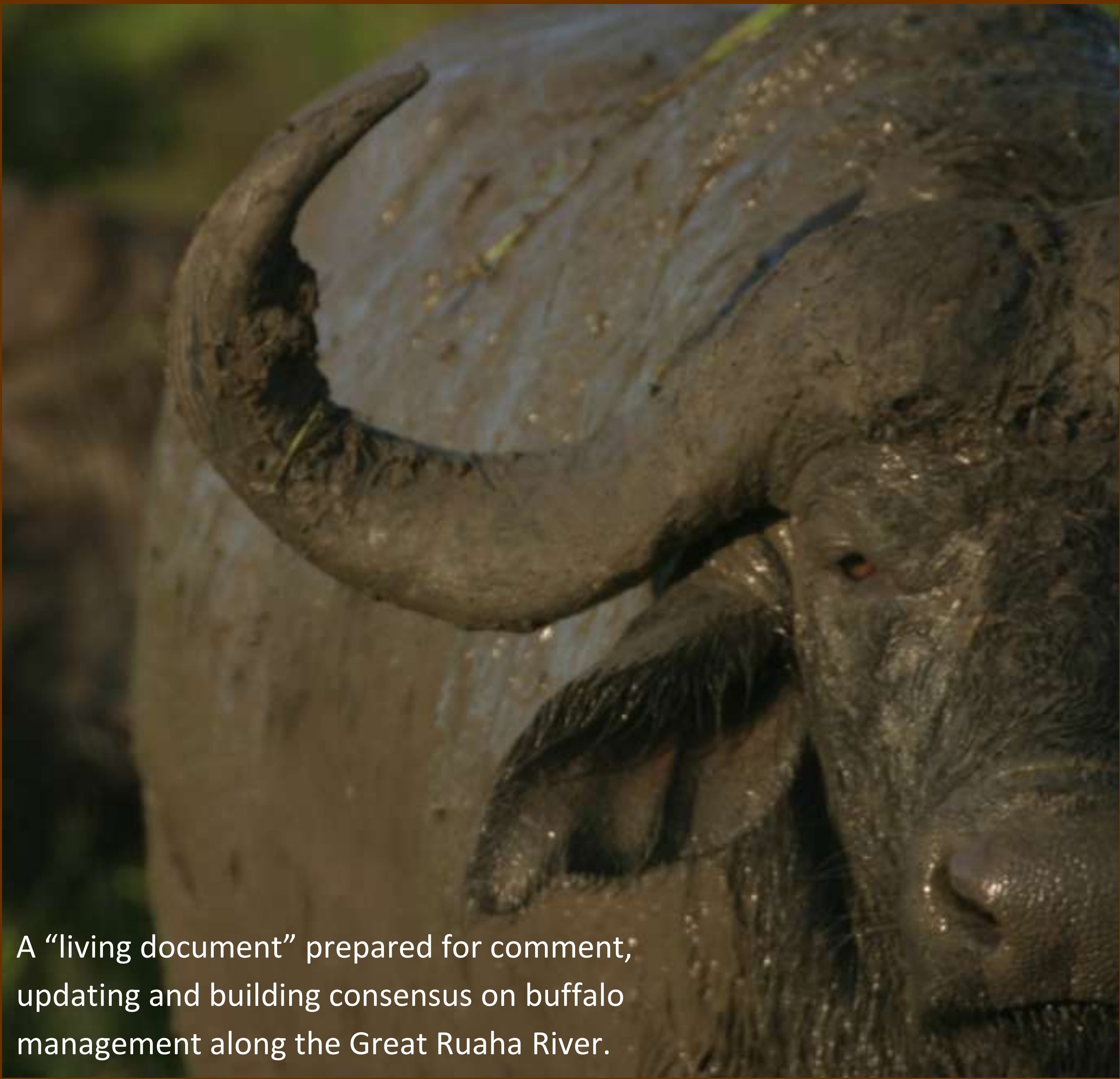
THE STATUS OF THE RUAHA RIVER BUFFALO
PART 1: SPATIAL PATTERNS



A "living document" prepared for comment, updating and building consensus on buffalo management along the Great Ruaha River.

Feedback Requested to:
Ruaha Landscape Program
PCoppolillo@WCS.org
www.RuahaConservation.org.

Introduction: Why Buffalo?

