The scale of grazing: its influence on rangeland quality, carrying capacity and herbivore population performance

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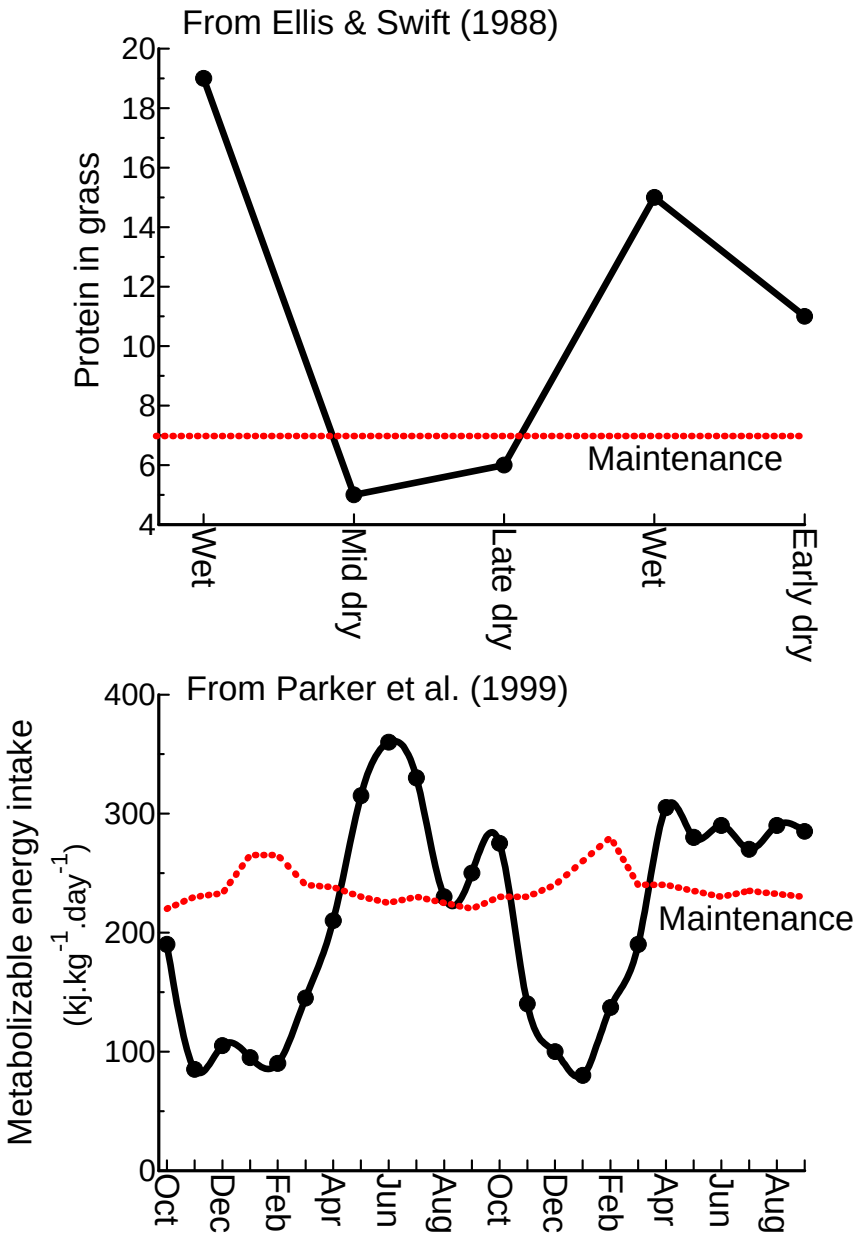
Scale-based effects on herbivore populations

There are three major factors determining the quality and productivity of rangeland as well as the productivity of herbivore populations

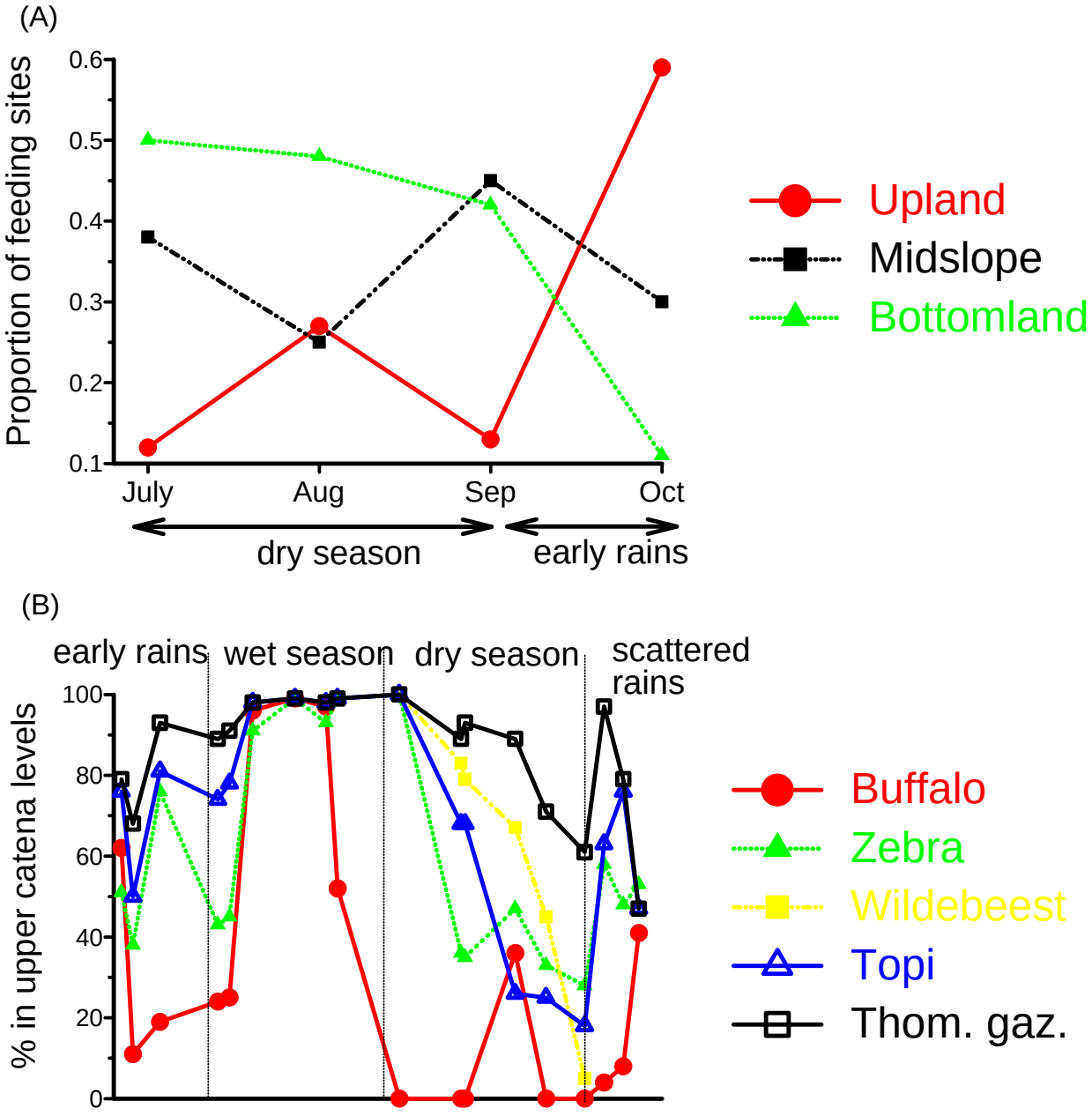
- The resource heterogeneity effect
- The trophic decoupling effect
- The herd effect

