Seasonal influence of rainfall and crops on home-range expansion by bull elephants

F. V. Osborn

9 Lezard Ave., Milton Park, Harare, Zimbabwe
email: fvosborn@elephantpepper.org

Abstract

The movement patterns of bull elephants were monitored over two years in central Zimbabwe. Range sizes and crossing patterns out of a protected area were compared by season. Findings suggest that the concept of range expansion at the end of the wet season is correlated with the movement of elephants into agricultural lands. Knowing how and when crop-raiding elephants move into subsistence agricultural land that surrounds many protected areas is considered essential to identifying the reasons why elephants and people come into conflict.

Résumé

Pendant deux ans, on a surveillé de façon continue le schéma des déplacements des éléphants mâles au centre du Zimbabwe. La taille des territoires et les schémas de déplacements ont été comparés avec ce qui se passe en dehors d'une aire protégée. Les découvertes suggèrent que l'expansion du territoire à la fin de la saison des pluies est liée aux mouvements des éléphants dans des terres cultivées. On considère qu'il est essentiel de savoir comment et quand les éléphants qui dévastent les cultures se déplacent vers les terres cultivées qui entourent de nombreuses aires protégées, afin d'identifier les raisons pour lesquelles hommes et éléphants entrent en conflit.

Introduction

In Sanderson's (1966) review of methods for studying the movements of mammals he notes that understanding the patterns of how wild animals use resources is essential for developing programmes to 'control' pest species. Knowledge of distribution and movement patterns in relation to their environment is essential if elephants are to be effectively managed because crop raiding is spatial and temporal in nature. Sukumar (1989) and Hoare (1999) have suggested that seasonal movements of elephants bring them into contact with farmland that now occupies part of their former range.

The distribution and patterns of relative abundance of animals depend largely on the seasonal availability of food and water (Odum 1971). It is generally accepted that seasonal variations in food availability and quality affect elephant ranging patterns and migration (Leuthold 1977; Sukumar 1989; Viljoen and Bothma 1990), modified by water availability, which is in turn dictated by rainfall (Leuthold 1977; Afolayan and Ajayi 1980; Western and Lindsay 1984). In regions where water availability is highly seasonal, researchers have reported that elephants concentrate near water points in the dry season then expand their range in the wet season. In Zimbabwe, Taylor (1983) noted that elephants in the Sebungwe region dispersed in the wet season, and Conybeare (1991) noted similar dispersal in Hwange National Park.

Most studies of elephant movement in southern and eastern Africa report distinct seasonal variation in range size and use. Generally in areas with annual rainfall under 1000 mm, the pattern is that elephants move away from permanent water sources at the beginning of the rainy season as water becomes widely available. Elephants are able to move into less heavily used areas of their range to find seasonally ephemeral foods such as fresh grasses, forbs and climbers. As seasonally available water dries up, elephants again start to concentrate near permanent water points (see Leuthold and Sale 1973; Poche 1974; Leuthold 1977; Western and Lindsay 1984; Viljoen 1989; Conybeare 1991). An obvious relationship exists between elephant movements and the pattern of rainfall in an area. Bull elephants may also be motivated to move when in musth. The objectives of this study were to obtain estimates of the home ranges of elephants in a protected area, to establish the seasonal crossing patterns into surrounding communal agriculture and to examine the concept of wet-season range expansion.

Study area

The study area was situated in and around the Sengwa Wildlife Research Area (SWRA) and the surrounding communal lands of Zimbabwe. The vegetation is generally deciduous and dry deciduous savannah woodland. The main vegetation associations are *Brachystegia–Julbernardia* woodland, *Colophospermum mopane* woodland, *Acacia* spp. riparian woodland, riverine grasslands and *Combretum* spp. thickets. A single rainy season usually occurs between November and April, but it is highly variable in timing and quantity. The mean annual rainfall is 668 mm (n = 30).

