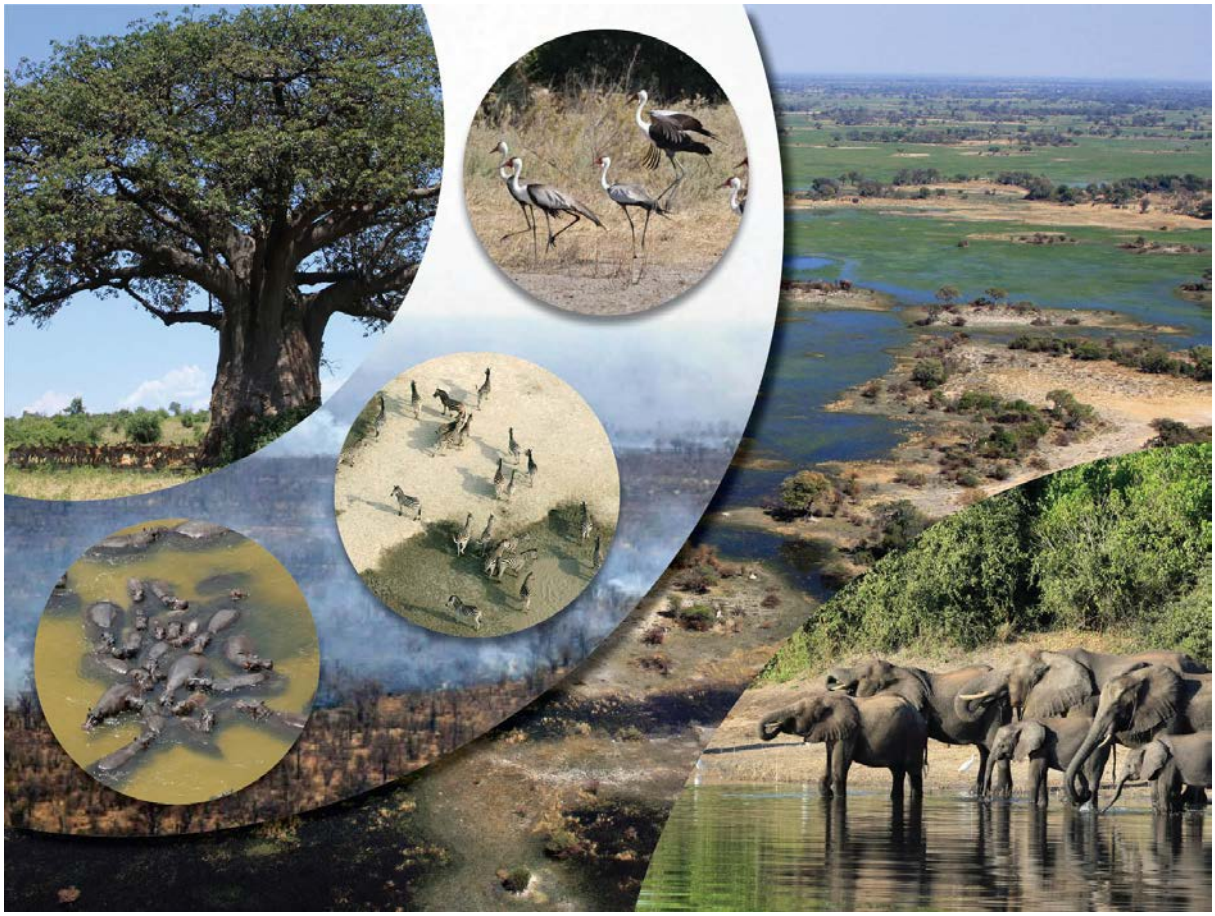
DRY SEASON FIXED-WING AERIAL SURVEY OF ELEPHANTS AND WILDLIFE IN NORTHERN BOTSWANA

SEPTEMBER – NOVEMBER 2010



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May 2011

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

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EXECUTIVE SUMMARY

During the 2010 dry season, a fixed-wing aerial survey of elephants and wildlife was flown over the core conservation areas of northern Botswana. This aerial survey was commissioned by Elephant Without Borders and the Department of Wildlife and National Parks (DWNP). A small fixed wing plane was used to fly a stratified sample survey, with parallel transects over the survey area, 73478km^2. It included Moremi Game Reserve (GR), Chobe National Park (NP), Makgadikgadi Nxai Pan NP and surrounding Wildlife Management Areas (WMAs) in the Ngamiland, Chobe and Central districts. 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 northern Botswana. This is the first independent aerial survey across northern Botswana to provide concession level wildlife estimates. This report provides the results of this survey, in addition to information on the spatial distribution, and abundance of wildlife and trend of elephant numbers. Maps and tables illustrating the distribution, numbers, density and trends of wildlife species in northern Botswana are provided.

The survey area was divided into 42 strata, which largely conformed to the boundaries of WMAs, and protected areas. 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 – 22 %. The overall sampling intensity was 14 %, a 10 % increase compared to earlier DWNP aerial surveys. Overall mean search effort was 1.3 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 northern Botswana.

The estimated number of elephant carcasses (2442) for the entire survey area represented 2 % of the total number of live and dead elephants. The carcass ratio (i.e. the ratio of elephant carcasses of all age categories) was 0.5 % for the whole survey area. Most of the elephant carcasses occurred in the Okavango Panhandle and Chobe Enclave, where arable farming is part of the land use. High numbers of elephant carcasses were in the Sibuyu Forest Reserve and Nogatsaa region of Chobe NP, these strata occur in remote areas where elephants are protected.

The estimated population numbers for the principal large herbivores, elephant carcasses and birds in northern Botswana were:

Species	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
Woodland Sp								
Elephants	128340	21833	25643351	9938	8	118402	138277	1.75
Elephant bulls	18963	3005	896304	1857	10	17105	20820	0.26
Elephant families	109376	18827	25294996	9870	10	99505	119246	1.49
Elephant carcass	597	88	6262	155	26	441	752	0.01
Elephant bones	1845	309	21313	286	16	1558	2131	0.03
Buffalo	39579	7958	29421006	10644	27	28934	50224	0.54
Eland	3311	418	1060698	2021	61	1289	5332	0.05
Gemsbok	2796	295	500385	1388	50	1407	4184	0.07
Giraffe	5537	982	208552	896	16	4640	6433	0.08
Hartebeest	634	69	97263	635	100	69	1269	0.06
Impala	51270	12021	18647001	8474	17	42795	59744	0.93
Kudu	2798	536	79041	551	20	2246	3349	0.04
Roan	710	107	33013	356	50	353	1066	0.01
Sable	3649	644	256455	994	27	2655	4643	0.07
Springbok	1565	159	951454	1914	122	350	3479	0.13
Tsessebe	3166	571	340638	1145	36	2020	4311	0.06
Warthog	3046	545	103583	631	21	2414	3677	0.06
Wildebeest	5097	782	1959347	2747	54	2349	7844	0.07
Zebra	41058	6254	70377840	16463	40	24954	57521	0.56
Wetland Sp								
Hippo	6054	1286	272579	1024	17	5029	7078	0.11
Lechwe	33246	6953	4293935	4666	14	29179	37312	0.61
Reedbuck	593	133	5895	150	26	442	743	0.01
Sitatunga	423	86	4555	132	31	290	555	0.01
Waterbuck	406	76	24939	310	76	96	716	0.01
Birds								
Bateleur eagle	714	142	6189	154	22	559	868	0.01
Fish eagle	1053	255	6165	154	15	898	1207	0.02
Ground hornbill	623	97	14452	235	38	387	858	0.01
Ostrich	1875	274	106711	641	34	1233	2516	0.03
Saddle-billed stork	1040	257	14719	238	23	801	1278	0.02
Wattled crane	785	194	28484	331	43	443	1106	0.02
Other Obs.								
Baobab tree	4517	659	294082	1064	24	3452	5581	0.06
Cattle	45563	9790	15637403	7760	17	37802	53323	0.62

A total of 659 baobab trees were seen during the survey, of which 154 were classified as small sized trees. Dead trees (i.e. 100 % damage, n = 29) accounted for 4.4 % of the total number seen within the survey area. A survey of part of NG 8, west of the Southern Buffalo Fence yielded an estimate of 32 cattle / km^2, but low wildlife numbers. The area however has the largest zebra population (2093) in the Okavango Delta. Many

veterinary fences which were probably damaged by elephants still appear to be effective in reducing the movement of cattle and encroachment of arable farming into wildlife conservation areas which surround Moremi GR.

This survey is the ninth aerial survey of wildlife populations in northern Botswana since 1993. Estimates of elephant numbers in Ngamiland and Chobe districts, Moremi GR and Chobe NP have remained similar to 2001. A trend analysis of wildlife estimates from earlier aerial surveys suggests that the estimated numbers of 11 large mammal species in the Okavango Delta have declined severely during the past ten years. The 2010 population estimates for wildlife species in the Okavango Delta are substantially lower than those from previous years. The analysis for Moremi GR recorded downward trends. The annual rate of decline, for giraffe (8 %), kudu (11 %), lechwe (7 %), tsessebe (13 %), and wildebeest (18 %), were all statistically significant. Wildebeest in Ngamiland declined from 23538 in 1999 to 1985 in 2010 at an annual rate of 18 % (P <0.003). These wildlife declines coincide with a 20 year drought which began in the 1980s. Annual rainfall and water flow records for the Okavango River were the lowest since record keeping began in the 1920s. This drought could be one explanation for the serious decline of wildlife in the Okavango Delta and other parts of northern Botswana.

Wildlife populations (except for springbok) are stable in the Makgadikgadi and Nxai Pan NPs. Protected areas and WMAs in northern Botswana are managed specifically for their large mammals, and wetland habitats which support and encourage tourism. Recent rainfall records and river flow data suggest that northern Botswana could be moving into a wet cycle, which underscores the necessity of conducting future aerial surveys to monitor the distribution and abundance of wildlife populations.

The 14000 elephants in the Okavango Panhandle present further management challenges as farming activities extend into the northern portions of NG 12 and 13. NG 13 has valuable mopane and miombo woodland habitats, and consideration should be given to designating NG 13 as Ngamiland's first Forest Reserve. NG 13 has the potential to act as an important wildlife corridor facilitating the natural dispersal of elephants out of the Okavango Panhandle into Namibia and Angola, but currently this management option for reducing elephant numbers naturally is being compromised by expanding agricultural activities and fences. If the region continues to be settled by people the opportunity to realign the Caprivi Border Fence along the southern boundary of NG 13 will be lost, and may pose serious environmental and human wildlife conflict problems.

The extent of bush fires during the survey across vast areas of northern Botswana is a concern and a fire management programme needs to be implemented. The level of deforestation and encroaching human activities for arable fields on the closed canopy forest islands west of Jao and Jedibe is destructive. Expanding human activities into the northwest floodplains of the Okavango Delta could be affecting the area's lechwe population, whose numbers have declined by 58 % compared to estimates in 1996. The allocation of arable fields in the middle of elephant pathways is hindering elephants access to water which will lead to an inevitable increase in human elephant conflict. There is reason to be concerned about the status of several species, whose numbers have declined on average by 10 % each year. Research is urgently needed to establish the causes and solutions that address these wildlife declines, especially in the Okavango Delta.

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Introduction

This fixed wing aerial survey of wildlife in northern Botswana was conducted during the dry season between September and November 2010. Although aerial surveys of northern Botswana have been flown during the last three decades by the Department of Wildlife and National Parks (DWNP), this is the first independent fixed-wing aerial survey to provide concession level estimates for wildlife populations. The survey coverage was 10 % greater than that used during previous DWNP surveys. Generally, sampling intensity was greater (20 %) in areas where wildlife was expected to be more numerous. 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 survey area, 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 other large herbivores, large birds, 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 northern Botswana.

Elephants Without Borders received funding from the DWNP's Conservation Trust Fund to conduct this survey and provide recent estimates of the abundance of wildlife species in northern Botswana. 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 this survey and compares wildlife estimates with previous aerial surveys (8) conducted by the DWNP. 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 Okavango Delta Management Plan, and Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA).

Study Area

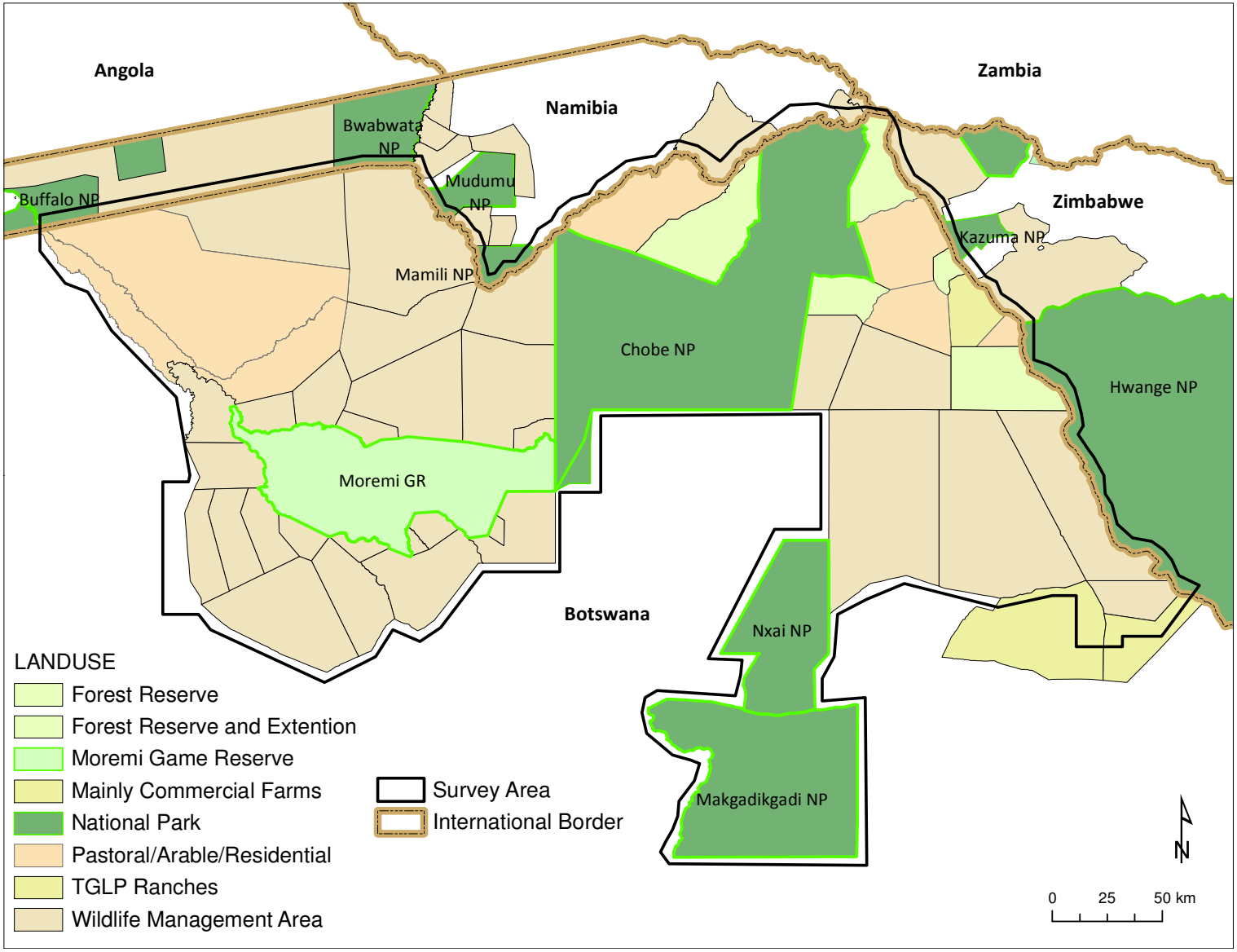
During the wet season the elephants of northern Botswana range over a 115800 km^2 area, stretching from the Boteti River in the south, extending north and west to the border with Namibia, and eastwards to the Zimbabwe border (Chase 2007). Within this range 22912 km^2 (~ 20 %) is protected, which includes Chobe National Park (NP)(10740 km^2), Makgadikgadi NP (4140 km^2) Nxai Pan NP (2590 km^2) and Moremi Game Reserve (GR) (4870 km^2). An additional 65 % (~ 75000 km^2) of this range is set aside for wildlife conservation in the form of Wildlife Management Areas (WMAs), which are primarily for photographic ecotourism or safari hunting (Timberlake & Childes 2004) (Figure 1). During the dry season, the elephant range is mainly concentrated around the perennial rivers and artificial waterholes (85000 km^2). The survey area covered 87 % of the dry season elephant range and WMAs which support most of the wildlife populations in northern Botswana.

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, Zambezi (800 m), and Okavango rivers are the largest rivers that provide abundant water throughout the year. The Khwai, Linyanti 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. The Okavango Delta is a large, inland wetland that floods annually over a 12000 km^2 area (McCarthy & Ellery 1998). 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).

To the north, the Caprivi Border Fence extends for 135 km along the border with the Caprivi Strip, beginning on the east bank of the Okavango River and ending 35 km west of the Kwando River where it joins the Northern Buffalo Fence. This latter fence extends 130 km south to the Okavango Delta. The Namibian Border Fence begins on the west bank of the Okavango River, extends westward for 85 km and then south along the border for 300 km. This fence joins the Khuke Fence that extends for another 300 km eastward and joins the Makalambedi Fence that turns north and connects with the Makgadikgadi/Nxai Pan and Southern Buffalo fences. The Ngwasha Fence connects with the Odiakwe Fence along the Maun – Nata road and extends eastward to the Zimbabwe border (Figure 11).

Figure 1. The survey area and land use in northern Botswana, and neighbouring countries.



Methods

Fixed-Wing Aerial Survey

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 developed by Dunham et al. (2009) and Gasaway et al. (1986) for analyzing and presenting wildlife aerial survey data.

Prior to the survey, the study area was subdivided into 42 strata[1] (Figure 2). 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).

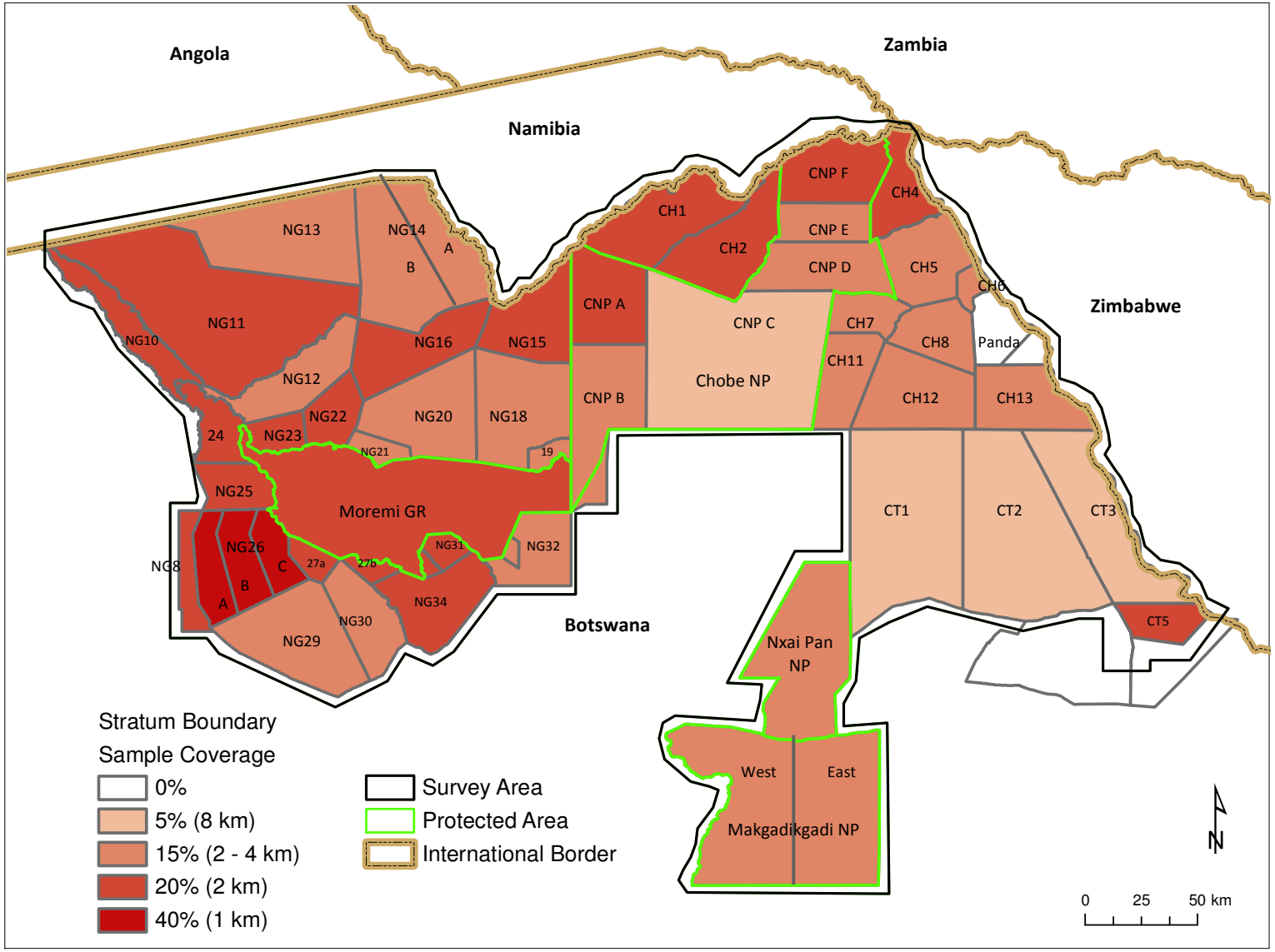
In order to maximize the precision of the estimate of the total number of elephant in the area sampled, the sampling intensity varied between strata. Hence, the distance between adjacent transects varied between strata, according to the planned sampling intensity in each stratum. We used three levels of sampling intensity. 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). Strip widths for Ngamiland (NG) 10, 11, 12 and 13 were increased to 500 m to conform to previous aerial surveys over these areas (Songhurst et al. 2011). In one instance concession holders provided additional funding (NG 26 EBS / Abu), and sampling coverage was increased to 40 %. Transects were spaced 4 km apart in areas that we designated for moderate sampling intensity, providing a sampling coverage of ~ 10 %. We used a transect spacing of 8 km for low intensity sampling, providing ~ 5 % sampling coverage (Figure 2). In practice, the transect spacing varied from 2 km in strata expected to contain numerous elephants, to 4 km in strata expected to contain moderate elephants and 8 km in strata expected to contain few elephants. Transect lengths were typically $\leq$ 30 km and could be flown in < 10 min, thereby reducing observer fatigue.

The area south of Chobe NP (NG 41, 42 and 43) were not surveyed to avoid double counting animals. It started to rain shortly after surveying stratum CT 1 and elephants tend to move into this region from the Okavango Delta in November (Chase 2007).

In strata designated for both agriculture and wildlife conservation (NG 8, 10,11,12, 13, and CH 1, 2 and 5), the survey results provide information on the numbers and spatial distribution of cattle.

[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 2. Survey stratum and sample coverage during 2010 dry season aerial survey of northern Botswana.



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

The survey was designed using DNR Garmin software and ArcView (ESRI 2002). Stratum boundaries were mapped in ArcView, and the transect orientation and spacing was generated using the DNR Garmin Sampling Extension in ArcView (ESRI 2002). This software generates flight lines (transects), with the first flight line offset from the end of the stratum by an entered random number. The start and end points for each transect were transferred as waypoints to Mapsource (Mapsource 2007). Prior to flying, all transects were incorporated into a digital map of the survey area with their beginning and end point coordinates (Decimal Degrees, WGS 84). This digital map was created using ArcView 3.2 (ESRI Redlands CA 2002) software and showed observable landmarks and boundaries. All transects were then mapped as routes (Mapsource 2007) prior to flying and then uploaded on a digital map within each GPS receiver (Tracks for Africa 2010) with their beginning and end point coordinates.

Flight Procedures

The survey was conducted during the height of the hot dry season when increased visibility of wildlife was expected (we had little rain during the survey). Although the hot-wet season typically begins in November, this survey is considered a dry season survey because little rain had occurred and all of the seasonal pans were dry. Transects were flown at an average speed of ~ 160 km per hour, at about 300 feet above ground level. Height above ground level was maintained using a Bendix King radar altimeter. The plane was equipped with three GPS receivers. The pilot used one GPS to navigate along transect lines, a second GPS was used by the front seat data recorder to ensure the pilot did not deviate off the transect line, and the third GPS was used to record animal observations. The track log of the aircraft was recorded using the track log function in the GPS, which noted the aircrafts location at intervals of 15 seconds (of time). Height above ground level, as indicated by the radar altimeter, was recorded at regular intervals [~ between 20 to 40 seconds (of time)] along transects, regardless of whether or not animals were seen. Later the mean height for each transect was calculated. The time at which the flight along each transect was started and ended was also recorded to provide a guide to the average speed (Craig & Gibson 2002, Dunham et al. 2009).

The aircraft crew included a pilot (Mike Holding), a data recorder (Michael Chase), who sat next to the pilot, and two observers (Kelly Landen and Allen Bekker) who sat behind the pilot and recorder. All four crew members were able to communicate efficiently through a four-way intercom headset receiver box. Observers in the plane called out their observations into a recorder, which had a 4 GB memory card. At the end of each day, recordings were played back on a laptop computer to verify hand-recorded data. The same two observers were used throughout the survey, one on each side of the plane. Both of the observers had extensive previous aerial survey experience (Kelly Landen > 1000 hrs, Allen Bekker > 150 hrs) prior to this project.

For all strata we used the standard methodology for transect sampling developed by Norton-Griffiths (1978). For each observation within the transect interval, the observer called out the numbers of species, when they were as nearly perpendicular to the plane as possible. Additionally, a mark was put on the plane window to help observers keep their eyes at a consistent height to maintain the same sighting angle for each observation (Appendix 1). This helped to keep consistent interval widths for each observation. Any animals outside of the area delineated by the wands were not counted. All animals seen by the observers within the search strips (see section Strip Width and Calibration below) were called to the recorder, who marked each observation as a waypoint in the GPS. The recorder also kept a written data log entered on a

datasheet for each observation within the strip including: the waypoint number and time, altitude from the radar altimeter, number of individuals observed, and which observer made the sighting. The start and end times for each transect were also recorded to the nearest second. Transects lengths were estimated using the Animal Movements Extension in ArcView 3.2.

On six occasions the aircraft left a transect that routed over an airstrip to provide the survey crew with a rest. The pilot and recorder used their GPSs to navigate to the location where the transect was stopped.

Observations

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 addition the following large birds, were counted: ostrich, bateleur eagle, fish eagle, ground hornbill, saddle bill stork, and wattled crane. 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 based upon 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.

Artificial waterholes, lodges and airstrips were identified. Those transects that ended over sections of veterinary fence provided the recorder with an opportunity to note breaks in the fence and its structural integrity.

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 sitatunga, 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 200/250 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 (Table 7).

Aerial photography is one technical tool frequently used to improve the precision and accuracy of wildlife surveys (Chase & Griffin 2009). Two digital EOS 7D Canon cameras (18 mega pixel) were fixed to specially adapted mounts on each window of the plane. The center of the lenses corresponded to marks on the plane window that were used to help observers keep

their eyes at a consistent height for each observation. The focal length of the lens was adjusted to incorporate the full counting strip width, providing a consistent viewing angle. If any animal group was too large for all the individuals within it to be counted, a digital photo was taken. These photos were used to verify herd size and the sighting of herds within the interval defined by the wands. The components of the camera system consisted of two cameras with 20-mm wide-angle lenses, camera backs with time code generators, remote switches and two window camera mounts. A camera was mounted on each side of the plane. The cameras provided high-resolution photos so that animals could be more accurately counted during subsequent analyses. A GPS time code and date were recorded to the second for every frame exposed (Appendix 1).

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 our reconnaissance flights. Makgadikgadi NP was subdivided into East and West strata to reduce fly long transects across the entire Park. In Ngamiland, NG 14 and NG 26 were subdivided into two and three strata respectively according to land cover changes. Some WMAs were too small to fly as one stratum, these were grouped with surrounding WMAs and flown as one stratum (Table 7). Two strata (NG 24 and 25) were both flown as single strata but subdivided prior to data analysis. The entire survey area, in this report is termed 'northern Botswana' while the survey area did not cover the entire part of 'northern Botswana' the term is used in reference to the area sampled (73478 km^2) within northern Botswana.

Following the guidelines developed by Norton-Griffiths (1978) we calculated abundance for individual strata from wildlife counted within the 200/250 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 2010 (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.

Linear Regression (Wildlife Trend Analysis)

Time series were constructed for each species in areas which were covered by the aerial surveys (Chobe District, Chobe NP, Ngamiland District, Moremi GR and Nxai Pan NP) for the period 1993 to 2010. Each of the time series included at least seven estimates from aerial surveys, which all covered similar or identical areas (Figure 4). The natural logarithms of estimates plus 1 (to compensate for estimates where the population was zero) linearly regressed against time yielded estimates of percentage exponential growth (slope of line x 100), their 95% confidence intervals and standard errors (Caughley 1977). In this analysis the slopes of the linear regressions represent annual growth rates (r). We distinguished between declining, increasing and stable populations within each surveyed area. We considered a population as stable when the exponential growth rate was $\geq$ - 1% and $\leq$ 1%, rather than when the 95% confidence intervals of the regression analysis included zero as the lack of precision associated with most of the estimates resulted in very wide confidence intervals.

For elephants piecewise linear regression with a single breakpoint (Toms & Lesperance 2003) was used to determine when a significant change in population growth occurred in a surveyed area (stratum).

Search Effort

The greater the time spent searching each square kilometre 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 73478 km^2 survey area, 947 transects ($\overline{X}$ = 29 km), totaling 25598 km were flown in 168 hours over 42 days (Table 6 & Figure 12). Flight altitude averaged 98.5 m (range 83 - 136 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 1.3 for the entire survey area (Table 7).

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, lechwe, roan, reedbuck, sable, tsessebe, wildebeest, zebra, hartebeest, sitatunga, springbok, waterbuck, ostrich, bateleur eagle, fish eagle, ground hornbill, wattled crane, baobab trees and cattle are given in Tables 8 to 41, 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**) in side 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 118402 and 138277 elephant in the survey area, with 128340 being the best estimate of the number of elephants within our survey area of northern Botswana. For practical purposes, one might say that there were between 120000 and 140000 elephants within northern Botswana during the late dry season of 2010, with 130000 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, rhino and wild dog were seen during the survey, and no attempt has been made to estimate the numbers of these species. While baboon, steenbok 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 2010 dry season aerial survey in northern Botswana.

Species	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
Woodland Sp								
Elephants	128340	21833	25643351	9938	8	118402	138277	1.75
Elephant bulls	18963	3005	896304	1857	10	17105	20820	0.26
Elephant families	109376	18827	25294996	9870	10	99505	119246	1.49
Elephant carcass	597	88	6262	155	26	441	752	0.01
Elephant bones	1845	309	21313	286	16	1558	2131	0.03
Buffalo	39579	7958	29421006	10644	27	28934	50224	0.54
Eland	3311	418	1060698	2021	61	1289	5332	0.05
Giraffe	5537	982	208552	896	16	4640	6433	0.08
Hartebeest	634	69	97263	635	100	69	1269	0.06
Impala	51270	12021	18647001	8474	17	42795	59744	0.93
Kudu	2798	536	79041	551	20	2246	3349	0.04
Roan	710	107	33013	356	50	353	1066	0.01
Sable	3649	644	256455	994	27	2655	4643	0.07
Springbok	1565	159	951454	1914	122	350	3479	0.13
Tsessebe	3166	571	340638	1145	36	2020	4311	0.06
Warthog	3046	545	103583	631	21	2414	3677	0.06
Wildebeest	5097	782	1959347	2747	54	2349	7844	0.07
Zebra	41058	6254	70377840	16463	40	24954	57521	0.56
Wetland Sp								
Hippopotamus	6054	1286	272579	1024	17	5029	7078	0.11
Lechwe	33246	6953	4293935	4666	14	29179	37312	0.61
Reedbuck	593	133	5895	150	26	442	743	0.01
Sitatunga	423	86	4555	132	31	290	555	0.01
Waterbuck	406	76	24939	310	76	96	716	0.01
Birds								
Bateleur eagle	714	142	6189	154	22	559	868	0.01
Fish eagle	1053	255	6165	154	15	898	1207	0.02
Ground hornbill	623	97	14452	235	38	387	858	0.01
Ostrich	1875	274	106711	641	34	1233	2516	0.03
Saddle billed stork	1040	257	14719	238	23	801	1278	0.02
Wattled crane	785	194	28484	331	43	443	1106	0.02
Other Obs.								
Baobab tree	4517	659	294082	1064	24	3452	5581	0.06
Cattle	45563	9790	15637403	7760	17	37802	53323	0.62

Observations

During the survey 9482 herd observations were recorded. The highest number of observations occurred for elephants (3041). Using a sex ratio of 2:3 bulls to cows within family groups suggests that there were 43750 bulls in the family herds (Craig & Gibson 2002). This gives an overall sex ratio of 1:1.05. Herd size for the family groups averaged 11 animals and 62 % of elephant observations occurred in groups of 10 or less. 55 % of the bulls were solitary, while 21 % were observed in pairs. Lechwe (1037), impala (729), and zebra (462) herds were observed frequently. Average herd sizes for impala (15) and zebra (13) were similar. Buffalo had the largest average herd size (30), although one herd numbered ~ 525 buffalo. Birds of national importance counted included wattled crane (194), saddle-bill stork (257) and fish eagle (255).

Baobab observations. A total of 659 baobab trees were seen during the survey, of which 121 were classified as large, 384 as medium and 154 as small sized tree. Most of the trees (n = 470) appeared to have had less than 10 % damage to them, 107 trees had between 11 - 30 % damage, 29 trees had between 31 – 50 % damage, and 24 trees had greater than 50 % damage. Dead trees (100 % damage, n = 29) accounted for 4.4 % of the total number seen within the survey area.

There have been suggestions that vegetation south of the Southern Buffalo Fence is less impacted by elephants. To help determine the impact elephants have on baobab trees on either side of the fence we conducted a comparative analyses of baobab trees seen east (NG 26) and west (NG 8 – Habu) of the fence. The majority of small baobabs (83 %) occurred west of the Southern Buffalo Fence in the Habu tribal lands where elephant densities are currently low (0.32 km^2). The number of small baobabs seen in NG 26 and Habu concession differed ($t = 2.6$, df = 9, $P = 0.02$), with Habu having 68 % more small trees (n = 37) than Abu (n = 22). Further, there was a statistically significant relationship between elephant density and baobab damage [(R = 0.3071, N = 116, p < = 0.001 (Z = 3.2937)].

Table 2. Numbers seen, groups counted and average group size of animals, baobabs, birds and carcasses seen during the 2010 dry season aerial survey in northern Botswana.

Species Observed	Number of individuals seen	Number of groups seen	Average group size	Min. group size	Max. group size	Std. Dev.
Woodland Sp						
Elephants	21833	3041	11	1	70	9.33
Elephant families	18827	1681	11	1	70	9.23
Elephant bulls	3005	1360	2	1	36	2.50
Elephant carcass	88	78	1	1	4	0.53
Elephant bones	309	261	1	1	4	0.40
Buffalo	7598	254	30	1	525	61.23
Eland	418	54	8	1	70	11.96
Gemsbok	298	62	5	1	22	5.78
Giraffe	982	377	3	1	20	3.31
Hartebeest	69	9	8	1	30	10.46
Impala	12021	729	15	1	100	15.82
Kudu	536	171	3	1	15	2.37
Lion	14	6	2	1	5	1.51
Hyaena	13	4	3	1	6	2.22
Roan	107	46	3	1	13	2.56
Sable	644	122	5	1	40	7.93
Springbok	159	12	13	2	60	16.03
Tsessebe	571	130	5	1	15	3.61
Warthog	545	216	3	1	35	2.98
Wildebeest	782	104	8	1	50	8.65
Zebra	6254	462	13	1	400	24.75
Wetland Sp						
Hippopotamus	1286	375	3	1	28	3.37
Lechwe	6953	1037	7	1	80	7.54
Reedbuck	133	87	1	1	3	0.64
Sitatunga	86	65	1	1	3	0.53
Waterbuck	76	21	4	1	20	4.49
Birds						
Bateleur eagle	142	128	1	1	2	0.24
Fish eagle	241	195	1	1	12	0.92
Ground hornbill	97	35	3	1	5	1.09
Ostrich	274	129	2	1	16	2.31
Saddle-billed stork	234	151	2	1	23	2.61
Wattled crane	194	73	3	1	30	3.60
Other Obs.						
Cattle	9790	578	17	1	200	17.75
Baobab tree	659	418	2	1	17	1.72
Total / mean	**73405**	**9482**	**8**	**1**	**450**	**15.37**

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 4), 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 88 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 = 309). 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 (2442) in the survey area during the dry season of 2010 represented 2 % of the estimated total number of live and dead elephants. The estimate for recent or fresh (category 1) carcasses was 597, representing a carcass ratio of 0.5 % (which reflects the mortality rate of elephant during the survey year). Most (72 %) of the total estimated elephant carcasses occurred in the Chobe District (1762), accounting for 3 % of the estimated total number of live and dead elephants, and a mortality rate of 1 % in this district.

Of the 88 fresh elephant carcasses seen during the entire survey 66 occurred in the Chobe district of which observers assumed that 20 % 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.

A large proportion (29 %) of the estimated total number of elephant carcasses (710) occurred in just three strata, NG 11 in the Okavango Panhandle, and CH 1 and 2 in the Chobe Enclave. Estimated elephant carcasses in the Sibuyu Forest Reserve (186), and the Nogatsaa area of Chobe NP (460) were high for areas which are protected.

