Tropical systems: dry forest and savannas

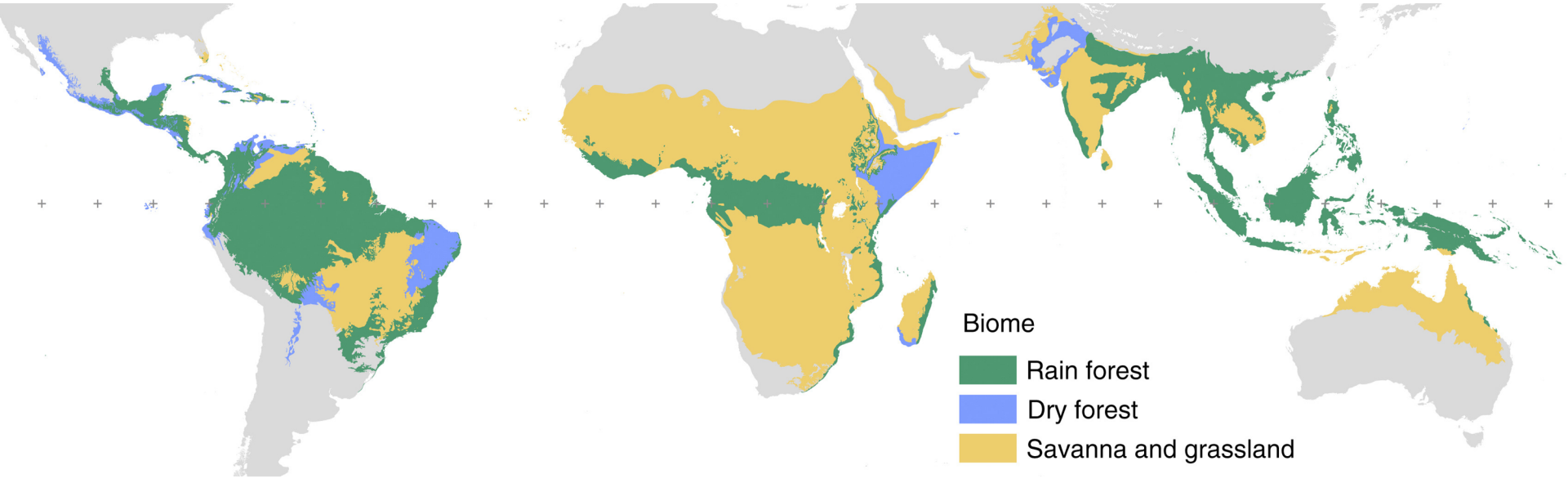
Overview of biome

Vegetation features

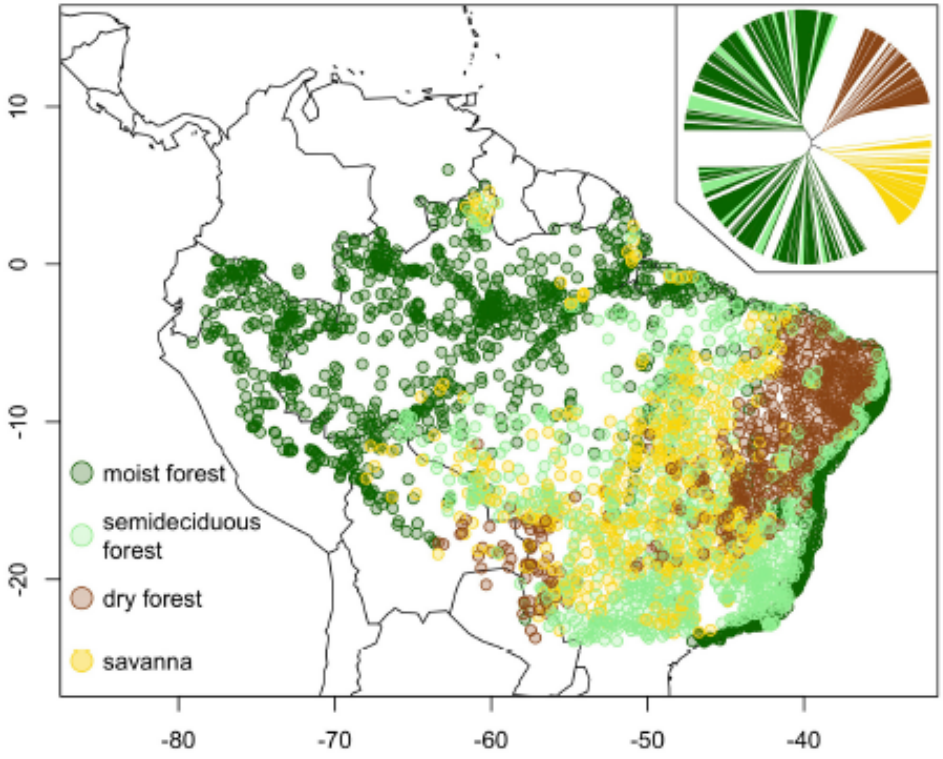
Savanna ecology

Dry forest examples

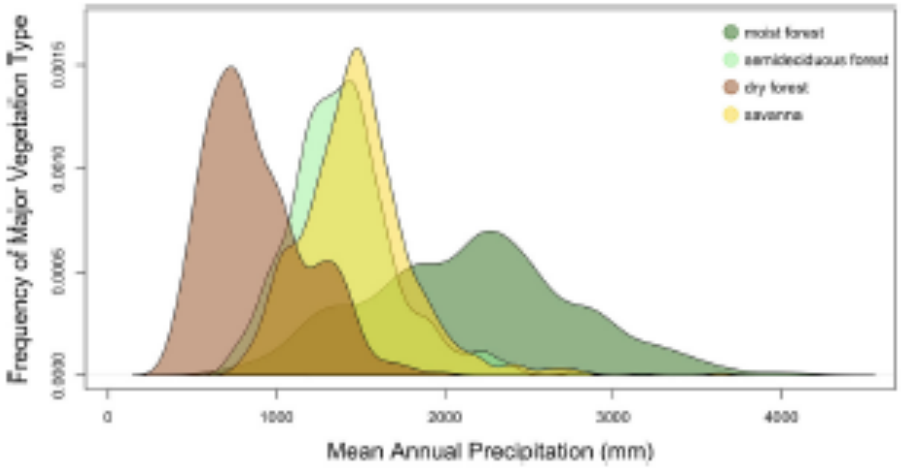
Distribution of rain forest, dry forest and savanna grassland



Distribution of rain forest, dry forest and savanna grassland



Clustering of sites based on tree species composition across lowland tropical South America



Frequency of sites over gradient of mean annual precipitation

Tropical savanna and dry forest

Savanna is an area of grassland with a scattering of trees, forms a gradient from grassland to dry forest

Large, diverse mammals characterize the African savanna

What factors cause savanna formation?

