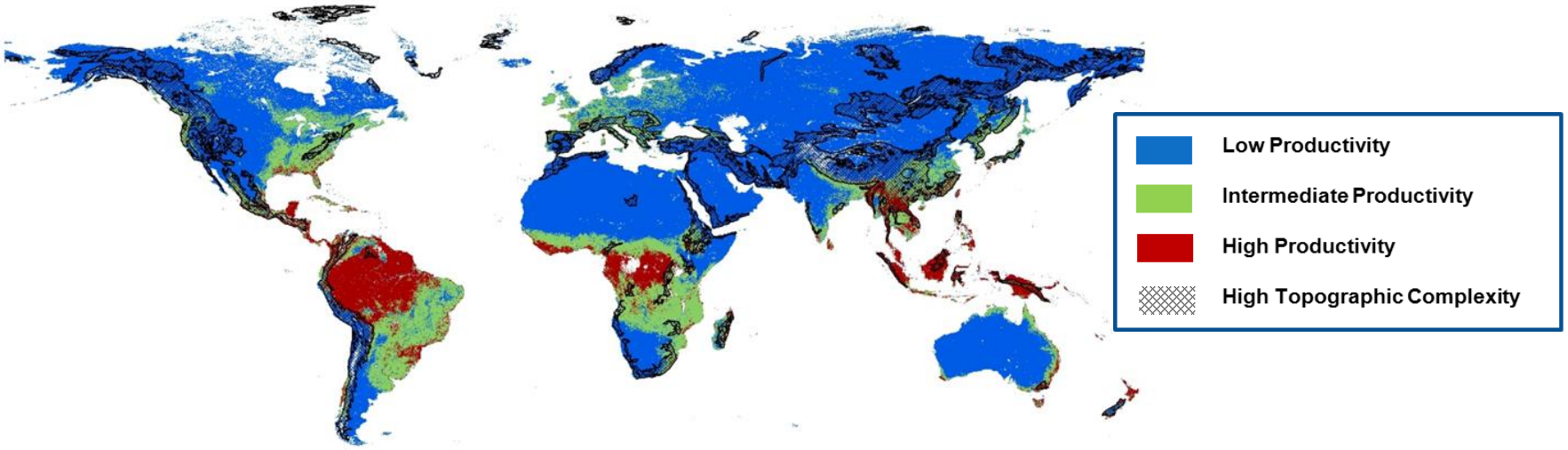
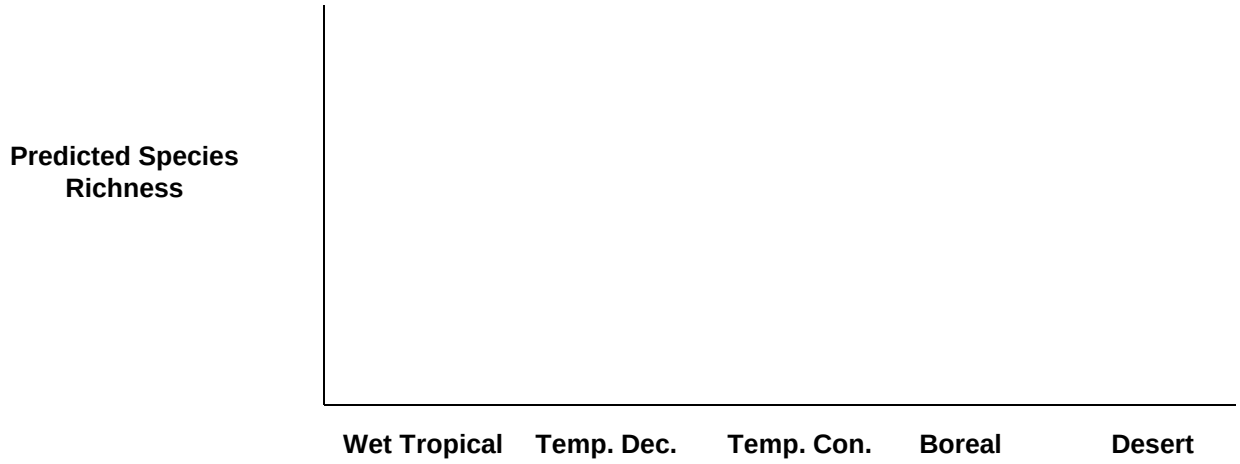
Community Diversity: Controls and Patterns

Topics

- **What is biodiversity and why is it important?**
- **What are the major drivers of species richness?**
- **How might the drivers of species richness and hence levels of species richness differ among biomes?**

Patterns of Biodiversity across Biomes





Community Diversity Defined

Biodiversity

Merriam-Webster - the existence of many different kinds of plants and animals in an environment.

Wikipedia - is the degree of variation of life forms within a given species, ecosystem, biome, or an entire planet.

U.S. Congress Office of Technology Assessment - the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different items and their relative frequency. For biological diversity, these items are organized at many levels, ranging from complete ecosystems to the chemical structures that are the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, genes, and their relative abundance."

Community Diversity Defined

Species richness -

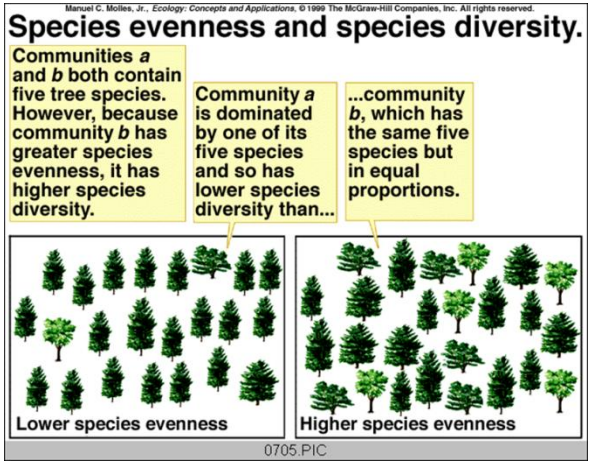
Species evenness -

Species diversity -

Community Diversity Defined

Species richness - number of species present in the community (without regard for their abundance).

Species evenness - relative abundance of the species that are present.



Species diversity - Considers both the number of species (richness) in the community and their relative abundance (evenness or equability).

