

Do artificial waterholes change the way herbivores use the landscape?

Herbivore distribution patterns around natural and artificial surface water sources in the Kruger National Park

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Water stabilisation programme

✦ Started in 1930's

✦ Provision of permanent and reliable water sources

- ✦ stabilise numbers of migratory species (fencing)

- ✦ stabilise and increase numbers of rare herbivores

✦ More than 300 boreholes, 50 earth dams, damming of rivers

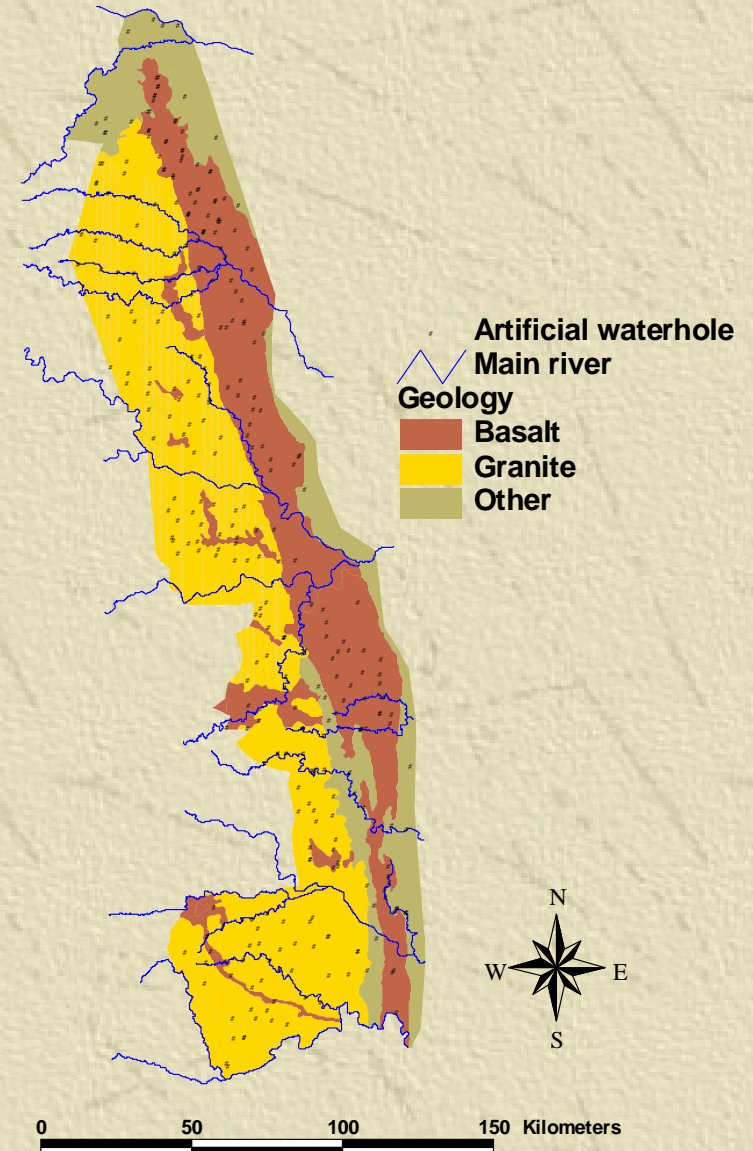


Effect of surface water provision

- ✦ Starvation induced mortality (Walker *et al.*, 1987)
- ✦ Degradation of herbaceous layer (Parker & Witkowski, 1999)
- ✦ Homogenisation
- ✦ Predation pressure (Harrington *et al.*, 1999)