Methods

Ten male (7 adult, 3 subadult) elephants were immobilized and fitted with radio transmitters in October 1994. The transmitters were the MOD 665, high-powered, UHF design by Telonics (Mesa, Arizona, USA). These transmitters are a three-stage device using a timer, a quartz crystal oscillator and an amplifier powered by lithium batteries. The transmitter was cast into acrylic and attached by brass plates and rivets to a 1-metre section of plastic belting. The collars were made of the 1-metre plastic transmitter belt fastened to either end of an eight-ply section of machine belting. Animals were tracked every 3 hours for 10 days each month between January 1995 and June 1996 using three directional antennae. Directional tracking towers were situated at points from which the positions of the animals could be triangulated.

The minimum convex polygon (MCP) and the kernel methods were used to estimate home range. Although it is recognized that MCP has numerous drawbacks, it was used because it provided a comparison with previous studies (Worton 1989). Both methods were used to analyse the size and the structure of the ranges each season, and for all the fixes collected per animal during the study. MCPs were drawn to enclose 100% area estimation for analysis of the entire tracking study, and 95% and 100% MCPs were drawn for the seasonal analysis. The utilization distribution was estimated using the kernel method and a fixed bivariate normal density kernel to compare seasonal cores and outer contours of the elephant's range with the software package RANGES V (Kenward and Holder 1995).

A sandy section of the southern SWRA boundary was patrolled to identify the location where elephants left or entered the SWRA (fig. 1). The spoor of elephants crossing into communal lands was examined to determine the number of animals and the direction of travel. If the number could not be assessed at the boundary road, spoor was tracked into communal lands and an effort made to obtain a count at some other point. The number of crossings was assessed taking the mean number of elephants crossing out and back into the SWRA on any given day. Each crossing point was swept daily so that new spoor could be recorded the following morning.

The 'three-month running mean' (3MRM) of rainfall was used as an indicator of soil-water availability to plants. Du Toit (1993, 1995) found this measure correlated well with changes in browse-to-grass ratios for mixed feeders and with proportional use of riverine habitat by large browsers. The rainfall total for a particular month was added to the totals for the previous two months and divided by three. This procedure essentially shifts the rainfall pattern to represent more accurately the moisture in the soil available to plants. The mean number of elephants crossing per month was calculated by dividing the total number of elephants that crossed out of the SWRA by the total number of days patrolled.

The seasons used in the analysis were divided into two-month blocks and are as follows: early-wet, late-wet, early-dry, mid-dry, and late-dry.

Results

Two distinct cores are identified when fixes are analysed using the kernel method (fig. 1). The 100% totals are similar for both methods (table 1). A one-way ANOVA test for the area enclosed by the 100% MCP indicated that there was a significant difference be-

