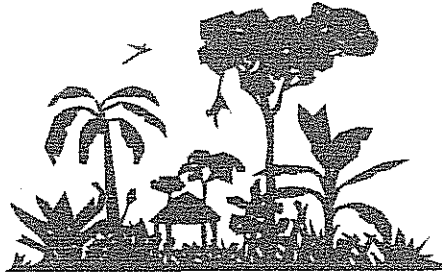


Elephant Distribution and Abundance in the Caprivi Strip: Results
of an Aerial Survey in 2003



**C O N S E R V A T I O N
I N T E R N A T I O N A L**

FINAL REPORT

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INTRODUCTION

The Caprivi Strip of Namibia provides important habitats for wildlife in the region. With its perennial rivers and relatively high rainfall, it provides a wide variety of riverine and woodland habitats in an otherwise arid to semi-arid country. Further, with its close proximity to large, free-ranging wildlife herds in northern Botswana and Zimbabwe, the Caprivi has the potential to support some of the highest densities of elephant and other wildlife in Namibia (Rodwell et al. 1995). It also provides great potential for promoting the natural dispersal and transboundary movement of wildlife from northern Botswana, thereby helping to reduce the impacts of the large elephant population in northern Botswana and helping to restore regional wildlife populations, especially in southern Angola and Zambia. Yet, several factors may be limiting the transboundary movements of wildlife in the region. First, the Caprivi Border Fence, a double electrified fence completed in 1997, now blocks wildlife movements across a large portion of the Botswana/Namibia border. The fence extends for 135 km from the Kavango River in the west to within 30 km of the Kwando River in the east, thereby restricting transboundary wildlife movements into the West Caprivi from northern Botswana. Secondly, there are many human settlements and extensive agriculture along the eastern side of the Kwando River, throughout the East Caprivi, especially along the Chobe and Zambezi Rivers (Fig. 1). Although there are extensive seasonal elephant movements across the Chobe River into the eastern Caprivi from Chobe National Park in Botswana, the extensive human settlements and agriculture pose major impediments to the movement of elephants and other wildlife into interior and northern portions of the East Caprivi where elephant populations are virtually absent. Thirdly, the civil conflict in the region has severely reduced wildlife populations, especially in southern Angola. Additionally, the multitude of unexploded land mines throughout Angola also pose a major threat to both human and wildlife movements, further complicating the natural dispersal of wildlife into the area as well as effective security for the conservation lands, particularly in the Luiana Partial Reserve (Demining Enterprises International, 2003).

Thus, the purpose of this study was to obtain more current information on the distribution and abundance of elephants in the region. We sought to duplicate and update the aerial surveys conducted in 1994 by Rodwell et al. (1995). Such data are critical for developing more effective land management strategies for conserving and enhancing transboundary wildlife movements. More importantly, such information will also contribute to enhancing sustainable tourism development in the region, such as the Kasika Community Conservancy being established adjacent to Chobe National Park. Finally, this information will also assist in developing the Okavango / Upper Zambezi Transfrontier Conservation Area (OUZTFCA), thereby promoting economic and social development in the East Caprivi, a very poor region where there are currently few economic opportunities.

STUDY AREA

The Caprivi region of Namibia (~18,000 km²) is surrounded by Angola, Zambia, and Botswana, lying between the Okavango River in the west, and the Zambezi and Chobe rivers in the east (Fig. 2). The Kwando River divides the region into the East and West Caprivi. The topography is flat with an average altitude of 930±1,100 m and average rainfall of 600±700 mm (Mendolsohn and Roberts, 1997). The region is dominated by mopane-burkea (*Colophospermum mopane*, *Burkea africana*) woodland, mixed shrubland, and Omuramba grasslands. There are extensive seasonally flooded wetlands along the Okavango, Kwando, Chobe and Zambezi Rivers.

The West Caprivi Game Reserve (WCGR) comprises most of the West Caprivi (5,715 km²), except for a small triangle of land along the Kwando River (Fig. 2). Approximately 4,500 people occur in small rural settlements within the WCGR (Fig. 2). The East Caprivi (12,000 km²) has a human population of about 74,000, scattered in rural settlements and concentrated in the town of Katima Mulilo (Mendolsohn and Roberts 1997)(Fig. 2). There are two national parks (Mudumu - 700 km² and Mamili - 350 km²) and a forest reserve (470 km²) in East Caprivi (Fig. 2).

Our aerial surveys encompassed 15,000 km² of the Caprivi Strip (Fig. 3a). The western boundary of the survey area extended 14-22 km west of the Okavango River (~600 km²) and extended eastward to the Zambezi and Chobe Rivers. We excluded a small area between Mudumu and Mamili parks (~640 km²) and a ~1,500 km² area in the central part of the East Caprivi. These areas were excluded based upon the occurrence of extensive human settlements and agriculture (Fig. 1).

METHODS

Aerial surveys were conducted on five days (Mar 26-29 and Apr 5, 2003). The break between surveys was due to poor flight conditions and other aerial survey commitments in Botswana. This period corresponded with the wet season when we expected elephants to be most dispersed.

Aerial surveys were conducted along flight transects using a Cessna 206. Prior to flying, all transects were incorporated into a digital map of the Caprivi with their beginning and end point coordinates. All flight transects were systematically flown along an east/west axis (Fig. 3a,b). All transects were mapped prior to flying and on-board real time navigation along flight transects was done using a GPS receiver (Garmin 12 xl) and DNR Garmin software (Minnesota Department of Natural Resources, MIS Bureau, GIS Section). On-board navigation was facilitated using a digital map of the Caprivi Strip and a real-time feed of the plane's GPS locations. The digital map was created using ArcView 3.2 (ESRI) software and showed observable landmarks and boundaries. All transects were mapped prior to flying and shown on the digital map with their beginning and end point coordinates. The pilot used this digital map for accurate transect navigation.