Aim

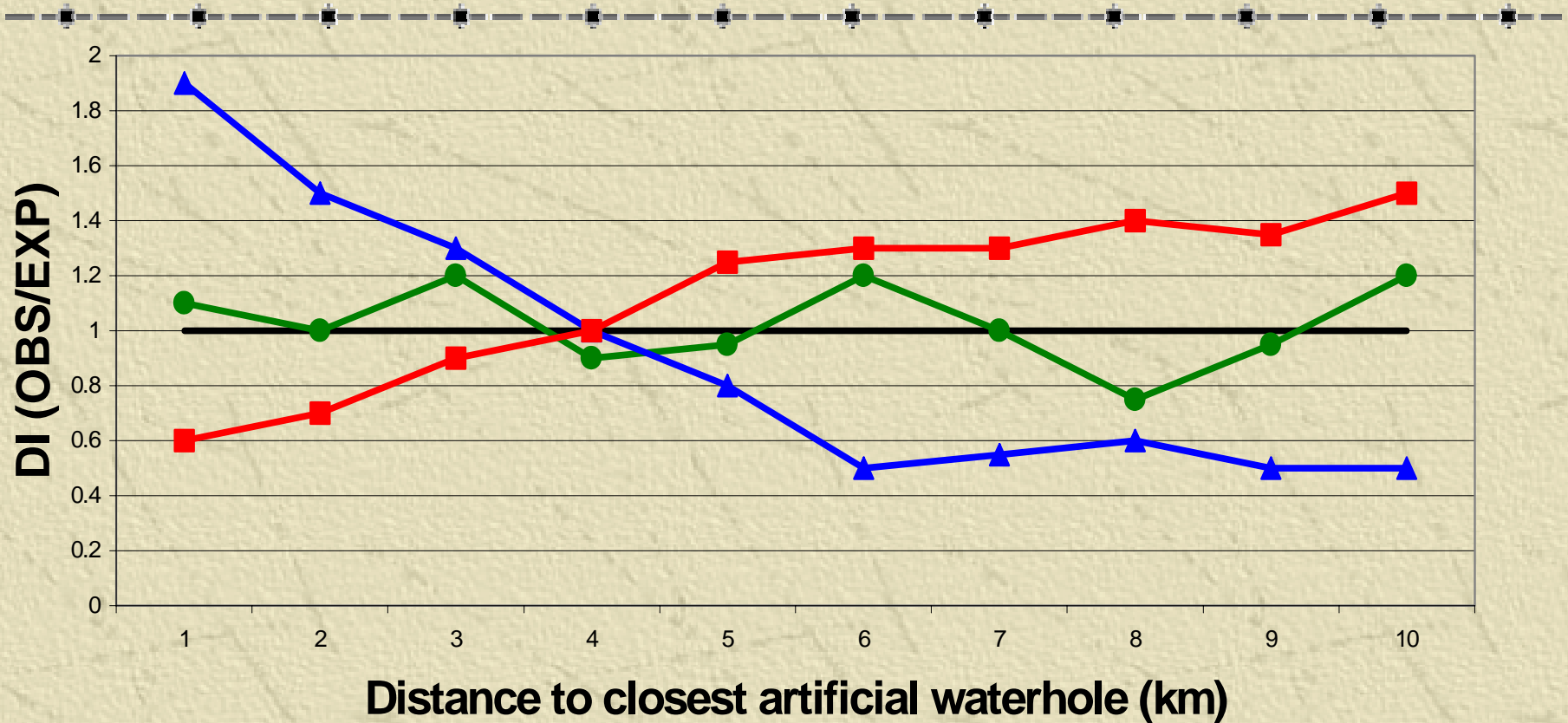
To determine if and how artificial waterholes and the main rivers influence the landscape scale distribution patterns of herbivores in the Kruger National Park, South Africa
(water provision policy)



Methodology

- ✦ **Data:** Aerial census data (dry season 1987-1993), GIS data layers (rivers, boreholes, geology)
- ✦ **Density Index:** Average observed density at distance class i (1987-1993) / Expected density (1987-1993) for all distance classes
- ✦ **Principle:** Detect whether unitless standardised density index (DI) vary systematically with increasing distance from closest artificial waterhole and closest main river
- ✦ **Interpretation:** Both location and shape of graph (intensity and consistency of pattern)