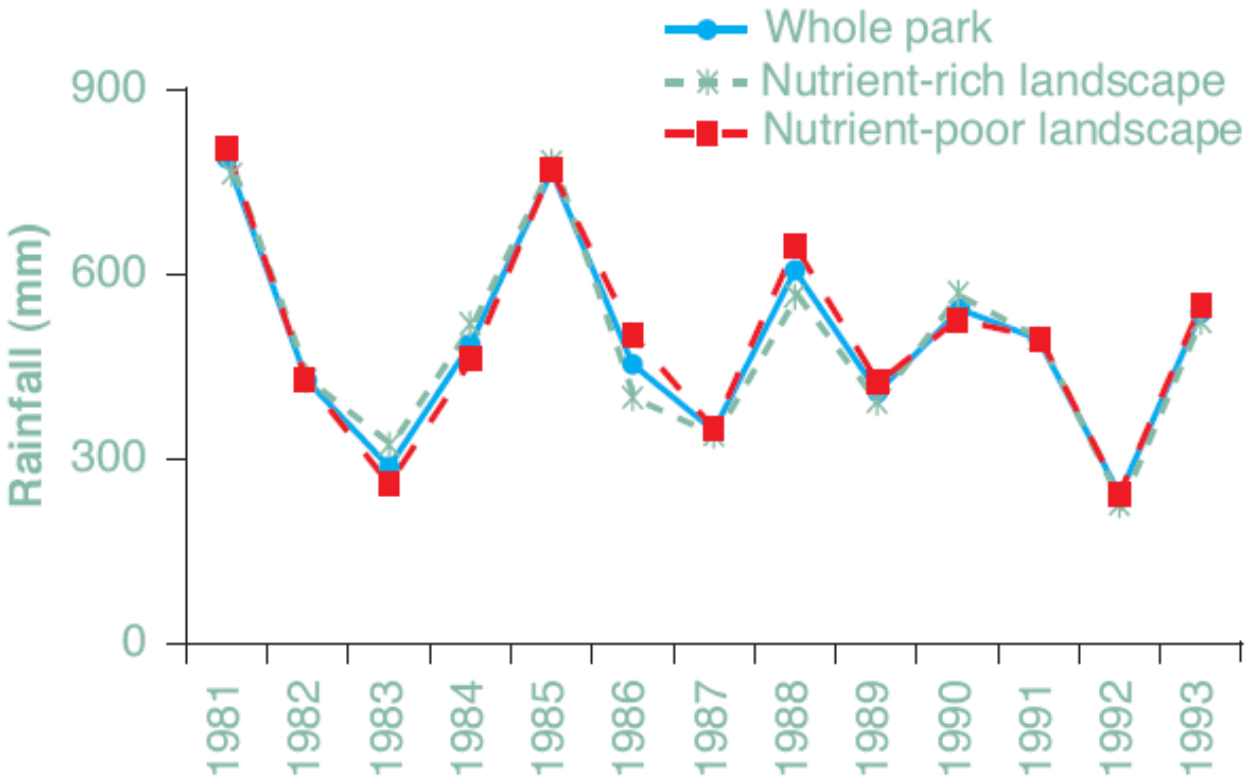
Tropical savanna and dry forest

Typically dry forests are characterized by little change in temperature, but with a pronounced dry season during part of the year

Average rainfall in Kruger National Park, South Africa

Precipitation is highly seasonal with severe dry seasons lasting several months followed by ample rainy seasons

Annual precipitation is highly variable, with “wet years” and “dry years”



Tropical savanna and dry forest - review

Typically dry forests are characterized by little change in temperature, but with a pronounced dry season during part of the year

Many unique adaptations in plants, often with high proportions of endemic species (restricted to dry forest habitat)

Tropical savanna and dry forest - review

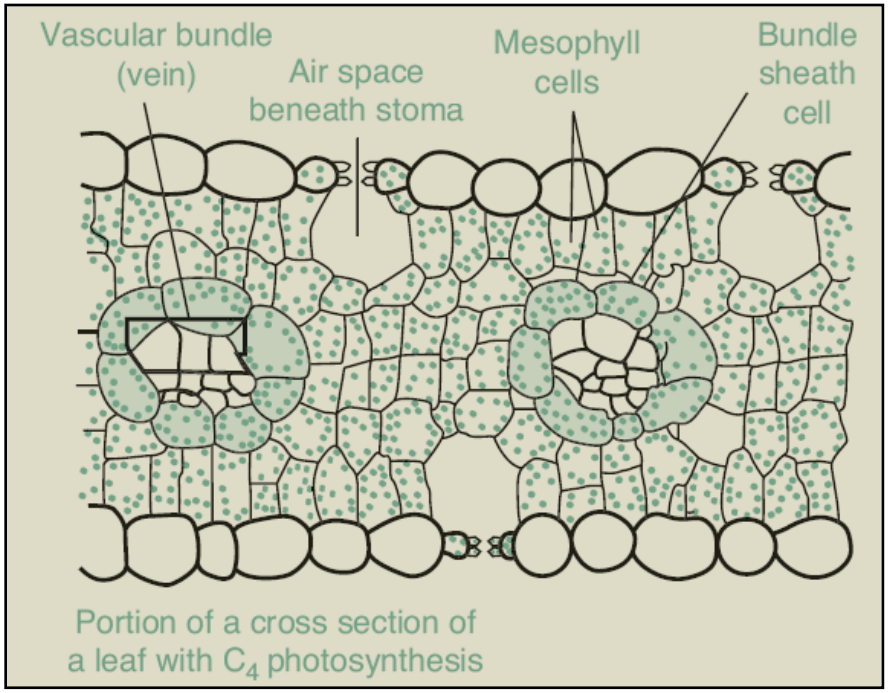
Prolonged and annually variable dry season favors xerophytic trees (adapted to arid conditions)

Tropical dry forest have deciduous species of trees that lose their leaves at the onset of the dry season

Some trees, like species in the genus *Ceiba* have photosynthetic bark, allowing growth after leaves drop

Fundamental parts of Savanna: xerophytic plants

Savanna has grass and sedge species that can tolerate hot, dry tropical climates. Many are C4 species (e.g., 90% of the total biomass of grasses in the Serengeti)



Cross-section of a leaf that uses C4 photosynthesis

Recall: in photosynthesis, CO2 enters the plant through stomata, which can be kept open or shut.