Fifty-six transects were flown, totaling 3,180.2 km. Transects were spaced 2.5 km apart in Mudumu and Mamili parks, along the western and eastern sides of the Okavango River, and in the Caprivi Forest Reserve. Spacing for all other transects were 5 km apart. Transects were flown primarily during morning hours (~0730 - ~1130 hrs). However, four transects were flown between 1600 – 1730 hrs on Mar 28. All transects were flown at 100 knots and at 76.2 m above ground level. Altitude was maintained using a radar altimeter.

The same two observers (T. Nkala (T) and R. Thakadu (R)) were used for each survey, one on each side of the plane. Both of the observers had much previous aerial survey experience (> 100 hrs) prior to this project. There was also a third person (M. Chase) in the plane that logged all elephant observations made by the observers and assisted the pilot with navigation along the pre-determined transect lines. For each elephant seen, the observer called out the numbers of elephants, herd type (bull or breeding herd), and the interval for the geometric center of the herd if it extended over multiple intervals. With each herd observation, the data recorder entered a waypoint on the GPS. The data recorder would also keep a written data log of the number of elephants observed and altimeter reading. A cassette recorder was used as a backup to log all observations. The cassette recorder was connected to the speaker-headphone system used by the two observers and data recorder.

Modifying the protocols used for aerial surveys of elephants by Chase and Griffin (2003) in northern Botswana and Rodwell et al. (1995) in the Caprivi Strip, we used strip transect sampling. We attached four wands to the wing struts of the plane to delineate three intervals (near, middle, far) for recording elephant observations. This allowed observers to determine the distance interval that elephants occurred in on the ground given the fixed height above the ground. Observers assigned elephants to these distance intervals when the elephants were as nearly perpendicular to the plane as possible. Additionally, a mark was put on the plane window to help observers keep their eyes at a consistent height to maintain the same sighting angle for each observation. This helped us to keep consistent interval widths for each observation. At 76 m altitude, the field of view for each distance interval was 100 m for near, 100 m for middle, 150 m for far. These intervals were confirmed prior to initiating the first survey by placing markers on the ground and conducting flyover tests. The aluminum wands were semi-permanently attached to the struts for the duration of each survey. Further, each wand was color-coded to facilitate interval recognition by the observers.

Using standard methodology for strip transect sampling developed by Norton-Griffiths (1978), only elephants that were observed within the three intervals were counted and recorded. Any animals outside of the area delineated by these three intervals were not counted.

To verify herd size and the interval location of herds, cameras were used. The components of the camera system consisted of two 35 mm cameras with 18 mm wide angle lenses, camera backs with time code generators, and two window camera mounts.

A camera was mounted on each side of the plane and the center of the lenses corresponded with the marks on the plane window that were used to help observers keep their eyes at a consistent height for each observation. The cameras provided high resolution photos so that animals could be more accurately counted during subsequent analyses. Typically, observers took a picture whenever herd size > 5. A GPS time code and date were recorded to the minute for every frame exposed.

Data Analyses

Photo-Interpretation. - The 35 mm photos of observations were interpreted and compared to the observers' counts. This method verified and/or corrected herd size as well as interval recorded by the observer. This method is especially helpful in counting large herds that are difficult to count accurately.

Strip Transect Sampling. - Following the guidelines developed by Norton-Griffiths (1978), we calculated abundance and variance estimates for strip transect counts utilizing observations obtained for a 350 m wide interval. We used the traditional Jolly's Method II for unequal sized sampling units (Jolly 1969) and adjusted for altitude following Norton-Griffiths (1978). We calculated estimates for our entire survey area, and for comparative analysis, the area surveyed in 1994 by Rodwell et al. (1995)(Fig 3b).

Statistical Analyses. - A two sample t-test was used to compare mean bull and breeding herd sizes per observer. We used χ^2 Goodness of Fit tests to compare numbers of total herds, bull herds, and breeding herds seen per observer. SYSTAT[®] 10.2 and Excel[®] were used for all statistical analyses.

RESULTS

For the entire 15,000 km² survey area, 56 transects were flown, totaling 3,180.2 km. Flight altitude averaged 77.02 m (range 67 – 88.4 m) for herd observations. One hundred-three elephant herds were observed throughout the survey area.

Distribution

Overall, most of the elephant herds observed occurred in the West Caprivi Game Reserve (n = 84) and within the parks of Mudumu (n = 28) and Mamili (n = 16) in the East Caprivi (Fig. 4). Only 3 herds were observed in the Forest Reserve, and no herds were observed within the eastern portion of the East Caprivi. Many of the elephant herds occurred along the Kavango and Kwando Rivers (Fig. 4). Within the Western Caprivi Game Reserve, elephants occurred within the thick mixed vegetation of the deep parallel sand dunes where seasonal water was available. Elephant herds also occurred along the Angolan border. Elephants were relatively numerous west of the Kwando River, where 30 km of the border fence between Botswana and Namibia has been removed. It appears that this fence-free area serves as a small but highly effective corridor, facilitating movement of animals between Botswana and Namibia. In contrast, to the west of this

fence-free area, it appears that elephants are not able to penetrate the border fence, effectively sealing off the Western Caprivi from elephant movements from Botswana. There was also a notable absence of herds observed 10km north or adjacent to the border fence in Namibia.

