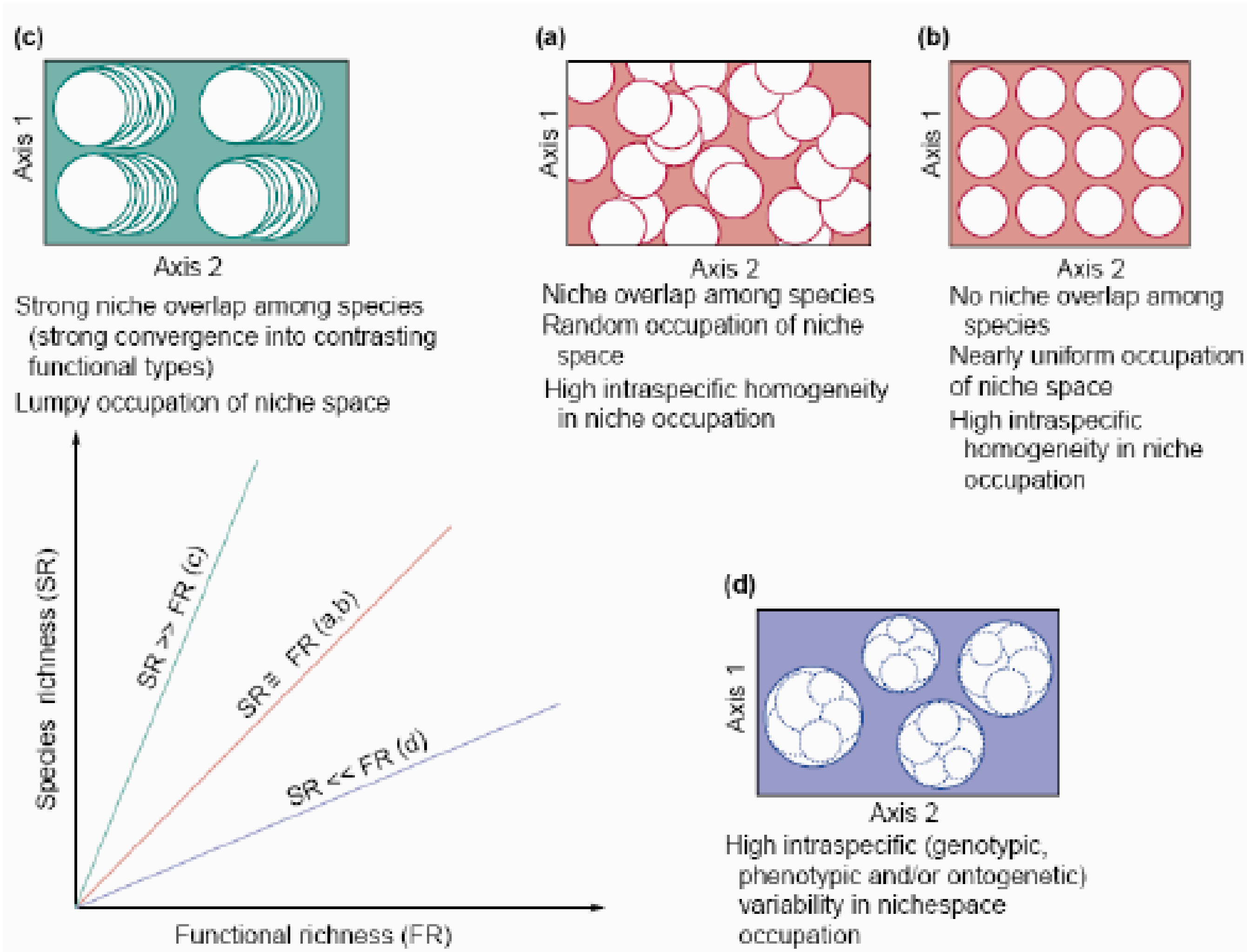
# Relationship between species richness and functional richness




Diaz and Cabido 2001 TREE

**Raunkiaer's life forms based on position of perennating buds:**

The guts of Raunkiaer's system was the classification of plants according the position of the overwintering (**perennating**) bud.

**Phanerophytes** are plants that have the perrenating buds on aerial shoots, as is the case with most trees.

**Chamaephytes** aer plants that have the buds near the ground surface, as is the case with most dwarf shrubs.

**Hemicryptophytes** are plants with buds at the ground surface.

**Geophytes** are plants with the overwintering buds beneath the ground surface and includes all plants with bulbs or tubers, such as lillies and potatoes.