The resource heterogeneity effect

The resource heterogeneity effect



The resource heterogeneity effect



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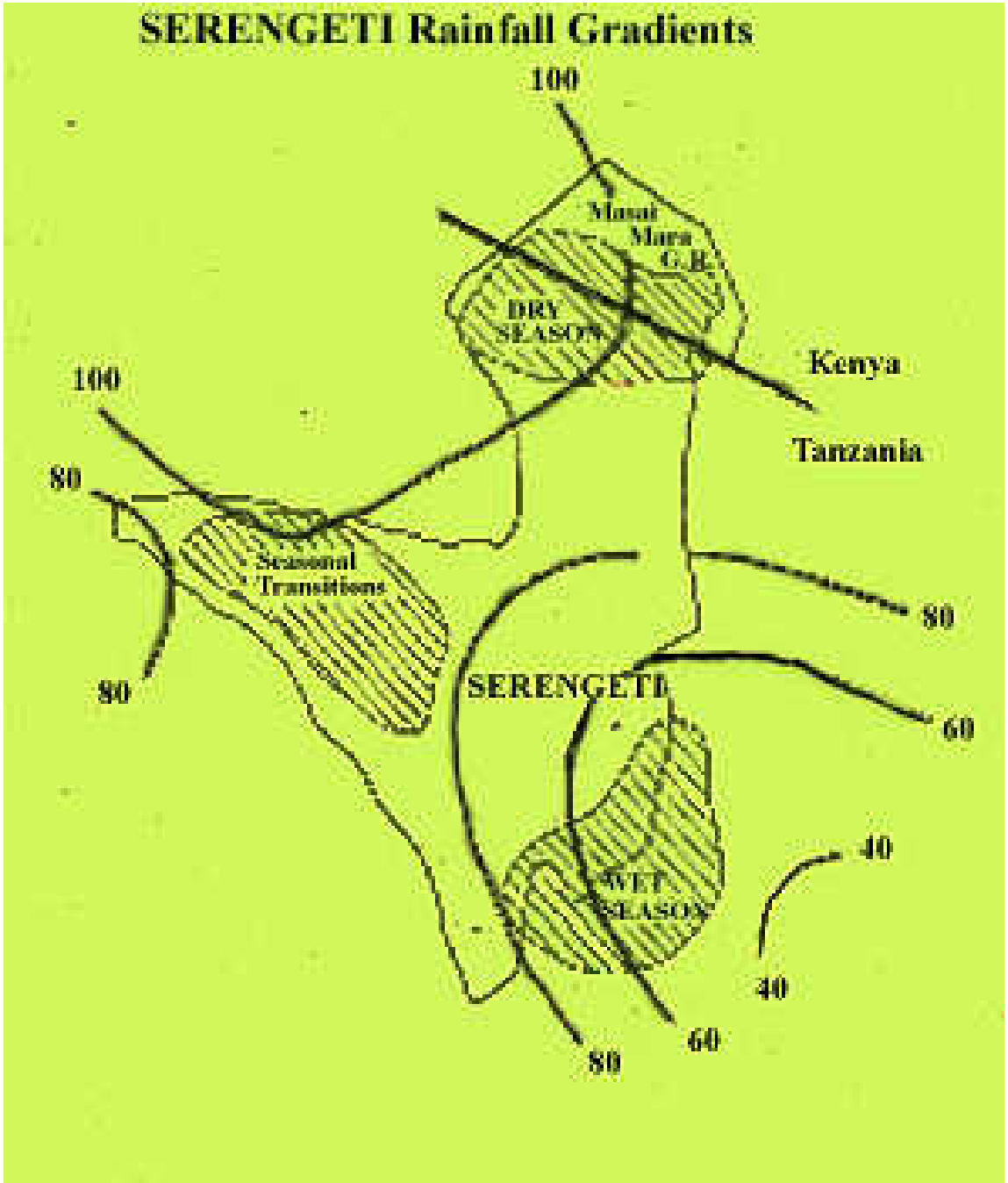
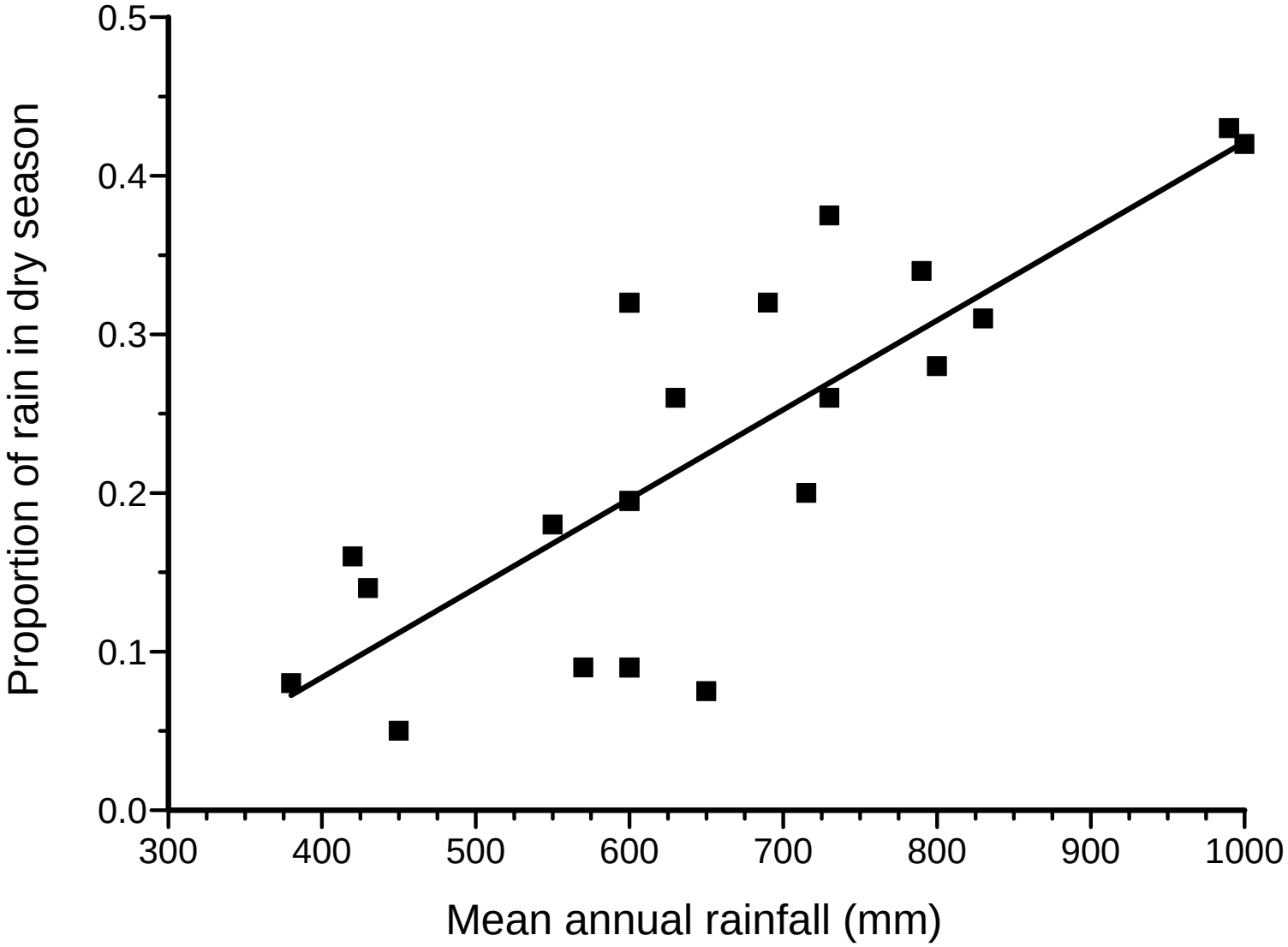


Why is it that during the dry season ungulates prefer high productivity grassland in high-rainfall regions or in lowland sites?