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

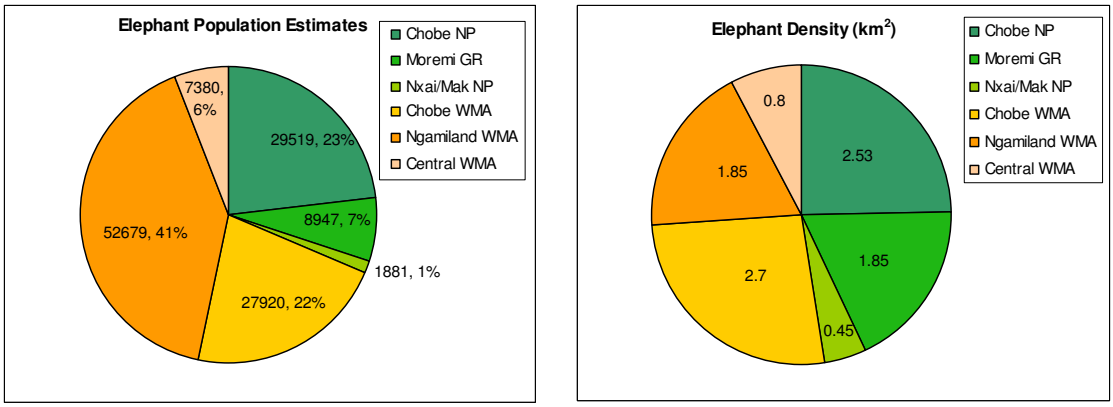
Species	Observed Number of individuals		Expected Number of individuals		Observed Number of herds		Expected Number of herds		Chi-square individuals	*P*	Chi-sq herds	*P*
Woodland Sp	Left	Right	Left	Right	Left	Right	Left	Right				
Elephant Families	10450	8389	8719	8520	915	766	778	760	345.7	0.000	24.19	0.000
Elephant Bulls	1738	1269	1392	1360	768	591	629	615	92.0	0.000	31.60	0.000
Elephant Carcass	47	43	42	41	40	36	35	34	0.8	0.366	0.74	0.390
Elephant Bones	171	119	134	131	150	111	121	118	11.2	0.001	7.48	0.006
Buffalo	4879	2729	3521	3441	148	106	118	115	671.0	0.000	8.57	0.003
Eland	281	170	209	204	23	31	25	24	30.5	0.000	1.93	0.165
Gemsbok	135	163	138	135	31	31	29	28	6.0	0.015	0.50	0.480
Giraffe	591	421	468	458	207	170	174	171	35.3	0.000	6.07	0.014
Hartebeest	40	29	32	31	4	5	4	4	2.2	0.139	0.22	0.640
Impala	6407	4512	5053	4938	406	323	337	330	399.5	0.000	14.10	0.000
Kudu	278	265	251	246	95	76	79	77	4.4	0.037	3.20	0.074
Springbok	65	94	74	72	7	5	6	5	7.8	0.005	0.41	0.522
Tsessebe	321	278	277	271	70	60	60	59	7.1	0.008	1.63	0.201
Warthog	338	214	255	250	122	93	100	97	62.0	0.000	5.27	0.022
Wildebeest	413	373	364	355	57	46	48	47	7.5	0.006	1.83	0.176
Zebra	3564	2625	2864	2799	242	219	213	208	182.0	0.000	4.38	0.036
Wetland Sp.												
Hippo	814	465	592	578	235	139	173	169	105.3	0.000	27.50	0.000
Lechwe	3961	3008	3225	3152	595	441	479	469	174.5	0.000	29.70	0.000
Reedbuck	81	42	57	56	58	29	40	39	13.5	0.000	10.54	0.001
Sitatunga	45	39	39	38	33	31	30	29	1.0	0.319	0.53	0.466
Waterbuck	48	35	38	38	9	12	10	9	2.6	0.109	0.71	0.399
Roan	47	77	57	56	17	29	21	21	9.7	0.002	4.09	0.043
Sable	346	319	308	301	65	56	56	55	5.9	0.016	1.48	0.224
Birds												
Bateleur	76	60	63	62	72	56	59	58	2.7	0.097	2.81	0.094
Fish eagle	153	102	118	115	113	82	90	88	11.9	0.001	6.17	0.013
Ground hornbill	54	59	52	51	16	19	16	16	1.3	0.259	0.64	0.425
Ostrich	177	104	130	127	83	46	60	58	21.1	0.000	11.70	0.001
Saddle-billed stork	163	94	119	116	84	66	69	68	20.6	0.000	3.11	0.078
Wattled crane	105	84	87	85	38	34	33	33	3.5	0.060	0.72	0.396
Other Obs												
Baobab tree	401	275	313	306	239	175	192	187	27.8	0.000	12.53	0.000
Cattle	4972	4830	4536	4433	268	307	266	260	81.1	0.000	8.49	0.004

Wildlife Distributions

The spatial distribution of wildlife is illustrated in Figures 8 to 40. 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 6). The distribution of animals during the 2010 dry season was generally similar to that seen in previous years. Wildlife was widely distributed throughout the survey area; this can be attributed to both the diverse number of species found in the area and the heterogeneous habitats which occur in northern Botswana. Most animals were found within the Okavango Delta, and within 30 km of the major perennial rivers. Wildlife densities were lowest in the dry interiors of the survey area and included the CT strata, and Chinamba stratum of Chobe NP.

Elephants were widely distributed throughout the entire survey area. A large number of elephants occurred within 30 km of the large perennial rivers, occasional observations were made in the drier interior of the CT WMAs (Figure 8). Most elephants (69 %) were found outside of NP (Figure 3). The Chobe NP had the highest densities of elephants, especially between the Linyanti and Savuti Rivers (8 / km^2) and along the Chobe River (5 / km^2).

Figure 3. The number and density (km^2) of elephants in relation to protected areas and WMAs.



Buffalo observations mainly occurred along the rivers and adjoining floodplains, but bachelor herds were seen near seasonal pans which still held water and artificial waterholes (Figure 18). Eland were primarily seen in the northeast Chobe district and along the Zimbabwe border (Figure 19). Giraffe were observed throughout the study area but mainly occurred in Moremi GR and southern WMAs of the Okavango Delta (Figure 20). Gemsbok were distributed mainly in Makgadikgadi and Nxai Pan NPs (Figure 21). Hippos occurred along the main river channels in the Okavango Delta, but were also seen along the floodplains and *lediba* (lagoons) associated with the Kwando, Linyanti and Chobe rivers (Figure 22). The most impala observations occurred on Chiefs Island in the Okavango Delta. Impala were also frequently seen on the floodplains or adjacent to the major rivers, none were seen in the CT areas (Figure 23). Kudu were observed mainly in the Okavango and along the Chobe and Boteti rivers (Figure 24). Lechwe were largely distributed adjacent to the Boro River in the northwest parts (NG 25 Jao

flats) of the Okavango Delta. Low numbers of lechwe were also observed along the Kwando River and upper portions of the Selinda spillway (Figure 25).

Roan observations were limited (46), and mainly observed in small groups (3 - 5). Most observations were made in the Chobe district; ~15 km south of the Linyanti and Chobe rivers, six herds were seen northeast of the Okavango Panhandle (Figure 26). Reedbuck were largely restricted to the Okavango Delta and in close proximity to sources of water (Figure 27). Sable were mostly seen in the Chobe district within the Kasane Forest Reserve and Chobe River stratum. Within Ngamiland most herds were seen in the Vumbra region, no herds were seen in the Central district (Figure 28). Tsessebe were mainly seen on the Vumbra and Shindi floodplains, and Third Bridge area of Moremi GR. South of Moremi GR, tsessebe occurred in NG 26 and NG 28. In Chobe district, tsessebe occurred mainly on the Northern Plains in CH 5 (Figure 29). Many warthog were seen on the Mababe Depression within Chobe NP, the Moremi GR and the WMAs south of Moremi GR (Figure 30). Wildebeest were largely observed on the dry savanna grasslands, in the Makgadikgadi NP, few observations were made in the Okavango, while in Chobe they were mostly observed within the Savuti region (Figure 31). Zebra occurred mainly in the Makgadikgadi NP, west of the Okavango Delta (Habu), and along the Chobe and Linyanti floodplains. No zebra were seen on the Savuti Marsh despite this area having water (Figure 32). Hartebeest and springbok were only observed in the Makgadikgadi and Nxai Pan NPs (Figure 33). Sitatunga occurred mainly in the Jao region of the Okavango Delta (Figure 33). Ostrich occurred throughout the survey area but at relatively low numbers (Figure 34). Bateleur eagle were mainly seen in the Ngamiland WMAs, but were generally observed throughout the survey area (Figure 35). Fish eagle, were mainly seen in the western portions of the Okavango Delta and along the Kwando, and Chobe Rivers (Figure 36). Ground hornbill were mostly seen in the WMAS south of Moremi GR and northeast Chobe district (Figure 37). Saddle-billed storks were restricted to the Okavango Delta, but for two observations on the Savuti marsh which had water (Figure 38). Wattled crane were largely seen in the upper western segments of the Okavango Delta (Figure 39). Baobab trees occurred throughout the survey area (Figure 40). In the multi-use concessions which allow agriculture, many cattle were observed (Figure 41).

Cattle Distribution

The survey was flown mainly over wildlife conservation areas, but within seven of the WMAs cattle farming (grazing rights in the case of CH 2) is permitted under a mixed land use system (Table 39). The survey included part of NG 8 (Habu), as the area is known to have a large zebra population but for which little information on the conservation status of the population existed. The survey also provided an opportunity to assess the structural integrity of the western portions of the Southern Buffalo Fence. The eastern part of Habu, which adjoins NG 26 is as an important wildlife refuge. With an estimated 2093 zebra, this area has the highest number of zebra in the Okavango Delta (Table 28). With a density of 32.5 cattle / km^2 within our survey area of Habu, there will be increasing competition for grazing land. Cattle were observed in two wildlife conservation areas, the Jao concession and eastern Makgadikgadi NP.

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 in the Habu area was 3 animals / km^2, while in the Abu concession it was 40 animals / km^2. Where people and livestock are concentrated, wildlife populations are lower.

Trends in Elephant Numbers in northern Botswana

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 Ngamiland district, Moremi GR, Chobe district, Chobe NP and Makgadikgadi and Nxai NP were compared to the DWNP aerial survey estimates. For the Ngamiland district analyses we used DWNP strata (Delta 27, 28 and 29), which are similar to the Ngamiland strata used on this survey. For all other stratum the areas covered by the surveys were identical. The time series of population estimates for each district and protected area were examined to determine trends over the past 17 years (Table 4 and Figure 4).

Elephant population estimates derived from the nine aerial surveys suggests that northern Botswana's elephant population increased during the early 1990s. From 2004 however, elephant population estimates in Chobe and Ngamiland have remained similar or declined respectively, and the protected areas within the two districts. This suggests that the elephant population has remained stable. Elephants have increased significantly in Makgadikgadi and Nxai Pan NPs. During the survey only bull elephants were observed within Makgadikgadi NP, therefore, this increase is due to the recent dispersal of bulls towards the Boteti River where elephants have been expanding their range west towards the central Kalahari and Kwebe hills.

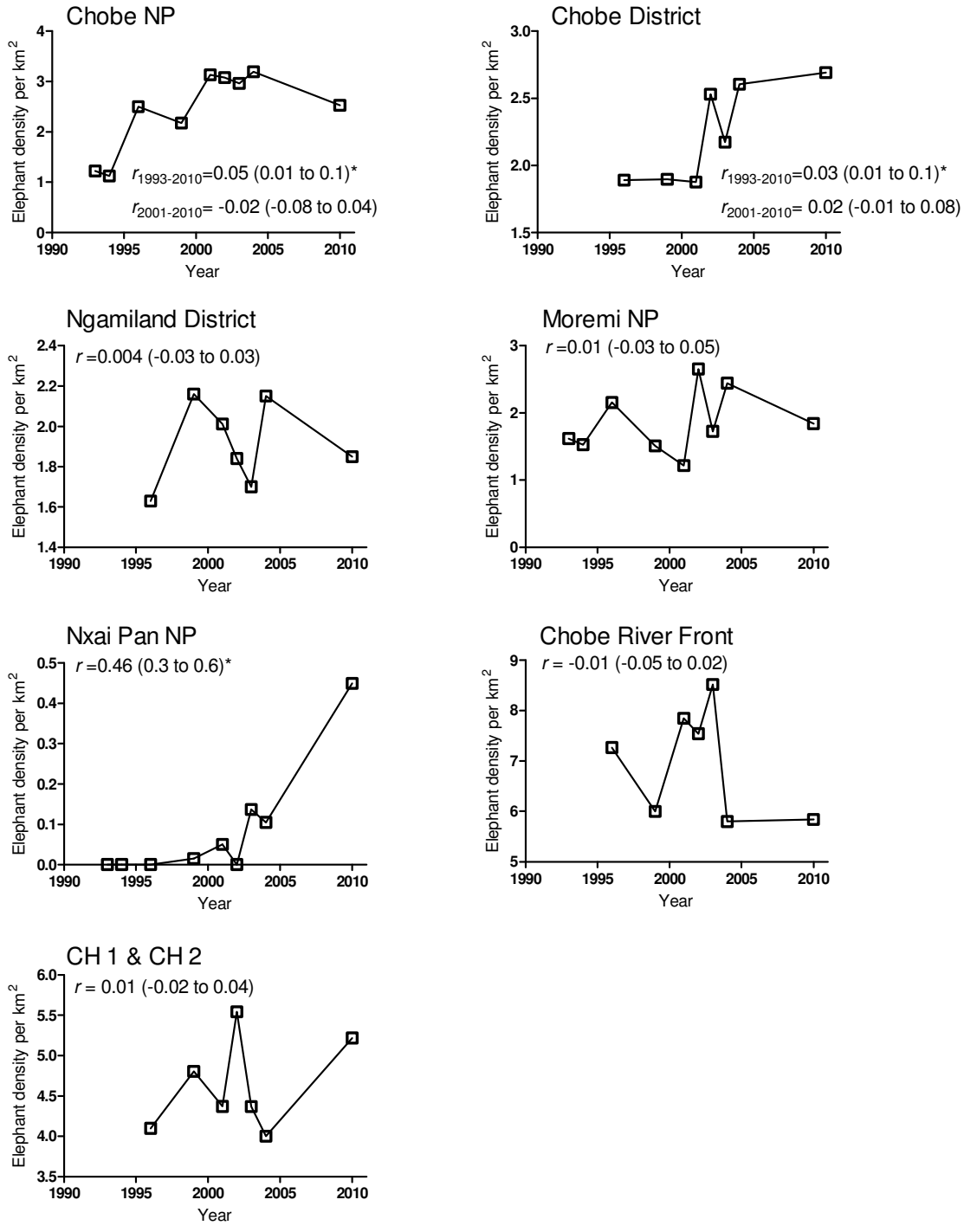
Table 4. Calculated growth rates (*r*) and 95% Confidence Intervals (CI) for elephants in seven strata covered by all aerial surveys in northern Botswana, 1993 - 2010.

District / Protected Area	aerial surveys	Std. Error	*r* (95% CI)	*F*	*P*
Chobe NP[a] 1993-2010	9	0.02	0.05 (0.01 – 0.1)	7.43	0.03*
Chobe NP 2001-2010	5	0.01	-0.02 (-0.08 – 0.04)	-	-
Chobe District 1996-2010	7	0.01	0.03 (0.01 – 0.1)	9.27	0.03*
Chobe River 1996-2010	7	0.02	-0.01 (-0.05 – 0.02)	0.75	0.42
Chobe River 2001-2010	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
Moremi GR	9	0.02	0.01 (-0.03 – 0.05)	0.54	0.48
Ngamiland District	7	0.01	0.004 (-0.03 – 0.03)	0.99	0.77
Mak. & Nxai Pan NP	9	0.07	0.46 (0.3 – 0.60)	48.49	0.0002*

[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 2010 have remained similar (~ 30000 elephants). The doubling of elephant numbers in Chobe NP in 1996s 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).

Figure 4. Trends in the densities of elephants for selected stratum in northern Botswana.



The differences in population size from 2003 to 2004 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 2003 and 2004 counts (Junker et al. 2008).

The 2010 Ngamiland district elephant estimate (61621) is 11154 lower that the 2004 estimate (72775), while within Moremi GR the 2004 (9143) and 2010 (8947) survey estimates are similar (Table 4, Figure 4 and Appendix 3).

Trends in Wildlife Numbers

Wildlife population estimates from the DWNP aerial surveys (8) between 1993 and 2010 suggest that in Chobe district animals are increasing or stable with the exception of wildebeest, whose numbers appear to be rapidly declining throughout northern Botswana (Figure 5 and 7, Table 5). The 2010 aerial survey estimate for eland, impala, lechwe, sable, tsessebe, warthog and zebra in Chobe district are the highest recorded from seven survey estimates. The 2010 wildebeest estimate (525) in Chobe district is low, but this is the highest estimate since 1999 (Figure 6 and Appendix 3).

The Okavango Delta in Ngamiland is a focal dry season concentration area for wildlife providing abundant water and food. However, in contrast to Chobe district, 11 species of wildlife counted in Ngamiland on this aerial survey have declined by 61 %, with the exception of hippos, which are increasing significantly (P = 0.025) (Figure 4 and 5). There has evidently been a district wide halving in the abundance of giraffe, kudu, lechwe, ostich, roan, tsessebe, warthog and wildebeest numbers since 1993, many of which are statistically significant (Figure 4, Appendix 3). The 2010 wildebeest population in Ngamiland is the lowest recorded for all seven aerial surveys, and declined (by 90 % from 19571, in 1996 to 1985 in 2010 at an annual rate of 18 % (P = 0.003). Similarly, giraffe, kudu, ostrich, tsessebe, and warthog have declined at an average annual rate of 10 %. The 2010 estimate for impala (44640) is double the estimate for 2004, and similar to the 1999 estimate (44247), and are increasing at an annual rate of 2 %.

Buffalo are increasing outside of Moremi GR, but appear to be declining within the Reserve. Buffalo numbers in the Ngamiland WMAs numbers seem to be rebounding, and have doubled (31489) since the last aerial survey in 2004 (15457). The Moremi GR has had similar declines in large grazing species to Ngamiland. Within the Reserve this survey yielded lower estimates for buffalo (70 %), giraffe (36 %), kudu (54 %), tsessebe (87 %), warthog (58 %) and wildebeest (90 %), which have declined on average by 10 % each year since 1996. Hippo have increased by 6 % each year, from 696 in 1996 to 2842 in 2010 (Figure 8).

Makgadikgadi and Nxai Pan NPs, have been combined to make comparisons with previous surveys. Within Makgadikgadi and Nxai Pan NP, wildlife populations are largely stable. Population estimates for gemsbok consistently declined until 1999, when the population estimate increased, following a significant upward trend thereafter (P = 0.014) (Table 5, Figure 9 & Appendix 3). In these two areas, ostrich numbers (911) are 72 % higher than the last aerial survey in 2004 (530). Springbok numbers appear to be declining by 9 % each year (Figure 9). The 2010 survey estimate (1565) is 71 % lower than the 1996 aerial survey estimate (3083).

Table 5. Summary of trend analyses calculated for 16 wildlife species occurring in the survey area in northern Botswana based on DWNP aerial surveys (9) between 1993 -2010.

Species	Chobe NP	Chobe district	Moremi GR	Ngamiland district	Mak. & Nxai Pan NP
Buffalo	Increase	Stable	Decline	Increase	-
Eland	Increase	Increase	-	Decline	-
Giraffe	Increase	Stable	Decline	Decline*	Stable
Hippo	Increase	Increase*	Increase	Increase*	-
Impala	Increase	Increase*	Stable	Decline	-
Kudu	Stable	Increase	Decline	Decline*	-
Lechwe	Increase*	Increase	Decline	Decline*	-
Ostrich	Increase	Decline	-	Decline*	Stable
Roan	Stable	Decline	-	Decline	-
Sable	Decline	Increase	-	Decline	-
Tsessebe	Decline	Stable	Decline*	Decline*	-
Warthog	Increase	Increase	Decline*	Decline	-
Wildebeest	Decline	Decline	Decline	Decline*	Increase
Zebra	Increase	Increase	Decline	Decline	Increase
Gemsbok	-	-	-	-	Increase*
Springbok	-	-	-	-	Decline

The author did not have access to the 2006 DWNP aerial survey data. It is, however, unlikely that the trend analyses and conclusions reached in this report would have been different had the data from that survey been included.

For the purpose of this presentation a species was considered stable if the rate of growth (r) (not including 95 % confidence intervals) was between -0.01 and 0.01, increasing if $r > 0.01$ and declining if $r < -0.01$. The star indicates a trend that differs significantly from zero. For the exact values of r, 95 % confidence intervals, and standard errors refer to Appendix 2.

Figure 5. Trends in the numbers of selected wildlife species in Chobe district.

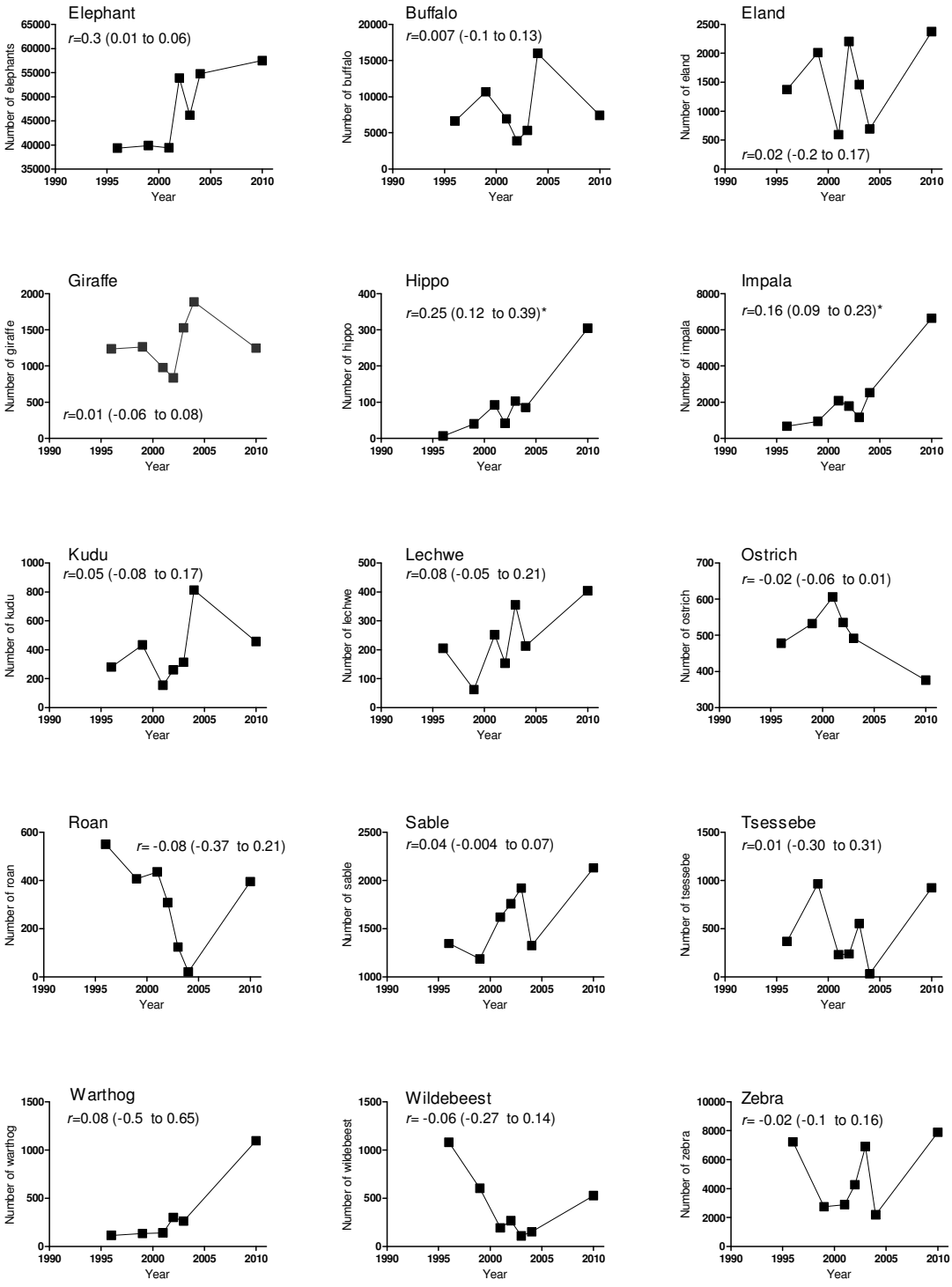


Figure 6. Trends in the numbers of selected wildlife species in Chobe NP.

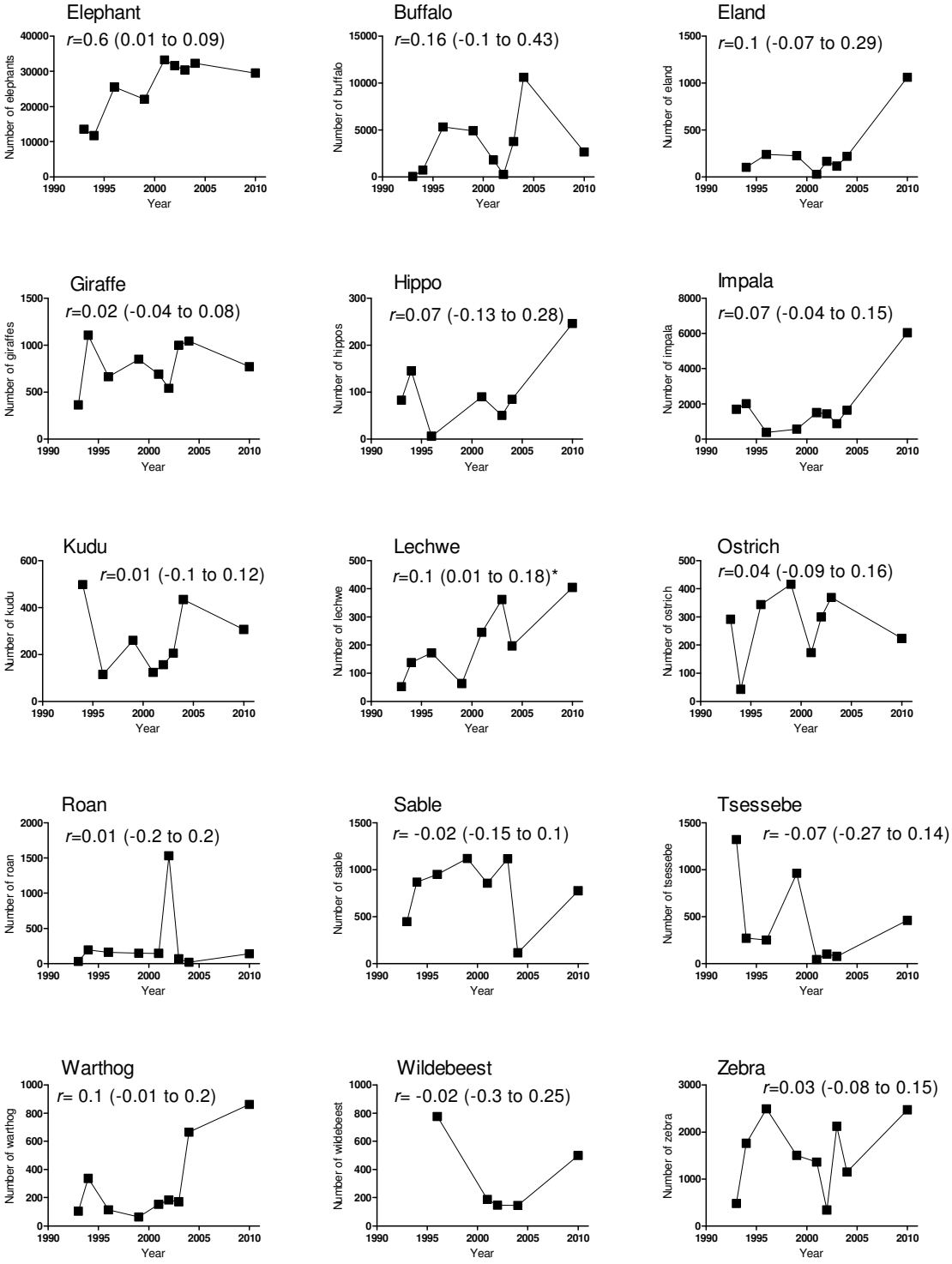


Figure 7. Trends in the numbers of selected wildlife species in Ngamiland district.

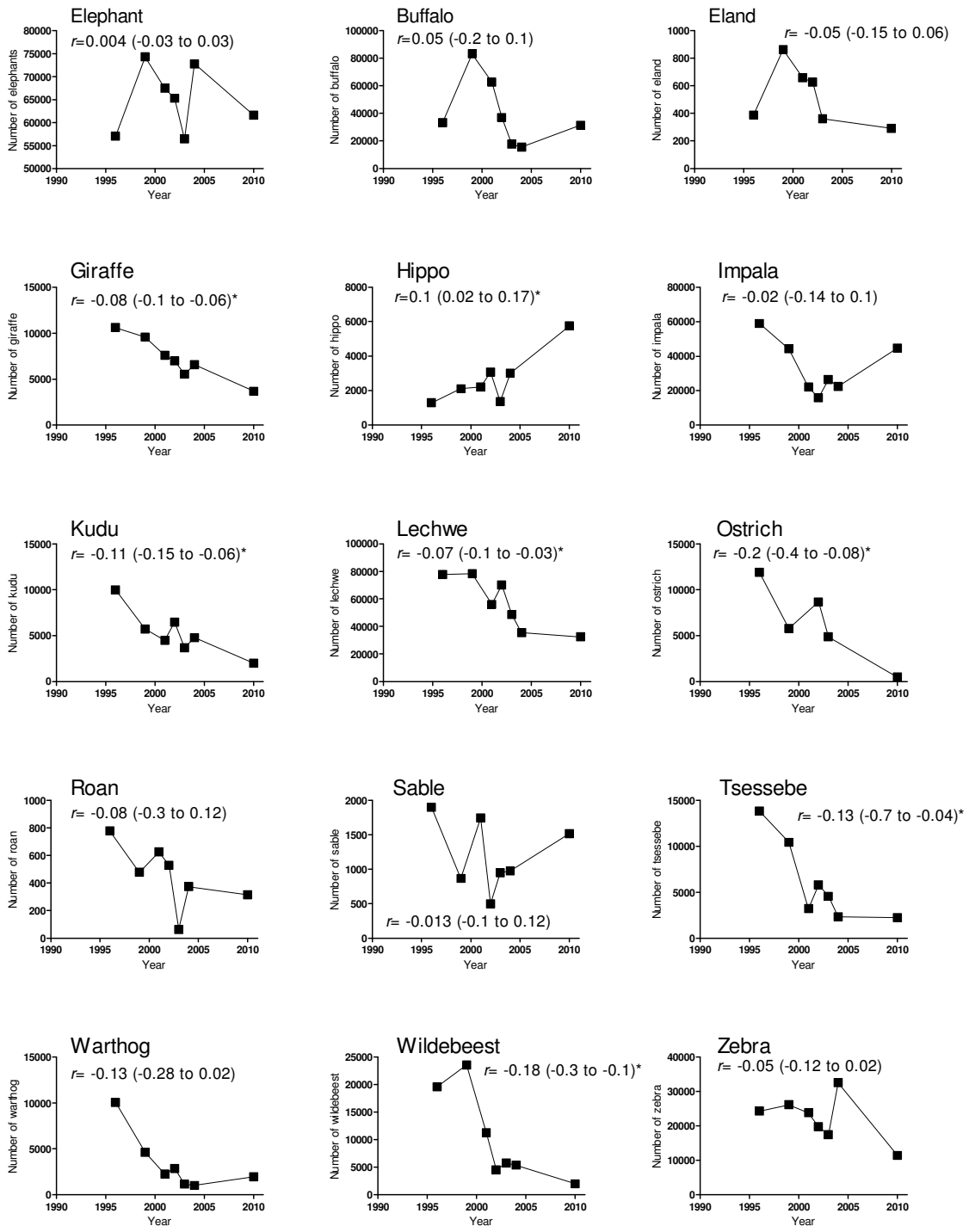


Figure 8. Trends in the numbers of selected wildlife species in Moremi GR.

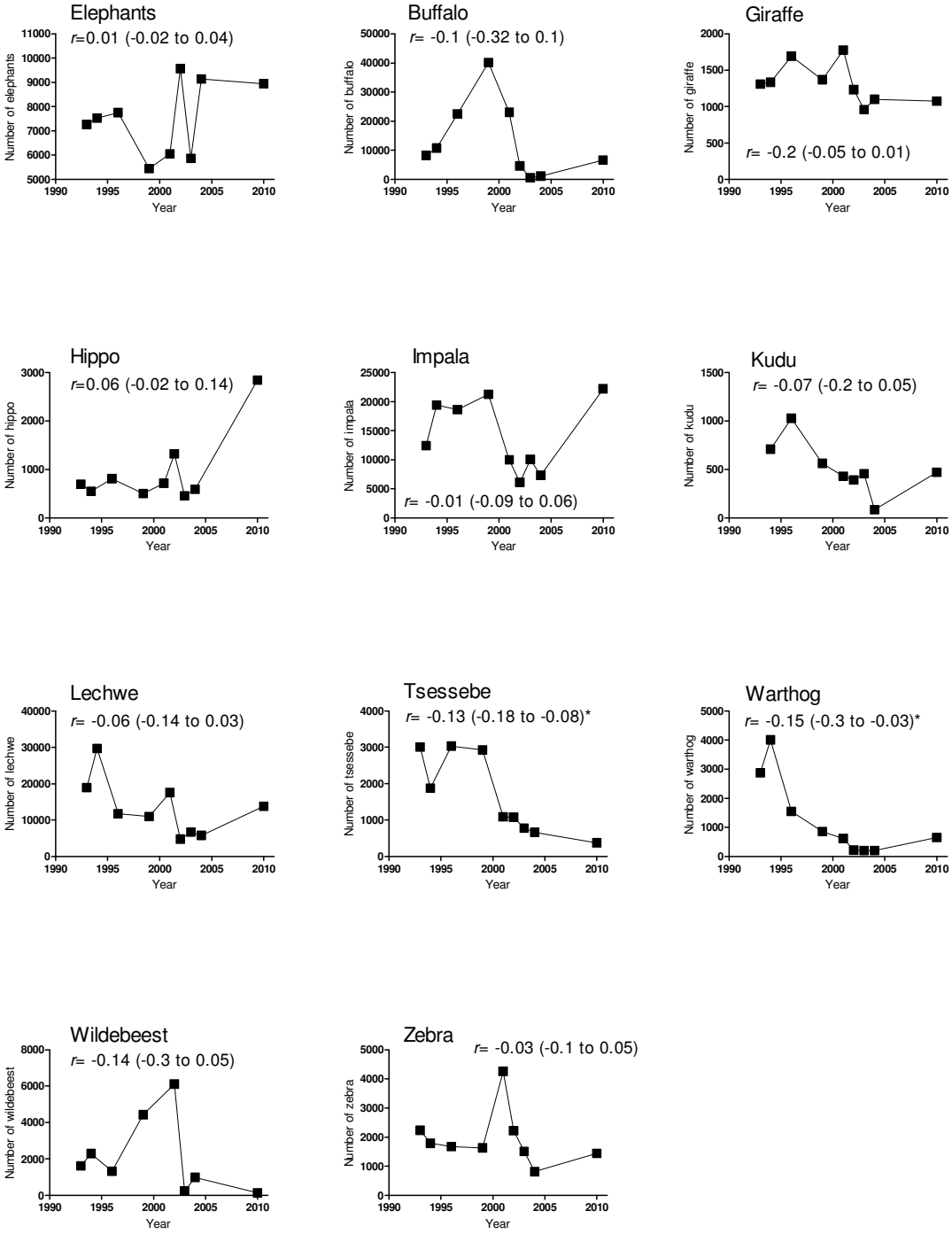
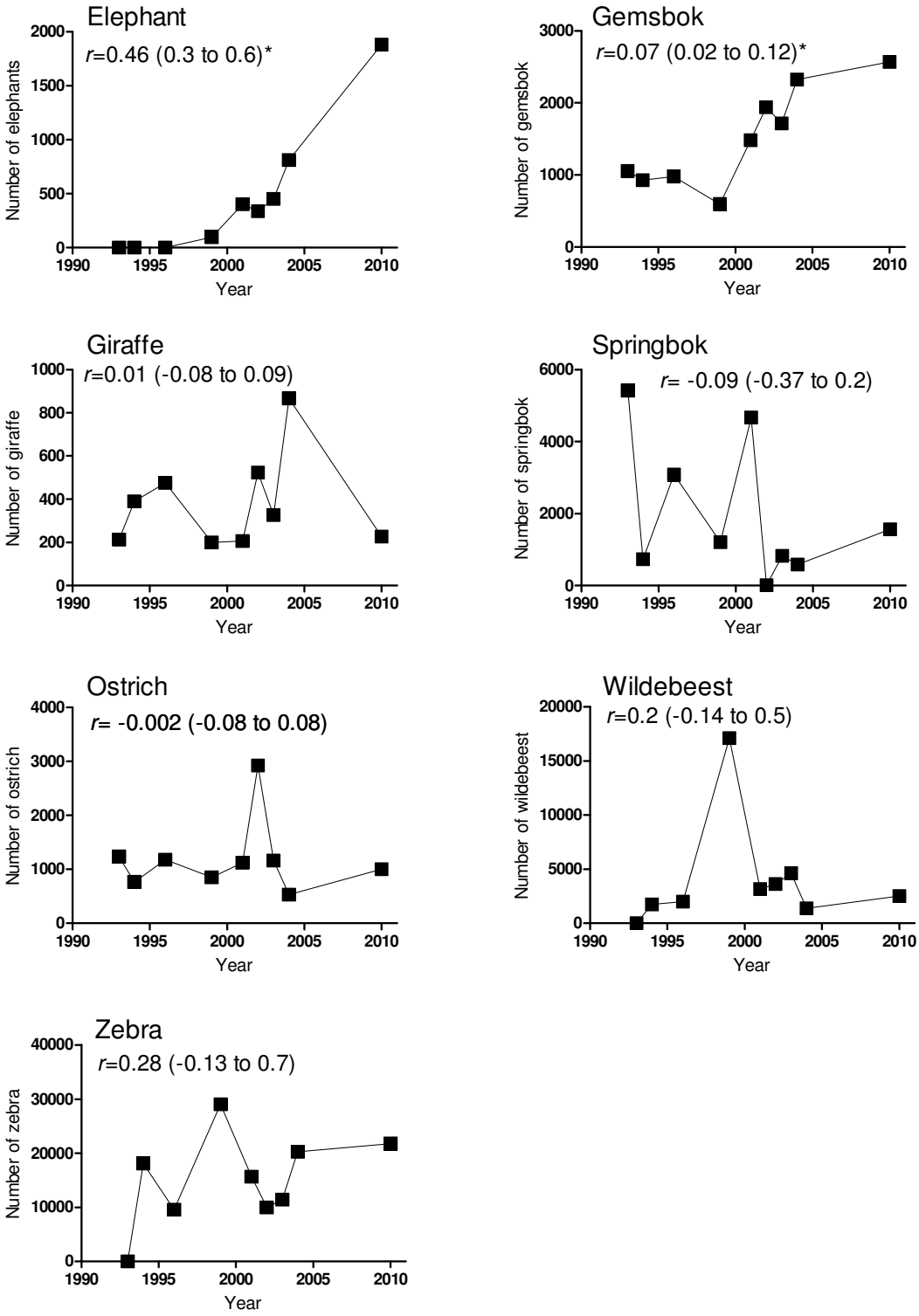


Figure 9. Trends in the numbers of selected wildlife species in Makgadikgadi and Nxai Pan NP.

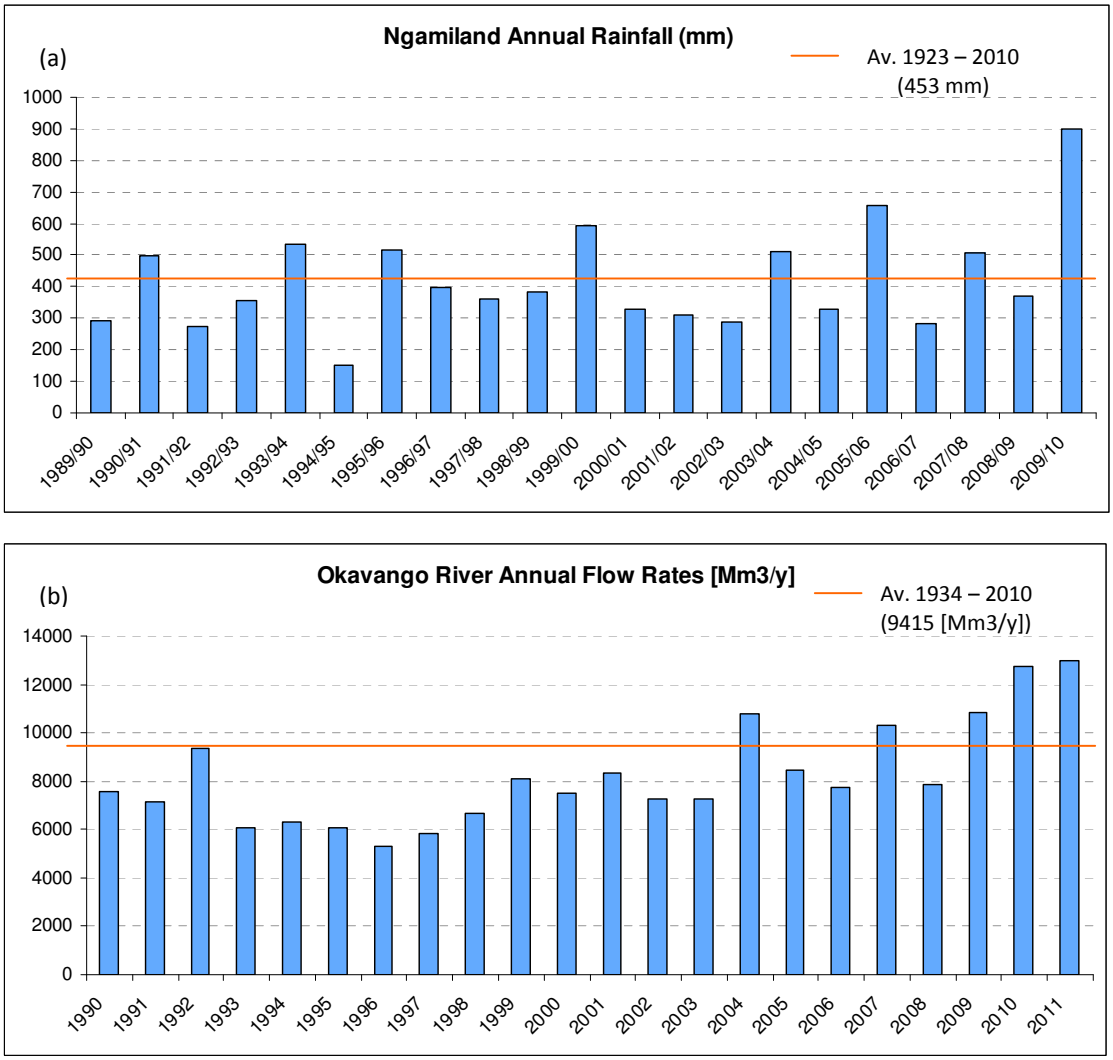


Factors effecting population trends

It is likely that the declines in large mammals in Ngamiland and Moremi GR have complex mixtures of local causes, which may be hard to fully understand without sufficient research and are not within the scope of this report. However, a brief and possible explanation in the decline of wildlife species in the Okavango Delta could be related to rainfall. Rainfall fluctuations in time and space influence the abundance and distribution of herbivores. Ngamiland rainfall records (Maun weather station) and Okavango River water flow data (Mohembo Station) from the 1920s, were graphed to investigate whether rainfall fluctuations during the 1990s had any influence on wildlife populations and whether a drought occurred during the period (Figure 10).