Herd Observations & Abundance

Of the 103 herds observed, 61 bull and 42 breeding herds were observed (Table 1). Herd size for bull and breeding herds combined averaged 8.3 elephants per herd (range 1 – 100)(Fig. 5). Bull herd size averaged 1.7 elephants/herd (range 1 – 7), while breeding herd size averaged 17.8 (range 1 – 100).

Table 1. Herd number and type and mean herd size by observer on strip transects for the Caprivi Strip, Namibia, March/April 2003.

Observer	No. herds observed	No. bull herds	No. of breeding herds	X bull herd size (SD)	X breeding herd size (SD)
R	38	24	14	1.67 (1.049)	13.6 (8.31)
T	65	37	28	1.70 (1.199)	19.8 (22.90)
Total	103	61	42	1.72 (1.14)	17.8 (19.39)

The number of herds observed by each observer were significantly different ($X^2 = 7.078$, $df = 1$, $P = 0.008$), with Observer T reporting almost twice the number ($n = 65$) of herds relative to Observer R ($n = 38$). The number of observations of bull herds was similar for the two observers ($X^2 = 2.77$, $df = 1$, $P = 0.096$); however, Observer T reported significantly more breeding herds ($n = 28$) than Observer R ($n = 14$) ($X^2 = 4.67$, $df = 1$, $P = 0.031$). There were no differences between the two observers for average bull herd size ($t = 0.29$, $df = 59$, $P = 0.77$) or breeding herd size ($t = 0.98$, $df = 40$, $P = 0.33$). Numbers of herds observed on east versus west flight transects (east = 47, west = 56) were not different ($X^2 = 0.786$, $df = 1$, $P = 0.375$). Combining the herd observations for both observers and accounting for the average flight altitude of 77.02 m, strip transect sampling provided an estimate of 5,740 elephants ($2,859 \leq N \leq 8,620 = 0.95$) using Jolly's Method II for unequal sized sampling units (Jolly 1969).

For comparison to the aerial surveys conducted in 1994 by Rodwell et al. (1995), we reanalyzed the survey data for a smaller area, encompassing approximately 6204.17 km²(Fig. 3b). For this smaller survey area, we used herd observations from 35 of the flight transects, totaling 1,575.6 km. Seventy-one elephant herds were observed. Combining the herd observations for both observers and accounting for the average flight altitude of 77.02 m, strip transect sampling provided an estimate of 5,318 elephants

($2,690 \leq N \leq 7,946 = 0.95$) using Jolly's Method II for unequal sized sampling units (Jolly 1969).

DISCUSSION

Distribution

In our 2003 aerial surveys, elephant distribution appeared to be highly affected by the distribution of human settlements and agriculture. Very few elephant herds occurred in those regions of the Caprivi where human settlements and agriculture are most prevalent (Figs.1 & 4). Yet, elephant herds did occur throughout the West Caprivi despite the sporadic occurrence of small subsistence agricultural fields and settlements. Although Rodwell et al. (1995) observed no elephant herds within interior portions of the central West Caprivi; away from the Okavango and Kwando rivers (their strata 2A & 2B), their survey was conducted during the dry season versus our wet season surveys when elephants were more widely distributed due to the occurrence of water in seasonal pans. However, within their high density stratum 1 along the Okavango River, it is noteworthy that Rodwell et al. (1995) observed only one herd north of the Trans-Caprivi Highway in 1994. Yet, during our 2003 survey, many herds were observed north of the highway as well as immediately adjacent to the Angolan border (Fig. 4). In the East Caprivi, our 2003 observations of elephant herd distribution was similar to those of Rodwell et al. (1995) for Mudumu and Mamili Parks, the only areas they surveyed in 1994. Although not surveyed in 1994 by Rodwell, the 'Chobe Floodplains Area' of the East Caprivi was considered to have 'particularly high concentrations of wildlife along the road from Katima Mulilo to the Botswana border' (Logan 1968 as cited in Rodwell et al. 1994:5). Yet, we had no observations of elephant herds for this area of the East Caprivi during our wet season Caprivi survey in 2003. Similarly, on the few aerial transects that traversed the border during our wet season aerial surveys of northern Botswana in 2002; we also had no observations of elephant herds in this region (Fig. 6). In contrast, during our September 2002 dry season aerial survey of northern Botswana, we observed many elephants on the eastern Caprivi floodplains on both sides of the border (Fig. 6). This suggests that the occurrence of elephant herds in the East Caprivi is largely restricted to the dry season, coincident with the period when large aggregations of elephants occur along the Chobe River in Botswana. Large numbers of elephants utilize the lush floodplain vegetation after the seasonal floodwaters begin to recede (Chase and Griffin 2003).

Since its construction in 1997, there has been much controversy about the Caprivi Fence along the Botswana/Namibia border. Albertson (1998:11) reported that the fence had 'terminated' all wildlife movements, including elephants, across the border. We observed no elephant herds in the Caprivi in the vicinity of the fence in 2003. Herds were only observed along the Botswana/Namibia border beyond the eastern end of the fence within 30 km of the Kwando River where the fence line has been removed (Fig. 4). Movements of six elephants recently (October 2003) tagged with satellite collars near Seronga in the Okavango panhandle of Botswana further reinforces that elephants are not

able to penetrate the double fence line into the Caprivi (S. Mosojane. pers. comm.). Yet, Rodwell (1995) reported regular movements of satellite-tagged elephants across the border in the early 1990's when the fence was absent. In contrast, there were many elephant herds observed along the Angolan border during our survey. We plan to conduct aerial surveys of southeastern Angola (Luiana) and southwestern Zambia (Sioma Ngwezi) in January 2004 to quantify the distribution and abundance of elephants and other wildlife in these two regions.