C3 photosynthesis is an ancient process, dating back 2.8 billion years

When open, CO2 enters, but H2O also leaves by diffusion through the same stomata 'doorway'

In warm wet environments, this is not problematic

Fundamental parts of Savanna: xerophytic plants

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~30 million years ago, the climate became drier and warmer, with a drop in carbon dioxide

Plants were more susceptible to desiccation – stomata would have to remain open to allow sufficient diffusion of CO2

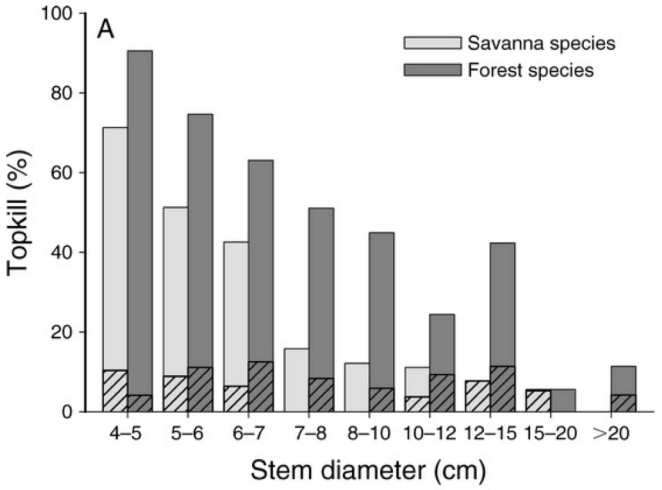
C4 pathway of photosynthesis evolved, which has increased rates of photosynthesis and greater efficiency of water use

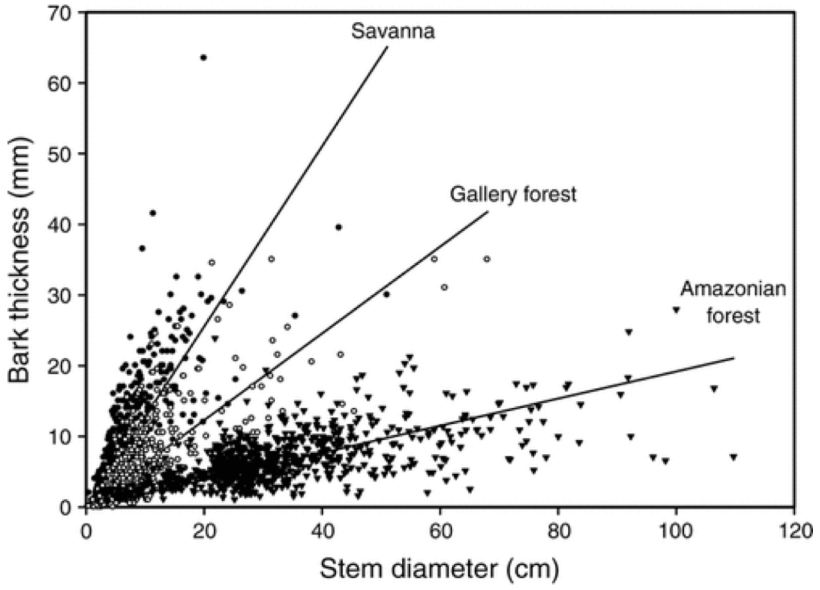
Fundamental parts of Savanna: fire tolerant plants

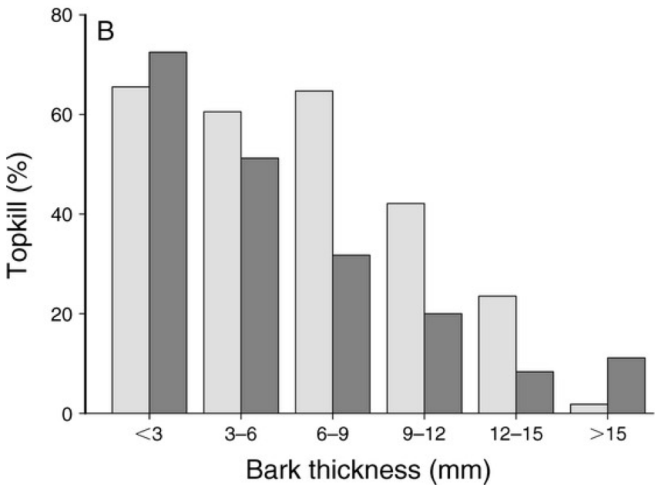
Many savanna and dry forest plants are pyrophytes (adapted to withstand occasional burning)

Fire can determine boundaries between grassy savanna and dry woodland

Savanna species have thicker bark and experience lower mortality from fire





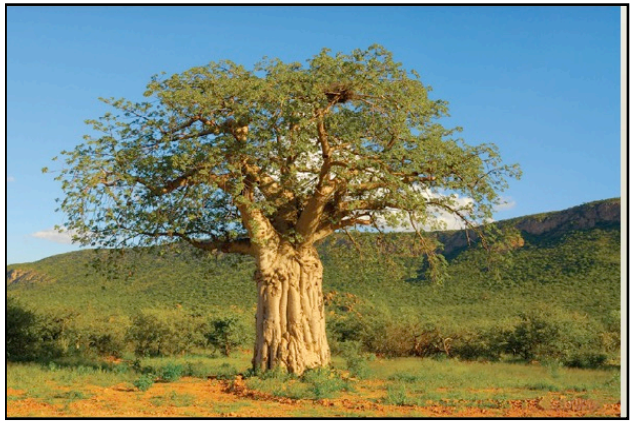


Hoffman et al. 2009, *Ecology*

Tropical savanna and dry forest - Africa

Africa contains expansive savanna forming an east-west belt across the central part of the continent, and is also the dominant biome in the southern part of the continent

Dry forests, dominated by acacia species, border savanna regions



Tropical savanna - Australia

Australia has vast savanna regions in the north, with unique flora and fauna, dominated by eucalyptus species and tall bunchgrasses

Herbivores are mostly marsupials such as wallabies and kangaroos

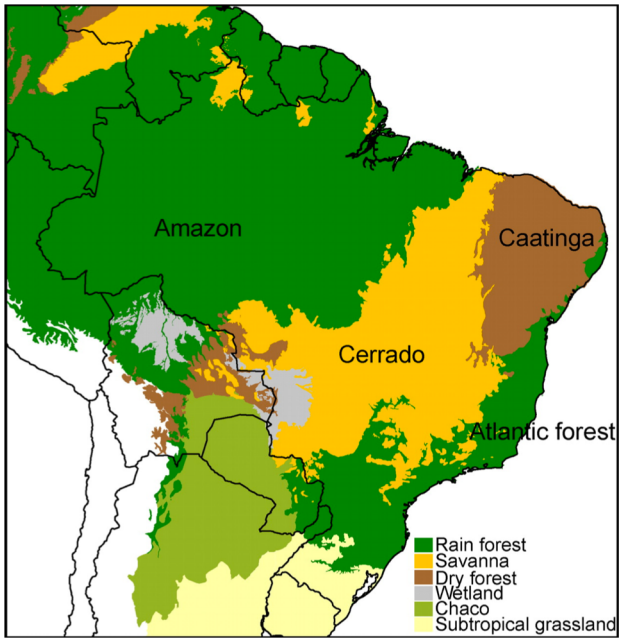
The wallaby is an extant marsupial species in Australia (many from Pleistocene are extinct)