The decline in large mammals coincided with a long dry cycle, which began in the 1980s. Changes in rainfall and water flow rates in the Okavango River, might explain declining wildlife numbers (Figure 10). Beginning in the 1980s and extending to 2005, the Okavango River water flow rates were the lowest since record keeping began in the 1930s. Low water levels in the Okavango Delta coincided with below average rainfall in the district during the same period. This 20 year drought was the most severe since the early 1920s and corresponds to significant declines in wildlife populations in Ngamiland District and Moremi GR. While there is a clear association between dry conditions and the decline in many resident (lechwe, warthog) and dispersing wildlife (zebra, wildebeest), this should not been seen as the only factor related to the observed declines. It is likely these declines are a result of multiple factors which need to be studied further.

Figure 10. Okavango Delta annual rainfall (a) and Okavango River annual flow rates (b), 1990 - 2010.



(Department of Water Affairs 2010)

The long-term impact of these climatic conditions coupled with land use changes on the population of wildlife species has not been sufficiently studied in Botswana. This analysis has emphasized the value of sample aerial surveys for monitoring trends in animal numbers. This time series analysis is based upon the use of similar methods on all aerial surveys, the observed difference in population numbers can confidently be assumed to be genuine and not a consequence of changing methods. The trend analysis has also underlined the importance of conducting aerial surveys at high sample coverage, rather than low sample coverage every 3 - 4 years, as is currently being done by DWNP.

Veterinary Fences

During the survey, we had the opportunity to fly over many of northern Botswana's veterinary fences, allowing the survey team to make visual assessments of the fences structural integrity and determine wildlife movements across sections of fence.

Caprivi Border Fence: this is a double electrified fence. We flew along the entire fence line from the Okavango River to the junction where it joins the Northern Buffalo Fence (135 km). We observed 26 breaks in the fence which ranged in distance from about 3 - 40 m, which mainly occurred adjacent to elephant pathways. The fence currently disrupts the spatial linkage of the Okavango Panhandle elephant population to Namibia and Angola, limiting the dispersal of elephants out of the Panhandle (Chase & Griffin 2009, Ferguson & Hanks 2010).

Northern Buffalo Fence: the northern sections of the fence appeared to be well maintained. We observed fence crews attending to breaks in the fence. The lower stretches of the fence had been pushed over. The current high water levels make the lower reaches near the Okavango inaccessible for fence maintenance crews. Gaps in the fence are occurring when cattle farming in the northeastern portions of the Okavango Panhandle (NG 13) are increasing, and will pose challenges if cattle and people move east of the fence into the Kwando and Selinda WMAs. Urgent attention should be given to securing the mature mopane and teak forests in NG 13. The region has the ability to be a key wildlife conservation area, as it supports unique and valuable habitats this area should be declared as Ngamiland's first Forest Reserve. A vast part of NG 10, 11, 12 and 13 was burning during our survey. We observed sable and roan trapped between the fences and approaching fire. The 35 km gap in the fence decommissioned by the Botswana Government serves as a small but highly effective wildlife corridor for animals moving from the Okavango through the Caprivi Strip into southeast Angola (Chase & Griffin 2009, Ferguson & Hanks 2010).

Southern Buffalo Fence: many sections of the fence were broken and appeared to have been breached by elephants. We observed no fence maintenance crews attempting to fix broken sections of the fence. This task is made more difficult by the high flooding the area is experiencing, and which may be the reason for its current state. The high density of cattle in Habu (32 / km^2) is causing severe land degradation and overgrazing. As the need for additional grazing land increases, the fence will act as important barrier limiting the movement of cattle into the western portions of the Okavango Delta. The presence of cattle in the Jao and Jedibe concessions exemplifies the impact the fence has had on stopping the advancement of cattle into the Okavango Delta. With increasing human pressure in the NG 8 area, the future management of this area's large zebra population should be considered by government authorities, especially when zebra numbers appear to be declining in Ngamiland district (Chase *unpublished data*). Options to conserve the zebra population could be the realignment of the Southern Buffalo Fence, the creation of a wildlife corridor, or the development of a community conservation conservancy. Further research and management is needed in this area.

Boteti River Fence (Makgadikgadi NP): the fence is a 1.8 m high electric fence, although recently built it has been destroyed in many places by rising water levels in the Boteti River, which has served to attract a large and now resident elephant bull population. Solar panels have been stolen, and elephants have destroyed large sections of the fence north of Kumaga viallge. Cattle have now been observed grazing in the NP (Dugmore *pers. comm.*). The decommissioning of the Nxai Pan fence has resulted in the resumption of a long-distance movement of zebra between the Makgadikgadi and the Okavango Delta and could have important conservation implications for increasing wildlife numbers in the region (Bartlam-Brooks, Bonyongo & Harris 2011).

Odiakwe / Ngwasha Fence: the fence has been broken in many places, likely by elephants. While flying between strata we observed numerous elephants in CT 6, between Gweta and the Ngwasha Fence.

While the fences had catastrophic impacts on wildlife numbers in the 1970s, they are now effective barriers ensuring the conservation of many of Botswana's wildlife areas. Realignment of the Caprivi Border Fence and Northern Buffalo Fence will alleviate human elephant conflict in the Panhandle and allow wildlife access to historical ranges (Ferguson & Hanks 2010).

Discussion

Wildlife Estimates

EWB and DWNP felt it was relevant that this survey increase the precision of population estimates for northern Botswana (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 (~ 14 %). 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, the Okavango Panhandle and Chobe Enclave. The estimated elephant mortality rate (0.5 %) is currently low in northern Botswana. Most incidences which appeared to be the result of elephant poaching occurred in the Chobe district. The GPS locations of possible poaching incidents recorded on our survey were reported to the Botswana Defense Force who acted upon our reports.

Baobab trees. This survey suggests that the current mortality rate of baobabs just within the NG 26 concession is between 5 - 6 %, (assuming the 100 % destroyed baobabs observed during the survey were killed within one year). The mean density of elephants (1.75 / km^2) across our survey area, and the occurrence of a low number of small baobabs, concession managers should consider tree protection programmes. In addition, and as a matter of priority, natural resources managers should establish seedling projects to encourage the regeneration of indigenous trees of concern in the Delta (Chase 2010). Incidental observations made by the survey crew noted that woodlands were less impacted by elephant browsing west of the Southern Buffalo Fence were elephant densities are currently low (0.32 elephant / km^2). The fence has acted as an effective barrier, limiting the movements of elephants west resulting in reduced impact on the vegetation.

Wildlife Distribution

The distribution of wildlife is likely to vary according to seasonal climatic conditions, the timing of the flood and the movements of animals. Wildlife was widely distributed throughout the survey area in Ngamiland district. This can be attributed to both the diverse number of wildlife species and the heterogeneous habitats which occur within the Okavango Delta. The distribution and density of elephants (on each side of the Southern Buffalo Fence) provides a valuable parameter to monitor vegetation changes. As the survey was conducted during the dry season, wildlife observations mostly occurred within 30 km of perennial rivers (Okavango, Chobe, Kwando, Linyanti, Savuti and Khwai) (Figure 11).

Trends in Elephant Numbers

From 1993 to this 2010 survey, nine dry season surveys were conducted in northern Botswana that included the same survey areas (Chobe District, Chobe NP, Ngamiland District north of the Southern Buffalo Fence and Moremi GR). The inclusion of Ngamiland district in our trend analysis conforms to strata used on both surveys and does not invalidate direct comparisons between these strata. Overall, elephant population numbers (within these strata) increased from 96397 in 1996 to 119078 in 2010. However, since the 2002 survey by DWNP, elephant numbers have remained similar (119156 vs 119078). These similar estimates over an 8-yr period are unexpected considering the usual recruitment rate of elephant populations in the region 5 % / yr (Martin 2005). This apparent stabilization is contradictory to many reports and the common held perception that north Botswana's elephant populations are increasing rapidly (Kalwij et al. 2010). Northern Botswana's elephant population is large, but the results of this survey imply that it is stable. The elephant population estimate for example in Chobe NP and Moremi GR, have remained similar since 2001. This suggests that elephant numbers in Ngamiland and 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 neighbouring 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).

Trends in Wildlife Numbers

An important implication of the trend analysis is that overall there have been large population declines in the Okavango Delta and Moremi GR. Large mammal populations decreased by 61 %, between 1996 and 2010, averaging a decline of 10 % each year. If the current situation persists, the populations of large plains game in northern Botswana are likely to remain low, while wildebeest and tsessebe numbers remain vulnerable.

These declines largely coincide with a 20 year drought. The survey area covered the ranges of most of these species, and we are confident in the results of our trend analyses. However, many species in Moremi GR move outside of this protected area at certain times for

migration or to maintain large ranges. Whilst outside of Moremi GR, these populations may be exposed to higher levels of threats such as hunting, fence related mortalities, and habitat fragmentation. The decline in large mammals coincided with increasing elephant numbers in the 1990s, but whose numbers now appear to have remained similar. The effect of the 20 year dry cycle could have been exacerbated by high elephant numbers and their dispersal to the Okavango Delta.

The only area showing population increases (except for springbok) is the Makgadikgadi and Nxai Pan NPs. Protected areas and WMAs in northern Botswana are managed specifically for their large mammals, and primarily for tourism. Early evidence suggests that we are now moving into a wet cycle (Wolski 2010), which may have positive consequences for wildlife in northern Botswana and underscores the necessity of conducting future aerial surveys to monitor the distribution and abundance of wildlife populations.

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 the catastrophic decline of wildlife (an economically important natural resource) and jeopardize the ecotourism industry in northern Botswana.

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 concession 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 most in need of attention.

Recommendations

Land use, habitat fragmentation, vegetation changes, drought, veterinary fences, 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. The potential factors attributing towards wildlife population declines presented in this report, need to be studied further and addressed by civil society organisations, government departments and private companies in the ecotourism industry. 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 the opportunity to document and identify the following conservation issues of concern:

- Habitat fragmentation and the environmental degradation associated with allocating fields for farming must be addressed by Land Boards. 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 on the upper western sections of the Okavango Delta are destructive.

- The Okavango Panhandle elephant population (14000) trapped between the Okavango River and the veterinary fences will continue to pose challenges. The expansion of human communities and the restriction of movements imposed by fences are leading to increasing incidents of human elephant conflict. With these restrictions to movements, it is critical that the 35-km-wide-fence-free area along the Botswana/Namibia border west of the Kwando River, be expanded by realigning the fences, providing for a wider conservation corridor for elephants and other wildlife moving between Botswana, Namibia, Angola and Zambia. This corridor offers the best potential for reducing the numbers of elephants in this area naturally, while restoring elephant and other wildlife populations into the conservation areas of southeast Angola and southwest Zambia. The area could be designated as Ngamiland's first Forest Reserve, as it has unique habitats of mature mopane and miombo woodlands. With human settlements now expanding into NG 13, the option and potential for this area to serve as a wildlife corridor for the movement of large animals is being seriously compromised.

- Much of the survey area in the late dry season of 2010 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 northern Botswana 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.

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Table 6. Stratum number, name, area (km^2) and survey coverage during the 2010 dry season aerial survey of wildlife in northern Botswana.

Stratum name	Stratum area (km^2)	Transect spacing (km)	Number of transects [=n]	Total transect length(km)	Area covered (km^2)	% of stratum sampled
NGAMILAND (NG) District						
NG 8 Habu	535	2	28	290	112	21%
NG 10 & 11	5140	2	63	2468	1234	24%
NG 12	1092	2.5	25	441	225	21%
NG 13	2500	5	15	440	193	8%
NG 14 Kwando						
NG14 A	1025	2	28	521	231	23%
NG14 B	1880	4	16	401	178	9%
NG14 Subtotals	2905	3	44	922	409	14%
NG 15 Linyanti	1232	2	19	590	260	21%
NG 16 Selinda	1350	2	28	634	280	21%
NG 18 & 19 Khwai	1959	2 & 4	23	700	308	16%
NG 20 & 21 Splash	2189	2 & 4	30	753	331	15%
NG 22 Vumbra	610	2	12	270	119	20%
NG 23 Duba Plains	440	2	12	178	78	18%
NG 24 Jedibe	758	2	12	353	155	20%
NG 25 Jao	617	2	14	279	109	18%
NG 26 Abu EBS						
NG26 A	646	1	51	589	260	40%
NG26 B	690	1	45	642	282	41%
NG26 C	517	1	38	475	209	40%
NG26 Subtotals	1853	1	134	1706	751	41%
NG 27 A&B & NG 30	1400	2	25	528	232	17%
NG 29 Rann	1900	4	15	454	200	11%
NG 31 & 17 Chitabe	300	2	15	142	62	21%
NG 32 Stanleys	1050	2	23	564	248	24%
NG 33 & 34 Santawane	900	2 & 4	13	318	140	16%
WMA Subtotals	28730	2	550	12030	5446	22%
Moremi GR NG 28	4830	2	68	4348	1033	21%
Ngamiland Subtotals	**33560**	**2**	**618**	**16378**	**6479**	**19%**

Stratum name	Stratum area (km^2)	Transect spacing (km)	Number of transects [=n]	Total transect length (km)	Area covered (km^2)	% of stratum 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	600	2	19	262	115	19%
CH 5 & 6 N. Plains / Kazuma	1400	4	10	320	141	10%
CH 7, 8 & 13 Sibuyu	2585	4	23	506	223	9%
CH 11 & 12 Bottle Pan	2530	4	15	534	235	9%
WMA & FR Subtotals	9712	4	109	2606	1147	12%
Chobe NP (CH 3)						
CNP A (Linyanti-Savute)	1400	2	22	639	281	20%
CNP B (Mababe-Khwai)	1950	2 & 4	25	550	242	12%
CNP C (Chinamba)	4850	8	8	506	258	5%
CNP D (Nogatsaa)	1350	4	16	348	153	11%
CNP E (Phofu)	805	4	12	203	103	13%
CNP F (Chobe River)	1320	2	23	647	285	22%
CNP NP Subtotals	11675	4	106	2893	1322	11%
Chobe District Subtotals	**21387**	**4**	**215**	**5499**	**2469**	12%
CENTRAL (CT) District						
CT 1 Nunga	4055	8	14	583	257	6%
CT 2 Mukusi	3960	8	7	446	196	5%
CT 3 Tamafupa	2220	4	19	499	220	10%
CT 5 Sepako	796	2	23	384	169	21%
Nxai Pan NP	2580	4	18	570	251	10%
Makgadikgadi NP						
Mak. NP East	2693	4	17	663	292	11%
Mak. NP West	2227	4	16	576	253	11%
Makgadikgadi Subtotals	4920	4	33	1239	545	11%
Central District Subtotals	**18531**	**4**	**114**	**3721**	**1638**	**11%**
Totals / mean	**73478**	**3.5**	**947**	**25598**	**10586**	**14%**

Table 7. Sampling statistics for the 2010 dry season aerial survey of wildlife in northern Botswana.

Stratum name	Time & date sampled	Flying time (hours)[a]			Search effort (km^2/min)
		Transect	Stratum	Total	
NGAMILAND (NG) District					
NG 8 Habu	pm 21 Oct	1.5	1.9	2.3	1.2[b]
NG 10 & 11	am 01-04 July	13.65	15	17	1.4
NG 12	am 05 July	2.8	3.4	5	1.3
NG 13	am 30 June	2.3	2.6	3.8	1.4
NG 14 Kwando					
NG14 A	am 09 Sept	3.7	4.2	5.5	1
NG14 B	am 10 Sept	2.4	2.8	4.2	1.2
NG14 Subtotals		6.1	7	9.7	1.1
NG 15 Linyanti	am 25 Oct	3.1	3.5	4.1	1.2
NG 16 Selinda	am & pm 10-11 Sept	3.3	3.8	4.5	1.1
NG 18 & 19 Khwai					
NG 20 & 21 Splash	am & pm 19-20 Sept	5.5	6.5	7	1.2
NG 22 Vumbra	am 21 Sept	1.7	1.9	2.5	1.2
NG 23 Duba Plains[c]	am 21 Sept	1.4	1.8	0	1.3
NG 24 Jedibe[c]	am 13 Dec	2.1	2.3	3.2	1.2
NG 25 Jao[c]	am 21 Oct	1.8	2	2.8	1
NG 26 Abu EBS					
NG26 A	am & pm 18 Oct	3.5	4.1	4.6	1.3
NG26 B	am 19 Oct	3.9	4.4	4.7	1.2
NG26 C	am 20 Oct	3.1	3.6	4	1.1
NG26 Subtotals		10.5	12.1	13.3	1.2
NG 27 A&B & NG 30	am 29 Sept	3.3	3.7	4.2	1.2
NG 29 Rann	pm 12 Dec	2.9	3	3.3	1.4
NG 31 & 17 Chitabe	am 27 Sept	1.3	1.5	1.9	0.8
NG 32 Stanleys	am 28 Sept	3.3	3.7	4	1.2
NG 33 & 34 Santawane[c]	am 27 Sept	2	2.18	0	1.2
WMA Subtotals		68.55	77.88	88.6	1
Moremi GR NG 28	am 23-26 Sept	12.5	13.8	15	1.4
Ngamiland Subtotals		**81.05**	**91.68**	**103.6**	**1.3**

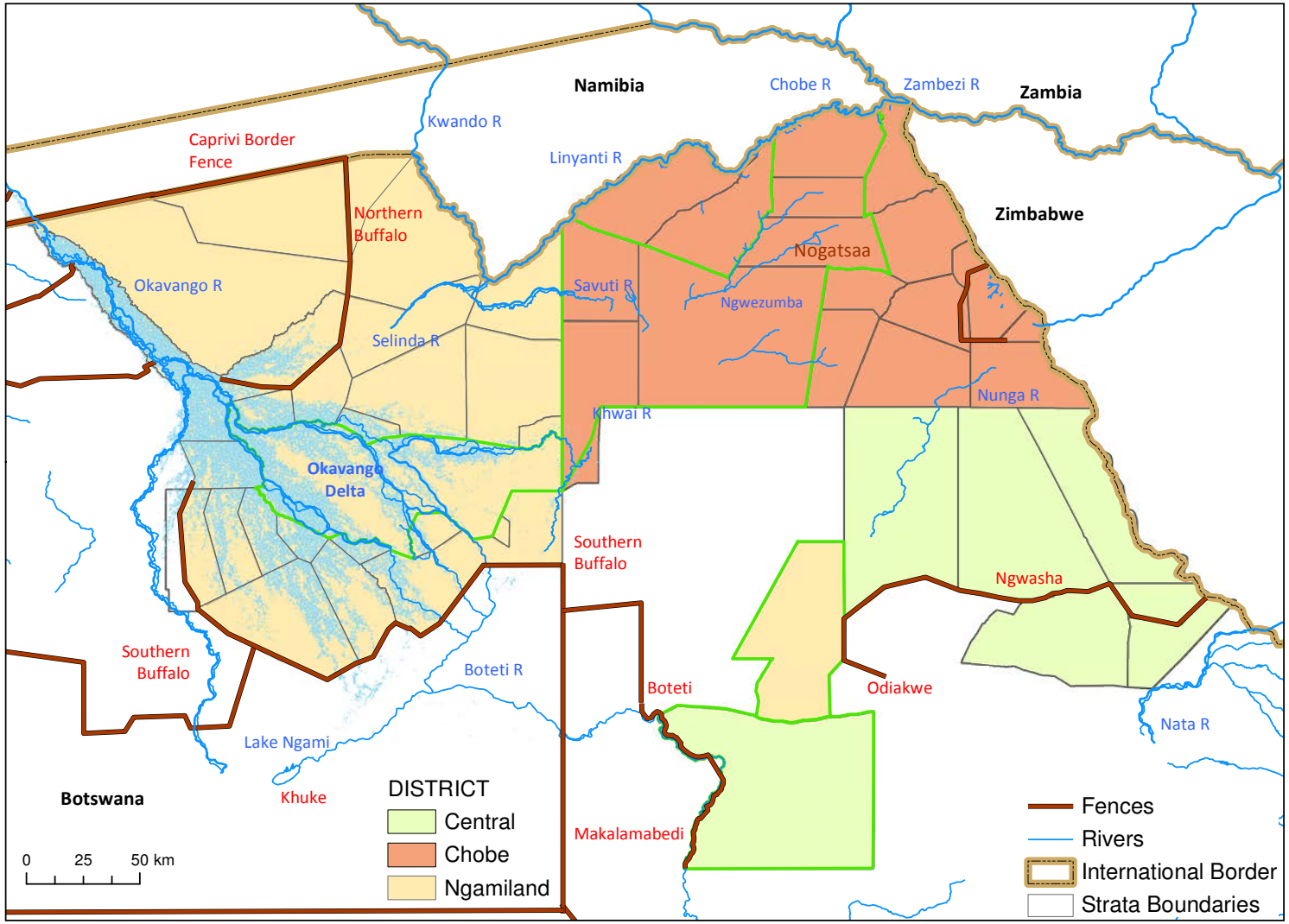
Stratum name	Time & date sampled	Flying time (hours)[a]			Search effort (km^2/min)
		Transect	Stratum	Total	
CHOBE (CH) District					
CH 1 Chobe Enclave	pm 25-26 Oct	2.8	3.2	4	1.3[b]
CH 2 Chobe Forest Res	am 02 Nov	3.1	3.3	3.8	1.1
CH 4 Kasane Forest Res	am 09 Nov	1.6	1.8	2.1	1.2
CH 5 & 6 N. Plains	am 09 Nov	1.75	1.95	0	1.3
CH 7, 8 & 13 Sibuyu	am 11 Nov	3.3	3.6	4.3	1.1
CH 11 & 12 Bottle Pan	am 12 Nov	2.7	2.9	3.7	1.5
WMA & FR Subtotals		15.25	16.75	17.9	1.3
Chobe NP (CH3)					
CNP A (Linyanti-Savute)	am 26 Oct	3.5	3.8	4	1.3
CNP B (Mababe-Khwai)	am 28 Oct	3.5	4.2	4.5	1.2
CNP C (Chinamba)	am 29 Oct	2.8	3.1	3.7	1.5
CNP D (Nogatsaa)	am 29 Oct	1.6	1.9	0	1.6
CNP E (Phofu)	pm 02 Nov	1.1	1.4	1.7	1.6
CNP F (Chobe River)	am 03 Nov	3.6	4	4.3	1.3
CNP NP Subtotals		16.1	18.4	18.2	1.4
Chobe District Subtotals		**31.35**	**35.15**	**36.1**	**1.3**
CENTRAL (CT) District					
CT 1 Nunga	am 17 Nov	2.9	3.25	3.75	1.5
CT 2 Mukusi	am 13 Nov	2	2.3	3	1.6
CT 3 Tamafupa	am 13 Nov	2.9	3.2	6.2	1.3
CT 5 Sepako	am 14 Nov	2.25	2.6	3	1.3
Nxai Pan NP	am 15 Nov	3.1	3.4	4	1.3
Makgadikgadi NP					
Mak East	pm 15 Nov	3.1	3.3	3.7	1.6
Mak West	am 16 Nov	3.4	4.3	5	1.2
Makgadikgadi Subtotals		6.5	7.6	8.7	1.4
Central District Subtotals		**19.65**	**22.35**	**28.65**	**1.4**
Totals / mean		**132.05**	**149.18**	**168.35**	**1.3**

[a] Transect time is the time spent searching the transects; stratum time is the transect time, plus the time spent flying between transects in the same stratum; and total time is the stratum time, plus the time spent traveling between the stratum and airstrip.

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

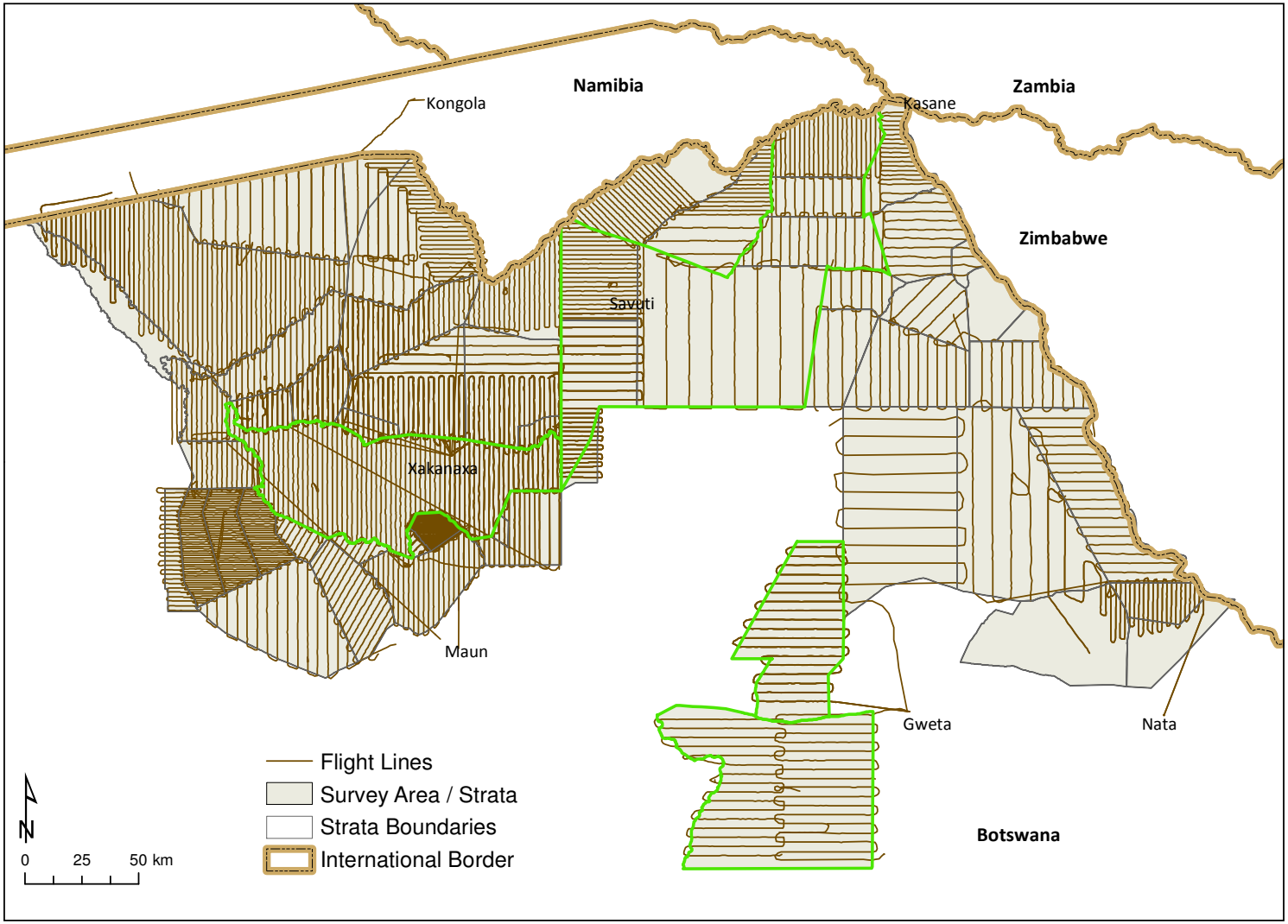
[c] Strata with the same superscript were treated as single stratum while flying the survey, but treated as separate strata during the analysis.

Figure 11. District boundaries, rivers and veterinary fences in northern Botswana.



The Okavango, Kwando, Chobe and Zambezi Rivers are perennial. The Selinda, Savuti, Khwai and Boteti Rivers were flowing during the survey. Green outlined areas indicate protected areas.

Figure 12. Recorded track log of flight lines indicting transects flown during the 2010 dry season aerial survey, northern Botswana.



Thin parallel brown lines indicate flight lines along transects. Place names indicate bases from which the survey was flown.

Table 8. Population estimates and statistics for elephants in northern Botswana, dry season 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	171	35	7114	169	99	35	340	0.32
NG 10 & 11	7498	1800	1225062	2212	30	5285	9710	1.46
NG 12	3109	640	926330	1986	64	1122	5095	2.85
NG 13	3471	378	780380	1813	52	1658	5283	1.39
NG 14 Kwando								
NG14 A	4952	1117	759245	1788	36	3164	6740	4.83
NG14 B	1850	174	224525	1010	55	830	2850	0.98
NG14 Subtotals	6802	1291	983770	2000	29	4791	8792	2.34
NG 15 Linyanti	3608	760	228178	1004	28	2605	4612	2.93
NG 16 Selinda	4146	857	415527	1322	32	2823	5468	3.07
NG 18 / 19 Khwai	3318	522	358596	1242	37	2076	4560	1.69
NG 20 /21 Splash	3350	507	254497	1046	31	2304	4397	1.53
NG 22 Vumbra	2644	514	416364	1420	54	1224	4064	4.33
NG 23 Duba Plains	1205	236	70744	585	49	620	1790	2.74
NG 24 Jedibe	4	3	19	26	200	5	23	0.01
NG 25 Jao	619	111	29667	372	60	247	991	1.00
NG 26 Abu EBS								
NG26 A	1577	626	32657	363	23	1214	1940	2.44
NG26 B	1181	484	27253	333	28	848	1513	1.71
NG26 C	848	343	21617	298	35	550	1146	1.64
NG26 Subtotals	3606	1453	81527	564	16	3042	4169	1.95
NG 27 A&B & NG 30	3017	501	914675	1974	65	1974	4991	2.16
NG 29 Rann	2378	250	855338	1984	83	359	4362	1.25
NG 31 + 17 Chitabe	940	195	38622	422	45	518	1361	3.13
NG 32 Stanleys	2048	484	198961	925	45	1123	2973	1.95
NG 33 & 34 Santawane	740	115	64707	554	75	185	1294	0.82
WMA Subtotals	52674	10652	7850078	5402	10	47181	58166	1.83
Moremi GR NG 28	8947	1914	1246751	2228	25	6718	11176	1.85
Ngamiland Subtotals	**61621**	**12566**	**9096829**	**5923**	**10**	**55698**	**67544**	**1.84**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	5815	1107	1590139	2639	45	3175	8454	4.97
CH 2 Chobe Forest Res	7807	1151	768884	1835	24	5972	9643	5.47
CH 4 Kasane Forest Res	1471	283	407950	1342	91	283	2813	2.45
CH 5 & 6 N Plains	617	62	45753	484	78	133	1101	0.44
CH 7, 8 & 13 Sibuyu	10681	920	3620902	3946	37	6735	14628	4.13
CH 11 & 12 Bottle Pan	1527	142	246653	1065	70	462	2593	0.60
WMA & FR Subtotals	27918	3665	6680281	5123	18	22796	33043	2.87
Chobe NP (CH3)								
CNP A (Linyanti-Savute)	11655	2342	1361852	2426	21	9228	14082	8.33
CNP B (Mababe-Khwai)	4498	558	705470	1734	39	2765	6232	2.31
CNP C (Chinamba)	5281	281	6756896	6146	116	865	11427	1.09
CNP D (Nogatsaa)	1871	212	405992	1358	73	513	3229	1.39
CNP E (Phofu)	951	122	48661	486	51	465	1436	1.18
CNP F (Chobe River)	5283	1139	587370	1589	30	3693	6872	4.00
CNP NP Subtotals	29539	4654	9866241	6228	21	23291	35748	2.53
Chobe District Subtotals	**57457**	**8319**	**16546522**	**8018**	**14**	**49439**	**65474**	**2.69**
CENTRAL (CT) District								
CT 1 Nunga	458	29	47991	473	103	29	931	0.11
CT 2 Mukusi	1311	65	242742	1064	81	247	2376	0.33
CT 3 Tamafupa	4692	464	1116874	2220	47	2471	6911	2.11
CT 5 Sepako	920	195	103084	675	73	245	1594	1.16
Nxai Pan NP	1141	111	151074	820	72	321	1961	0.44
Makgadikgadi NP								
Mak East	28	3	360	40	143	13	68	0.01
Mak West	712	81	50968	478	67	233	1190	0.32
Makgadikgadi Subtotals	740	84	51328	461	62	278	1201	0.15
Central District Subtotals	**9262**	**948**	**1713093**	**2593**	**28**	**6668**	**11855**	**0.50**
Totals	**128340**	**21833**	**25643351**	**9938**	**8**	**118402**	**138277**	**1.75**

Table 9. Dry season population estimates and statistics for elephant bulls in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	76	15	582	48	63	27	124	0.14
NG 10 & 11	754	181	11806	212	28	537	971	0.15
NG 12	704	145	31676	367	52	337	1071	0.64
NG 13	184	20	2067	93	51	90	277	0.07
NG 14 Kwando								
NG14 A	164	37	1584	81	49	82	246	0.16
NG14 B	423	40	62990	534	126	111	958	0.23
Subtotals	587	77	64574	512	87	74	1099	0.20
NG 15 Linyanti	717	151	44779	444	62	272	1161	0.58
NG 16 Selinda	929	192	39036	405	44	523	1334	0.69
NG 18 / 19 Khwai	1214	191	33473	379	31	835	1593	0.62
NG 20 /21 Splash	998	151	51534	470	47	527	1468	0.46
NG 22 Vumbra	159	31	8432	202	127	43	361	0.26
NG 23 Duba Plains	117	23	2155	102	87	23	219	0.27
NG 24 Jedibe	4	1	19	10	200	5	23	0.01
NG 25 Jao	223	40	4372	143	64	80	366	0.36
NG 26 Abu / EBS								
NG26 A	345	137	1785	85	25	260	430	0.53
NG26 B	112	46	384	39	35	58	152	0.16
NG26 C	74	30	195	28	38	45	102	0.14
Subtotals	531	213	2364	96	18	435	627	0.29
NG 27 A&B &NG 30	373	62	8760	193	52	180	566	0.27
NG 29 Rann	342	36	7239	182	53	160	525	0.18
NG 31 & 17 Chitabe	135	28	1365	79	59	56	214	0.45
NG 32 Stanleys	457	108	13174	238	52	219	695	0.44
NG 33 & 34 Santawane	148	23	1757	91	61	57	239	0.16
WMA Subtotals	8652	1688	329164	3308	38	5345	11960	0.30
Moremi GR (NG 28)	996	213	12439	222	22	773	1218	0.21
Ngamiland Subtotals	**9648**	**1901**	**341603**	**1147**	**12**	**8501**	**10797**	0.29

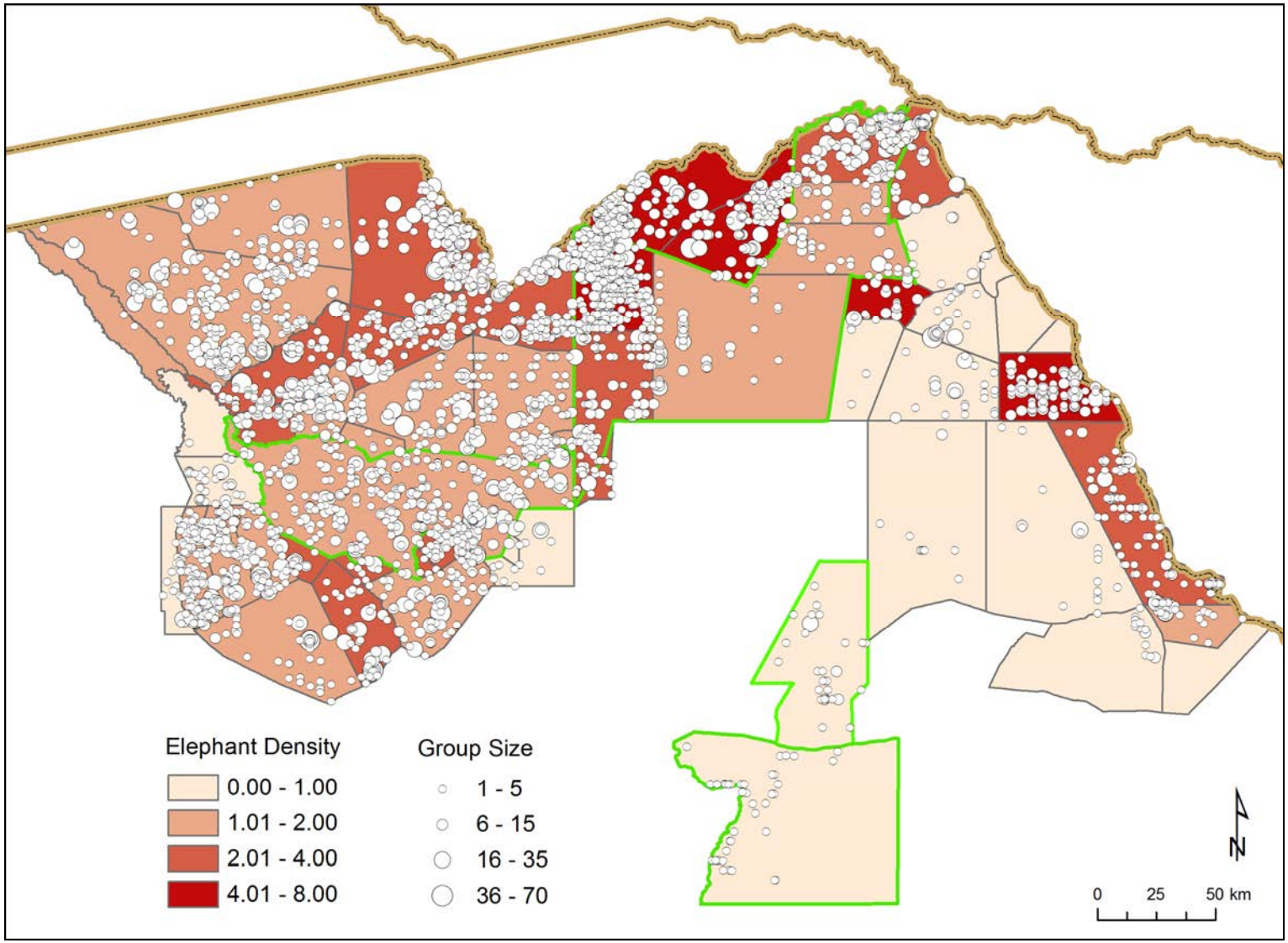
Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	247	47	6032	163	66	84	409	0.21
CH 2 Chobe Forest Res	617	91	43889	439	71	179	1056	0.43
CH 4 Kasane Forest Res	104	20	3276	120	115	20	224	0.17
CH 5 & 6 N Plains	358	36	18901	311	87	47	670	0.26
CH 7, 8 & 13 Sibuyu	1753	151	138488	771	44	981	2524	0.68
CH 11 & 12 Bottle Pan	204	19	8002	191	94	12	396	0.08
WMA & FR Subtotals	3283	364	218588	926	28	2356	4209	0.34
Chobe NP (CH3)								
CNP A (Linyanti-Savute)	865	174	31661	370	43	495	1236	0.62
CNP B (Mababe-Khwai)	1072	133	45726	441	41	631	1514	0.55
CNP C (Chinamba)	376	20	18599	322	86	53	698	0.08
CNP D (Nogatsaa)	300	34	14132	253	84	47	553	0.22
CNP E (Phofu)	55	7	280	37	67	18	91	0.07
CNP F (Chobe River)	116	25	2465	103	89	25	219	0.09
CNP NP Subtotals	2784	393	112863	666	24	2117	3450	0.24
Chobe District Subtotals	**6067**	**757**	**331451**	**1134**	**19**	**4932**	**7201**	**0.28**
CENTRAL (CT) District								
CT 1 Nunga	205	13	33768	396	193	191	602	0.05
CT 2 Mukusi	262	13	32494	389	148	127	651	0.07
CT 3 Tamafupa	1072	106	46505	453	42	618	1525	0.48
CT 5 Sepako	321	68	5555	156	49	164	477	0.40
Nxai Pan NP	648	63	53600	488	75	159	1136	0.25
Makgadikgadi NP								
Mak East	28	3	360	40	143	13	68	0.01
Mak West	712	81	50968	478	67	233	1190	0.32
Makgadikgadi NP Subtotals	740	84	51328	461	62	278	1201	0.15
Central District Subtotals	**3248**	**347**	**223250**	**936**	**29**	**2311**	**4184**	**0.18**
Totals	**18963**	**3005**	**896304**	**1857**	**10**	**17105**	**20820**	**0.26**

Table 10. Dry season population estimates and statistics for elephant family groups in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	94	20	7017	168	179	20	263	0.18
NG 10 & 11	6744	1619	1148241	2142	31	4602	8886	1.31
NG 12	2405	495	720649	1752	73	652	4157	2.20
NG 13	3287	358	801296	1837	56	1450	5124	1.31
NG 14 Kwando								
Kwando A	4788	1080	719040	1740	36	3048	6528	4.67
Kwando B	1427	135	209691	976	68	451	2403	0.76
Subtotals	6215	1215	928731	1943	31	4271	8158	2.14
NG 15 Linyanti	2891	609	160878	843	29	2049	3734	2.35
NG 16 Selinda	3217	665	379465	1264	39	1953	4481	2.38
NG 18 / 19 Khwai	2104	331	422517	1348	64	756	3452	1.07
NG 20 /21 Splash	2352	356	212928	957	41	1396	3309	1.07
NG 22 Vumbra	2485	483	396260	1385	56	1100	3870	4.07
NG 23 Duba Plains	1088	213	74459	600	55	487	1688	2.47
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	396	71	25905	348	88	71	743	0.64
NG 26 Abu / EBS								
NG26 A	1232	489	32041	367	30	865	1600	1.91
NG26 B	1069	438	23494	309	29	760	1377	1.55
NG26 C	774	313	20703	291	38	482	1065	1.50
NG26 Subtotals	3075	1240	76238	546	18	2528	3621	1.66
NG 27 A&B / NG30	2644	439	841951	1894	72	750	4538	1.89
NG 29 Rann	2036	214	835961	1961	96	214	3997	1.07
NG 31 & 17 Chitabe	805	167	31883	383	47	422	1188	2.68
NG 32 Stanleys	1591	376	172409	861	54	730	2452	1.52
NG 33 & 34 Santawane	592	92	61543	541	91	51	1132	0.66
WMA Subtotals	44021	8963	7298331	5305	12	38715	49326	1.53
Moremi GR NG 28	7951	1701	1141868	2132	27	5818	10084	1.65
Ngamiland Subtotals	**51972**	**10664**	**8440199**	**5705**	**11**	**46266**	**57677**	**1.55**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	5568	1060	1511650	2573	46	2995	8141	4.76
CH 2 Chobe Forest Res	7190	1060	711410	1765	24	5425	8956	5.04
CH 4 Kasane Forest Res	1367	263	368737	1275	93	92	2643	2.28
CH 5 & 6 N Plains	259	26	16750	292	112	34	551	0.19
CH 7, 8 & 13 Sibuyu	8928	769	3287189	3760	42	5168	12688	3.45
CH 11 & 12 Bottle Pan	1323	123	221187	1008	76	314	2332	0.52
WMA & FR Subtotals	24635	3301	6116923	4902	20	19732	25937	2.54
Chobe NP (CH3)								
CNP A (Linyanti-Savute)	10790	2168	1433355	2490	23	8300	13280	7.71
CNP B (Mababe-Khwai)	3426	425	727657	1760	51	1666	5187	1.76
CNP C (Chinamba)	4905	261	6327094	5948	121	1043	10853	1.01
CNP D (Nogatsaa)	1571	178	432705	1402	89	178	2973	1.16
CNP E (Phofu)	896	115	46545	474	52	422	1371	1.11
CNP F (Chobe River)	5167	1114	556724	1547	30	3619	6714	3.91
CNP NP Subtotals	26755	4261	9524080	6119	23	20635	32874	2.29
Chobe District Subtotals	**51390**	**7562**	**15641003**	**7795**	**15**	**43954**	**59185**	**2.40**
CENTRAL (CT) District								
CT 1 Nunga	253	16	20811	311	123	59	565	0.06
CT 2 Mukusi	1049	52	167573	884	84	164	1933	0.26
CT 3 Tamafupa	3620	358	880938	1971	54	1647	5591	1.63
CT 5 Sepako	599	127	84213	610	102	127	1208	0.75
Nxai Pan NP	493	48	60259	517	104	24	1011	0.19
Makgadikgadi NP								
Mak East	0	0	0	0	0	0	0	0.00
Mak West	0	0	0	0	0	0	0	0.00
Makgadikgadi Subtotals	0	0	0	0	0	0	0	0.00
Central District Subtotals	**6014**	**601**	**1213794**	**2182**	**36**	**3831**	**8196**	**0.32**
Totals	**109376**	**18827**	**25294996**	**9870**	**10**	**99505**	**119246**	**1.49**

Figure 13. Distribution and density (km^2) of elephants in northern Botswana during 2010 dry season aerial survey.