The resource heterogeneity effect

Adapted from McNaughton (1985)
Ecological monographs 55: 262



The resource heterogeneity effect

"At the height of the dry season in October and November the nomadic wildebeest herds were concentrated in the high rainfall northwestern part of the region. Tall *Hyparrhenia—Loudetia* grasslands are common there"

"Because of their extended growing season those tall grasslands were the last reservoir of green forage available at the end of the dry season"

McNaughton (1985) Ecological Monographs 55:276

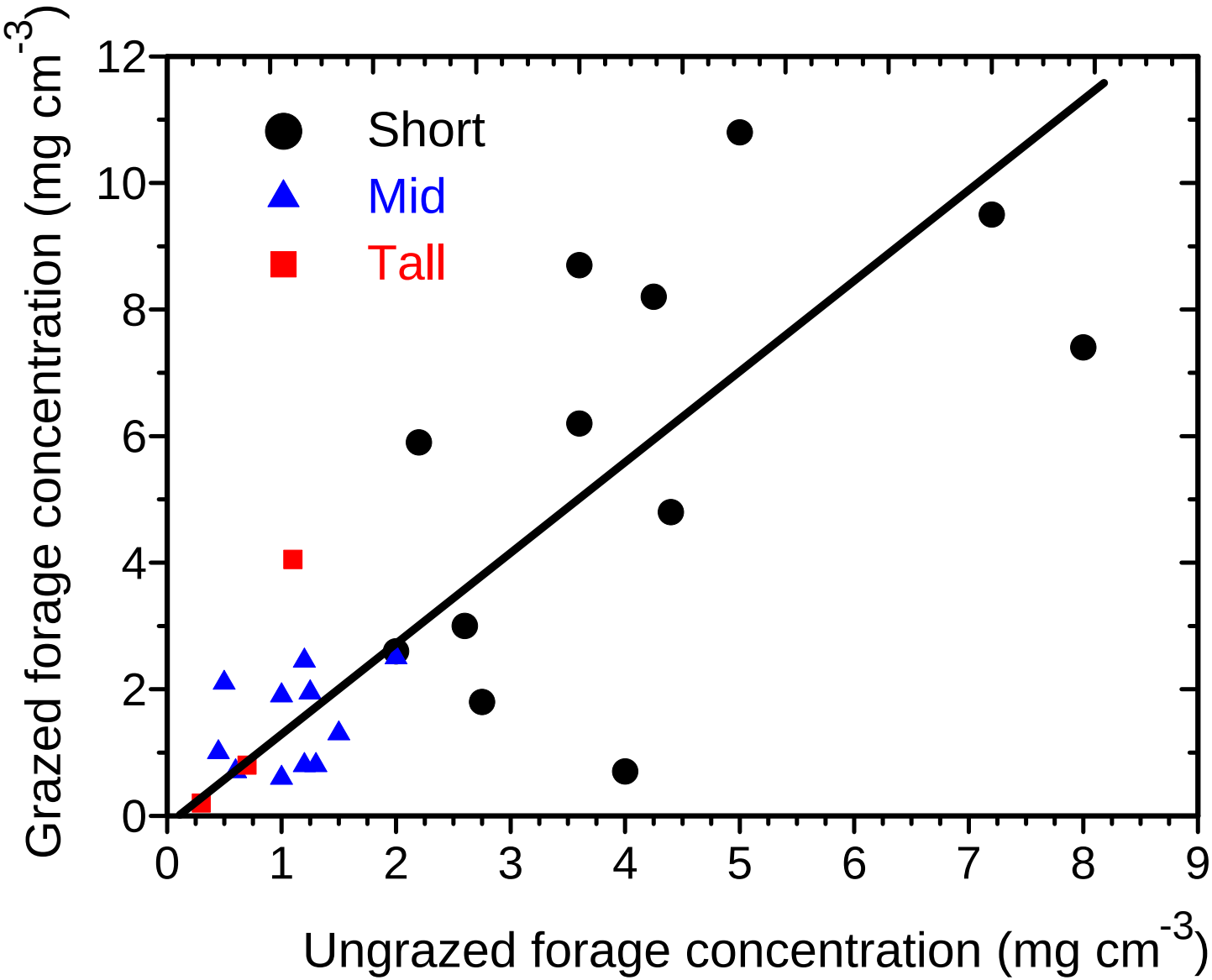
The resource heterogeneity effect

"But the fact that the perennial flood plain grasses shoot up **green** after trampling or burning, without the incidence of rain, insures that ample pasture is available **during the dry season**"

Vesey-Fitzgerald (1960) Journal of Mammalogy 41: 167

Why is it that during the wet season ungulates prefer low productivity grassland in low-rainfall regions or in upland sites?

The resource heterogeneity effect



The resource heterogeneity effect

- Short grassland regions have been shown to provide forage with higher concentration of protein, calcium and especially phosphorus than more productive tall grassland (Breman and de Wit 1983; Fryxell 1987; McNaughton and Banyikwa 1995; Murray 1995; Grant and Scholes 2006).

The resource heterogeneity effect

- Tall-grass sites have poor quality and digestibility during the growing season owing to their high productivity – The Dilution Effect (Jarrell and Beverly 1981; Breman and de Wit 1983; van der Vijver et al. 1999; Fryxell 1987; Wilmshurst and Fryxell 1995; Wilmshurst et al. 1999).

- Green leaf tends to become more dispersed and diluted amongst stem and senescent leaves in taller grassland (McNaughton 1984, 1985; Fryxell 1987).

Sward biomass at which various herbivores are expected to maximize energy intake. Derived from the work of Wilmshurst, Fryxell and Bergman (2000).

Species	Mass (kg)	Optimum sward biomass ($g\ m^{-2}$)
Thomson's gazelle	20	10.7
Wildebeest	97	41.7
Caribou	104	44.3
Elk	266	99.4
Cow	548	185.1
Cow	750	242.4