Shannon-Wiener Diversity Index

$$H' = -\sum_{i=1}^{s} p_i \log_e p_i$$

Where:

H' = the value of the Shannon-Wiener diversity index

p_i = the proportion of the ith species

$\log_e$ = the natural logarithm

s = the number of species in the community

Community Diversity Defined

Community

- **Richness**
- **Shannon's index**
- **Abundance**

Guild – group of species that make their living in a similar way

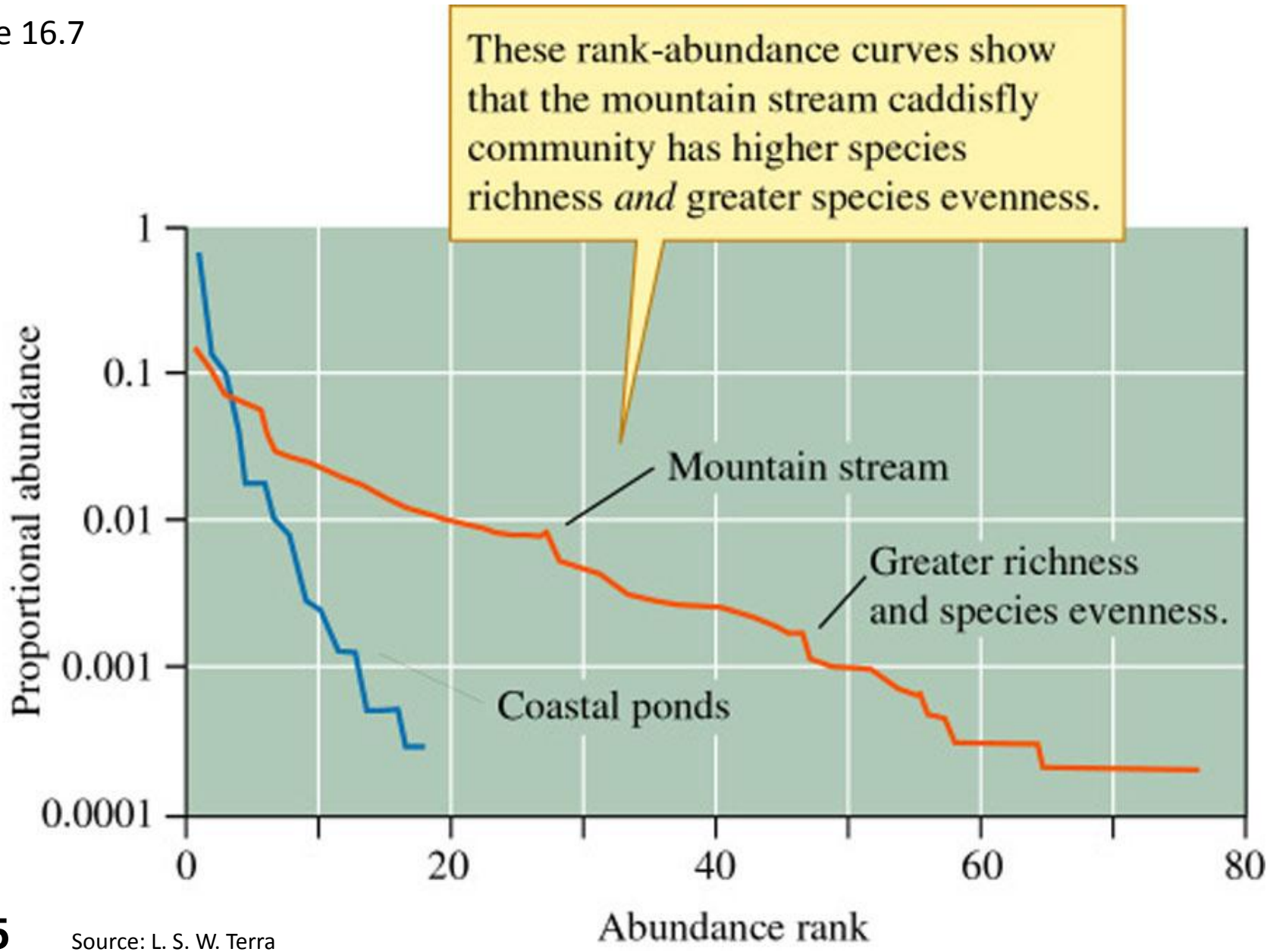
- **Richness**
- **Shannon's index**
- **Abundance**