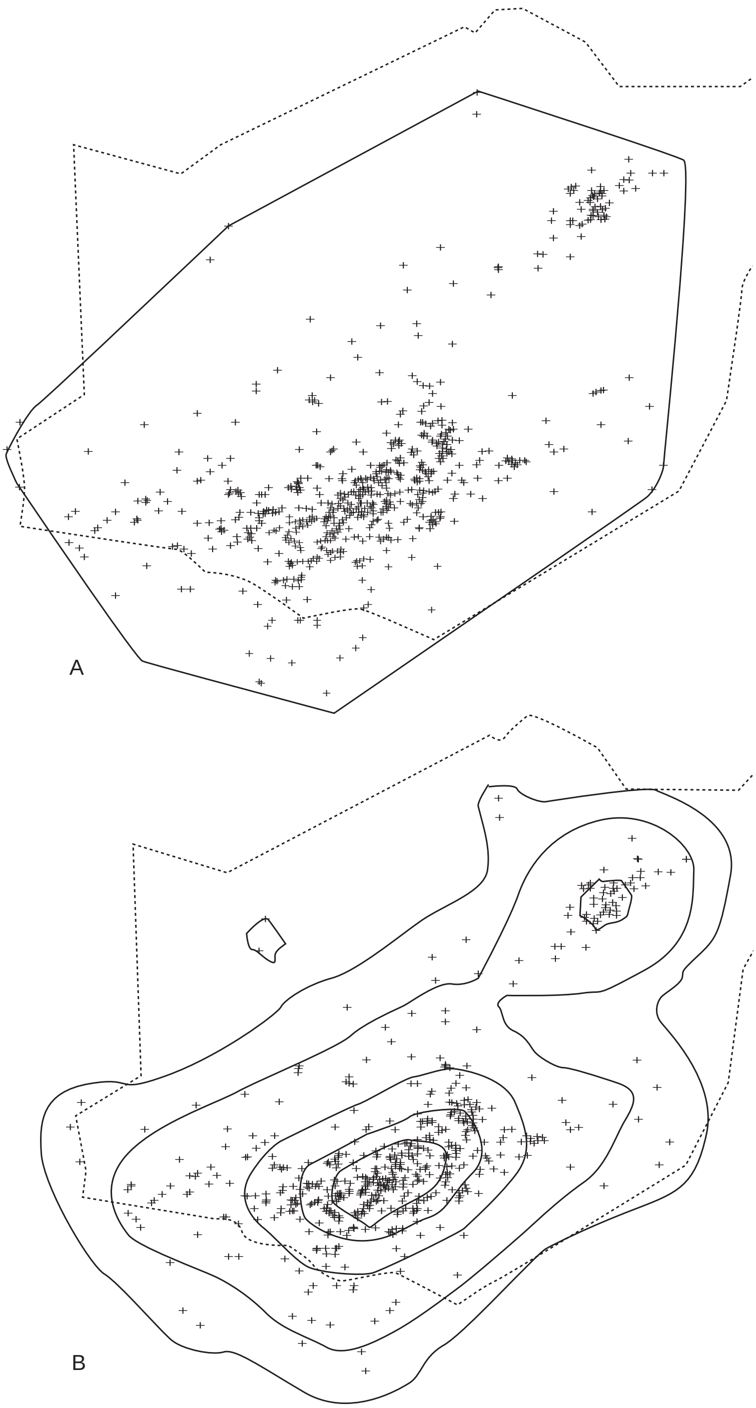

Figure 1. A) Map of the Sengwa Wildlife Research Area (outline in dotted line) showing the home range determined by the minimum convex polygon method (100% edges, solid line) for an elephant between December 1994 and June 1996. Each + represents one fix (n = 571) range size = 311.71 km^2. B) Map showing 25, 50, 75, 95 and 100% home-range contours using the kernel method (solid lines).

tween the seasonal ranges (F = 8.082, df = 51, P = 0.001) Note the marked rise in range size between the late-dry and early-wet season in 1996 (fig. 2). For the kernel analysis, a one-way ANOVA indicates that there was no significant difference between the four seasons in the area enclosed by the 25% (F = 1.902, df = 33, P = 0.15) and 50% (F = 2.85, df = 33, P = 0.053) contours. There was, however, a significant difference for the 75% (F = 3.4, df = 33, P = 0.03), 95% (F = 4.48, df = 33, P = 0.01) and 100% (F = 4.67, df = 33, P = 0.001) contours.

The contours of the kernel analysis for elephant no. 28 during the late-dry season 1995 to the early-dry season 1996 show the increase in range size in the late-wet season (fig. 3). There is a significant increase in range size between the early-wet and the late-wet seasons for the 95% and 100% contours. Also note that a considerable number of locations were outside the protected area.

The southern boundary of the SWRA was patrolled on 831 days between June 1993 and June 1996. Elephant crossings were recorded on 617 or 74% of the patrols. On only three occasions was the spoor of young elephants identified. If the assumption that young elephants would be present with female groups is correct, then it would appear that male elephants are responsible for most of the crossings and subsequent crop raiding in this area. The 3MRM of rainfall is plotted against the mean number of elephants crossing out of the SWRA per month over the period of the study (fig. 4), and figure 5 plots the 3MRM of rainfall and the mean number of elephants crossing out of the SWRA.