**Helophytes** are plants which have submerged rhizomes. Many sedges have this type of bud.

**Hydrophytes** are true aquatic plants with their buds in the water.

**Therophytes** are plants with no buds. Desert annuals are therophytes.

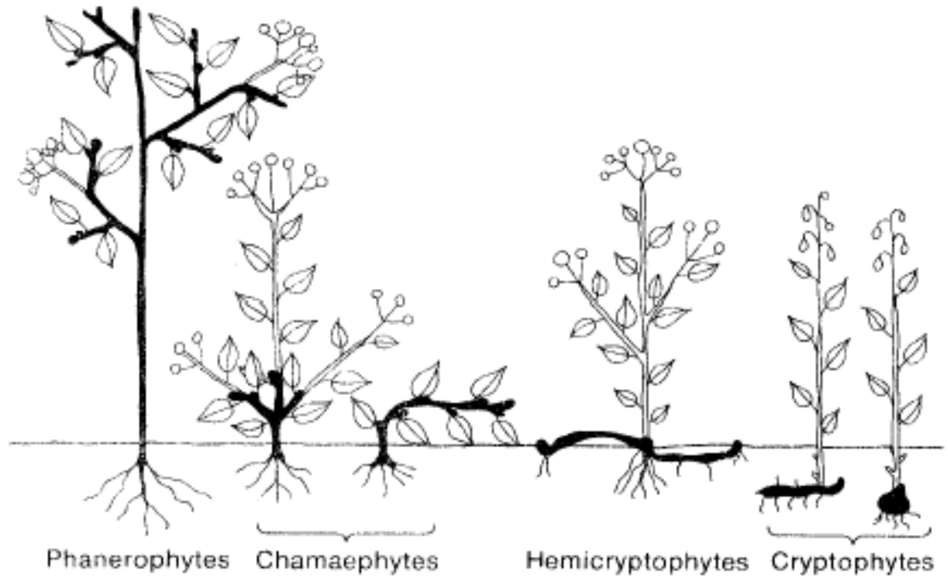



Figure 6-3 Diagrammatic representation of Raunkiaer's life forms. Unshaded parts of the plant die back during unfavorable seasons, while the solid black portions persist and give rise to the following year's growth. Proceeding from left to right, the buds are progressively better protected (after Raunkiaer 1937).

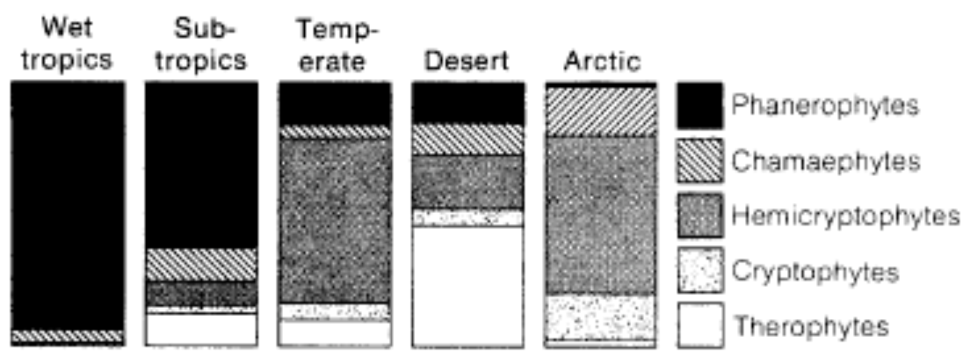



Figure 6-4 Proportion of plant life forms, classified according to Raunkiaer (1934, 1937), in various climatic regions (after compilations of Richards 1952, Dansereau 1957, Daubenmire 1968).

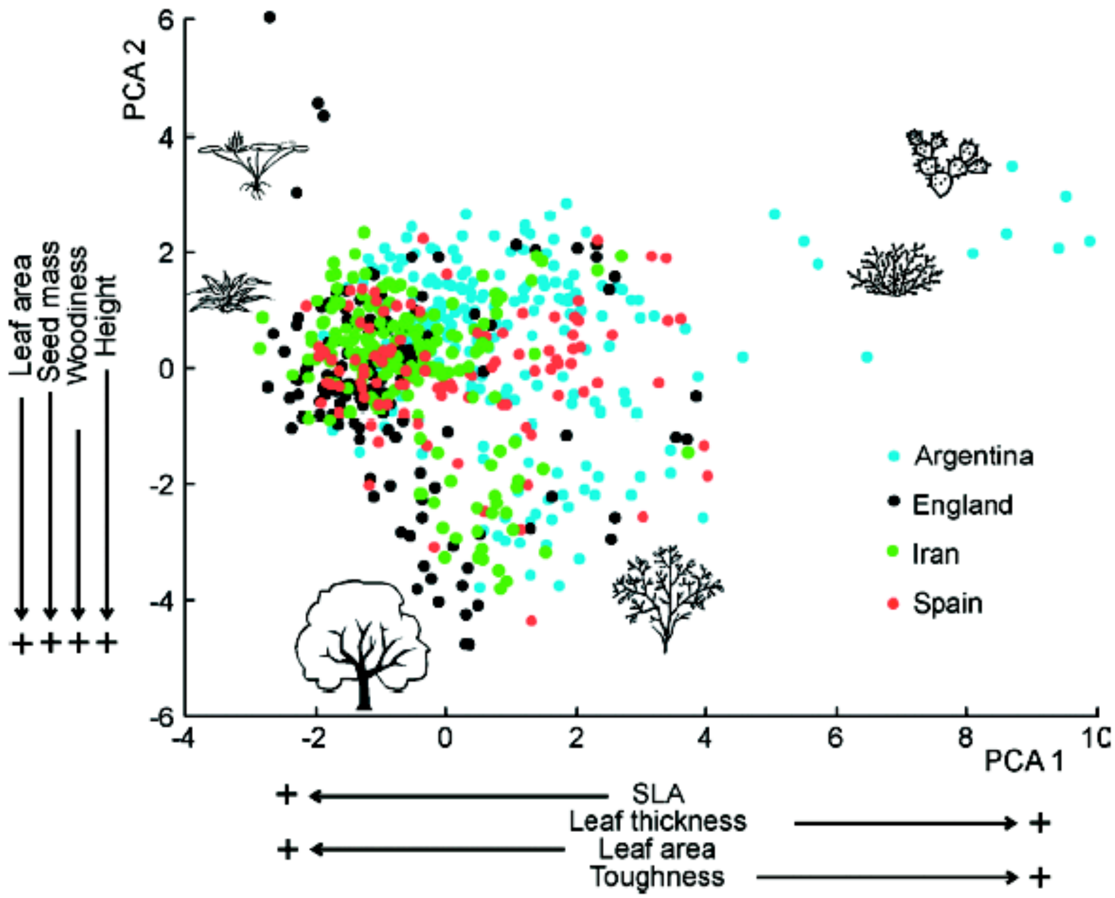
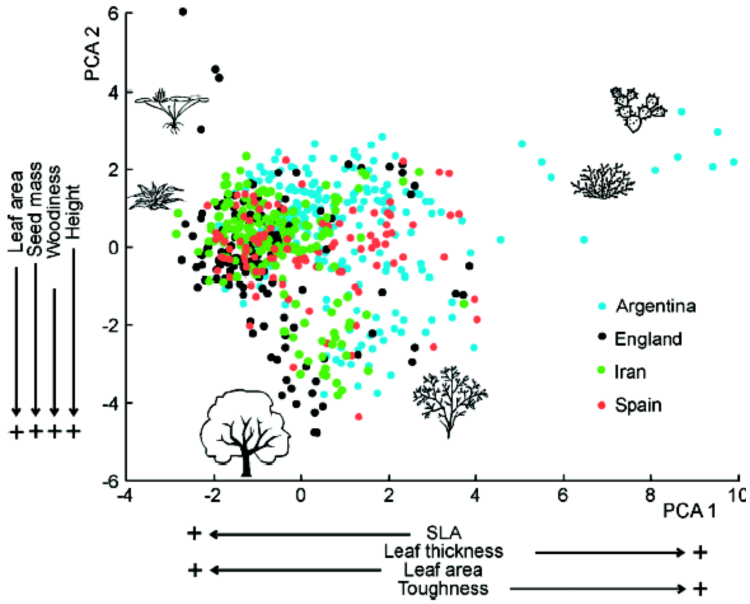