We believe that the 30-km wide fence-free area west of the Kwando River serves as a critical conservation corridor linking northern Botswana, the central Caprivi, and southern Angola and Zambia. Similar to the 1994 surveys conducted by Rodwell et al. (1995), we observed numerous herds in this area during our 2003 aerial surveys. Further, three adult elephants satellite-collared by Conservation International in the Kwando region of Botswana in August 2003 have extensively used this area. Movements from one adult cow (herd size, 23) have revealed large wet season home ranges when elephants move away from their dry season concentration areas along the Kwando river to the western interior of the Caprivi Game Reserve. This adult cow has moved 96 km west along the border fence in the Caprivi towards the Okavango River. One sub adult bull collared on the Caprivi border (northern Botswana) has moved 10km into southern Angola, further indicating the importance of the Kwando corridor to releasing the high seasonal aggregation of elephants along the Kwando and Linyanti systems.

Herd Observations & Abundance

The two observers differed in their total number of herds seen ($P = 0.008$) with Observer T observing twice the number of breeding herds as Observer R ($P = 0.031$). This result suggests that the detection ability of the two observers may differ and, if so, could bias our elephant population estimate. However, both observers were well trained and very experienced observers, having logged well in excess of 100 hrs of aerial surveys of elephants in northern Botswana in 2002. Although it was not possible to incorporate a strict double count method into the survey design (Jachmann 2001), the data recorder (M. Chase) was monitoring the same side of the aircraft as Observer R throughout the survey. Based upon the observations of the recorder, we are confident that Observer R was not missing herds. Further, the photographic record of the herds observed by both observers indicated that herds beyond the interval width were not being counted. Thus, we believe that this difference in herds seen by the two observers is real and not an artifact of observer bias.

Our estimate of 5,318 elephants was equivalent to the count of 5,556 elephants reported by Rodwell et al. (1995) for the same survey area in 1994. Further, incorporating the additional 21 transects (1,604.6 km) flown over the Forest Reserve and eastern portion of the East Caprivi, resulted in a population estimate of 5,740 elephants for the larger Caprivi sample area. This small difference between the two survey areas emphasizes the small numbers of elephants in the East Caprivi outside of Mudumu and Mamili Parks (Fig. 4). It also underscores the absence of population growth of the Caprivi

elephant population since 1994, in dramatic contrast to elephant populations in northern Botswana.

Although Rodwell et al. (1995) considered their 1994 elephant count to be a total count without any measure of precision; they also considered it an underestimate of total numbers. Yet, from research we conducted at Kruger National Park during August 2002 (Griffin et al. 2003), we know that estimates obtained from strip transect sampling are much lower than actual numbers. In this Kruger study, we independently assessed the accuracy of strip transect sampling methods for estimating elephant numbers in comparison to a total helicopter census count. The estimate obtained from strip transect sampling was 34% lower than the helicopter census. In other words, an adjustment factor of 1.5 would need to be applied to the strip transect estimates to obtain the helicopter census count value for Kruger. If this same adjustment factor was applied to our larger Caprivi estimate, it would yield an estimate of 8,610 elephants. However, application of this adjustment factor to our Caprivi Strip estimate would assume that the herd detection probabilities were the same in the Caprivi Strip as in Kruger National Park, and this may not be the case considering differences in vegetation types, transect widths used, observers, and seasons surveyed between the Kruger and Caprivi studies. Additional field research needs to be conducted in the Caprivi to determine the true error rate of elephant population estimates derived from strip transect sampling.

CONCLUSION

Consideration should be given to the following proposed activities:

Surveys

- Periodic systematic wet and dry surveys of elephant populations in the Caprivi Strip which will help determine the seasonal distribution of elephants into southern Angola and Zambia.
- Surveys that will help better understand the habitat needs of elephants in the OUZTFCA.
- Surveys that will help further determine the seasonal abundance of elephants in the Caprivi Strip.

Enhance Wildlife Movements

- Remove additional portions of the Caprivi fence along the 135km border with Botswana, specifically along the old valleys (parallel sand dunes) which served as vital wildlife corridors between the two countries.
- Reduce/prevent incursions of human settlements into protected areas.

Conservation Initiatives

- Protection of the Kwando River Corridor, along the western boundary of the River extending from Botswana, through the Caprivi into Angola and Zambia.
- Accelerate & expand conservancies (Kasika Conservancy) in the East Caprivi to provide habitat and economic enhancement for local communities.

- Initiate de-mining of the Luiana Partial Reserve. Initially a 40km section along the Kwando River, extending 50km west into southern Angola.
- Accurately designate and demarcate protected land management in southern Angola and Zambia.

Research

- Estimates of error rates associated with aerial survey methods.
- Initiate telemetry movement studies of elephants in the Caprivi, southern Angola & Zambia to help determine the boundary of the OUZTFCA. This research will also help quantify the extent and duration of tranfrontier movements and the effects of demining exercises in the Luiana. This component of the research will further support the need for Human Elephant Conflict information in the Caprivi.