Spinifex grasses in dry forest of Australia

Tropical savanna – Central, South America and West Indies

Caribbean pine and palmettos are common in Central America savannas

Brazil contains 250 million hectares of grassland, savanna and dry forest

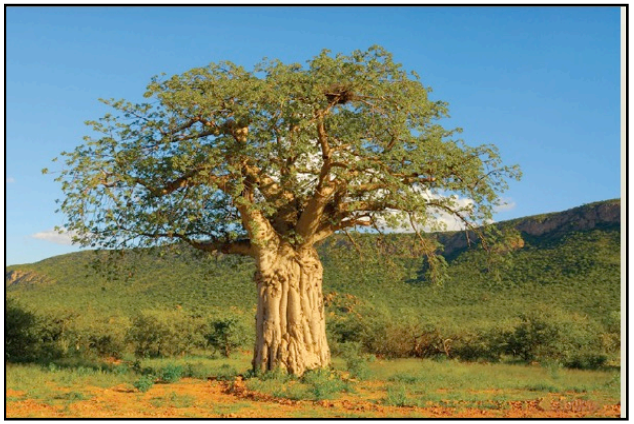


Caatinga

Cerrado

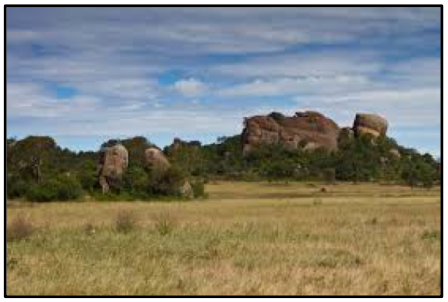
Tropical savanna - Africa

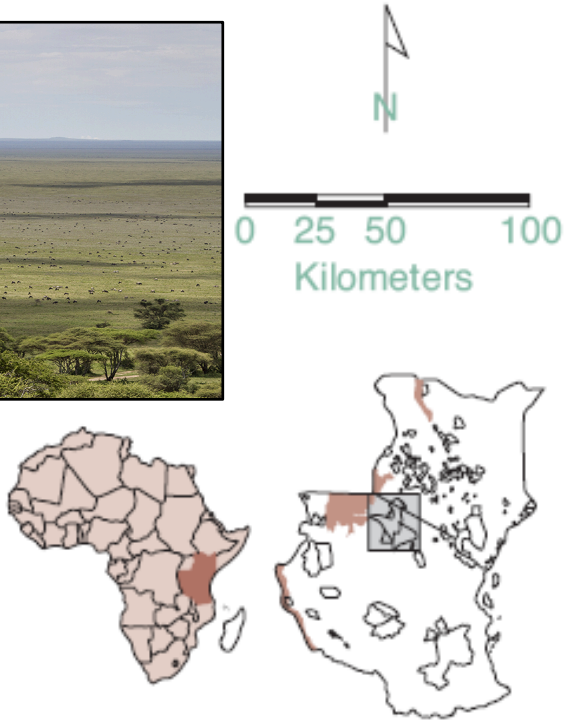
The African savanna is unique, as it still has intact megafauna typical of the large animal diversity that existed through the Pleistocene

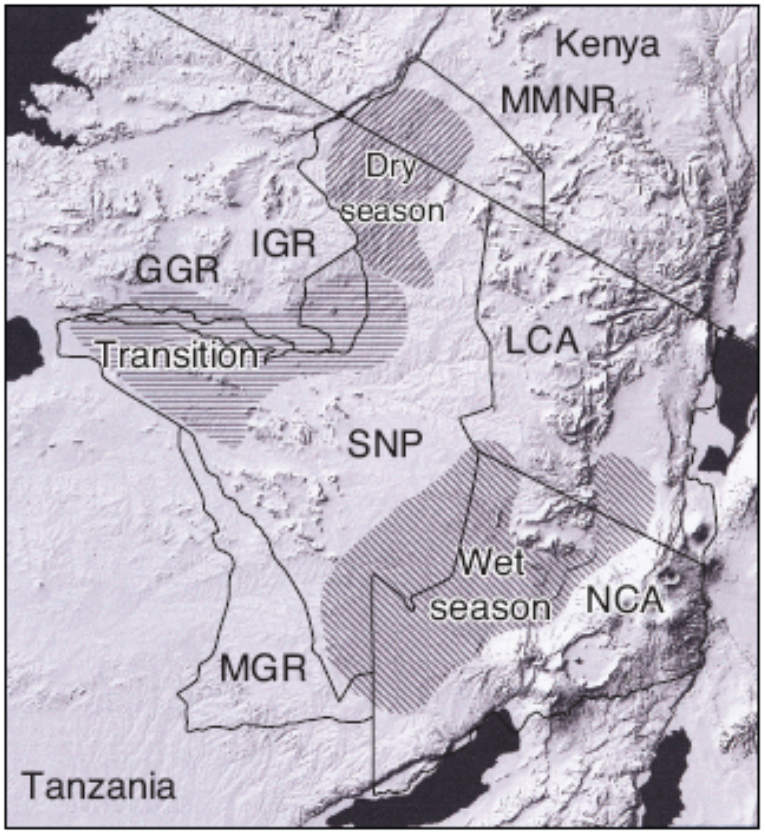


Serengeti ecosystems – short grass and long grass plains

The Serengeti ecosystem of Tanzania and Kenya is one of the most intensively studied savanna ecosystems







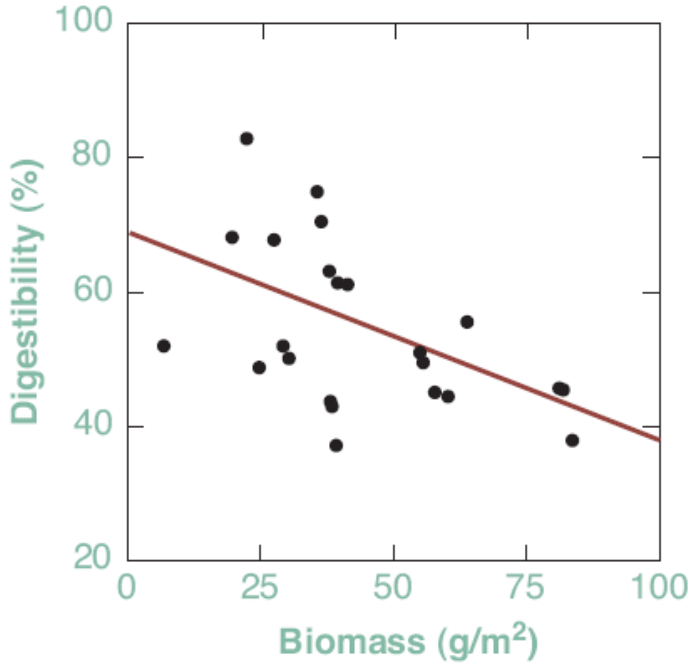
Megafauna presence has major role in savanna ecology

Thomson's gazelle move nomadically across the Serengeti, with a lifestyle tied to the quality of food.

Affected by the rate at which animals can crop graze and the animal's ability to digest.