**Fig. 1.** PCA ordination of 640 plant species from Argentina, England, Iran and Spain, on the basis of 12 traits. Labels display traits with the highest eigenvector scores on PCA axes 1 and 2, with the label with the highest score presented nearest to the axis. Stylized figures indicate extreme types, such as aquatics and tender-leaved ephemerals at the lower end of PCA axis 1, *Cactaceae* at the higher end of PCA axis 1, and large-leaved deciduous trees and shrubs at the lower end of PCA axis 2. Eigenvector scores of all traits along PCA axes 1-3 are in Table 3. Locations of individual species on the ordination plane are available from the corresponding author.

Diaz et al. 2004 Journal of Vegetation Science



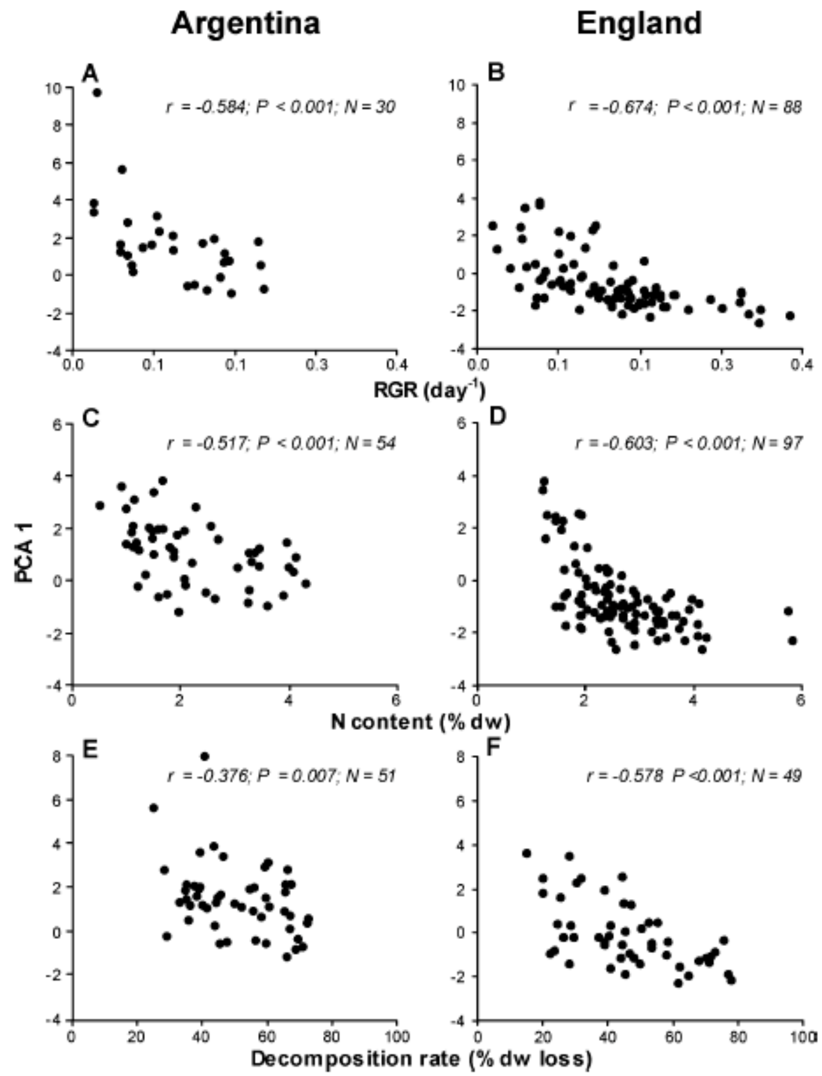




**Fig. 4.** Relationships between PCA axis 1 scores from Fig. 1 and relative growth rate **(A, B)**, leaf nitrogen content **(C, D)**, and potential decomposition rate **(E, F)** of subsets of species from Argentina and England, selected to represent the whole range of habitats, growth forms, and taxa present in the main database. dw = dry weight; *r* = Spearman Rank Correlation Coefficient. See App. 1 for list of Argentine and British species involved in this comparison.

