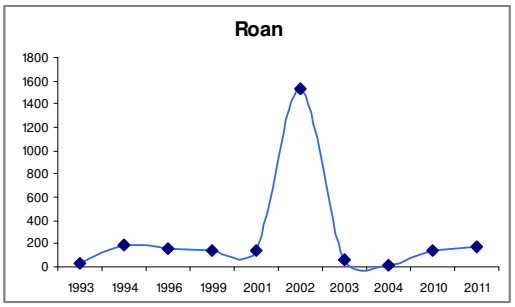


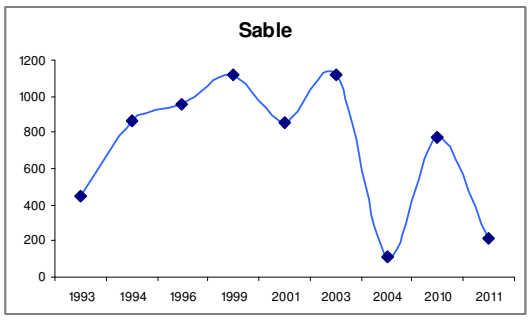


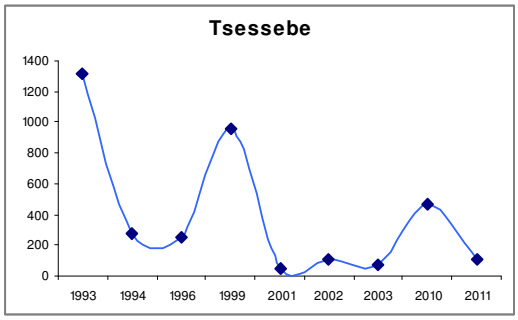


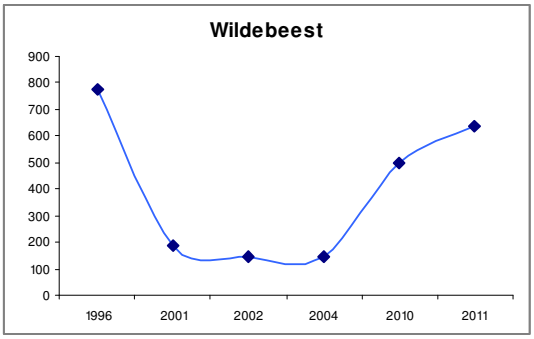


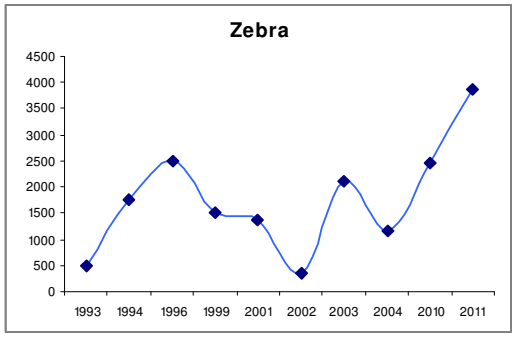












The variances associated with the DWNP data estimates for most wildlife species were so high, statistically speaking; the lower confidence limits were usually negative. For the purposes of the graphical presentations of wildlife species trends in Chobe District the standard errors were used to display variance.

Differences between 2011 dry and 2012 wet season wildlife estimates

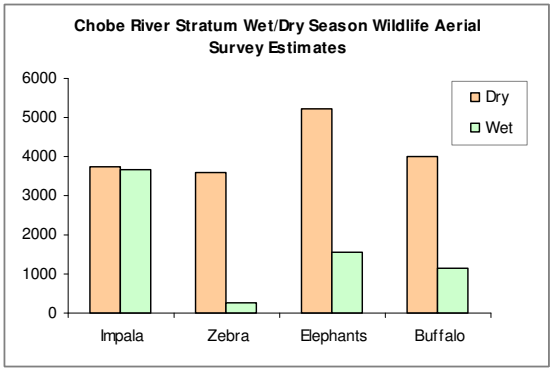
Species estimates were generally higher during the dry season especially in those strata that had permanent water (Table 8). Strata that did not have permanent water in the dry season yielded higher estimates during the wet season when water is available in seasonal pans (Figure 9 & 10).

Table 8. Comparison between dry (2011) and wet (2012) season aerial survey estimates for selected wildlife species.

Stratum	**Dry (2011) and Wet (2012) Aerial Survey Estimates**									
Survey Season	**2011 Dry**	**2012 Wet**	**2011 Dry**	**2012 Wet**	**2011 Dry**	**2012 Wet**	**2011 Dry**	**2012 Wet**	**2011 Dry**	**2012 Wet**
Species	Elephants		Elephant Bulls		Elephant Family		Carcass (Cat 1.)		Bones (Cat. 2)	
CH 2 Chobe Forest Res	4965	2442	448	224	4517	2218	20	34	224	156
CH 4 Kasane Forest Res	542	782	98	43	443	738	25	0	62	43
CH 5 Seloko Plains	381	327	294	0	87	327	104	0	78	33
CH 7 Maikaelelo Forest Res	78	1272	78	237	0	1035	0	0	36	16
CH 13 Sibuya Forest Res	659	4511	117	406	542	4105	10	0	68	64
FR & WMA Subtotals	6625	9334	1035	910	5589	8423	159	34	468	312
Chobe NP (CH 3)										
CNP F (Chobe River)	5215	1546	94	89	5120	1457	33	19	217	137

Stratum	**Dry (2011) and Wet (2012) Aerial Survey Estimates**									
Survey Season	**2011 Dry**	**2012 Wet**	**2011 Dry**	**2012 Wet**	**2011 Dry**	**2012 Wet**	**2011 Dry**	**2012 Wet**	**2011 Dry**	**2012 Wet**
Species	Buffalo		Giraffe		Roan		Sable		Zebra	
CH 2 Chobe Forest Res	929	271	0	34	0	0	210	156	814	0
CH 4 Kasane Forest Res	62	542	37	49	25	0	486	277	86	277
CH 5 Seloko Plains	0	0	173	377	17	218	234	50	138	1407
CH 7 Maikaelelo Forest Res	0	0	43	134	0	0	0	0	0	32
CH 13 Sibuya Forest Res	0	331	112	96	15	96	39	43	44	192
FR & WMA Subtotals	991	1144	365	690	57	314	969	526	1082	1908
Chobe NP (CH 3)										
CNP F (Chobe River)	3984	1160	118	222	28	0	915	316	3593	255

Figure 9. Comparison between dry and wet season aerial survey estimates for Chobe River Stratum.



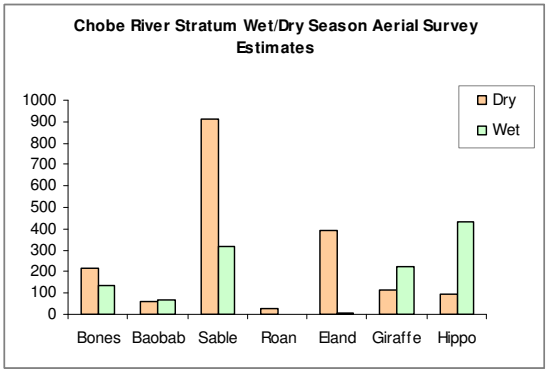
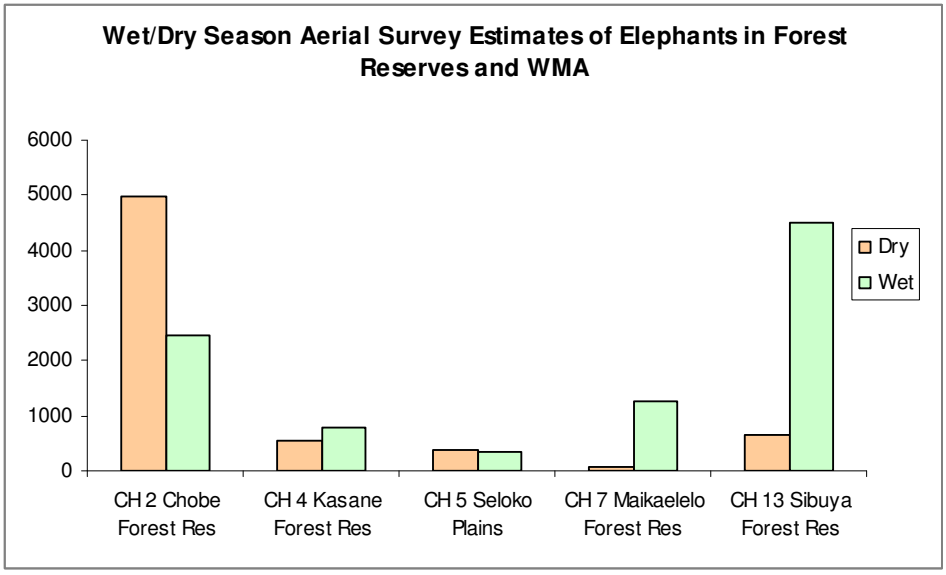


Figure 10. Dry (2011) and wet (2012) season aerial survey estimates for elephants in selected survey strata in Chobe District.



For the Chobe River stratum wet season estimates for all species except giraffe and hippo were lower than the dry season estimate (Figure 9). During the rainy season when seasonal pans are full of water elephants disperse away from the Chobe River. Estimates of the wet season survey were higher in strata that had few elephants during the dry season when they had no water (Figure 9).

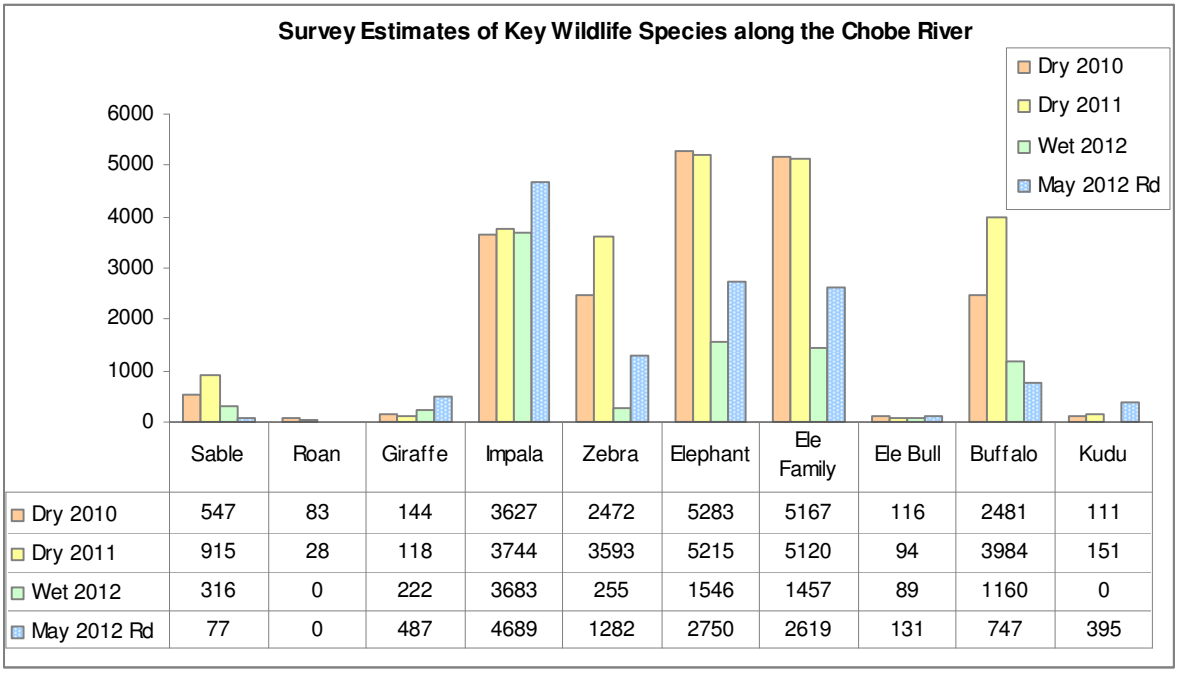
Road strip count along the Chobe River

A road strip count along the Chobe River was conducted from 22 – 25 May in order to determine the numbers of wildlife along the Chobe Riverfront during the transition from wet to dry season (Table 9, Figure 11).

Table 9. Road strip survey estimates of wildlife along the Chobe River, May 2012.

Species	Est.	No. Seen	Herd Obs.	Av. Herd Size	Max	Min	% Seen
Baboon	289	79	7	11.29	41	1	2.81%
Elephant Family	1560	426	53	8.04	31	2	15.14%
Buffalo	747	204	14	14.57	154	1	7.25%
Elephant Bull	128	35	21	1.67	5	1	1.24%
Bushbuck	4	1	1	1.00	1	1	0.04%
Giraffe	487	133	35	3.80	16	1	4.73%
Hippo	216	59	9	6.56	38	1	2.10%
Impala	4687	1280	153	8.37	143	1	45.50%
Kudu	395	108	24	4.50	13	1	3.84%
Lechwe	124	34	7	4.86	16	1	1.21%
Puku	103	28	10	2.80	6	1	1.00%
Sable	77	21	3	7.00	18	1	0.75%
Warthog	135	37	18	2.06	7	1	1.32%
Waterbuck	66	18	3	6.00	16	1	0.64%
Zebra	1282	350	8	43.75	159	1	12.44%
Grand Total	10300	2813	366	7.69	159	1	100.00%

Figure 11. Comparison between three aerial surveys (Dry 2010 - 2012, Wet 2012) and one strip round estimates (May 2012 Rd) for selected wildlife along the Chobe River.



	Sable	Roan	Giraffe	Impala	Zebra	Elephant	Ele Family	Ele Bull	Buffalo	Kudu
Dry 2010	547	83	144	3627	2472	5283	5167	116	2481	111
Dry 2011	915	28	118	3744	3593	5215	5120	94	3984	151
Wet 2012	316	0	222	3683	255	1546	1457	89	1160	0
May 2012 Rd	77	0	487	4689	1282	2750	2619	131	747	395

The road count estimates suggests that migratory species such as zebra and elephant are beginning to move back to the river during the month of May. While estimates for non-migratory species such as impala and giraffe are slightly higher than estimates derived from the air.

Buffalo - partial total count

Time and budget constraints limit aerial total counts, so we attempted to more accurately count buffalo during the survey. Buffalo numbers have been extremely variable in previous surveys, ranging from 3874 to > 17 000 (this survey's strip estimate). This is typical of sample counts of highly aggregated species such as buffalo, which tend to occur in large herds; the sample count may count only a few groups, and those very large – removing or adding a single group by chance can change the estimate by more than half or double, respectively. The buffalo population in the Chobe District is mostly contained in several large herds (several hundred to a thousand individuals), along the Khwai, Linyanti and Chobe Rivers, as well as lower reaches of the Mababe Depression (where one herd numbered 1463 animals) and Savuti Marsh. We used the 'mixed method' following Frederick (2011) to give a truer representation of the total number of buffalo than has been achieved to date (Table 10).

Table 10. Buffalo partial total count in the Chobe District, 2011 dry season aerial survey.

Area	2011 Dry Season Buffalo Count
Chobe NP	
Linyanti	86
Savuti	670
Mababe/Khwai	2489
Chobe River	988
WMA/CHAs	
CH 1	873
CH 2	368
District Totals	**5474**

Savuti Marsh – partial total count of wildlife

A total wildlife count was flown over the flooded area of the Savuti marsh (Table 11). Large elephant herd were observed on the southern extent of the flooded marsh, where water was flowing through encroached *Acacia hebeclada* shrubland, which intern created a flush of green vegetation.

Table 11. Wildlife numbers on the Savuti Marsh, 03 September 2011.

Species	Count
Elephant Bull	71
Elephant Family	417
Buffalo	670
Giraffe	7
Impala	143
Kudu	4
Ostrich	9
Roan	1
Saddle bill Stork	16
Tsessebe	21
Warthog	95
Waterbuck	2
Wildebeest	248
Lechwe	2
Grand Total	1706

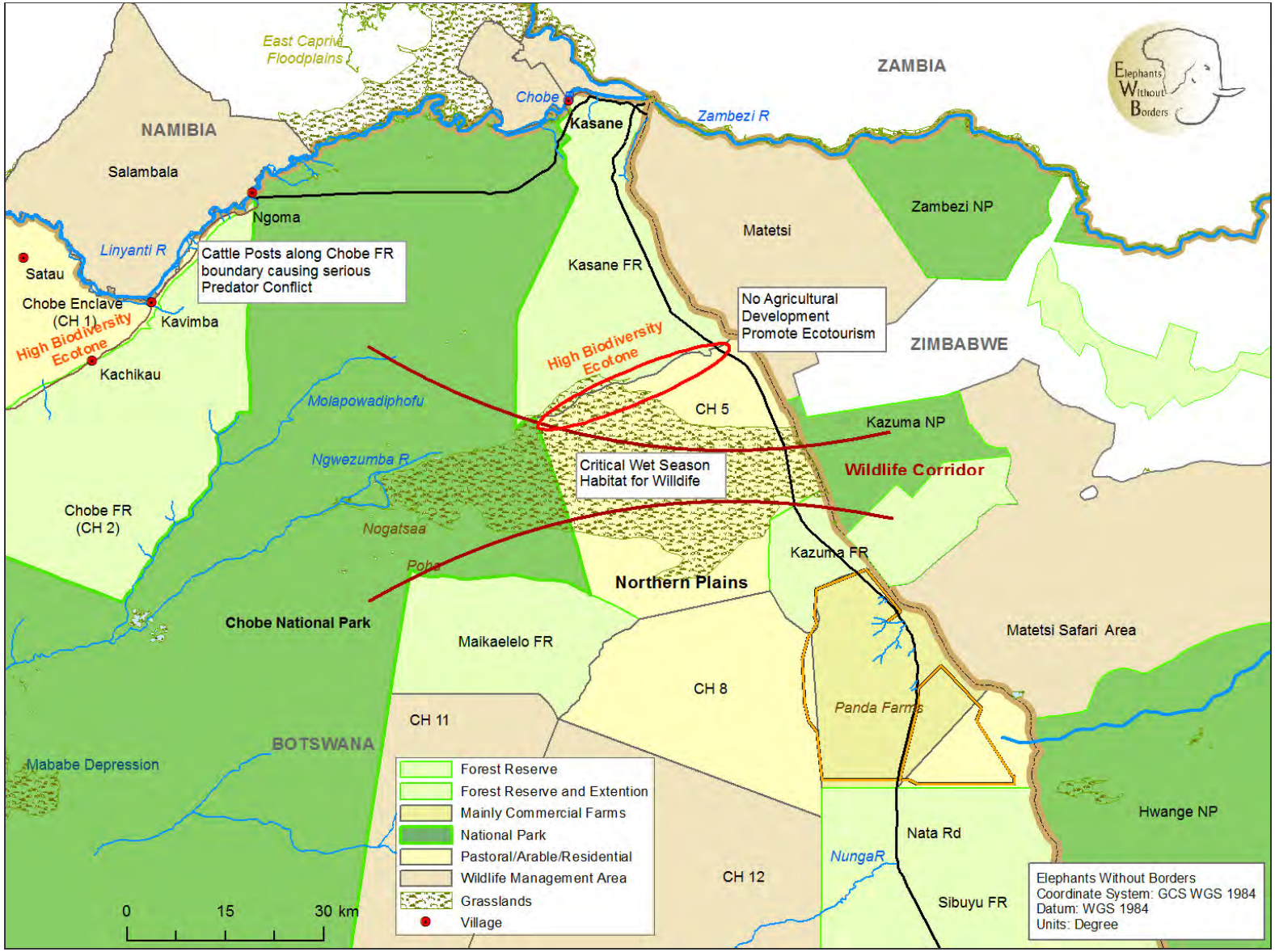
Factors effecting population trends

Habitat fragmentation, poaching, fires and human wildlife conflict impact wildlife population trends. Fire frequency of one every two years on average is considered to be high, the calculated natural fire frequency for the Hwange NP is that an area is on average burnt every 6.6 years (Frost 1990). It is considered unlikely that natural regeneration will be able to maintain woodlands unless fire and other damage is minimized. Bird hunting in the FR is a 'disturbing' activity, and open to abuse as these areas are not regularly patrolled. The magnitude of this disturbance and illegal off take within the FR is unknown, yet maybe the most important factor in the decline of certain wildlife species and

the distribution and dispersal of animals. The new vigilance by the Botswana Defense Force (BDF) and recent establishment of field bases in the Sibuyu, Kasane and Chobe FRs should help in curbing illegal activities and combating the alleged upsurge in cross-border poaching. The number of animals killed in the protection of crops and livestock is not accurately known, official reported figures do not reflect the magnitude of the problem. Many complaints receive no reaction from the DWNP, and the author knows that more animals are being killed than are shown in the official figures…there is no hard data. Based upon personal observations by the author, within one year six Lions were killed by farmers in the Chobe Enclave. The number of predators killed is excessive, and could be related to the sharp decline in Lion numbers within the Chobe NP. A reduction in carnivore populations due to killing by farmers in Chobe District can lead to decreased revenue from safaris (Nijhawan 2008).