The Caprivi is a vitally important dispersal zone, because it is sandwiched between northern Botswana and the extensive open ranges of Angola and Zambia. The effective conservation land use planning in the eastern Caprivi will help with the dispersal of the large elephant population source in the Kwando and Linyanti systems of northern Botswana. Further research can help quantify the extent of elephant dispersal away from these high concentration regions, vegetation regeneration, and the economic impact of having elephants in newly formed conservancies and the protected areas in southern Angola and Zambia.

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Fig. 1 Agricultural fields, and settlements in the Caprivi Strip of Namibia

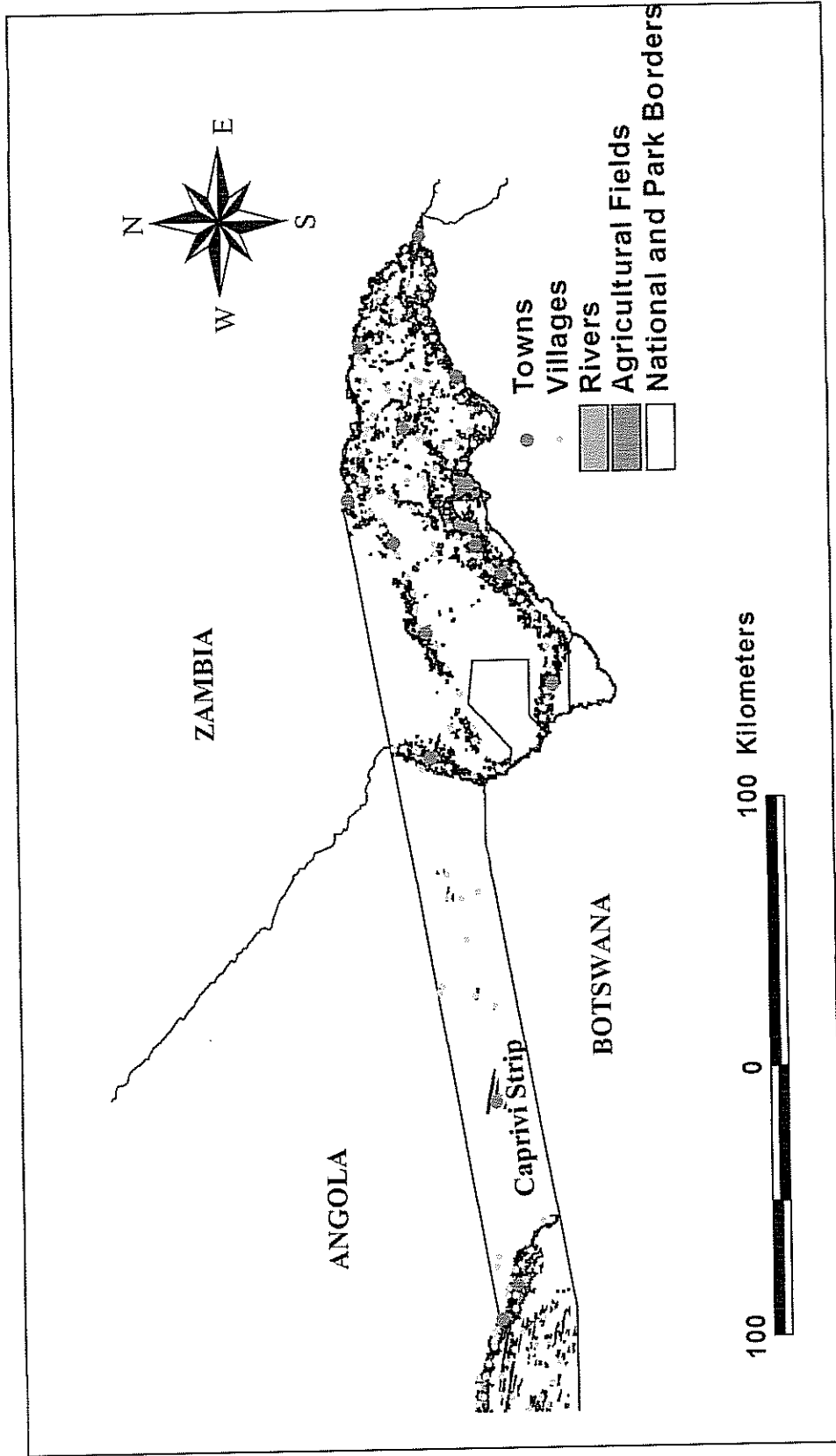


Fig. 2 Landuse (Protected Areas) in the Caprivi Strip

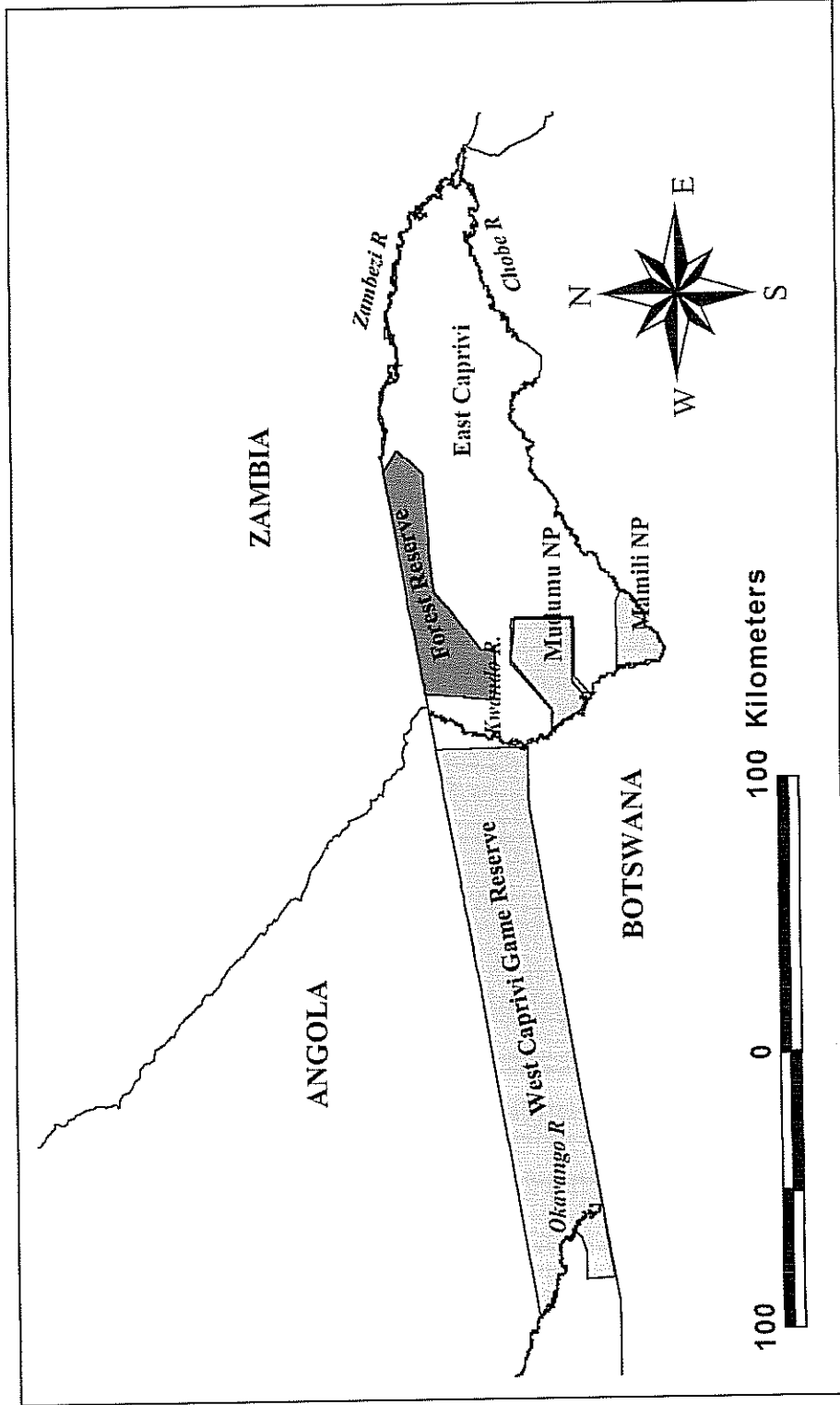
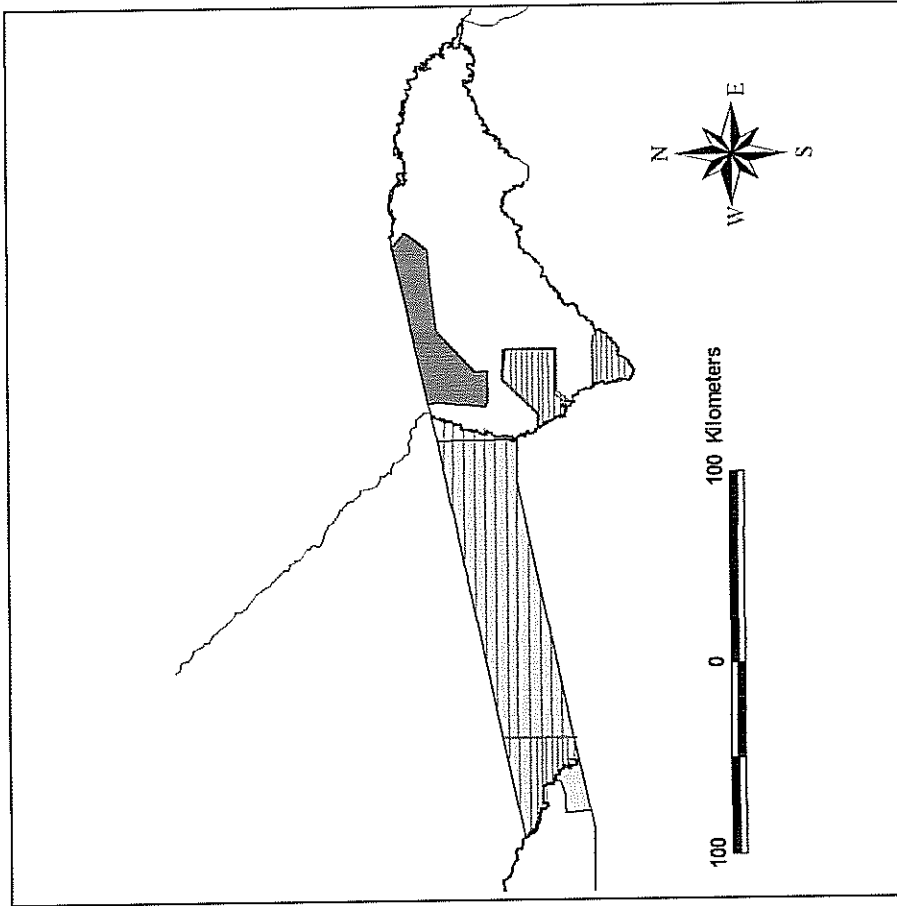