Buffalo as a model for site-based planning

Buffalo are an iconic part of African Savannas. The African Buffalo's widespread distribution, abundance in many areas and high trophy value make it an economic cornerstone of the tourist hunting industry. Photographic tourism also benefits from buffalo, as their large herds attract visitors interested in Africa's mega-herbivores and the carnivores that follow them. Buffalo hold cultural significance, having been used traditionally by numerous ethnic groups and as a symbol of African strength and wilderness. Ecologically, buffalo are equally significant, acting as a bulk grazer to reduce tall swards, redistributing nutrients, disturbing soils by traveling in large herds, and acting as prey for Africa's large carnivores. All these characteristics hold true in the Ruaha Landscape, an area recognized as both an important buffalo population and a good place to see them.

Threats to buffalo in the Ruaha Ecosystem

Both because of their economic significance and in spite of it, buffalo are also threatened. In the Ruaha Landscape, disease, illegal hunting, the drying of the Great Ruaha River and fire all probably affect buffalo, but the intensity and magnitude of these threats and their combined effects on the Ruaha Buffalo population are unknown. Some observers within the Ruaha Landscape have reported significant declines in buffalo, with both qualitative and quantitatively support for their observations. This paper is an attempt to document Buffalo status along the Great Ruaha River and to begin the process of outlining preliminary steps for sustainable management should these be necessary.

The discussion here is confined to the spatial distribution of buffalo, as these data provide the most basic, and consequently robust, assessment of the situation. A companion piece examining correlates of occupancy and disappearance is in preparation.

Methods

SRF data

Systematic Reconnaissance Flight (SRF) data were collected from 1972-2002 by the Tanzania Wildlife Research Institute[1] and Ecosystems Limited[2] Methods were consistent with Norton Griffiths[3]

[1] TAWIRI (2003). Aerial Census in the Ruaha-Rungwa Ecosystem, Dry Season, 2002. Arusha, Tanzania, Tanzania Wildlife Research Institute: 38.

[2] EcosystemsLtd (2002). Game Surveys of Lunda_Mkwambi Game Controlled Area and Adjacent Areas of Ruaha National Park. Sixth Aerial Survey 14-25 October, 2002. London and Nairobi, Ecosystems Consultants: 74.

[3] Norton-Griffiths, M. (1978). Counting animals. Nairobi, African Widlife Foundation.

Total Count data

Total count data were collected by flying over the study area at an elevation that allowed individual buffalo to be observed. In practice, this varied from 200-600 meters (~700-2000 feet) above ground level, depending on the openness of the vegetation and ruggedness of the terrain. Transect lines were spaced to allow approximately 20% overlap between counting strips so that no buffalo were missed.

Area of Analysis

The area of this analysis is limited to the zone adjacent to the Great Ruaha River. This area was chosen for a number of reasons; first, the bulk of Ruaha's tourism occurs in this zone; second, claims that buffalo have declined in this area have been made and contested; third, data are available for this area, but spotty SRF coverage precludes a similar analysis over the entire landscape. The area of analysis is shown in Figure 1.