Methodology: Interpretation



— Expected under perfect no association

● No association

▲ Positive association

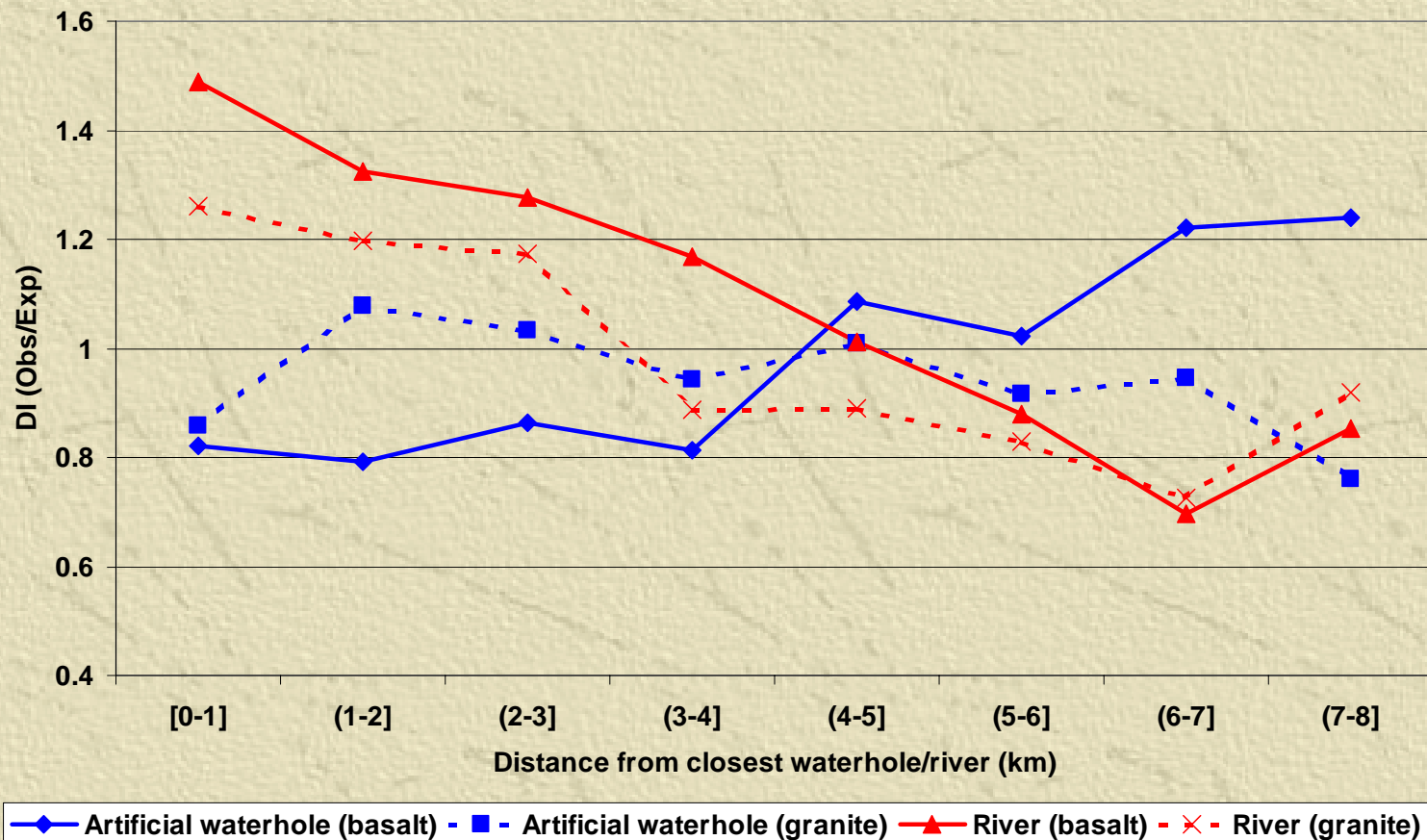
■ Negative association

Results: Giraffe (browser)