The points indicate the locations of elephant seen *within the search strips*, together with an indication of the size of each herd. Small points overlaying larger points indicate two or more groups of elephant seen in close proximity. The dark lines indicate survey strata and the shaded areas reflect the average density of elephants within that stratum, all shades of red indicate the area sampled. Green outlined areas indicate protected areas, and brown lines indicate international borders.

Figure 14. Distribution and density (km^2) of elephant bulls in northern Botswana during 2010 dry season aerial survey.

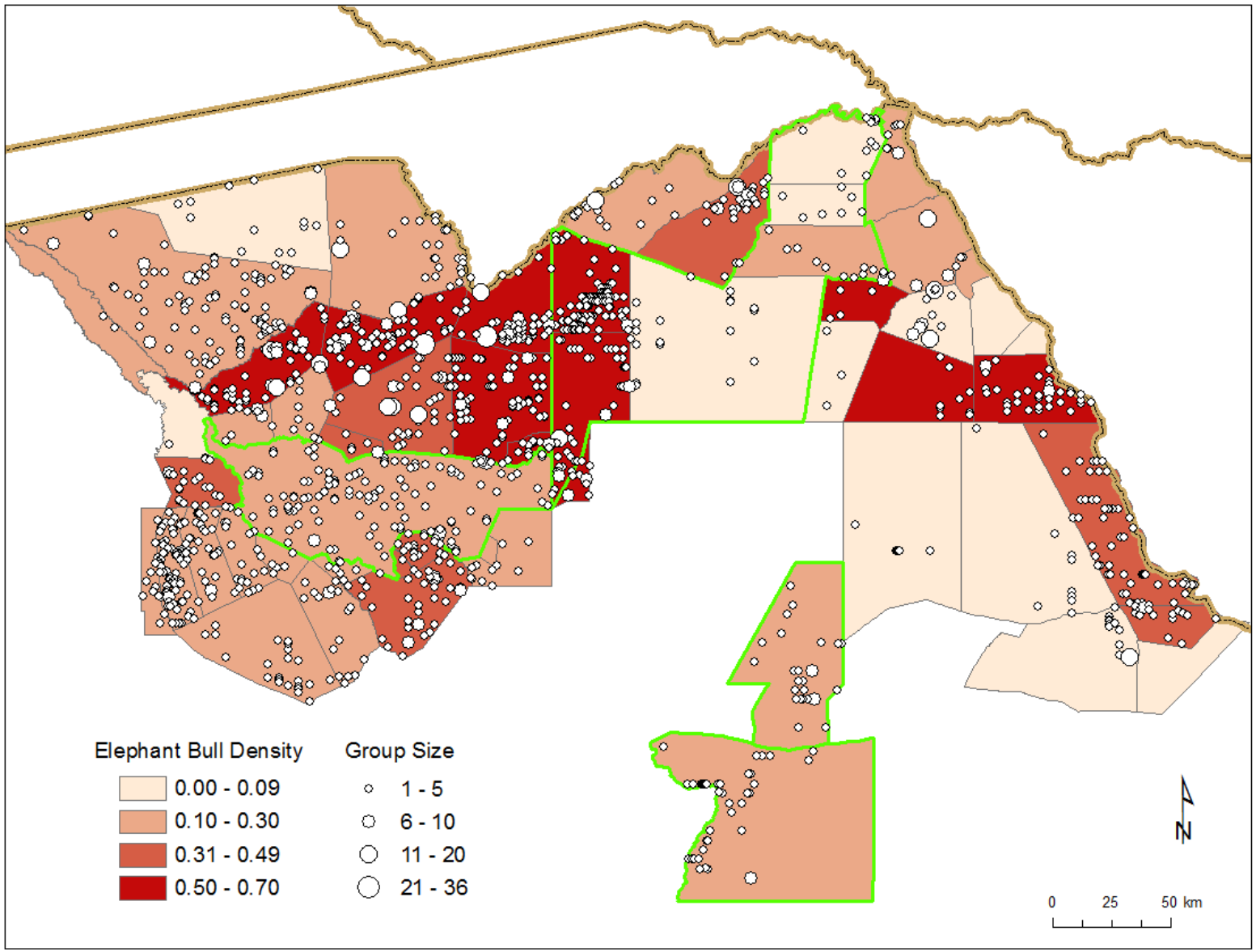


Figure 15. Distribution and density (km^2) of elephant family groups in northern Botswana during 2010 dry season aerial survey.

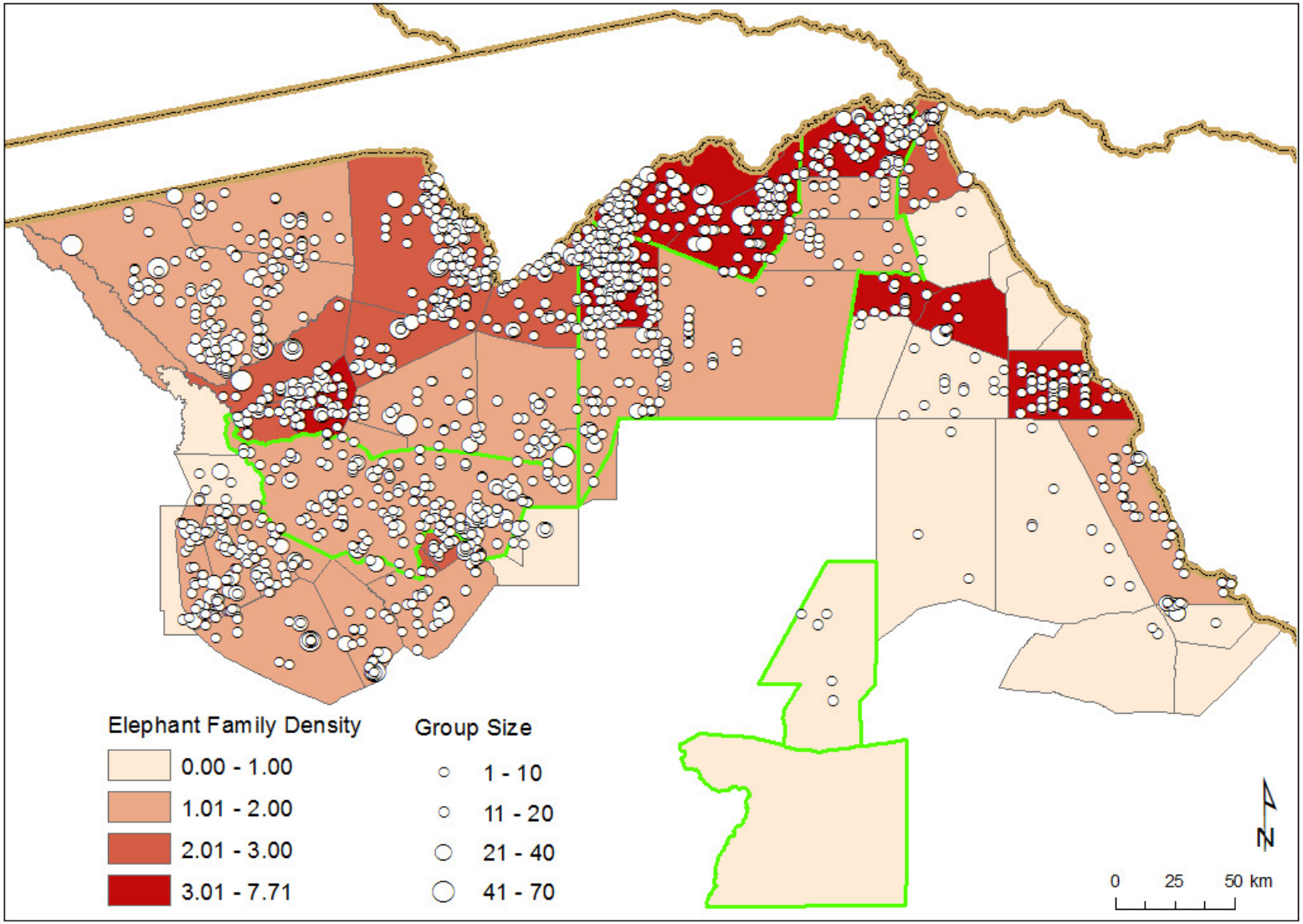


Table 11. Dry season population estimates and statistics for elephant carcasses (Cat.1) in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	0	0	0	0	0	0	0	0.00
NG 10 & 11	28	7	149	24	86	7	52	0.01
NG 12	0	0	0	0	0	0	0	0.00
NG 13	9	1	81	18	200	9	28	0.00
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	31	3	546	49	158	18	81	0.02
NG 14 Subtotals	31	3	546	49	158	18	81	0.01
NG 15 Linyanti	0	0	0	0	0	0	0	0.00
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 / 19 Khwai	0	0	0	0	0	0	0	0.00
NG 20 /21 Splash	6	1	37	12	200	6	19	0.00
NG 22 Vumbra	5	1	21	10	200	5	15	0.01
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS								
NG 26 A	0	0	0	0	0	0	0	0.00
NG 26 B	0	0	0	0	0	0	0	0.00
NG 26 C	0	0	0	0	0	0	0	0.00
NG 26 Subtotals	0	0	0	0	0	0	0	0.00
NG 27 A&B / NG30	12	2	62	16	133	4	28	0.01
NG 29 Rann	0	0	0	0	0	0	0	0.00
NG 31 & 17 Chitabe	0	0	0	0	0	0	0	0.00
NG 32 Stanleys	4	1	13	8	200	3	12	0.00
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA Subtotals	95	16	909	59	62	36	154	0.00
Moremi GR NG 28	0	0	0	0	0	0	0	0.00
Ngamiland Subtotals	**95**	**16**	**909**	**59**	**62**	**36**	**154**	**0.003**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	63	12	475	46	73	17	109	0.054
CH 2 Chobe Forest Res	109	16	961	65	60	44	173	0.076
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0.000
CH 5 & 6 N. Plains	0	0	0	0	0	0	0	0.000
CH 7, 8 & 13 Sibuyu	105	9	2640	106	101	9	211	0.041
CH 11 & 12 Bottle Pan	32	3	278	35	109	4	68	0.013
WMA & FR Subtotals	309	40	4354	131	42	178	440	0.032
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	30	6	103	21	70	9	51	0.021
CNP B (Mababe-Khwai)	8	1	58	16	200	8	24	0.004
CNP C (Chinamba)	0	0	0	0	0	0	0	0.000
CNP D (Nogatsaa)	26	3	176	28	108	3	55	0.019
CNP E (Phofu)	39	5	166	28	72	10	67	0.048
CNP F (Chobe River)	51	11	268	34	67	17	85	0.039
CNP NP Subtotals	154	26	771	55	36	99	209	0.013
Chobe District Subtotals	**463**	**66**	**5125**	**141**	**30**	**321**	**604**	**0.022**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.000
CT 2 Mukusi	0	0	0	0	0	0	0	0.000
CT 3 Tamafupa	20	2	168	27	135	7	47	0.009
CT 5 Sepako	19	4	60	16	84	3	35	0.024
Nxai Pan NP	0	0	0	0	0	0	0	0.000
Makgadikgadi NP								
Mak East	0	0	0	0	0	0	0	0.000
Mak West	0	0	0	0	0	0	0	0.000
Makgadikgadi NP Subtotals	0	0	0	0	0	0	0	0.000
Central District Subtotals	**39**	**6**	**228**	**30**	**77**	**9**	**69**	**0.002**
Totals	**597**	**88**	**6262**	**155**	**26**	**441**	**752**	**0.008**

Table 12. Dry season population estimates and statistics for elephant carcasses (Cat. 2) in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	5	1	10	6	120	1	9	0.01
NG 10 & 11	124	31	391	39	31	84	163	0.02
NG 12	15	3	48	14	93	3	29	0.01
NG 13	18	2	125	23	128	5	41	0.01
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	27	6	108	21	77	6	48	0.01
NG 14 Subtotals	21	2	176	28	133	7	49	0.01
NG 15 Linyanti	9	2	29	11	122	2	21	0.01
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	13	2	66	16	123	4	29	0.01
NG 20 & 21 Splash	6	1	37	12	200	6	19	0.00
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS								
NG 26 A	55	22	89	19	35	36	73	0.09
NG 26 B	5	2	7	5	100	2	10	0.01
NG 26 C	5	1	8	8	160	1	13	0.01
NG 26 Subtotals	65	25	104	20	31	44	85	0.04
NG 27 A&B &NG 30	30	5	209	30	100	5	60	0.02
NG 29 Rann	48	5	443	45	94	5	93	0.03
NG 31 & 17 Chitabe								0.00
NG 32 Stanleys	34	8	195	29	85	5	63	0.03
NG 33 & 34 Santawane	32	5	204	31	97	5	63	0.04
WMA subtotals	491	121	2073	89	18	401	580	0.02
Moremi GR NG 28	19	4	64	16	84	4	35	0.00
Ngamiland Subtotals	**510**	**125**	**2137**	**90**	**18**	**419**	**600**	**0.02**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	58	11	334	38	66	20	96	0.05
CH 2 Chobe Forest Res	319	47	8438	192	60	127	511	0.22
CH 4 Kasane Forest Res	57	11	413	42	74	15	100	0.10
CH 5 & 6 N. Plains	30	3	385	44	147	15	74	0.02
CH 7, 8 & 13 Sibuyu	81	7	1452	79	98	7	160	0.03
CH 11 & 12 Bottle Pan	21	2	204	30	143	9	52	0.01
WMA & FR Subtotals	566	81	11226	210	37	356	776	0.06
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	15	3	56	16	107	3	31	0.01
CNP B (Mababe-Khwai)	24	3	160	26	108	3	50	0.01
CNP C (Chinamba)	113	6	528	54	48	58	167	0.02
CNP D (Nogatsaa)	185	21	3394	124	67	61	310	0.14
CNP E (Phofu)	210	27	1627	89	42	122	299	0.26
CNP F (Chobe River)	186	40	1770	87	47	98	273	0.14
CNP NP Subtotals	733	100	7535	172	23	600	945	0.06
Chobe District Subtotals	**1299**	**181**	**18761**	**270**	**21**	**1029**	**1570**	**0.06**
CENTRAL (CT) District								
CT 1 Nunga	16	1	238	33	206	17	49	0.00
CT 2								0.00
CT 3 Tamafupa	20	2	177	28	140	8	48	0.01
CT 5 (Sepako)	0	0	0	0	0	0	0	0.00
Nxai Pan NP	0	0	0	0	0	0	0	0.00
Makgadikgadi NP								
Mak East	0	0	0	0	0	0	0	0.00
Mak West	0	0	0	0	0	0	0	0.00
Makgadikgadi Subtotals	0	0	0	0	0	0	0	
Central District Subtotals	**36**	**3**	**415**	**40**	**111**	**3**	**76**	**0.0002**
Totals	**1845**	**309**	**21313**	**286**	**16**	**1558**	**2131**	**0.03**

Figure 16. Distribution and density (km^2) of elephant carcasses (Cat.1) in northern Botswana during 2010 dry season aerial survey.

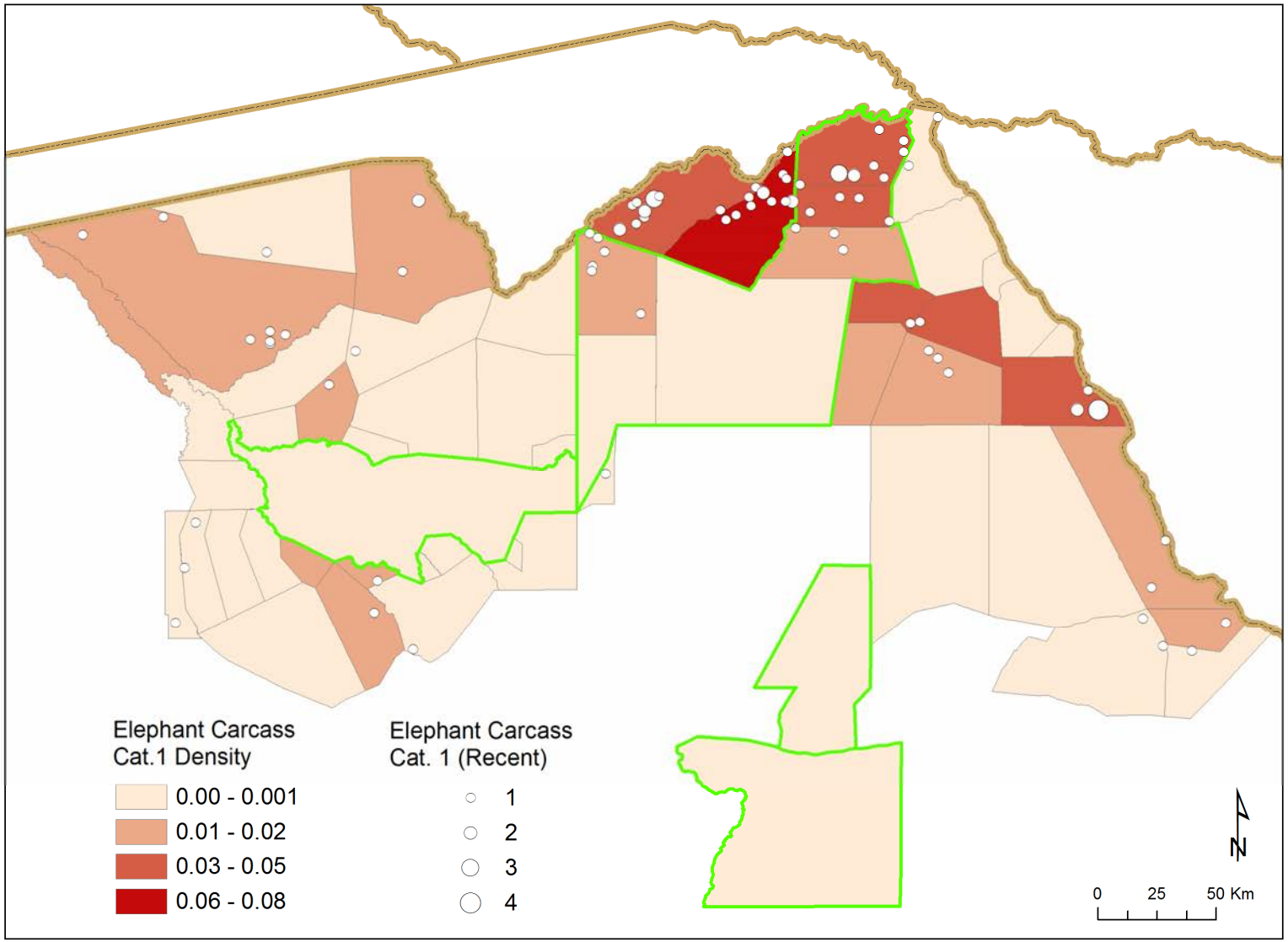


Figure 17. Distribution and density (km^2) of elephant carcasses (Cat. 2) in northern Botswana during 2010 dry season aerial survey.

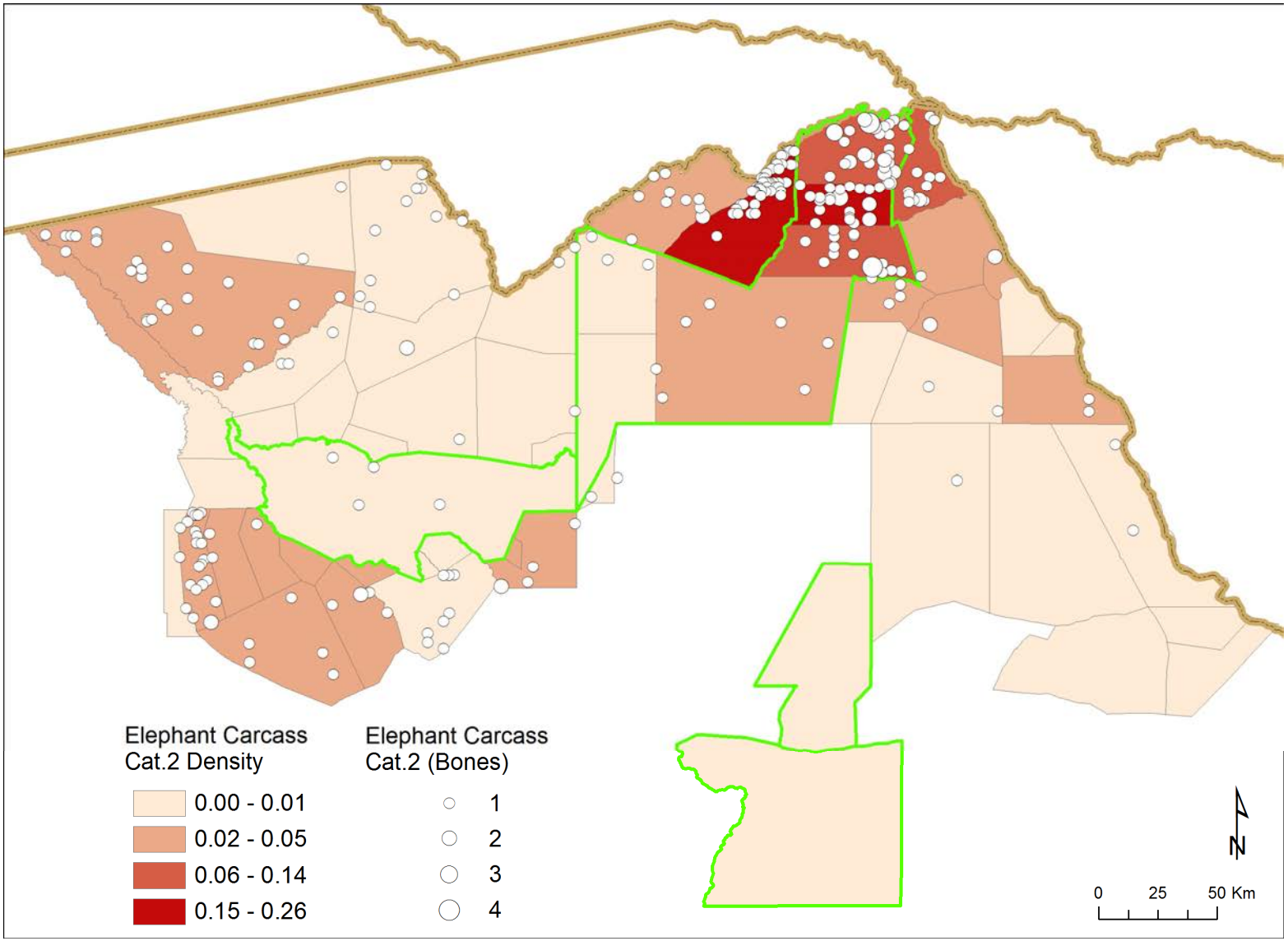


Table 13. Dry season population estimates and statistics for buffalo in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	14	3	155	25	179	3	39	0.03
NG 10 & 11	0	0	0	0	0	0	0	0
NG 12	0	0	0	0	0	0	0	0
NG 13	0	0	0	0	0	0	0	0
NG 14 Kwando								
NG 14 A	2934	662	1672532	2653	90	662	5588	2.86
NG 14 B	698	66	257569	1081	155	383	1779	0.37
NG 14 Subtotals	3632	728	1930101	2801	77	830	6433	1.25
NG 15 Linyanti	465	98	108805	693	149	228	1158	0.38
NG 16 Selinda	1548	320	532116	1497	97	320	3044	1.15
NG 18 / 19 Khwai	1417	223	544244	1530	108	223	2947	0.72
NG 20 /21 Splash	912	138	371264	1263	138	351	2175	0.42
NG 22 Vumbra	1554	302	1900182	3033	195	1480	4587	2.55
NG 23 Duba Plains	551	108	207882	1003	182	452	1555	1.25
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	55	10	1630	87	158	31	143	0.09
NG 26 Abu / EBS								
NG 26 A	716	294	102716	644	90	294	1360	1.11
NG 26 B	1098	450	206113	915	83	450	2013	1.59
NG 26 C	1931	779	431334	1330	69	779	3262	3.74
NG 26 Subtotals	3745	1523	740163	1701	45	2043	5446	2.02
NG 27 A&B / NG30	4963	824	7939670	5815	117	853	10778	3.55
NG 29 Rann	3026	318	1458964	2591	86	435	5617	1.59
NG 31 & 17 Chitabe	2192	455	3291202	3891	178	1699	6083	7.31
NG 32 Stanleys	669	158	148032	798	119	129	1467	0.64
NG 33 & 34 Santawane	122	19	9208	209	171	87	331	0.14
WMA subtotals	24865	5227	19183618	8601	35	16203	33466	0.87
Moremi GR NG 28	6624	1417	5545318	4700	71	1924	11324	1.37
Ngamiland Subtotals	**31489**	**6644**	**24728936**	**9765**	**31**	**21723**	**41254**	**0.94**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	1717	327	832695	1910	111	192	3628	1.47
CH 2 Chobe Forest Res	699	103	139591	782	112	83	1481	0.49
CH 4 Kasane Forest Res	447	86	66000	539	121	92	987	0.75
CH 5 & 6 N Plains	0	0	0	0	0	0	0	0.00
CH 7, 8 & 13 Sibuyu	1753	151	2701947	3408	194	1655	5162	0.68
CH 11 & 12 Bottle Pan	150	14	7918	190	127	40	341	0.06
WMA & FR Subtotals	4766	681	3748151	3837	81	928	8603	0.49
Chobe NP (CH3)								
CNP A (Linyanti-Savute)	114	23	5939	159	139	44	273	0.08
CNP B (Mababe-Khwai)	48	6	2109	95	198	46	143	0.02
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)	2481	535	837291	1898	77	584	4379	1.88
CNP NP Subtotals	2643	564	845339	1823	69	820	4466	0.23
Chobe District Subtotals	**7409**	**1245**	**4593490**	**4224**	**57**	**3184**	**11633**	**0.35**
CENTRAL (CT) District								
CT 1 Nunga	190	12	8522	199	105	12	389	0.05
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	303	30	79450	592	195	288	895	0.14
CT 5 Sepako	75	16	1092	69	92	6	144	0.09
Nxai Pan NP	113	11	9516	206	182	92	319	0.04
Makgadikgadi NP								
Mak East	0	0	0	0	0	0	0	0.00
Mak West	0	0	0	0	0	0	0	0.00
Makgadikgadi NP Subtotals	0	0	0	0	0	0	0	0.00
Central District Subtotals	**681**	**69**	**98580**	**622**	**91**	**69**	**1303**	**0.04**
Totals	**39579**	**7958**	**29421006**	**10644**	**27**	**28934**	**50224**	**0.54**

Figure 18. Distribution and density (km^2) of buffalo in northern Botswana during 2010 dry season aerial survey.

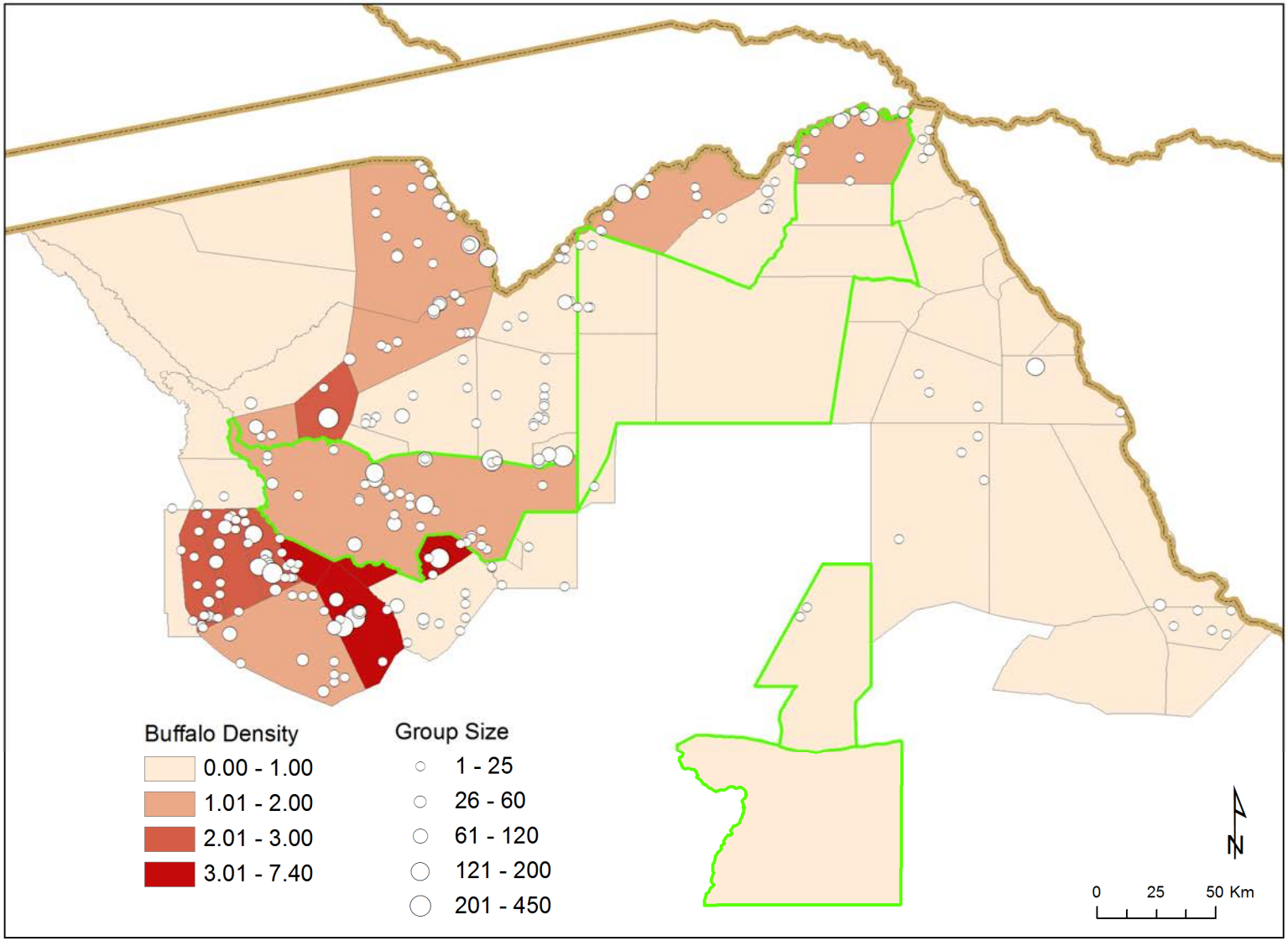


Table 14. Dry season population estimates and statistics for eland in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	0	0	0	0	0	0	0	0.00
NG 10 & 11	0	0	0	0	0	0	0	0.00
NG 12	0	0	0	0	0	0	0	0.00
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	0	0	0	0	0	0	0	0.00
NG 15 Linyanti	43	9	1381	78	181	35	121	0.03
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	190	30	30722	363	191	172	554	0.10
NG 20 & 21 Splash	6	1	37	12	200	6	19	0.003
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS								
NG 26 A	0	0	0	0	0	0	0	0.00
NG 26 B	0	0	0	0	0	0	0	0.00
NG 26 C	0	0	0	0	0	0	0	0.00
NG 26 Subtotals	0	0	0	0	0	0	0	0.00
NG 27 A&B & NG 30	0	0	0	0	0	0	0	0.00
NG 29 Rann	0	0	0	0	0	0	0	0.00
NG 31 & 17 Chitabe	0	0	0	0	0	0	0	0.00
NG 32 Stanleys	0	0	0	0	0	0	0	0.00
NG 33 & 34 Santawane	51	8	2139	101	198	49	152	0.06
WMA subtotals	290	48	34279	364	126	74	654	0.01
Moremi GR NG 28	0	0	0	0	0	0	0	0.00
Ngamiland Subtotals	**290**	**48**	**34279**	**364**	**126**	**74**	**654**	**0.01**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	52	10	1802	89	171	36	141	0.04
CH 2 Chobe Forest Res	305	45	53852	486	159	180	791	0.21
CH 4 Kasane Forest Res	109	21	9129	200	183	91	310	0.18
CH 5 & 6 N Plains	687	69	235085	1097	160	410	1784	0.49
CH 7, 8 & 13 Sibuyu	162	14	14482	249	154	87	412	0.06
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	1315	159	314350	1111	84	203	2426	0.14
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0	0	0	0	0	0	0	0.00
CNP B (Mababe-Khwai)	56	3	748	65	116	8	121	0.03
CNP C (Chinamba)	0	0	0	0	0	0	0	0.00
CNP D (Nogatsaa)	706	80	434550	1405	199	699	2111	0.52
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	297	64	14046	246	83	51	542	0.23
CNP NP Subtotals	1059	147	449344	1329	125	270	2388	0.09
Chobe District Subtotals	**2374**	**306**	**763694**	**1722**	**73**	**651**	**4096**	**0.11**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	637	63	262629	1076	169	440	1714	0.29
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	10	1	96	21	210	10	31	0.00
Makgadikgadi NP (Mak. NP)								
Mak. NP East	0	0	0	0	0	0	0	0.00
Mak. NP West	0	0	0	0	0	0	0	0.00
Mak. NP Subtotals	0	0	0	0	0	0	0	0.00
Central District Subtotals	**647**	**64**	**262725**	**1015**	**157**	**368**	**1662**	**0.03**
Totals	**3311**	**418**	**1060698**	**2021**	**61**	**1289**	**5332**	**0.05**

Figure 19. Distribution and density (km^2) of eland in northern Botswana during 2010 dry season aerial survey.

