Main Points

1) Diet

-- primitive monogastric, cecal fermentation, and ruminant fermentation

-- ruminant digestion and an adaptive radiation

-- example: the global distribution of mammalian herbivores

2) Metabolism and allometries

-- universal patterns in ecology

-- example: allometries for population density in carnivores

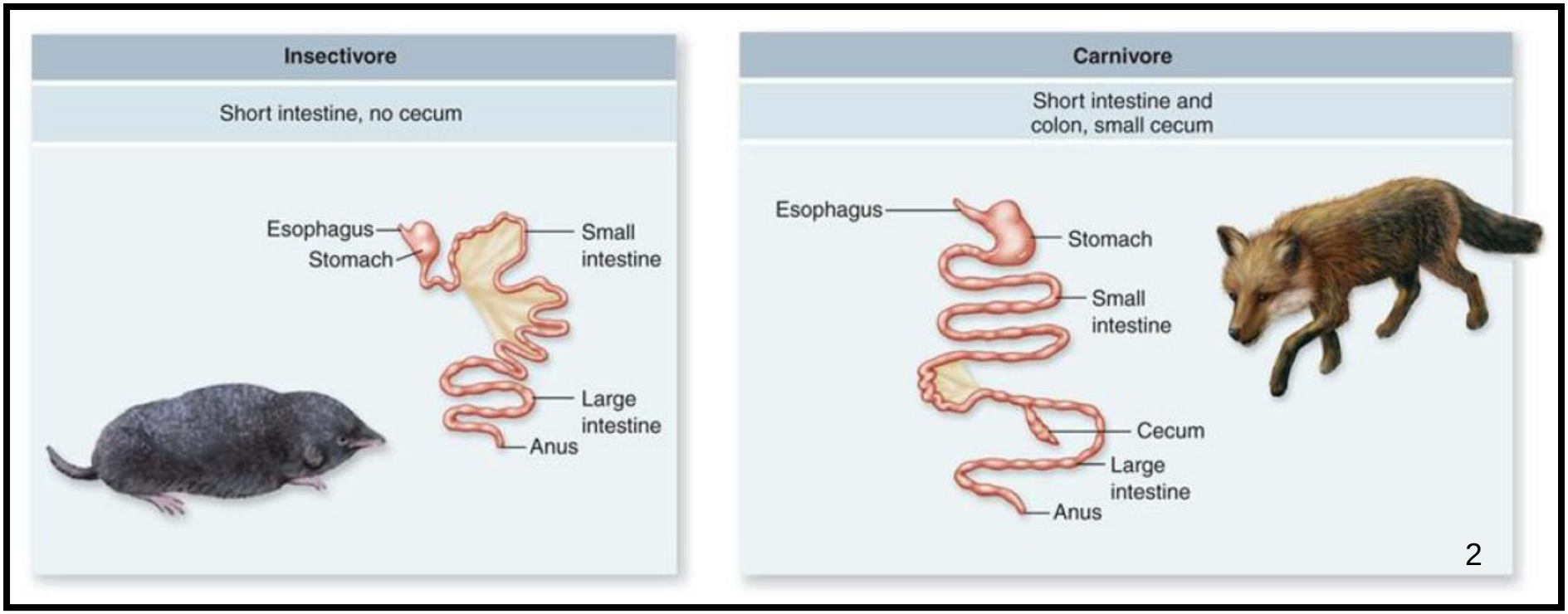
Terms: cellulose, meristem, frugivory, coprophagy, fermentation, cud, succession, metabolic rate, allometry, energy-equivalence rule

Pre-reading: Wednesday 11 October = NA

Monday 16 October = Emlen and Oring

Diet: Insectivores and Carnivores

- **insectivory (including myrmecophagy) and carnivory**
  -- simplest digestive tract
  -- no fermentation or cecum (or cecum is very small)
  -- food is readily digested, because of high energy content, no cell walls, and low fiber



Diet: Herbivores

- **Plants as mammal food:**
  -- leaves are low in protein
  -- sugars less concentrated
  -- protected by biotic, chemical, and mechanical defenses

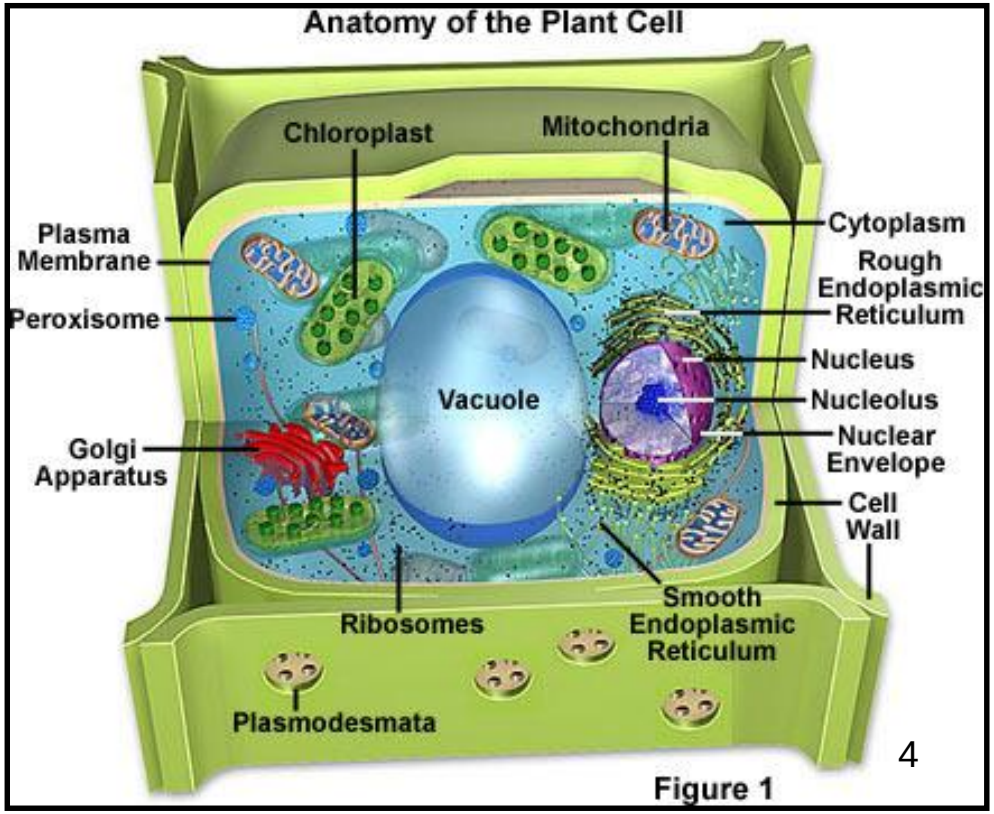
barrel cactus
w/mechanical defense
(spines)

bullhorn acacia
w/mechanical (thorns) and
biotic defense (ants)

chili
w/chemical defense
(capsaicin)

Diet: Herbivores

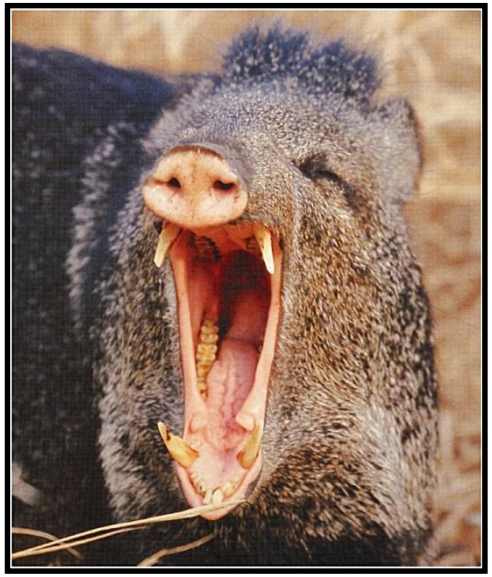
- **Plants as mammal food**
  -- <u>cellulose</u> in cell walls
  -- ontogeny of plants
  -- graminoid vs. forb <u>meristems</u>