Table 1. Range size for nine bulls tracked between January 1995 and June 1996

Collar	N	MCP (km²)	Kernel (km²)				
		100%	25%	50%	75%	95%	100%
3	1006	392.76	5.06	25.58	61.17	148.97	329.83
8	571	311.71	8.20	21.68	54.91	181.90	322.36
13	776	372.75	6.57	30.35	74.32	203.05	393.57
18	782	391.75	16.77	43.36	100.06	230.66	477.81
28	531	292.80	8.77	24.31	59.82	160.65	267.67
33	776	331.37	8.11	28.03	65.45	147.88	294.83
48	498	322.00	13.07	35.25	92.36	207.39	372.57
53	366	224.04	7.67	19.26	44.26	125.00	226.00
55	702	260.46	11.76	29.71	64.52	156.00	320.00
Mean	668	322.18	9.55	28.61	68.54	173.50	333.85

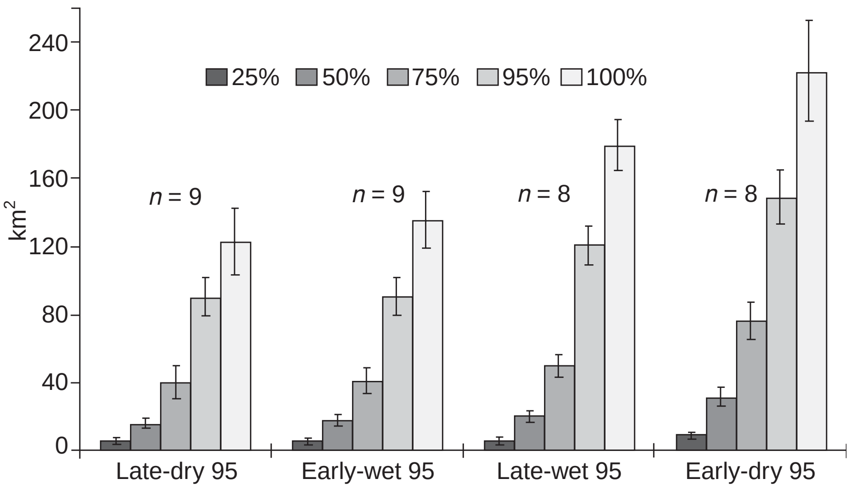

Figure 2. Seasonal variation in the area enclosed by 25, 50, 75, 95 and 100% contours as determined by the kernel method. The *n* indicates the number of elephants used in the analysis.

Discussion

The range expansion seen at the end of the wet season identified using the kernel method coincides with the onset of crop raiding. A possible explanation for the observed late-wet-season increase in range size may be due to grass growth. In the SWRA, elephants feed primarily on new grasses in the early-wet season and do not have to move large distances (Osborn 1998). They switch from a diet primarily of grass back to browse, and they may expand their range because they need to increase their area to forage. While no causal relationship was identified, this finding may be important for identifying an ultimate 'cause' for crop raiding.

Numerous natural and human-induced factors influence the movements and seasonal occupation by elephants in the different habitats available to them (Hoare 1999). Natural factors include distribution of water, either surface or in the vegetation, and seasonal changes in the quality and availability of food. In many semi-arid savannahs, surface water is more limited and forage is drier and lower in quality during the dry season. In places where surface water is abundant and perennial, this restriction is less inhibiting, but distribution of best-quality forage is still likely to change seasonally (Conybeare 1991). Human-induced factors include reducing and fragmenting traditional range, disturbing the animals through illegal hunting, and subsistence agriculture encroaching on their range.

Results from this study indicate that the pattern of range expansion at the beginning of the wet season, seen in other studies, occurs later with bulls in the SWRA (see Taylor 1983; Conybeare 1991). This may be due to the fact that the SWRA is comparatively well watered all year round and elephant movements are dictated by the availability of food rather than water. The super-abundant grass growth after the rains makes food readily available and there is no reason why these bulls need to expand their ranges to find food in the