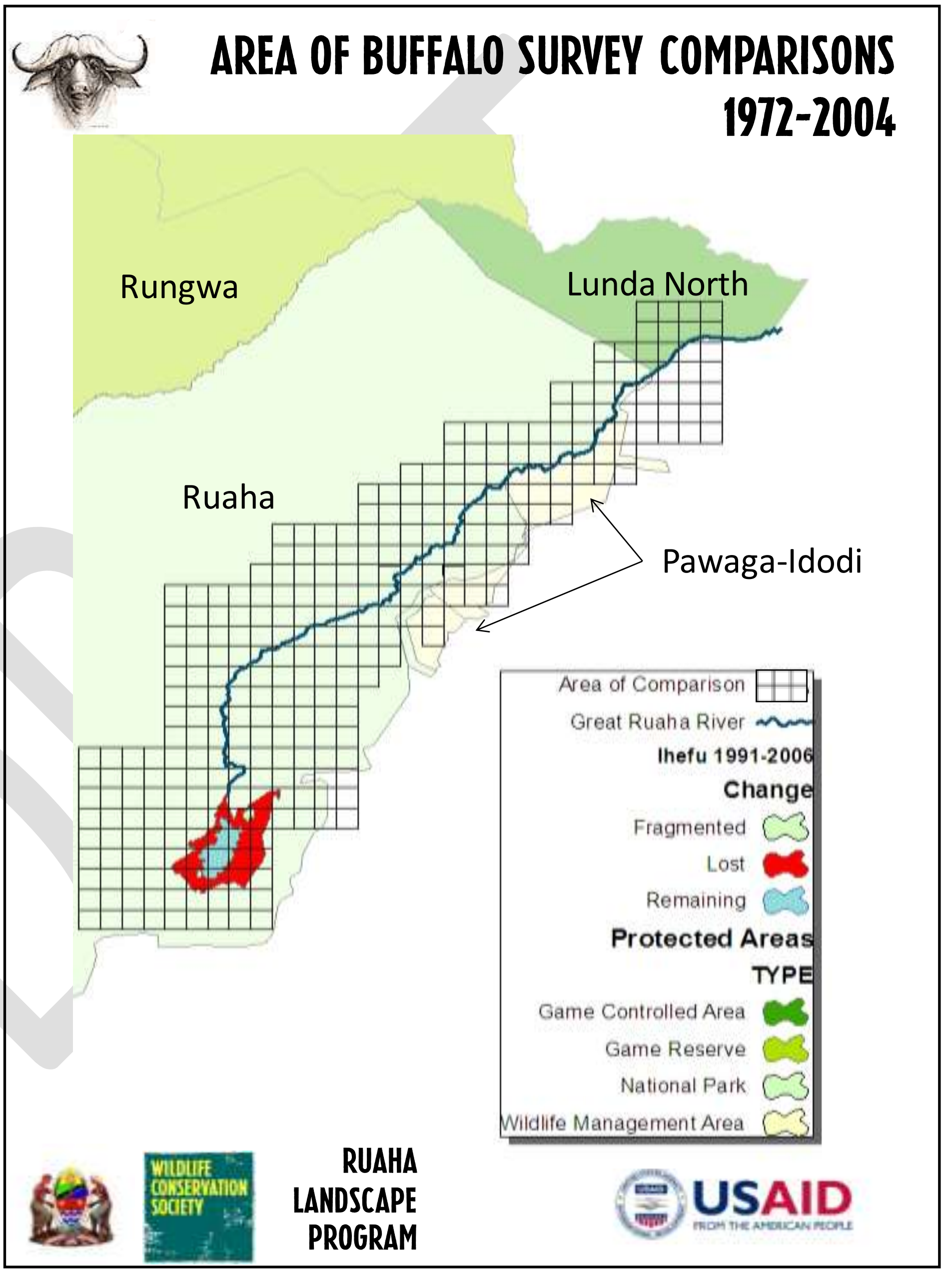


Figure 1: (Right) Area in which Buffalo distributions were examined.

Buffalo distributions

Spatial distributions were constructed from aerial survey data using the TAWIRI 5km x 5km standard systematic reconnaissance flight survey grids. Cells with buffalo occurrences were identified, and for each survey, buffalos' extent of occurrence – that is, the areas they were presumed to use based on the area of occupancy – was identified as the minimum convex polygons created by cells with occurrences. This process is shown in Figure 2.