Habitat quality

Habitat quality

Habitat quality

Habitat quality

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Habitat quality

Habitat quality

Habitat quality

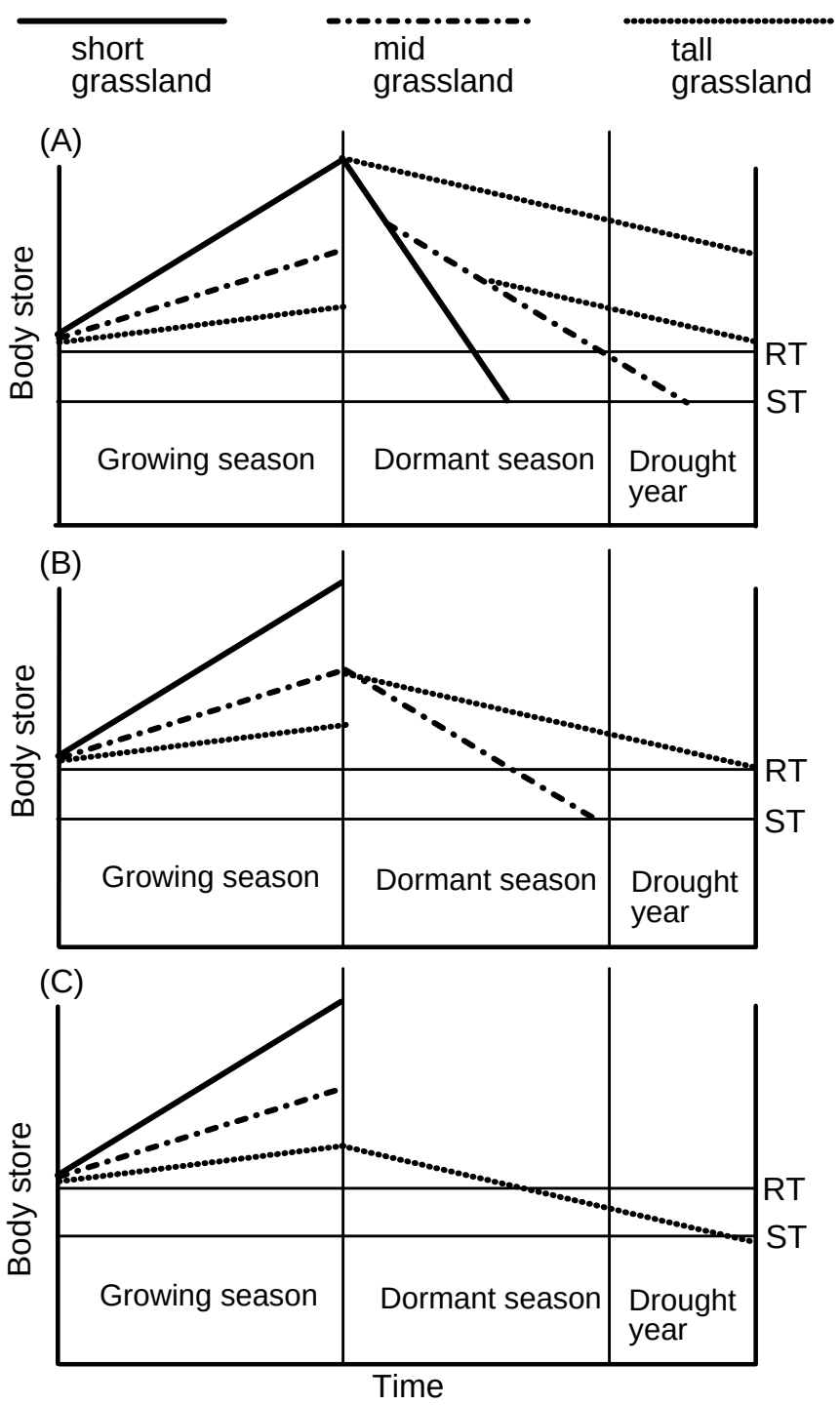
The resource heterogeneity effect

High quality growing-season resource (Na, P, Protein & Energy intake)

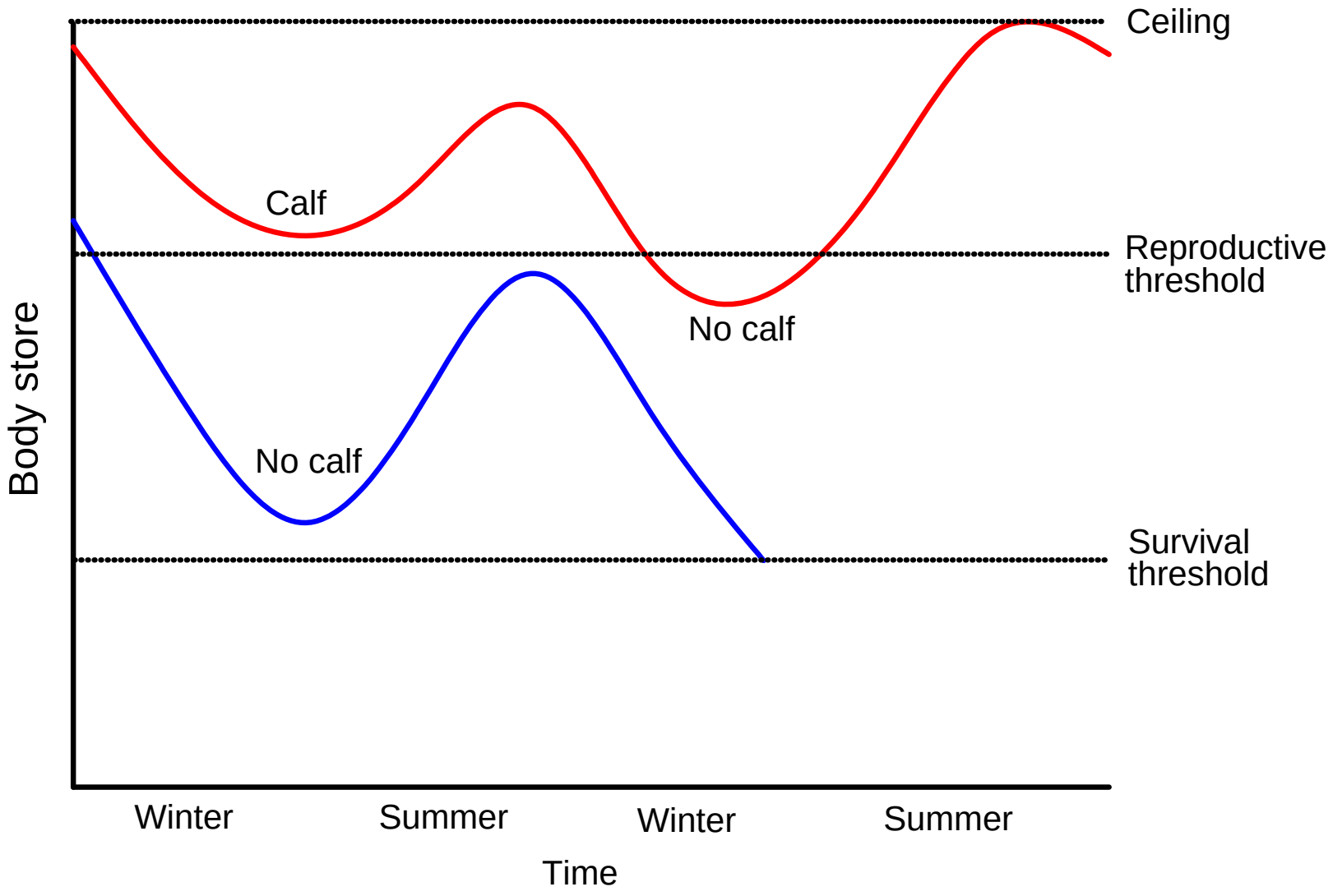
- Lactation
- Calf growth rates
- Age at first conception
- Size of adults
- Protein and fat storage (for dormant season)