Diet: Herbivores

- **primitive monogastric digestion**
  -- simple alimentary canal (AKA digestive tract)
  -- often leads to <u>frugivory</u> or omnivory

collared peccary

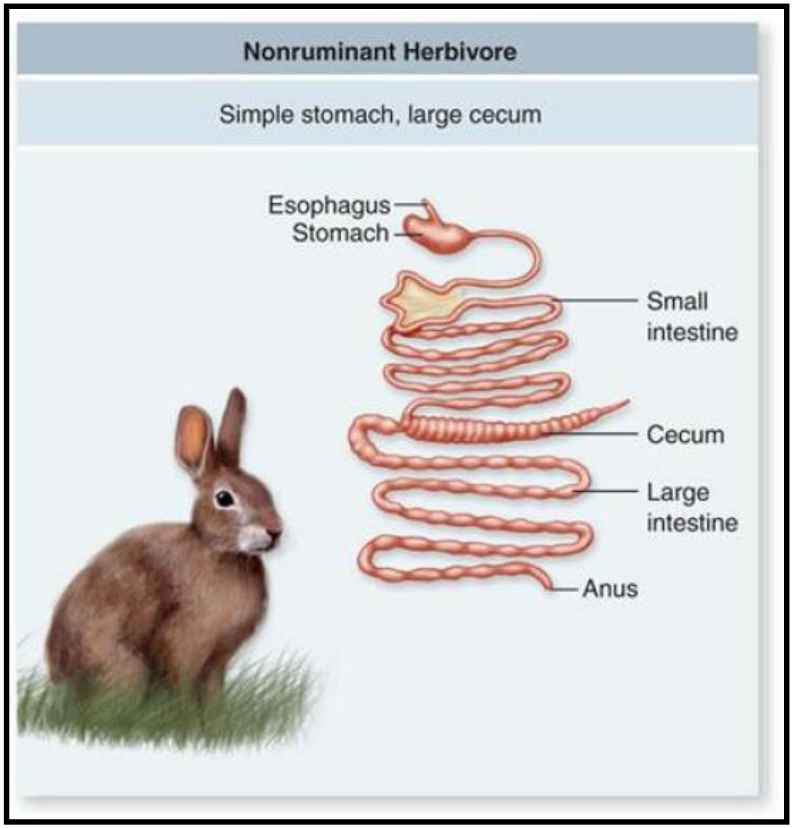


bearded pig

giant forest hog

Diet: Herbivores

- **hindgut or cecal fermentation**
  -- enlarged cecum houses fermentation
  -- short rate of passage, low cellulose utilization
  -- may lead to <u>coprophagy</u> in smaller species

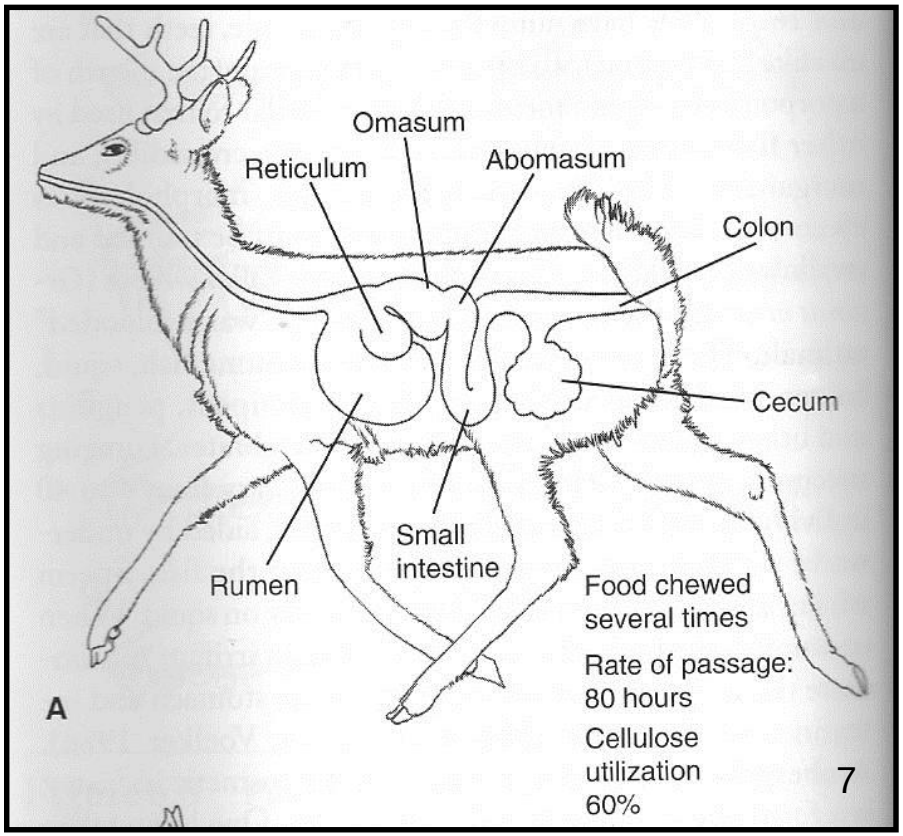


mountain tapir

Diet: Herbivores

- **foregut or ruminant fermentation**
  -- fermentation occurs in four-chambered stomach
  -- long rate of passage, high cellulose utilization, <u>cuds</u>

American bison

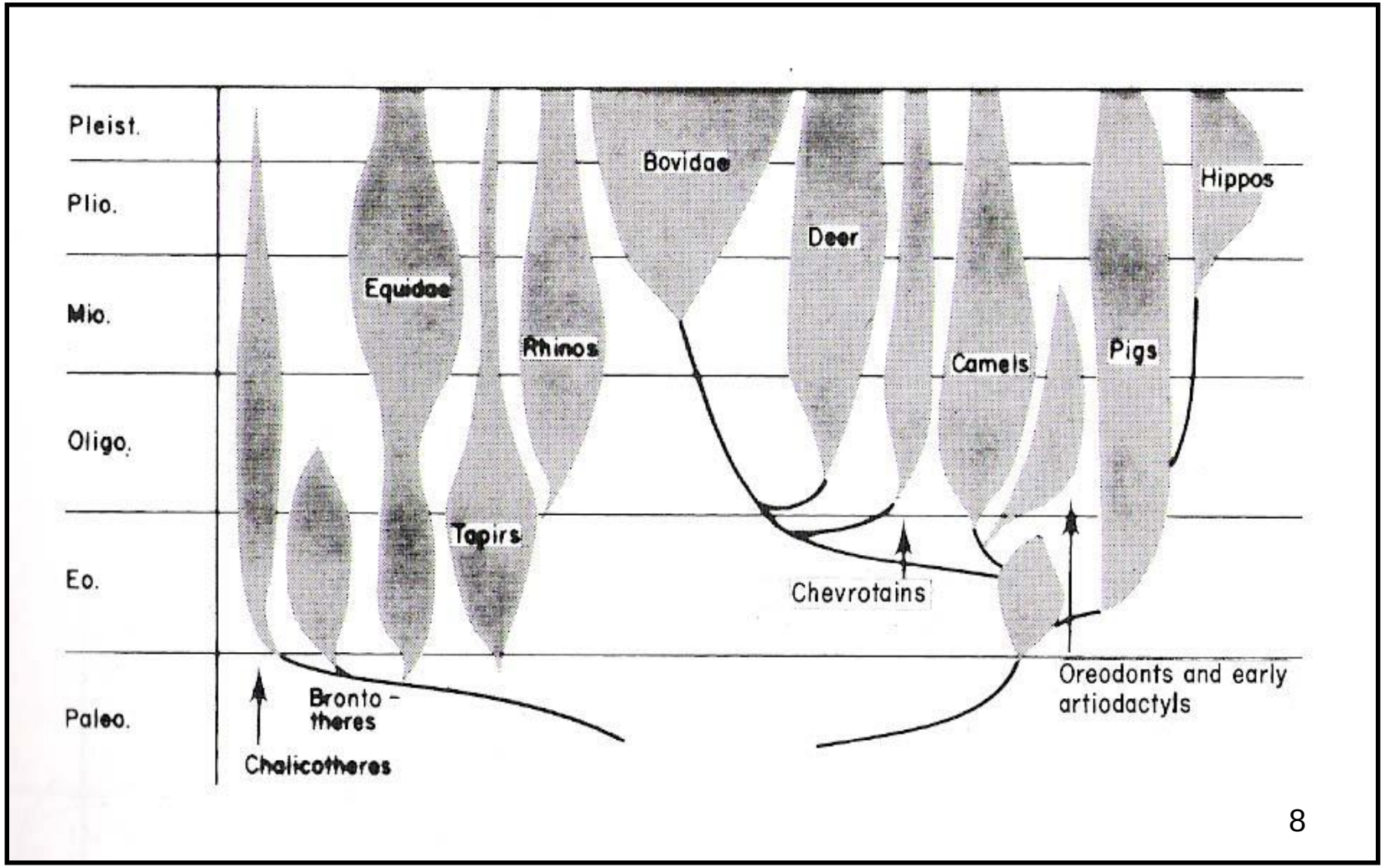


Discussion Q: Families Bovidae and Cervidae have proliferated in the past 15,000 years, while rhinos, horses, and equids have declined in number. Come up with a hypothesis for why this has happened.