Fig. 3b Rodwell Aerial Transects and Survey Area



**Fig. 3a Aerial Transects for Elephant Surveys, Caprivi Strip
March – April 2003**

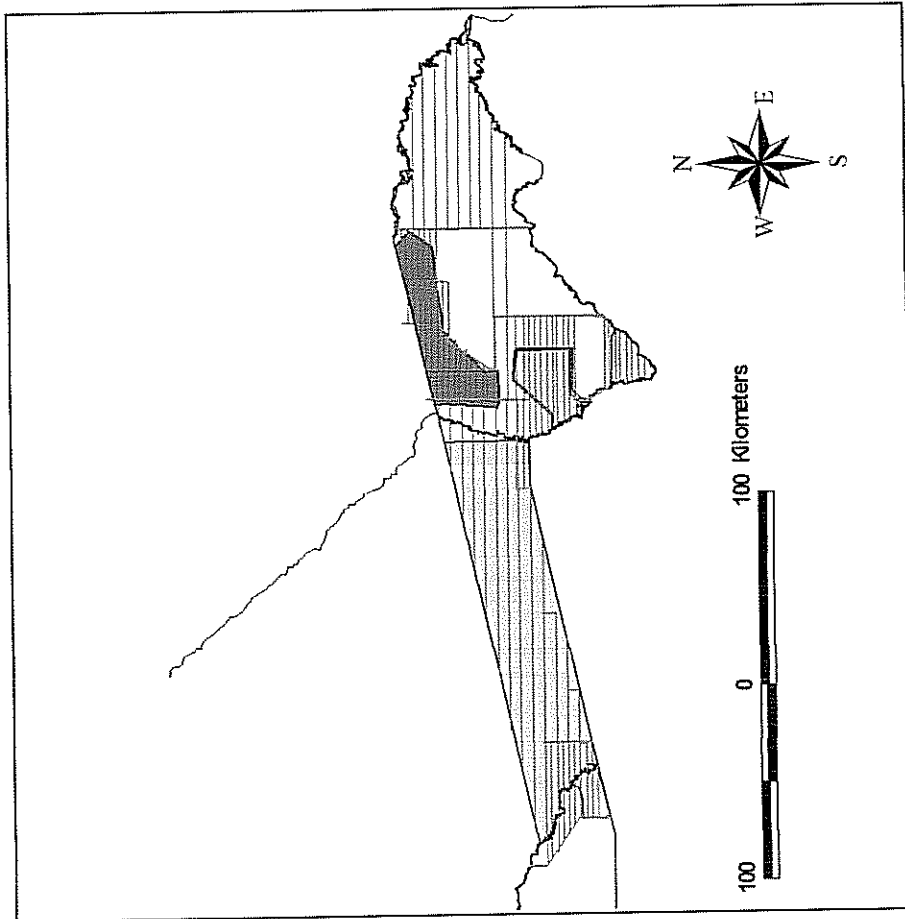


Fig. 4 Distribution of Elephant Herds on Aerial Surveys, Caprivi Strip, March –April 2003