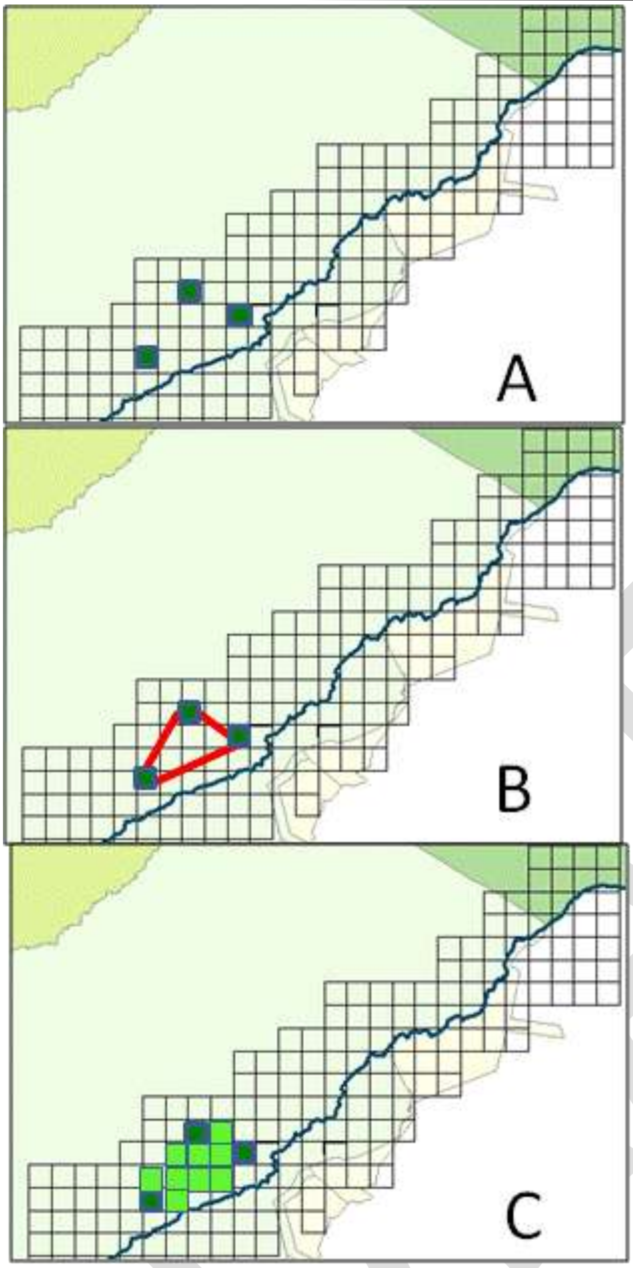


Figure 2: Cells where Buffalo were observed are labeled the "Area of Occupancy," or AoO, as shown by the dark green cells in panel A; Cells contained within the minimum convex polygons created by , shown by the red lines in panel B, constitute the presumed "Extent of Occurrence," sown in the lighter green cells in panel C. These terms are consistent with the IUCN 2001 Red List Categories and Criteria[4] definitions and are applied accordingly.

Analysis of cell transitions

Coding cells

In a given survey, cells were coded as a local extinction if they were within the extent of occurrence during the previous survey, but not in the survey being assessed. For cells which were unsearched in the immediately preceding census, the most recent one was used. (TELL FOR HOW MANY CELLS THIS WAS AN ISSUE). Only cells for which a previous and a current distribution were available were considered in the regression for each time step.

Cells could be coded as extinct only once. For example if buffalo were present in a particular cell in 1972, absent in 1993 and absent in 1996, that cell would be coded as extinct in 1993, but NOT in 1996. This minimizes the number of cells where extinctions are observed.

A separate regression was run on all cells' transitions from 1972 to 2004, and any cell that had an extinction at any time from 1972 to 2004 was coded as "extinction".

Cells were coded as re-colonized if they were coded as extinct or unoccupied in a previous survey and within the extent of occurrence in the current survey. Cells with buffalo present (in the EOA in the previous survey) were coded as 'no data' for recolonization, because being occupied makes the

[4] http://www.iucnredlist.org/info/categories_criteria2001 (Sections 9 and 10)

concept of recolonization meaningless (even though some immigration of individuals could in theory occur).

Results

Nine surveys were conducted between 1972 and 2004. These are shown in Figure 3.