Short grass is rich and protein and easy to digest, so gazelles are limited by the rate at which they can forage and digest

Tall grass is harder to digest and has more fibrous material (better foraging for larger grazers – wildebeest, zebra – who can better digest fibrous material

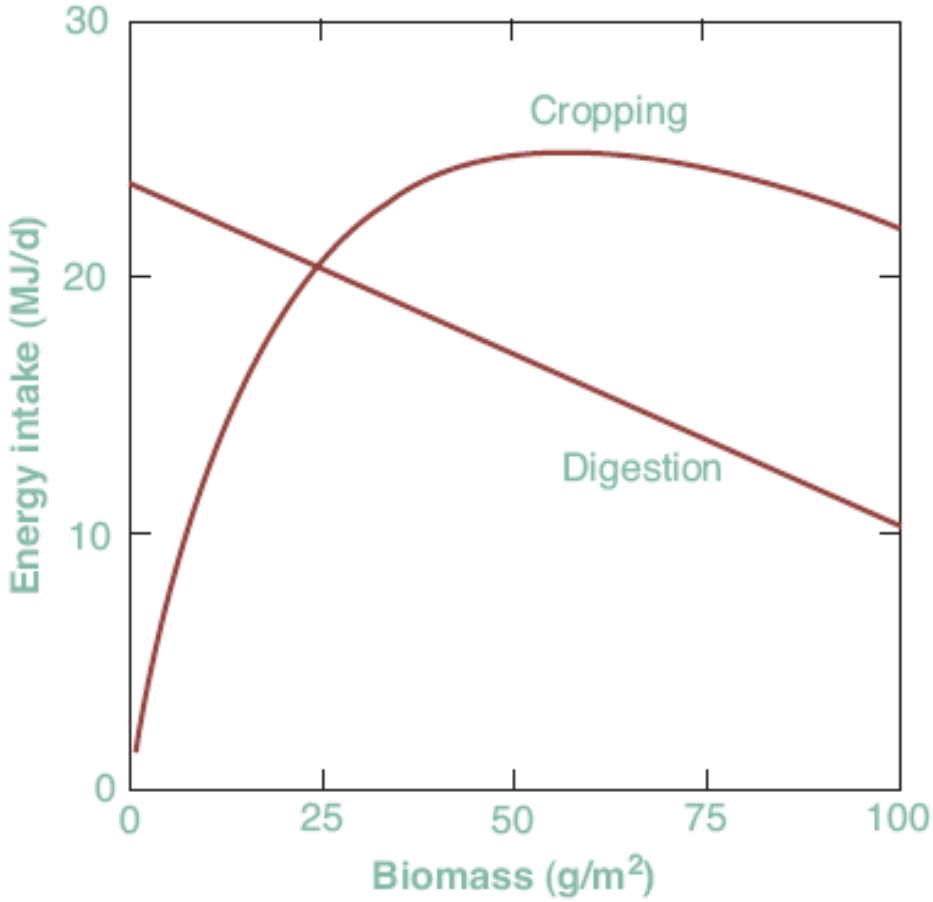


Megafauna presence has major role in savanna ecology

This model shows that maximum energy intake occurs at the intersection between cropping and digestibility ~ 25 g / m^2

Gazelles closely track changes in distribution of short grasses – abandoned patches when daily intake dropped below expected intake

Recognize a *shifting mosaic* of food value among grass patches and switch accordingly



Megafauna presence has major role in savanna ecology

Abundant grazing mammals are wildebeest, zebra, Thomson's gazelle, topi and African buffalo

Lions account for >50% of predation on the Serengeti (among cheetahs, leopards, hyenas and wild dogs)

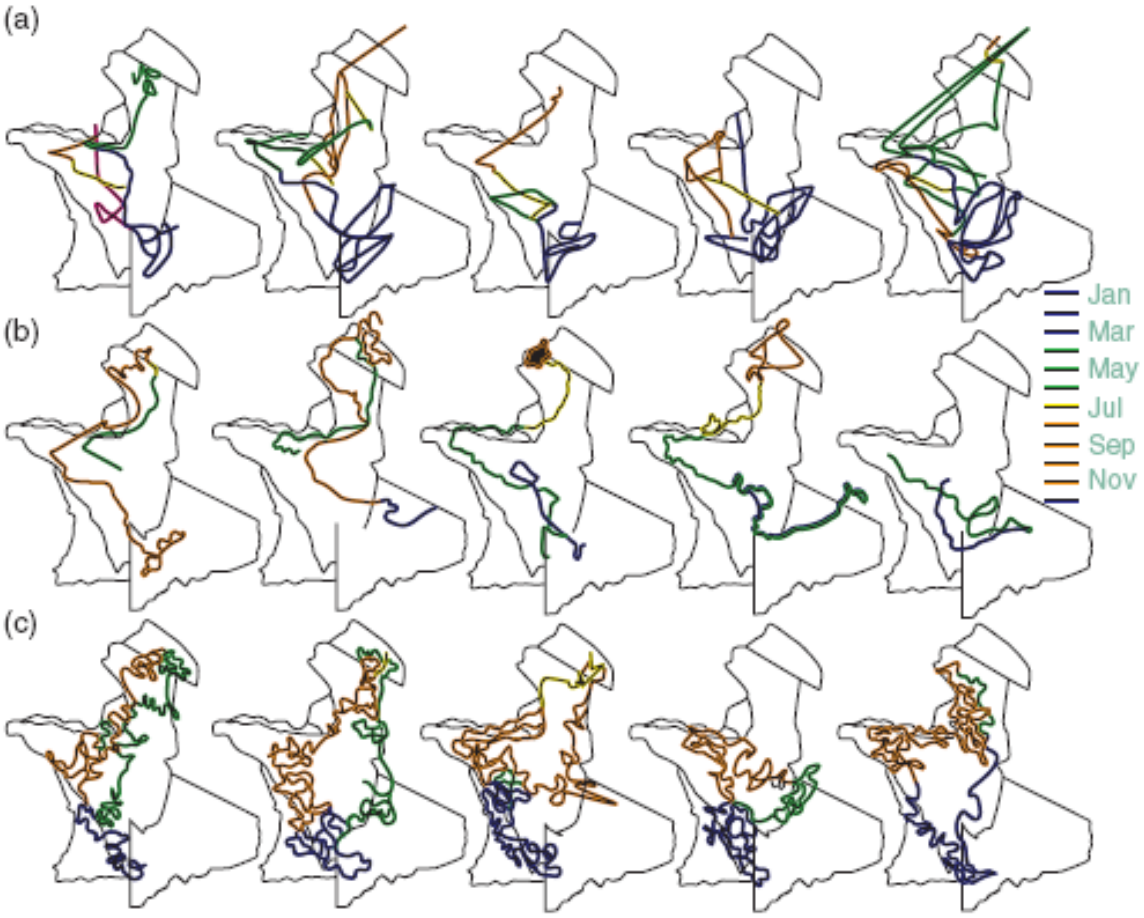
Movements of many grazing mammals are migratory, as dry seasons force them to move

Predatory mammals do not migrate seasonally, but occupy local territories

Serengeti migration – one of the most significant animal migrations on Earth

Grazers must move continuously to track grass patches that vary in productivity

On this complex mosaic of variable grass patches are periodic effects of fire and rainfall, which drive migrations