Individual species

- **Abundance**

Rank-abundance curves for caddisflies

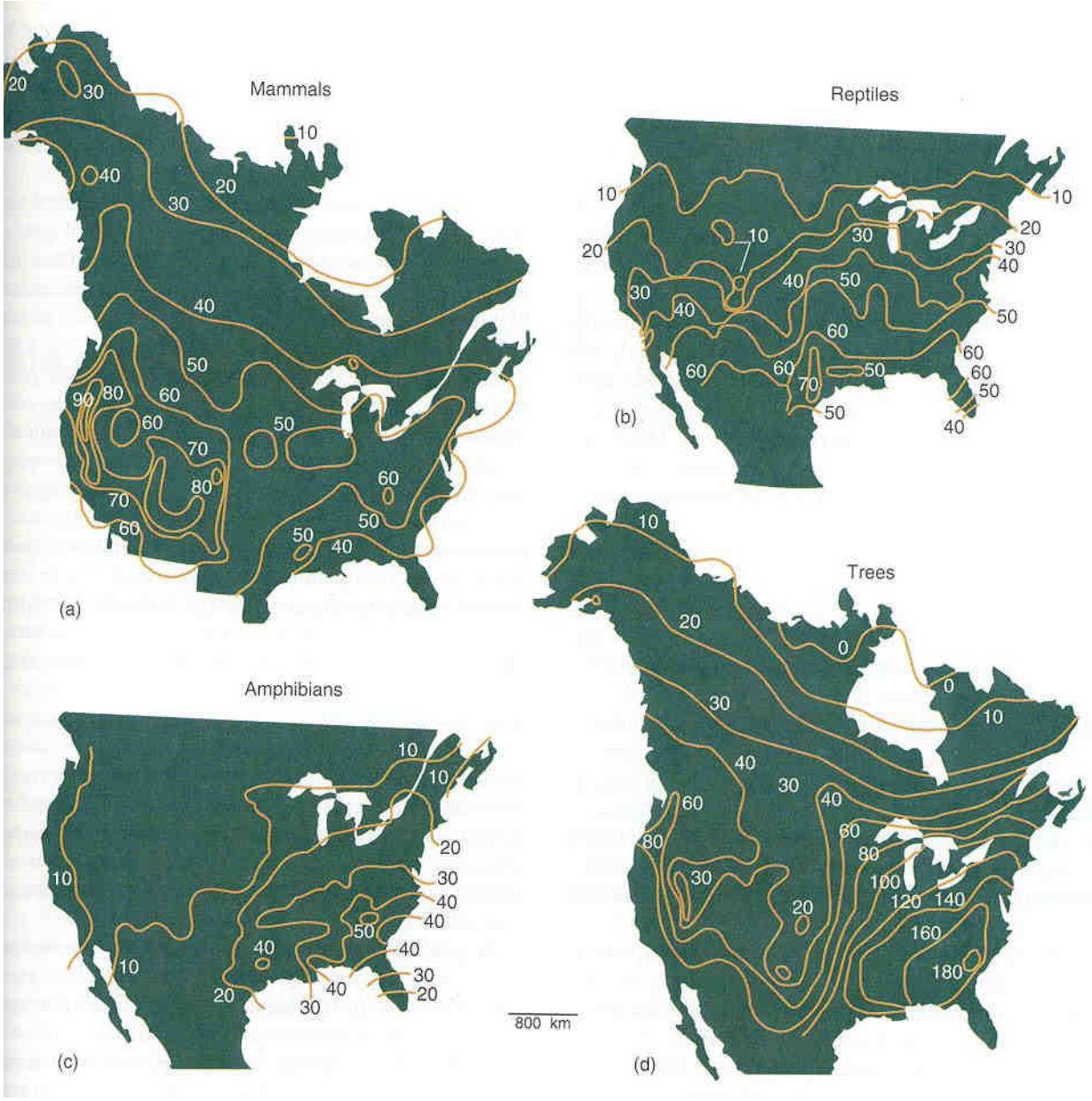
Figure 16.7



Source: L. S. W. Terra

Community Diversity Defined

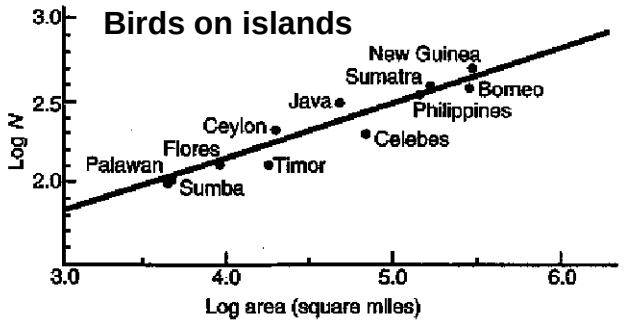
Why do we care about biodiversity?