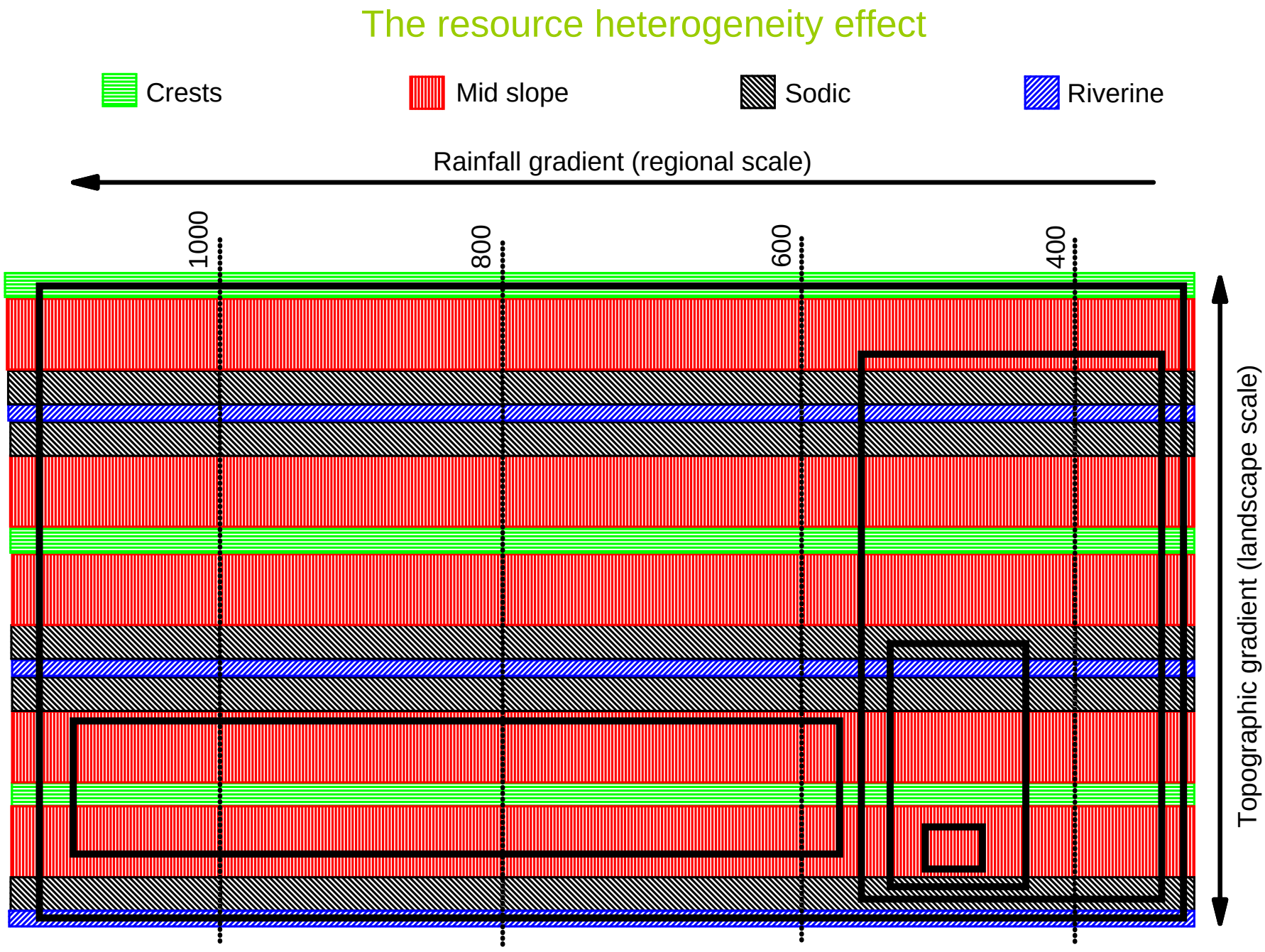
Dormant-season buffer resource

- Minimize rates of use of body stores
- Maintain foetus
- Calf size at birth


short grassland
mid grassland
tall grassland
(A)
Body store
RT
ST
Growing season
Dormant season
Drought year
(B)
Body store
RT
ST
Growing season
Dormant season
Drought year
(C)
Body store
RT
ST
Growing season
Dormant season
Drought year
Time

A nutritional balance framework – Parker et al. 2009




The resource heterogeneity effect
Crests
Mid slope
Sodic
Riverine
Rainfall gradient (regional scale)
1000
800
600
400
Topographic gradient (landscape scale)

The resource heterogeneity effect

- Greater spatial scale of movement allows greater access to resources:

- High quality short grass sites in summer
- Mid grass sites in early winter
- Key resources in the dormant period
- Migration on productivity/forage quality gradients
- Tracking patchiness of rainfall and fire
- Finding suitable mineral licks

The resource heterogeneity effect

In semi-arid environments tracking green grazing associated with patchy thunderstorms is a critical strategy for productive herbivore populations

The resource heterogeneity effect

"One of the remarkable features of the migratory wildebeest herd, of course, was its members' unerring ability to find these isolated regions of high green biomass. During the June, September and December surveys, the animals were always concentrated in the high green biomass regions. This was particularly evident in December when the two high green biomass patches were approximately 80km by air apart, and the wildebeest were present on both"

(McNaughton 1979)

The resource heterogeneity effect

Tracking greenness associated with patchy rainfall events is a major strategy for many herbivores during the growing season:

- **wildebeest** (McNaughton 1979; Wilmshurst et al. 1999),
- **Topi** (Bro-Jorgensen et al. 2008),
- **Hartebeest** (Verlinden & Masogo 1997),
- **Mongolian gazelle** (Mueller et al. 2008),
- **Dorcas gazelle** (Carlisle & Ghobrial 1968), and
- **livestock herders** in transhumance systems (Wilson 1977)

- **Also fire:** (Fuhlendorf & Engle 2004; Archibald et al. 2005)

The resource heterogeneity effect

- “virtually every major population movement in the present study was associated with rain in the area, towards which the wildebeest moved” (Talbot & Talbot 1963)

- The animals would often leave a grassy area and move to a dry area where rain was falling; then stand or mill around there with no food for a day or two until grass sprouts appeared (Talbot & Talbot 1963)

The resource heterogeneity effect

"While in their summer ranges, especially during drier years, zebra are particularly reactive to local showers and vast population shifts in response to proximate showers have frequently been observed in the Satara and Lindanda areas" (Smuts 1972 – PhD Thesis on Kruger Zebra)

The resource heterogeneity effect

"At the first thunder the animals raised their heads and looked around. There was increasing activity in the herd for about 30 minutes, then the herd began moving in the direction of the rain" (Talbot & Talbot 1963)

The resource heterogeneity effect

"Sir, in the last moon the lightning came, there upon the distant horizon. I beheld Mangwa (the zebra). In times of drought he always watches the sky for the lightning of a passing thunderstorm. Mangwa is the cleverest of all the game animals. He is always first in an area of new grass. He reaches it well before the others, who wait to smell where the rain has fallen"
(Njalabane – a Shangaan chief to BveKenya in "The Ivory Trail")

The resource heterogeneity effect

The resource heterogeneity effect

Factors affecting the ability of herbivores to make foraging decisions have the greatest consequences for their populations at the **regional scale**

(Senft et al. 1987; Wiens 1989; Rettie & Messier 2000; Parker et al. 2009)