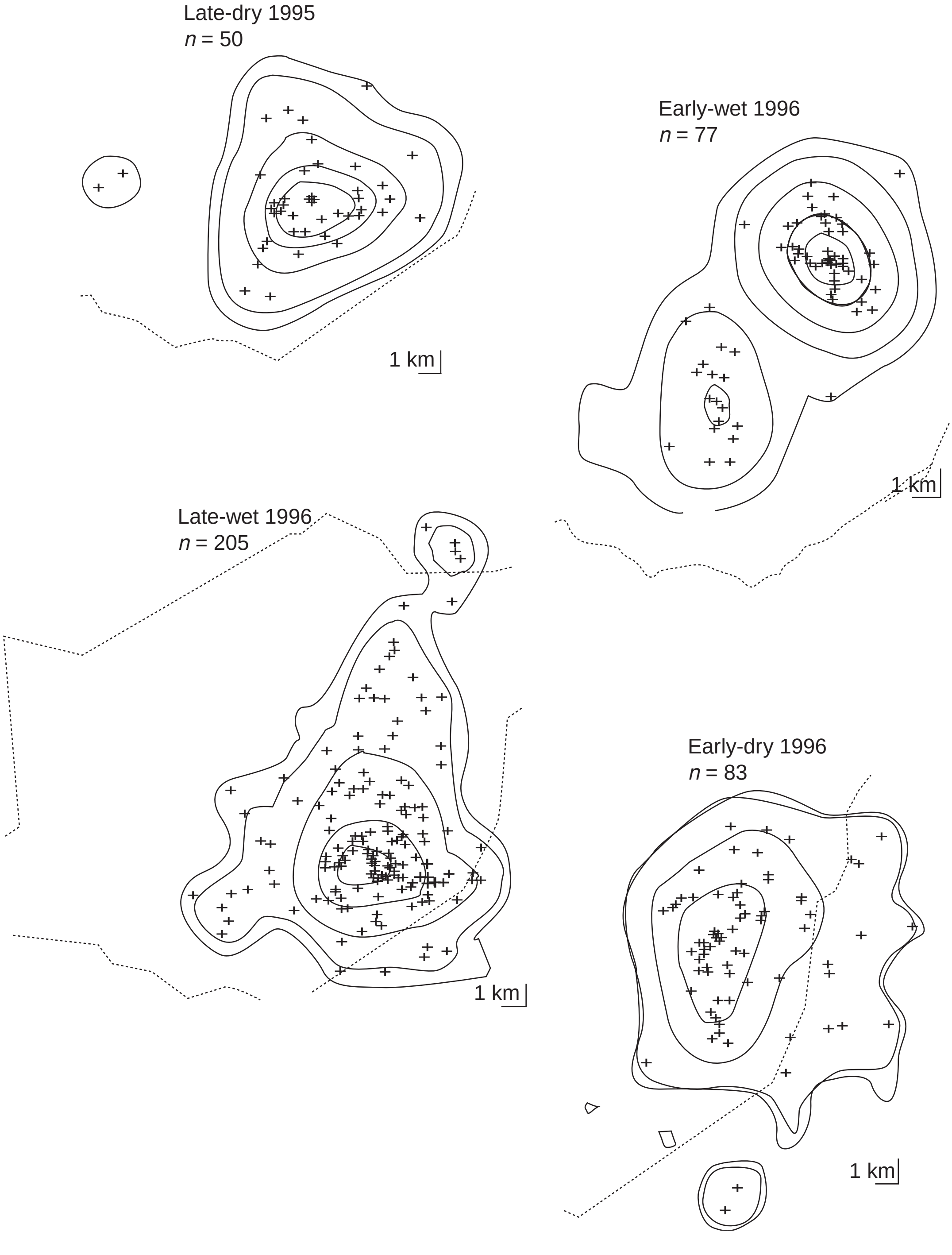

Figure 3. Range of an elephant in the late-dry season 1995 and the early-wet, late-wet and early-dry season 1996. Range determined using the kernel method; 25, 50, 75, 95 and 100% isolines shown. The light dotted line is the boundary of the SWRA.