15,000

5 MYA

34 MYA

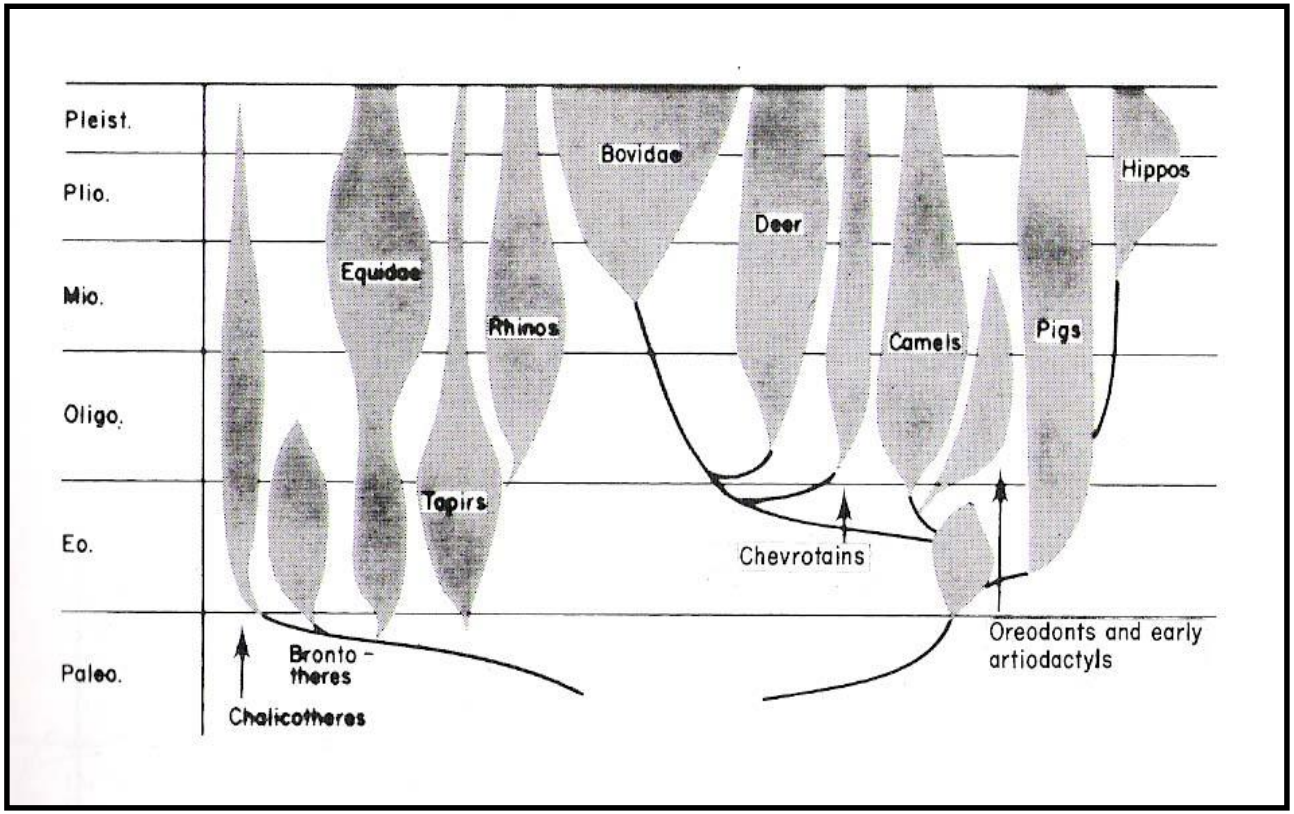


elk

vicuna

saiga

saola



water chevrotain

- **<u>succession</u> = predictable changes through time in ecological communities**

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- **Grazing succession**

  -- materials pass twice as fast through cecal fermenters

  -- protein assimilation less efficient than ruminants

- **Grazing succession**

  -- smaller animals have higher mass-specific metabolic rates

  -- smaller animals have higher relative energy demands, but lower absolute energy demands

  -- for smaller animals, intake is less, but assimilation must be high

Metabolism and body size

- **<u>metabolic rate</u> = energy consumption or expenditure, typically measured in kJ or kCal consumed per day**