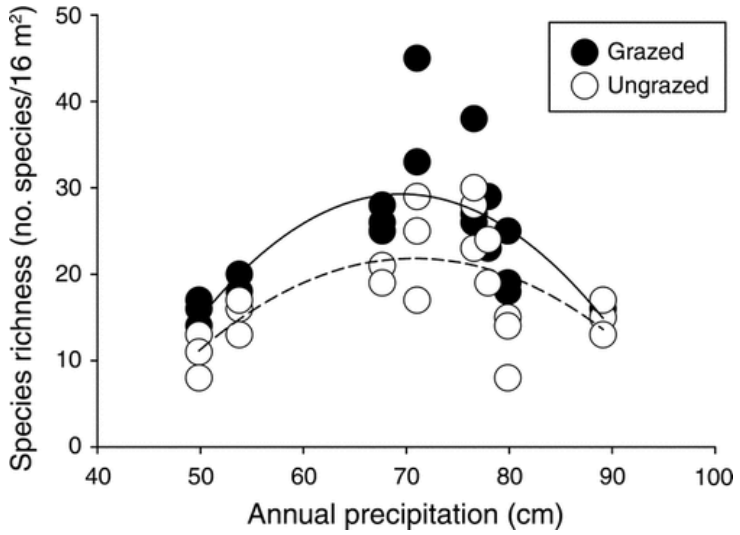
Pathways of VHF and GPS-tracked wildebeest match optimal migratory route models

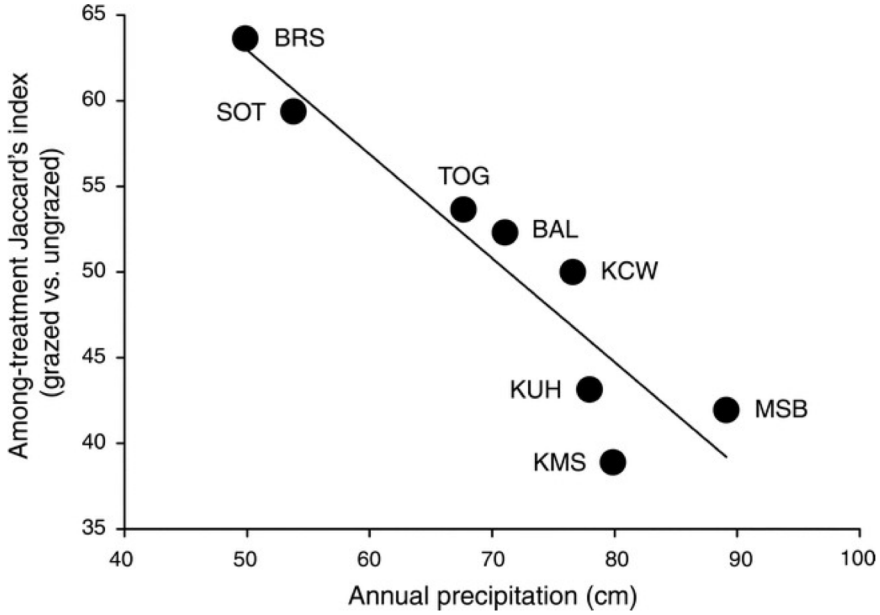
Top down and bottom up influences on the Serengeti

Herbivores affect plant species richness – experimentally excluding herbivores resulted in increased plant richness (with intermediate precip)

The similarity in species composition between grazed and ungrazed areas depended on precipitation

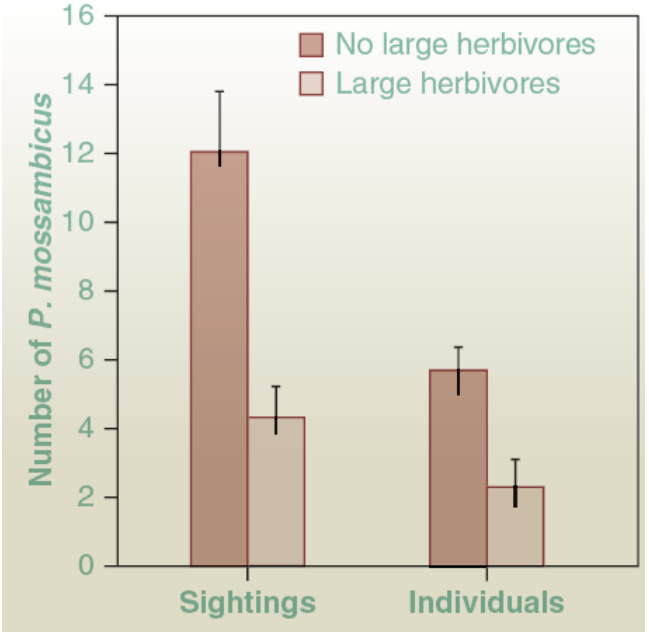
The higher the precipitation, the more dissimilar grazed and ungrazed communities were





Top down and bottom up influences (?) on the Serengeti

In the study of areas where large herbivores were excluded and those with large ungulates present, over 19 months, olive hissing snakes increased in abundance, but only where large herbivores were excluded



A bottom-up or top-down effect??

The pouched mouse (and other small mammals) became more abundant in the absence of large herbivores, boosting snake populations