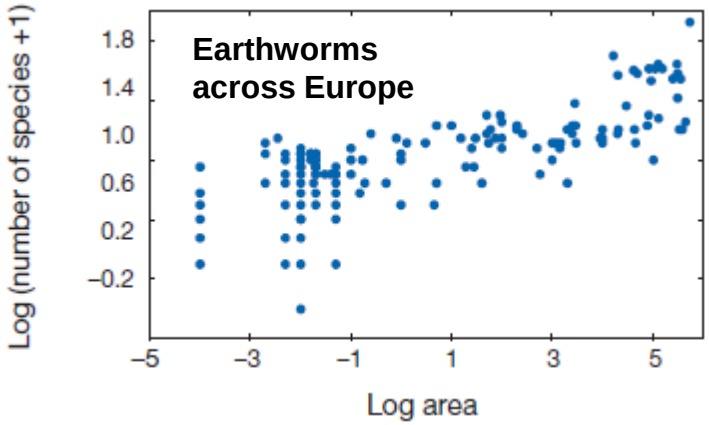

Mammals
(a)
Reptiles
(b)
Amphibians
(c)
Trees
(d)
800 km

Factors Influencing Biodiversity

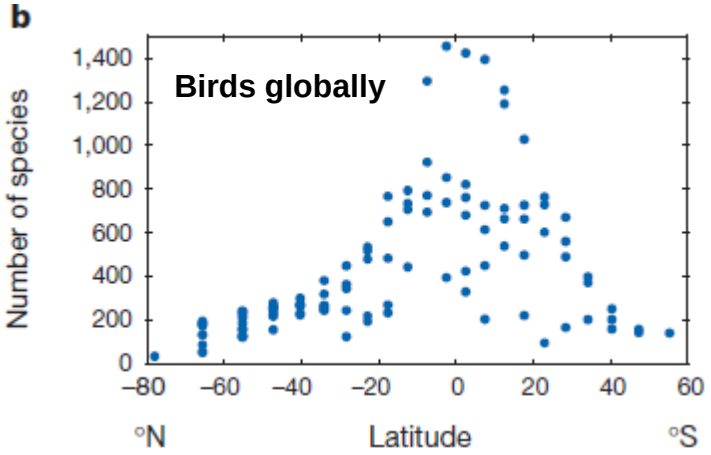
Proximate Factors

- **Area**



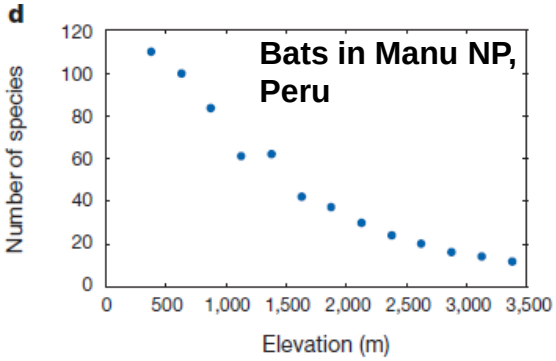


- **Latitude**



Gaston 2000

- **Elevation**



Factors Influencing Biodiversity

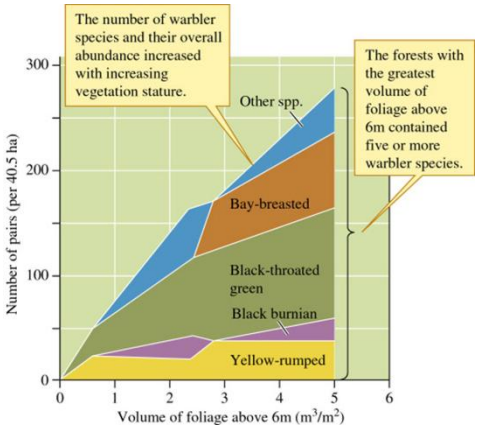
Ultimate Factors

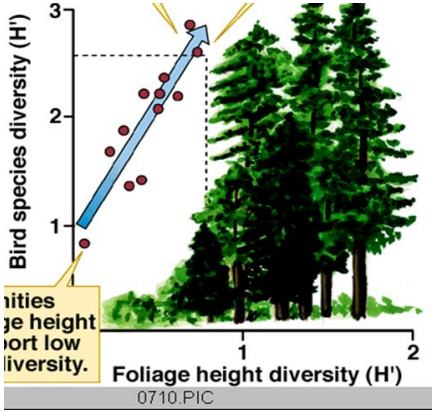
- **Habitat heterogeneity***
- **Disturbance***
- **Biogeographic history (e.g., glaciation)**
- **Trophic structure**
- **Rates of evolution**
- **Climate**
- **Primary productivity***

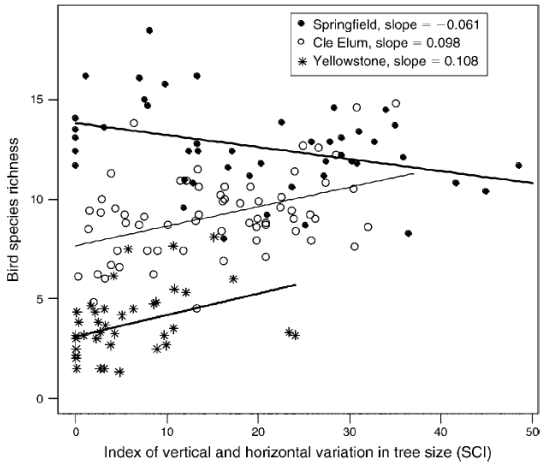
Factors Influencing Biodiversity

Habitat Heterogeneity

Species richness increases with vertical and horizontal habitat heterogeneity because habitat comprises niche axes for species and more niches can fit into areas with heterogeneous habitats.





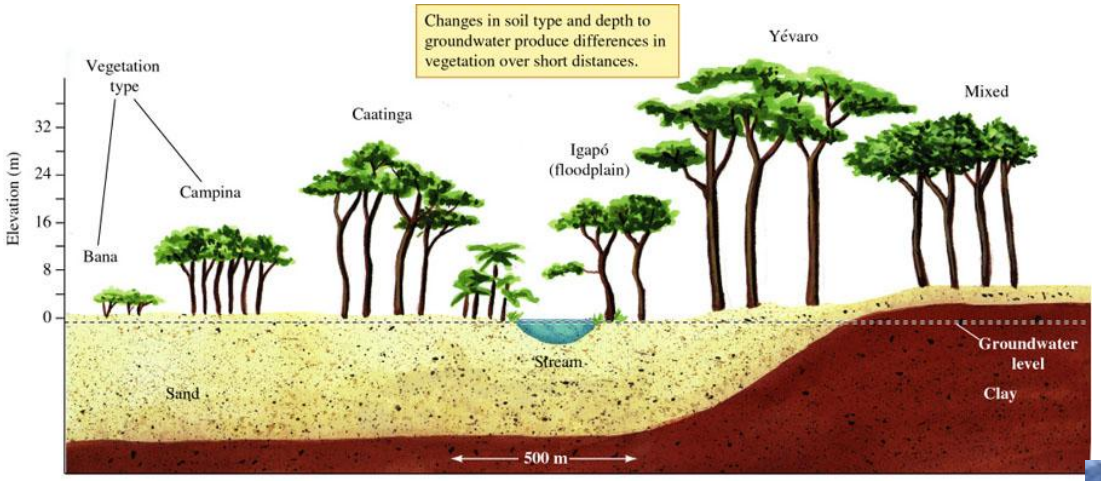


Verschuyl et al. 2008

Factors Influencing Biodiversity

Habitat Heterogeneity

Geomorphic variation also contributes to habitat heterogeneity



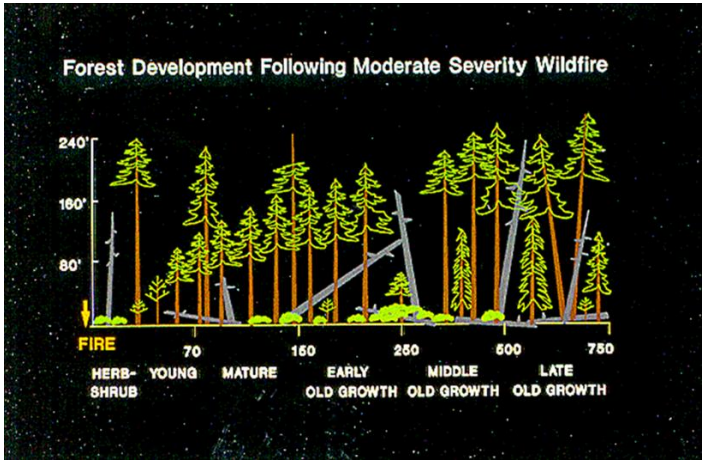
Factors Influencing Biodiversity

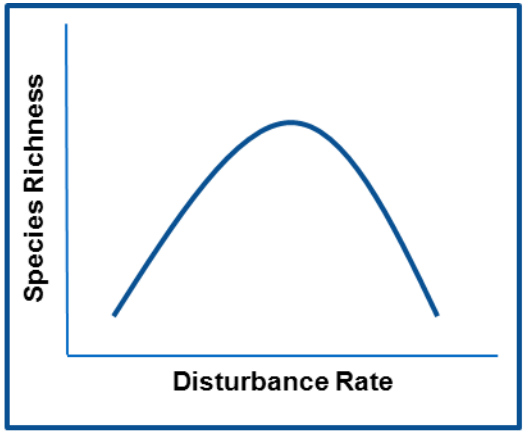
Disturbance

Species richness is maximized at intermediate rates of disturbance because habitat is provided for both early and late seral specialists.

r-selected species –

K-selected species -





Intermediate Disturbance Hypothesis
(Connell 1978)

Factors Influencing Biodiversity

Ecosystem Energy

Biodiversity is often strongly correlated with energy.