The Northern Plains and the grasslands are important wet season grazing habitat for wildlife in the Chobe District. Landuse activities (cattle posts and bird hunting) in the areas outside the Chobe NP and within the FRs are a major determinant in the functioning of the natural system (Figure 12).

Figure 12. Conservation threats, wildlife corridors and important wildlife habitat in the Chobe District.



The dry season survey yielded an estimate of 4800 cattle within the survey area (note the survey area did not cover the northeast section of CH 1 where cattle numbers are known to be high). Cattle generally occurred within 10 km of villages, and overgrazing is evident around the villages of Satau, Parakarungu, Mabele and Kavimba. This is mainly due to the fact people keep their livestock close to the village where livestock is safe from predators and nearer to water. The recent allocation of cattle posts along the Chobe FR boundary may increase grazing pressure and predator conflicts in the FR and Chobe NP.

Discussion

Wildlife Estimates

EWB and DWNP felt it was relevant that this survey increase the precision of population estimates for Chobe District (i.e. to reduce the confidence interval of the estimate, but the population estimate itself may be biased, that is, usually on the low side). This survey was conducted in a robust manner, at high sampling coverage (~ 15 %). This relatively high sample aerial survey over a large area has yielded estimates of wildlife and established a sound basis for wildlife numbers needed to follow population trends. These data can now be used to evaluate the efficacy of conservation activities and trends in wildlife populations with the ability to prioritize conservation projects against any severe variations in wildlife numbers.

Observations

Comparison of observers. Both our aerial observers had experience in counting animals from the air. The two observers appear to have been equally efficient at detecting groups of animals. However, there does appear to have been a difference (for some species) between the observers in their ability to count or estimate the number of animals in a group, once a group was detected.

Elephant carcasses. Many of the elephant carcasses seen during the survey occurred in human elephant conflict hotspots, specifically the Chobe Enclave. Carcasses which appeared to be the result of poaching occurred in the Nogatsaa region. The GPS locations of possible poaching incidents recorded on our survey were reported to the Botswana Defense Force who acted upon our reports.

Wildlife Distribution

The distribution of wildlife is likely to vary according to seasonal climatic conditions, the timing of the flood in the Kwando, Linyanti and Chobe rivers and the movements of animals. As the dry season survey was conducted during the height of the dry season, wildlife observations mostly occurred within 30 km of perennial rivers (Chobe, Kwando, Linyanti, Savuti and Khwai) (Figure 1). There was much difference in herd distribution between the wet and dry season surveys. While most of the herds occurred in the center of the District on the Mar12 wet season survey, during the dry season survey most of the herds were scattered along the northern portion of the District. This difference in distribution between the wet and dry seasons is related to the availability of water in seasonal pans and occurrence of human settlements. During the wet season when there is water in the numerous seasonal pans throughout the District, wildlife may be concentrating in the center of the District/Chobe NP where there are no human settlements (Figure 1) and associated disturbance. Whereas in the dry season when water in pans is more limited, wildlife shift their distribution to the northern portions of the District where there are few human settlements. Although we observed numerous pans with water in the northern portion of the Park during the Mar12 wet season survey, we did not record water in any of these pans during the dry season survey.

Most wildlife species in the Chobe District undergo seasonal change in home range, associated with wide spread surface water in the wet season. Most species showed a marked seasonal movement away from the perennial rivers in the north towards the FR and Northern Plains regions in the wet season. The wet season movement of zebra south of the Ngoma floodplains in eastern Chobe NP needs to be researched and their dispersal/migration route mapped and conserved. This survey suggests there could be a new migration towards the Northern Plains grasslands in the west season. The movement patterns of zebra recorded by Vanderwalle (1988) are likely to have changed during the past 20 years in response to expanding human settlements in the Chobe Enclave. As for other large mammal dispersal patterns the Chobe FRs are critical ecological units incorporating part of a larger ecosystem connected to Chobe NP and protected areas in Zimbabwe.

Trends in Elephant Numbers

From 1993 to this 2011 survey, ten dry season surveys were conducted over the Chobe District. The Districts elephant population is large, but the results of this survey imply that it is stable. The elephant population estimate for Chobe NP has remained similar since 2001. This suggests that elephant numbers in Chobe have apparently stabilized, possibly due to the onset of density-dependence (Junker et al. 2009). A similar stabilization has been noted for elephants in neighboring Hwange NP in Zimbabwe (Chamaillé-Jammes et al. 2008). This could be due to reduced reproductive output at high densities, increased mortalities at high densities and /or increased dispersal at high densities. The recent dispersal of elephants into Angola, Namibia and Zambia from northern Botswana may account for this apparent stabilization (Chase & Griffin 2008, Chase & Griffin 2009, Cushman et al. 2010). The apparent stabilisation in elephant numbers and the underlying mechanisms for such stabilisation are not yet clear, but would be of special importance for elephant conservation management for northern Botswana (Junker et al. 2009 & Chase 2011).

Trends in Wildlife Numbers

Any time-series analysis depends on the use of similar (ideally identical) methods during successive surveys, so that any observed differences in population number can confidently be assumed to be genuine and not simply a consequence of changing methods. Given the difficulty of ensuring that methods are identical (e.g. the same observers are often not available for successive surveys), the application of high and consistent standards during the execution of surveys is important. Future aerial surveys should standardize their coverage (20 %). While DWNP have conducted aerial surveys over northern Botswana, their survey stratum were not delineated along WMA concession boundaries, rather their surveys tend to lump multiple WMAs together making it difficult to infer trends about wildlife numbers at smaller scales.

Conducting aerial surveys in a standardized way should lead to repeatable and comparable indices of abundance. Having started out with a broad scale sampling design (possible under sampling, DWNP 1996 - 2004), this survey has provided valuable information about trends in wildlife numbers. An urgent and comprehensive research initiative to study the ecology of large mammals should be developed. A specially elected team of wildlife ecologists appointed to conduct a rapid assessment and funded in part by the Botswana Government will help determine the factors influencing the spatial and temporal variability and declines in wildlife populations. The failure to initiate such a programme that helps to identify the threats to wildlife could lead to unnecessary declines of selected wildlife (an economically important natural resource) and risk the ecotourism industry in Chobe District.

Conservation Implications

For the past 30 years the Department of Forestry and Range Resources have essentially had a hands off, 'laisser faire' management approach in the FR. This report suggests that the FRs provide important wet season refuge for wildlife in the Chobe District. While the FRs contribute to the supply of forest products for people living in Chobe (timber, poles, fire wood and cattle grazing), they have great potential to fulfill a much border role in the diversification of ecotourism in the District. This potential has long been recognized but not implemented. There has been a plethora of repeated proposals, and management plans that encourage the Government to create ecotourism ventures in the FR (Norwegian Forest Society 1992, Basalumi 2004, Basalumi 2006).

Northern/Seloko Plains. The Northern Plains along the Botswana - Zimbabwe border occur in the Kazuma Depression. Pure basalt soils flood seasonally into slippery deep anaerobic clay pans, then crack and churn as they dry. As agriculture on these 'black cotton' soils is risky the plains have escaped agricultural development and remained relatively open for wildlife to disperse across the Kazuma Depression between Chobe NP in Botswana and Kazuma NP in Zimbabwe. Hunter and Kerley (1999) in a study on the movements of buffalo demonstrated that herds use the Kazuma Depression as a movement corridor and concluded '*the importance of protecting this valuable corridor for all large mobile species to continue moving between Botswana and Zimbabwe cannot be understated*'. The high numbers of wildlife observed on the Plains during the wet season provide convincing new evidence that the plains are critical grazing habitat for wildlife during the rains. Protection of the Northern Plains would involve not only abandoning expansion of agriculture as proposed by the Zambezi Integrated Agro-Commercial Development Project but also the careful allocation of fields and cattle posts by the Chobe Land Board. The areas rugged terrain makes it inaccessible to vehicles and people during the wet season, it is this minimal disturbance and grassland habitat which makes Northern Plains a critical wildlife sanctuary which the government should consider conserving by either integrating this region within Chobe NP, or creating sustainable ecotourism ventures e.g. walking, horseback safaris. Currently the allocation of agricultural land adjacent and within the Plains will seriously compromise conservation efforts of one of Botswana's little known but impressive wildlife spectacles.

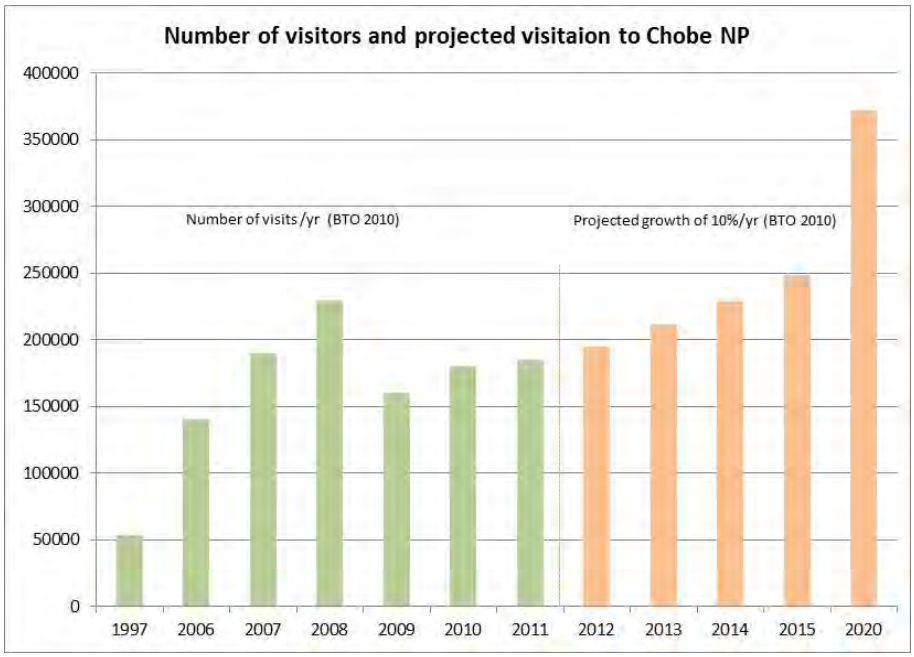
The alluvial grasslands of CH 5 (northern Plains) are an important ecological link between Hwange / Kazuma ecosystem in the east and the Chobe / Nogatsaa ecosystem in the west. The ecotone zone and parallel drainage lines provide critical and unique habitats, but which are being settled either for fields or cattle posts. There are already human wildlife conflicts in the area, which are expected to be exacerbated by the further allocation of agriculture by the Chobe Land Board. The Kasane FR and CH 5 boundary form an interface between Kalahari sand the clay soils of the Northern Plains and support high habitat diversity.

Habitat Fragmentation. The 2011 population census estimates 22 000 people living in Chobe District, growing at 2.5 % per annum. Increasing human population and associated development activities have led to infringement into neighboring FR. This has necessitated appropriation of some land from the FR to meeting increasing land requirements. Recently government de-gazetted 6000 ha of land from Chobe FR to cater for the land requirements of Chobe west, 3000 ha of Kasane FR Ext. to augment the Kasane-Kazungula planning area and 1200 ha from Kazuma FR for extension of the Pandamatenga Commercial Farms.

Chobe District has the highest rainfall compared to the rest of Botswana. Agriculture outside of Pandamatenga is basically for subsistence arable and livestock farming. Arable farming is nevertheless constrained by poor soils and crop damage due to wildlife. Chobe District is a key hub for tourism

development in northern Botswana (Figure 13). Tourist arrivals have increased from approximately 90 000 in 2003 to 130 000 in 2005 (Dept. of Tourism Statistics 2006).

Figure 13. Number of visitors and projected visitation to Chobe NP (BTO 2010).



Currently there are no active tourism activities within the FR, but such conservation based development programmes remain compromised by the expanding development of agriculture. FRs are currently underutilized and experience extensive damage from both veld fires and disturbance from bird hunting and cattle grazing activities. The economic potential of FR is not fully recognized, despite a study by the Department of Forestry and Range Resources which surveyed all six FR for tourism activities and identified several sites in each of the FR for potential tourism development.

Conclusion

This survey and subsequent analyses have emphasized the value of aerial surveys for monitoring wildlife trends. Apart from their immediate value to conservation management, aerial surveys of wildlife conducted at the Forest Reserve level, will often provide data which will greatly improve wildlife managers understanding of the population dynamics of several large herbivores species in northern Botswana. Further, information on population sizes of individual species from this survey can also be used to set priorities, allowing conservation effort to be focused on those species and habitats most in need of attention.

Recommendations

Land use, habitat fragmentation, vegetation changes, drought, fires and poaching have been cited as contributing factors to the decline of wildlife in Africa (Chase & Griffin 2008, Fynn & Bonyongo 2011). Data from aerial surveys are often used to calculate population growth rates and make management decisions for large herbivores. Effective conservation management requires a good understanding of wildlife population dynamics and reliable estimates of population densities. This is

especially true in many of Botswana's concession areas where ecotourism is the main source of income. To provide accurate estimates of population sizes of large animals ranging over extensive areas, aerial surveys are often the only practical way to monitor wildlife trends. Future surveys based upon the methods used on this survey should be conducted, and would provide critical information on wildlife distribution, abundance and trends. Higher coverage, concession level aerial surveys are critical when current DWNP aerial surveys are intermittent and do not cover the area at the sampling intensity required to detect trends at finer spatial scales. Indeed, the execution, data compilation and analysis of this survey, provides a good example of collaboration and mutualism between government management and civil society organisations like Elephants Without Borders. The current aerial survey routine should now be continued.

In addition to collecting data on wildlife populations, the aerial survey provided an opportunity to identify the following conservation issues:

- Habitat fragmentation and the environmental degradation associated with allocating fields for farming must be addressed by Chobe Land Board. The encroachment of farming fields in prime wildlife habitat and deforestation in the middle of key wildlife migratory corridors will continue to increase human wildlife conflict, disrupt connectivity between seasonal ranges and result in wildlife declines. Land Boards should reconsider their land allocation sites in prime wildlife conservation areas and not promote the cutting of large trees on these fields. The levels of deforestation along the Kachikau ridge (border of CH 1 and CH 2) are destructive.

- Much of the survey area in the late dry season of 2011 was burning. The extent of bush fires, the timing and intensity of these fires and their effects on the distribution and abundance of wildlife populations and vegetation communities needs to be studied.

- Definitive conclusions about the trends and possible stabilization of elephant numbers in Chobe District will be difficult to justify without assessments of elephant population trends based on population parameters derived from the assessment of age structures and age related reproductive and survival rates. Such a study will provide valuable information on elephant growth rates, and inferences about the causes of a possible stabilisation.

- Complimentary species specific aerial surveys need to be flown together with ground based demographic profiling that includes determining age and sex structures which will allow DWNP to understand the uncertainties in aerial survey data.

- Ecotourism ventures in the Forest Reserve should be established as a matter of priority. Many reports and consultancies, dating back as early as the 1980s have recommended the development of tourism activities in the Forest Reserves but government has not responded to these repeated recommendations. Current use of the FRs appear to favor agricultural interests over and above those of developing tourism.

- It is critical that Chobe Land Board, DFRR and the DWNP maintain established wildlife movement routes through designation of migration corridors.