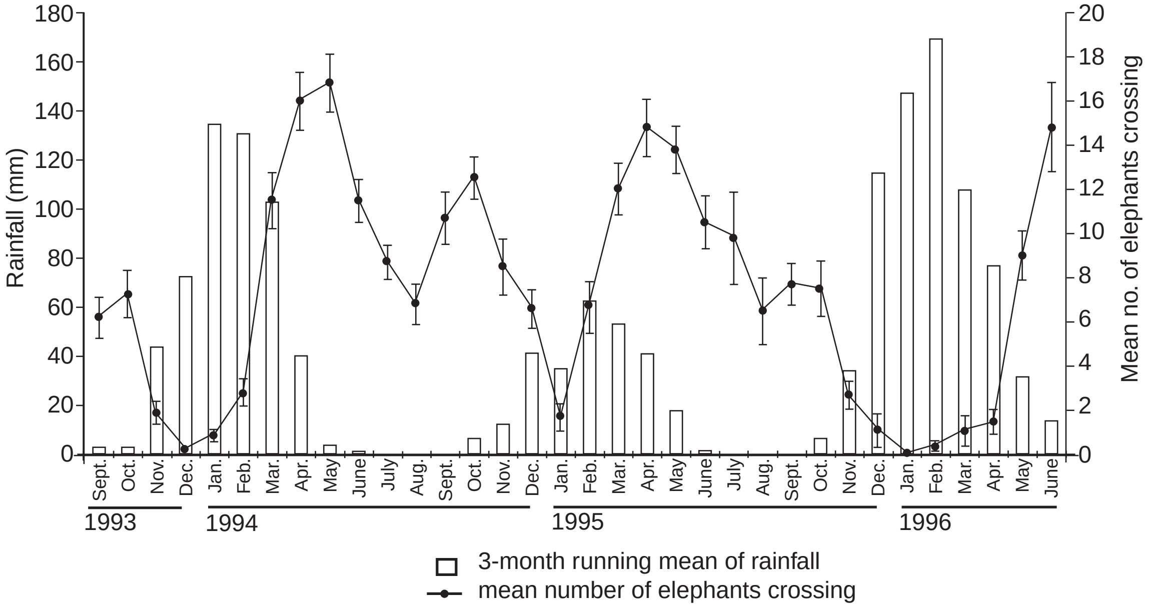

Figure 4. A plot of the three-month running mean of rainfall and the mean number of elephants crossing out of the SWRA.

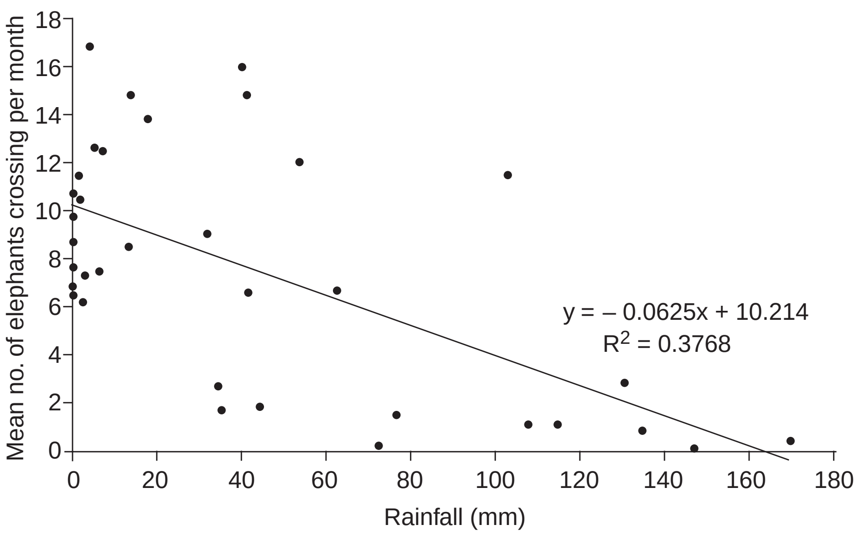

Figure 5. The three-month running mean of rainfall plotted against the mean number of elephants crossing out of the SWRA between September 1993 and June 1996 (Persons R = 0.6138, P = 0.001).

early-wet season. The expansion of range occurs at the end of the wet season when these elephants switch from feeding primarily on grass to feeding on browse. They may be attracted by a combination of late-maturing crops and wild browse species still abundant in the communal lands (Osborn 1998). This behaviour may have not been identified before due to the insensitivity of the MCP method.

Figures 4 and 5 indicate that a significant relationship exists between moisture in the soil available to the vegetation and movement of elephants into communal lands. Crossing of elephants out of the SWRA is inversely correlated with the 3MRM of rainfall. The peak crossing periods coincide with the range expansion. In wet years and months the crossings are low, and in dry years and months the level of crossing is high. While not tested, this finding suggests that elephants may be motivated to leave the SWRA when the moisture content of wild grasses within the SWRA declines. The variation between seasons also supports the contention that rainfall and plant moisture are factors that influence when elephants start to cross into the communal lands.

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