Energy

Heat – e.g., temperature, potential evapotranspiration

Ecological productivity – e.g., NPP

Why?

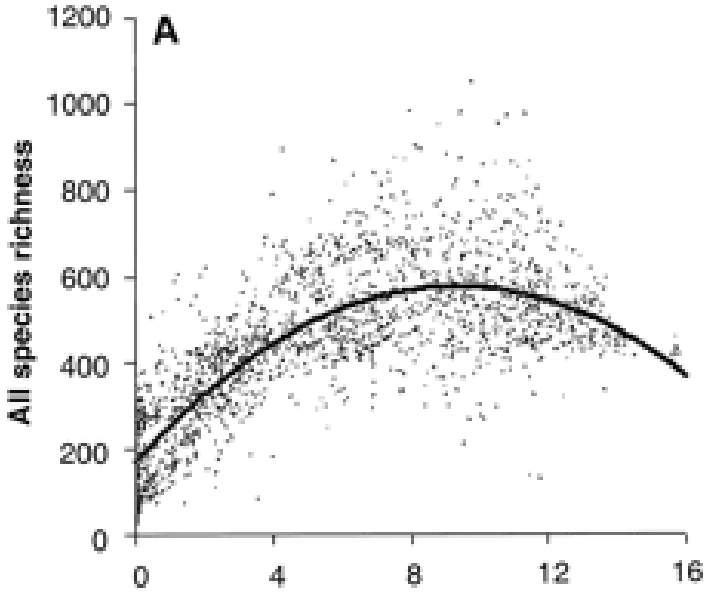
Abundant food resources or warmer thermal conditions allow higher survival and reproduction of individuals within a population, and larger population sizes reduce the chance of species extinctions (Wright 1983).

"Measures of energy (heat, primary productivity)…[and water balance]…explain spatial variation in richness better than other… variables in 82 of 85 cases", Hawkins et al. 2003.