Diaz et al. 2004 Journal of Vegetation Science

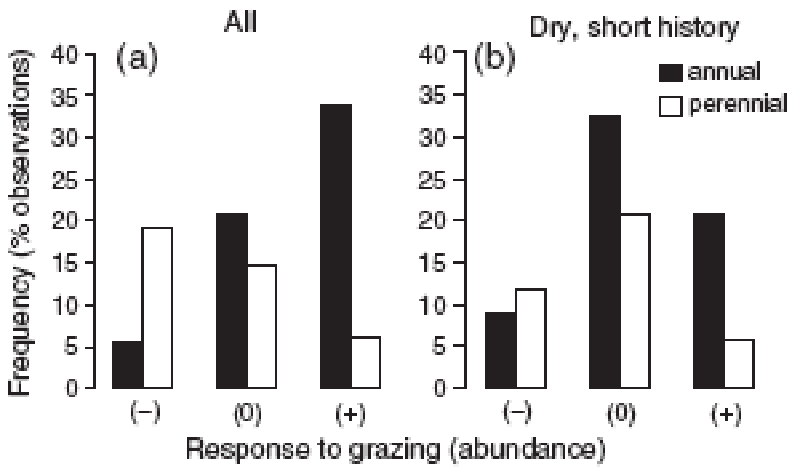
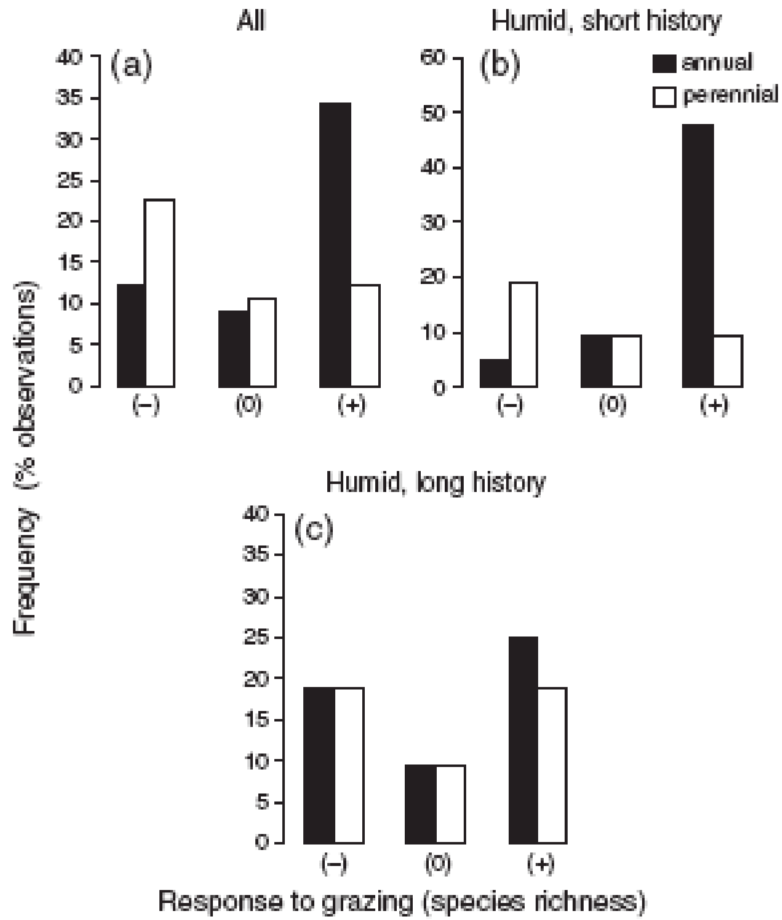
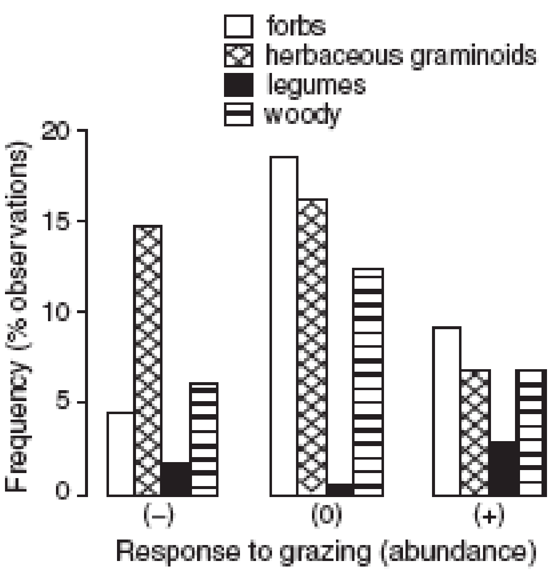



**Fig. 1** Relative frequency of observations in which the abundance of annual and perennial plants decreased (–), did not change (0) or increased (+) with grazing. (a) Considering all sites, and controlling for the effects of precipitation (dry or humid) and evolutionary history of grazing (short or long): $P<0.0001$.