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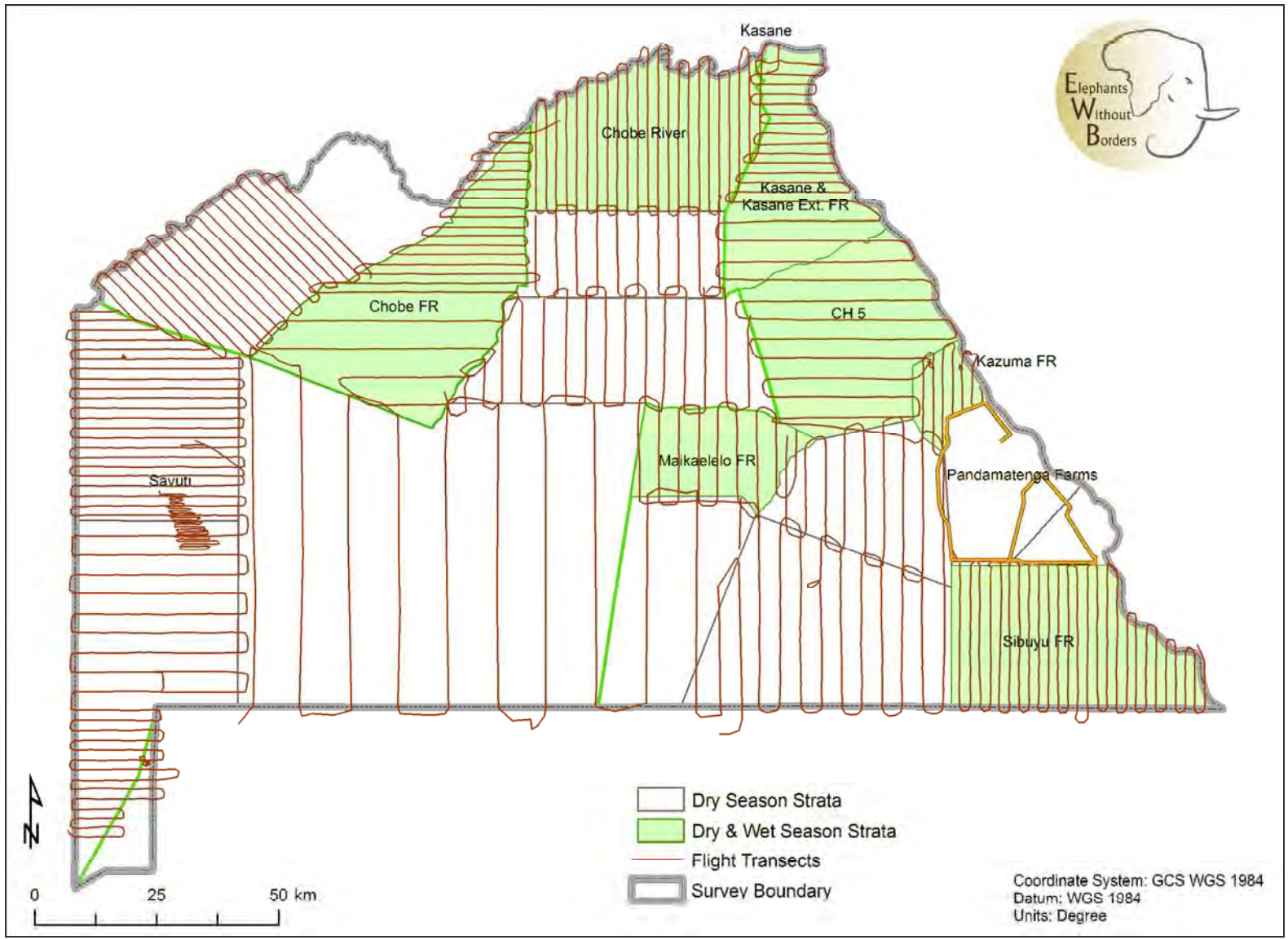
Table 12. Stratum number, name, area (km^2) and survey coverage during the 2011 dry season aerial survey of wildlife in Chobe District.

Stratum Name	Stratum area (km^2)	Transect spacing (km)	Number of transects (=n)	Total transect length (km)	Area covered (km^2)	% of area sampled
CHOBE (CH) DISTRICT						
CH 1 Chobe Enclave	1170	2	20	506	223	19%
CH 2 Chobe Forest Res	1427	2 & 4	22	478	210	15%
CH 4 Kasane Forest Res	800	2	19	296	130	19%
CH 5 & 6 N Plains	1400	2 & 4	17	368	162	12%
CH 7 Maikaelelo Forest Res	550	4	9	151	77	14%
CH 8 Community Hunting	855	4	9	214	109	13%
CH 11	935	8	4	126	55	6%
CH 12 Bottle Pan	1600	4	13	376	192	12%
CH 13 Sibuya Forest Res	1300	2 / **4**	26	605	266	20%
FR & WMA Subtotals	10037	2.8	139	3120	1424	14%
Chobe NP (CH 3)						
CNP A (Linyanti-Savute)	1400	2	22	639	281	20%
CNP B (Mababe-Khwai)	1950	2 & 4	23	492	216	12%
CNP C (Chinamba)	4850	8	8	506	258	5%
CNP D (Nogatsaa)	1250	4	16	286	126	10%
CNP E (Phofu)	805	4	12	203	103	13%
CNP F (Chobe River)	1260	2	23	607	267	21%
CNP NP Subtotals	11515	4	104	2733	1251	11%
Chobe District Totals	**21552**	**4**	**243**	**5853**	**2675**	**12%**

[a] Stratum in bold green font were flown during the wet season, the survey coverage was identical to the dry season except for the Sibuyu FR where we spaced transects 4 km apart, covering 10% of the sample area.

Figure 14. Recorded track log of flight lines indicting transects flown during aerial surveys, Chobe District.



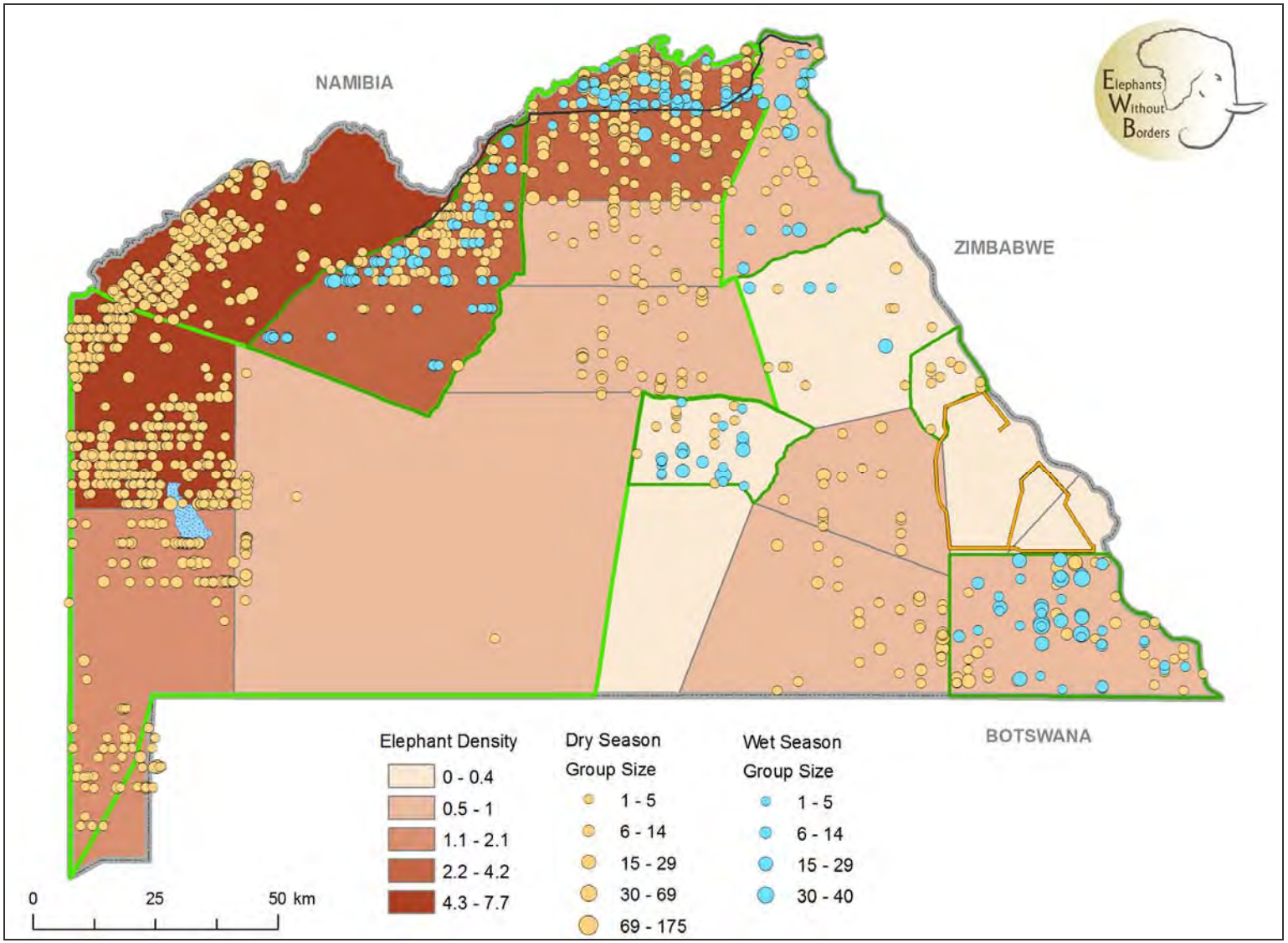
Thin parallel brown lines indicate flight lines along transects. Place names indicate bases from which the survey was flown, and 2012 wet season survey strata.

Table 13. Population estimates and statistics for elephants in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	9003	1714	3656201	4002	44%	5001	13005	7.69
CH 2 Chobe Forest Res	4965	732	1140107	2235	45%	2730	7200	3.48
CH 4 Kasane Forest Res	542	88	21568	308	57%	233	850	0.68
CH 5 & 6 N Plains	381	44	14207	270	71%	111	650	0.27
CH 7 Maikaelelo Forest Res	78	11	1670	90	115%	11	168	0.14
CH 8 Community Hunting	454	58	61835	547	120%	93	1001	0.53
CH 11	0	0	0	0	0%	0	0	0.00
CH 12 Bottle Pan	1437	172	425826	1436	100%	172	2873	0.90
CH 13 Sibuya Forest Res	659	135	38138	406	62%	252	1065	0.55
FR & WMA Subtotals	17519	2954	5359552	4577	26%	12941	22096	1.76
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	9550	1919	1761062	2759	29%	6970	12310	6.82
CNP B (Mababe-Khwai)	4100	467	1036319	2101	51%	2000	6201	2.10
CNP C (Chinamba)	2650	141	5802885	5696	215%	141	8346	0.55
CNP D (Nogatsaa)	1112	112	181215	907	82%	204	2019	0.89
CNP E (Phofu)	371	46	73129	595	160%	223	966	0.46
CNP F (Chobe River)	5215	1106	677461	1706	33%	3508	6922	4.14
CNP NP Subtotals	22998	3791	9532071	6119	27%	16878	29117	2.00
Chobe District Totals	**40517**	**6745**	**14891623**	**7601**	**19%**	**32915**	**48118**	**1.89**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
Chobe Forest Res								
CH 2 Chobe Forest Res	2442	360	243871	1034	42%	1408	3476	1.71
CH 4 Kasane Forest Res	782	127	99753	663	85%	127	1445	0.98
CH 5 Seloko Plains	327	39	39593	450	138%	39	777	0.31
CH 7 Maikaelelo Forest Res	1272	161	155072	867	68%	405	2138	2.31
CH 13 Sibuyu Forest Res	4511	422	2034572	3139	70%	1371	7650	3.47
Chobe NP (CH 3)								
CNP F (Chobe River)	1546	328	68119	541	35%	1005	2088	1.23

Figure 15. Distribution and density (km^2) of elephants in Chobe District during 2011 dry and 2012 wet season aerial surveys.



The points indicate the locations of elephant seen within the search strips (brown dry season, blue wet season), together with an indication of the size of the herd. Small points overlying larger points indicate two or more groups of elephant seen in close proximity. The grey lines indicate survey strata and the shaded areas reflect the average dry season density of elephants within that stratum. The bold grey line indicates the area sampled. The light green outlined area indicates Chobe NP, while dark green indicate Forest Reserves.

Table 14. Population estimates and statistics for elephant bulls in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	441	84	8189	189	43%	252	631	0.38
CH 2 Chobe Forest Res	448	66	13114	239	53%	208	687	0.31
CH 4 Kasane Forest Res	98	16	2968	114	116%	16	213	0.12
CH 5 & 6 N Plains	294	34	10302	230	78%	65	524	0.21
CH 7 Maikaelelo Forest Res	78	11	1670	90	115%	11	168	0.14
CH 8 Community Hunting	250	32	16708	284	114%	34	535	0.29
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	75	9	753	60	80%	14	135	0.05
CH 13 Sibuya Forest Res	117	24	3205	117	100%	24	235	0.09
FR & WMA Subtotals	1801	276	56909	472	26%	1329	2272	0.18
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	1379	277	52745	478	35%	901	1856	0.99
CNP B (Mababe-Khwai)	1448	165	112701	653	45%	756	2142	0.74
CNP C (Chinamba)	75	4	2927	128	171%	52	203	0.02
CNP D (Nogatsaa)	129	13	3007	117	91%	13	246	0.10
CNP E (Phofu)	16	2	228	33	206%	2	49	0.02
CNP F (Chobe River)	94	20	746	57	61%	38	151	0.07
CNP NP Subtotals	3141	481	172354	823	26%	2318	3964	0.27
Chobe District Totals	**4942**	**757**	**229263**	**943**	**19%**	**3999**	**5885**	**0.23**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	224	33	2945	113	50%	110	337	0.16
CH 4 Kasane Forest Res	43	7	617	52	121%	7	95	0.05
CH 5 Seloko Plains	0	0	0	0	0%	0	0	0.00
CH 7 Maikaelelo Forest Res	237	30	15483	274	116%	30	511	0.43
CH 13 Sibuya Forest Res	406	38	15784	276	68%	130	682	0.31
Chobe NP (CH 3)								
CNP F (Chobe River)	89	19	731	56	63%	33	146	0.07

Table 15. Population estimates and statistics for elephant family groups in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	8562	1630	3573113	3956	46%	4605	12518	7.32
CH 2 Chobe Forest Res	4517	666	1091473	2187	48%	2331	6704	3.17
CH 4 Kasane Forest Res	443	72	19426	293	66%	150	736	0.55
CH 5 & 6 N Plains	87	10	6864	187	215%	10	274	0.06
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 8 Community Hunting	204	26	37460	426	209%	26	630	0.24
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	1362	163	394951	1383	102%	163	2745	0.85
CH 13 Sibuya Forest Res	542	111	35407	391	72%	150	933	0.42
FR & WMA Subtotals	15717	2678	5158694	4491	29%	11226	20208	1.57
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	8172	1642	1443112	2498	31%	5673	10670	5.84
CNP B (Mababe-Khwai)	2656	302	655833	1671	63%	980	4323	1.36
CNP C (Chinamba)	2575	137	5560286	5575	217%	137	8150	0.53
CNP D (Nogatsaa)	983	99	162785	860	87%	123	1843	0.73
CNP E (Phofu)	355	44	74018	599	169%	243	954	0.44
CNP F (Chobe River)	5120	1086	669115	1696	33%	3424	6817	3.88
CNP NP Subtotals	19861	3310	8565149	5801	29%	14060	25662	1.70
Chobe District Totals	**35578**	**5988**	**13723843**	**7292**	**20%**	**28280**	**42875**	**1.64**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	2218	327	216773	974	44%	1244	3193	1.55
CH 4 Kasane Forest Res	738	120	97314	655	89%	120	1394	0.92
CH 5 Seloko Plains	327	39	39593	450	138%	39	777	0.31
CH 7 Maikaelelo Forest Res	1035	131	109407	728	70%	307	1763	1.88
CH 13 Sibuya Forest Res	4105	384	2032998	3138	76%	966	7243	3.16
Chobe NP (CH 3)								
CNP F (Chobe River)	1457	309	65406	530	36%	927	1987	1.16

Figure 16. Distribution and density (km^2) of elephant bulls in Chobe District during 2011 dry and 2012 wet season aerial surveys.

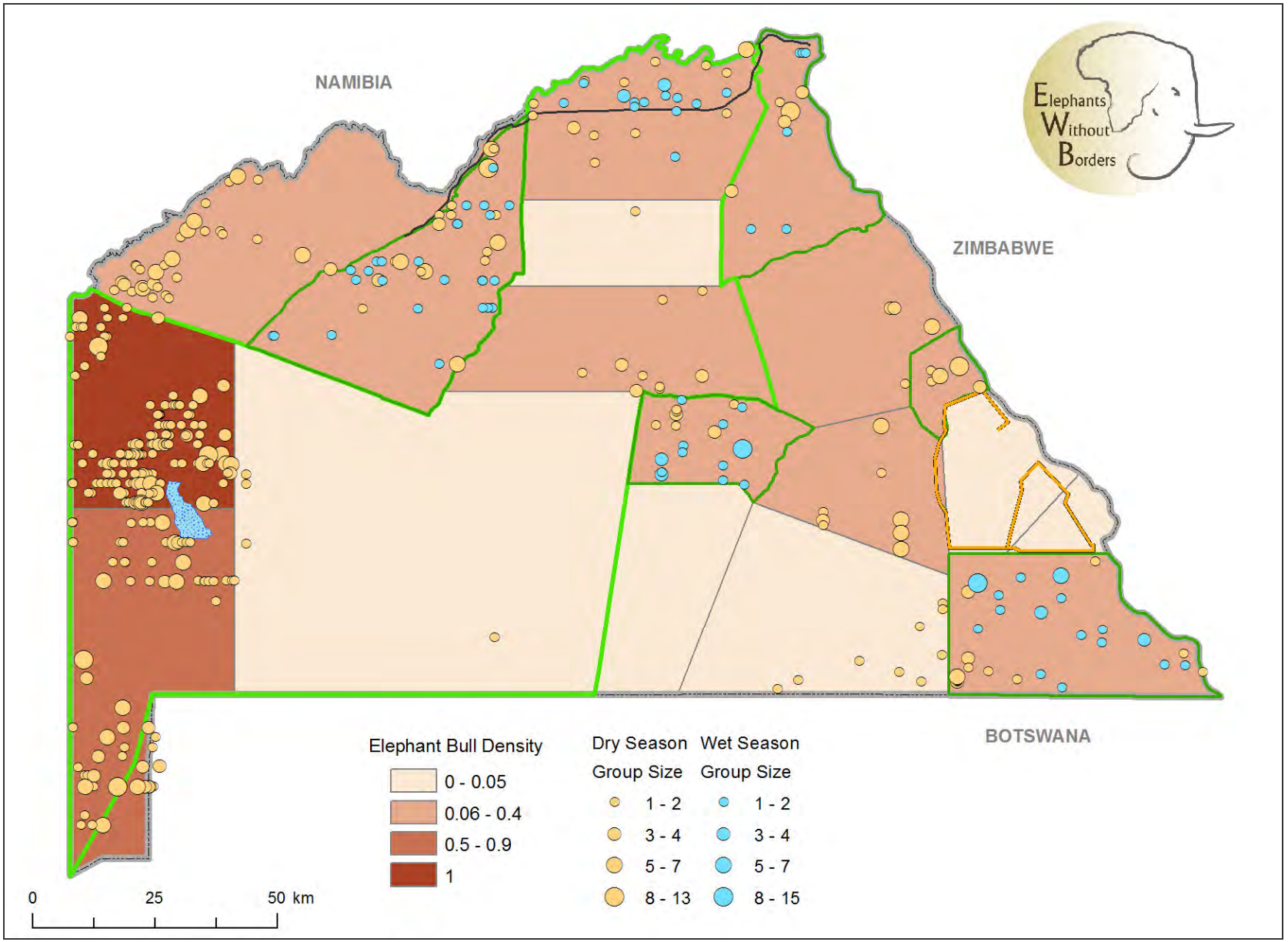


Figure 17. Distribution and density (km^2) of elephant family groups in Chobe District during 2011 dry and 2012 wet season aerial survey.