Metabolism and body size

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Metabolism and body size

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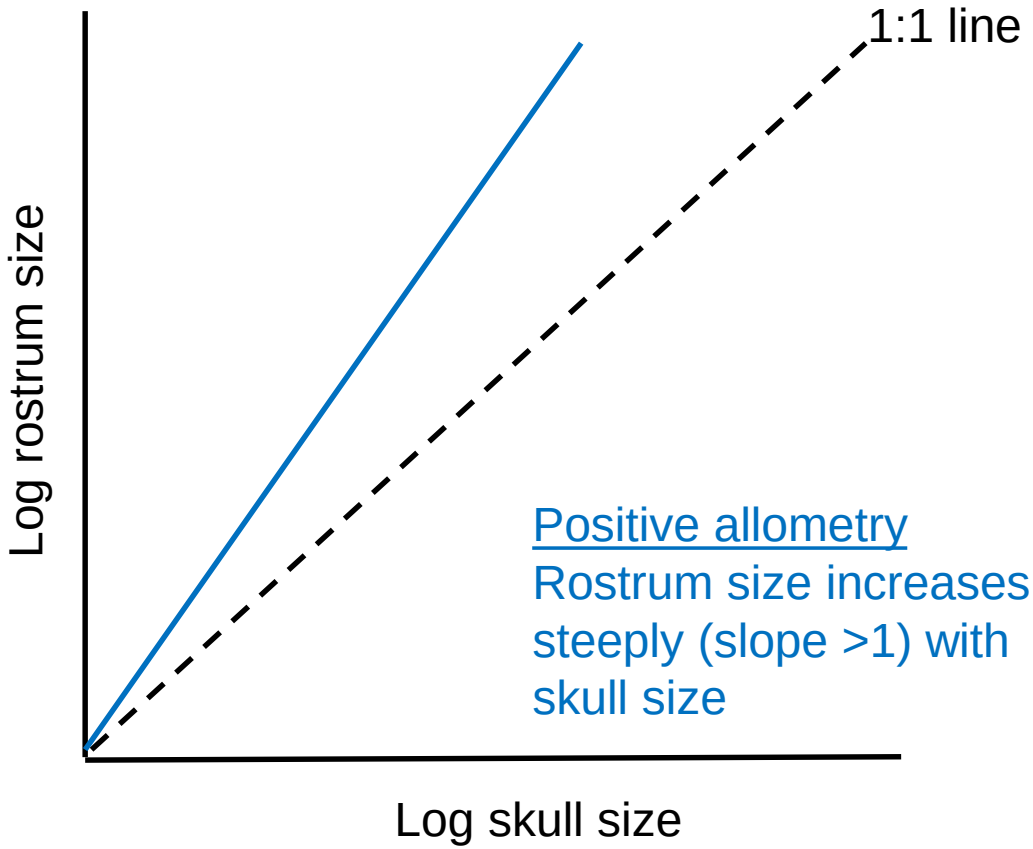
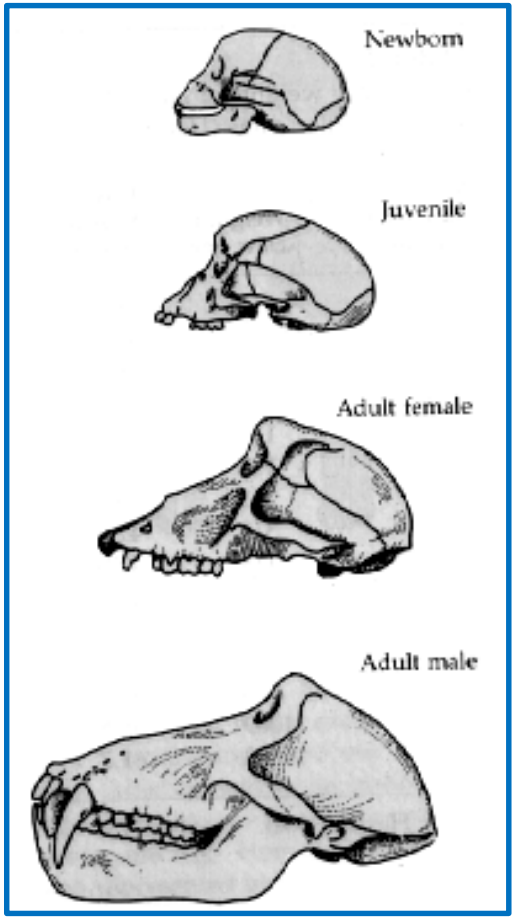
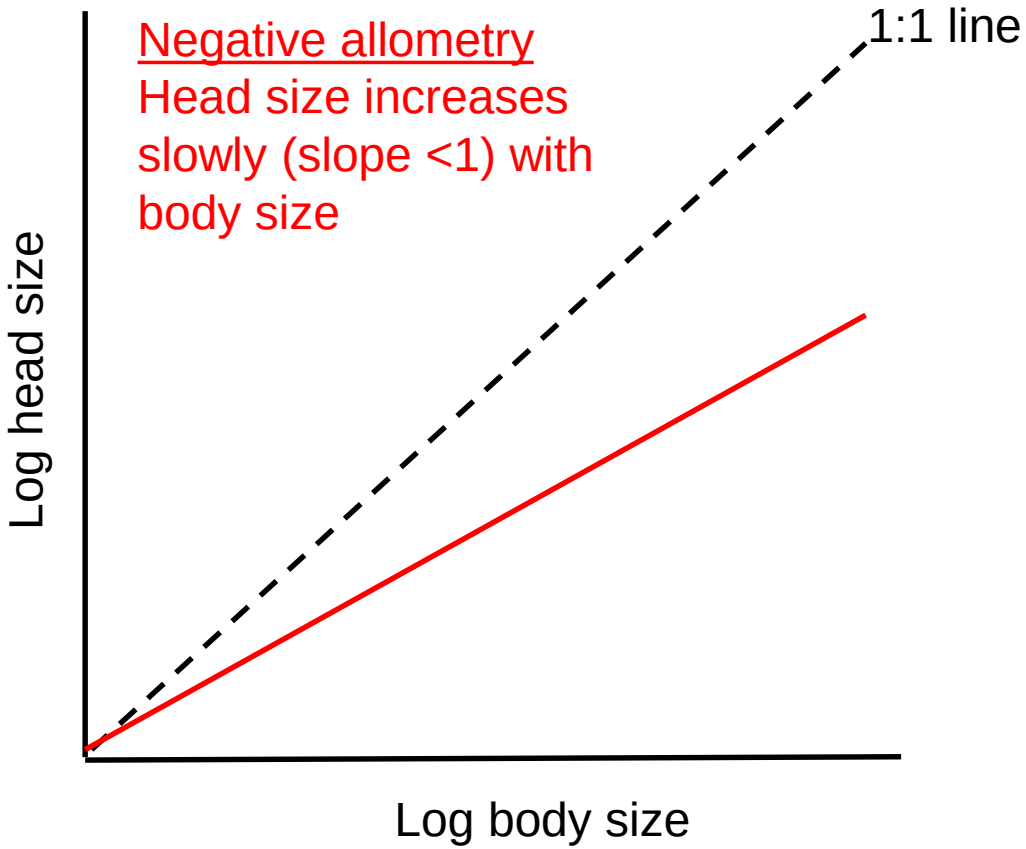
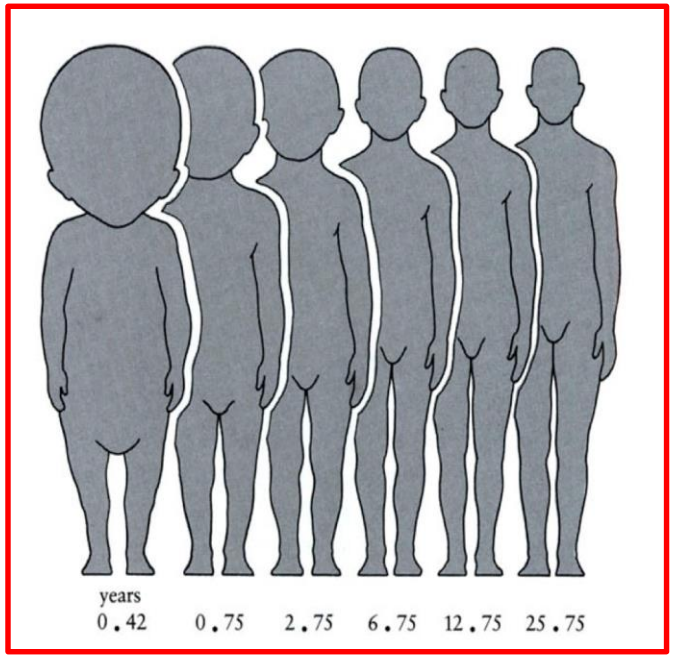




Metabolism and body size

- **<u>allometry</u> = change in trait or process with body size that is non-linear**