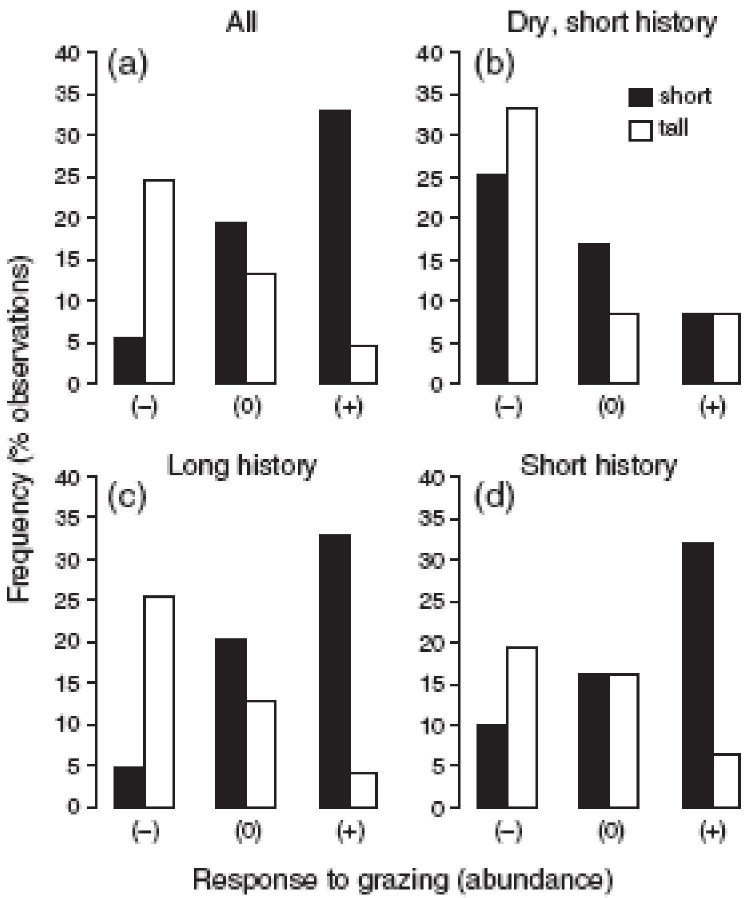


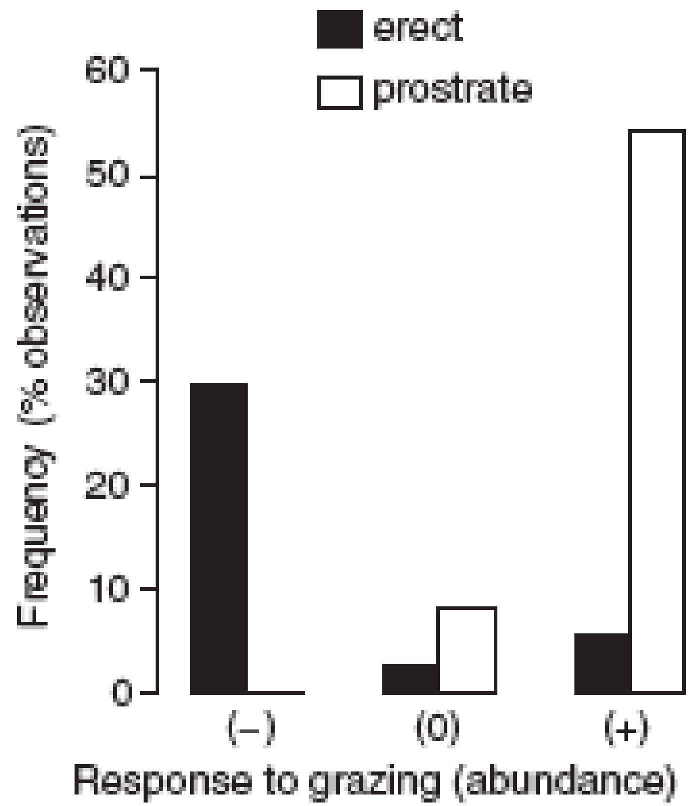




Annuals vs. perennials:

Annuals generally increase with grazing except in humid habitats with a long history of grazing.