Positive association with main rivers

No association close to waterholes

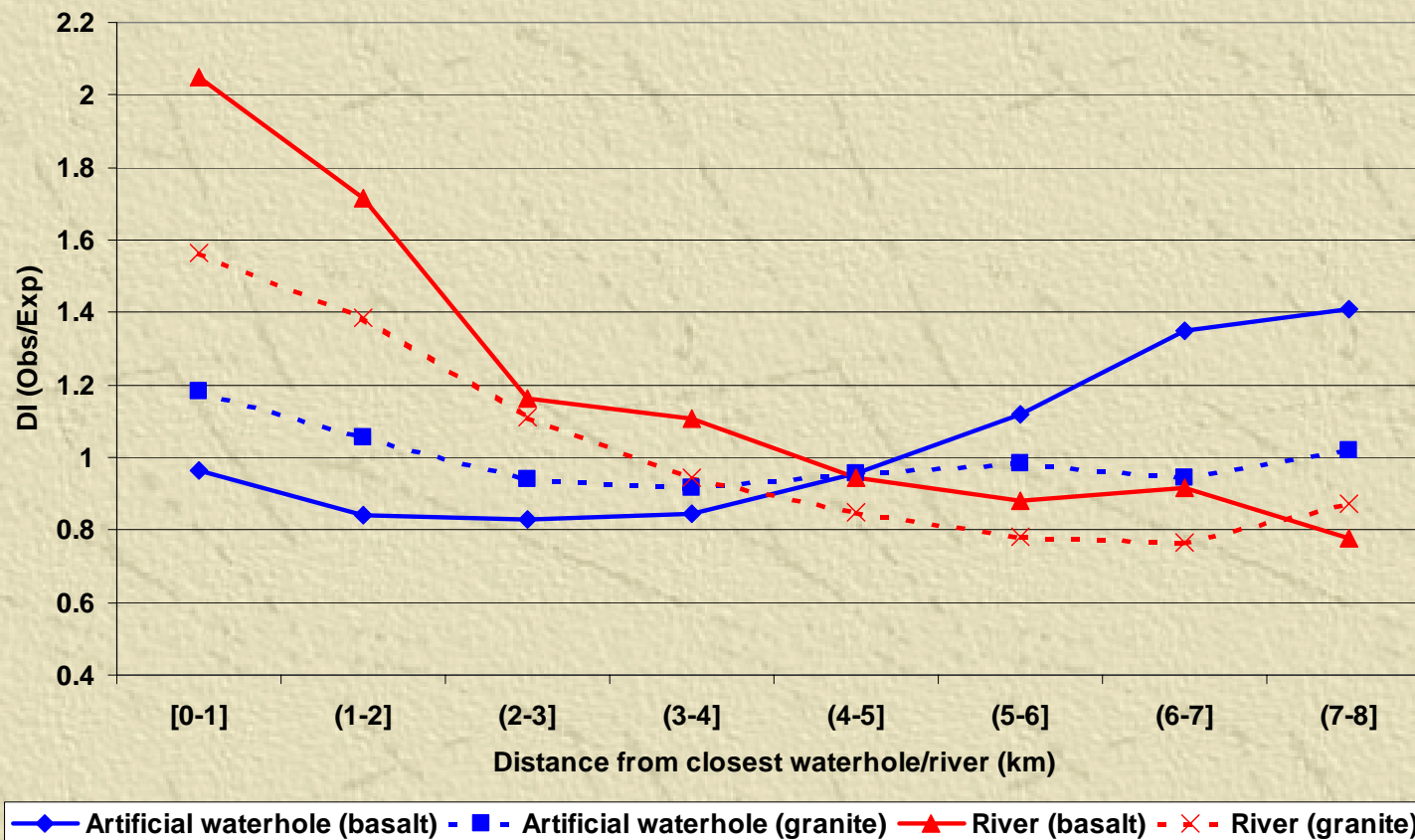
Density Index of giraffe at increasing distance from waterholes



Results: Impala (mixed feeder)

- ✦ Positive association with main rivers, strong on basalts
- ✦ Weak association close to waterholes