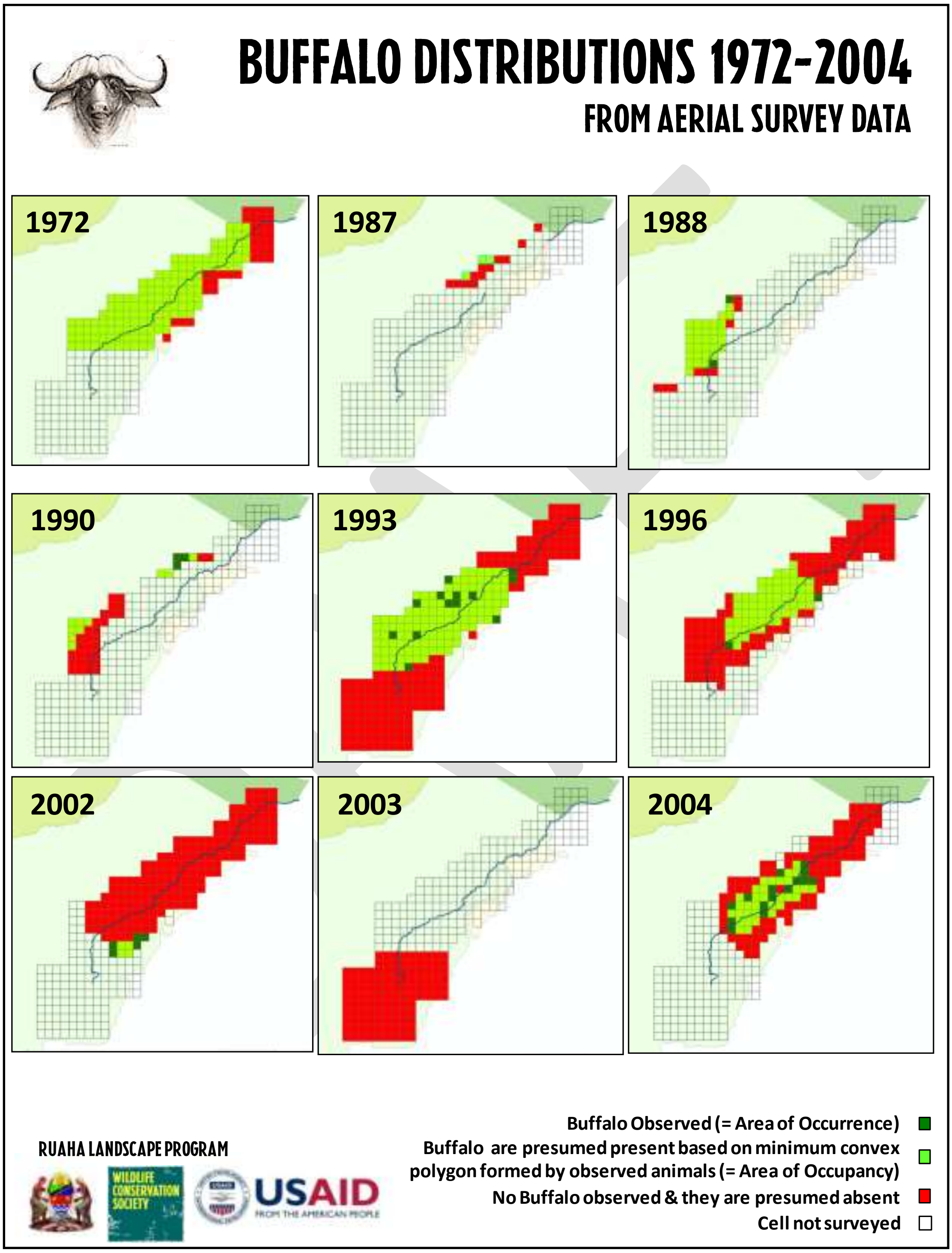


Figure 3: Buffalo Surveys 1972-2004

Of all the surveys from 1972-2004, five (carried out in 1972, 1993, 1996, 2002 and 2004) covered a sufficiently large portion of the study area to be included in this analysis. Examination of these five surveys shows that the area occupied by buffalo declined from around 80% in 1972, to less than 10% in 2002, with an apparent rebound in 2004, as shown in Figure 4.