The Trophic Decoupling Effect

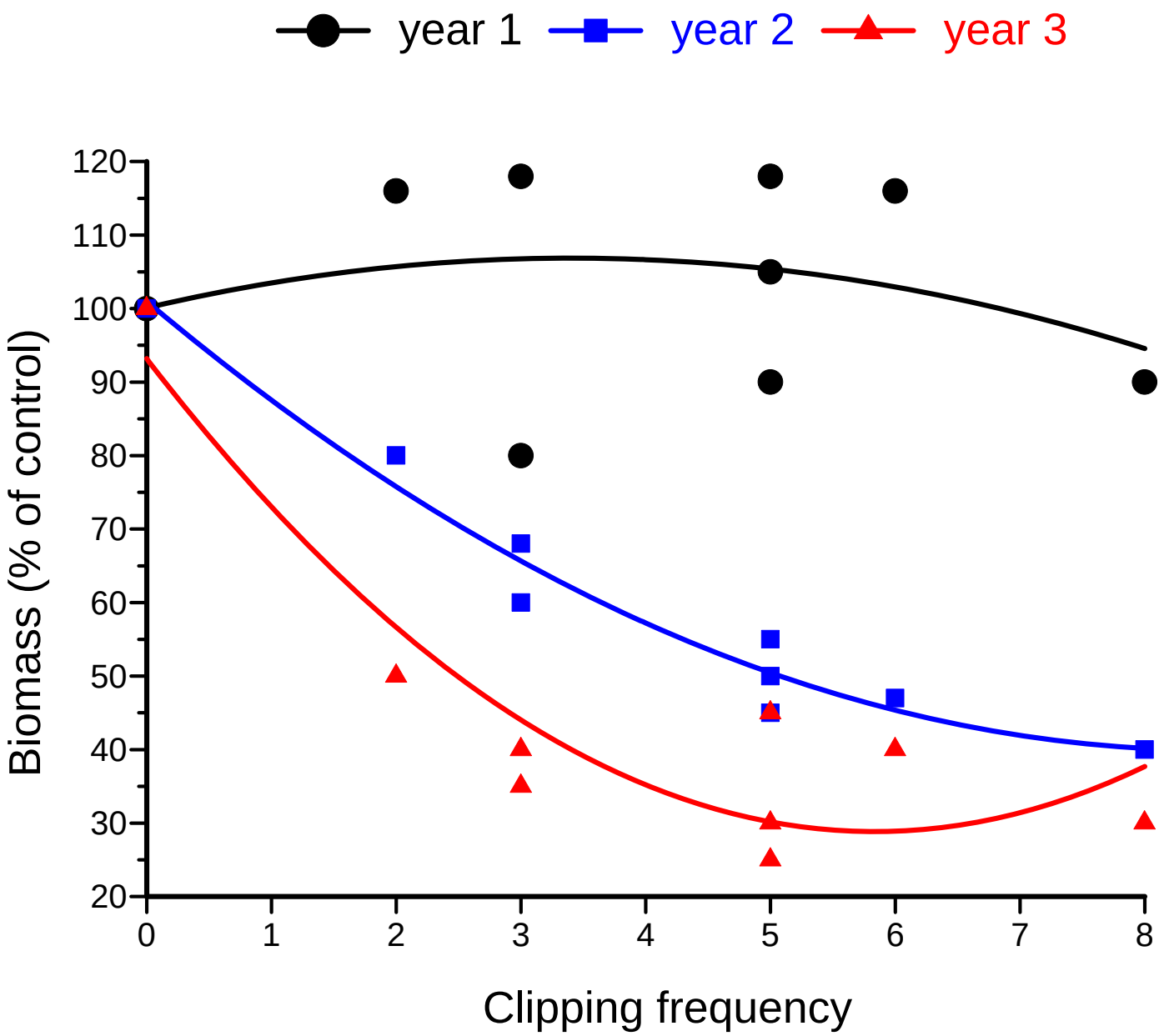
Herbivore-Resource Decoupling

The trophic decoupling effect

Herbivore-resource decoupling increases with increasing spatial scale because herbivores are increasingly able to:

- ➢ Avoid drought
  - Prevents grazing damage of drought-stressed forage
- ➢ Use different regions each year because of the stochastic and patchy nature of rainfall
  - Allows greater rest and recovery periods for forage