Pouched mouse

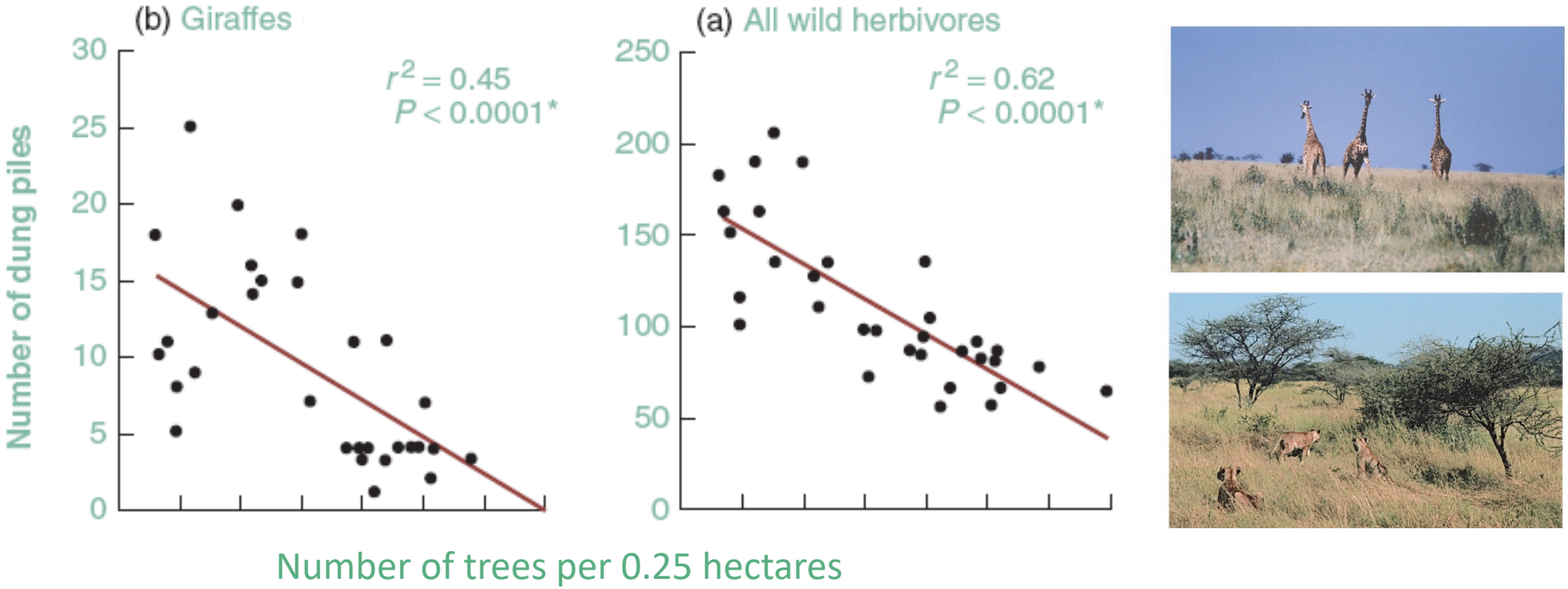
Olive hissing snake

Top down and bottom up influences on the Serengeti

Savannas vary in tree density, and browsing animals use these areas for foraging

Trees affect the quality of herbivorous vegetation, but trees also give cover to predators

Landscape of fear: perceived predation risk affects decisions by herbivorous mammals



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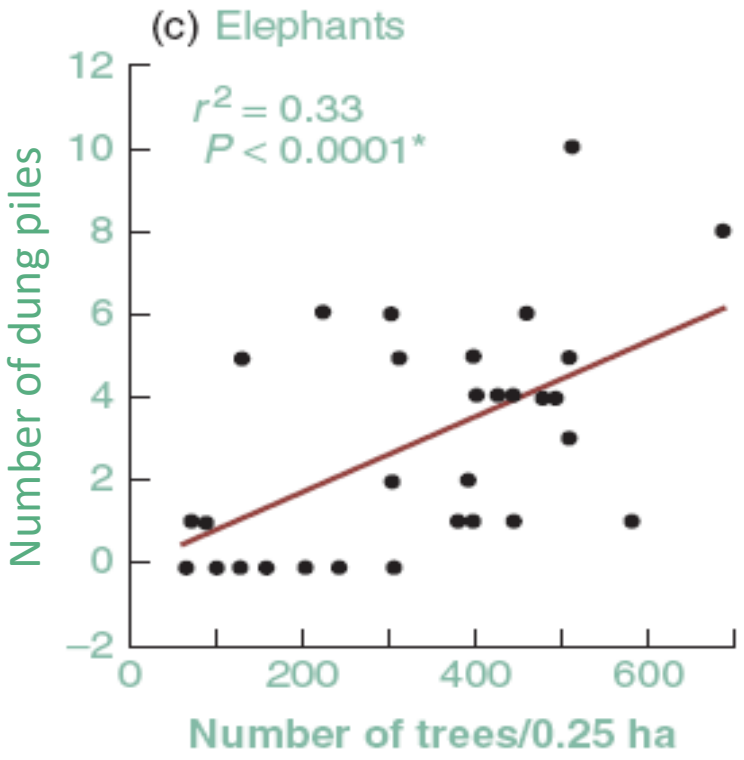


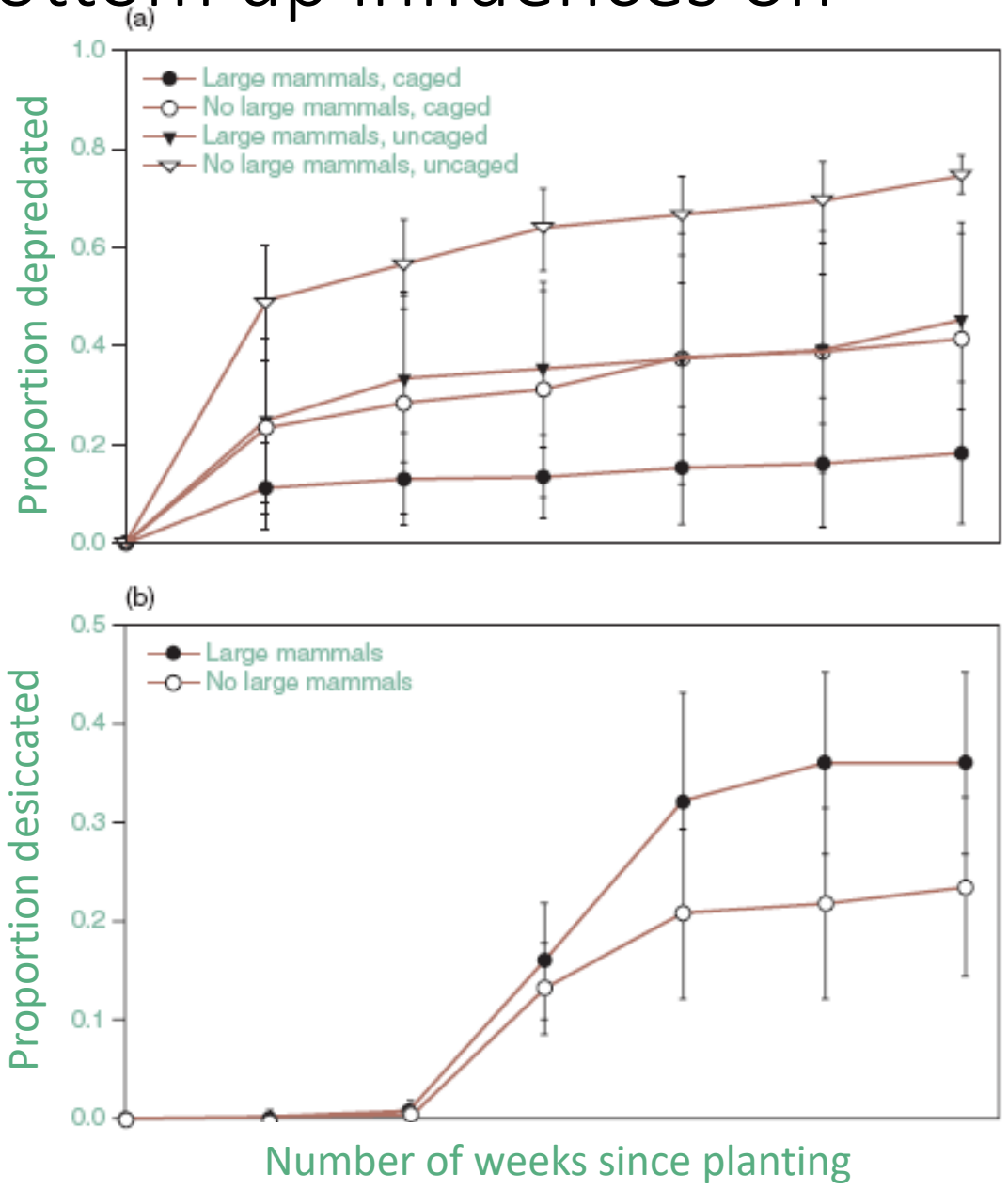
Elephants have little aversion to being in areas of high tree density