Factors Influencing Biodiversity

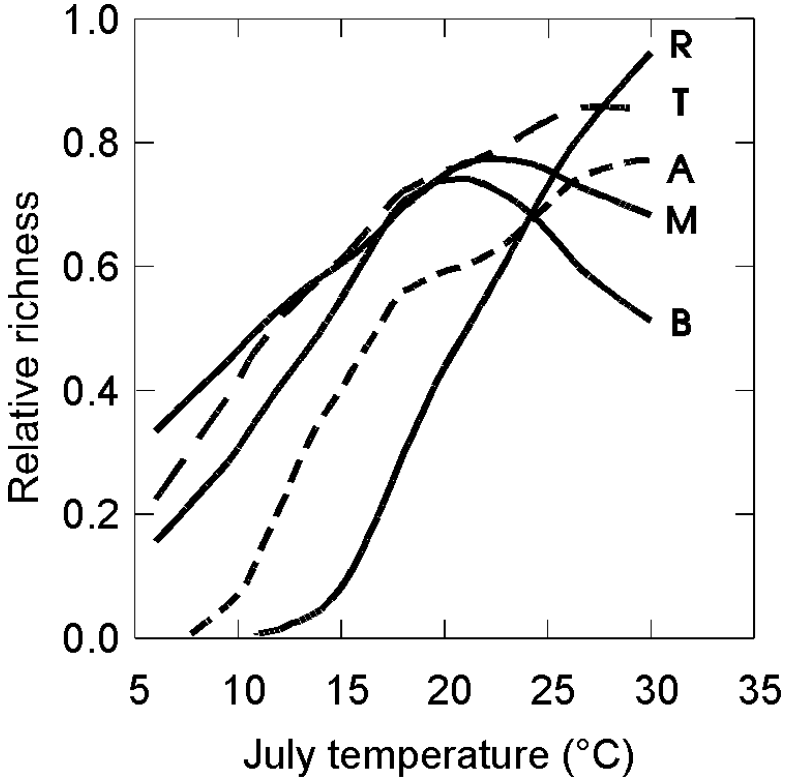
Ecosystem Energy

African Vertebrate Richness



Currie 1991

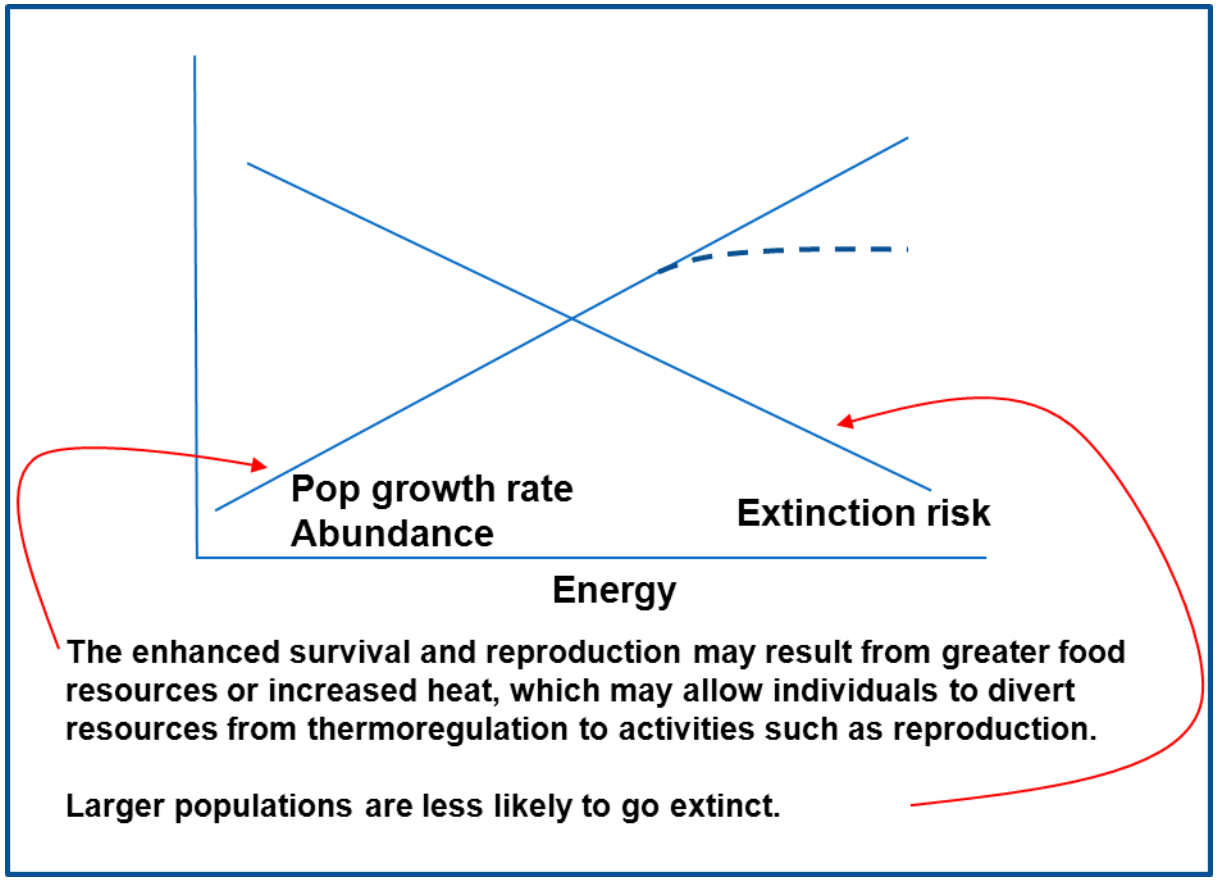
North American Groups



Currie 2002

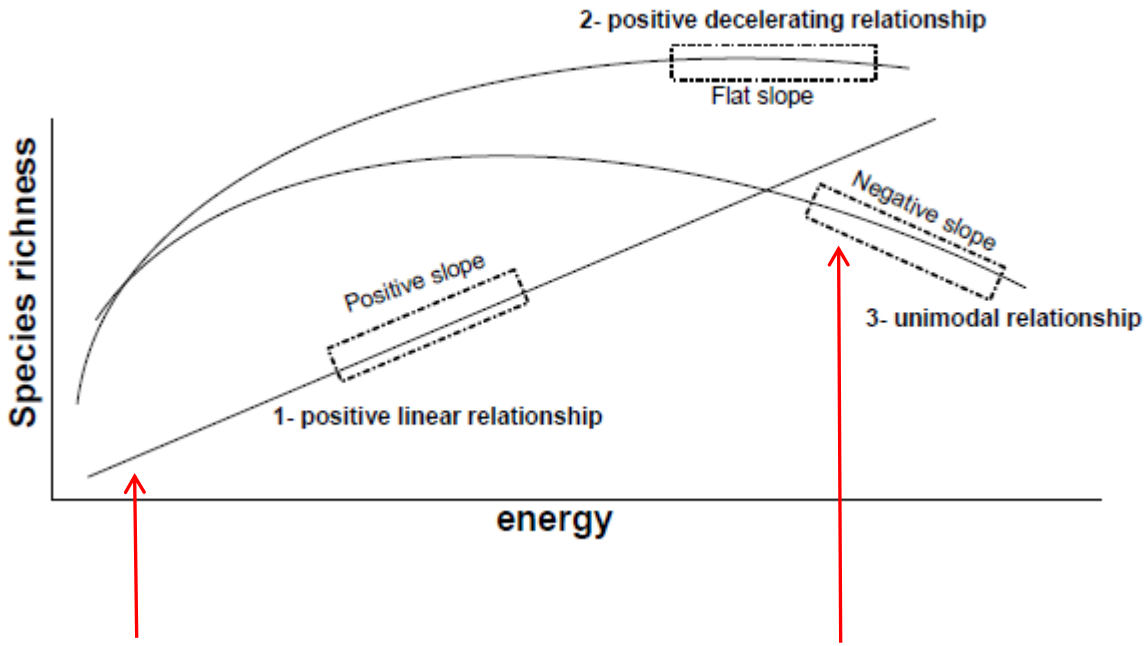
Factors Influencing Biodiversity

Ecosystem Energy



Factors Influencing Biodiversity

Ecosystem Energy



More Individuals Hypothesis

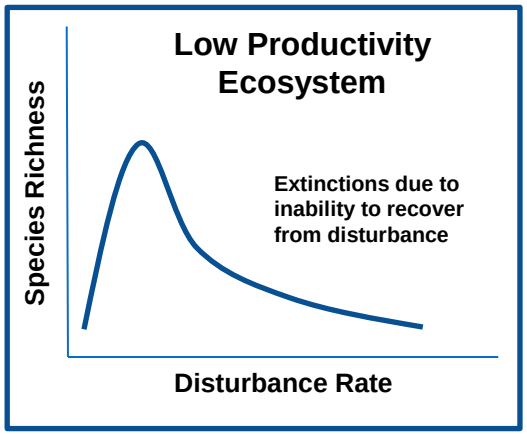
Abundant food resources or warmer thermal conditions allow higher survival and reproduction of individuals within a population, and larger population sizes reduce the chance of species extinctions

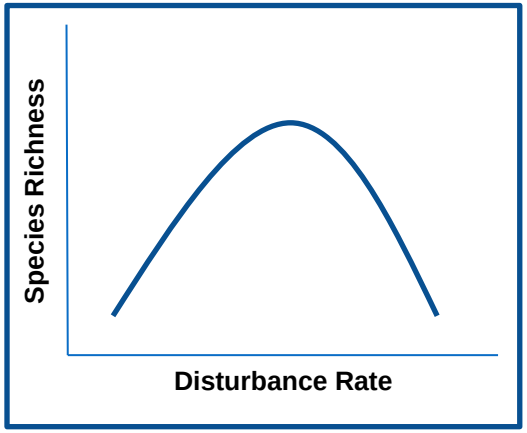
Competitive Exclusion Hypothesis

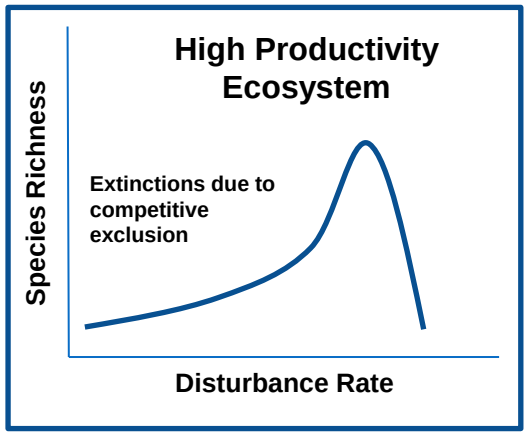
One or a few canopy tree species dominate the community and competitively exclude other plant species and plant diversity, structural complexity and foods for consumers.