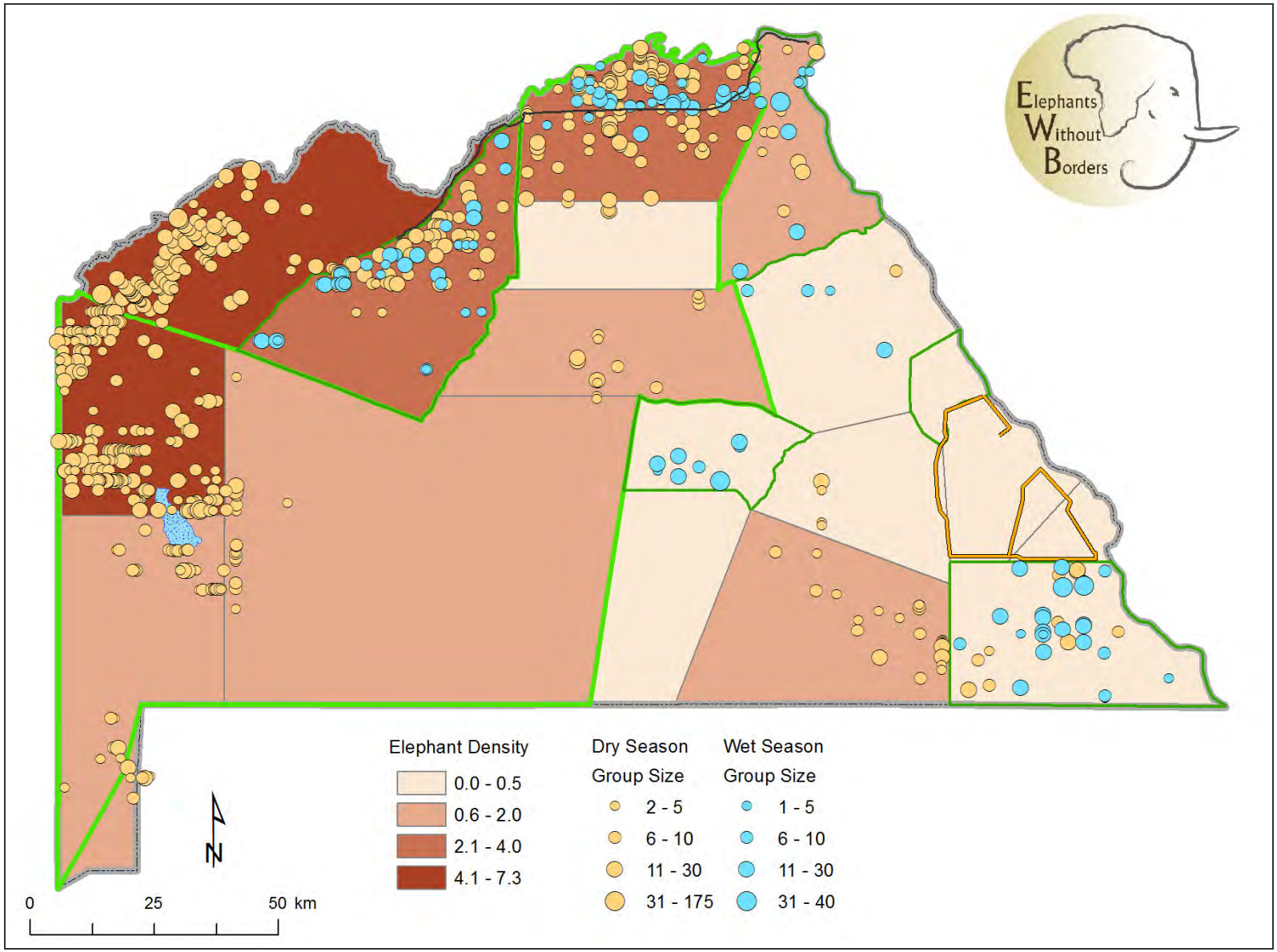


Table 16. Population estimates and statistics for elephant carcasses (Cat.1) in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	21	4	212	30	143%	4	51	0.02
CH 2 Chobe Forest Res	20	3	102	21	105%	3	41	0.01
CH 4 Kasane Forest Res	25	4	115	22	88%	4	47	0.03
CH 5 & 6 N Plains	104	12	2619	51	49%	12	219	0.07
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 8 Community Hunting	0	0	0	0	0	0	0	0.00
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0	0	0	0.00
CH 13 Sibuya Forest Res	10	2	35	12	120%	2	22	0.01
FR & WMA Subtotals	180	25	3083	110	61%	70	290	0.02
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	5	1	20	9	180%	4	14	0.00
CNP B (Mababe-Khwai)	18	2	129	23	128%	5	41	0.01
CNP C (Chinamba)	19	1	323	48	253%	1	61	0.00
CNP D (Nogatsaa)	50	5	2166	99	198%	5	148	0.04
CNP E (Phofu)	57	7	1021	70	123%	13	126	0.07
CNP F (Chobe River)	33	7	229	31	94%	7	64	0.03
CNP NP Subtotals	182	23	3888	123	68%	58	305	0.02
Chobe District Totals	**362**	**71**	**10859**	**205**	**57%**	**339**	**749**	**0.02**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	34	5	350	39	115%	5	73	0.02
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 Seloko Plains	0	0	0	0	0	0	0	0
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 13 Sibuya Forest Res	0	0	0	0	0	0	0	0
Chobe NP (CH 3)								
CNP F (Chobe River)	19	4	97	20	105%	4	39	0.02

Table 17. Population estimates and statistics for elephant carcasses (Cat. 2, Bones) in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	105	20	847	61	58%	44	166	0.09
CH 2 Chobe Forest Res	224	33	5919	161	72%	63	385	0.16
CH 4 Kasane Forest Res	62	10	402	42	68%	19	104	0.08
CH 5 & 6 N Plains	78	9	993	71	91%	9	149	0.06
CH 7 Maikaelelo Forest Res	36	5	392	43	119%	7	79	0.07
CH 8 Community Hunting	47	6	387	43	91%	6	90	0.05
CH 11	0	0	0	0	0%	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0%	0	0	0.00
CH 13 Sibuya Forest Res	68	14	978	65	96%	14	133	0.05
FR & WMA Subtotals	620	97	9918	197	32%	423	816	0.06
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	40	8	196	29	73%	10	69	0.03
CNP B (Mababe-Khwai)	61	7	454	44	72%	17	105	0.03
CNP C (Chinamba)	0	0	0	0	0%	0	0	0.00
CNP D (Nogatsaa)	149	15	5051	151	101%	15	300	0.11
CNP E (Phofu)	202	25	1300	79	39%	122	281	0.25
CNP F (Chobe River)	217	46	1246	73	34%	143	290	0.16
CNP NP Subtotals	669	101	8247	180	27%	489	849	0.06
Chobe District Totals	**1289**	**198**	**18165**	**265**	**21%**	**1023**	**1554**	**0.06**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	156	23	2013	94	60%	62	250	0.11
CH 4 Kasane Forest Res	43	7	393	41	95%	7	84	0.05
CH 5 Seloko Plains	33	4	305	39	118%	4	73	0.03
CH 7 Maikaelelo Forest Res	16	2	89	20	125%	2	37	0.03
CH 13 Sibuya Forest Res	64	6	682	57	89%	6	121	0.05
Chobe NP (CH 3)								
CNP F (Chobe River)	137	29	583	50	36%	87	187	0.11

Figure 18. Distribution and density (km^2) of elephant carcasses (Cat.1) in Chobe District during 2011 dry season aerial survey.

Figure 19. Distribution and density (km^2) of elephant carcasses (Cat. 2, bones) in Chobe District during 2011 dry season aerial survey.

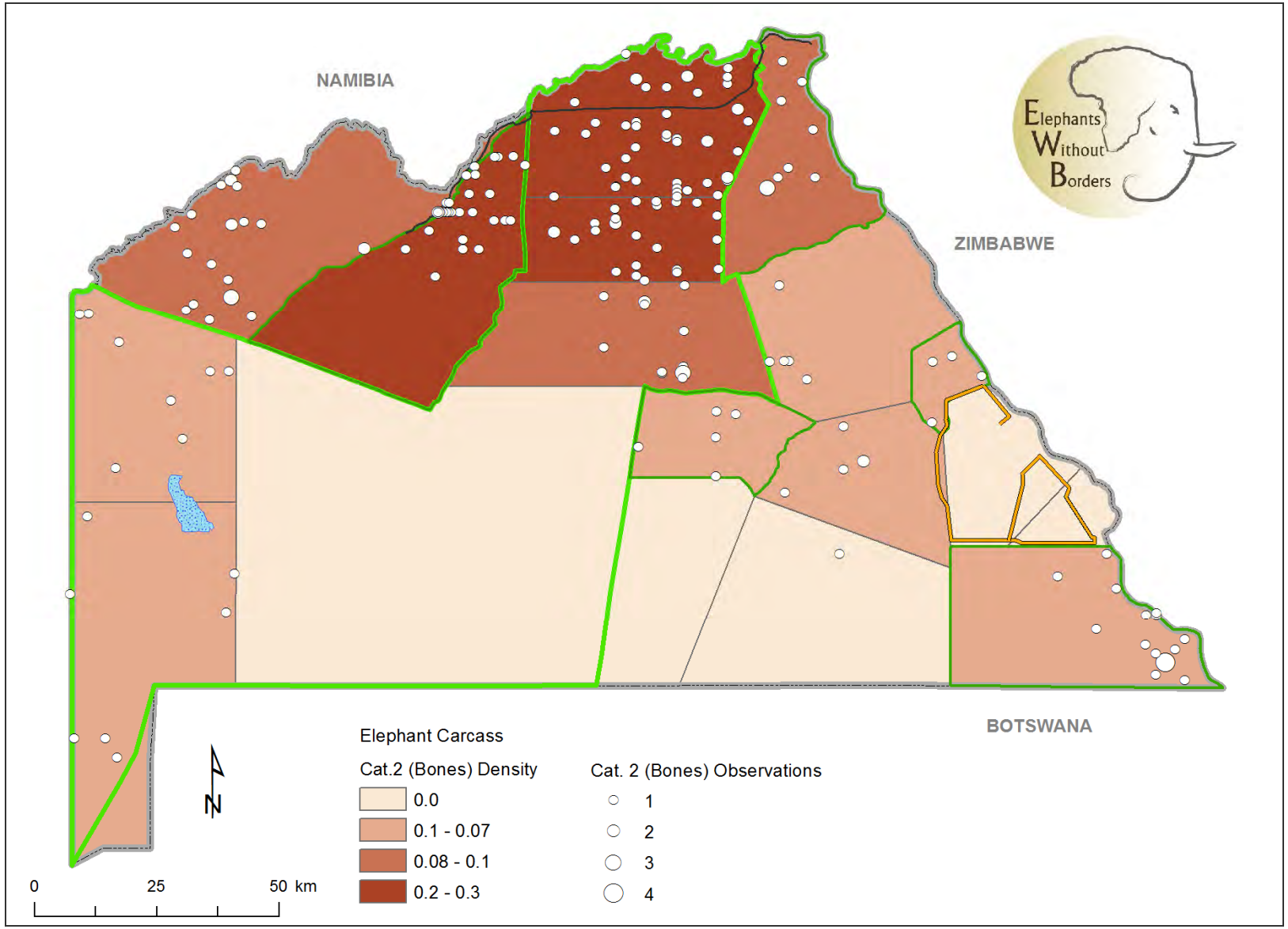


Table 18. Population estimates and statistics for buffalo in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	2443	465	1946281	2920	120%	465	5362	2.09
CH 2 Chobe Forest Res	929	137	369053	1271	137%	137	2201	0.65
CH 4 Kasane Forest Res	62	10	2246	100	161%	10	61	0.08
CH 5 & 6 N Plains	0	0	0	0	0%	0	0	0.00
CH 7 Maikaelelo Forest Res	0	0	0	0	0%	0	0	0.00
CH 8 Community Hunting	0	0	0	0	0%	0	0	0.00
CH 11	0	0	0	0	0%	0	0	0.00
CH 12 Bottle Pan	75	9	2172	102	136%	27	177	0.05
CH 13 Sibuya Forest Res	0	0	0	0	0%	0	0	0.00
FR & WMA Subtotals	3509	621	2319752	3011	86%	621	6520	0.35
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	234	47	14182	258	110%	47	481	0.17
CNP B (Mababe-Khwai)	9623	1096	42680277	13483	140%	3860	23106	4.93
CNP C (Chinamba)	0	0	0	0	0%	0	0	0.00
CNP D (Nogatsaa)	20	2	348	40	200%	2	60	0.01
CNP E (Phofu)	0	0	0	0	0%	0	0	0.00
CNP F (Chobe River)	3984	845	4058389	4177	105%	845	8162	3.02
CNP NP Subtotals	13861	1990	46753196	13553	98%	1990	27414	1.19
Chobe District Totals	**17370**	**2611**	**49072948**	**13799**	**79%**	**3571**	**31168**	0.80

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	271	40	58912	508	187%	40	779	0.19
CH 4 Kasane Forest Res	542	88	192676	922	170%	88	1463	0.68
CH 5 Seloko Plains	0	0	0	0	0	0	0	0.00
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 13 Sibuya Forest Res	331	31	46065	472	143%	31	803	0.25
Chobe NP (CH 3)								
CNP F (Chobe River)	1160	246	395191	1303	112%	246	2464	0.92

Figure 20. Distribution and density (km^2) of buffalo in Chobe District during 2011 dry and 2012 wet season aerial survey.

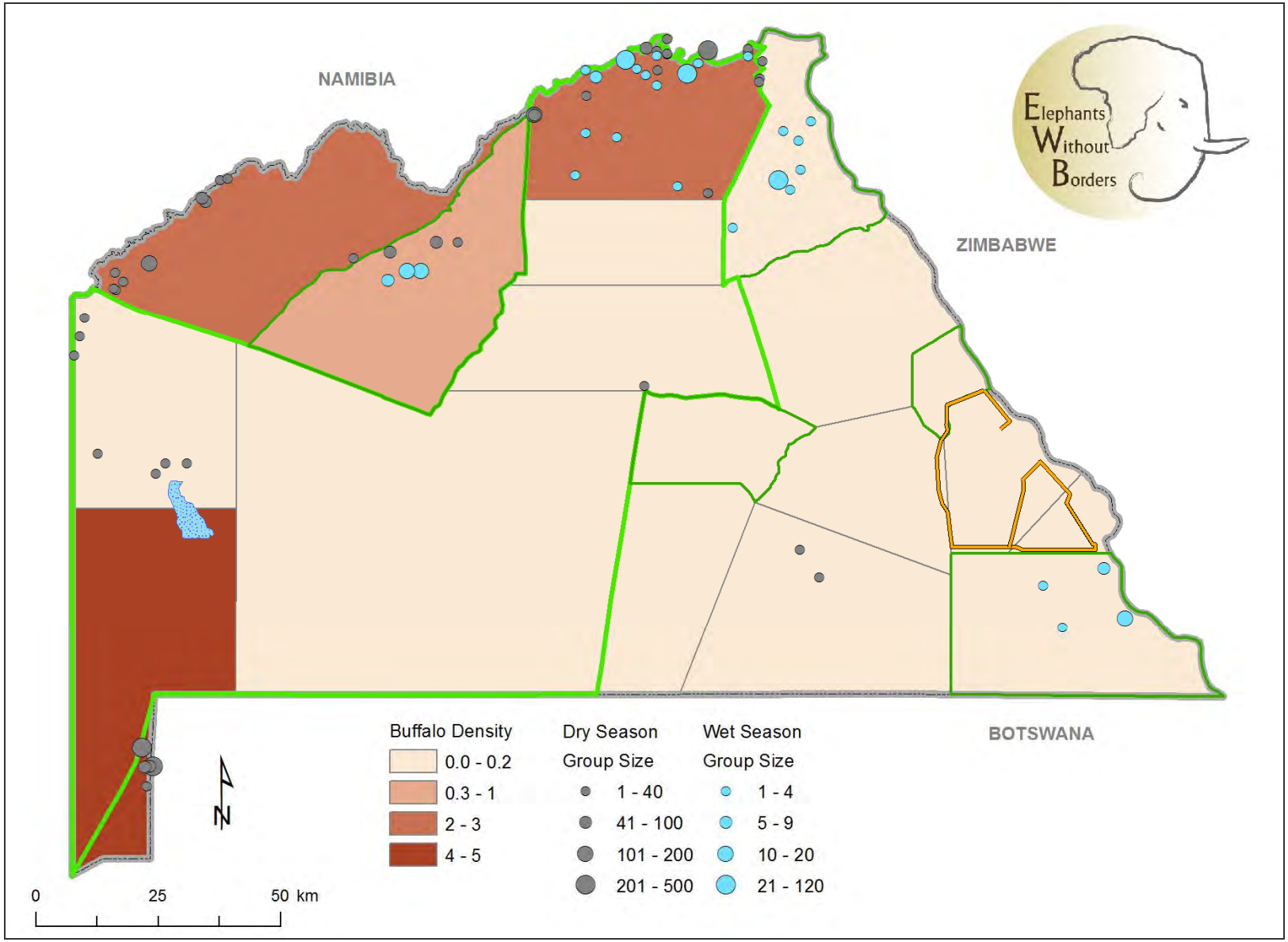


Table 19. Population estimates and statistics for eland in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	0		0	0	0	0	0	0.00
CH 2 Chobe Forest Res	41	6	370	40	98%	6	81	0.03
CH 4 Kasane Forest Res	105	17	2426	103	98%	17	208	0.13
CH 5 & 6 N Plains	571	66	47231	492	86%	79	1063	0.41
CH 7 Maikaelelo Forest Res	0	0	0	0	0%	0	0	0.00
CH 8 Community Hunting	23	3	103	22	96%	3	46	0.03
CH 11	0	0	0	0	0%	0	0	0.00
CH 12 Bottle Pan	25	3	276	36	144%	3	61	0.02
CH 13 Sibuyu Forest Res	34	7	391	41	121%	7	75	0.03
FR & WMA Subtotals	799	102	50797	446	56%	353	1245	0.08
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	20	4	107	21	105%	4	41	0.01
CNP B (Mababe-Khwai)	0	0	0	0	0%	0	0	0.00
CNP C (Chinamba)	19	1	323	42	221%	1	61	0.00
CNP D (Nogatsaa)	0	0	0	0	0%	0	0	0.00
CNP E (Phofu)	8	1	57	17	213%	1	24	0.01
CNP F (Chobe River)	391	83	39979	415	106%	83	806	0.30
CNP NP Subtotals	438	89	40466	399	91%	89	836	0.04
Chobe District Totals	**1237**	**191**	**91263**	**595**	**48%**	**642**	**1832**	**0.06**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 Seloko Plains	477	57	30313	393	82%	84	871	0.84
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 13 Sibuyu Forest Res	235	22	48920	486	207%	22	722	0.56
Chobe NP (CH 3)								
CNP F (Chobe River)	9	2	70	17	189%	2	27	0.02

Figure 21. Distribution and density (km^2) of eland in Chobe District during 2011 dry and 2012 wet season aerial survey.