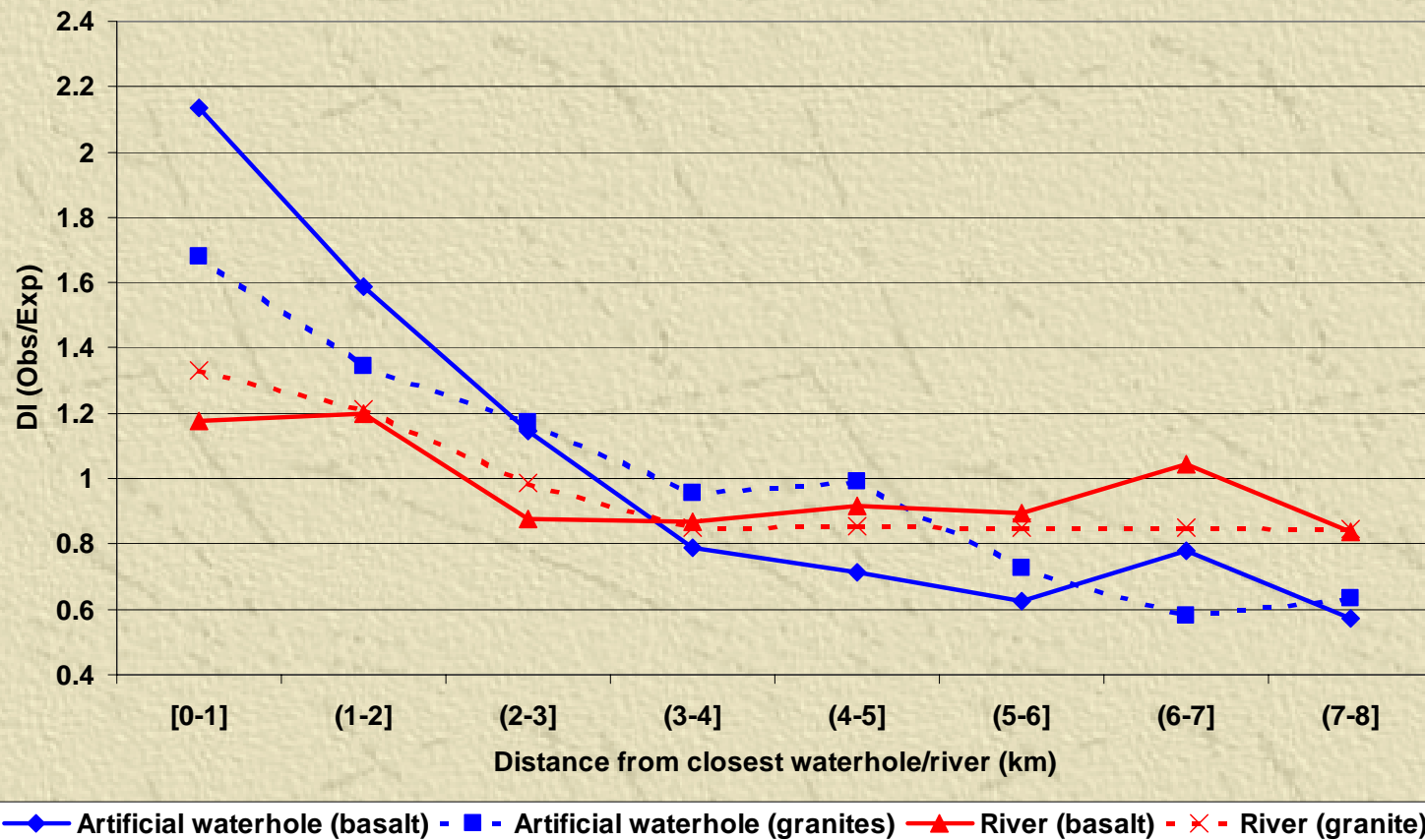
Density Index of impala at increasing distance from waterholes



Results: Wildebeest (grazer)

- ✦ Positive association with waterholes, stronger on basalts
- ✦ Weak positive association close to main rivers

Density Index of wildebeest at increasing distance from waterholes



Results: Generalisations

- ✦ Consistencies within and differences between distribution of feeding groups w.r.t. waterholes and rivers.
 - ✦ Browsers (giraffe & kudu): associated with main river courses, not waterholes.
 - ✦ Mixed feeders (elephant & impala): associated with river courses, not waterholes.
 - Exception: eland (distribution similar to grazers)
 - ✦ Grazers (zebra, tsessebe, sable, roan): aggregate around waterholes, and not rivers.
 - Exceptions: waterbuck (rivers & not waterholes), wildebeest (waterholes & rivers), buffalo (waterholes & rivers) & rhino (no association).
- ✦ Associations usually stronger on basalts than granites.