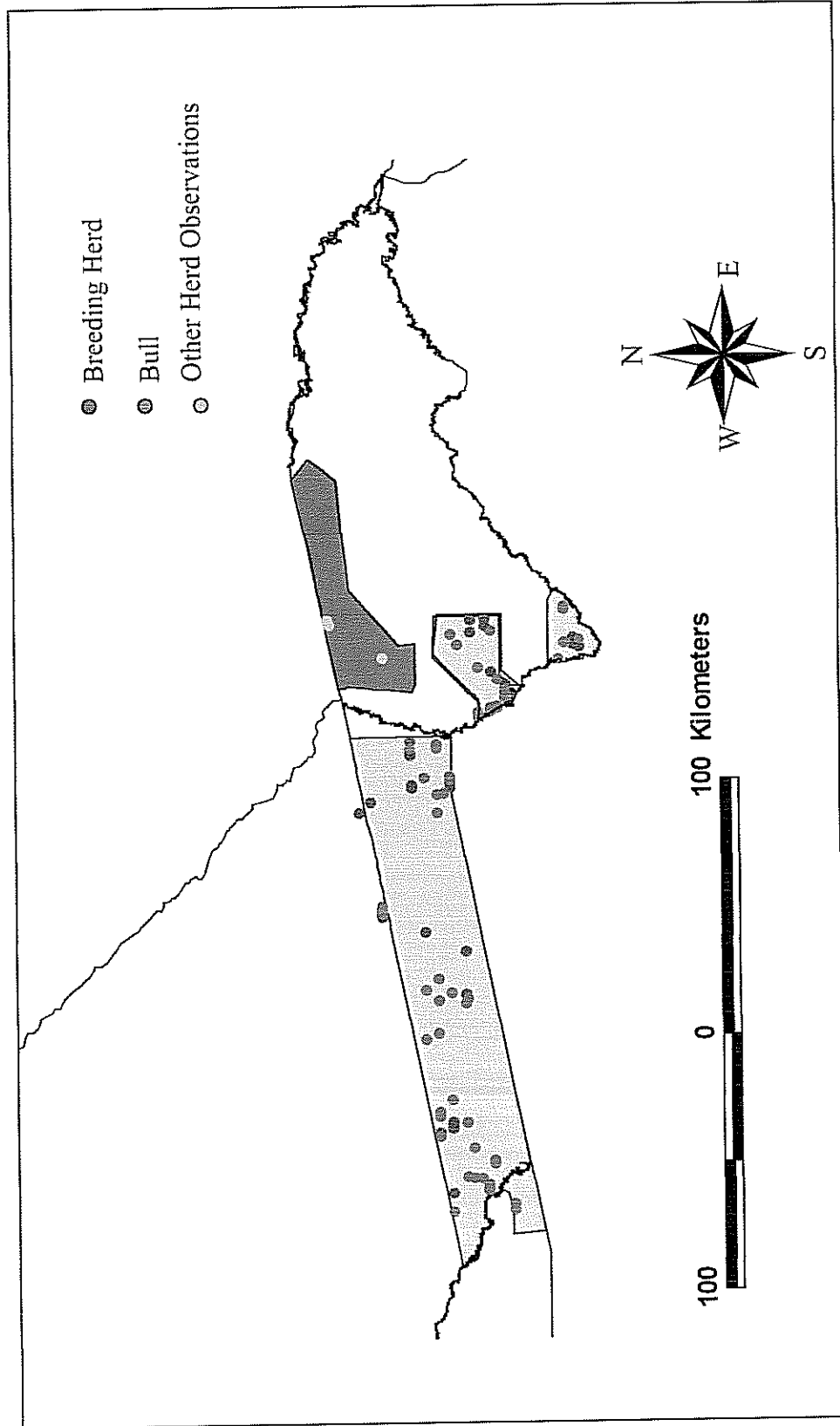


Fig. 5 Elephant Herd Size on Aerial Surveys, Caprivi Strip, March - April 2003

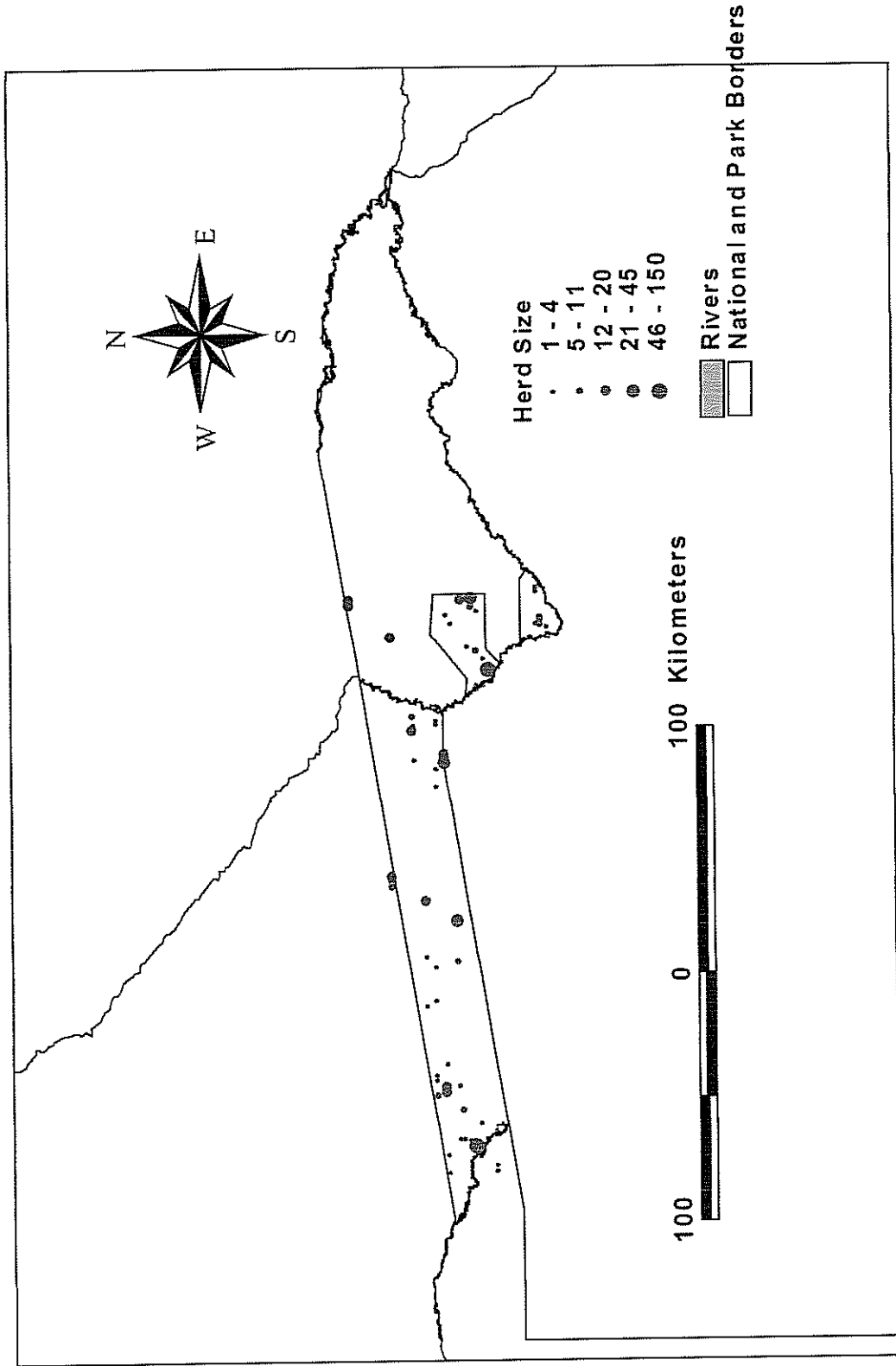


Fig. 6 Distribution of Elephant Herds on Aerial Surveys, Northern Botswana and Caprivi Strip