Top down and bottom up influences on the Serengeti

This study transplanted Acacia seedlings to plots were large mammals were included or excluded

Significant top down effect: More seedlings survived in the presence of large ungulates

Most frequent cause of death in areas with large mammals was desiccation (not predation)

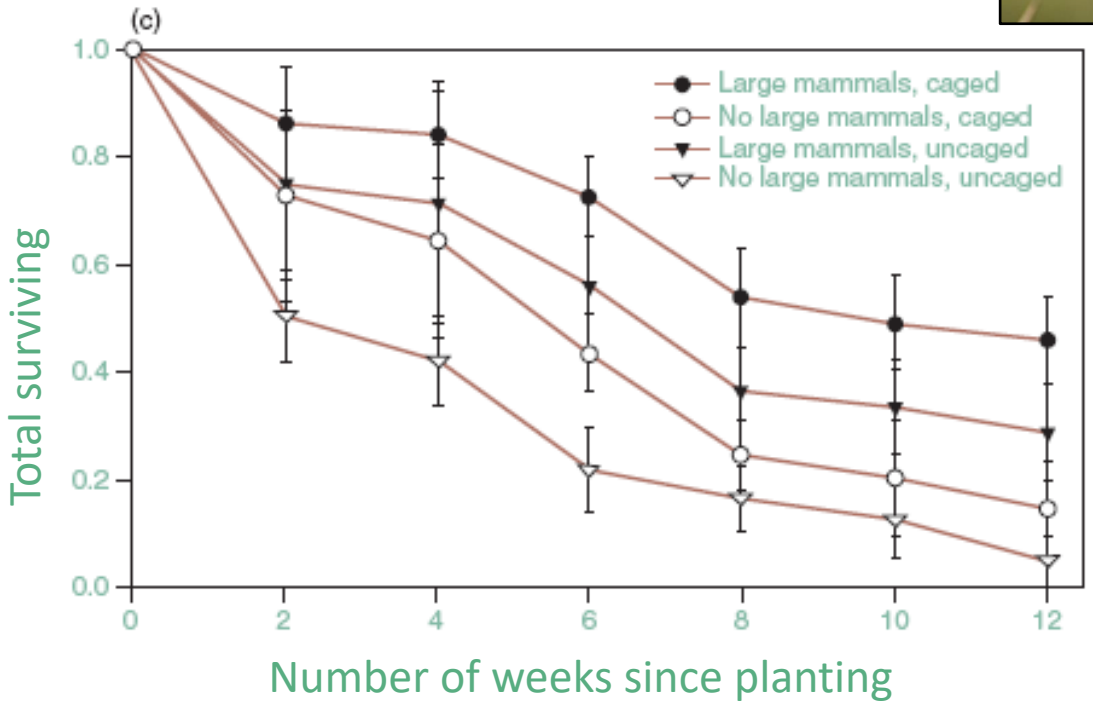


Goheen et al. 2004, *Ecology*

Top down and bottom up influences on the Serengeti

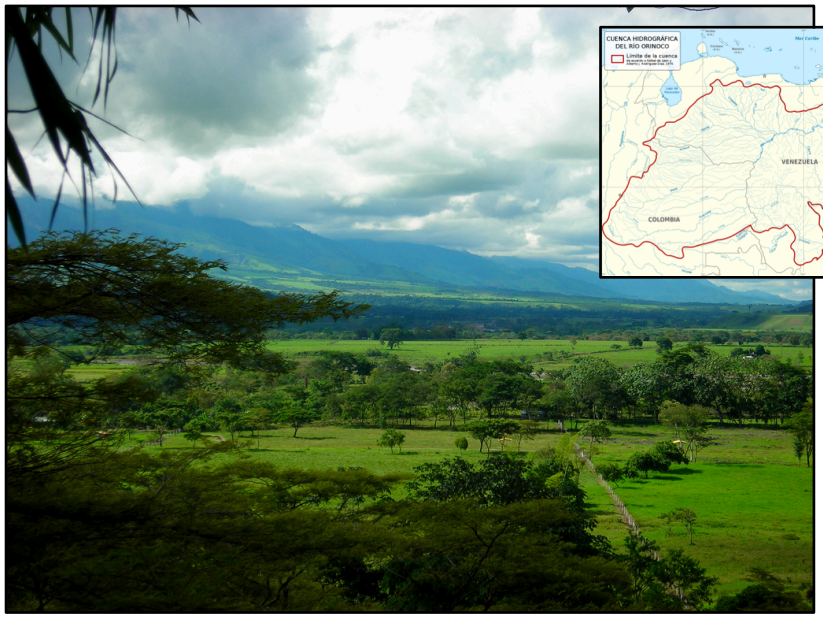
Movement of ungulates kept rodents and insects from having unlimited access to seedlings

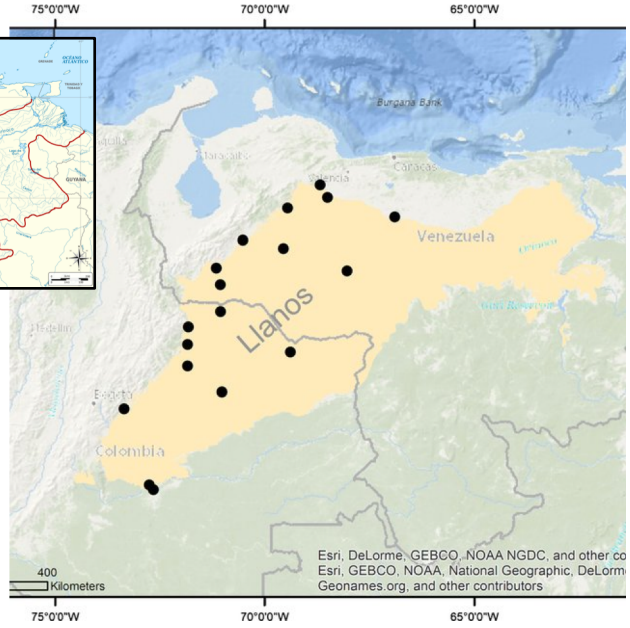
Seedlings with large mammals present have higher survival



Neotropical savannas – Los Llanos

Seasonal savannas of Venezuela and Colombia, generated within the floodplain of the Orinoco River





Neotropical savannas – Pantanal

Southern equivalent of the *Llanos*, within Mato Grosso do Sul in Brazil

Neotropical savannas – Brazilian Cerrado

Expansive open woodland on nutrient-poor sandy soils
Harbors ~4,000 endemic species, 137 Cerrado species are listed as threatened