Ecological interpretation

✦ Browsers and mixed feeders associated with rivers:

✦ quantity and quality of browse more favourable closer to river valleys (“landscape scale catenal shift” & browsing feedback loop) (du Toit *et al.*, 1990; du Toit, 1995)

✦ Grazers are water dependent and most species strongly associate with waterholes (except rhino & waterbuck). Waterholes preferred to rivers due to lack of grazing and poor visibility (predation) close to rivers.

✦ Aggregation around rivers and waterholes stronger on basalts than granites due to herbivores’ ability to satisfy nutritional requirements closer to water (< travel distance) (Redfern *et al.*, 2003)

Spatial autologistic regression

$$\text{Log}[p_i/\{1-p_i\}] = \alpha + \beta_1 * \text{dist_w'hole} + \beta_2 * \text{dist_river} + \beta_3 * \text{herb_biomass} + \beta_{4-6}(\text{first order interaction}) + \beta_7 * \text{autocov}$$

p_i = probability that species is present

autocov = (# occupied cells)/(# of cells) within 2 km radius

- ✦ If spatial dependence is ignored in logistic regression, contribution of factors often overestimated
- ✦ Include covariate (autocov) based on the response from neighbouring area (Augustine *et al.*, 1996)
- ✦ Used 2 km autocov to account for small-scale spatial dependence.

Spatial autologistic regression: results

Significant (5%) factors in autologistic regression

	Autocov.	<i>Dist. to w'hole</i>	Dis. to river	Biomass	W'hole* River	W'hole* Biomass	River* Biomass
Zebra	Sign (+)	<i>Sign (-)</i>	-----	-----	-----	-----	-----
Wildebeest	Sign (+)	<i>Sign (-)</i>	-----	Sign (+)	-----	-----	-----
Tsessebe	Sign (+)	<i>Sign (-)</i>	-----	Sign (+)	-----	-----	-----
Sable	Sign (+)	<i>Sign (-)</i>	Sign(+)	-----	-----	Sign (+)	-----
Roan	Sign (+)	<i>Sign (-)</i>	Sign(+)	-----	-----	-----	Sign (+)
Buffalo	Sign (+)	<i>Sign (-)</i>	Sign (-)	Sign (-)	Sign (-)	Sign (+)	-----
Waterbuck	Sign (+)	-----	Sign (-)	Sign (+)	-----	-----	Sign (+)
Rhino	Sign (+)	-----	-----	Sign (+)	-----	-----	-----

Management implications

- ✦ Results imply that water provision policy will:
 - ◆ influence distribution of grazers (excluding rhino & waterbuck) more directly than mixed feeders and browsers
 - ◆ create stronger grazing gradients on basalts compared to granites
- ✦ Results do not necessarily imply that:
 - ◆ waterholes will only be to the advantage of grazers (starvation induced mortality, quality of herbaceous layer, predation risk, etc.)