Factors Influencing Biodiversity

Interactions Among Factors



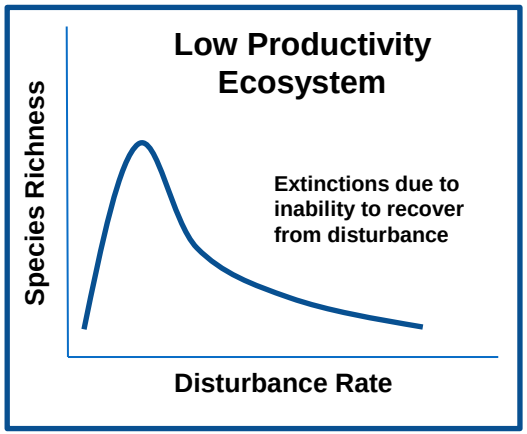


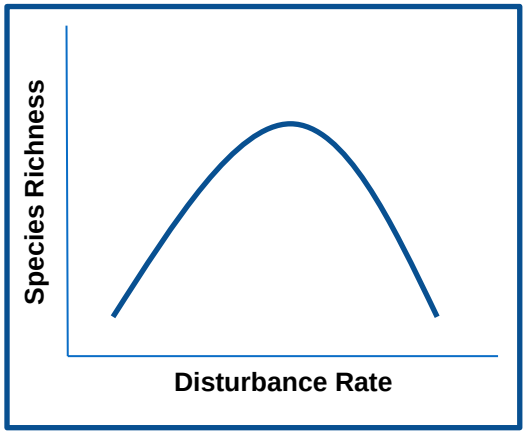


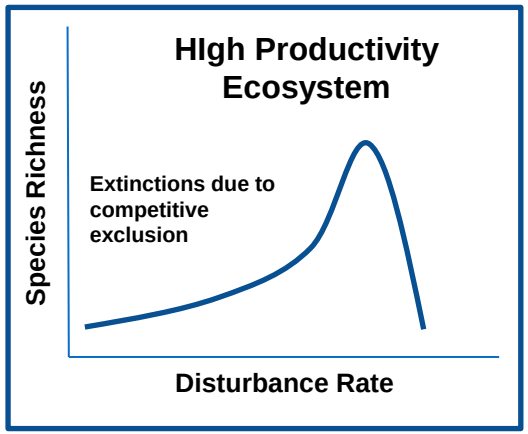
Dynamic Equilibrium Hypothesis

Factors Influencing Biodiversity

Interactions Among Factors





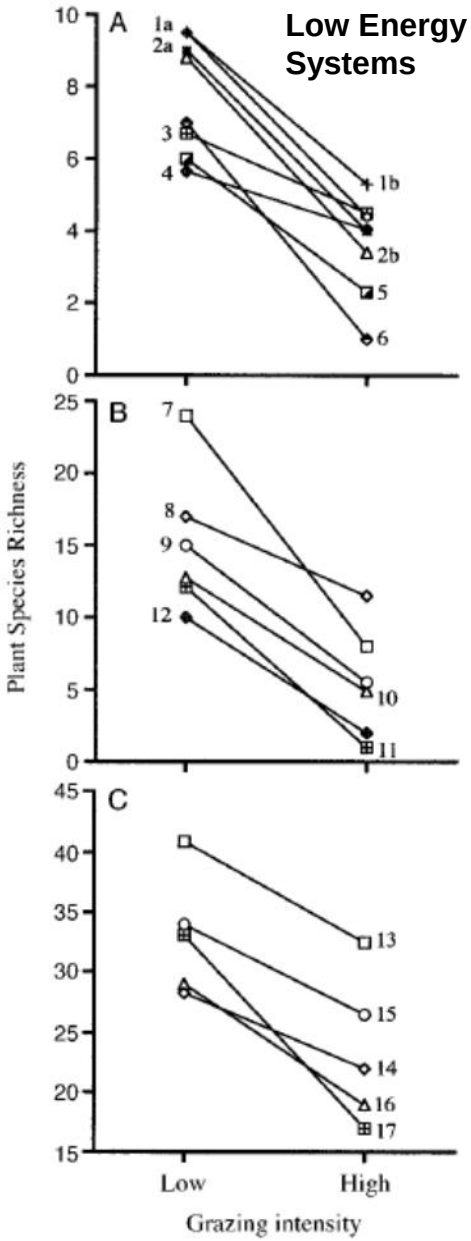


Increased disturbance reduces species richness.

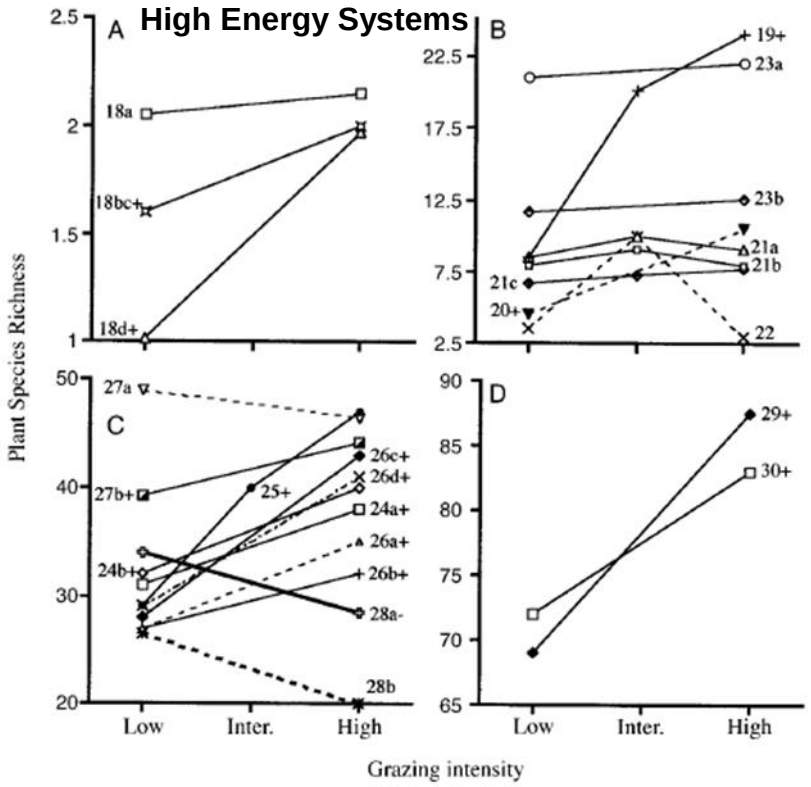
Increased disturbance increases species richness.