The trophic decoupling effect

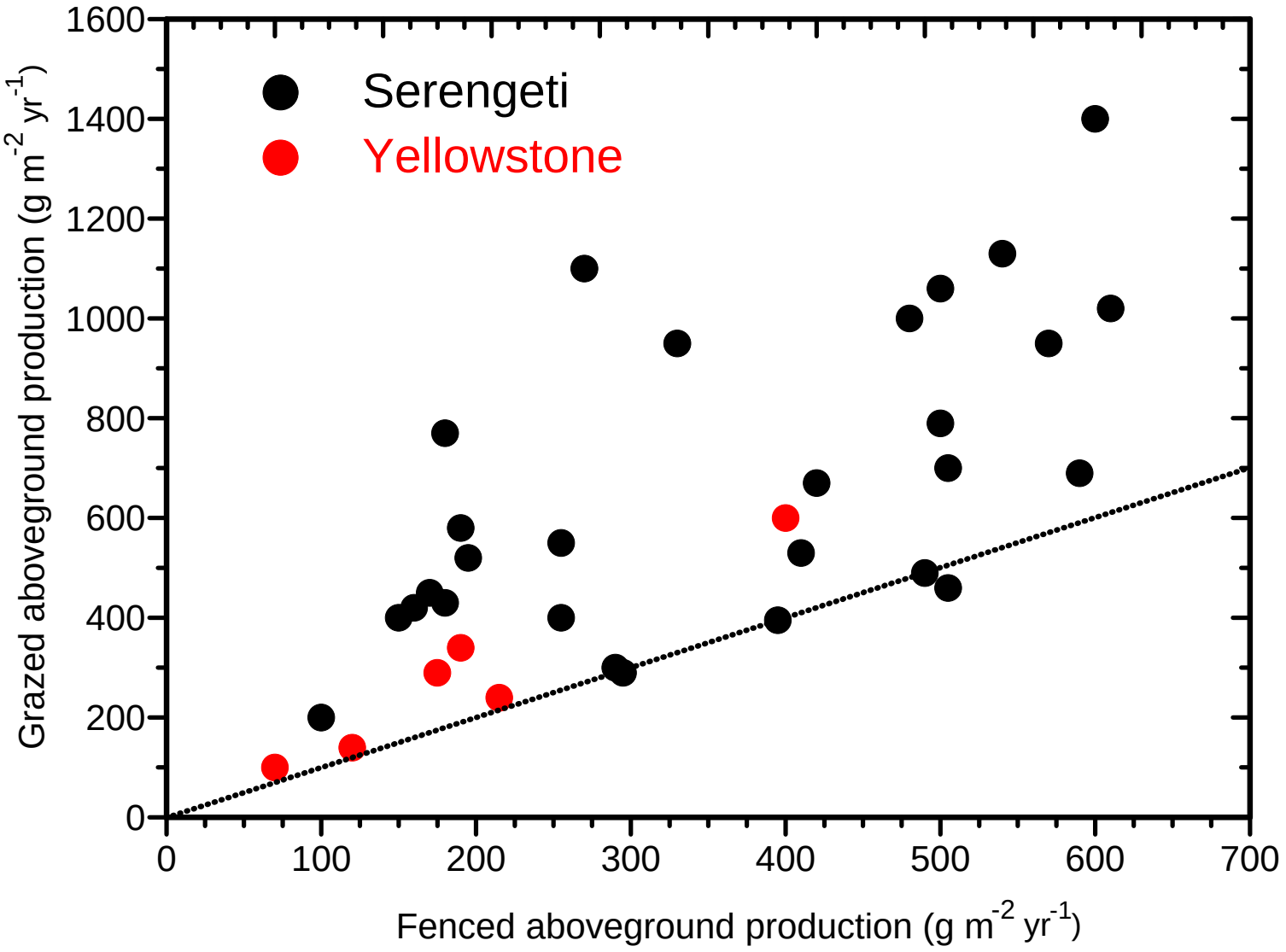


The trophic decoupling effect

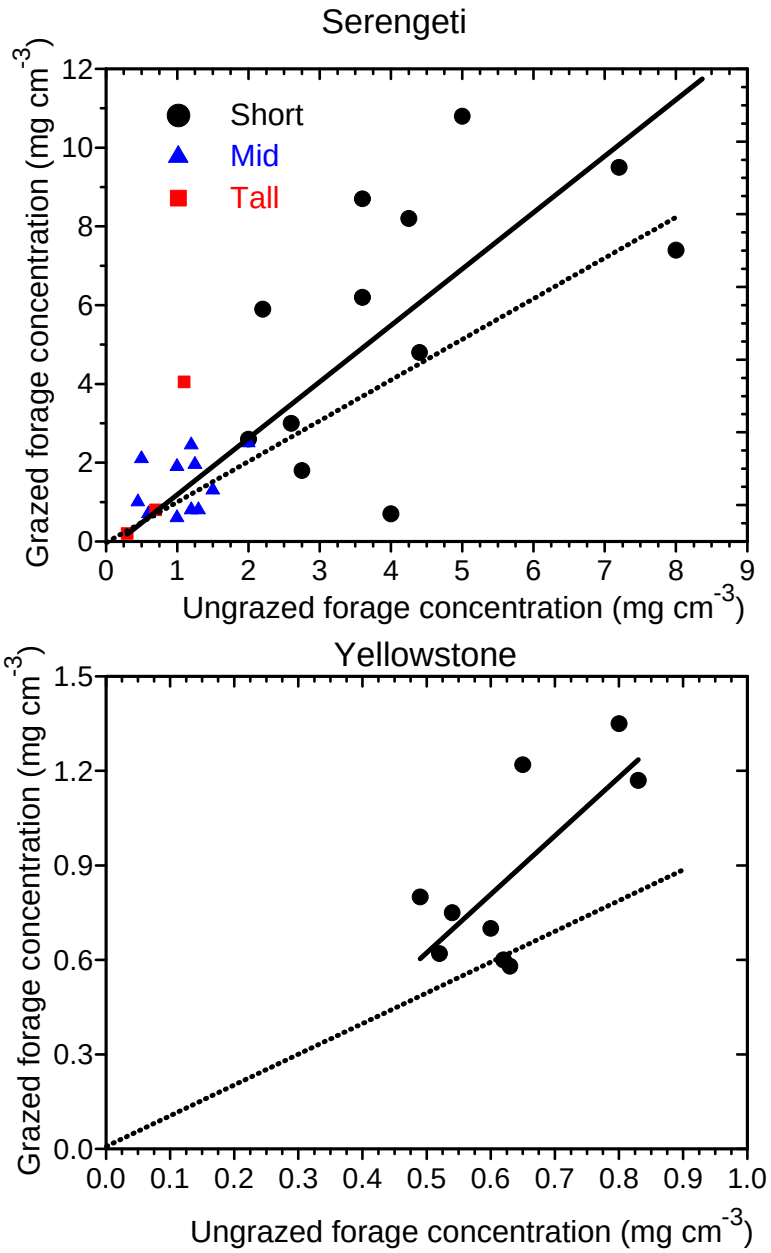
Herbivore-resource decoupling allows much better resting and recovery periods for grassland, which creates a vigorous and healthy forage base which is able to respond positively to grazing

The Herd Effect

The herd effect



The herd effect



The herd effect

Many studies show that lack of grazing impact results in low plant density and large bare spaces:

- Fuhlendorf & Smeins 1999;
- Fuhlendorf et al. 2001;
- Guevara et al. 2002;
- Gonnet et al. 2003;
- Derner & Whitman 2009

The herd effect

Large-scale migratory grazing systems result in:

- Greater density of grasses
- More productive grasses
- Greater biomass concentration
- Maintain the grassland in a short, nutritious state

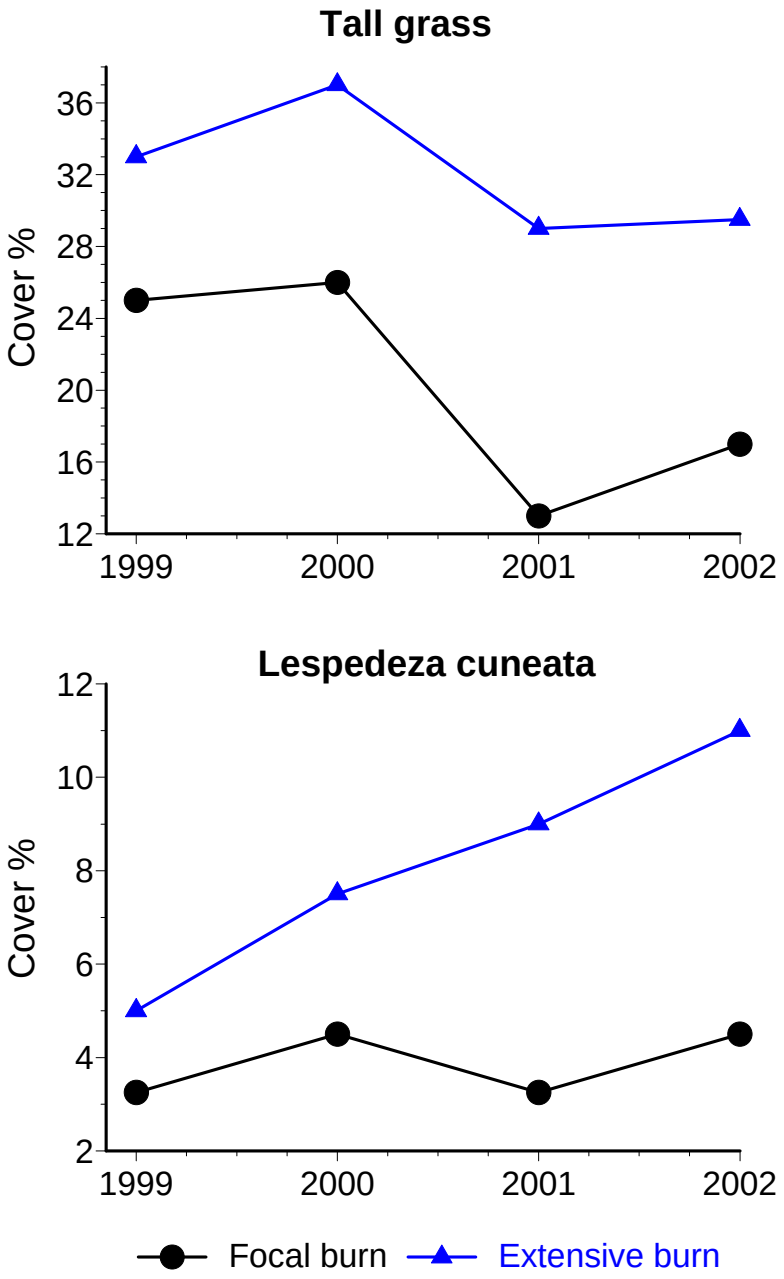
Consequently, greatly reduced tree invasion