Diaz et al. 2007.
Global Change Biology



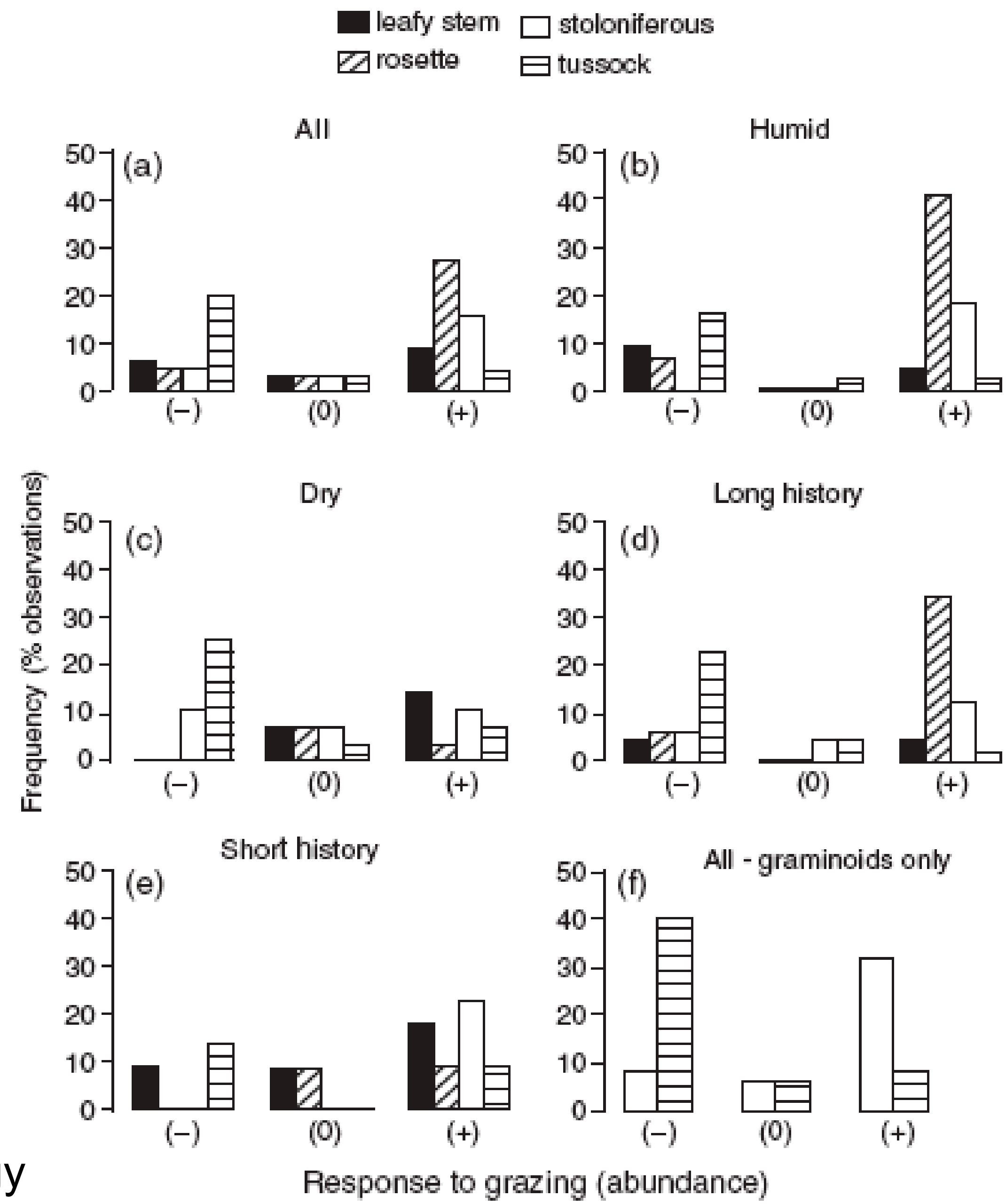

Diaz et al. 2007.
Global Change Biology

Short vs. tall plants:

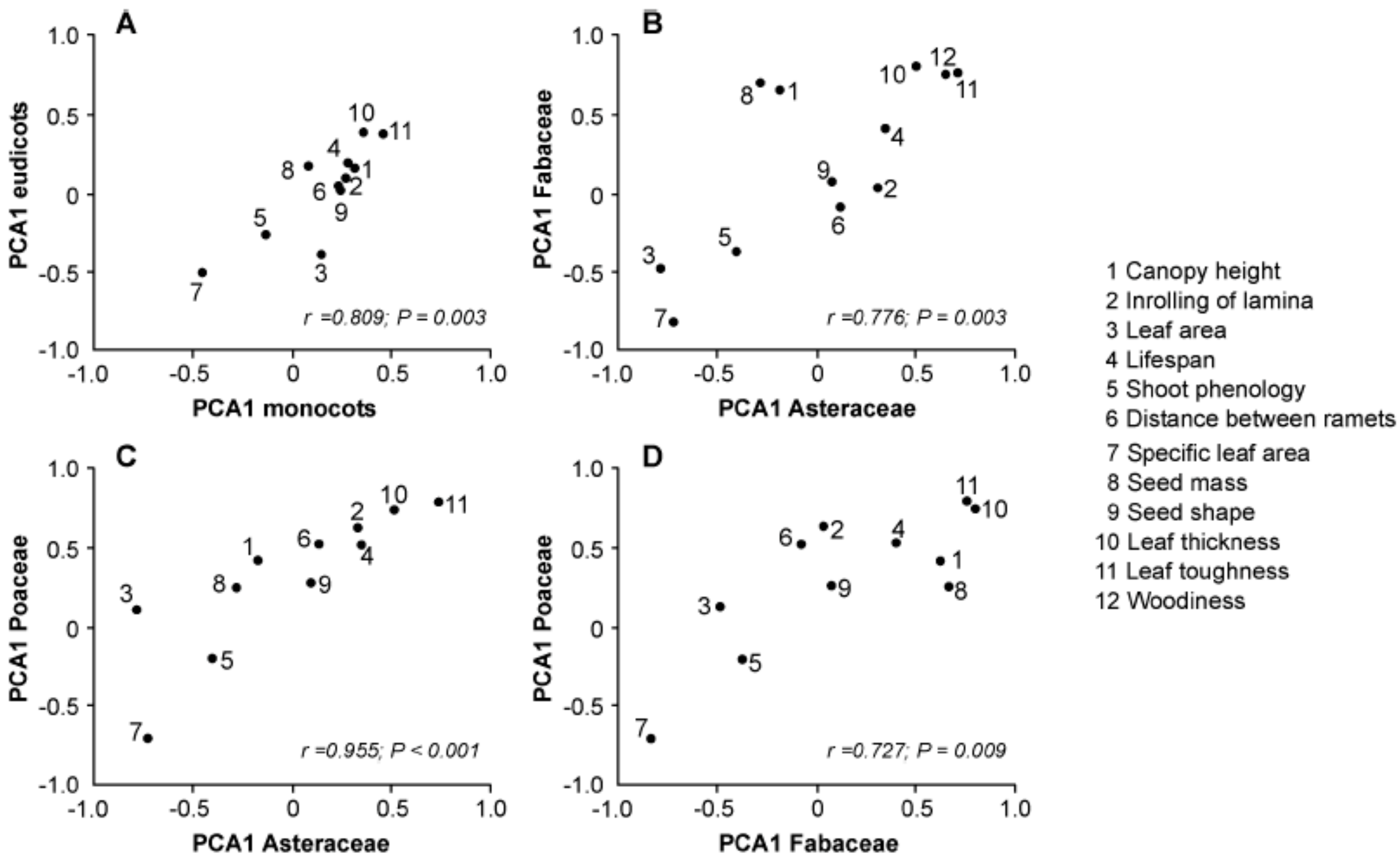
Short plants generally increase with grazing except in dry habitats with a short history of grazing.