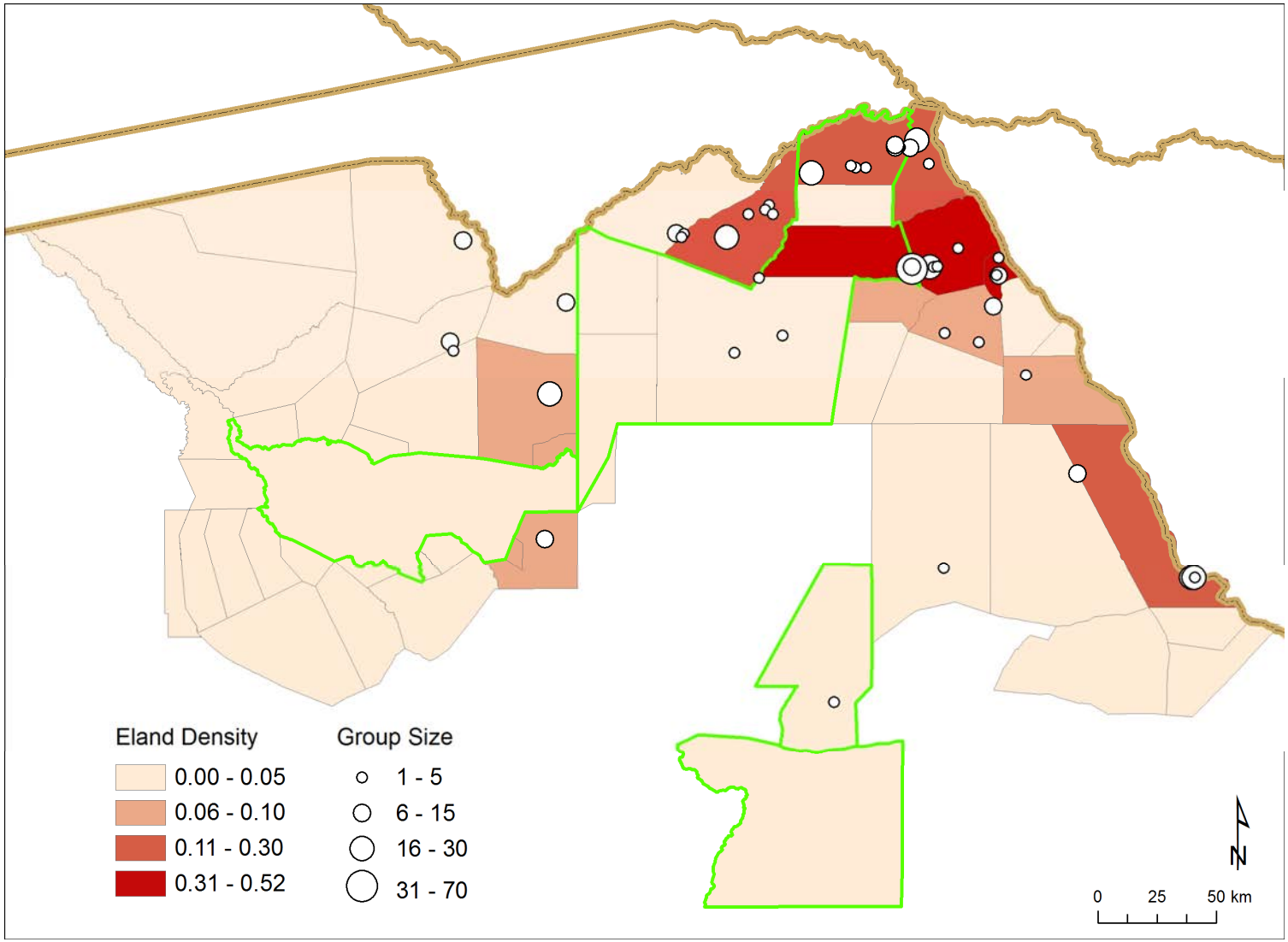


Table 15. Dry season population estimates and statistics for giraffe in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	0	0	0	0	0	0	0	0.00
NG 10 & 11	0	0	0	0	0	0	0	0.00
NG 12	0	0	0	0	0	0	0	0.00
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	84	19	1023	65	77	19	150	0.08
NG 14 B	53	5	1283	76	143	23	129	0.03
NG 14 Subtotals	137	24	2306	97	71	40	233	0.05
NG 15 Linyanti	109	23	1268	75	69	34	184	0.09
NG 16 Selinda								
NG 18 & 19 Khwai	140	22	3185	117	84	23	256	0.07
NG 20 & 21 Splash	343	52	16091	263	77	80	607	0.16
NG 22 Vumbra	62	12	647	56	90	12	118	0.10
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS								
NG 26 A	152	61	1519	78	51	74	230	0.24
NG 26 B	212	87	2084	92	43	120	304	0.31
NG 26 C	62	25	377	39	63	25	101	0.12
NG 26 Subtotals	426	173	3980	124	29	310	550	0.23
NG 27 A&B / NG30	434	72	13661	241	56	192	675	0.31
NG 29 Rann	295	31	8680	200	68	95	495	0.16
NG 31 & 17 Chitabe	183	38	4180	139	76	44	322	0.61
NG 32 Stanleys	279	66	4875	145	52	135	424	0.27
NG 33 & 34 Santawane	193	30	3515	129	67	64	322	0.21
WMA subtotals	2601	543	62388	490	19	2110	3091	0.09
Moremi GR NG 28	1075	230	54515	466	43	609	1541	0.22
Ngamiland Subtotals	**3676**	**773**	**116903**	**671**	**18**	**3004**	**4347**	**0.11**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	26	5	141	25	96	5	51	0.02
CH 2 Chobe Forest Res.	20	3	178	28	140	8	48	0.01
CH 4 Kasane Forest Res.	41	8	411	42	102	8	84	0.07
CH 5 & 6 N Plains	209	21	33783	416	199	206	615	0.15
CH 7, 8 & 13 Sibuyu	104	9	1311	75	72	29	179	0.04
CH 11 & 12 Bottle Pan	75	7	3828	132	176	57	207	0.03
WMA & FR Subtotals	475	53	39652	395	83	80	870	0.05
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	60	12	380	40	67	19	100	0.04
CNP B (Mababe-Khwai)	282	35	6216	163	58	119	445	0.14
CNP C (Chinamba)	150	8	15372	243	162	143	444	0.03
CNP D (Nogatsaa)	79	9	1120	71	90	9	151	0.06
CNP E (Phofu)	55	7	876	65	118	11	120	0.07
CNP F (Chobe River)	144	31	2233	98	68	46	242	0.11
CNP NP Subtotals	770	102	26197	320	42	449	1040	0.07
Chobe District Subtotals	**1245**	**155**	**65849**	**505**	**41**	**739**	**1750**	**0.06**
CENTRAL (CT) District								
CT 1 Nunga	111	7	7032	181	163	71	292	0.03
CT 2 Mokusi								
CT 3 Tamafupa	222	12	10275	212	95	22	435	0.10
CT 5 (Sepako)	56	12	729	56	100	12	113	0.07
Nxai Pan NP	165	16	4562	143	87	23	307	0.06
Makgadikgadi NP								
Mak. East	0	0	0	0	0	0	0	0.00
Mak. West	62	7	3202	120	194	58	181	0.03
Makgadikgadi Subtotals	62	7	3202	120	194	58	181	0.01
Central District Subtotals	**616**	**54**	**25800**	**318**	**52**	**297**	**934**	**0.03**
Totals	**5537**	**982**	**208552**	**896**	**16**	**4640**	**6433**	**0.08**

Figure 20. Distribution and density (km^2) of giraffe in northern Botswana during 2010 dry season aerial survey.

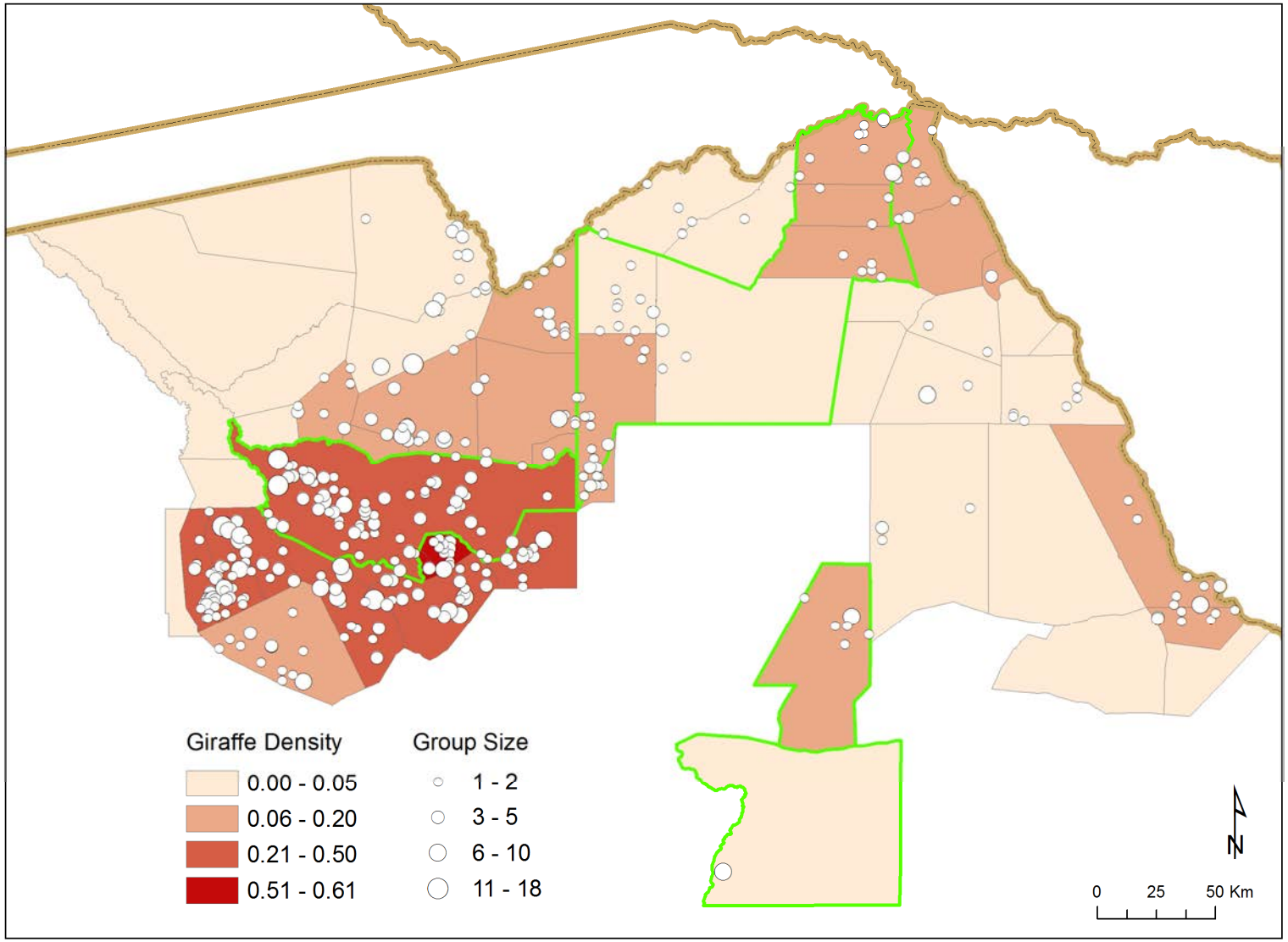


Table 16. Dry season population estimates and statistics for gemsbok in northern Botswana, 2010.

Stratum	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.	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, 8 & 13 Sibuyu	23	2	479	45	1.96	22	68	0.01
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	23	2	479	45	1.96	22	68	0.00
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0	0	0	0	0	0	0	0.00
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)	26	3	611	52	200	26	79	0.02
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	26	3	611	52	200	26	79	0.00
Chobe District Subtotals	**49**	**5**	**1090**	**65**	**133**	**16**	**114**	**0.00**
CENTRAL (CT) District								
CT 1 Nunga	110	7	6105	169	154	58	279	0.03
CT 2 Mokusi	101	5	4969	152	150	51	253	0.03
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 (Sepako)	9	2	31	12	133	3	21	0.01
Nxai Pan NP	329	32	80665	599	182	270	928	0.13
Makgadikgadi NP (Mak. NP)								
Mak. NP East	1108	120	304456	1170	106	120	2277	0.41
Mak. NP West	1090	124	102969	680	62	409	1770	0.49
Mak. NP Subtotals	2198	244	407425	1300	59	897	3498	0.45
Central District Subtotals	**2747**	**290**	**499195**	**1399**	**51**	**1347**	**4146**	**0.15**
Totals	**2796**	**295**	**500285**	**1388**	**50**	**1407**	**4184**	**0.07**

No gemsbok were seen within the survey area in Ngamiland district, except for three observed in NG 26.

Figure 21. Distribution and density (km^2) of gemsbok in northern Botswana during 2010 dry season aerial survey.

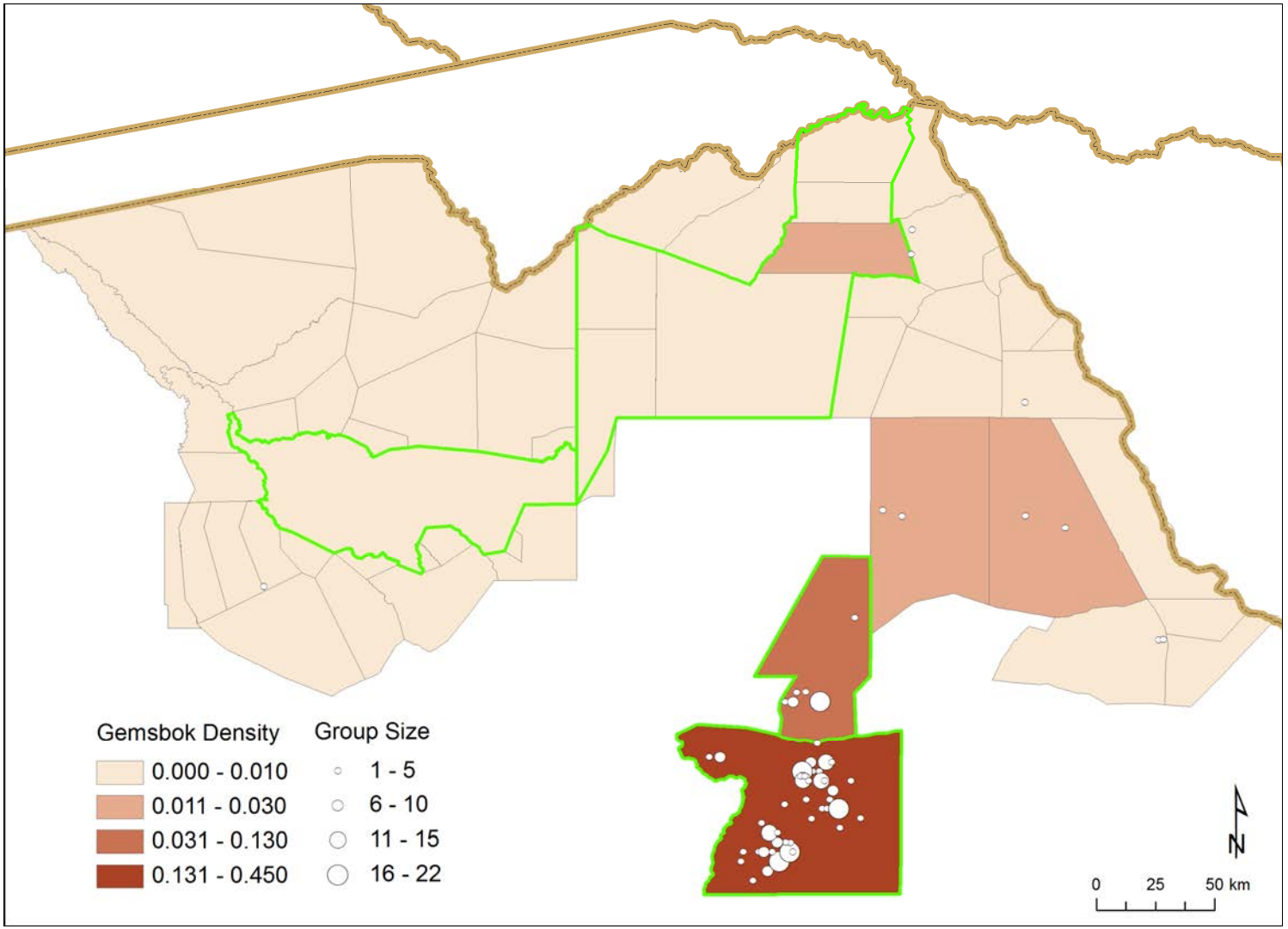


Table 17. Dry season population estimates and statistics for hippo in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	76	16	2068	93	122	16	169	0.14
NG 10 & 11	120	30	2333	96	80	23	217	0.02
NG 12	369	76	11787	224	61	145	593	0.34
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	332	75	7045	172	52	160	505	0.32
NG 14 B								0.00
NG 14 Subtotals	332	75	7045	172	52	160	505	0.11
NG 15 Linyanti	71	15	653	54	76	17	125	0.06
NG 16 Selinda	160	33	8897	193	121	33	353	0.12
NG 18 & 19 Khwai	82	13	2917	112	137	29	195	0.04
NG 20 & 21 Splash	297	45	11570	223	75	74	520	0.14
NG 22 Vumbra	149	29	2558	111	74	38	260	0.24
NG 23 Duba Plains	15	3	94	21	140	6	36	0.03
NG 24 Jedibe	142	29	1431	83	58	58	225	0.19
NG 25 Jao	134	24	2721	113	84	24	246	0.22
NG 26 Abu / EBS								
NG 26 A	37	15	373	39	105	15	76	0.06
NG 26 B	102	42	1181	69	68	42	171	0.15
NG 26 C	148	60	1501	78	53	70	227	0.29
NG 26 Subtotals	287	117	3055	109	38	177	396	0.15
NG 27 A&B / NG30	241	40	8296	188	78	53	429	0.17
NG 29 Rann	228	24	35030	401	176	173	630	0.12
NG 31 & 17 Chitabe	82	17	697	57	70	25	139	0.27
NG 32 Stanleys	123	29	1284	74	60	48	197	0.12
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA subtotals	2908	615	102436	628	22	2279	3536	0.10
Moremi GR NG 28	2842	608	158539	795	28	2048	3637	0.59
Ngamiland Subtotals	**5750**	**1223**	**260975**	**1003**	**17**	**4746**	**6753**	**0.17**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	58	11	1128	70	121	13	128	0.05
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, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	58	11	1128	70	121	13	128	0.01
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	70	14	2353	100	143	31	170	0.05
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)	176	38	8123	187	106	38	363	0.13
CNP NP Subtotals	246	52	10476	202	82	52	449	0.02
Chobe District Subtotals	**304**	**63**	**11604**	**212**	**70**	**91**	**516**	**0.01**
Totals	**6054**	**1286**	**272579**	**1024**	**17**	**5029**	**7078**	**0.11**

Figure 22. Distribution and density (km^2) of hippo in northern Botswana during 2010 dry season aerial survey.

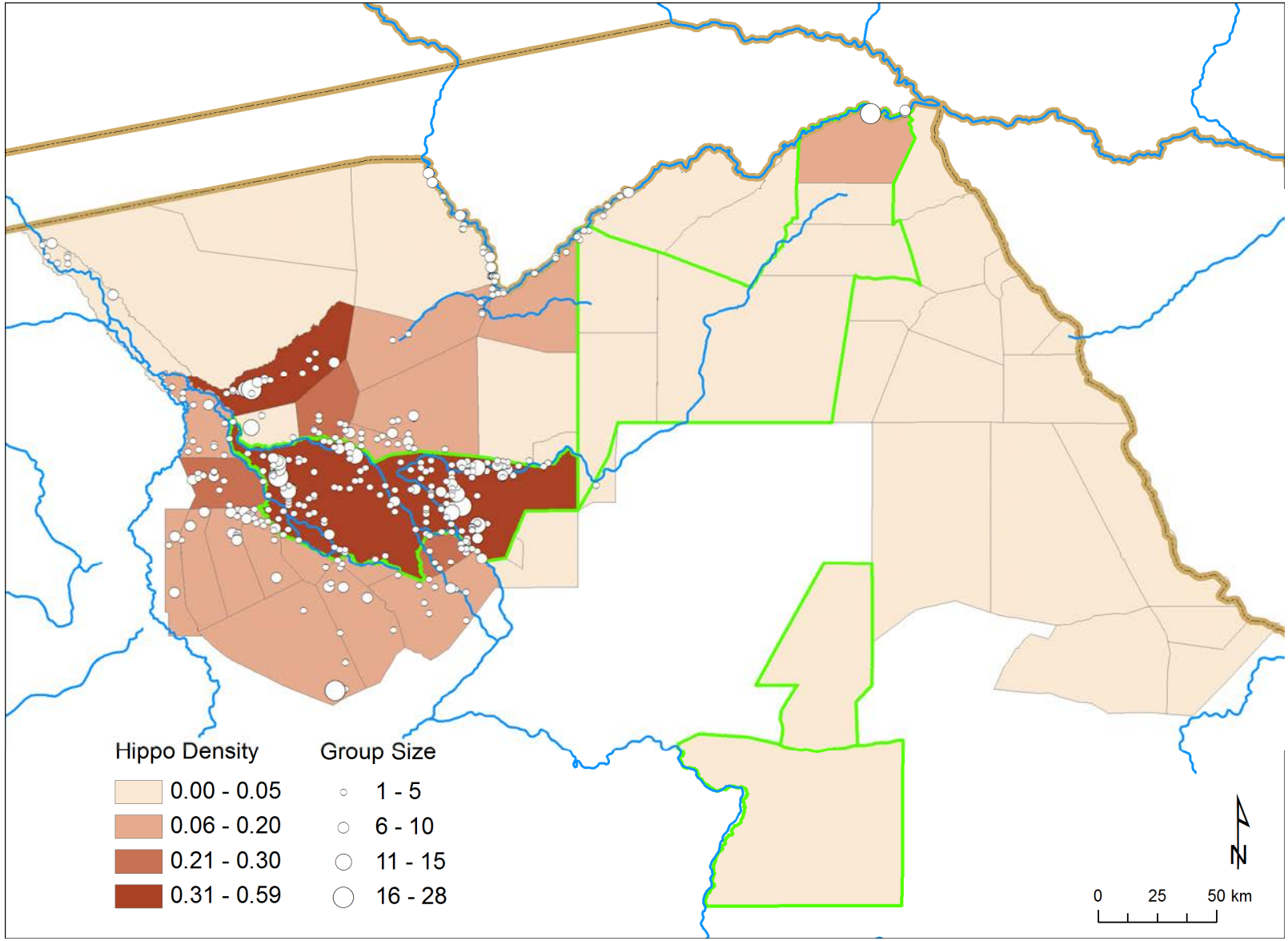


Table 18. Dry season population estimates and statistics for impala in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	100	21	3778	126	126	21	225	0.19
NG 10 & 11	0	0	0	0	0	0	0	0.00
NG 12	155	32	4859	144	93	32	299	0.14
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	598	135	27511	340	56	258	939	0.58
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	598	135	27511	340	56	258	939	0.21
NG 15 Linyanti	1624	342	151522	818	50	806	2441	1.32
NG 16 Selinda	160	33	8897	193	121	34	353	0.12
NG 18 & 19 Khwai	1144	180	610228	1620	142	475	2764	0.58
NG 20 & 21 Splash	219	1447	194722	915	418	532	2362	0.10
NG 22 Vumbra	1106	215	178154	930	84	177	2035	1.81
NG 23 Duba Plains	388	76	38548	432	111	76	820	0.88
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	217	39	10322	219	101	39	436	0.35
NG 26 Abu / EBS								
NG 26 A	1557	625	150790	780	50	777	2337	2.41
NG 26 B	800	328	22525	302	38	498	1103	1.16
NG 26 C	348	141	3624	122	35	226	470	0.67
NG 26 Subtotals	2705	1094	176939	832	31	1873	3537	1.46
NG 27 A&B / NG30	6191	1028	4516038	4386	71	1805	10577	4.42
NG 29 Rann	1722	181	285085	1145	66	577	2868	0.91
NG 31 & 17 Chitabe	1788	371	326934	1226	69	561	3014	5.96
NG 32 Stanleys	2709	640	354044	1234	46	1475	3943	2.58
NG 33 & 34 Santawane	1614	251	228461	1041	64	573	2656	1.79
WMA subtotals	22440	6085	7116042	5238	23	17201	27678	0.78
Moremi GR NG 28	22200	4749	10104949	6345	29	15855	28545	4.60
Ngamiland Subtotals	**44640**	**10834**	**17220991**	**8149**	**18**	**36490**	**52789**	**1.33**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	147	28	6337	166	113	28	314	0.13
CH 2 Chobe Forest Res	271	40	67776	544	201	273	816	0.19
CH 4 Kasane Forest Res	0	0	0	0	0	0	0	0.00
CH 5 & 6 N Plains	149	15	19083	312	209	163	462	0.11
CH 7, 8 & 13 Sibuyu	12	1	120	22	183	11	34	0.00
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	579	84	93316	605	104	84	1184	0.06
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	264	53	15337	258	98	53	521	0.19
CNP B (Mababe-Khwai)	2160	268	811312	1859	86	301	4020	1.11
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)	3627	782	506045	1475	41	2151	5102	2.75
CNP NP Subtotals	6051	1103	1332694	2289	38	3762	8340	0.52
Chobe District Subtotals	**6630**	**1187**	**1426010**	**2353**	**35**	**4276**	**8983**	**0.31**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	0	0	0	0	0	0	0	0.00
Makgadikgadi NP	0	0	0	0	0	0	0	0.00
Mak East	0	0	0	0	0	0	0	0.00
Mak West	0	0	0	0	0	0	0	0.00
Makgadikgadi Subtotals	0	0	0	0	0	0	0	0.00
Central District Subtotals	0	0	0	0	0	0	0	0.00
Totals	**51270**	**12021**	**18647001**	**8474**	**17**	**42795**	**59744**	**0.70**

Figure 23. Distribution and density (km^2) of impala in northern Botswana during 2010 dry season aerial survey.

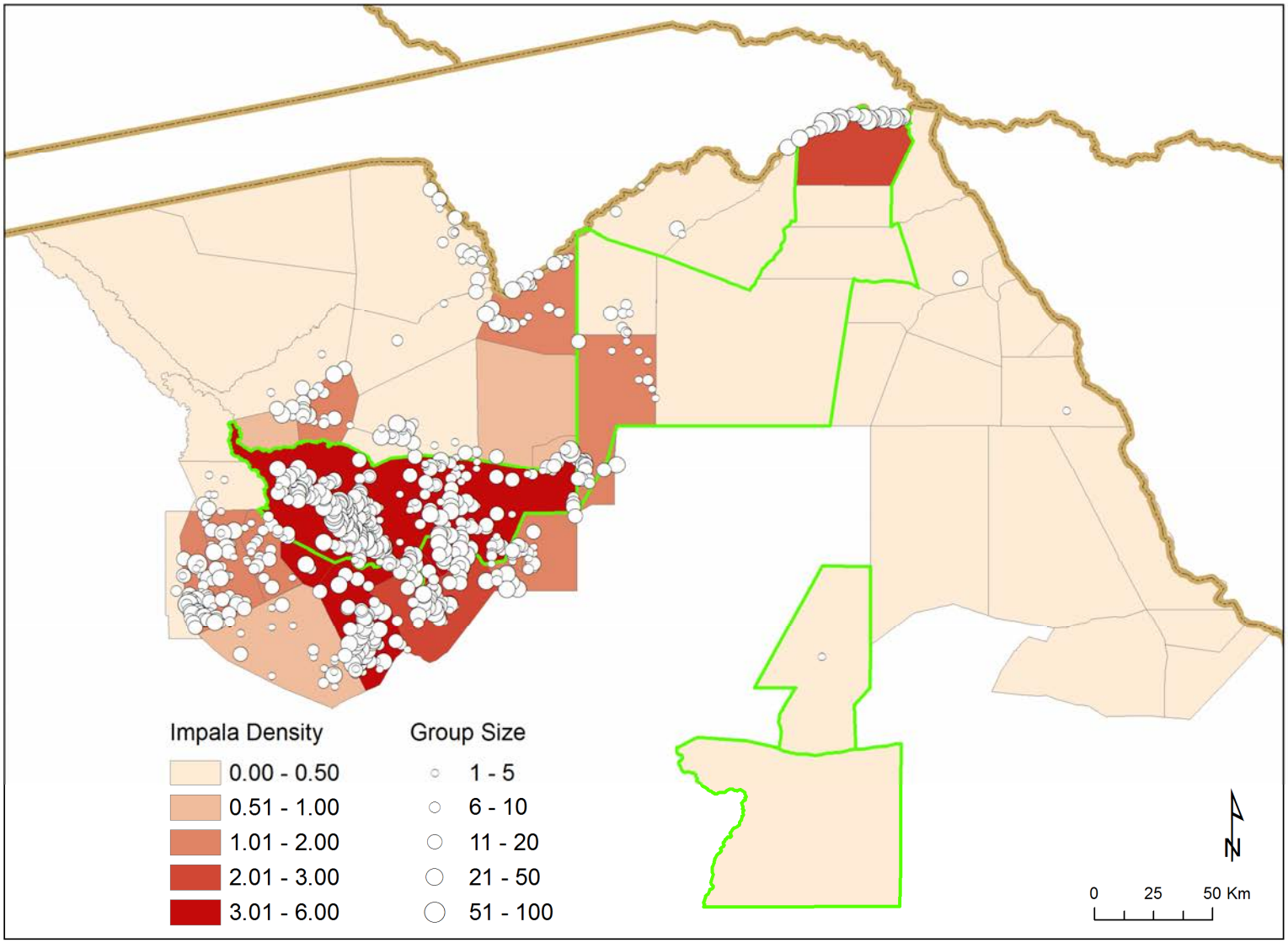


Table 19. Dry season population estimates and statistics for kudu in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	42	9	1160	70	167	9	112	0.08
NG 10 & 11	32	8	257	32	100	8	64	0.01
NG 12	53	11	1004	65	123	12	119	0.05
NG 13	83	9	2597	105	127	22	187	0.03
NG 14 Kwando								
NG 14 A	115	26	2777	108	94	26	223	0.11
NG 14 B	53	5	1283	76	143	23	129	0.03
NG 14 Subtotals	168	31	4060	128	76	38	295	0.06
NG 15 Linyanti	66	14	903	63	95	14	130	0.05
NG 16 Selinda	68	14	1336	75	110	14	142	0.05
NG 18 & 19 Khwai	76	12	820	59	78	17	136	0.04
NG 20 & 21 Splash	105	16	3035	114	109	16	220	0.05
NG 22 Vumbra	10	2	86	20	200	10	30	0.02
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS								
NG 26 A	152	61	1231	70	46	81	222	0.24
NG 26 B	119	49	685	53	45	67	172	0.17
NG 26 C	37	15	135	23	62	15	61	0.07
NG 26 Subtotals	308	125	2051	89	29	218	397	0.17
NG 27 A&B / NG30								
NG 29 Rann	162	17	7496	186	115	24	347	0.09
NG 31 & 17 Chitabe	87	18	1183	74	85	18	161	0.29
NG 32 Stanleys	80	19	1461	79	99	19	160	0.08
NG 33 & 34 Santawane	199	31	6332	173	87	26	373	0.22
WMA subtotals	1539	336	33781	361	23	1178	1900	0.05
Moremi GR NG 28	472	101	16023	252	53	219	725	0.10
Ngamiland Subtotals	**2011**	**437**	**49804**	**438**	**22**	**1572**	**2449**	**0.06**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	11	2	89	20	182	10	30	0.01
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	139	14	9083	215	155	76	355	0.10
CH 7, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	150	16	9172	190	127	40	340	0.02
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0	0	0	0	0	0	0	0.00
CNP B (Mababe-Khwai)	129	16	6344	164	127	35	293	0.07
CNP C (Chinamba)	0	0	0	0	0	0	0	0.00
CNP D (Nogatsaa)	35	4	1099	71	203	35	106	0.03
CNP E (Phofu)	31	4	850	64	206	33	95	0.04
CNP F (Chobe River)	111	24	2321	100	90	24	211	0.08
CNP NP Subtotals	306	48	10614	204	67	101	510	0.03
Chobe District Subtotals	**456**	**64**	**19786**	**277**	**61**	**178**	**733**	**0.02**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	111	11	3697	127	114	16	238	0.05
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	51	5	1549	83	163	32	134	0.02
Makgadikgadi NP								
Mak. East	28	3	683	55	196	28	83	0.01
Mak. West	141	16	3522	126	89	16	266	0.06
Makgadikgadi Subtotals	169	19	4205	132	78	37	301	0.03
Central District Subtotals	**331**	**35**	**9451**	**192**	**58**	**138**	**523**	**0.02**
Totals	**2798**	**536**	**79041**	**551**	**20**	**2246**	**3349**	**0.04**

Figure 24. Distribution and density (km^2) of kudu in northern Botswana during 2010 dry season aerial survey.

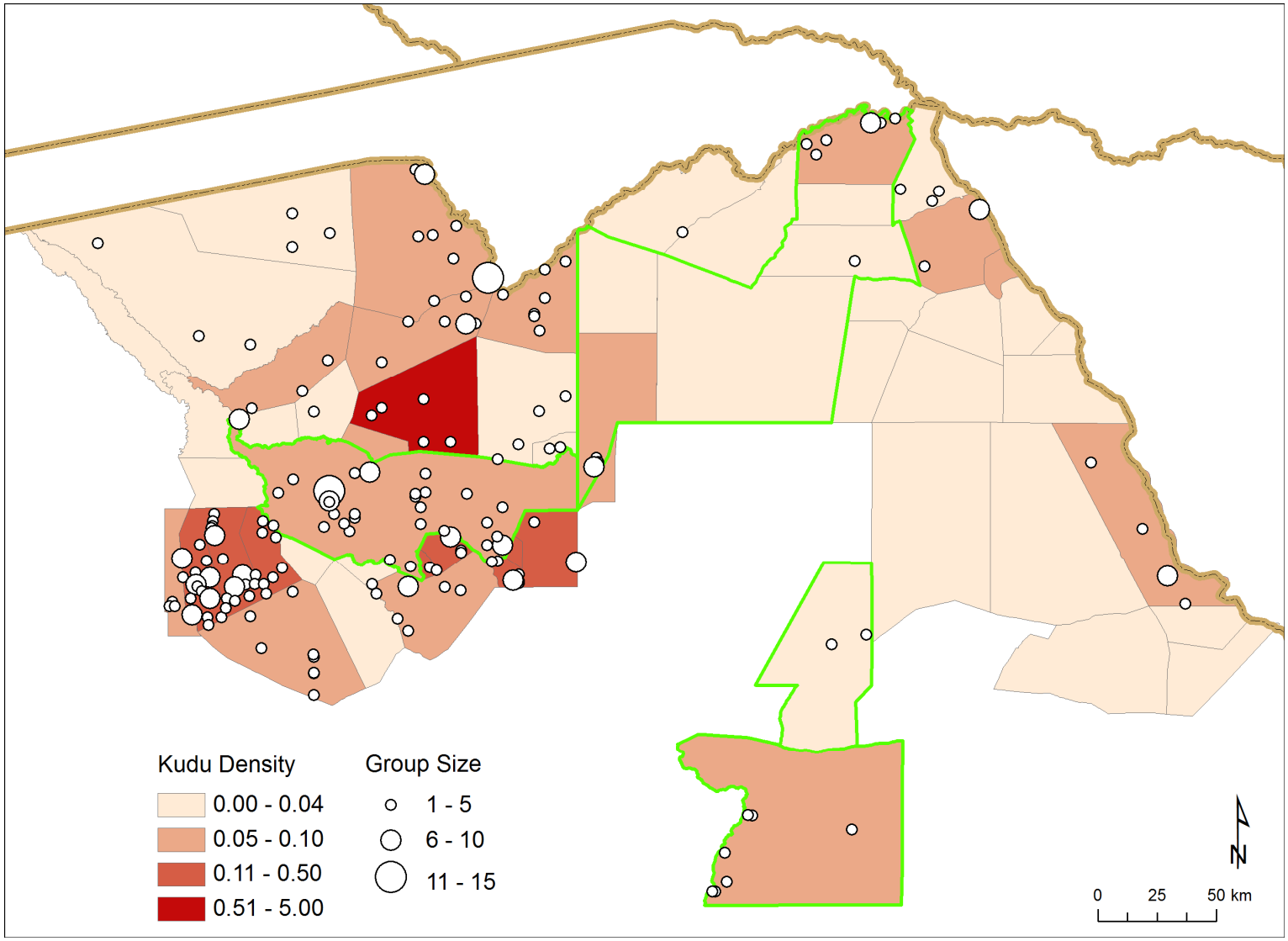


Table 20. Dry season population estimates and statistics for lechwe in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8								
NG 10 & 11								
NG 12	534	110	38512	403	75	131	937	0.49
NG 13								0.00
NG 14 Kwando								
NG 14 A	253	57	7218	174	69	78	427	0.25
NG 14 B								
NG 14 Subtotals	253	57	7218	174	69	78	427	0.09
NG 15 Linyanti	104	22	2698	109	105	22	213	0.08
NG 16 Selinda	281	58	39908	410	146	129	690	0.21
NG 18 & 19 Khwai	413	65	45839	444	108	31	857	0.21
NG 20 & 21 Splash	2623	397	450372	1392	53	1232	4015	1.20
NG 22 Vumbra	1353	243	95253	679	50	674	2032	2.22
NG 23 Duba Plains	2600	509	448365	1474	57	1126	4073	5.91
NG 24 Jedibe	1799	368	320282	1246	69	551	3043	2.37
NG 25 Jao	3552	637	439061	1431	40	2121	4984	5.76
NG 26 Abu / EBS								
NG 26 A	122	49	7562	174	143	49	296	0.19
NG 26 B	429	177	5869	154	36	275	584	0.62
NG 26 C	1444	585	34313	375	23	1068	1819	2.79
NG 26 Subtotals	1995	811	47744	432	22	1563	2427	1.08
NG 27 A&B & NG 30	1530	254	106870	675	44	855	2204	1.09
NG 29 Rann	542	57	31532	381	70	162	923	0.29
NG 31 & 17 Chitabe	670	139	51247	486	73	184	1155	2.23
NG 32 Stanleys	830	196	20905	300	36	530	1130	0.79
NG 33 & 34 Santawane	19	3	300	38	200	18	57	0.02
WMA subtotals	19098	3926	2146106	2878	15	16221	21975	0.66
Moremi GR NG 28	13744	2940	2126602	2911	21	10833	16655	2.85
Ngamiland Subtotals	**32842**	**6866**	**4272708**	**4059**	**12**	**28782**	**36901**	**0.98**

Stratum	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.	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, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	0	0	0	0	0	0	0	0.00
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	5	1	20	10	200	5	14	0.00
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)	399	86	21207	302	76	97	701	0.30
CNP NP Subtotals	404	87	21227	289	72	115	693	0.03
Chobe District Subtotals	**404**	**87**	**21227**	289	72	115	693	**0.02**
Totals	**33246**	**6953**	**4293935**	**4666**	**14**	**29179**	**37312**	**0.61**

Figure 25. Distribution and density (km^2) of lechwe in northern Botswana during 2010 dry season aerial survey.