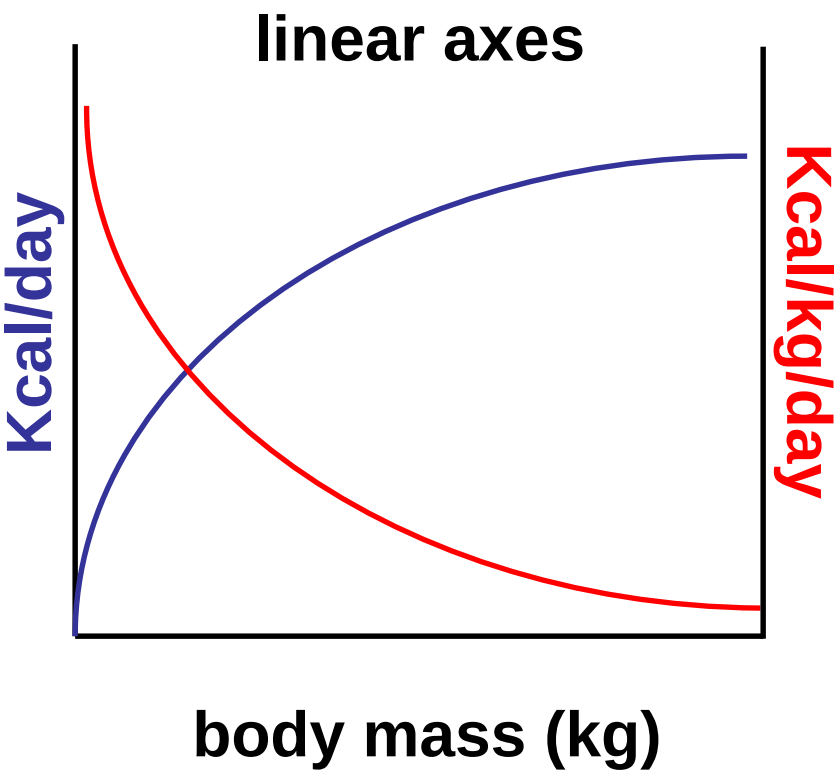


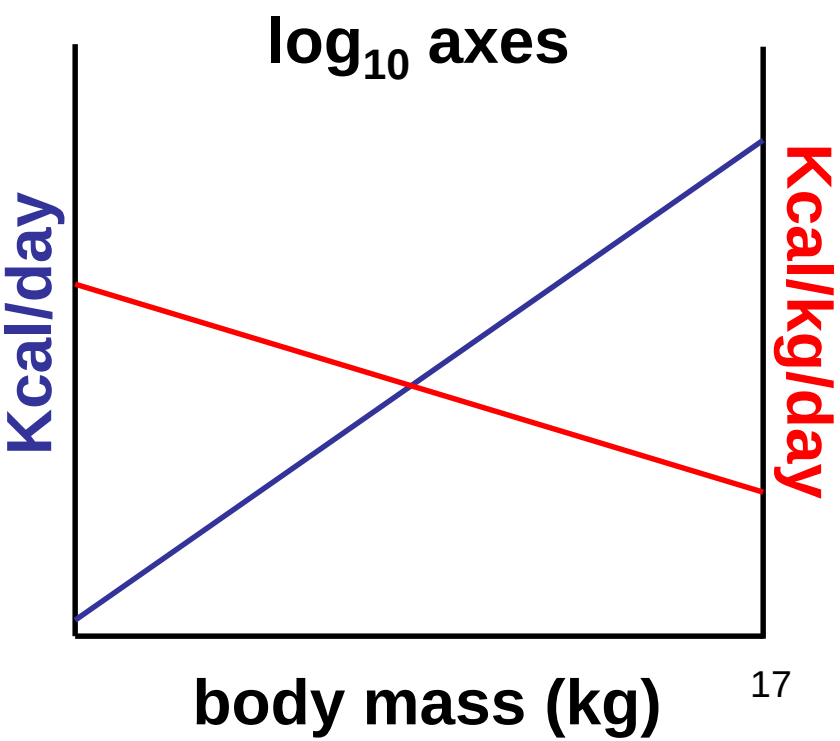


Metabolism and body size

- **<u>metabolic rate</u>**

- **<u>allometry</u>**





Metabolism and body size

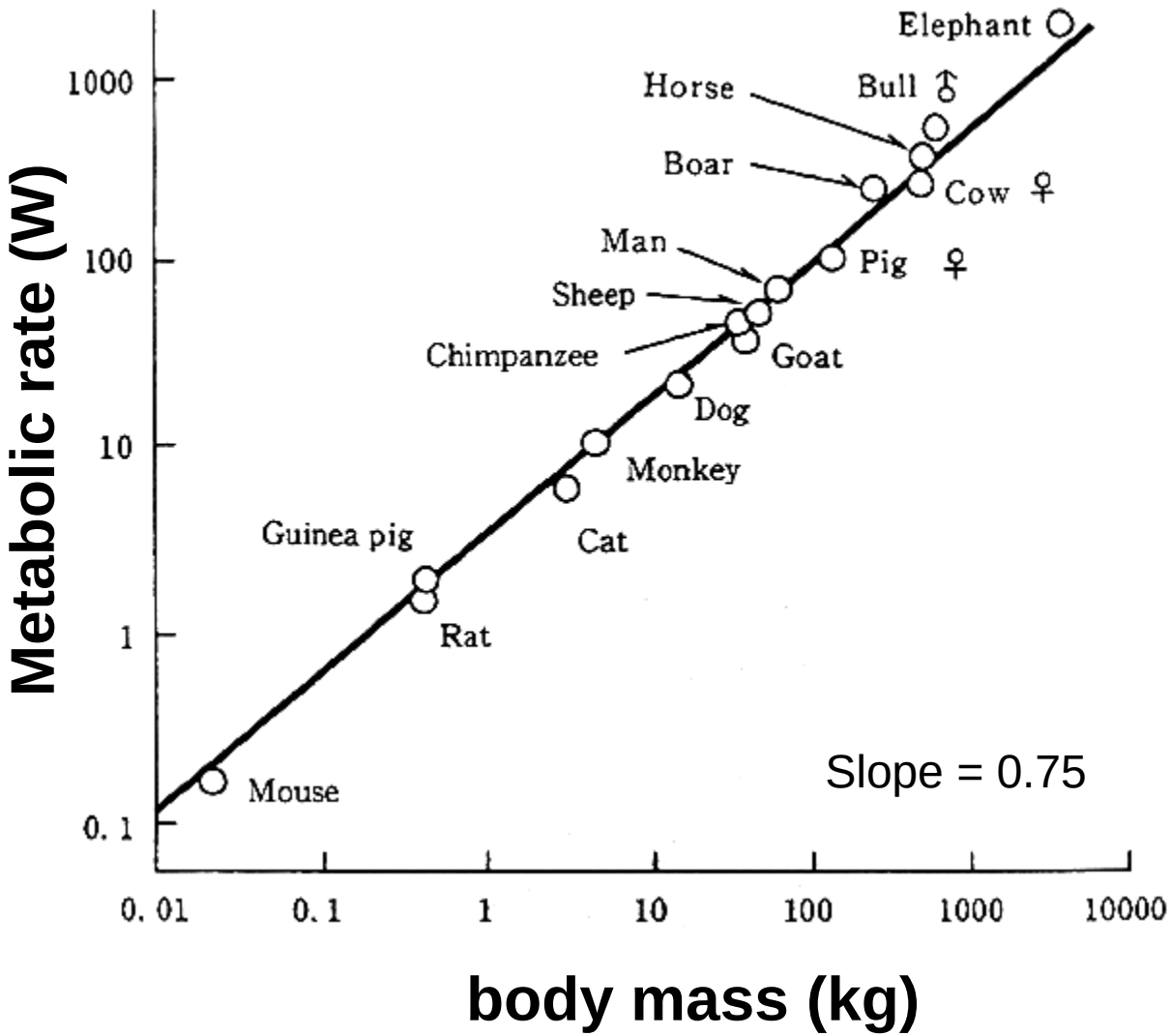
- **<u>metabolic rate</u>**

- **<u>allometry</u>**

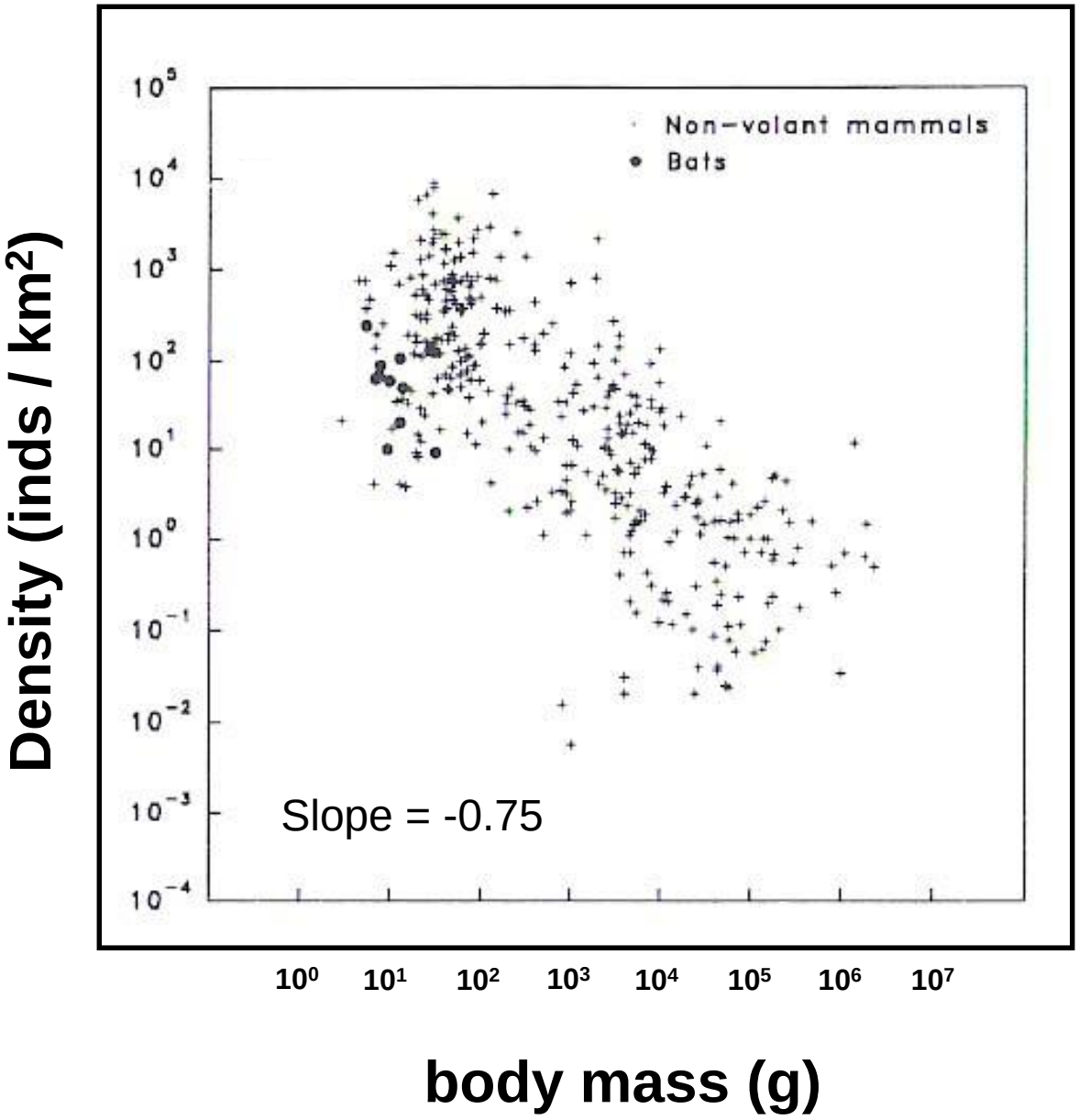
  total metabolism (kJ) = a(mass^0.75)

  mass-specific metabolism (kJ) = a(mass^-0.25)