Stem morphology:

Tussock plants generally decrease with grazing whereas rosette plants increase globally.



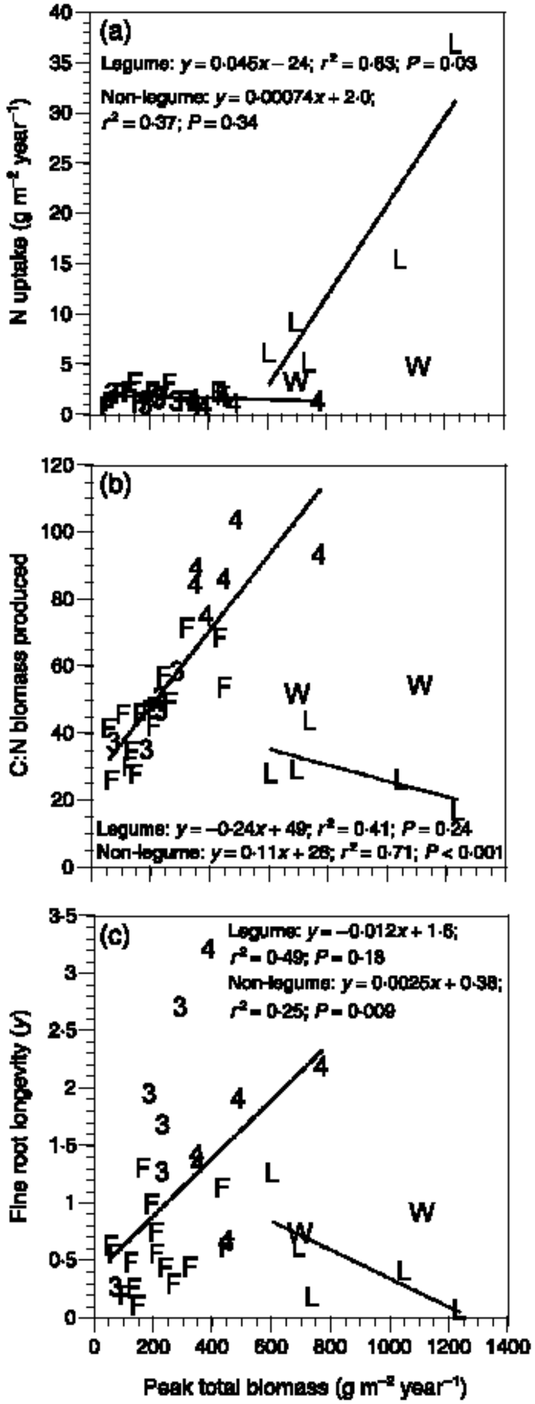

Diaz et al. 2007.
Global Change Biology




Results of analyses of trait variation among four different floras show that the same trade offs occur among putative functional types. Diaz et al. concluded that grasses and legumes are not functionally all that different because these groups show the same trait trade-offs.