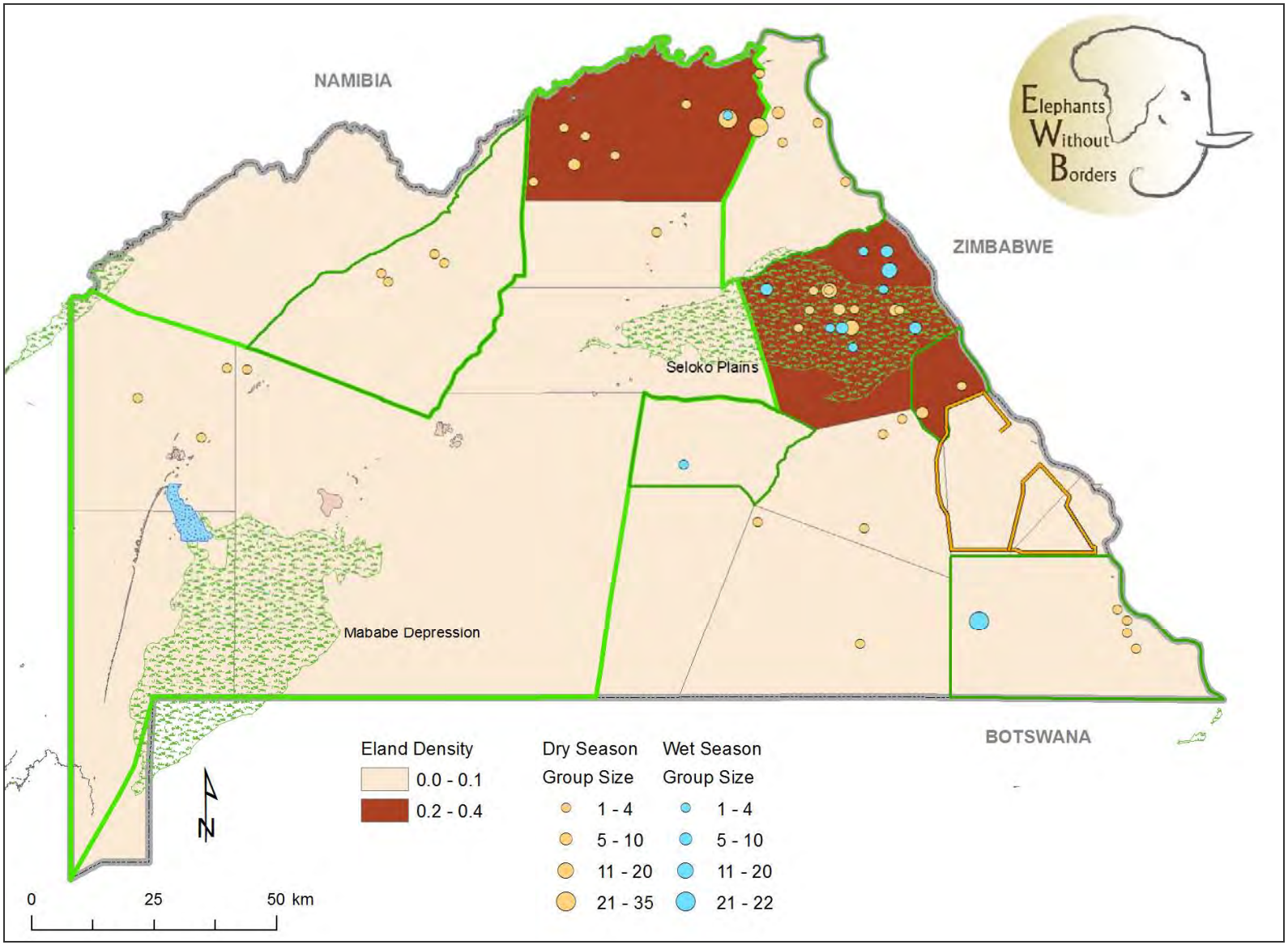


Table 20. Dry season population estimates and statistics for giraffe in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	94	18	1510	81	86%	18	175	0.08
CH 2 Chobe Forest Res	0	0	0	0	0%	0	0	0.00
CH 4 Kasane Forest Res	37	6	200	30	81%	7	67	0.05
CH 5 & 6 N Plains	173	20	7710	198	114%	25	371	0.12
CH 7 Maikaelelo Forest Res	43	6	438	46	107%	6	89	0.08
CH 8 Community Hunting	55	7	1335	80	145%	25	135	0.06
CH 11	0	0	0	0	0%	0	0	0.00
CH 12 Bottle Pan	192	23	7298	188	98%	23	380	0.12
CH 13 Sibuyu Forest Res	112	23	3301	119	106%	23	231	0.09
FR & WMA Subtotals	706	103	21792	292	41%	414	998	0.07
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	139	28	2234	98	71%	41	238	0.10
CNP B (Mababe-Khwai)	202	23	4138	133	66%	69	335	0.10
CNP C (Chinamba)	282	15	35979	448	159%	15	730	0.06
CNP D (Nogatsaa)	20	2	348	40	200%	2	60	0.01
CNP E (Phofu)	16	2	228	33	206%	2	49	0.02
CNP F (Chobe River)	118	25	1626	84	71%	34	202	0.09
CNP NP Subtotals	777	95	44553	418	54%	358	1195	0.07
Chobe District Totals	**1483**	**198**	**66345**	**507**	**34%**	**975**	**1990**	**0.07**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	34	5	1041	67	197%	5	101	0.02
CH 4 Kasane Forest Res	49	8	660	54	110%	8	103	0.06
CH 5 Seloko Plains	377	45	19398	315	84%	62	692	0.36
CH 7 Maikaelelo Forest Res	134	17	7740	193	144%	17	328	0.24
CH 13 Sibuyu Forest Res	96	9	1859	95	99%	9	191	0.07
Chobe NP (CH 3)								
CNP F (Chobe River)	222	47	4080	132	59%	89	354	0.18

Figure 22. Distribution and density (km^2) of giraffe in Chobe District during 2011 dry and 2012 wet season aerial survey.

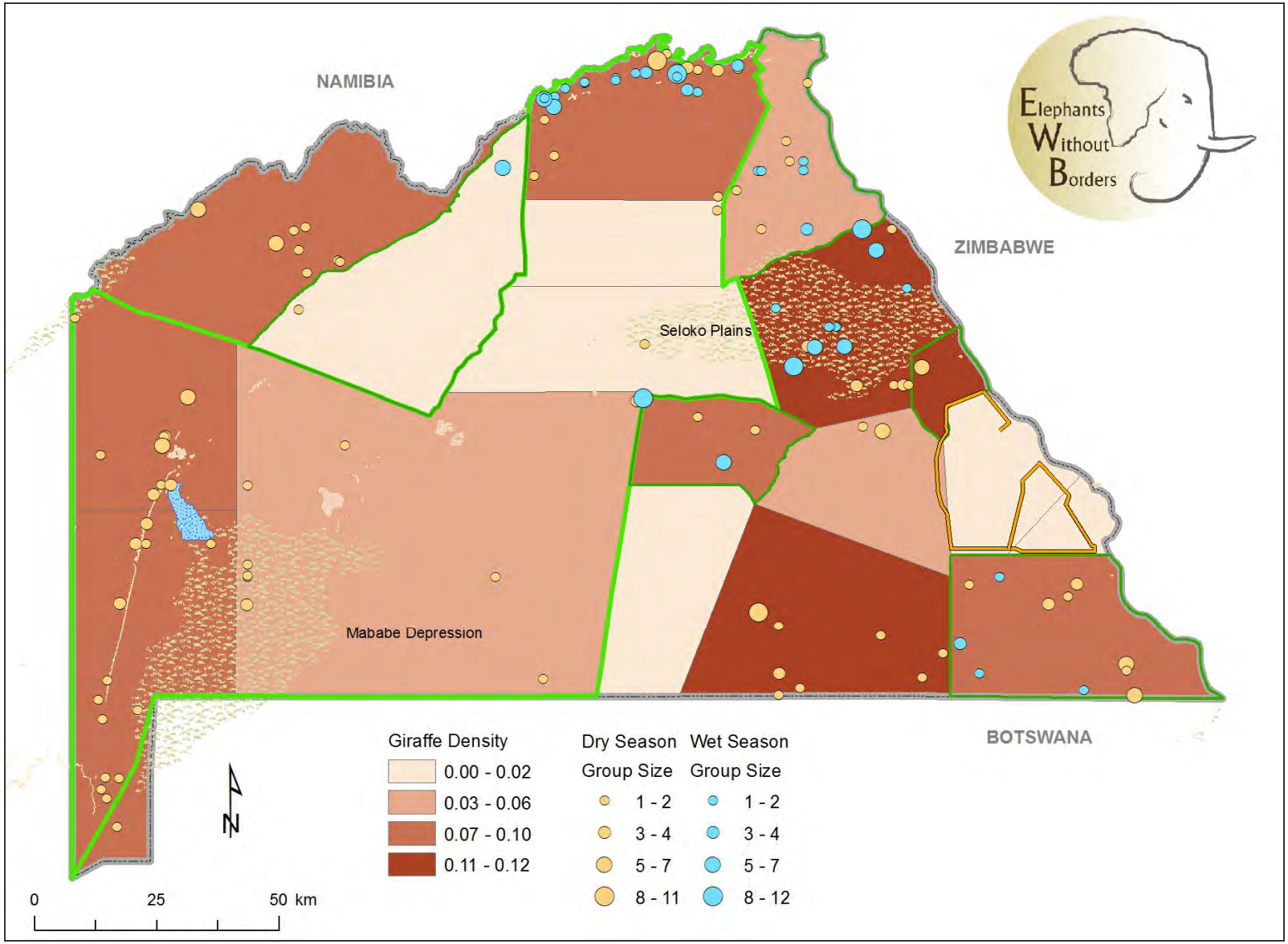


Table 21. Population estimates and statistics for gemsbok in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	0	0	0	0	0	0	0	0
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 & 6 N Plains	104	12	5032	160	154%	56	264	0.07
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 8 Community Hunting	0	0	0	0	0	0	0	0
CH 11	0	0	0	0	0	0	0	0
CH 12 Bottle Pan	0	0	0	0	0	0	0	0
CH 13 Sibuya Forest Res	0	0	0	0	0	0	0	0
FR & WMA Subtotals	104	12	5032	160	154%	56	264	0.01
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0	0	0	0	0	0	0	0
CNP B (Mababe-Khwai)	0	0	0	0	0	0	0	0
CNP C (Chinamba)	0	0	0	0	0	0	0	0
CNP D (Nogatsaa)	0	0	0	0	0	0	0	0
CNP E (Phofu)	0	0	0	0	0	0	0	0
CNP F (Chobe River)	0	0	0	0	0	0	0	0
CNP NP Subtotals	0	0	0	0	0	0	0	0
Chobe District Totals	104	12	5032	160	154%	56	264	0.00

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 Seloko Plains	59	7	1355	83	141%	7	142	0.06
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 13 Sibuya Forest Res	0	0	0	0	0	0	0	0
Chobe NP (CH 3)								
CNP F (Chobe River)	0	0	0	0	0	0	0	0

Table 22. Population estimates and statistics for hippo in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	58	11	1192	72	124%	11	130	0.05
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 & 6 N Plains	0	0	0	0	0	0	0	0
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 8 Community Hunting	0	0	0	0	0	0	0	0
CH 11	0	0	0	0	0	0	0	0
CH 12 Bottle Pan	0	0	0	0	0	0	0	0
CH 13 Sibuyu Forest Res	0	0	0	0	0	0	0	0
FR & WMA Subtotals	58	11	1192	72	124%	11	130	0.01
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	44	5	1762	87	198%	5	130	0.03
CNP B (Mababe-Khwai)	0	0	0	0	0	0	0	0.00
CNP C (Chinamba)	0	0	0	0	0	0	0	0.00
CNP D (Nogatsaa)	0	0	0	0	0	0	0	0.00
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	94	20	4346	136	145%	42	231	0.07
CNP NP Subtotals	138	25	6108	155	112%	25	293	0.01
Chobe District Totals	**196**	**36**	**7300**	**168**	**86%**	**36**	**364**	0.01

Stratum	Estimates	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
Survey Estimates								
Chobe NP (CH 3)								
CNP F (Chobe River Wet 2012)	434	92	46984	449	103%	92	883	0.34
CNP F (Chobe River Rd 2012)	216	59						

Table 23. Population estimates and statistics for impala in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	26	5	556	49	188%	5	76	0.02
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0.00
CH 4 Kasane Forest Res	25	4	506	47	188%	4	72	0.03
CH 5 & 6 N Plains	0	0	0	0	0	0	0	0.00
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 8 Community Hunting	0	0	0	0	0	0	0	0.00
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	267	32	31525	390	146%	32	658	0.17
CH 13 Sibuyu Forest Res	0	0	0	0	0	0	0	0.00
FR & WMA Subtotals	318	41	32587	357	112%	39	806	0.03
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	383	77	31480	369	96%	77	752	0.27
CNP B (Mababe-Khwai)	1133	129	242953	1017	90%	115	2150	0.58
CNP C (Chinamba)	38	2	1291	85	224%	47	122	0.01
CNP D (Nogatsaa)	0	0	0	0	0	0	0	0.00
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	3744	794	2060104	2978	80%	767	6721	2.84
CNP NP Subtotals	5298	1002	2335828	3029	57%	2268	8327	0.45
Chobe District Totals	**5616**	**1043**	**2368415**	**3031**	**54%**	**2584**	**8647**	**0.26**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	49	8	2130	97	198%	8	146	0.06
CH 5 Seloko Plains	0	0	0	0	0	0	0	0.00
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 13 Sibuyu Forest Res	75	7	4952	155	207%	7	230	0.06
Chobe NP (CH 3)								
CNP F (Chobe River)	3683	781	1475819	2519	68%	1163	6202	2.92

Figure 23. Distribution and density (km^2) of impala in Chobe District during 2011 dry season aerial survey.