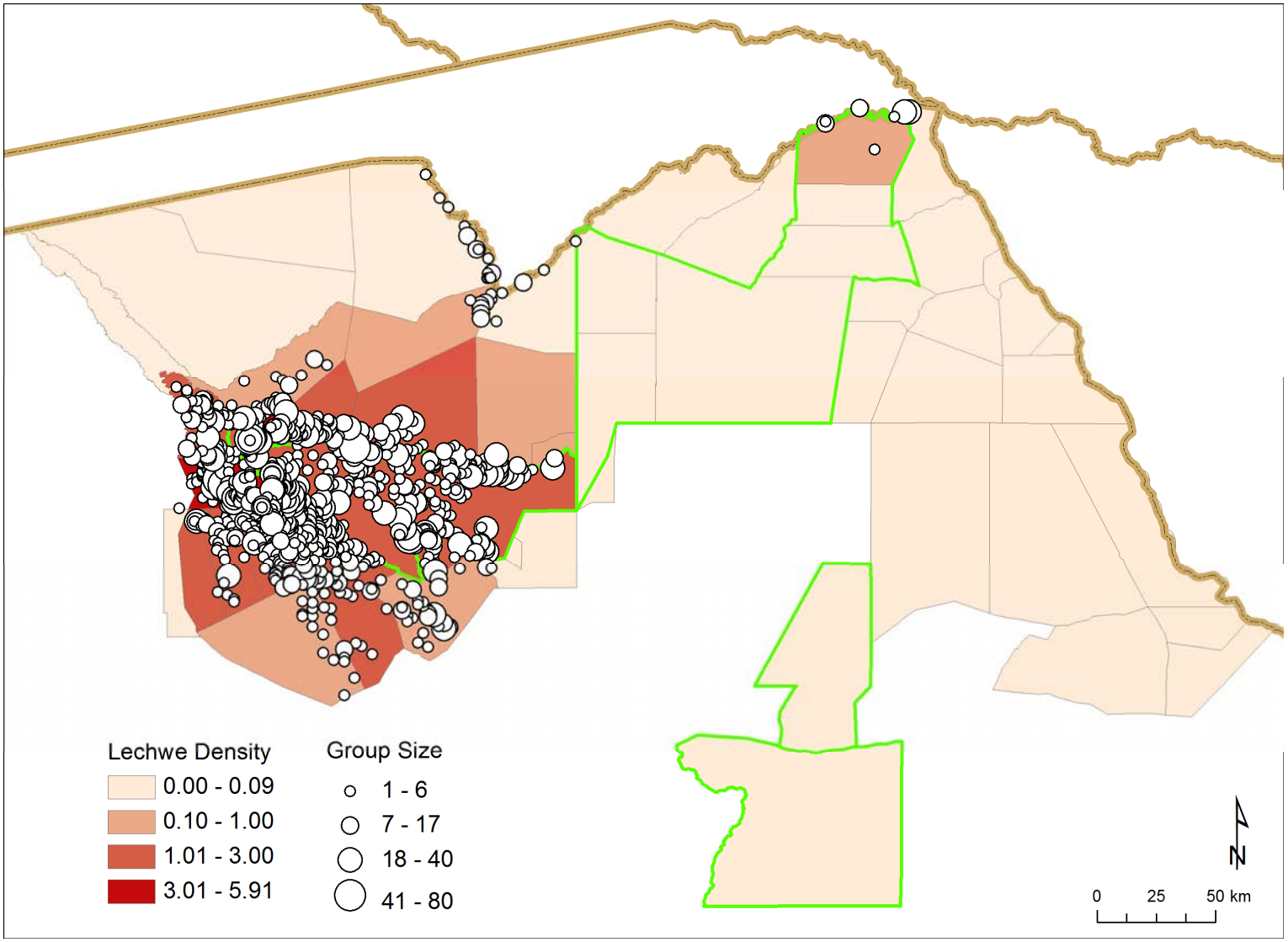


Table 21. Dry season population estimates and statistics for roan in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	0	0	0	0	0	0	0	0
NG 10 & 11	40	10	487	44	110	10	84	0.01
NG 12	0	0	0	0	0	0	0	0.00
NG 13	119	13	6104	160	134	41	279	0.05
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	0	0	0	0	0	0	0	0.00
NG 15 Linyanti	38	8	207	30	79	8	68	0.03
NG 16 Selinda								
NG 18 & 19 Khwai	89	14	2400	101	113	14	190	0.05
NG 20 & 21 Splash	20	3	333	37	185	18	57	0.01
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS								
NG 26 A	0	0	0	0	0	0	0	0.00
NG 26 B	0	0	0	0	0	0	0	0.00
NG 26 C	0	0	0	0	0	0	0	0.00
NG 26 Subtotals	0	0	0	0	0	0	0	0.00
NG 27 A&B & NG 30	0	0	0	0	0	0	0	0.00
NG 29 Rann	0	0	0	0	0	0	0	0.00
NG 31 & 17 Chitabe	0	0	0	0	0	0	0	0.00
NG 32 Stanleys	0	0	0	0	0	0	0	0.00
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA Subtotals	306	48	9531	191	62	114	497	0.01
Moremi GR NG 28	9	2	35	11	122	2	21	0.00
Ngamiland Subtotals	**315**	**50**	**9566**	**192**	**61**	**123**	**507**	**0.01**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	79	15	1507	81	103	15	160	0.07
CH 2 Chobe Forest Res								0.00
CH 4 Kasane Forest Res	5	1	20	10	200	4	15	0.01
CH 5 & 6 N Plains	20	2	157	28	140	8	48	0.01
CH 7, 8 & 13 Sibuyu	151	13	20301	295	195	144	446	0.06
CH 11 & 12 Bottle Pan								0.00
WMA & FR Subtotals	255	31	21985	294	115	40	549	0.03
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	30	6	382	41	137	11	71	0.02
CNP B (Mababe-Khwai)	8	1	58	15	188	8	24	0.00
CNP C (Chinamba)	19	1	330	43	226	24	62	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)	83	18	692	55	66	29	138	0.06
CNP NP Subtotals	140	26	1462	76	54	64	216	0.01
Chobe District Subtotals	**395**	**57**	**23447**	**301**	**76**	**93**	**696**	**0.02**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	0	0	0	0	0	0	0	0.00
Makgadikgadi NP (Mak. NP)								
Mak. NP East	0	0	0	0	0	0	0	0.00
Mak. NP West	0	0	0	0	0	0	0	0.00
Mak. NP Subtotals	0	0	0	0	0	0	0	0.00
Central District Subtotals	0	0	0	0	0	0	0	0.00
Totals	**710**	**107**	**33013**	**356**	**50**	**353**	**1066**	**0.01**

Figure 26. Distribution and density (km^2) of roan in northern Botswana during 2010 dry season aerial survey.

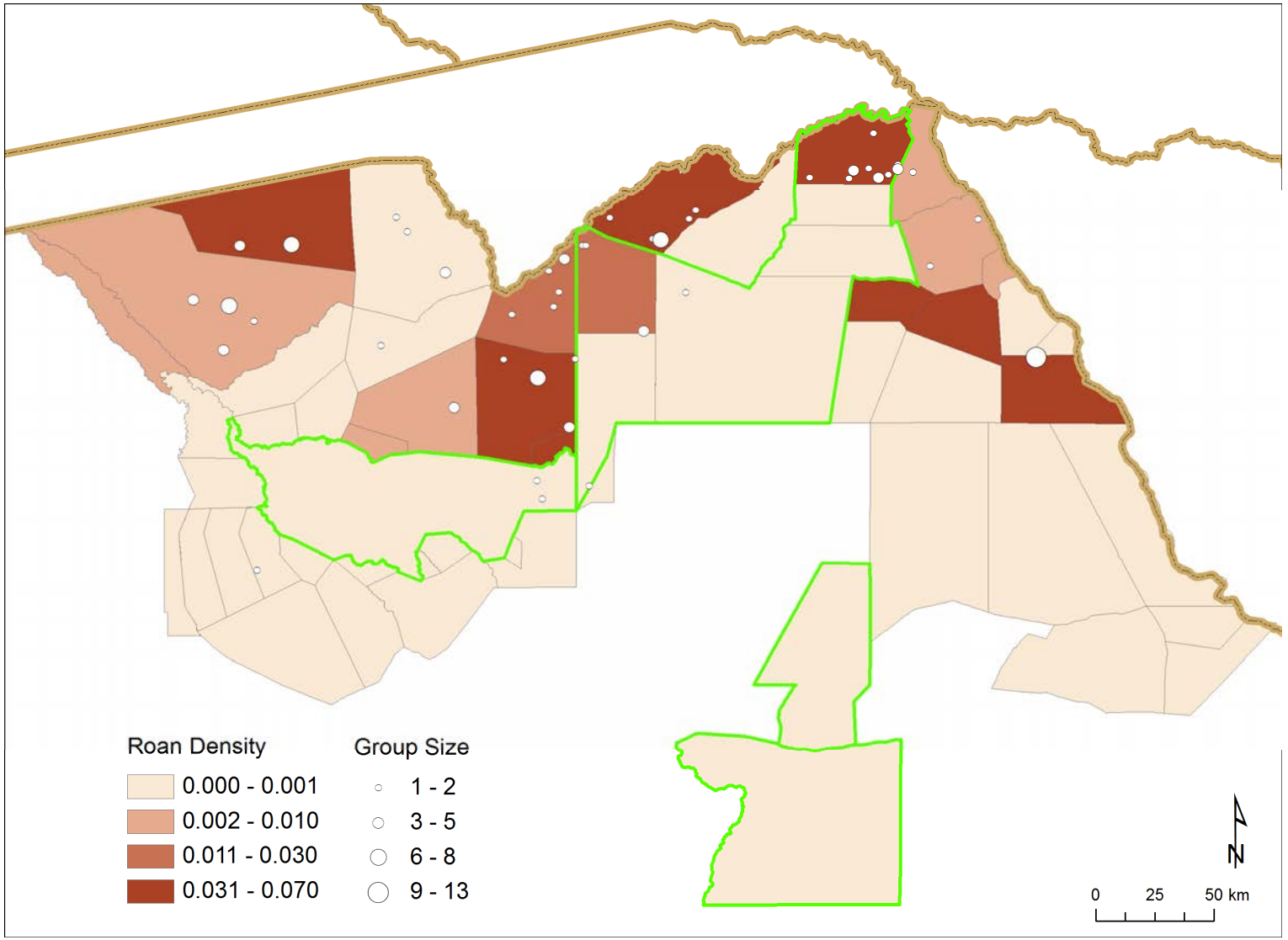


Table 22. Dry season population estimates and statistics for reedbuck in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	9	2	33	11	122	2	21	0.02
NG 10 & 11	0	0	0	0	0	0	0	0.00
NG 12	29	6	200	29	100	6	58	0.03
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	0	0	0	0	0	0	0	0.00
NG 15 Linyanti	19	4	97	21	111	4	40	0.02
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	0	0	0	0	0	0	0	0.00
NG 20 & 21 Splash	20	3	103	21	105	1	40	0.01
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	20	4	200	31	155	11	51	0.05
NG 24 Jedibe	4	1	18	9	225	5	14	0.01
NG 25 Jao	17	3	61	17	100	3	33	0.03
NG 26 Abu / EBS								
NG 26 A	22	9	68	16	73	9	40	0.03
NG 26 B	19	8	60	15	79	8	35	0.03
NG 26 C	17	7	28	10	59	7	28	0.03
NG 26 Subtotals	58	24	156	24	41	33	83	0.03
NG 27 A&B / NG 30	60	10	455	44	73	16	104	0.04
NG 29 Rann	86	9	1458	82	95	9	168	0.05
NG 31 & 17 Chitabe	0	0	0	0	0	0	0	0.00
NG 32 Stanleys	25	6	139	25	100	6	50	0.02
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA subtotals	347	72	2920	106	29	256	468	0.01
Moremi GR NG 28	201	43	2184	93	46	108	294	0.04
Ngamiland Subtotals	**548**	**115**	**5104**	**140**	**25**	**422**	**703**	**0.02**

Stratum	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	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	30	3	791	63	210	33	93	0.02
CH 7, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	30	3	791	63	210	33	93	0.00
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0	0	0	0	0	0	0	0.00
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)	0	0	0	0	0	0	0	0.00
CNP NP Subtotals	0	0	0	0	0	0	0	0.00
Chobe District Subtotals	**30**	**3**	**791**	**63**	**210**	**33**	**93**	**0.00**
Totals	**578**	**118**	**5895**	**150**		**442**	**743**	**0.01**

Figure 27. Distribution and density (km^2) of reedbuck in northern Botswana during 2010 dry season aerial survey.

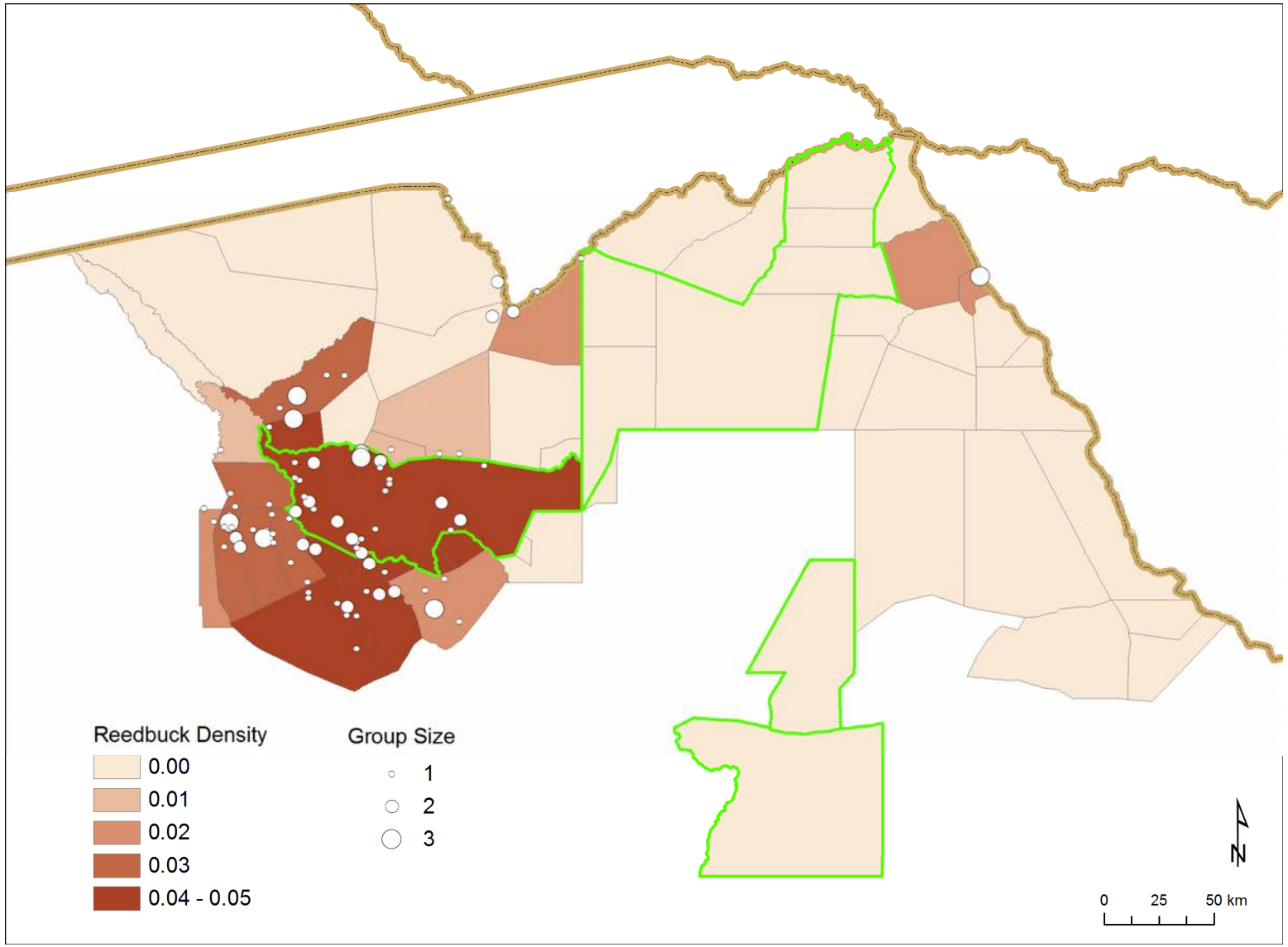


Table 23. Dry season population estimates and statistics for sable in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	0	0	0	0	0	0	0	0
NG 10 & 11	204	51	11400	213	104	51	418	0.04
NG 12	92	19	3269	118	128	26	210	0.08
NG 13	0	0	0	0	0	0	0	0
NG 14 Kwando								
NG 14 A	192	43	24442	320	166	128	513	0.19
NG 14 B	211	20	13049	243	115	32	454	0.11
NG 14 Subtotals	403	63	37491	390	97	63	793	0.14
NG 15 Linyanti	138	29	8737	196	142	59	334	0.11
NG 16 Selinda	111	23	4398	136	123	24	247	0.08
NG 18 & 19 Khwai	178	28	232	316	178	138	494	0.09
NG 20 & 21 Splash	185	28	24817	327	177	142	512	0.08
NG 22 Vumbra	175	34	4795	152	87	22	327	0.29
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS								
NG 26 A								
NG 26 B								
NG 26 C								
NG 26 Subtotals	0	0	0	0	0	0	0	0
NG 27 A&B & NG 30	0	0	0	0	0	0	0	0
NG 29 Rann	0	0	0	0	0	0	0	0
NG 31 & 17 Chitabe	0	0	0	0	0	0	0	0
NG 32 Stanleys	0	0	0	0	0	0	0	0
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0
WMA subtotals	1486	275	95139	606	41	881	2092	0.05
Moremi GR NG 28	32	7	851	58	181	25	91	0.01
Ngamiland Subtotals	**1518**	**282**	**95990**	**608**	**40**	**909**	**2126**	**0.05**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	352	67	40219	420	119	68	772	0.30
CH 2 Chobe Forest Res.	20	3	97	20	100	3	41	0.01
CH 4 Kasane Forest Res.	489	94	20930	304	62	185	793	0.82
CH 5 & 6 N. Plains	99	10	5097	161	163	61	261	0.07
CH 7, 8 & 13 Sibuyu	383	33	59020	503	131	120	886	0.15
CH 11 & 12 Bottle Pan	11	1	102	21	191	11	32	0.00
WMA & FR Subtotals	1354	208	125465	702	52	652	2056	0.14
Chobe NP (CH3)								
CNP A (Linyanti-Savute)	124	25	11275	221	178	96	345	0.09
CNP B (Mababe-Khwai)	0	0	0	0	0	0	0	0.00
CNP C (Chinamba)	19	1	330	43	226	24	62	0.00
CNP D (Nogatsaa)	79	9	2423	105	133	25	184	0.06
CNP E (Phofu)	8	1	52	16	200	8	24	0.01
CNP F (Chobe River)	547	118	20920	300	55	247	848	0.41
CNP NP Subtotals	777	154	35000	370	48	406	1147	0.07
Chobe District Subtotals	**2131**	**362**	**160465**	**789**	**37**	**1341**	**2920**	**0.10**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	0	0	0	0	0	0	0	0.00
Makgadikgadi NP								
Mak. East	0	0	0	0	0	0	0	0.00
Mak. West	0	0	0	0	0	0	0	0.00
Makgadikgadi Subtotals	0	0	0	0	0	0	0	0.00
Central District Subtotals	0	0	0	0	0	0	0	0.00
Totals	**3649**	**644**	**256455**	**994**	**27**	**2655**	**4643**	**0.07**

Figure 28. Distribution and density (km^2) of sable in northern Botswana during 2010 dry season aerial survey.

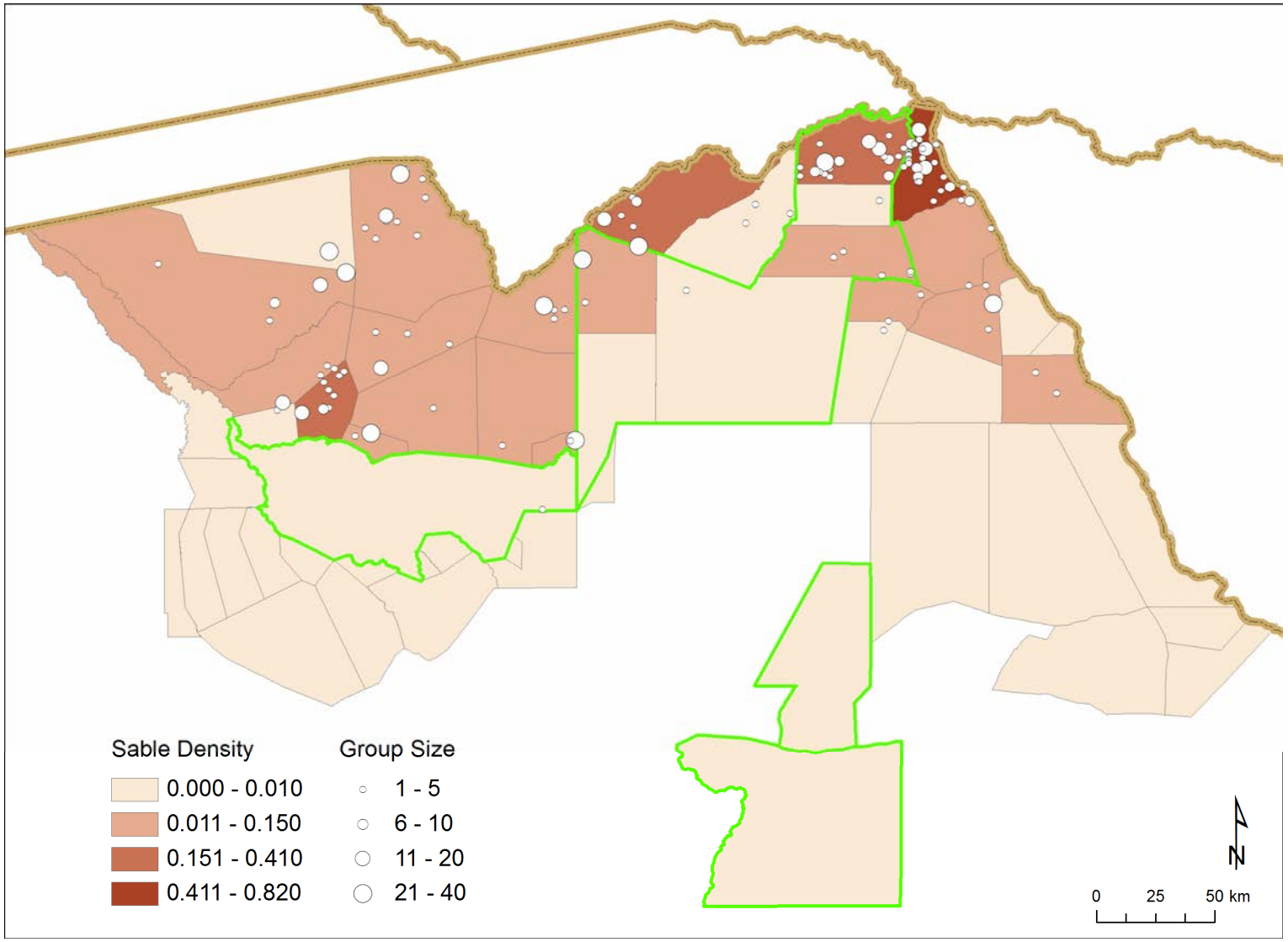


Table 24. Dry season population estimates and statistics for tsessebe in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	0	0	0	0	0	0	0	0.00
NG 10 & 11	0	0	0	0	0	0	0	0.00
NG 12	73	15	3127	115	158	42	188	0.07
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando	0	0	0	0	0	0	0	0.00
NG 14 A	80	18	1396	76	95	18	157	0.08
NG 14 B	32	3	208	30	94	3	62	0.02
NG 14 Subtotals	112	21	1604	80	71	31	193	0.04
NG 15 Linyanti	19	4	172	27	142	9	46	0.02
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	6	1	34	12	200	6	18	0.00
NG 20 & 21 Splash	324	49	12691	233	72	90	557	0.15
NG 22 Vumbra	206	40	6169	173	84	33	379	0.34
NG 23 Duba Plains	87	17	1319	80	92	17	167	0.20
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS	0	0	0	0	0	0	0	0.00
NG 26 A	102	41	856	58	57	43	161	0.16
NG 26 B	107	42	1176	69	64	42	176	0.16
NG 26 C	69	28	320	36	52	33	105	0.13
NG 26 Subtotals	278	111	2352	95	34	182	374	0.15
NG 27 A&B / NG 30	367	61	19933	291	79	76	659	0.26
NG 29 Rann	143	15	19165	297	208	154	440	0.08
NG 31 & 17 Chitabe	149	31	4767	148	99	31	297	0.50
NG 32 Stanleys	76	18	1332	76	100	18	152	0.07
NG 33 & 34 Santawane	26	4	231	33	127	7	59	0.03
WMA subtotals	1866	387	72896	530	28	1336	2396	0.06
Moremi GR NG 28	374	80	8416	183	49	191	557	0.08
Ngamiland Subtotals	**2240**	**467**	**81312**	**560**	**25**	**1680**	**2800**	**0.07**

Stratum	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.	0	0	0	0	0	0	0	0.00
CH 4 Kasane Forest Res.	26	5	547	49	188	23	75	0.04
CH 5 & 6 N Plains	438	44	196038	1001	229	563	1439	0.31
CH 7, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	464	49	196585	878	189	414	1343	0.05
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	15	3	176	27	180	13	43	0.01
CNP B (Mababe-Khwai)	121	15	9267	199	164	78	320	0.06
CNP C (Chinamba)	56	3	2973	129	230	73	185	0.01
CNP D (Nogatsaa)	238	27	49498	474	199	236	712	0.18
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	32	7	827	60	188	27	92	0.02
CNP NP Subtotals	462	55	62741	496	107	35	959	0.04
Chobe District Subtotals	**926**	**104**	**259326**	**1003**	**108**	**104**	**1929**	**0.04**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	0	0	0	0	0	0	0	0.00
Makgadikgadi NP (Mak. NP)								
Mak. NP East	0	0	0	0	0	0	0	0.00
Mak. NP West	0	0	0	0	0	0	0	0.00
Mak. NP Subtotals	0	0	0	0	0	0	0	0.00
Central District Subtotals	0	0	0	0	0	0	0	0.00
Totals	**3166**	**571**	**340638**	**1145**	**36**	**2020**	**4311**	**0.04**

Figure 29. Distribution and density (km^2) of tsessebe in northern Botswana during 2010 dry season aerial survey.

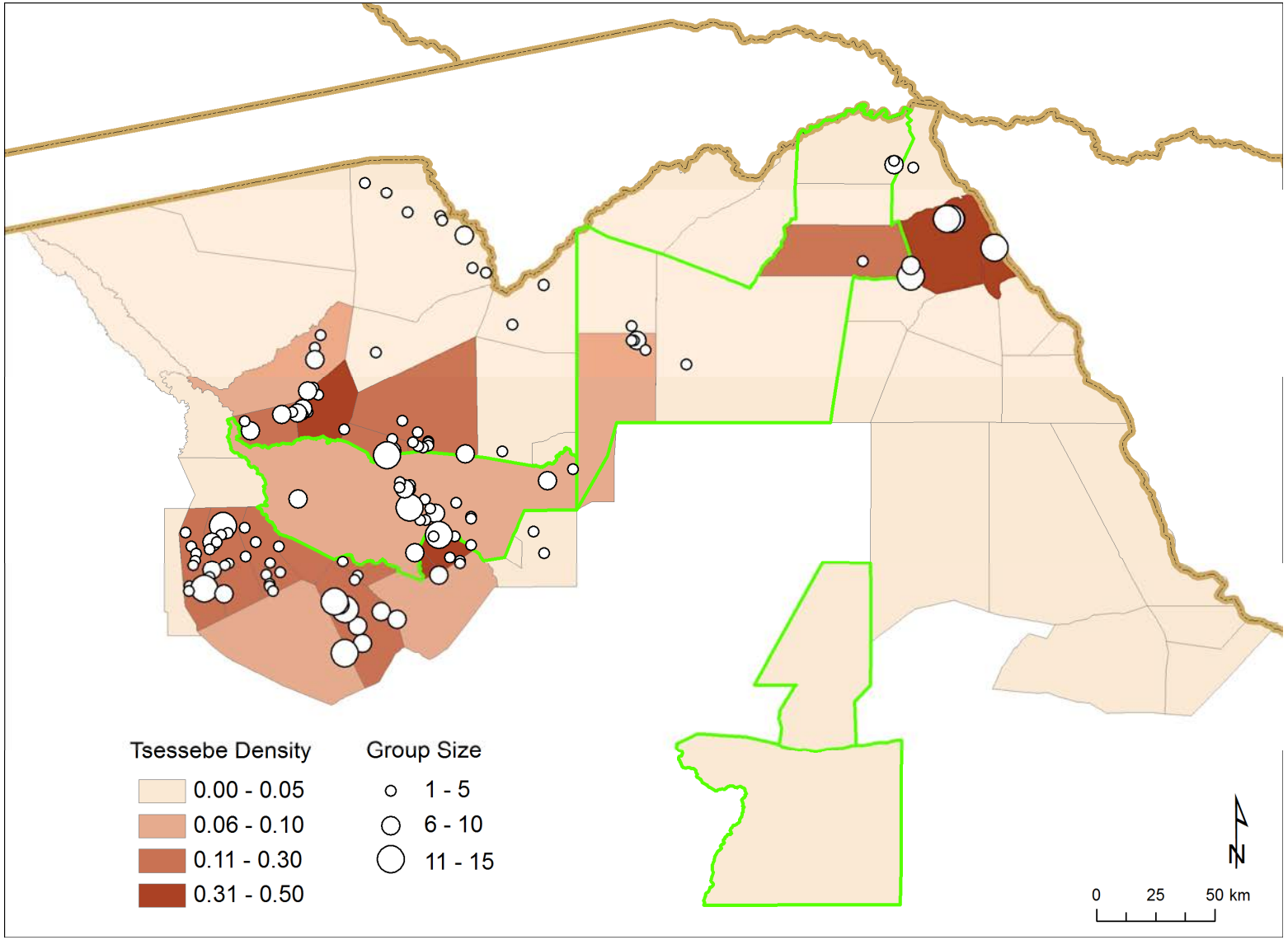


Table 25. Dry season population estimates and statistics for warthog in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	0	0	0	0	0	0	0	0.00
NG 10 & 11	48	12	542	46	96	12	95	0.01
NG 12	83	17	2100	95	114	17	177	0.08
NG 13	73	8	4617	139	190	66	213	0.03
NG 14 Kwando								
NG 14 A	89	20	1305	74	83	20	162	0.09
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	89	20	1305	74	83	20	162	0.03
NG 15 Linyanti	81	17	1016	67	83	17	148	0.07
NG 16 Selinda	75	15	777	57	76	15	130	0.06
NG 18 & 19 Khwai	19	3	306	36	189	17	55	0.01
NG 20 & 21 Splash	73	11	1322	75	103	11	148	0.03
NG 22 Vumbra	46	9	482	48	104	9	94	0.08
NG 23 Duba Plains	66	13	529	50	76	15	117	0.15
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	78	14	1120	72	92	14	150	0.13
NG 26 Abu / EBS								
NG 26 A	80	30	290	34	43	45	114	0.12
NG 26 B	39	16	100	20	51	19	59	0.06
NG 26 C	12	5	37	12	100	5	24	0.02
NG 26 Subtotals	131	51	427	41	31	90	171	0.07
NG 27 A&B / NG 30								
NG 29 Rann	247	26	11669	232	94	26	429	0.13
NG 31 & 17 Chitabe	39	8	335	39	100	8	78	0.13
NG 32 Stanleys	114	27	900	63	55	52	176	0.11
NG 33 & 34 Santawane	39	6	697	57	146	19	96	0.04
WMA Subtotals	1301	257	28144	329	25	971	1630	0.05
Moremi GR NG 28	650	139	37218	385	59	264	1035	0.13
Ngamiland Subtotals	**1951**	**396**	**65362**	**502**	**26**	**1448**	**2543**	**0.06**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	84	16	583	51	61	33	135	0.07
CH 2 Chobe Forest Res.	20	3	191	30	150	9	49	0.01
CH 4 Kasane Forest Res.	0	0	0	0	0	0	0	0.00
CH 5 & 6 N Plains	40	4	603	55	138	15	95	0.03
CH 7, 8 & 13 Sibuyu	46	4	1258	73	159	27	120	0.02
CH 11 & 12 Bottle Pan	43	4	764	59	137	16	102	0.02
WMA & FR Subtotals	233	31	3399	115	49	117	348	0.02
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	40	8	312	37	93	8	77	0.03
CNP B (Mababe-Khwai)	613	76	30215	359	59	254	971	0.31
CNP C (Chinamba)	56	3	1426	89	159	33	146	0.01
CNP D (Nogatsaa)	18	2	125	24	133	6	41	0.01
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	135	29	2744	108	80	29	243	0.10
CNP NP Subtotals	862	118	34822	370	43	492	1232	0.07
Chobe District Subtotals	**1095**	**149**	**38221**	**385**	**35**	**709**	**1480**	**0.05**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	0	0	0	0	0	0	0	0.00
Makgadikgadi NP (Mak. NP)								
Mak. NP East	0	0	0	0	0	0	0	0.00
Mak. NP West	0	0	0	0	0	0	0	0.00
Mak. NP Subtotals	0	0	0	0	0	0	0	0.00
Central District Subtotals	0	0	0	0	0	0	0	0.00
Totals	**3046**	**545**	**103583**	**631**	**21**	**2414**	**3677**	**0.04**

Figure 30. Distribution and density (km^2) of warthog in northern Botswana during 2010 dry season aerial survey.

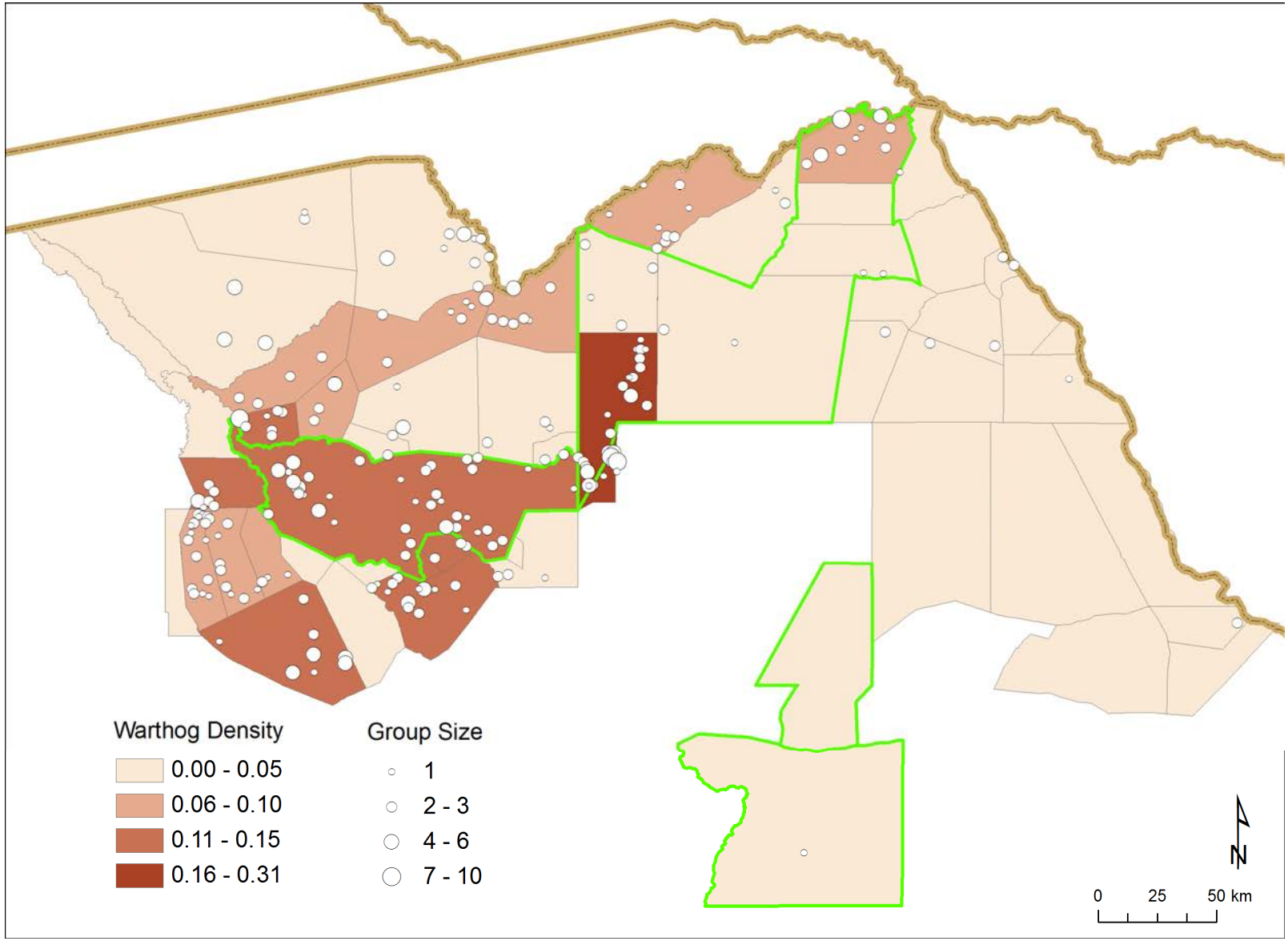


Table 26. . Dry season population estimates and statistics for wildebeest in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	0	0	0	0	0	0	0	0.00
NG 10 & 11	0	0	0	0	0	0	0	0.00
NG 12	29	6	348	38	131	9	68	0.03
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	355	80	16320	262	74	92	617	0.35
NG 14 B	0	0	0	0	0	0	0	
NG 14 Subtotals	355	80	16320	262	74	92	617	0.12
NG 15 Linyanti	180	38	13791	247	137	66	427	0.15
NG 16 Selinda	111	23	5168	147	132	36	258	0.08
NG 18 & 19 Khwai	0	0	0	0	0	0	0	0.00
NG 20 & 21 Splash	125	19	3964	130	104	19	256	0.06
NG 22 Vumbra	26	5	273	36	138	11	62	0.04
NG 23 Duba Plains	5	1	20	9	180	5	15	0.01
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	33	6	907	65	197	32	98	0.05
NG 26 Abu / EBS								
NG 26 A	80	30	1026	64	80	30	144	0.12
NG 26 B	44	18	1020	64	145	18	108	0.06
NG 26 C	27	9	361	38	141	11	65	0.05
NG 26 Subtotals	151	57	2407	97	64	57	248	0.08
NG 27 A&B & NG 30	253	42	39050	408	161	155	661	0.18
NG 29 Rann	171	18	24374	335	196	164	506	0.09
NG 31 & 17 Chitabe	140	29	6182	169	121	29	308	0.47
NG 32 Stanleys	275	65	7894	184	67	91	459	0.26
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA Subtotals	1854	389	120698	682	37	1172	2536	0.06
Moremi GR NG 28	131	28	3215	113	86	28	244	0.03
Ngamiland Subtotals	**1985**	**417**	**123913**	**691**	**35**	**1293**	**2676**	**0.06**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	5	1	22	10	200	5	15	0.00
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	20	2	157	28	140	8	48	0.01
CH 7, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	25	3	179	26	104	3	51	0.00
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	110	22	7843	184	167	75	294	0.08
CNP B (Mababe-Khwai)	339	42	48049	452	133	114	791	0.17
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)	51	11	1177	71	139	20	122	0.04
CNP NP Subtotals	500	75	57069	474	95	75	974	0.04
Chobe District Subtotals	**525**	**78**	**57248**	**471**	**90**	**53**	**996**	**0.02**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 Sepako	71	15	3926	131	185	61	202	0.09
Nxai Pan NP	72	7	4544	142	197	70	214	0.03
Makgadikgadi NP (Mak. NP)								
Mak. NP East	2418	262	1769131	2819	117	401	5238	0.90
Mak. NP West	26	3	585	51	196	25	78	0.01
Mak. NP Subtotals	2444	265	1769716	2709	111	265	5153	0.50
Central District Subtotals	**2587**	**287**	**1778186**	**2641**	**101**	**287**	**5224**	**0.14**
Totals	**5097**	**782**	**1959347**	**2747**	**54**	**2349**	**7844**	**0.07**

Figure 31. Distribution and density (km^2) of wildebeest in northern Botswana during 2010 dry season aerial survey.