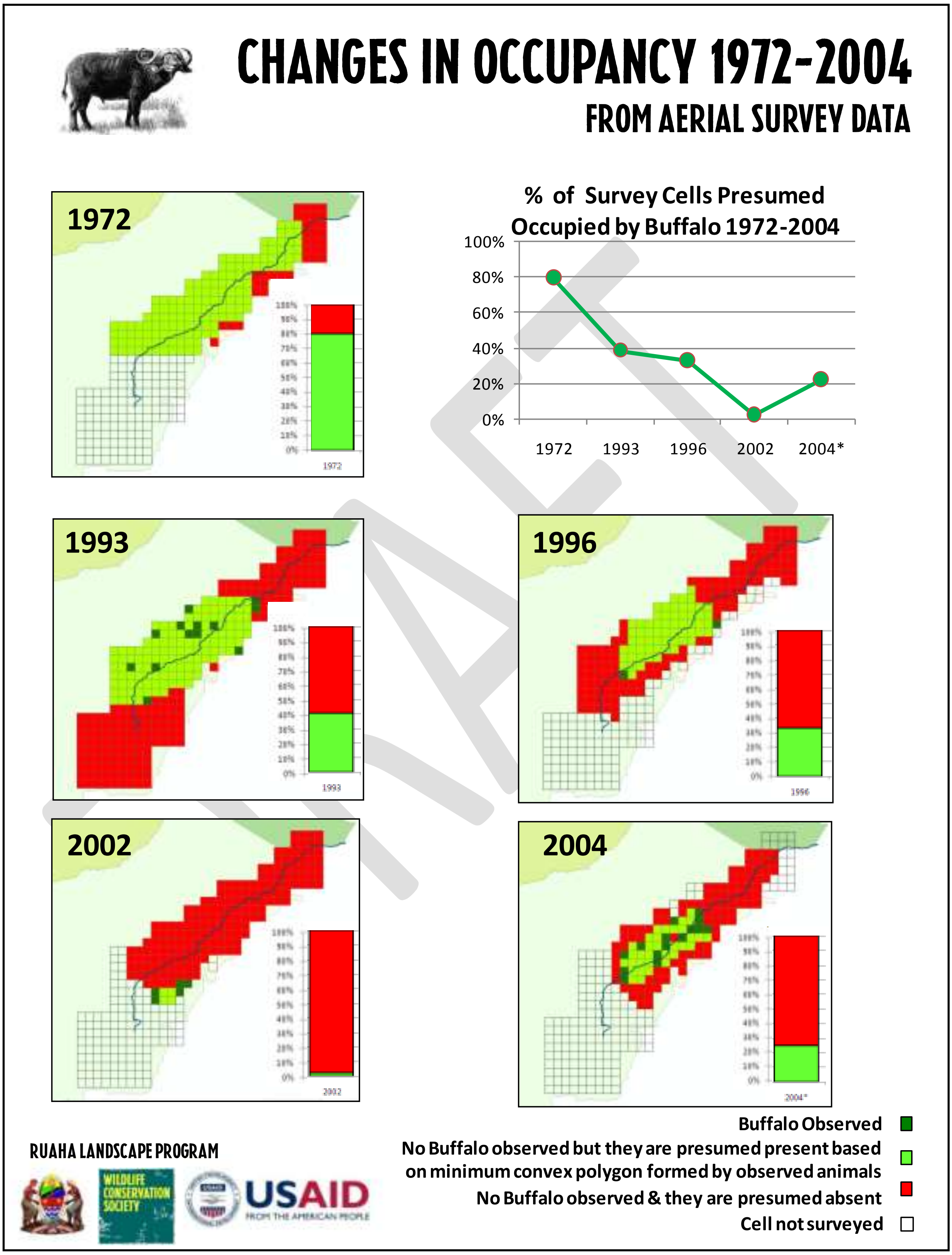


Figure 4: Changes in Buffalo Occupancy 1972-2004

Discussion

Translating the data presented here into buffalo numbers is problematic because areas were surveyed in different seasons and using different methods (total count vs. SRF). However, the spatial data appear to show a decline in the area occupied by buffalo along the Great Ruaha River, as shown in the percentage of cells presumed occupied, in Figure 4. This pattern warrants concern because numerical population declines are often preceded by a local range contraction[5], so the spatial contraction in range is interpreted here as evidence of decline.

Does the increase in extent in 2004 signal an increase in buffalo numbers? Probably not, for the following reasons. First, the 2004 data were collected as part of a total count, whereas 1972, 93, and 96 were SRFs. Second, in a total count, 100% of the area is searched (compared to around 10% for an SRF) so the likelihood of buffalo presence in a cell is much greater. Also note that all occupied cells are treated the same regardless of whether it is occupied by one or one thousand buffalo. This greater search effort could alone explain the increase in 2004[6]. A third piece of information arguing against the 2004 data as an indication of recovery is that anecdotal reports suggest buffalo occurrences have decreased substantially. Tour operators report fewer sightings and smaller herds[7], and the herd of "Msembe bulls" is also now gone, disappearing since 2004. Finally, both the biology of buffalo and the physical characteristics of the landscape suggest that long range movement out of the study area is unlikely[8,9]. Buffalo do not generally migrate long distances, and the steep escarpment and lack of dry season water to the north make it unlikely that buffalo would have simply moved there. Movement to the south is also unlikely, as the area is densely settled by the 21 villages of Idodi and Pawaga divisions.

Hypothesized effects from known threats

If the Ruaha Buffalo have declined, what are the potential causes? Below, we briefly discuss four potential "threats" that could be affecting buffalo numbers and distribution.

Disease is the least known potential threat to buffalo in the Ruaha Landscape. Assessments of buffalo health within the landscape have been rare, and in some cases the data and/or samples from the assessments have been lost[10]. Bovine Tuberculosis (*Mycobacterium bovis:* henceforth BTB) has been found in buffalo sampled in the Ruaha Landscape[11]. This is significant because buffalo

---

[5] Brashares, J. S. and M. K. Sam (2005). " How Much is Enough? Estimating the Minimum Sampling Required for Effective Monitoring of African Reserves." Biodiversity and Conservation **14**(11): 2709-2722.

[6] The 2002 total count did not find a similar increase in area however. The difference between 2002 and 2004 count was conducted by consultants from outside of Tanzania, so it is possible that a lack of familiarity with the landscape made it more difficult to find buffalo; it is also possible that differences in vegetation cover between 2002 and 2004 could affect detectability.

[7] C. Fox, personal Communication.

[8] Sinclair, A. (1977). The African buffalo: a study of resource limitation of populations, University of Chicago Press.