Metabolism and body size



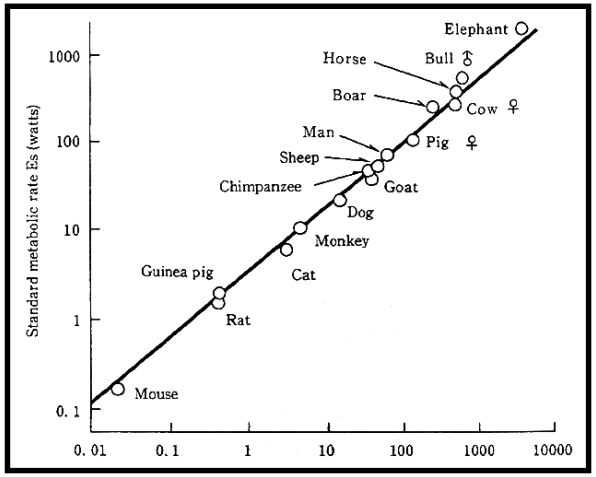
Metabolism and body size



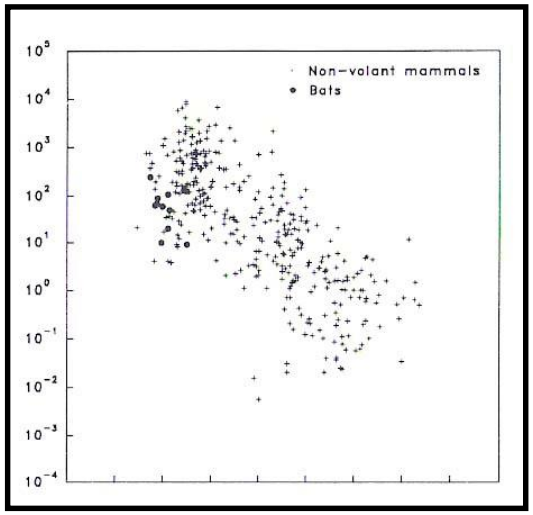
From Brown 1995

Metabolism and body size

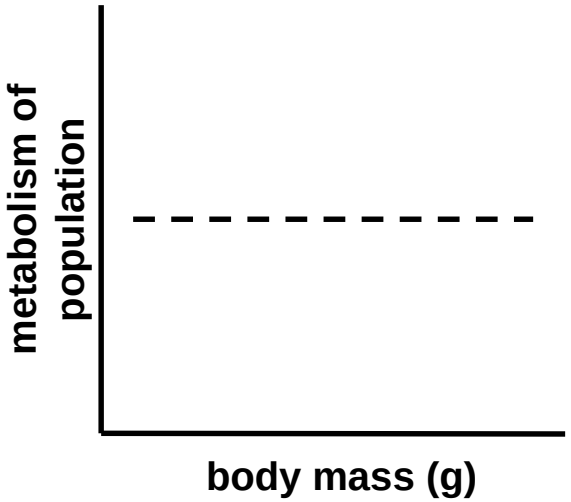
- **<u>Energetic-equivalence rule</u> = change in abundance with body size is offset by change in metabolic rate with body size, so that populations exhibit invariance in energy use with respect to size.**

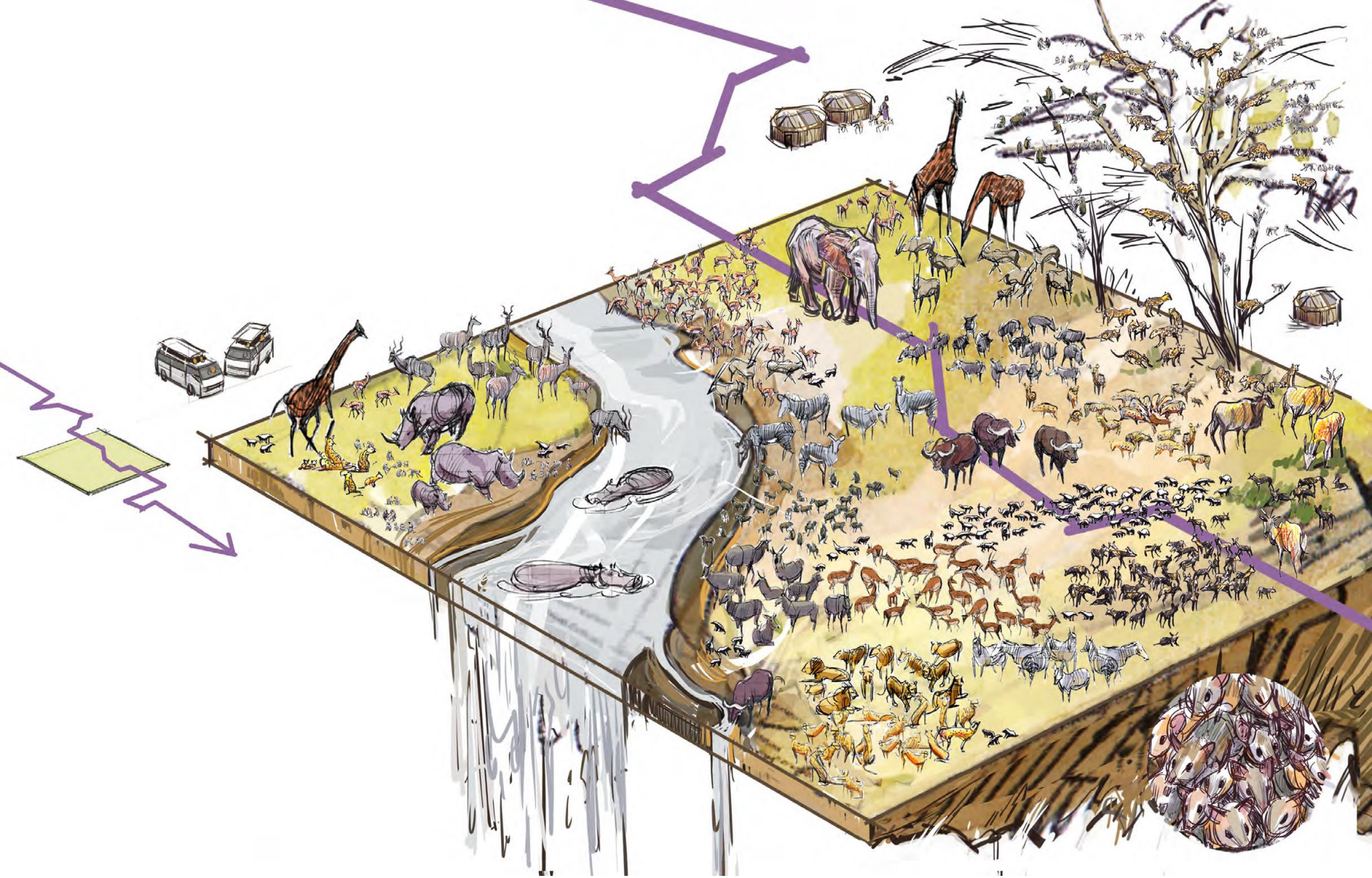


body mass (g)



body mass (g)