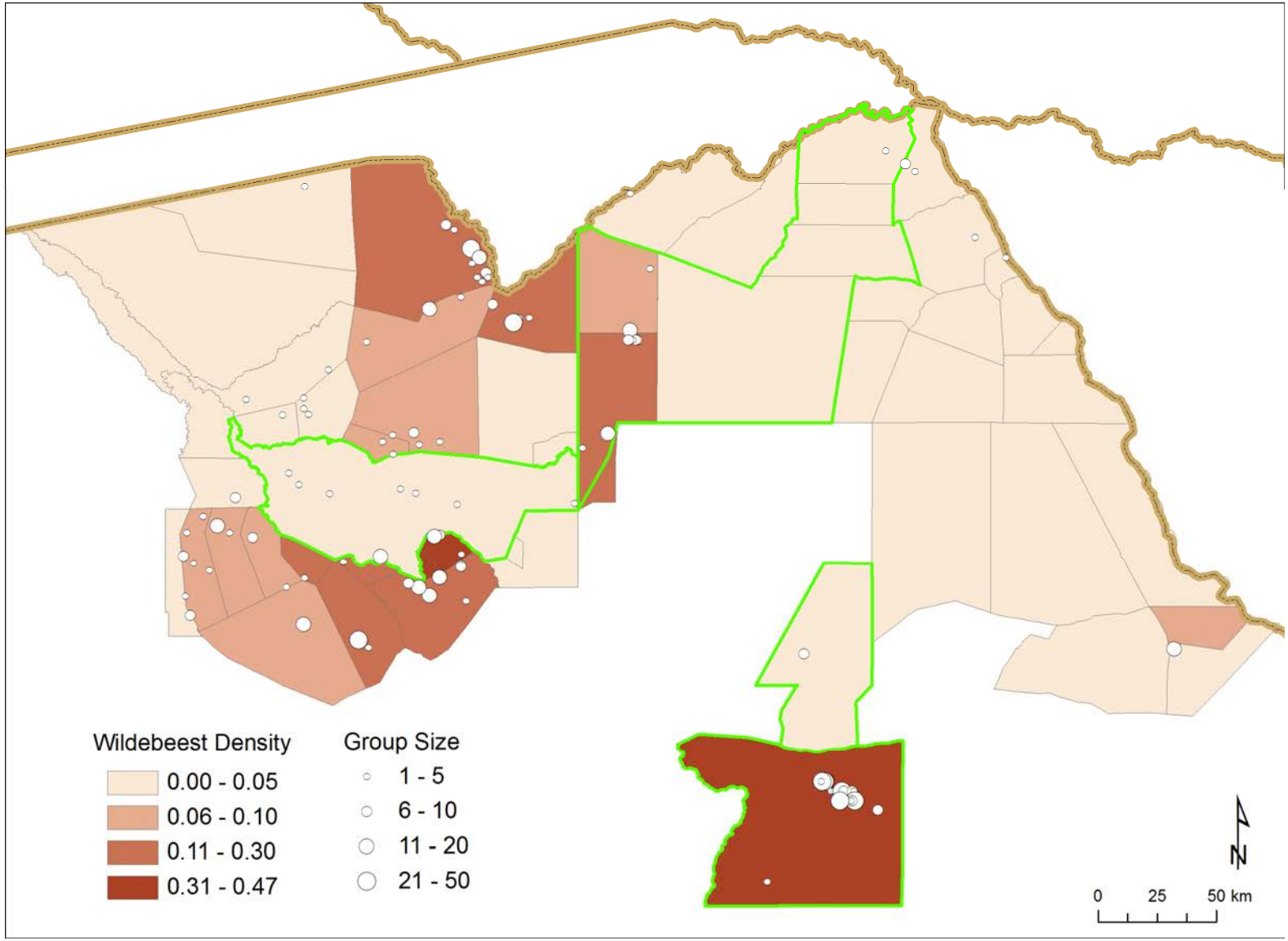


Table 27. Dry season population estimates and statistics for zebra in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	2093	441	386912	1276	61	817	3370	3.91
NG 10 & 11	132	33	3089	111	84	33	243	0.03
NG 12	894	184	48388	454	51	440	1348	0.82
NG 13	248	27	22456	307	124	60	555	0.10
NG 14 Kwando								
NG 14 A	426	95	19679	288	68	138	714	0.42
NG 14 B	235	22	9598	208	89	26	444	0.13
NG 14 Subtotals	661	117	29277	345	52	315	1006	0.23
NG 15 Linyanti	546	115	34353	389	71	157	935	0.44
NG 16 Selinda	135	28	4991	144	107	28	280	0.10
NG 18 & 19 Khwai	140	22	4328	136	97	22	276	0.07
NG 20 & 21 Splash	813	123	135728	764	94	123	1576	0.37
NG 22 Vumbra	67	13	3174	124	185	57	190	0.11
NG 23 Duba Plains	291	57	41991	451	155	160	742	0.66
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	223	40	20810	311	139	88	535	0.36
NG 26 Abu / EBS								
NG 26 A	1031	413	54089	467	45	564	1498	1.60
NG 26 B	161	66	1233	70	43	74	232	0.23
NG 26 C	111	45	1688	83	75	28	194	0.21
NG 26 Subtotals	1303	524	57010	472	36	831	1775	0.70
NG 27 A&B & NG 30	813	135	125782	732	90	135	1545	0.58
NG 29 Rann	571	60	43534	448	78	123	1018	0.30
NG 31 & 17 Chitabe	130	27	5242	155	119	27	285	0.43
NG 32 Stanleys	783	185	30385	361	46	422	1144	0.75
NG 33 & 34 Santawane	148	23	4090	139	94	23	287	0.16
WMA subtotals	9991	2154	1001540	1965	20	8025	11965	0.35
Moremi GR NG 28	1435	307	1257244	708	49	727	2143	0.30
Ngamiland Subtotals	**11426**	**2461**	**2258784**	**2951**	**26**	**8474**	**14377**	0.34

CHOBE (CH) District								
CH 1 Chobe Enclave	3125	595	1496333	2560	82	565	5685	2.67
CH 2 Chobe Forest Res	1485	219	1853358	2849	192	1363	4335	1.04
CH 4 Kasane Forest Res	21	4	326	38	181	17	59	0.04
CH 5 & 6 N Plains	40	4	1456	86	215	46	126	0.03
CH 7, 8 & 13 Sibuyu	696	60	58889	503	72	193	1199	0.27
CH 11 & 12 Bottle Pan	43	4	1742	89	207	46	132	0.02
WMA & FR Subtotals	5410	886	3412104	3661	68	1748	9071	0.56
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0	0	0	0	0	0	0	0.00
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)	2472	533	789560	1842	75	629	4315	1.87
CNP NP Subtotals	2472	533	789560	1842	75	629	4315	0.21
Chobe District Subtotals	**7882**	**1419**	**4201664**	**4040**	**51**	**3841**	**11922**	**0.37**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	0	0	0	0	0	0	0	0.00
Makgadikgadi NP (Mak. NP)								
Mak. NP East	18463	2000	61994981	16691	90	1771	35154	6.86
Mak. NP West	3287	374	1922411	2939	89	374	6226	1.48
Mak. NP Subtotals	21750	2374	63917392	16284	75	5465	38034	4.42
Central District Subtotals	**21750**	**2374**	**63917392**	**16284**	**75**	**5465**	**38034**	**1.17**
Totals	**41058**	**6254**	**70377840**	**16463**	**40**	**24954**	**57521**	**0.56**

Figure 32. Distribution and density (km^2) of zebra in northern Botswana during 2010 dry season aerial survey.

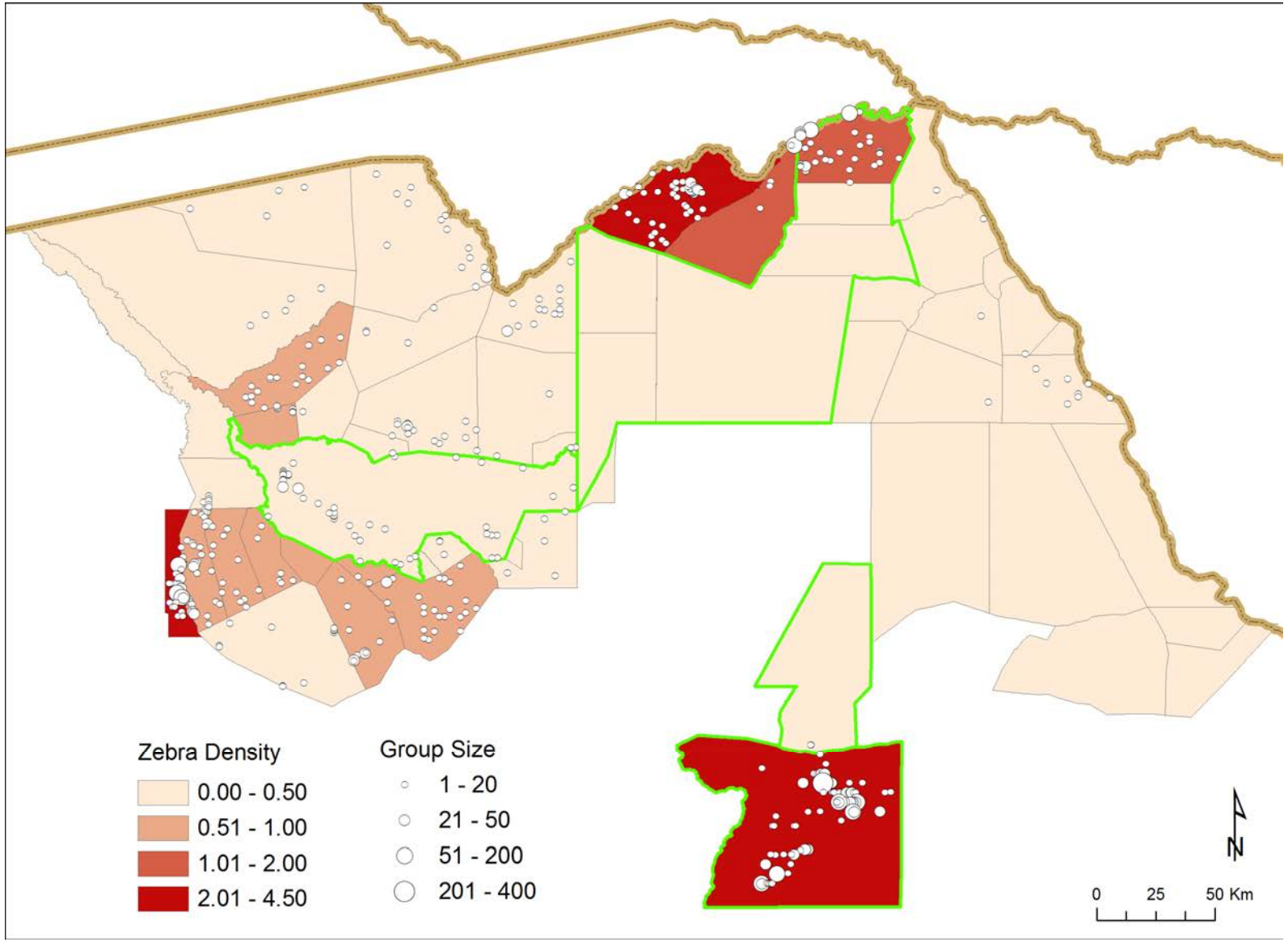


Table 28. Dry season population estimates and statistics for hartebeest in Makgadikgadi NP, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CENTRAL (CT) District								
Makgadikgadi NP (CT 9)								
Mak. East	590	64	96163	657	111	66	1248	0.22
Mak. West	44	5	1100	70	159	26	114	0.02
Makgadikgadi NP Subtotals	634	69	97263	635	100	69	1269	0.13
Totals	**634**	**69**	**97263**	**635**	**100**	**69**	**1269**	**0.06**

No hartebeest were seen within the survey area of Ngamiland and Chobe districts.

Table 29. Dry season population estimates and statistics for springbok in Makgadikgadi NP, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CENTRAL (CT) District								
Nxai Pan NP	967	94	813287	1902	197	935	2869	0.37
Makgadikgadi NP								
Mak. East	572	62	137567	786	137	214	1359	0.21
Mak. West	26	3	600	52	200	26	78	0.01
Makgadikgadi Subtotals	**598**	**65**	**138167**	**757**	**127**	**159**	**1355**	0.12
Totals	**1565**	**159**	**951454**	**1914**	**122**	**350**	**3479**	**0.13**

Table 30. Dry season population estimates and statistics for sitatunga in Okavango Delta, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	0	0	0	0	0	0	0	0.00
NG 10 & 11	24	6	213	29	121	6	53	0.005
NG 12	0	0	0	0	0	0	0	0.00
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	0	0	0	0	0	0	0	0.00
NG 15 Linyanti	0	0	0	0	0	0	0	0.00
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	0	0	0	0	0	0	0	0.00
NG 20 & 21 Splash	0	0	0	0	0	0	0	0.00
NG 22 Vumbra	10	2	84	20	200	10	30	0.016
NG 23 Duba Plains	10	2	37	13	130	3	23	0.023
NG 24 Jedibe	190	39	2532	111	58	80	301	0.251
NG 25 Jao	100	18	751	59	59	41	160	0.162
NG 26 Abu / EBS								
NG 26 A	0	0	0	0	0	0	0	0.00
NG 26 B	0	0	0	0	0	0	0	0.00
NG 26 C	0	0	0	0	0	0	0	0.00
NG 26 Subtotals	0	0	0	0	0	0	0	0.00
NG 27 A&B / NG30	0	0	0	0	0	0	0	0.00
NG 29 Rann	0	0	0	0	0	0	0	0.00
NG 31 & 17 Chitabe	0	0	0	0	0	0	0	0.00
NG 32 Stanleys	0	0	0	0	0	0	0	0.00
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA subtotals	334	67	3617	118	35	216	452	0.012
Moremi GR NG 28	89	19	938	61	69	28	150	0.018
Ngamiland Subtotals	423	86	4555	132	31	290	555	0.013
Totals	**423**	**86**	**4555**	**132**	**31**	**290**	**555**	**0.013**

Table 31. Dry season population estimates and statistics for waterbuck in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	0	0	0	0	0	0	0	0.00
NG 10 & 11	0	0	0	0	0	0	0	0.00
NG 12	39	8	635	52	133	13	91	0.04
NG 14 Kwando								
NG 15 Linyanti	76	16	2617	107	141	32	183	0.06
NG 16 Selinda								
NG 18 & 19 Khwai	0	0	0	0	0	0	0	0.00
NG 20 & 21 Splash	0	0	0	0	0	0	0	0.00
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS								
NG 27 A&B & NG 30	6	1	29	11	183	5	17	0.00
NG 29 Rann	0	0	0	0	0	0	0	0.00
NG 31 & 17 Chitabe	29	6	630	54	186	25	83	0.10
NG 32 Stanleys	4	1	13	8	200	4	12	0.00
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA Subtotals	154	32	3924	123	80	32	277	0.01
Moremi GR NG 28	70	15	1275	71	101	15	141	0.01
Ngamiland Subtotals	**224**	**47**	**5199**	**141**	**63**	**82**	**365**	**0.01**
CHOBE District								
CH 1 Chobe Enclave	5	1	22	10	200	5	15	0.00
CH 2 Chobe Forest Res.	142	21	18680	286	201	143	428	0.10
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, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	147	22	18702	271	184	124	418	0.02
Chobe NP (CH3)								
CNP A (Linyanti-Savute)	35	7	1038	67	191	32	102	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)	0	0	0	0	0	0	0	0.00
CNP NP Subtotals	35	7	1038	67	191	32	102	0.00
Chobe District Subtotals	**182**	**29**	**19740**	**276**	**152**	**94**	**458**	**0.01**
Totals	**406**	**76**	**24939**	**310**	**76**	**96**	**716**	**0.01**

Figure 33. Distribution of hartebeest, reedbuck, sitatunga, springbok and waterbuck in northern Botswana during 2010 dry season aerial survey.

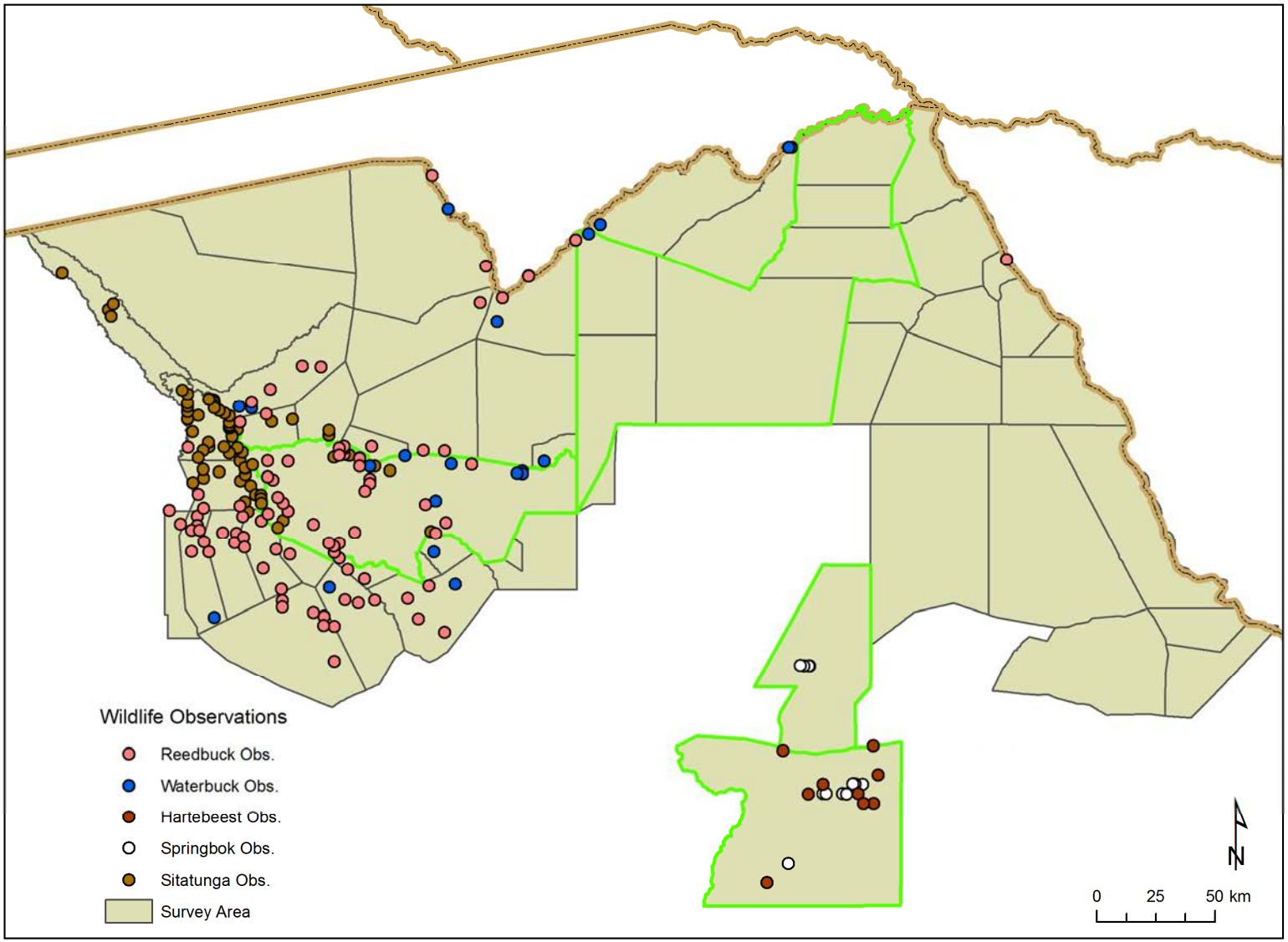


Table 32. Dry season population estimates and statistics for ostrich in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	261	55	6256	162	62	99	423	0.488
NG 10 & 11	12	3	59	15	125	4	27	0.002
NG 12	0	0	0	0	0	0	0	0.000
NG 13	0	0	0	0	0	0	0	0.000
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.000
NG 14 B	0	0	0	0	0	0	0	0.000
NG 14 Subtotals	0	0	0	0	0	0	0	0.000
NG 15 Linyanti	43	9	925	64	149	21	107	0.035
NG 16 Selinda	0	0	0	0	0	0	0	0.000
NG 18 & 19 Khwai	0	0	0	0	0	0	0	0.000
NG 20 & 21 Splash	6	1	39	13	217	6	19	0.003
NG 22 Vumbra	5	1	22	10	200	5	15	0.008
NG 23 Duba Plains	0	0	0	0	0	0	0	0.000
NG 24 Jedibe	0	0	0	0	0	0	0	0.000
NG 25 Jao	0	0	0	0	0	0	0	0.000
NG 26 Abu / EBS								
NG 26 A	74	30	1010	64	86	30	188	0.115
NG 26 B	7	3	17	8	114	3	15	0.010
NG 26 C	16	2	31	20	125	2	36	0.031
NG 26 Subtotals	97	35	1058	64	66	35	161	0.052
NG 27 A&B / NG 30	0	0	0	0	0	0	0	0.000
NG 29 Rann	0	0	0	0	0	0	0	0.000
NG 31 & 17 Chitabe	10	2	82	20	200	10	29	0.033
NG 32 Stanleys	30	7	346	39	130	9	68	0.029
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.000
WMA subtotals	464	113	8787	184	40	280	648	0.016
Moremi GR NG 28	33	7	175	26	79	7	59	0.007
Ngamiland Subtotals	**497**	**120**	**8962**	**186**	**37**	**311**	**783**	**0.015**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	68	13	1597	84	124	15	152	0.058
CH 2 Chobe Forest Res.	0	0	0	0	0	0	0	0.000
CH 4 Kasane Forest Res.	5	1	20	10	200	4	15	0.008
CH 5 & 6 N Plains	80	8	4119	145	181	65	224	0.057
CH 7, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.000
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.000
WMA & FR Subtotals	153	22	5736	150	98	22	303	0.016
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	5	1	20	10	200	5	14	0.004
CNP B (Mababe-Khwai)	165	12	2572	104	63	13	209	0.085
CNP C (Chinamba)	0	0	0	0	0	0	0	0.000
CNP D (Nogatsaa)	18	2	125	24	133	6	42	0.013
CNP E (Phofu)	16	2	211	32	200	16	48	0.020
CNP F (Chobe River)	19	4	127	23	121	5	42	0.014
CNP NP Subtotals	223	21	3055	110	49	113	333	0.019
Chobe District Subtotals	**376**	**43**	**8791**	**184**	**49**	**191**	**560**	**0.018**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.000
CT 2 Mukusi	0	0	0	0	0	0	0	0.000
CT 3 Tamafupa	0	0	0	0	0	0	0	0.000
CT 5 (Sepako)	19	4	134	24	126	5	43	0.024
Nxai Pan NP	72	7	3510	125	174	53	197	0.028
Makgadikgadi NP (Mak. NP)								
Mak. NP East	665	72	81307	604	91	72	1269	0.247
Mak. NP West	246	28	4007	134	54	112	380	0.110
Mak. NP Subtotals	911	100	85314	594	65	316	1505	0.185
Central District Subtotals	**1002**	**111**	**88958**	**590**	**59**	**411**	**1592**	**0.054**
Totals	**1875**	**274**	**106711**	**641**	**34**	**1233**	**2516**	**0.026**

Figure 34. Distribution and density (km^2) of ostrich in northern Botswana during 2010 dry season aerial survey.

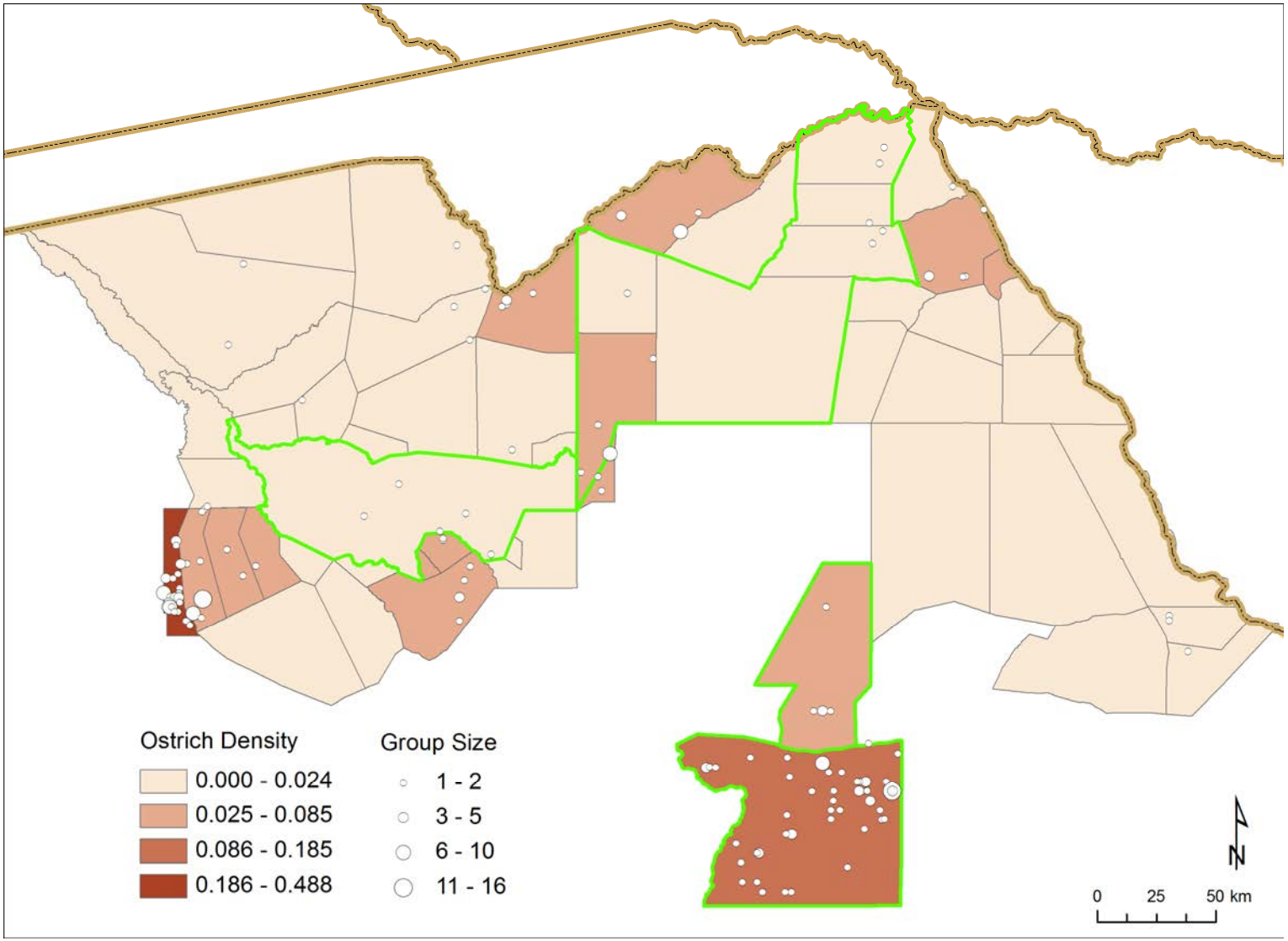


Table 33. Dry season population estimates and statistics for bateleur eagle in northern Botswana, 2010[a].

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	0	0	0	0	0	0	0	0.00
NG 10 & 11	-	-	-	-	-	-	-	-
NG 12	-	-	-	-	-	-	-	-
NG 13	-	-	-	-	-	-	-	-
NG 14 Kwando								
NG 14 A	40	9	236	31	78	9	71	0.04
NG 14 B	31	3	471	46	148	14	78	0.02
NG 14 Subtotals	71	12	707	53	75	17	124	0.02
NG 15 Linyanti	14	3	90	20	143	6	34	0.01
NG 16 Selinda	29	6	86	19	66	10	48	0.02
NG 18 & 19 Khwai	63	10	481	45	71	18	109	0.03
NG 20 & 21 Splash	40	6	327	37	93	6	77	0.02
NG 22 Vumbra	15	3	58	16	107	3	32	0.02
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	5	1	18	9	180	5	14	0.01
NG 25 Jao	11	2	100	21	191	10	33	0.02
NG 26 Abu / EBS								
NG 26 A	0	0	0	0	0	0	0	0.00
NG 26 B	21	8	55	15	71	17	36	0.03
NG 26 C	0	0	0	0	0	0	0	0.00
NG 26 Subtotals	21	8	55	62	295	62	126	0.01
NG 27 A&B & NG 30	18	3	154	26	144	8	44	0.01
NG 29 Rann	10	1	81	19	190	10	29	0.01
NG 31 & 17 Chitabe	34	7	144	26	76	8	60	0.11
NG 32 Stanleys	13	3	41	13	100	3	26	0.01
NG 33 & 34 Santawane	6	1	38	14	233	7	19	0.01
WMA Subtotals	350	66	2380	96	27	254	446	0.01
Moremi GR NG 28	107	23	567	47	44	60	155	0.02
Ngamiland Subtotals	**457**	**89**	**2947**	**106**	**23**	**350**	**563**	**0.01**

[a] Bateleur were counted when observers saw them flying in close proximity to the wands delineating the strip width intervals

- Bateleur were not counted in these strata

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District	0	0	0	0	0	0	0	0.00
CH 1 Chobe Enclave	0	0	0	0	0	0	0	0.00
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0.00
CH 4 Kasane Forest Res	10	2	40	13	130	3	24	0.02
CH 5 & 6 N Plains	0	0	0	0	0	0	0	0.00
CH 7, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	22	2	197	30	136	8	51	0.01
WMA & FR Subtotals	32	4	237	30	94	4	63	0.00
Chobe NP (CH3)								
CNP A (Linyanti-Savute)	10	2	78	18	180	8	28	0.01
CNP B (Mababe-Khwai)	8	1	58	16	200	8	24	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)	9	1	31	12	133	2	21	0.01
CNP NP Subtotals	27	4	167	26	96	4	53	0.00
Chobe District Subtotals	**59**	**8**	**404**	**40**	**68**	**19**	**99**	**0.00**
CENTRAL (CT) District								
CT 1 Nunga	95	6	1531	84	88	10	179	0.02
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	51	5	732	57	112	6	107	0.02
CT 5 Sepako	28	6	82	19	68	9	47	0.04
Nxai Pan NP	21	2	180	28	133	8	49	0.01
Makgadikgadi NP (Mak. NP)								
Mak. NP East	0	0	0	0	0	0	0	0.00
Mak. NP West	3	26	313	37	12	11	64	0.00
Mak. NP Subtotals	3	26	313	37	12	11	64	0.00
Central District Subtotals	**198**	**45**	**2838**	**105**	**53**	**92**	**303**	**0.01**
Totals	**714**	**142**	**6189**	**154**	**22**	**559**	**868**	**0.01**

Figure 35. Distribution and density (km^2) of bateleur eagle in northern Botswana during 2010 dry season aerial survey.

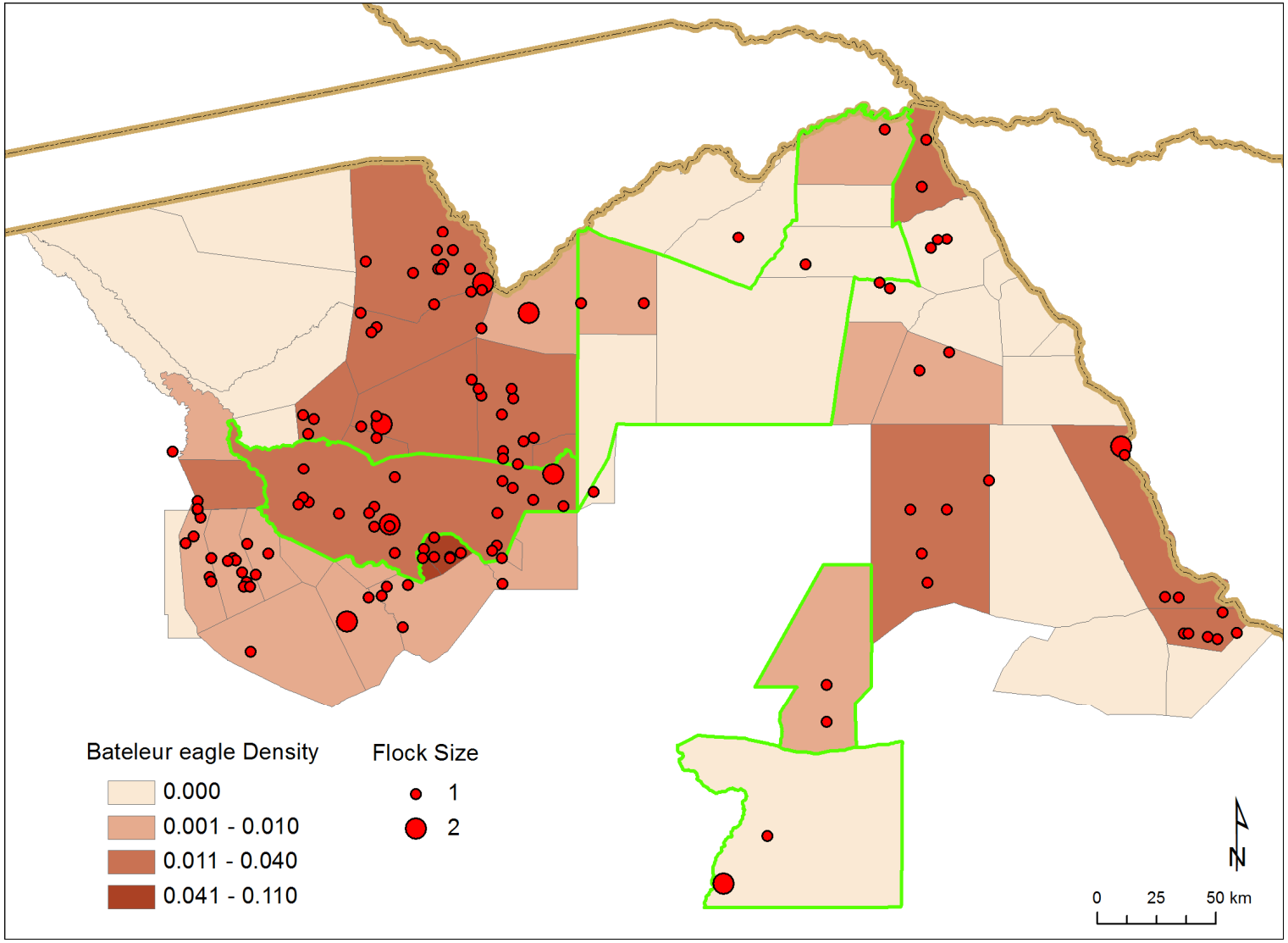


Table 34. Dry season population estimates and statistics for fish eagle in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	0	0	0	0	0	0	0	0.00
NG 10 & 11	-	-	-	-	-	-	-	-
NG 12	-	-	-	-	-	-	-	-
NG 13	-	-	-	-	-	-	-	-
NG 14 Kwando								
NG 14 A	-	-	-	-	-	-	-	-
NG 14 B	-	-	-	-	-	-	-	-
NG 14 Subtotals	-	-	-	-	-	-	-	-
NG 15 Linyanti	24	5	165	27	113	5	51	0.02
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	0	0	0	0	0	0	0	0.00
NG 20 & 21 Splash	0	0	0	0	0	0	0	0.00
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	83	17	406	44	53	39	127	0.11
NG 25 Jao	162	29	849	63	39	99	225	0.26
NG 26 Abu / EBS								
NG 26 A	13	5	17	8	61	5	21	0.02
NG 26 B	37	15	59	15	40	21	52	0.05
NG 26 C	96	39	448	43	45	53	139	0.19
NG 26 Subtotals	146	59	524	45	31	101	191	0.08
NG 27 A&B & NG 30	96	16	663	53	55	43	150	0.07
NG 29 Rann	19	2	127	24	126	5	43	0.01
NG 31 & 17 Chitabe	15	3	43	14	93	3	29	0.05
NG 32 Stanleys	59	14	290	35	59	24	95	0.06
NG 33 & 34 Santawane								
WMA subtotals	580	140	2902	106	18	474	686	0.02
Moremi GR NG 28	458	98	3077	110	24	347	568	0.09
Ngamiland Subtotals	**1038**	**238**	**5979**	**152**	**15**	**886**	**1190**	**0.03**

Stratum	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	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, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	0	0	0	0	0	0	0	0.00
WMA & FR Subtotals	0	0	0	0	0	0	0	0.00
Chobe NP (CH3)								
CNP A (Linyanti-Savute)	15	3	186	28	187	13	43	0.01
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)	0	0	0	0	0	0	0	0.00
CNP NP Subtotals	0	0	0	0	0	0	0	0.00
Chobe District Subtotals	**15**	**3**	**186**	**28**	**187**	**13**	**43**	**0.00**
Totals	**1053**	**241**	**6165**	**154**	**15**	**898**	**1207**	**0.02**

Figure 36. Distribution and density (km^2) of fish eagle in northern Botswana during 2010 dry season aerial survey.

Table 35. Dry season population estimates and statistics for ground hornbill in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	0	0	0	0	0	0	0	0.00
NG 10 & 11	4	1	12	7	175	3	11	0.00
NG 12	15	3	165	26	173	12	41	0.01
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	0	0	0	0	0	0	0	0.00
NG 15 Linyanti	19	4	285	35	184	16	54	0.02
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	0	0	0	0	0	0	0	0.00
NG 20 & 21 Splash	39	6	719	55	141	16	95	0.02
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	10	2	83	20	200	10	30	0.02
NG 24 Jedibe	0	0	0	0	0	0	0	0.00
NG 25 Jao	0	0	0	0	0	0	0	0.00
NG 26 Abu / EBS								
NG 26 A	22	8	232	8	36	8	52	0.03
NG 26 B	0	0	0	0	0	0	0	0.00
NG 26 C	32	7	347	33	103	16	65	0.06
NG 26 Subtotals	54	15	579	45	83	15	99	0.03
NG 27 A&B &NG 30	66	11	1199	71	108	11	138	0.05
NG 29 Rann	48	5	1880	93	194	45	140	0.03
NG 31 & 17 Chitabe	19	4	288	36	189	17	56	0.06
NG 32 Stanleys	34	8	294	36	106	8	69	0.03
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA Subtotals	308	59	5504	146	47	162	454	0.01
Moremi GR NG 28	0							
Ngamiland Subtotals	**308**	**59**	**5504**	**146**	**47**	**162**	**454**	**0.01**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE District								
CH 1 Chobe Enclave	0	0	0	0	0	0	0	0.00
CH 2 Chobe Forest Res	0	0	0	0	0	0	0	0.00
CH 4 Kasane Forest Res	31	6	361	40	129	9	71	0.05
CH 5 & 6 N Plains	40	4	824	65	163	25	105	0.03
CH 7, 8 & 13 Sibuyu	81	7	2780	109	135	28	190	0.03
CH 11 & 12 Bottle Pan	54	5	2554	108	200	54	162	0.02
WMA & FR Subtotals	206	22	6519	160	78	46	366	0.02
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	10	2	78	18	180	8	28	0.01
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)	71	8	2028	96	135	25	167	0.05
CNP E (Phofu)	0	0	0	0	0	0	0	0.00
CNP F (Chobe River)	28	6	323	37	132	9	65	0.02
CNP NP Subtotals	109	16	2429	98	90	11	207	0.01
Chobe District Subtotals	**315**	**38**	**8948**	**186**	**59**	**128**	**501**	**0.01**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	0	0	0	0	0	0	0	0.00
Makgadikgadi NP (Mak. NP)								
Mak. NP East	0	0	0	0	0	0	0	0.00
Mak. NP West	0	0	0	0	0	0	0	0.00
Mak. NP Subtotals	0	0	0	0	0	0	0	0.00
Central District Subtotals	0	0	0	0	0	0	0	0.00
Totals	**623**	**97**	**14452**	**235**	**38**	**387**	**858**	**0.01**

Figure 37. Distribution and density (km^2) of ground hornbill in northern Botswana during 2010 dry season aerial survey.