[9] Prins, H. T. T. (1996). Ecology and Behaviour of the African Buffalo: Social Inequality and Decision-making. , Springer.

[10] R. Kock & C. Dulle, pers comm. 2007

[11] D. Clifford, Rudovick Kazwala[2], Peter Coppolillo[3], Julius John[2], Titus Mlengeya[4], Epaphras Alex[4], Dominic Kambarage[2], and Jonna A.K. Mazet[1] 2007 "Bovine Tuberculosis at the Wildlife-Livestock Interface In The Ruaha Ecosystem, Tanzania" Paper Presented at the 2007 TAWIRI Scientific Conference, Arusha, Tanzania.

populations can maintain and spread BTB infections even in the absence of cattle, thereby serving as a source for infection of other species, especially predators like lion, hyena and wild dog. See Kazwala[12, 13] , Michel et al[14], Caron et al[15]**Error! Bookmark not defined.**, and Rodwell[16] for overviews of the epidemiology and potential effects of BTB on buffalo.

Our discussion of disease is focused largely on diseases affecting buffalo at the interface with domestic livestock. Disease transmission between domestic and wild herbivores has not been demonstrated in the landscape, nor is it warranted to claim that this is the only or even a significant source of disease for buffalo. We are examining disease at the livestock wildlife interface however, because Tanzania's policy is to let natural disease run its course, so diseases circulating "naturally" in the wild herbivore population would be treated as a natural ecological process, rather than a threat. BTB is also important because it has the potential to infect humans and could be a risk factor for hunters, skinners and consumers of buffalo meat. BTB also has important economic implications for livestock and wildlife products—its presence in livestock or wildlife may have important management implication for the other. For these reasons, the discussion of disease here is focused on BTB, recognizing the possibility that other diseases may also be important. Based on these assumptions and recognizing the limitations of the analysis it is possible to hypothesize that if disease is limiting the distribution of Buffalo they will disappear from areas of overlap with livestock, and possibly adjacent areas as disease spreads through the Buffalo population itself. Other demographic effects may also be visible, like poor recruitment or the loss of older age classes.

The drying of the Great Ruaha may also be affecting Buffalo, by constraining their dry season distribution. Buffalo's dependence on water is well documented[8,9,]**Error! Bookmark not defined.**, and the Ruaha population appears to have a similar association with water[1,2] but the critical thresholds for Buffalo use in terms of size, depth or water quality are unknown. It is also not known how far Buffalo will commute to and from water and the springs of the base of the escarpment may constitute a water source for Ruaha Buffalo. Nevertheless, it can be said that water stress in the northeastern reaches of the Great Ruaha is greater than it has been in the past. Therefore, if water is limiting the distribution Buffalo, their distribution will contract northeast to southwest along the Great Ruaha River. It is also worth noting that water and disease may interact. Limited water availability in the dry season may intensify interaction between buffalo and other species (wild or domestic) and lead to greater disease transmission. Water stress may also weaken buffalo and predispose them to disease, and the converse has been observed in that BTB-infected herds are more severely affected by drought and recover more slowly from population declines[15].

---

[12] Daborn CJ, G. J., Kazwala RR. (1996). "The bovine tuberculosis cycle--an African perspective." Soc Appl Bacteriol Symp Ser. **25**: 27S-32S.

[13] Jiwa, S. F. H., R. R. Kazwala, et al. (1997). "Bovine tuberculosis in the Lake Victoria zone of Tanzania and its possible consequences for human health in the HIV/AIDS era. ." Veterinary Research Communications **21**(8): 533-539.

[14] A.L. Michel, R.G. Bengis, D.F. Keet , M. Hofmeyr, L.M. de Klerk , P.C. Cross, A.E. Jolles, D. Coope, I.J. Whyte, P. Buss, J. Godfroid, (2006) "Wildlife tuberculosis in South African conservation areas: Implications and challenges" Veterinary Microbiology 112 p91–100

[15] Caron, A., P. C. Cross, et al. (2003). "Ecological Implications ff Bovine Tuberculosis In African Buffalo Herds." Ecological Applications **13**(5): 1338–1345.

[16] Rodwell, T. C., N. P. Kriek, et al. (2001). "Prevalence of Bovine Tuberculosis in African Buffalo at Kruger National Park." Journal of Wildlife Diseases **37**(2): 258–264.