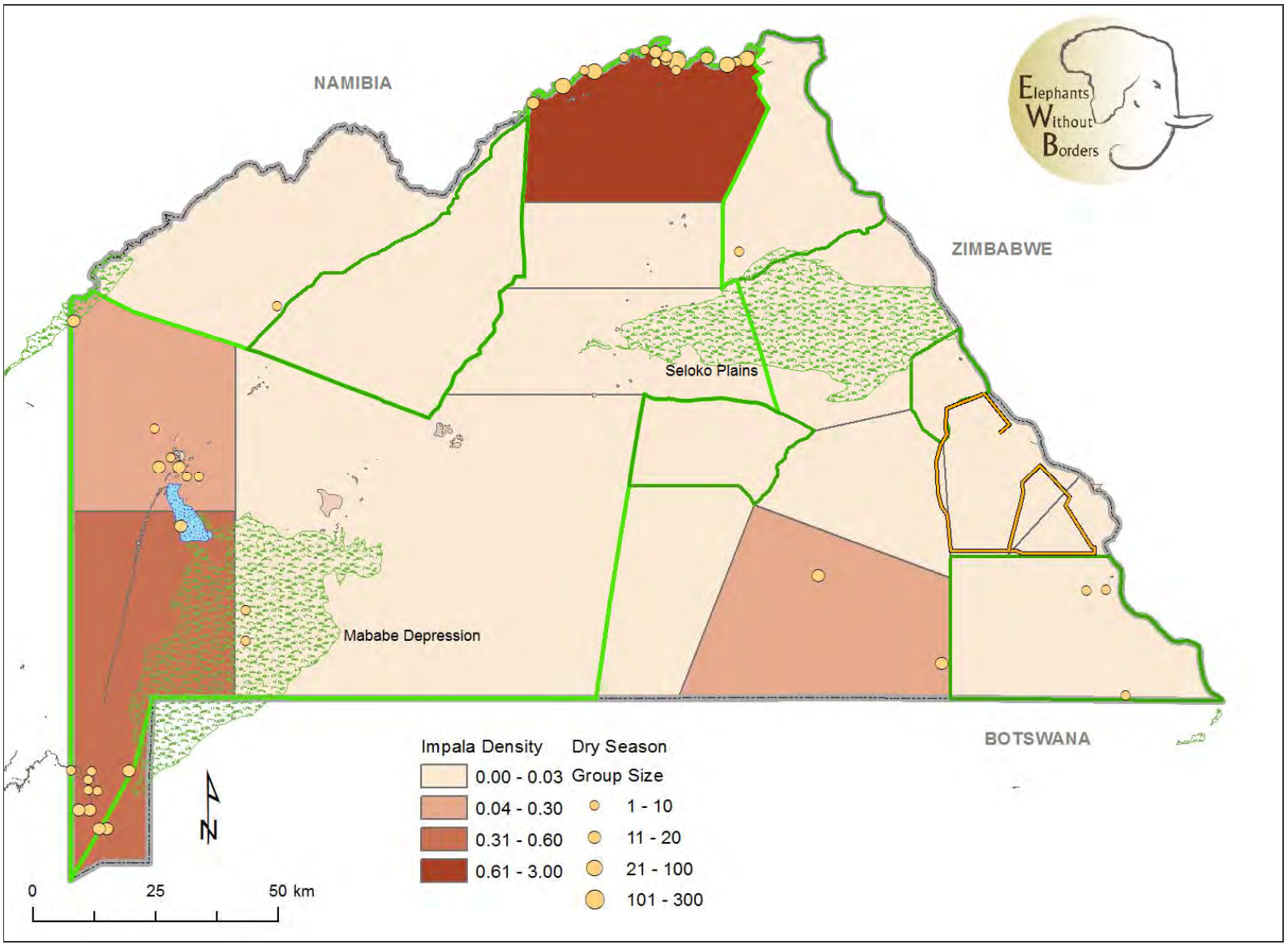


Table 24. Population estimates and statistics for kudu in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	53	10	601	51	96%	10	104	0.05
CH 2 Chobe Forest Res	47	7	556	49	104%	7	97	0.03
CH 4 Kasane Forest Res	31	5	730	57	184%	5	87	0.04
CH 5 & 6 N Plains	35	4	696	60	171%	25	94	0.03
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 8 Community Hunting	0	0	0	0	0	0	0	0.00
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0	0	0	0.00
CH 13 Sibuya Forest Res	34	7	253	33	97%	7	67	0.03
FR & WMA Subtotals	200	33	2836	105	53%	95	305	0.02
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	20	4	148	25	125%	5	45	0.01
CNP B (Mababe-Khwai)	97	11	5053	146	151%	50	243	0.05
CNP C (Chinamba)	56	3	2973	129	230%	3	185	0.01
CNP D (Nogatsaa)	0	0	0	0	0	0	0	0.00
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	151	32	3856	129	85%	32	280	0.11
CNP NP Subtotals	324	50	12030	217	67%	107	541	0.03
Chobe District Totals	**524**	**83**	**14866**	**240**	**46%**	**284**	**764**	**0.02**

Stratum	Wet 2012 Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	31	5	790	59	190%	5	89	0.04
CH 5 Seloko Plains	0	0	0	0	0	0	0	0
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 13 Sibuya Forest Res	0	0	0	0	0	0	0	0
Chobe NP (CH 3)								
CNP F (Chobe River)	0	0	0	0	0	0	0	0

Figure 24. Distribution of kudu in Chobe District, 2011 dry season aerial survey.

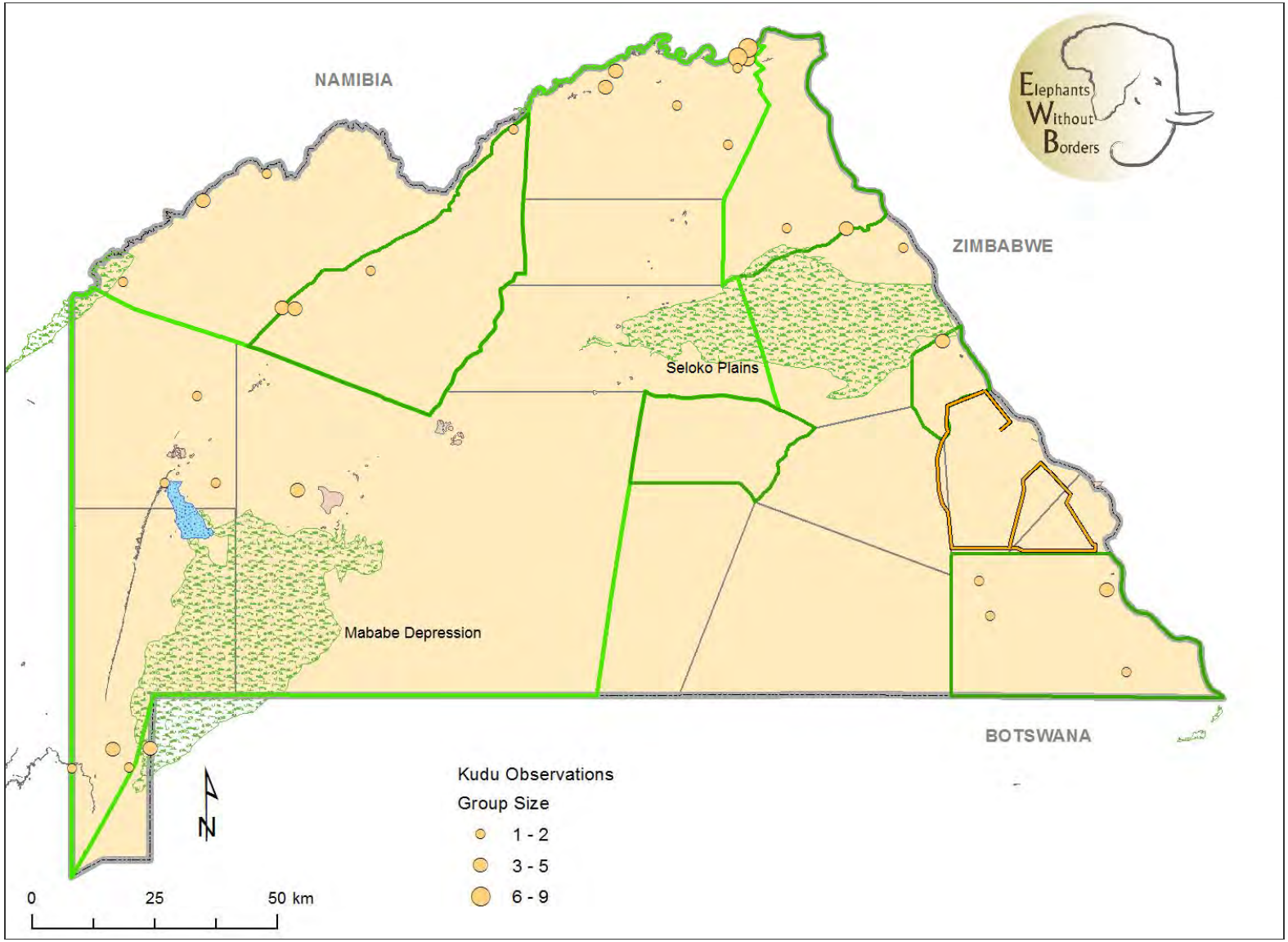


Table 25. Population estimates and statistics for roan in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	53	10	1408	79	149%	10	131	0.05
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0.00
CH 4 Kasane Forest Res	25	4	323	38	152%	4	62	0.03
CH 5 & 6 N Plains	17	2	300	39	229%	2	56	0.01
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 8 Community Hunting	0	0	0	0	0	0	0	0.00
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0	0	0	0.00
CH 13 Sibuya Forest Res	15	3	168	27	180%	12	41	0.01
FR & WMA Subtotals	110	19	2199	93	85%	19	203	0.01
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	60	12	614	52	87%	12	111	0.04
CNP B (Mababe-Khwai)	79	9	2058	94	119%	14	173	0.04
CNP C (Chinamba)	0	0	0	0	0	0	0	0
CNP D (Nogatsaa)	10	1	87	20	200%	1	30	0.01
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	28	6	231	31	111%	6	60	0.02
CNP NP Subtotals	177	28	2990	108	61%	67	285	0.02
Chobe District Totals	**287**	**47**	**5189**	**141**	**49%**	**145**	**429**	**0.01**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
Forest Reserves (Res)								
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 Seloko Plains	218	26	5079	161	74%	56	379	0.21
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 13 Sibuya Forest Res	96	9	8187	199	207%	9	295	0.07
Chobe NP (CH 3)								
CNP F (Chobe River)	0	0	0	0	0	0	0	0

Figure 25. Distribution and density (km^2) of roan in Chobe District on 2011 dry and 2012 wet season aerial survey.

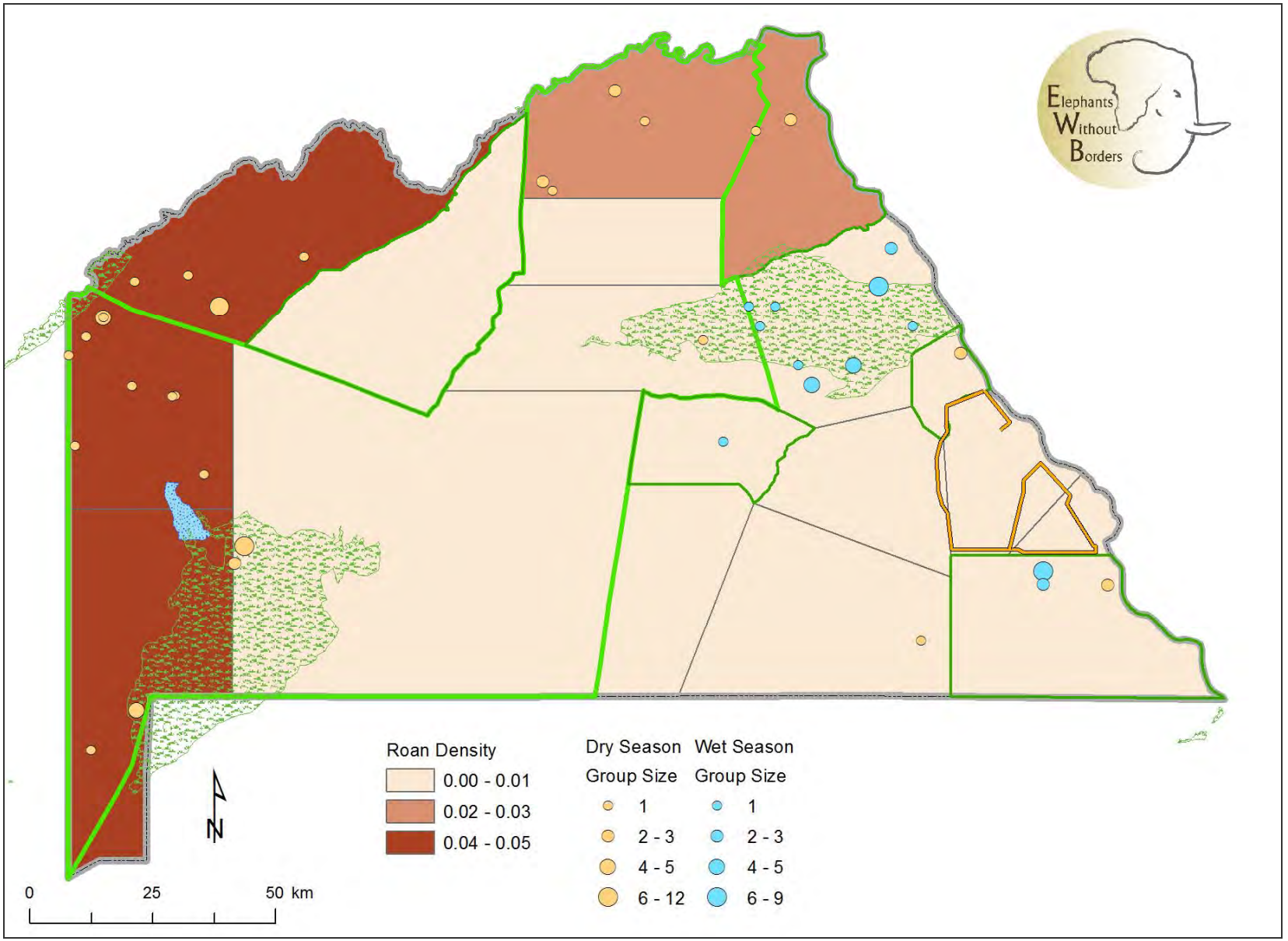


Table 26. Population estimates and statistics for sable in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	89	17	1824	89	100%	17	178	0.08
CH 2 Chobe Forest Res	210	31	13131	240	114%	31	450	0.15
CH 4 Kasane Forest Res	486	79	44380	443	91%	79	929	0.61
CH 5 & 6 N Plains	234	27	32919	410	175%	176	644	0.17
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 8 Community Hunting	23	3	117	24	104%	3	47	0.03
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0	0	0	0.00
CH 13 Sibuya Forest Res	39	8	918	63	162%	23	102	0.03
FR & WMA Subtotals	1081	165	93289	604	56%	477	1685	0.11
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	40	8	1356	76	190%	37	116	0.03
CNP B (Mababe-Khwai)	0	0	0	0	0	0	0	0.00
CNP C (Chinamba)	0	0	0	0	0	0	0	0.00
CNP D (Nogatsaa)	70	7	3135	119	170%	7	188	0.05
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	915	194	128212	743	81%	172	1657	0.69
CNP NP Subtotals	1025	209	132703	722	70%	303	1747	0.09
Chobe District Totals	**2106**	**374**	**225992**	**936**	**44%**	**1169**	**3042**	**0.10**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
Forest Reserves (Res)								
CH 2 Chobe Forest Res	156	23	9270	201	129%	23	357	0.11
CH 4 Kasane Forest Res	277	45	11784	228	82%	49	505	0.35
CH 5 Seloko Plains	50	6	544	53	106%	6	103	0.05
CH 7 Maikaelelo Forest Res	0	0	0	0	0%	0	0	0.00
CH 13 Sibuya Forest Res	43	4	939	67	156%	4	110	0.03
Chobe NP (CH 3)								
CNP F (Chobe River)	316	67	24980	328	104%	67	644	0.25

Figure 26. Distribution and density (km^2) of sable in Chobe District on 2011 dry and 2012 wet season aerial survey.

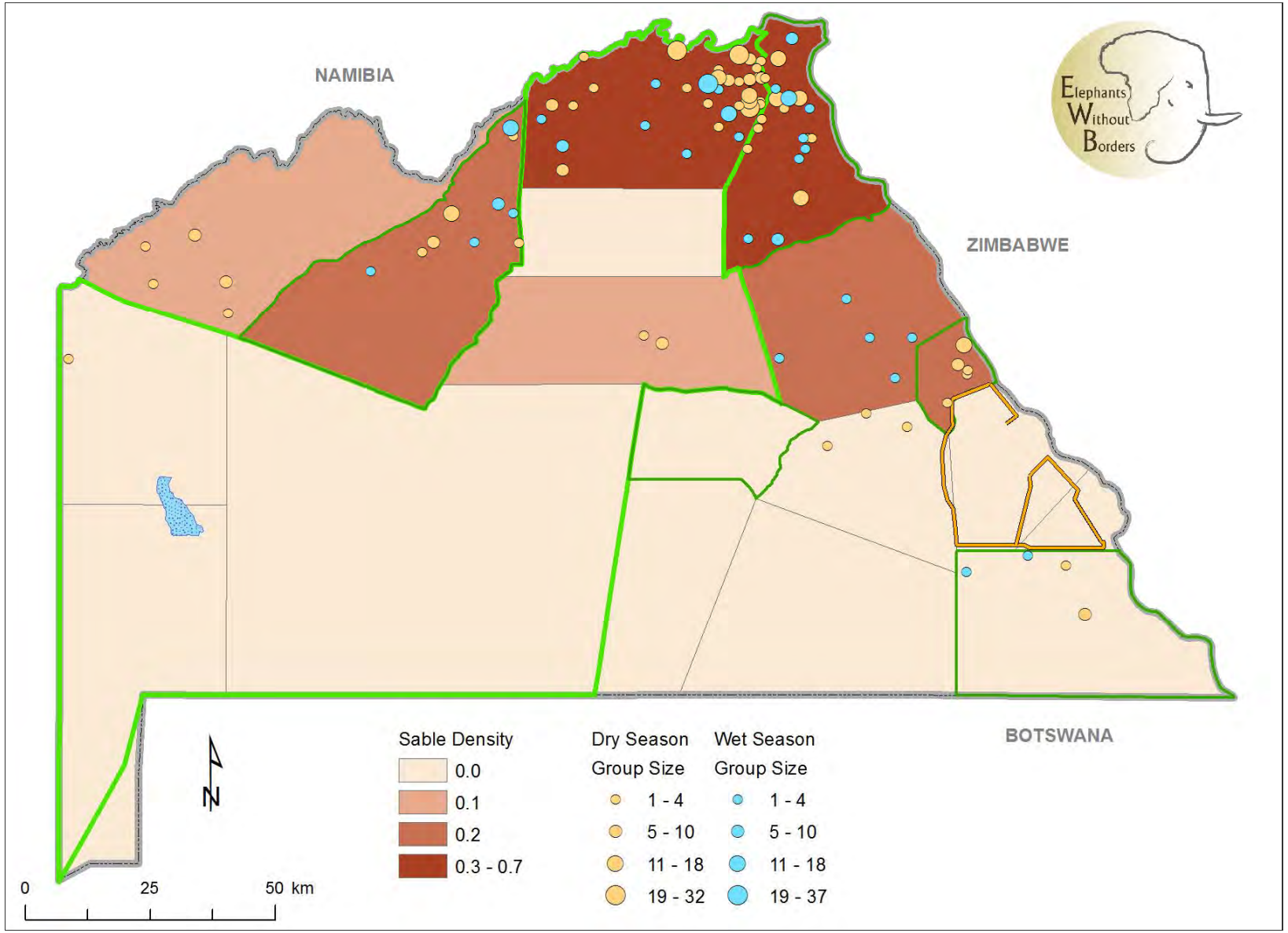


Table 27. Population estimates and statistics for tsessebe in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	11	2	87	20	182%	17	30	0.01
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0.00
CH 4 Kasane Forest Res	68	11	4071	134	197%	11	201	0.09
CH 5 & 6 N Plains	112	13	5143	162	145%	49	274	0.20
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 8 Community Hunting	0	0	0	0	0	0	0	0.00
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0	0	0	0.00
CH 13 Sibuya Forest Res	39	8	721	56	144%	16	94	0.03
FR & WMA Subtotals	230	34	10022	198	86%	34	428	0.02
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0	0	0	0	0	0	0	0.00
CNP B (Mababe-Khwai)	26	3	591	50	192%	3	76	0.01
CNP C (Chinamba)	0	0	0	0	0	0	0	0.00
CNP D (Nogatsaa)	0	0	0	0	0	0	0	0.00
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	85	18	1483	80	94%	18	165	0.06
CNP NP Subtotals	111	21	2074	90	81%	21	201	0.01
Chobe District Totals	**341**	**55**	**12096**	**217**	**64%**	**124**	**558**	**0.02**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 Seloko Plains	127	15	5276	164	129%	15	290	0.12
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 13 Sibuya Forest Res	0	0	0	0	0	0	0	0
Chobe NP (CH 3)								
CNP F (Chobe River)	0	0	0	0	0	0	0	0

Figure 27. Distribution of tsessebe in Chobe District, 2011 dry season aerial survey.