Dynamic Equilibrium Hypothesis

Factors Influencing Biodiversity



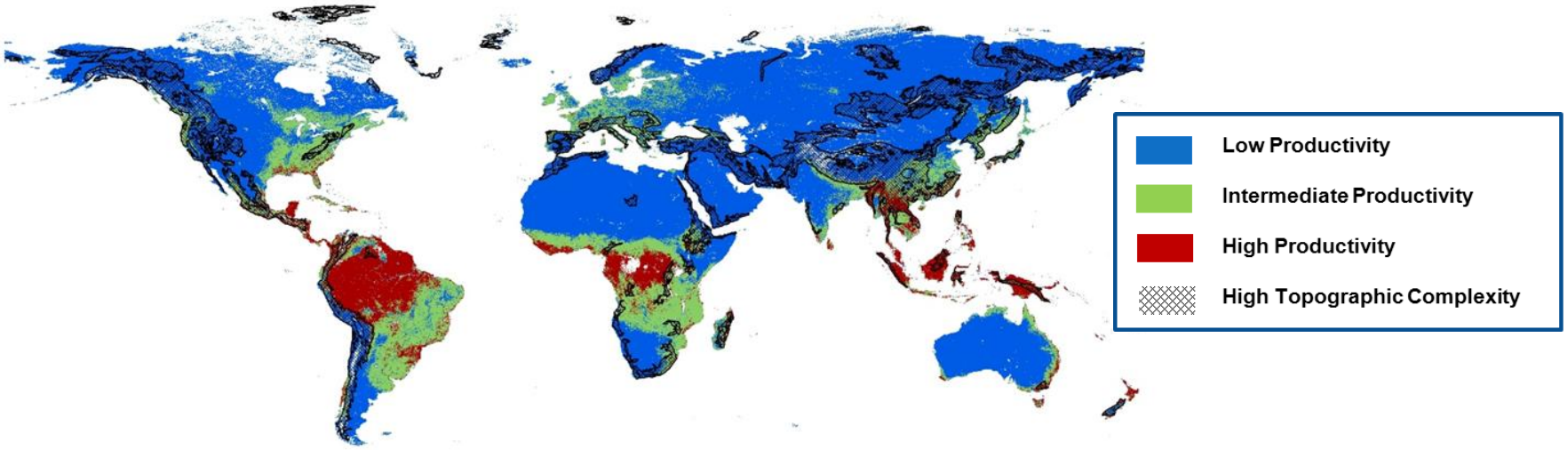
Proulx and Mazumder (1998) - Meta analysis of 30 studies of plant species richness in lake, stream, grassland, and forest grazing systems.

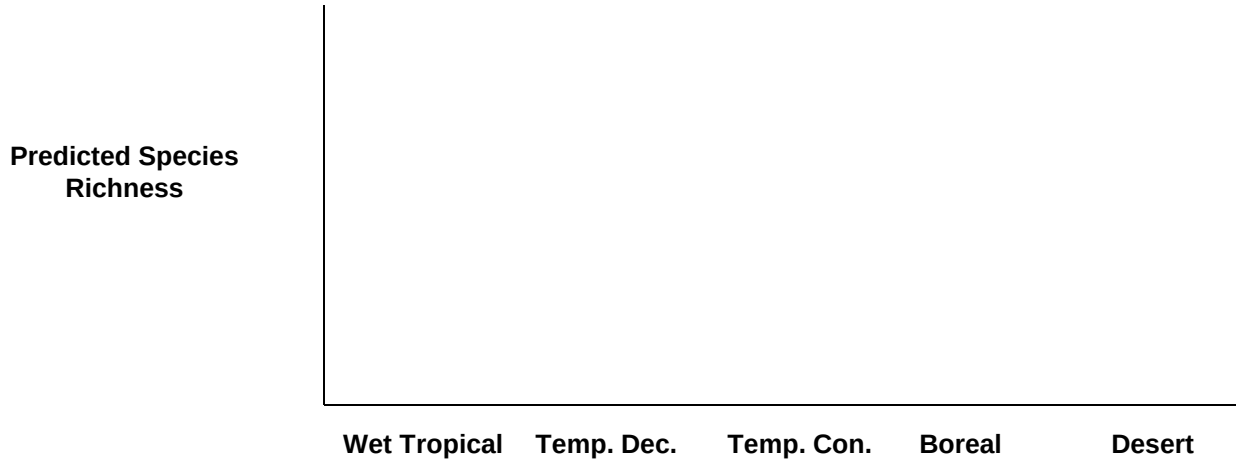


All 19 comparisons from non-enriched or nutrient-poor ecosystems exhibited significantly lower species richness under high grazing than under low grazing.

14 of 25 comparisons from enriched or nutrient-rich ecosystems showed significantly higher species richness under high grazing than under low grazing.

Patterns of Biodiversity across Biomes





Community Diversity: Controls and Patterns

Conclusions

- **Biodiversity may be influenced by many factors**
- **Interactions among drivers can result in complex patterns of biodiversity**
- **Taxonomic groups and guilds may respond differentially to driving factors.**
- **Despite the complexity, major factors can explain up to 90% of the variation in biodiversity locally to globally.**
- **Thus global predictions about patterns of biodiversity, driving factors, and consequences for management are possible.**