Fire may also be affecting buffalo by reducing the amount or quality of forage. Because buffalo are a widely cited example of resource limitation[8], these changes in range quality may affect their abundance and/or distribution. Soils in the region are known to be phosphorus poor, and rainfall is low (between 200-600mm along the Ruaha River), so volatilization of nutrients lost in fires may represent a significant loss of nutrients. Poor nutrition could affect buffalo populations by causing low body condition which could limit lactation and/or calf survival, ovulation and/or conception or predispose undernourished individuals to disease or predation. If fire is limiting the distribution of Buffalo, they will likely disappear from areas where fire is more common.

Over-hunting, both legal and illegal, could represent another threat. While actual rates of illegal hunting are difficult to quantify or characterize spatially, it is reasonable to assume that illegal hunting is facilitated by access. Therefore, in areas adjacent to villages and outside protected areas where less enforcement takes place, more illegal hunting likely takes place along roads. Similarly, access inside protected areas probably improves enforcement, so while roads may increase hunting outside protected areas, we assume that roads facilitate enforcement inside protected areas and that less illegal hunting will take place near roads there. In contrast, legal hunting is confined Lunda North and Mkupule hunting blocks; if legal hunting is a factor in the decline of Buffalo, then these two areas should be visible as foci of disappearance.

Table 1 below summarizes the hypothesized effects of the four threats discussed above.

Table 1: Threats to buffalo and hypothesized effects

Threat	Spatial Prediction	Demographic
Livestock Disease (BTB)	Decline/ loss from areas of overlap with livestock (Usangu and Pawaga)	Low or no recruitment; decreased survival of older animals; significant declines in drought years with slower recoveries in affected areas.
Water	Absence from water-stressed areas (downstream)	Unknown.
Fire	In areas most affected by fire	Possibly no or low recruitment
Hunting	Border areas (Usangu, Mkupule, Lunda) and areas with greater access (outside PAs) and less enforcement (inside PAs).	Loss of adults, but good recruitment continuing

Next Steps

Given the patterns presented here, we suggest two broad categories of action: 1) explore the patterns in more detail and in conjunction with data on threats to buffalo; and 2) to gather current and supplementary data. Each of these is discussed below.

First, the patterns presented here warrant more analysis, particularly in conjunction with existing data on the anthropogenic factors that affect buffalo. The threats discussed earlier could be affecting the abundance and distribution of buffalo (as hypothesized in **Table 1**). While data on these threats are by no means complete, data do exist and preliminary analysis is possible[17]. If the threats presented in **Table 1** are affecting buffalo numbers and/or distribution, we would expect that cells enduring greater intensities of each threat, or more affected by them would be more likely to lose buffalo. In part two of this report these patterns will be explored using existing data.

Second, new data are needed to understand and confirm the patterns presented here. These data are required whether or not spatial patterns presented here demonstrate a significant decline. If the population has actually declined, more data will facilitate diagnosis of the causes and the magnitude of the decline. If the population has not declined, these data will confirm the status of the population and suggest more effective measures for monitoring buffalo status in the future. These data should include the following:

1. **Updating the existing Aerial Data**. The most recent total count was 2004, so a 2008 dry season total count for buffalo is recommended.
2. **Demographic Assessment:** All herds within the study area should be surveyed from the ground and the composition of the herds be assessed quantitatively (males : females : calves). Herd composition data will help to identify whether low recruitment is a constraint, and longitudinal data on survivorship would provide information on the sources of mortality and their effects on the population structure and overall numbers.
3. **New Data sources:** Alternative data sources should also be identified and explored. The most obvious of these is tourist sightings. Photographic tourism focuses on areas of highest density and visibility, so the sampling is non-random, but it is consistent. If the number of herds has declined, or if their area of occupancy has contracted, the frequency with which tourists sight buffalo should also have decreased. One limitation may be that tourist sightings would probably not capture changes in herd sizes or composition, since most tourists do not systematically count large herds or make note of age and sex classes, so this exercise should not substitute for 1 and 2, above.
4. **Buffalo Movement Data:** The ranging behavior and survivorship of buffalo must be assessed. If movement of herds is responsible for the patterns observed, the obvious question is: why? Movement data is also essential for identifying the scale over which these movements are occurring and whether other factors may be affecting survivorship or movement.
5. **Health Assessment:** Finally, it is essential to know the health status of buffalo on the ground in Ruaha. Knowing the diseases to which they have been exposed, necropsies of dead animals and an assessment of animals' nutritional status would shed light on the effects of disease and fire.

---

[17] These analyses are the subject of part 2 of this report, which is forthcoming, so only a brief discussion is presented here.