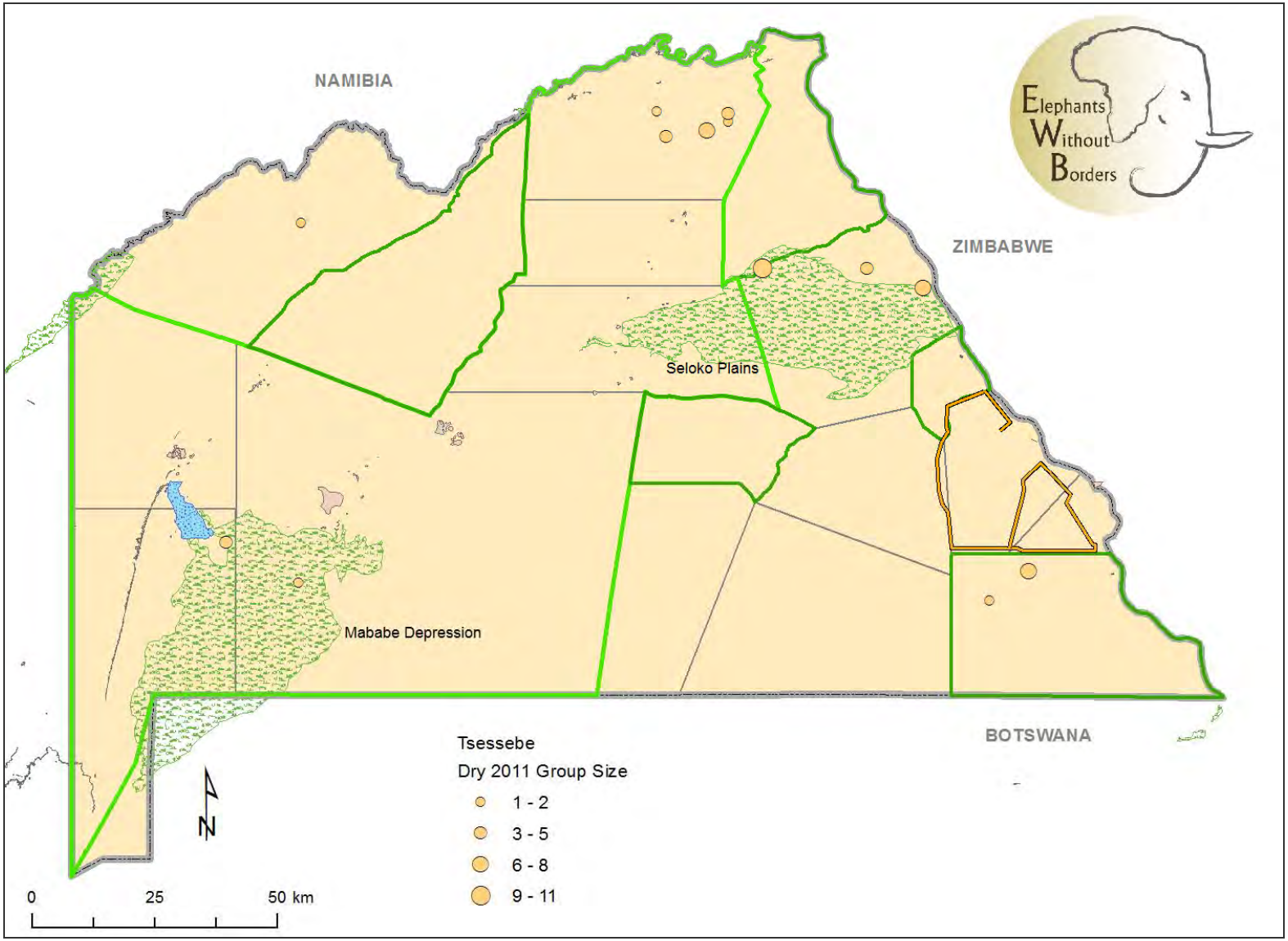


Table 28. Population estimates and statistics for wildebeest in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	0	0	0	0	0	0	0	0
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 & 6 N Plains	0	0	0	0	0	0	0	0
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 8 Community Hunting	0	0	0	0	0	0	0	0
CH 11	0	0	0	0	0	0	0	0
CH 12 Bottle Pan	0	0	0	0	0	0	0	0
CH 13 Sibuya Forest Res	0	0	0	0	0	0	0	0
FR & WMA Subtotals	0	0	0	0	0	0	0	0
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	90	18	2753	109	121%	20	198	0.06
CNP B (Mababe-Khwai)	544	62	182929	882	162%	338	1427	0.28
CNP C (Chinamba)	0	0	0	0	0	0	0	0.00
CNP D (Nogatsaa)	0	0	0	0	0	0	0	0.00
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	0	0	0	0	0	0	0	0.00
CNP NP Subtotals	634	80	185682	854	135%	220	1488	0.05
Chobe District Totals	**634**	**80**	**185682**	**848**	**134%**	**214**	**1482**	**0.05**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 Seloko Plains	0	0	0	0	0	0	0	0
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 13 Sibuya Forest Res	0	0	0	0	0	0	0	0
Chobe NP (CH 3)								
CNP F (Chobe River)	0	0	0	0	0	0	0	0

Figure 28. Distribution of wildebeest in Chobe District, 2011 dry season aerial survey.

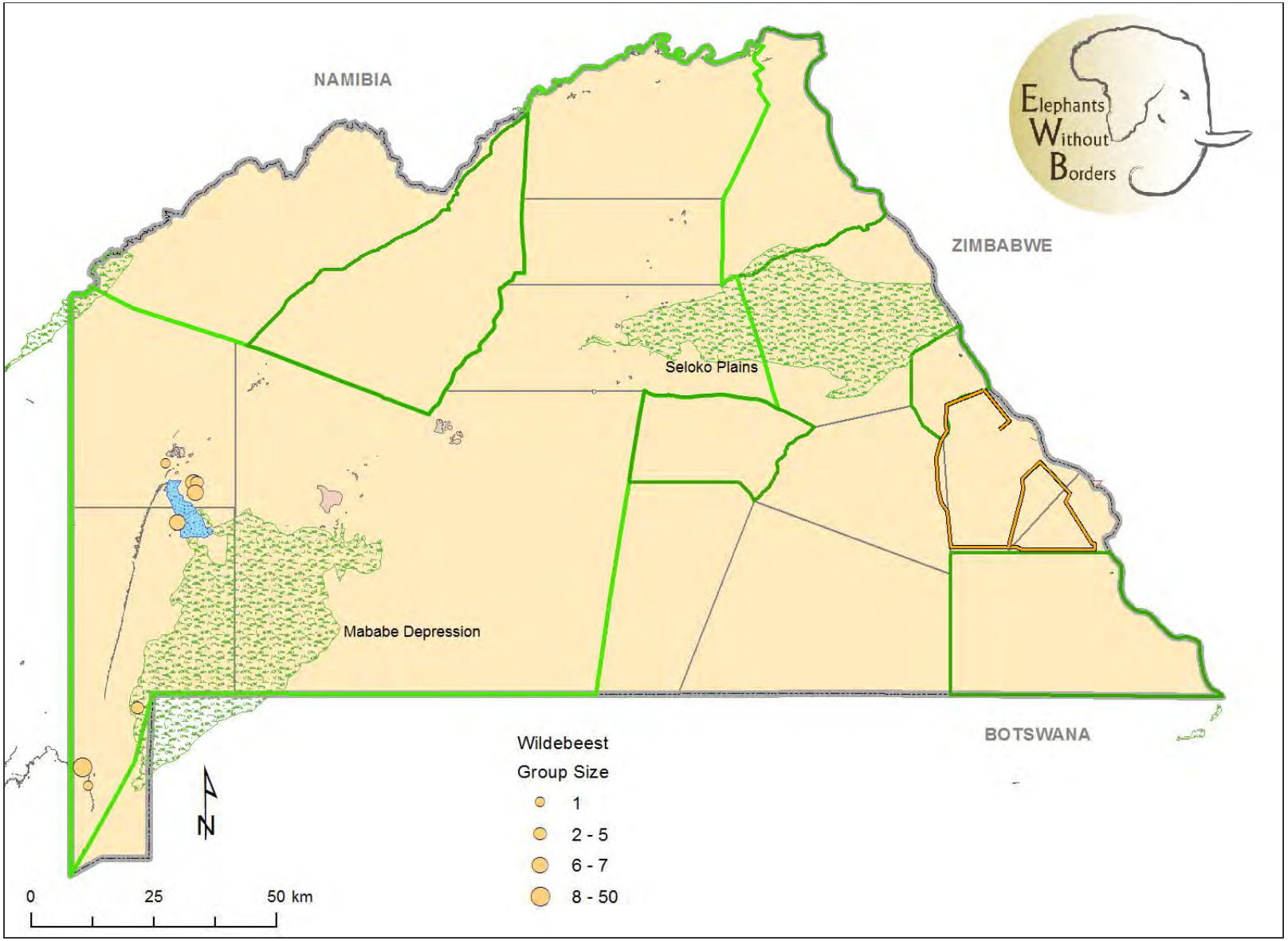


Table 29. Population estimates and statistics for zebra in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	1492	284	99043	659	44%	833	2150	1.28
CH 2 Chobe Forest Res	814	120	126048	743	91%	120	1557	0.57
CH 4 Kasane Forest Res	86	14	2442	104	121%	17	190	0.11
CH 5 & 6 N Plains	138	16	14747	274	199%	16	413	0.10
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 8 Community Hunting	94	12	7405	189	201%	12	283	0.11
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0	0	0	0.00
CH 13 Sibuya Forest Res	44	9	414	42	95%	9	86	0.03
FR & WMA Subtotals	**2668**	**455**	**250099**	**989**	**37%**	**1679**	**3656**	**0.27**
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	105	21	2865	111	106%	21	216	0.08
CNP B (Mababe-Khwai)	176	20	7474	178	101%	20	354	0.09
CNP C (Chinamba)	0	0	0	0	0	0	0	0.00
CNP D (Nogatsaa)	0	0	0	0	0	0	0	0.00
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	3593	762	2070619	2984	83%	609	6577	2.72
CNP NP Subtotals	**3874**	**803**	**2080958**	**2859**	**74%**	**1014**	**6733**	**0.33**
Chobe District Totals	**6542**	**1258**	**2331057**	**3007**	**46%**	**3535**	**9550**	**0.30**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
Forest Reserves (Res)								
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	277	45	15351	260	94%	45	537	0.35
CH 5 Seloko Plains	1407	168	275289	1187	84%	220	2594	1.35
CH 7 Maikaelelo Forest Res	32	4	846	64	200%	4	96	0.06
CH 13 Sibuya Forest Res	192	18	15348	272	142%	18	465	0.15
Chobe NP (CH 3)								
CNP F (Chobe River)	255	54	12061	228	89%	54	482	0.20

Figure 29. Distribution and density (km^2) of zebra in Chobe District during 2011 dry and 2012 wet season aerial survey.

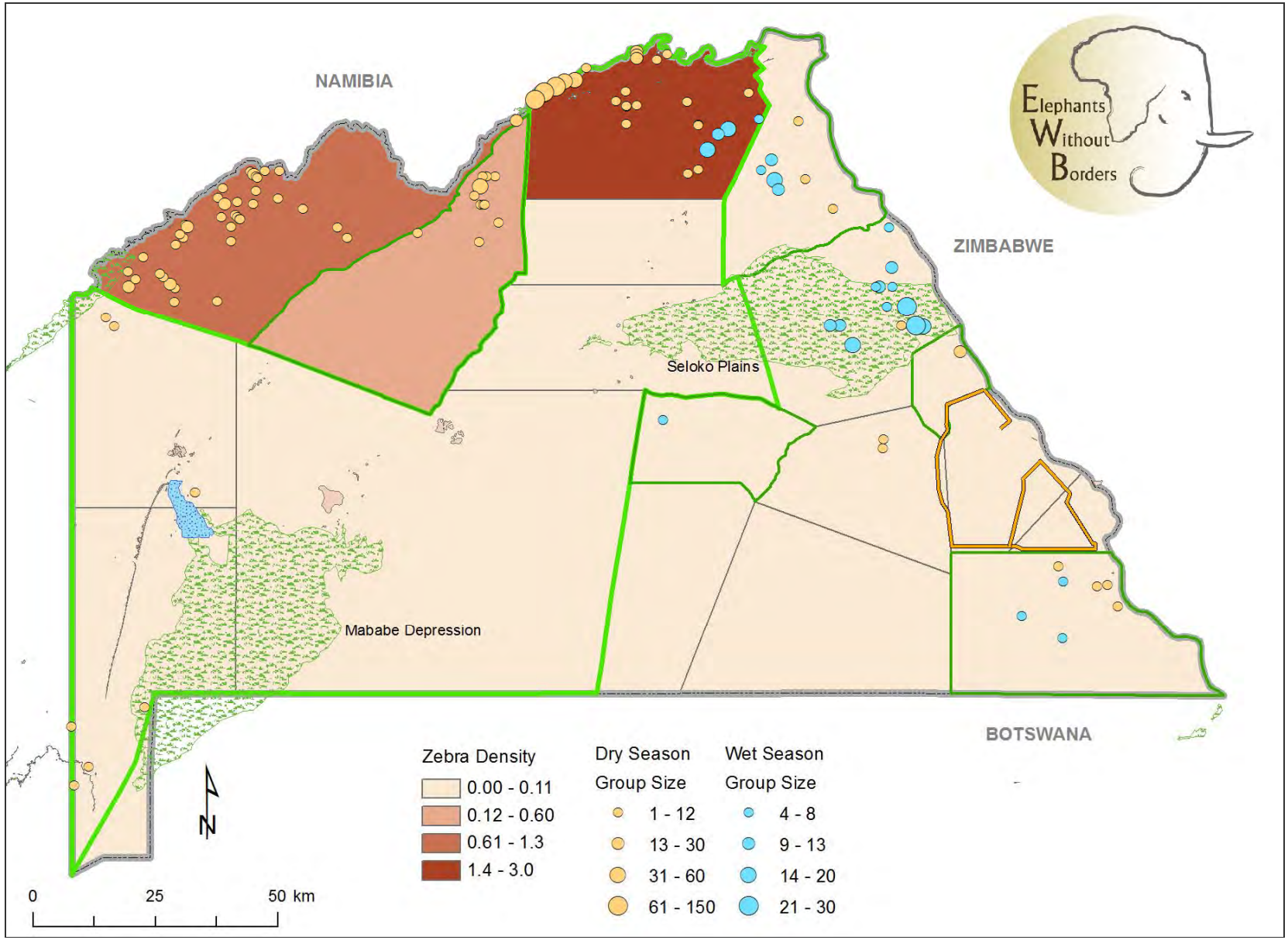


Table 30. Population estimates and statistics for ostrich in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	32	6	140	25	78%	6	56	0.03
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0.00
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0.00
CH 5 & 6 N Plains	0	0	0	0	0	0	0	0.00
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 8 Community Hunting	0	0	0	0	0	0	0	0.00
CH 11	0	0	0	0	0	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0	0	0	0.00
CH 13 Sibuya Forest Res	0	0	0	0	0	0	0	0.00
FR & WMA Subtotals	32	6	140	25	78%	6	56	0.00
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	55	11	1587	83	151%	28	138	0.04
CNP B (Mababe-Khwai)	26	3	334	38	146%	11	64	0.01
CNP C (Chinamba)	0	0	0	0	0	0	0	0.00
CNP D (Nogatsaa)	0	0	0	0	0	0	0	0.00
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	0	0	0	0	0	0	0	0.00
CNP NP Subtotals	81	14	1921	87	107%	14	168	0.01
Chobe District Totals	**113**	**20**	**2061**	**89**	**79%**	**23**	**202**	**0.01**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0
CH 5 Seloko Plains	109	13	3931	141	129%	13	251	0.10
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0
CH 13 Sibuya Forest Res	0	0	0	0	0	0	0	0
Chobe NP (CH 3)								
CNP F (Chobe River)	0	0	0	0	0	0	0	0

Table 31. Population estimates and statistics for cattle in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	630	120	322044	1187	188%	120	1818	0.54
CH 2 Chobe Forest Res	4185	617	3081215	3674	88%	617	7859	2.93
CH 4 Kasane Forest Res	0	0	0	0	0%	0	0	0.00
CH 5 & 6 N Plains	0	0	0	0	0%	0	0	0.00
CH 7 Maikaelelo Forest Res	0	0	0	0	0%	0	0	0.00
CH 8 Community Hunting	0	0	0	0	0%	0	0	0.00
CH 11	0	0	0	0	0%	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0%	0	0	0.00
CH 13 Sibuya Forest Res	0	0	0	0	0%	0	0	0.00
FR & WMA Subtotals	4815	737	3403259	3648	76%	1167	8463	0.48
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0	0	0	0	0%	0	0	0
CNP B (Mababe-Khwai)	0	0	0	0	0%	0	0	0
CNP C (Chinamba)	0	0	0	0	0%	0	0	0
CNP D (Nogatsaa)	0	0	0	0	0%	0	0	0
CNP E (Phofu)	0	0	0	0	0%	0	0	0
CNP F (Chobe River)	0	0	0	0	0%	0	0	0
CNP NP Subtotals	0	0	0	0	0%	0	0	0
Chobe District Totals	**4815**	**737**	**3403259**	**3648**	**76%**	**1167**	**8463**	**0.48**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	2713	400	1435476	2507	92%	400	5221	1.90

Figure 30. Distribution of cattle in the Chobe District, 2011 dry season aerial survey.