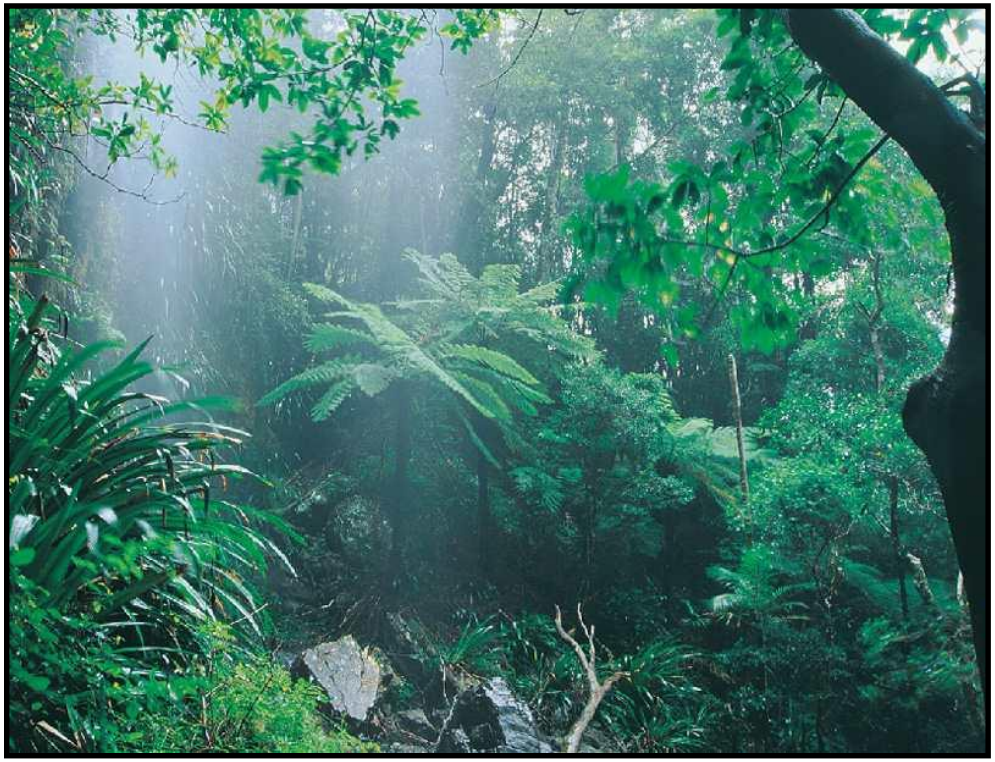


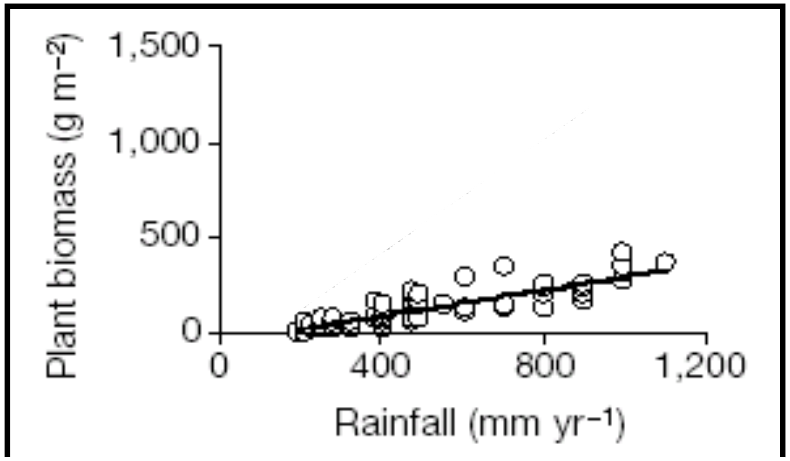


K. Roy. 2017.
“How to be an elephant”
http://katherineroy.com/elephants/

Digestion and global diversity of ungulates

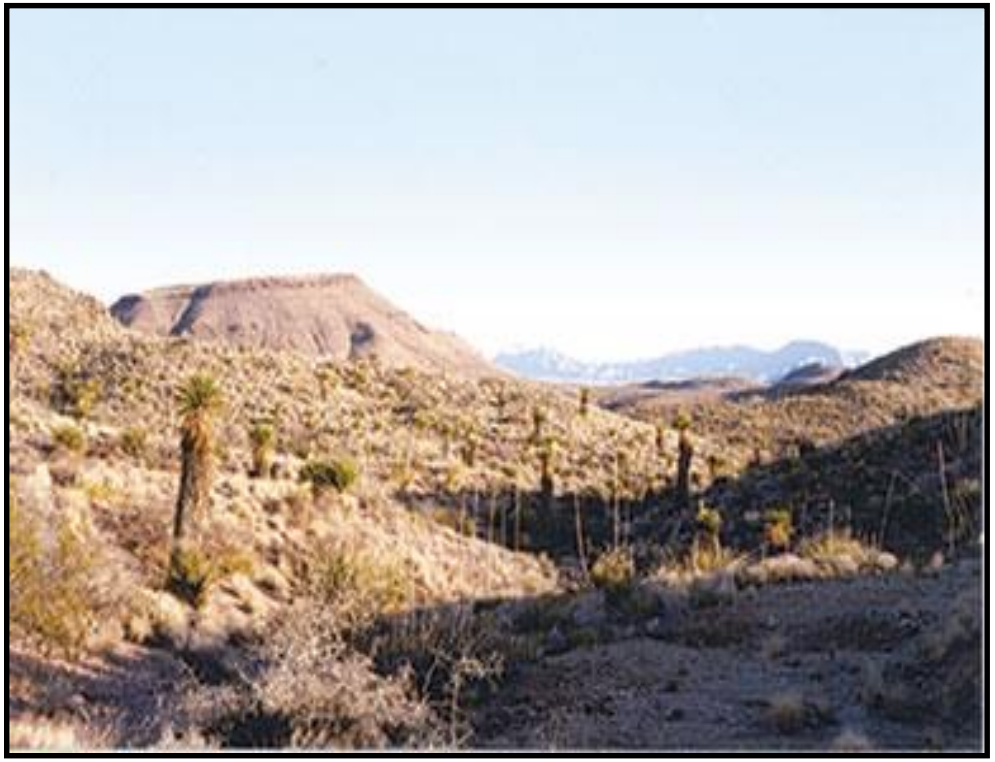
- **Predictors of *plant quantity*:**
  -- more rain = more plants
  -- higher soil fertility = more plants

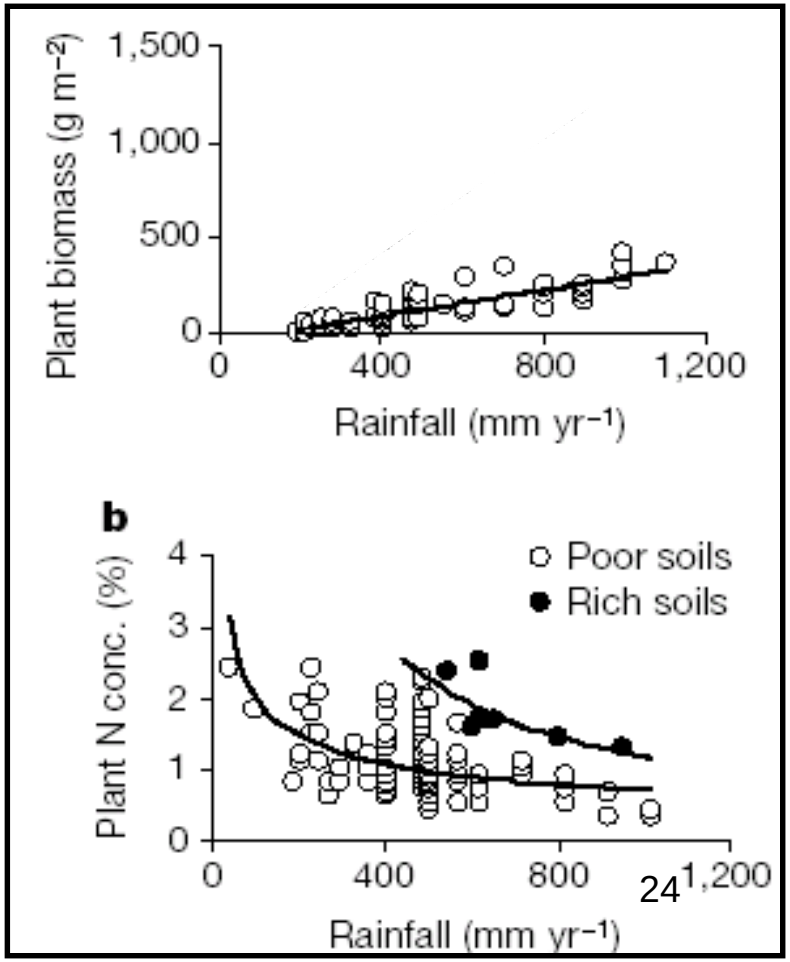




Digestion and global diversity of ungulates

- **Predictors of *plant quality*:**
  -- more rain = lower N and P content
  -- higher soil fertility =
  higher N and P content





Digestion and global diversity of ungulates

- **Plants are most abundant in wet, high-fertility environments**

klipspringer ~20 kg

plains zebra ~200 kg

buffalo ~800 kg

Digestion and global diversity of ungulates

- **Plants are most abundant in wet, high-fertility environments**

- **Plants are most nutritious in dry, high-fertility environments**

klipspringer ~20 kg

plains zebra ~200 kg

buffalo ~800 kg

Dicussion Q: in light of the fact that plant quantity is most important to large ungulates, and plant quality is most important to small ungulates, come up with a hypothesis for where ungulate diversity should be highest.