The herd effect

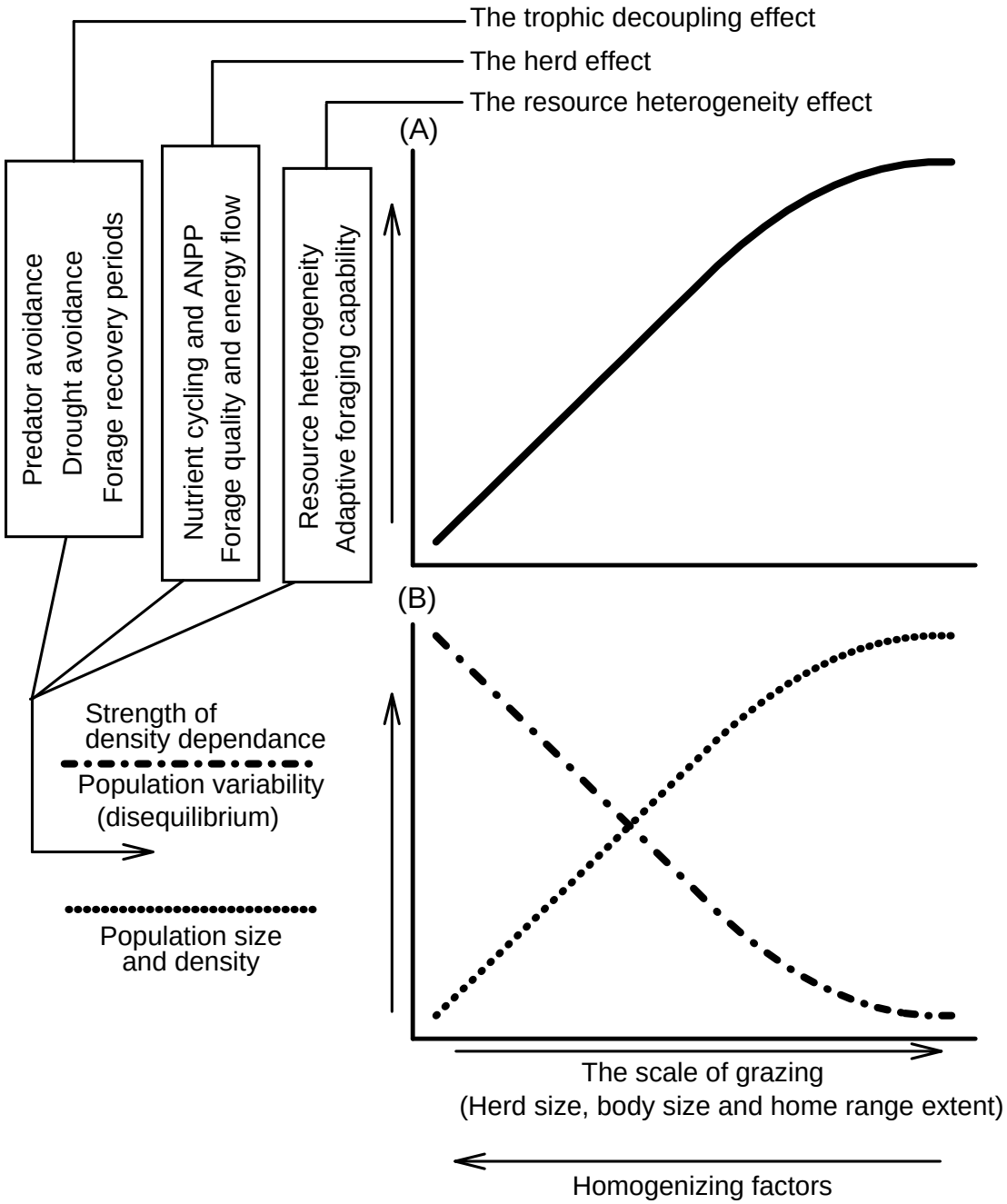
The herd effect

Changing the scale at which animals graze (herd size, density and mobility) has large effects on the degree of selective grazing, trampling effects, dung inputs and resting and recovery periods of the forage resource base

The herd effect



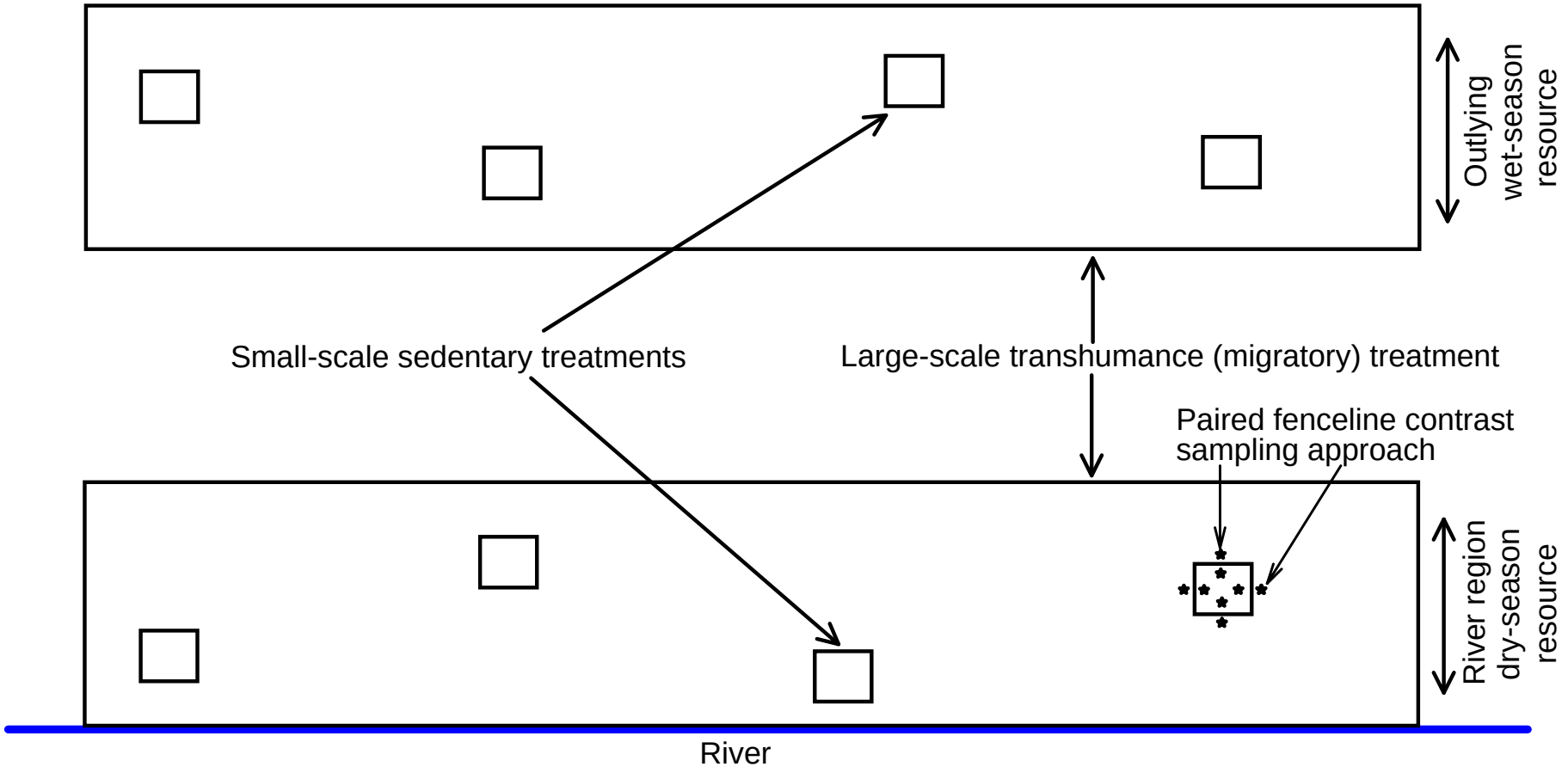
Scale-based determinants of herbivore population performance



Implications for management and research

- Functional wildlife systems cannot just be the left over land that the farmers didn't want
- Livestock managers in arid and semi-arid regions need to expand their scale of management to encompass ecological gradients (rainfall, floodplains, altitude) and enable sufficient adaptive ability to patchy and stochastic rainfall
- Researchers need to start setting up multiple-scale grazing experiments

Implications for management and research




Thank you!