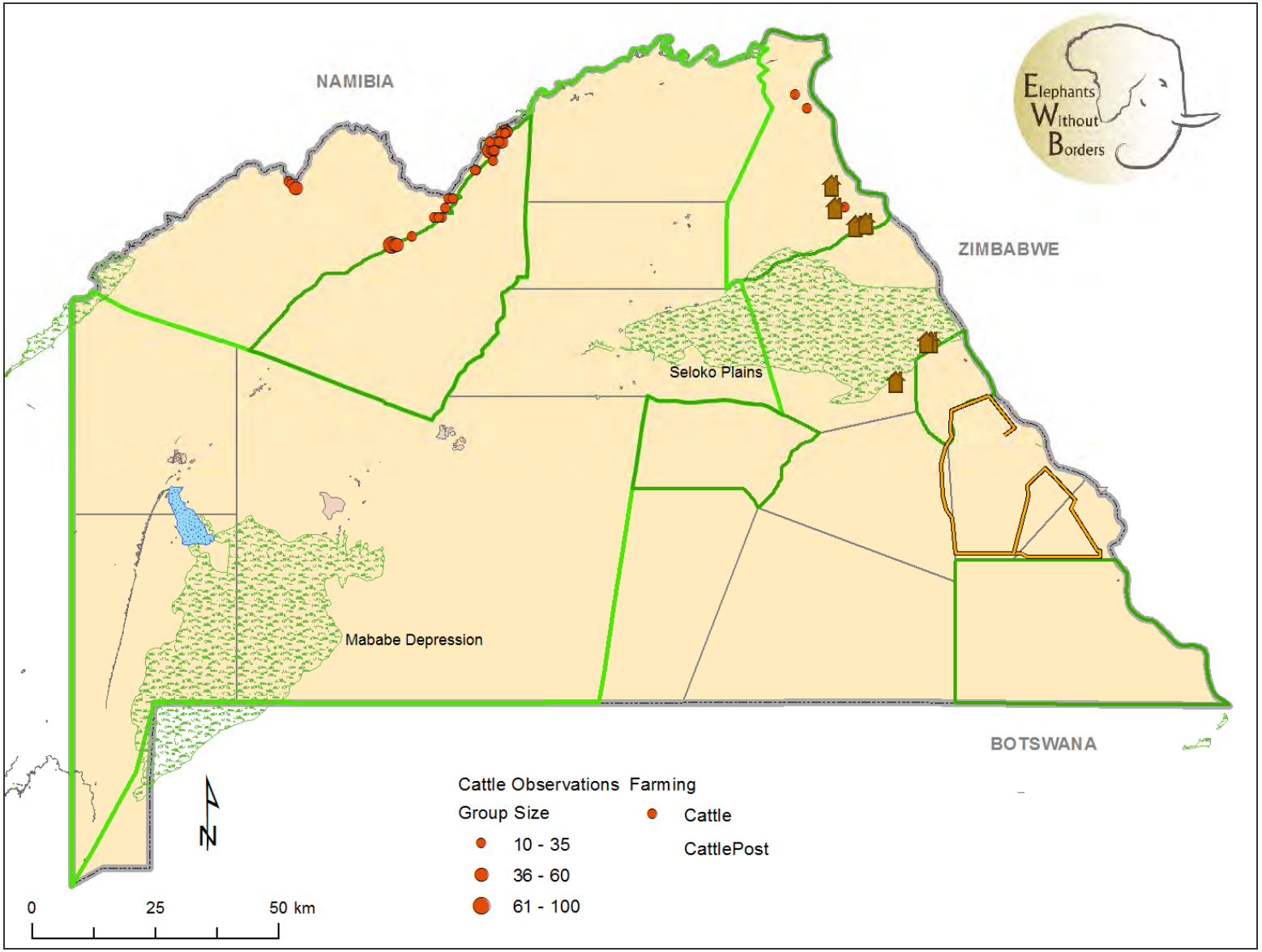
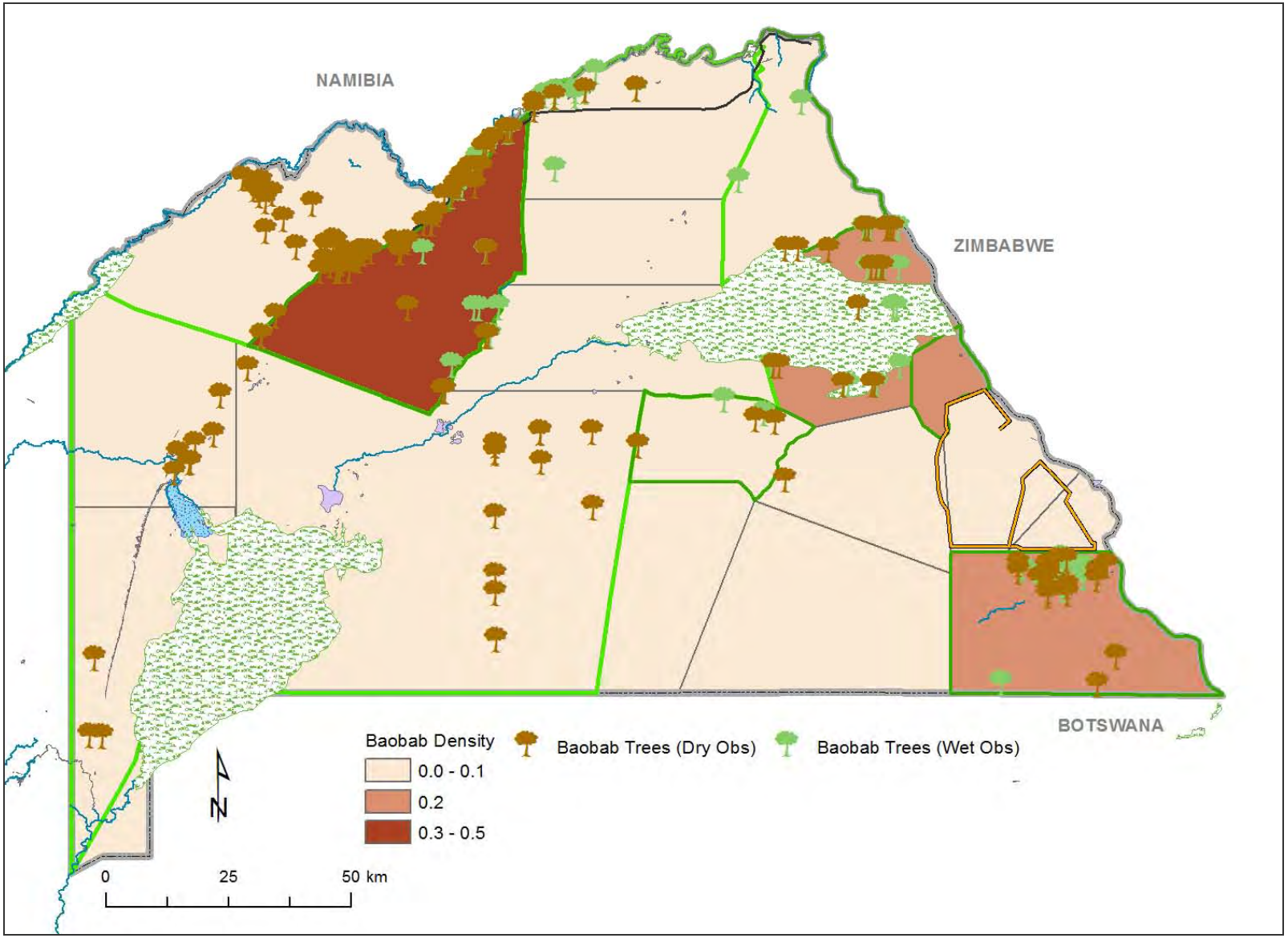


Table 32. Estimates and statistics for baobab trees in Chobe District.

Stratum	2011 Dry Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 1 Chobe Enclave	0	0	0	0	0%	0	0	0.00
CH 2 Chobe Forest Res	726	107	350082	392	54%	333	1118	0.51
CH 4 Kasane Forest Res	12	2	126	24	200%	2	36	0.02
CH 5 & 6 N Plains	251	29	13139	259	103%	29	510	0.18
CH 7 Maikaelelo Forest Res	21	3	92	21	100%	3	42	0.04
CH 8 Community Hunting	0	0	0	0	0%	0	0	0.00
CH 11	0	0	0	0	0%	0	0	0.00
CH 12 Bottle Pan	0	0	0	0	0%	0	0	0.00
CH 13 Sibuya Forest Res	244	50	8714	194	80%	50	438	0.19
FR & WMA Subtotals	1254	191	372153	186	15%	90	464	0.12
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0				0%			0.00
CNP B (Mababe-Khwai)	26	3	332	38	146%	11	64	0.01
CNP C (Chinamba)	338	18	29895	408	121%	18	747	0.07
CNP D (Nogatsaa)	0	0	0	0	0%	0	0	0.00
CNP E (Phofu)	0	0	0	0	0%	0	0	0.00
CNP F (Chobe River)	61	13	1055	67	110%	13	129	0.05
CNP NP Subtotals	425	34	31282	350	82%	74	776	0.04
Chobe District Totals	**1679**	**225**	**403435**	**395**	**24%**	**306**	**1097**	**0.08**

Stratum	2012 Wet Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) DISTRICT								
CH 2 Chobe Forest Res	312	46	8192	189	61%	122	504	0.22
CH 4 Kasane Forest Res	12	2	61	16	133%	2	28	0.02
CH 5 Seloko Plains	352	42	21304	328	93%	42	680	0.34
CH 7 Maikaelelo Forest Res	0	0	0	0	0	0	0	0.00
CH 13 Sibuyu Forest Res	363	34	15379	273	75%	90	636	0.28
Chobe NP (CH 3)								
CNP F (Chobe River)	66	14	1008	66	100%	14	132	0.05

Figure 31. Distribution and density (km^2) of baobab tress in Chobe District.



Appendix 1. Data analysis and plane set-up for aerial survey

Jolly's (1969) method (II) for blocks of unequal size was used to calculate estimates of density and variance for each species in each stratum as follows:

$$R = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} z_i}$$

$$\hat{Y} = Z.R$$

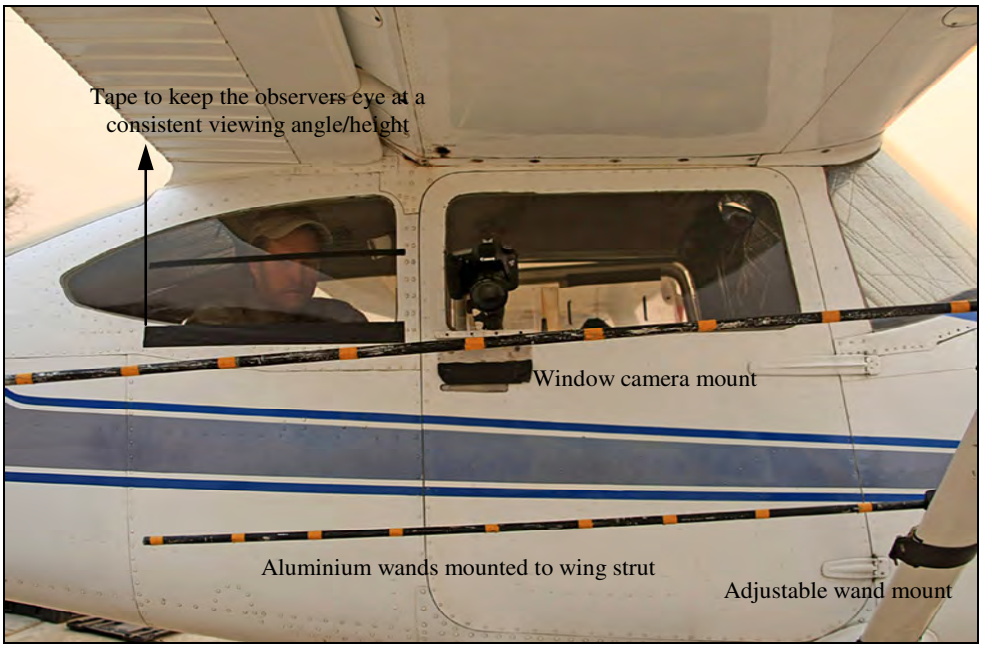
$$V_{\hat{Y}} = \frac{N(N-n)}{n}.(s_y^2 - 2.R.s_{zy} + R^2.s_z^2)$$

where:

R	= density of animals
$\hat{Y}$	= total number estimated
Z	= total area of stratum
yi	= number of animals counted in transect i
zi	= area of transect i
n	= number of transects
N	= number of transects possible in stratum where: $N = n.Z / \Sigma z$
s^2_y	= variance of number seen per transect y
s^2_z	= variance of transect areas z
s_{zy}	= covariance between number seen per transect and transect area
V	= variance of estimated number in stratum (i.e. variance of Y)

Overall estimates and variances were obtained from the sums of the stratum estimates and their variances. The standard error (*SE*) of the estimate is the square root of the variance and the 95% confidence limits of the estimate is $\hat{Y} \pm t\ .\ SE$, where t is Student's t for a two-tailed probability of 0.05 and n-1 degrees of freedom.

Fixed Wing Plane (Cessna 182) equipped for an aerial survey.



Appendix 2. Wildlife numbers within the new Pandamatenga Farming area, March 2012.

Wildlife numbers within the new Pandamatenga Farming Area

12 March 2012

A Summary Report Prepared for:

The Ministry of Agriculture
Attention: Mr. Neil Fitt

Prepared by:

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Introduction

On the 7th March an aerial survey of wildlife over the new Pandmantenga agricultural development area was flown. The purpose of this survey was to determine the number and distribution of wildlife which occur within the area. The area measures approximately, 20 km^2, and is enclosed with a ~ 2 m electric fence.

The survey was requested by Mr. Neil Fitt. Elephants Without Borders was conducting a wildlife survey in the region and offered to fly the area to determine the numbers of wildlife trapped with in this area. It is the intention of the Ministry of Agriculture to remove these animals from the area. Currently ~200 m of fencing has been pushed down, providing a gap for the animals to move out of the area.

Animals might be hesitant to cross this downed section of fence, unless they are driven out with the support of a helicopter. Given the numbers of animals observed, many of which are considered vulnerable within northern Botswana, the Ministry should make every effort to push the animals out before completely enclosing the fence and the animals are destroyed for raiding crops. The animals especially elephants are likely to cause extensive damage to crops and infrastructure if left inside this area.

Method

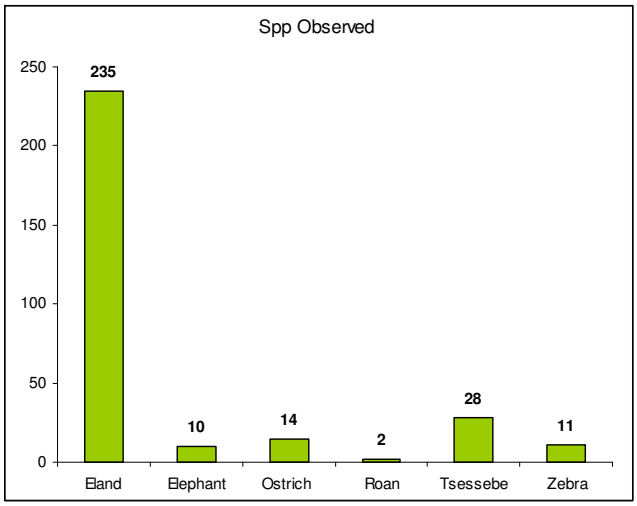
A small fixed wing plane (Cessna 182) flying at 300 feet above ground level was used to count animals within the area. The region was demarcated prior to flying and 2 km transects were digitally mapped for the pilot to fly along. Two observers seated behind the pilot and data recorder counted all the animals they saw. Observers also took a digital photograph with cameras mounted on the windows of the plane, to help verify the exact numbers of animals seen. Some animals may have been missed by the observers between the 2 km wide transects.

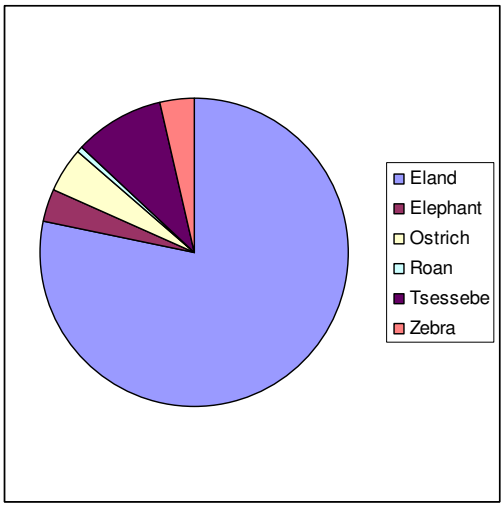
Results

Eland occurred in the highest numbers (235) within the area (Table 1). The number of Eland seen within the entire Chobe District on a dry season aerial survey conducted by EWB in 2011 was 1200. The number of Eland seen within the new Pandamatenga farming area represents 20 % of the total Eland estimate for the Chobe District. Tsessebe numbers are low in northern Botswana, with just 340 occurring in the Chobe District (Chase 2012), 28 were seen within the area. Given the low numbers of these species, the Ministry of Agriculture's intentions to remove them from this enclosed area would serve a needed and worthy conservation effort.

Table 1. Wildlife species and numbers seen by observers within the new Pandamatenga farming area.

Species	Number Seen	Herds Observed	% of Total Seen
Eland	235	2	78.33%
Elephant	10	1	3.33%
Ostrich	14	2	4.67%
Roan	2	2	0.67%
Tsessebe	28	2	9.33%
Zebra	11	1	3.67%
Grand Total	**300**	**10**	**100.00%**





Species were observed throughout the region (Figure 1). The downed section of fence occurs along the southern boundary. Animals were seen 12 km away from this gap. Herding wildlife out of such confined closed areas with the aid of a helicopter has been successful. If the animals are pushed to hard they will die form heat exhaustion. It is of paramount importance that the animals are herded without causing stress, and injuring themselves (broken legs). Many of the animals had young calves too. Within the area we observed no water for the animals to drink. Kraaling the animals with a helicopter should be done by an experienced pilot with a wildlife capture rating and a veterinarian.

To the south of the farming area, in the Sibuyu Forest Reserve, we observed numerous elephants. The electric fence should curtail the movements of these animals into the farming area. It is therefore important that the fence be maintained to stop these elephants from crop raiding.

Figure 1. The study area, demarcated by the red line (electric fence) and wildlife observations within the new farming area.