Management implications: some thoughts on rare antelope

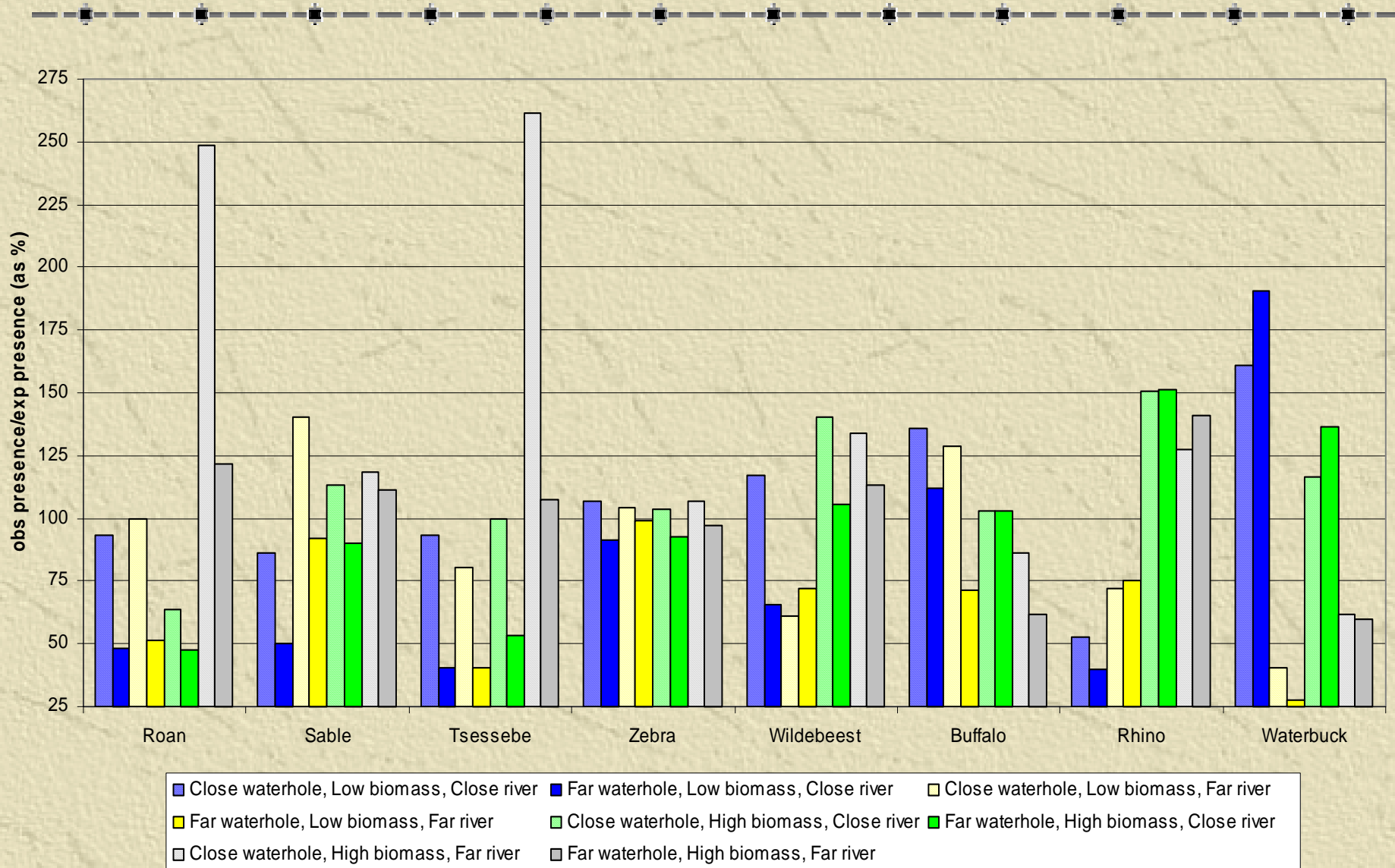
- ✦ Hypothesis previously proposed:
Rare grazers declined in 1990s due
to density of surface water
 - Herbaceous layer
 - Predation risk

However

- ✦ Rare grazer numbers did not
respond to waterhole closure
(>1998)
- ✦ Current study suggests rare
antelope densities higher close to
waterholes
- ✦ Dilemma! Are waterholes
detrimental or beneficial for rare
grazer populations?
- ✦ Solution?: waterholes without high
density common grazers

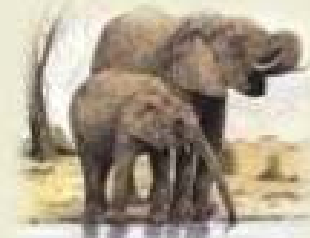


Waterhole effect under varying biomass and distance to rivers conditions (spatial stratification)



Conclusions

- ✦ Most grazers occur in higher densities close to waterholes
- ✦ Mixed feeders and browsers occur in higher densities close to rivers
- ✦ Grazing gradients steeper on the nutrient rich basalts compared to the nutrient poor granities
- ✦ Rare antelope: drilling of new or closing of existing waterholes maybe too simplistic a solution





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