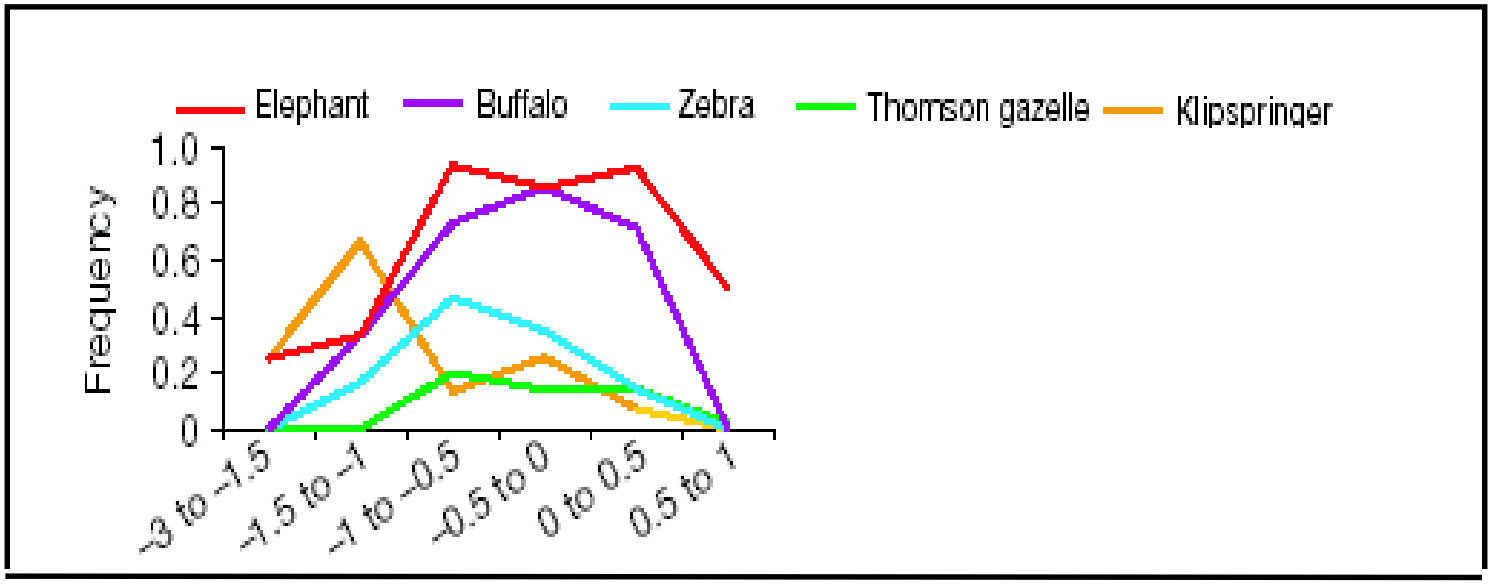
klipspringer ~20 kg

plains zebra ~200 kg

buffalo ~800 kg

Global diversity of ungulates

3000 kg → 15 kg



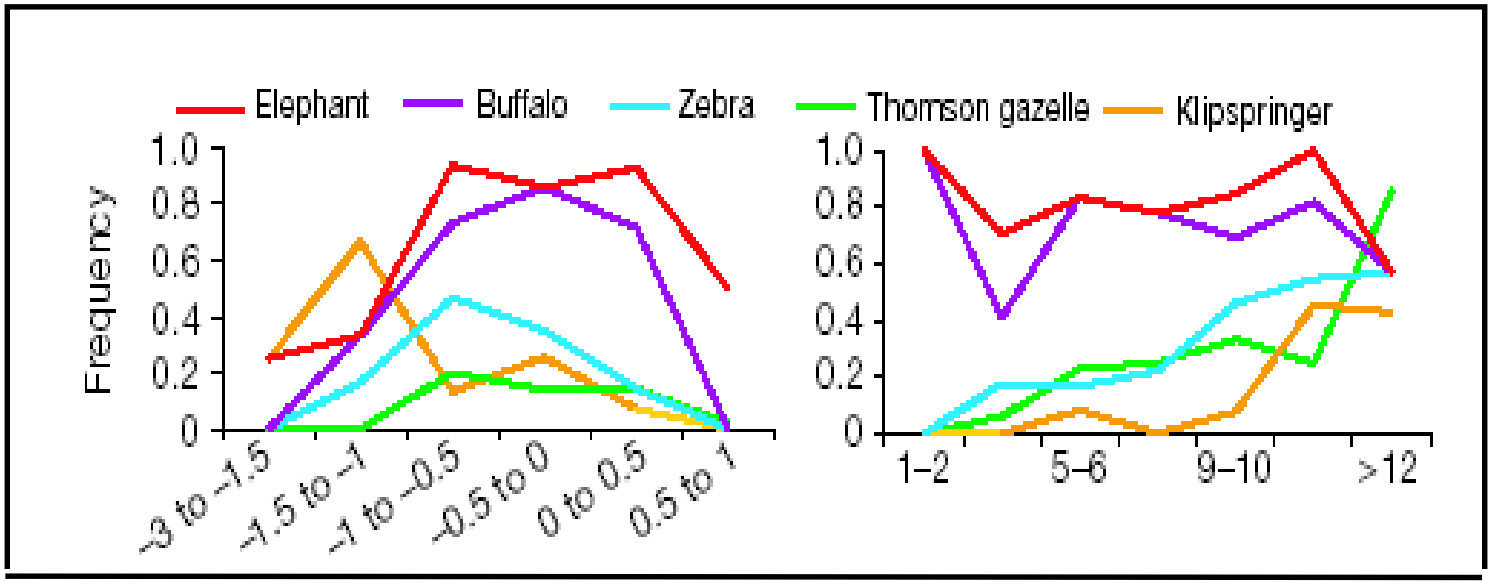
Plant available moisture

Plant available N

From Olff et al. 2002.

Global diversity of ungulates

3000 kg → 15 kg



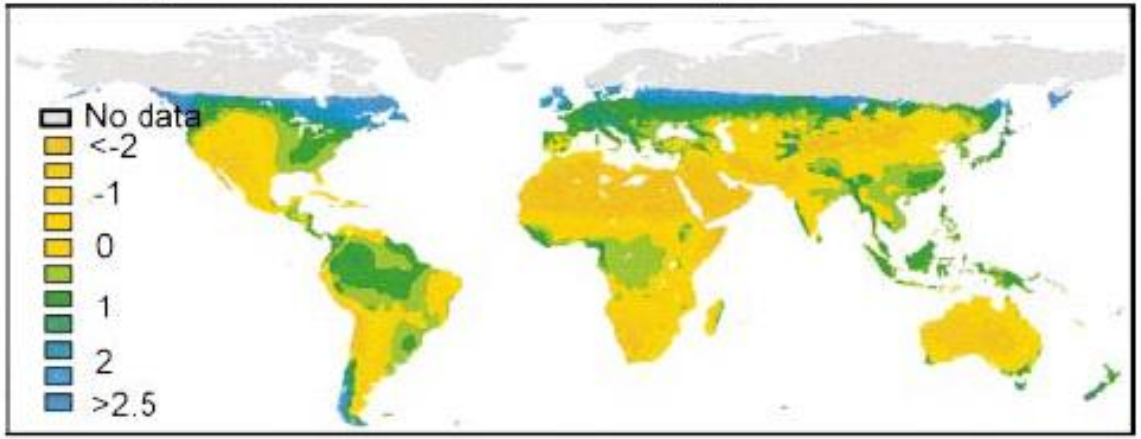
Plant available moisture

Plant available N

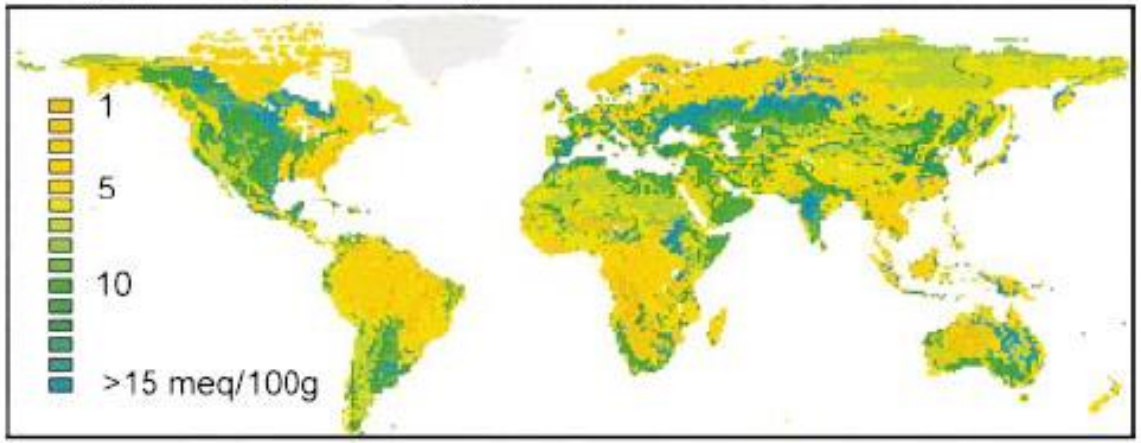
From Olff et al. 2002.

Global diversity of ungulates

a Plant available moisture



b Plant available N



Global diversity of ungulates

- **High correspondence between predicted and observed diversity of large herbivores, based on rain and soil fertility**

- **Suggests that plant-available nutrients and moisture *maintain* species diversity of ungulates**