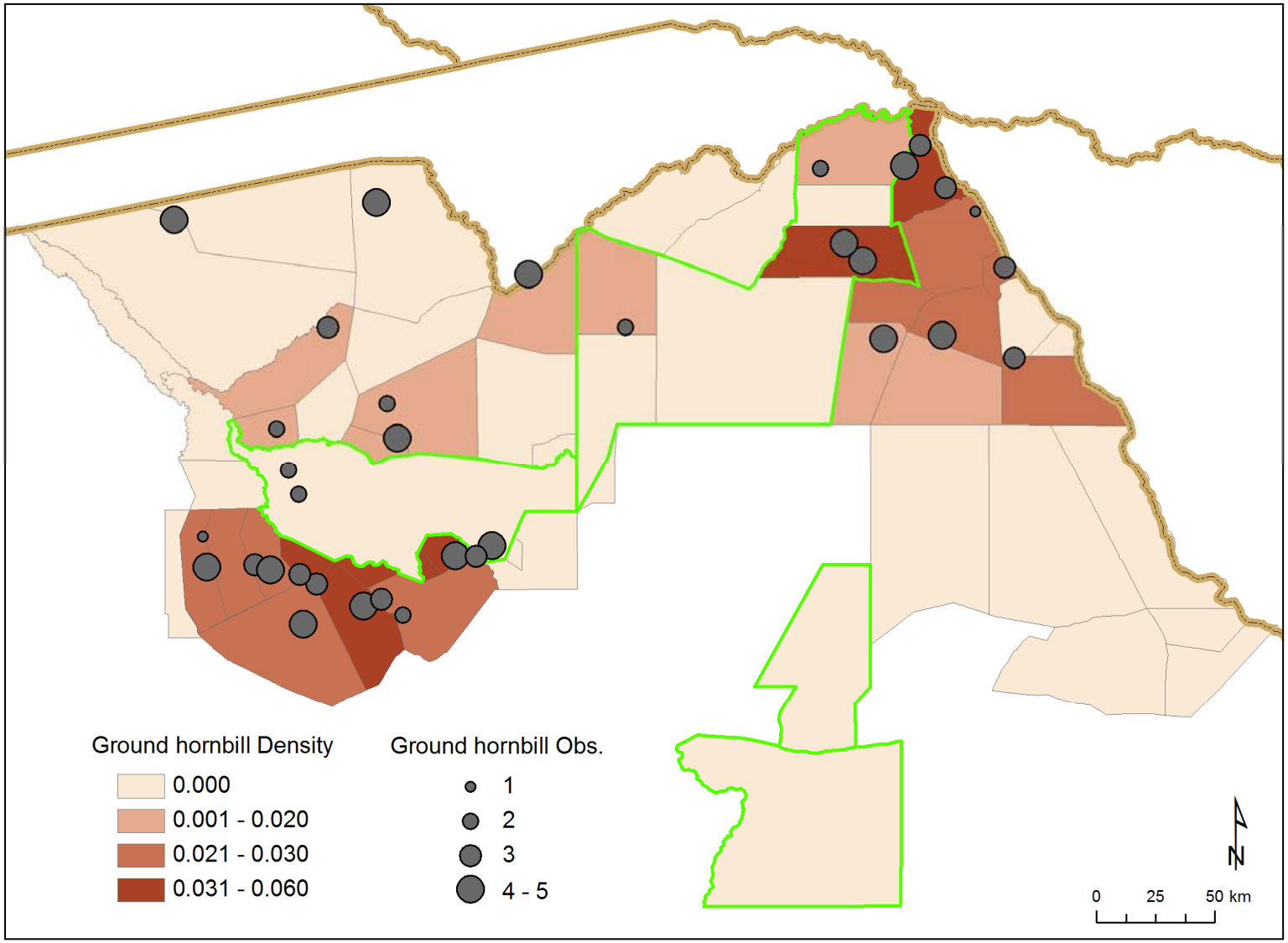


Table 36. Dry season population estimates and statistics for saddle billed stork in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	0	0	0	0	0	0	0	0.00
NG 10 & 11	0	0	0	0	0	0	0	0.00
NG 12	0	0	0	0	0	0	0	0.00
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	0	0	0	0	0	0	0	0.00
NG 15 Linyanti	0	0	0	0	0	0	0	0.00
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	6	1	34	12	200	6	18	0.00
NG 20 & 21 Splash	99	15	738	56	57	42	155	0.05
NG 22 Vumbra	15	3	95	21	140	6	37	0.02
NG 23 Duba Plains	20	4	148	27	135	6	47	0.05
NG 24 Jedibe	63	13	475	48	76	15	111	0.08
NG 25 Jao	89	16	718	58	65	31	147	0.14
NG 26 Abu / EBS								
NG 26 A	22	9	43	13	59	9	36	0.03
NG 26 B	41	17	89	19	46	22	60	0.06
NG 26 C	91	35	317	36	40	55	127	0.18
NG 26 Subtotals	154	61	449	42	27	112	196	0.08
NG 27 A&B & NG 30	60	10	591	50	83	10	110	0.04
NG 29 Rann	29	3	386	42	145	14	71	0.02
NG 31 & 17 Chitabe	19	4	112	23	121	4	42	0.06
NG 32 Stanleys	17	4	77	18	106	4	35	0.02
NG 33 & 34 Santawane								
WMA subtotals	571	134	3823	121	21	449	692	0.02
Moremi GR NG 28	444	95	10406	204	46	240	648	0.09
Ngamiland Subtotals	**1015**	**229**	**14229**	**234**	**23**	**780**	**1249**	**0.03**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	25	5	490	46	184	21	71	0.02
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)	0	0	0	0	0	0	0	0.00
CNP NP Subtotals	25	5	490	46	184	21	71	0.00
Totals	**1040**	**234**	**14719**	**238**	**23**	**801**	**1278**	**0.02**

Figure 38. Distribution and density (km^2) of saddle billed stork in northern Botswana during 2010 dry season aerial survey.

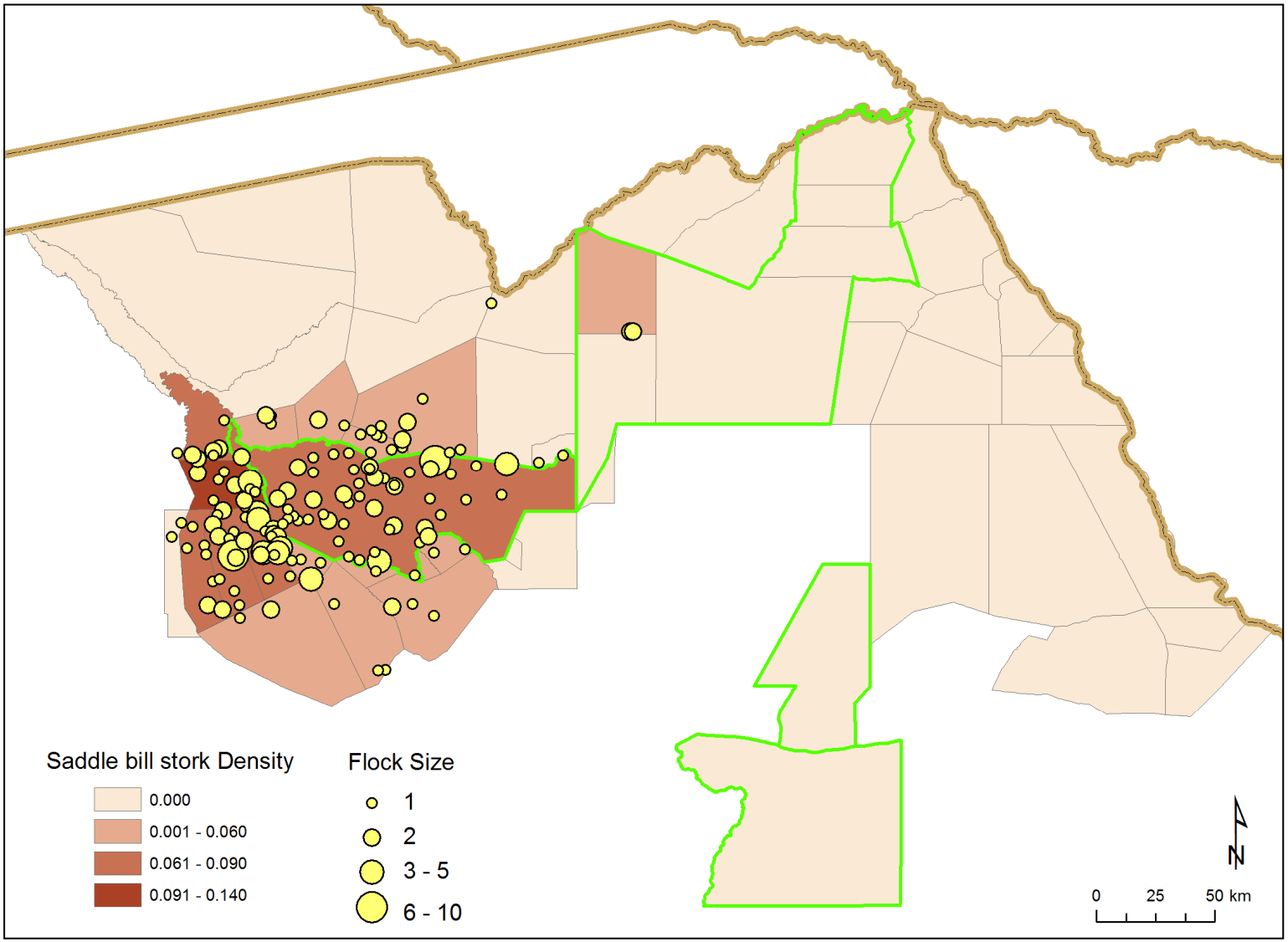


Table 37. Dry season population estimates and statistics for wattled crane in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	0	0	0	0	0	0	0	0.00
NG 10 & 11	80	20	3645	120	150	40	200	0.02
NG 12	15	3	95	20	133	6	35	0.01
NG 13	0	0	0	0	0	0	0	0.00
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	0	0	0	0	0	0	0	0.00
NG 15 Linyanti	0	0	0	0	0	0	0	0.00
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	0	0	0	0	0	0	0	0.00
NG 20 & 21 Splash	0	0	0	0	0	0	0	0.00
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	20	4	157	27	135	7	50	0.05
NG 24 Jedibe	88	18	784	62	70	26	150	0.12
NG 25 Jao	245	44	21535	317	129	71	562	0.40
NG 26 Abu / EBS								
NG 26 A	25	10	132	23	92	10	48	0.04
NG 26 B	34	14	86	18	53	15	38	0.05
NG 26 C	89	35	549	36	40	41	136	0.17
NG 26 Subtotals	148	59	767	54	36	93	202	0.08
NG 27 A&B & NG 30	24	4	241	32	133	8	56	0.02
NG 29 Rann	10	1	77	19	190	9	28	0.01
NG 31 & 17 Chitabe	0	0	0	0	0	0	0	0.00
NG 32 Stanleys	0	0	0	0	0	0	0	0.00
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA Subtotals	630	153	27301	324	51	315	964	0.02
Moremi GR NG 28	145	31	1183	68	47	76	213	0.03
Ngamiland Subtotals	**775**	**184**	**28484**	**331**	**43**	**443**	**1106**	**0.02**
Totals	**785**	**194**	**28484**	**331**	**43**	**443**	**1106**	**0.02**

Figure 39. Distribution and density (km^2) of wattled crane in northern Botswana during 2010 dry season aerial survey.

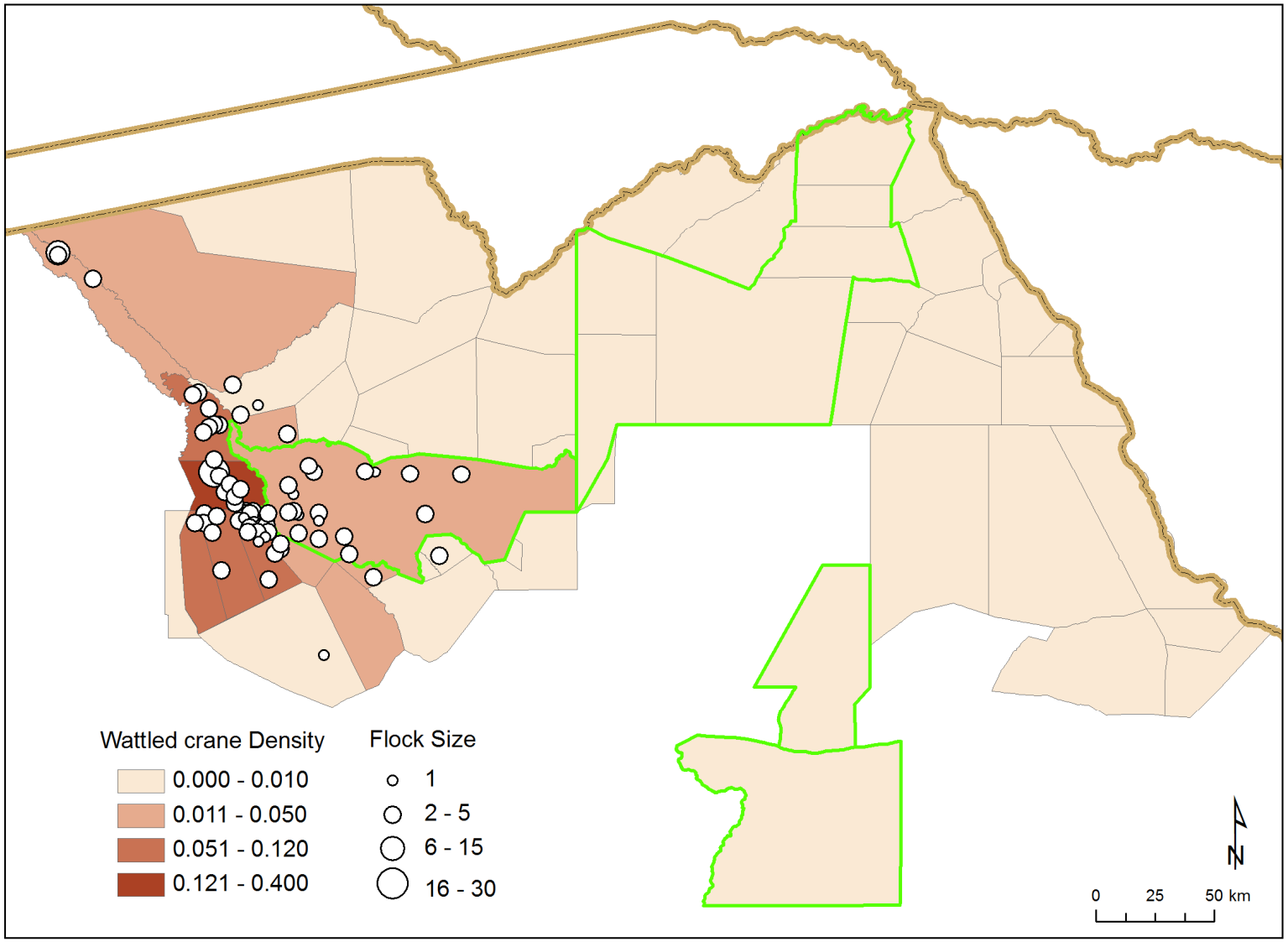


Table 38. Dry season estimates and statistics for baobab trees in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8	223	47	4870	140	63	82	363	0.42
NG 10 & 11	-	-	-	-	-	-	-	-
NG 12	-	-	-	-	-	-	-	-
NG 13	-	-	-	-	-	-	-	-
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	0	0	0	0	0	0	0	0.00
NG 15 Linyanti	5	1	17	9	180	4	13	0.00
NG 16 Selinda	82	17	717	55	67	27	137	0.06
NG 18 / 19 Khwai	82	13	596	51	62	32	133	0.04
NG 20 /21 Splash	13	2	71	17	131	4	30	0.01
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	195	40	2481	110	56	86	305	0.26
NG 25 Jao	33	6	297	37	112	6	30	0.05
NG 26 Abu / EBS								
NG 26 A	162	65	686	52	32	109	214	0.25
NG 26 B	95	37	516	46	48	49	141	0.14
NG 26 C	34	14	36	12	35	22	46	0.07
NG 26 Subtotals	291	116	1238	69	24	221	360	0.16
NG 27 A&B / NG 30	54	9	508	46	85	9	101	0.04
NG 29 Rann	19	2	148	26	137	7	45	0.01
NG 31 & 17 Chitabe	15	3	78	19	127	5	34	0.05
NG 32 Stanleys	47	11	529	48	102	11	94	0.04
NG 33 & 34 Santawane	6	1	33	13	217	6	19	0.01
WMA Subtotals	1065	268	11583	211	20	854	1276	0.04
Moremi GR NG 28	164	35	1123	67	41	97	230	0.03
Ngamiland Subtotals	**1229**	**303**	**12706**	**221**	**18**	**1007**	**1450**	**0.04**

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
CHOBE (CH) District								
CH 1 Chobe Enclave	242	46	8405	192	79	50	434	0.21
CH 2 Chobe Forest Res	515	76	24030	324	63	191	840	0.36
CH 4 Kasane Forest Res	16	3	209	30	188	15	46	0.03
CH 5 & 6 N Plains	0	0	0	0	0	0	0	0.00
CH 7, 8 & 13 Sibuyu	766	66	78840	582	76	184	1348	0.30
CH 11 & 12 Bottle Pan	11	1	102	21	191	11	32	0.00
WMA & FR Subtotals	1550	192	111586	662	43	887	2212	0.16
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	90	18	3292	119	132	30	209	0.06
CNP B (Mababe-Khwai)	16	2	234	32	200	16	48	0.01
CNP C (Chinamba)	488	26	52706	543	111	54	1031	0.10
CNP D (Nogatsaa)	79	9	1528	83	105	9	163	0.06
CNP E (Phofu)	8	1	53	16	200	8	24	0.01
CNP F (Chobe River)	135	29	2974	113	84	29	248	0.10
CNP NP Subtotals	816	85	60787	489	60	327	1304	0.07
Chobe District Subtotals	**2366**	**277**	**172373**	**818**	**35**	**1547**	**3184**	**0.11**
CENTRAL (CT) District								
CT 1 Nunga	32	2	450	45	141	14	77	0.01
CT 2 Mukusi	242	12	4837	150	62	91	392	0.06
CT 3 Tamafupa	364	36	84792	611	168	247	975	0.16
CT 5 Sepako	9	2	31	12	133	3	21	0.01
Nxai Pan NP	247	24	18210	284	115	38	531	0.10
Makgadikgadi NP								
Mak East	28	3	683	55	196	28	83	0.01
Mak West	0	0	0	0	0	0	0	0.00
Makgadikgadi NP Subtotals	28	3	683	55	196	28	83	0.01
Central District Subtotals	**922**	**79**	**109003**	**654**	**71**	**268**	**1576**	**0.05**
Totals	**4517**	**659**	**294082**	**1064**	**24**	**3452**	**5581**	**0.06**

Figure 40. Distribution and density (km^2) of baobab trees in northern Botswana during 2010 dry season aerial survey.

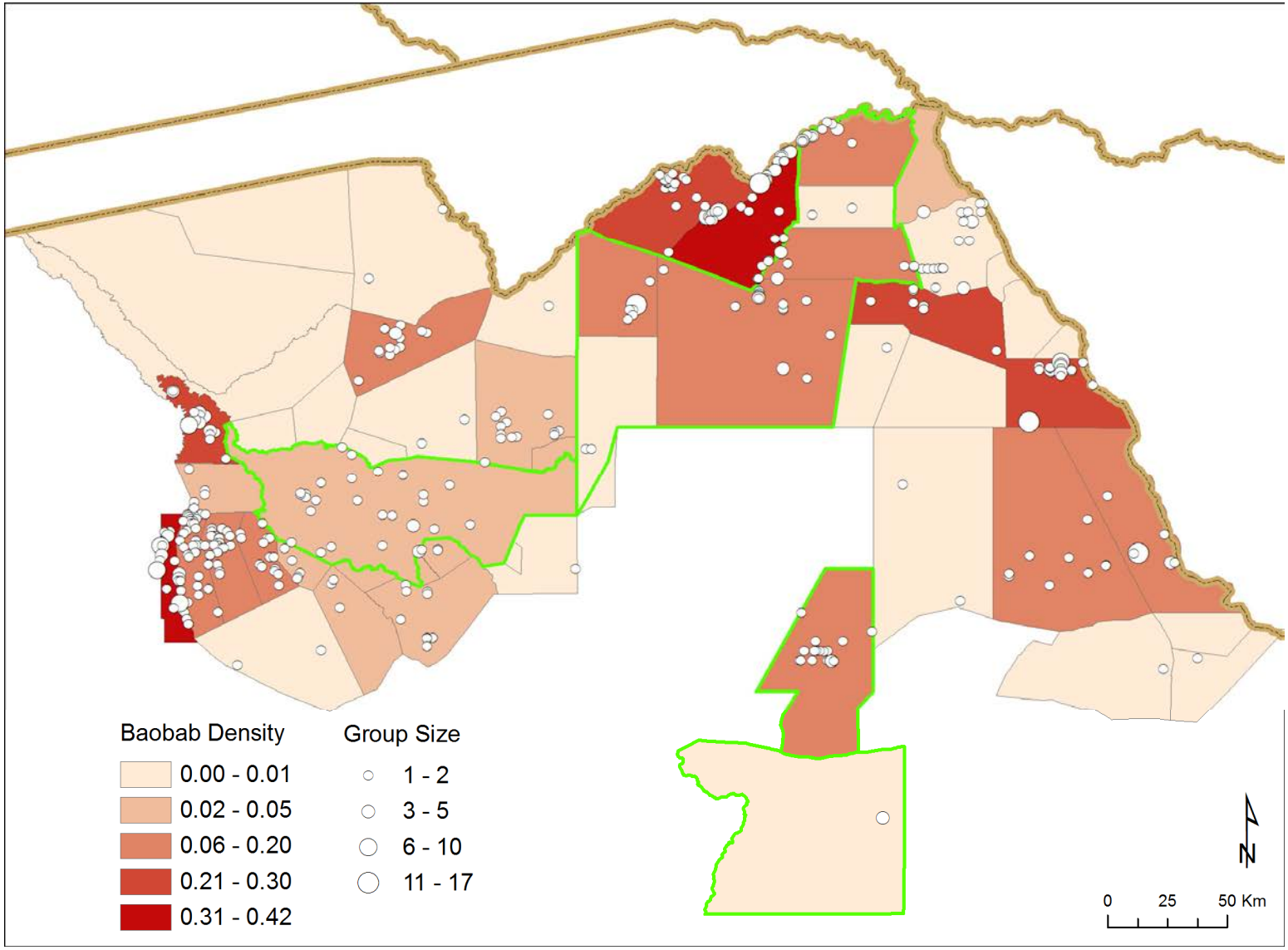
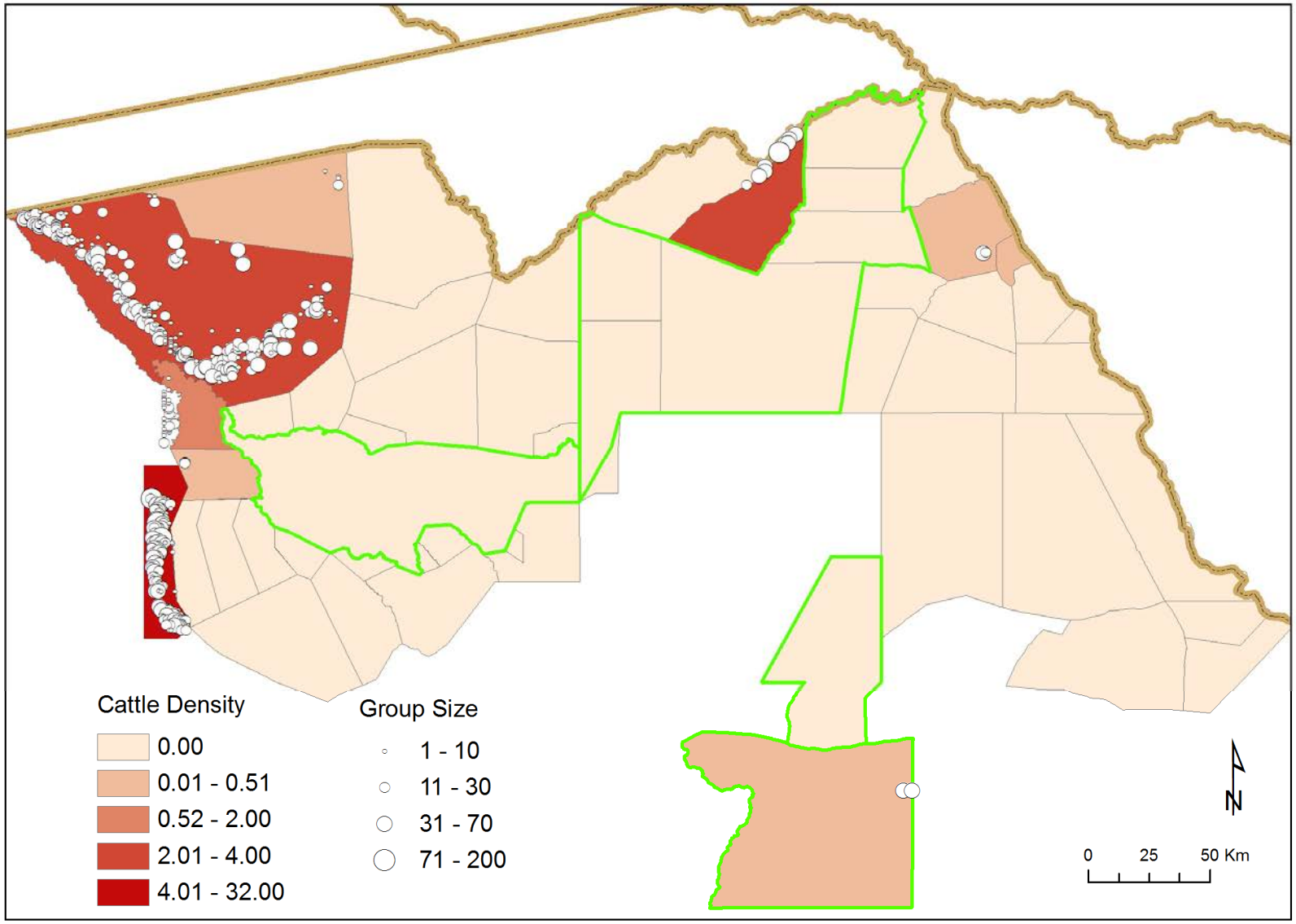


Table 39. Dry season population estimates and statistics for cattle in surveyed strata in northern Botswana, 2010.

Stratum	Estimate	No. Seen	Variance	CI	% CI	Lower CL	Upper CL	Density (km^2)
NGAMILAND (NG) District								
NG 8 Habu	17339	3659	4228348	4219	24	13120	21559	32.41
NG 10 & 11	16955	4233	1742236	2638	16	14316	19593	3.30
NG 12	3945	812	872850	1928	49	2016	5873	3.61
NG 13	312	34	58359	496	159	183	808	0.12
NG 14 Kwando								
NG 14 A	0	0	0	0	0	0	0	0.00
NG 14 B	0	0	0	0	0	0	0	0.00
NG 14 Subtotals	0	0	0	0	0	0	0	0.00
NG 15 Linyanti	0	0	0	0	0	0	0	0.00
NG 16 Selinda	0	0	0	0	0	0	0	0.00
NG 18 & 19 Khwai	0	0	0	0	0	0	0	0.00
NG 20 & 21 Splash	0	0	0	0	0	0	0	0.00
NG 22 Vumbra	0	0	0	0	0	0	0	0.00
NG 23 Duba Plains	0	0	0	0	0	0	0	0.00
NG 24 Jedibe	1132	232	366727	1333	118	232	2466	1.49
NG 25 Jao	312	56	78354	604	194	292	917	0.51
NG 26 Abu / EBS								
NG 26 A	0	0	0	0	0	0	0	0.00
NG 26 B	0	0	0	0	0	0	0	0.00
NG 26 C	0	0	0	0	0	0	0	0.00
NG 26 Subtotals	0	0	0	0	0	0	0	0.00
NG 27 A&B / NG30	0	0	0	0	0	0	0	0.00
NG 29 Rann	0	0	0	0	0	0	0	0.00
NG 31 & 17 Chitabe	0	0	0	0	0	0	0	0.00
NG 32 Stanleys	0	0	0	0	0	0	0	0.00
NG 33 & 34 Santawane	0	0	0	0	0	0	0	0.00
WMA subtotals	39995	9026	7346874	5322	13	34672	45318	1.39
Moremi GR NG 28	0	0	0	0	0	0	0	0
Ngamiland Subtotals	**39995**	**9026**	**7346874**	**5322**	**13**	**34672**	**45318**	**1.19**

Stratum	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	4226	623	2519696	3322	79	904	7548	2.96
CH 4 Kasane Forest Res	0							
CH 5 & 6 N Plains	558	56	271818	1179	211	621	1737	0.40
CH 7, 8 & 13 Sibuyu	0	0	0	0	0	0	0	0.00
CH 11 & 12 Bottle Pan	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0.00
WMA & FR Subtotals	4784	679	2791514	3311	69	1472	8095	0.49
Chobe NP (CH 3)								
CNP A (Linyanti-Savute)	0	0	0	0	0	0	0	0.00
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)	0	0	0	0	0	0	0	0.00
CNP NP Subtotals	0	0	0	0	0	0	0	0.00
Chobe District Subtotals	**4784**	**679**	**2791514**	**3311**	**69**	**1472**	**8095**	**0.22**
CENTRAL (CT) District								
CT 1 Nunga	0	0	0	0	0	0	0	0.00
CT 2 Mukusi	0	0	0	0	0	0	0	0.00
CT 3 Tamafupa	0	0	0	0	0	0	0	0.00
CT 5 Sepako	0	0	0	0	0	0	0	0.00
Nxai Pan NP	0	0	0	0	0	0	0	0.00
Makgadikgadi NP (Mak. NP)								
Mak. NP East	784	85	5499015	1570	200	786	2355	0.29
Mak. NP West	0	0	0	0	0	0	0	0.00
Mak. NP Subtotals	784	85	5499015	1570	200	786	2355	0.16
Central District Subtotals	**784**	**85**	**5499015**	**1570**	**200**	**786**	**2355**	**0.04**
Totals	**45563**	**9790**	**15637403**	**7760**	**17**	**37802**	**53323**	**0.62**

Figure 41. Distribution of cattle in the strata surveyed within northern Botswana during 2010 dry season aerial survey.



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. Trend analyses results

Table 2a. Growth rates (*r*) and 95% Confidence Intervals (CI) calculated for 14 species of animals within the Chobe District.

Species	Number of Data Points	Standard Error	*r* (95% CI)	F-value for slope of regression	P-value
Buffalo	7	0.05	0.01 (-0.1 – 0.13)	0.024	0.88
Eland	7	0.06	0.02 (-0.2 – 0.17)	0.189	0.68
Giraffe	7	0.03	0.01 (-0.06 – 0.08)	0.17	0.69
Hippo	7	0.05	0.25 (0.12 – 0.39)	32.44	0.005**
Impala	7	0.03	0.16 (0.09 – 0.23)	32.44	0.002**
Kudu	7	0.05	0.05 (-0.08 – 0.17)	0.85	0.40
Lechwe	7	0.05	0.08 (-0.05 – 0.21)	2.51	0.17
Ostrich	6	0.01	-0.02 (-0.06 – 0.01)	2.74	0.17
Roan	7	0.1	-0.08 (-0.37 – 0.21)	0.44	0.53
Sable	7	0.02	0.04 (-0.004 – 0.07)	5.19	0.07
Tsessebe	7	0.1	0.01 (-0.30 – 0.31)	0.002	0.96
Warthog	6	0.2	0.08 (-0.5 – 0.65)	0.12	0.74
Wildebeest	7	0.08	-0.06 (-0.27 – 0.14)	0.62	0.46
Zebra	7	0.05	0.02 (-0.1 – 0.16)	0.18	0.68

Table 2b. Growth rates (*r*) and 95% Confidence Intervals (CI) calculated for 14 species of animals within the Chobe National Park.

Species	Number of Data Points	Standard Error	*r* (95% CI)	F-value for slope of regression	P-value
Buffalo	7	0.1	0.16 (-0.1 – 0.43)	2.14	0.18
Eland	7	0.07	0.10 (-0.07 – 0.29)	1.98	0.28
Giraffe	7	0.02	0.02 (-0.04 – 0.08)	0.77	0.41
Hippo	7	0.08	0.07 (-0.13 – 0.28)	0.88	0.39
Impala	7	0.05	0.07 (-0.04 – 0.15)	2.17	0.18
Kudu	7	0.05	0.01 (-0.1 – 0.12)	0.05	0.83
Lechwe	7	0.04	0.1 (0.01 – 0.18)	7.72	0.03*
Ostrich	6	0.05	0.04 (-0.09 – 0.16)	0.46	0.52
Roan	7	0.09	0.01 (-0.2 – 0.2)	0.02	0.88
Sable	7	0.05	-0.02 (-0.15 – 0.1)	0.13	0.73
Tsessebe	7	0.08	-0.07 (-0.27 – 0.14)	0.63	0.46
Warthog	6	0.05	0.1 (-0.01 – 0.20)	4.47	0.07
Wildebeest	7	0.09	-0.02 (-0.3 – 0.25)	0.07	0.81
Zebra	7	0.05	0.03 (-0.08 – 0.15)	0.42	0.54

The F- and P- values indicate when the slope of the regression line (which represents rate of growth) differs significantly from zero.

Table 2c. Growth rates (*r*) and 95% Confidence Intervals (CI) calculated for 10 species of animals within Moremi GR.

Species	Number of Data Points	Standard Error	*r* (95% CI)	F-value for slope of regression	P-value
Buffalo	9	0.09	-0.1 (-0.32 – 0.1)	1.47	0.24
Giraffe	9	0.01	-0.02 (-0.05 – 0.01)	2.64	0.15
Hippo	9	0.03	0.06 (-0.02 – 0.14)	3.56	0.10
Impala	9	0.03	-0.01 (-0.09 – 0.06)	0.20	0.66
Kudu	9	0.05	-0.07 (-0.2 – 0.05)	1.88	0.22
Lechwe	9	0.03	-0.06 (-0.14 – 0.03)	2.41	0.16
Tsessebe	9	0.02	-0.13 (-0.18 – 0.08)	33.55	0.004*
Warthog	9	0.05	-0.15 (-0.3 – -0.03)	8.30	0.023*
Wildebeest	9	0.08	-0.14 (-0.3 – 0.05)	3.38	0.12
Zebra	9	0.03	-0.03 (-0.1 – 0.05)	0.71	0.42

Table 2d. Growth rates (*r*) and 95% Confidence Intervals (CI) calculated for 14 species of animals within Ngamiland district.

Species	Number of Data Points	Standard Error	*r* (95% CI)	F-value for slope of regression	P-value
Buffalo	7	0.06	0.05 (-0.2 – 0.1)	0.83	0.41
Eland	6	0.04	-0.05 (-0.15 – 0.06)	1.42	0.30
Giraffe	7	0.01	-0.08 (-0.1 – -0.06)	82.26	0.0003**
Hippo	7	0.03	0.1 (0.02 – 0.17)	9.91	0.025*
Impala	7	0.04	-0.02 (-0.14 – 0.1)	0.20	0.67
Kudu	7	0.02	-0.11 (-0.15 – -0.06)	29.62	0.003*
Lechwe	7	0.02	-0.07 (-0.1 – -0.03)	17.00	0.01*
Ostrich	5	0.05	-0.2 (-0.4 – -0.08)	19.57	0.01*
Roan	7	0.08	-0.08 (-0.3 – 0.12)	0.97	0.37
Sable	7	0.05	-0.01 (-0.13 – 0.12)	0.02	0.88
Tsessebe	7	0.04	-0.13 (-0.74 – -0.04)	13.23	0.015*
Warthog	7	0.06	-0.13 (-0.28 – 0.02)	4.79	0.08
Wildebeest	7	0.03	-0.18 (-0.3 – -0.1)	27.93	0.003*
Zebra	7	0.03	-0.05 (-0.12 – 0.02)	3.84	0.11

The F- and P- values indicate when the slope of the regression line (which represents rate of growth) differs significantly from zero.

Table 2e. Growth rates (*r*) and 95% Confidence Intervals (CI) calculated for six species of animals within Makgadikgadi and Nxai Pan National Parks.

Species	Number of Data Points	Standard Error	*r* (95% CI)	F-value for slope of regression	P-value
Gemsbok	9	0.02	0.07 (0.02 – 0.12)	10.65	0.014*
Giraffe	9	0.04	0.01 (-0.08 – 0.09)	0.36	0.85
Ostrich	9	0.03	-0.002 (-0.08 – 0.08)	0.002	0.96
Springbok	9	0.12	-0.09 (-0.37 – 0.2)	0.50	0.50
Wildebeest	9	0.15	0.2 (-0.14 – 0.16)	2.04	0.19
Zebra	9	0.17	0.28 (-0.13 – 0.70)	2.62	0.15

The F- and P- values indicate when the slope of the regression line (which represents rate of growth) differs significantly from zero.

Appendix 3. Estimates of wildlife numbers from nine aerial surveys flown over northern Botswana

Table 3a. Estimates of wildlife numbers from nine aerial surveys flown over Chobe district and Chobe NP, 1993 - 2010.

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

Table 3b. Estimates of wildlife numbers from nine aerial surveys flown over Ngamiland district Moremi GR, and Makgadikgadi Nxai Pan NPs, 1993 – 2010.

Species	Wildlife Population Estimates Ngamiland, Moremi GR & Mak. Nxai Pan NP								
Year of survey	1993	1994	1996	1999	2001	2002	2003	2004	2010
Ngamiland									
Elephant	-	-	57066	74281	67471	65294	56412	72775	61621
Buffalo	-	-	33396	83108	62605	36985	17697	15457	31489
Eland	-	-	388	863	658	625	360	0	290
Giraffe	-	-	10608	9578	7577	6985	5517	6566	3676
Hippo	-	-	1293	2107	2217	3079	1362	3010	5750
Impala	-	-	58960	44247	22030	15880	26419	22382	44640
Kudu	-	-	9984	5718	4496	6471	3693	4780	2011
Lechwe	-	-	77671	78267	56066	70030	48628	35509	32482
Ostrich	-	-	11893	5787	7886	8681	4868	0	497
Roan	-	-	778	478	625	529	64	374	315
Sable	-	-	1897	866	1744	498	949	975	1518
Tsessebe	-	-	13829	10425	3208	5812	4560	2330	2240
Warthog	-	-	10044	4623	2251	2866	1148	1008	1951
Wildebeest	-	-	19571	23538	11210	4500	5765	5359	1985
Zebra	-	-	24268	26119	23772	19734	17447	32514	11426
Moremi GR									
Elephant	7261	7525	7758	5442	6048	9562	5862	9143	8947
Buffalo	8248	10768	22510	40160	23044	4585	597	1089	6624
Giraffe	1309	1334	1692	1370	1777	1233	958	1101	1075
Hippo	696	551	812	507	717	1320	458	593	2842
Impala	12424	19406	18615	21262	10017	6109	10071	7341	22200
Kudu		710	1028	563	430	392	458	85	472
Lechwe	18906	29636	11752	10978	17513	4759	6682	5793	13744
Tsessebe	3002	1872	3033	2928	1089	1074	778	665	374
Warthog	2867	4001	1542	854	616	218	208	206	650
Wildebeest	1618	2288	1310	4429	-	6109	236	980	131
Zebra	2233	1786	1674	1633	4256	2220	1500	810	1435
Mak.Nxai NP									
Elephant	0	0	0	99	403	337	453	810	1881
Gemsbok	1053	925	979	594	1482	1941	1717	2326	2572
Giraffe	214	390	475	200	206	524	327	867	227
Ostrich	1237	768	1181	854	1122	2926	1165	530	911
Springbok	5420	733	3083	1205	4668	14	825	586	1565
Wildebeest	0	1721	2016	17113	3155	3625	4609	1371	2516
Zebra	0	18119	9541	29019	15640	9976	11415	20257	21750

Table 3c. Estimates of elephant densities and numbers from nine aerial surveys flown over selected strata[a] in northern Botswana 1993 – 2010.

Species	Elephant Density Estimates								
Year of survey	1993	1994	1996	1999	2001	2002	2003	2004	2010
Chobe District	-	-	1.891	1.897	1.876	2.529	2.173	2.606	2.69
Chobe NP	1.226	1.126	2.5	2.17	3.131	3.08	2.96	3.196	2.53
Ngamiland District	-	-	1.63	2.16	2.011	1.84	1.7	2.15	1.85
Moremi GR	1.618	1.528	2.153	1.51	1.218	2.654	1.727	2.443	1.84
Nxai.Mak. NP	0	0	0	0.015	0.05	0	0.137	0.105	0.45

Species	Elephant Density Estimates								
Year of survey	1993	1994	1996	1999	2001	2002	2003	2004	2010
Chobe River Density	-	-	7.266	5.998	7.847	7.542	8.516	5.798	5.837
Chobe River Number	-	-	10961	8922	12644	13028	14640	9463	7705

Species	Elephant Density Estimates								
Year of survey	1993	1994	1996	1999	2001	2002	2003	2004	2010
CH 1 & 2 Density	-	-	4.100	4.804	4.370	5.544	4.367	4.004	5.220
CH 1 & 2 Number	-	-	11808	13647	12416	15891	12290	11376	13622

[a] Selected strata are strata that were covered on all the aerial surveys that were similar or identical in area for which estimates and densities could be compared.