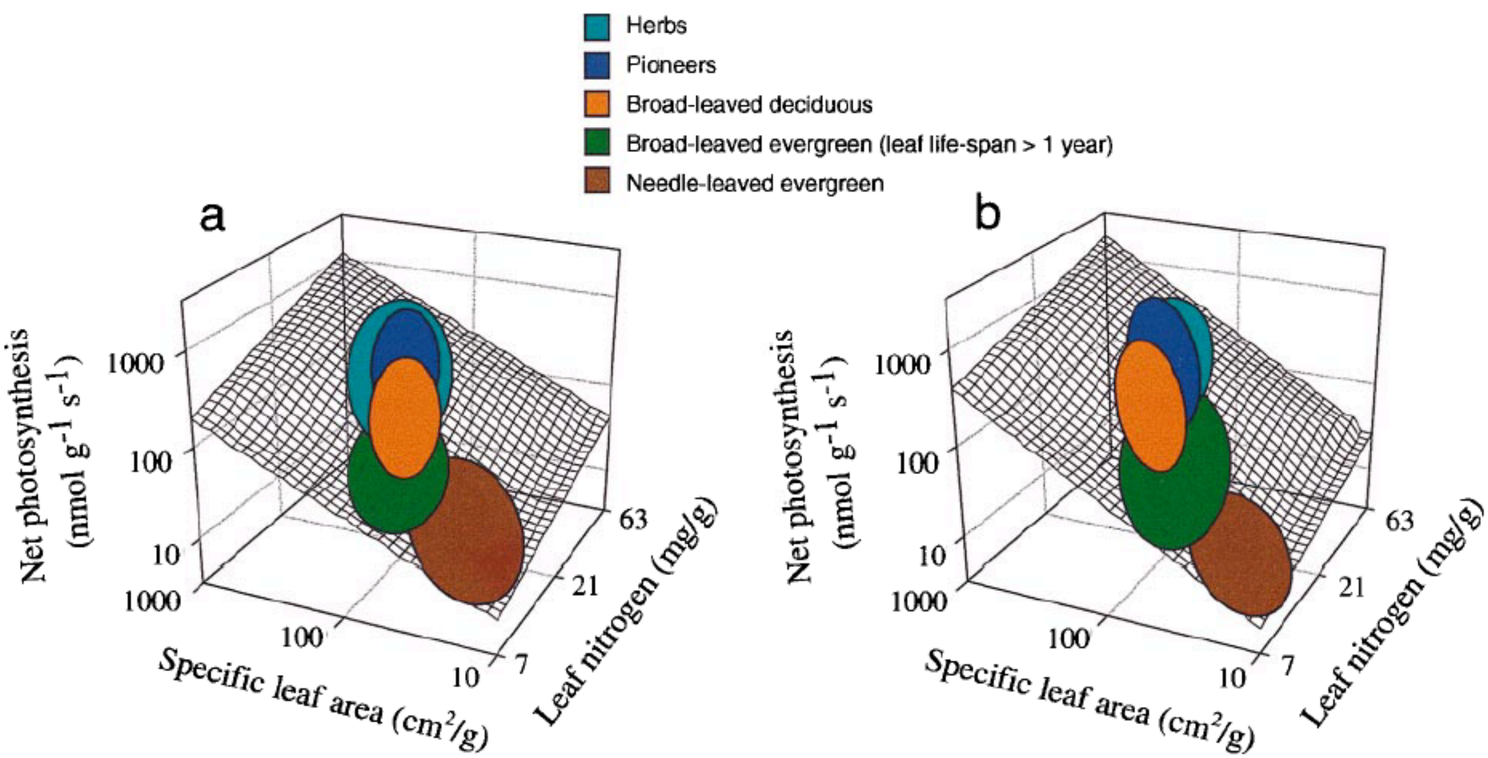
Diaz et al. 2004 Journal of Vegetation Science

Craine et al. 2001
Functional Ecology

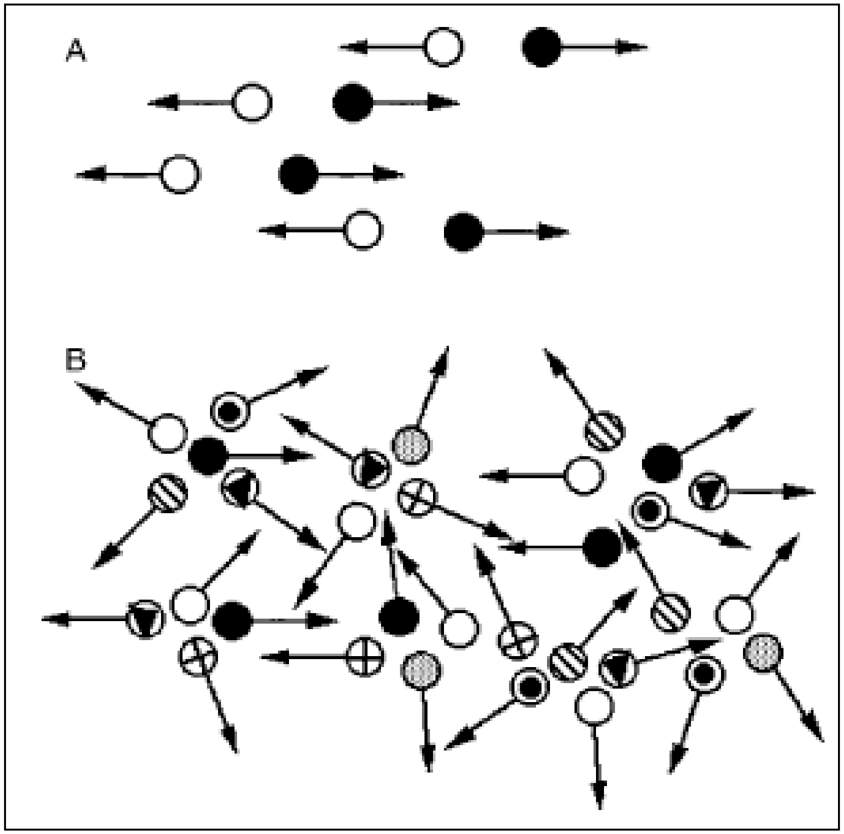



Results from Craine et al. would suggest just the opposite. Legumes respond distinctly differently than other broadly based functional groups (grasses, woody species, forbs).

Ecology: Reich *et al.* *Proc. Natl. Acad. Sci. USA 94 (1997)* 13733



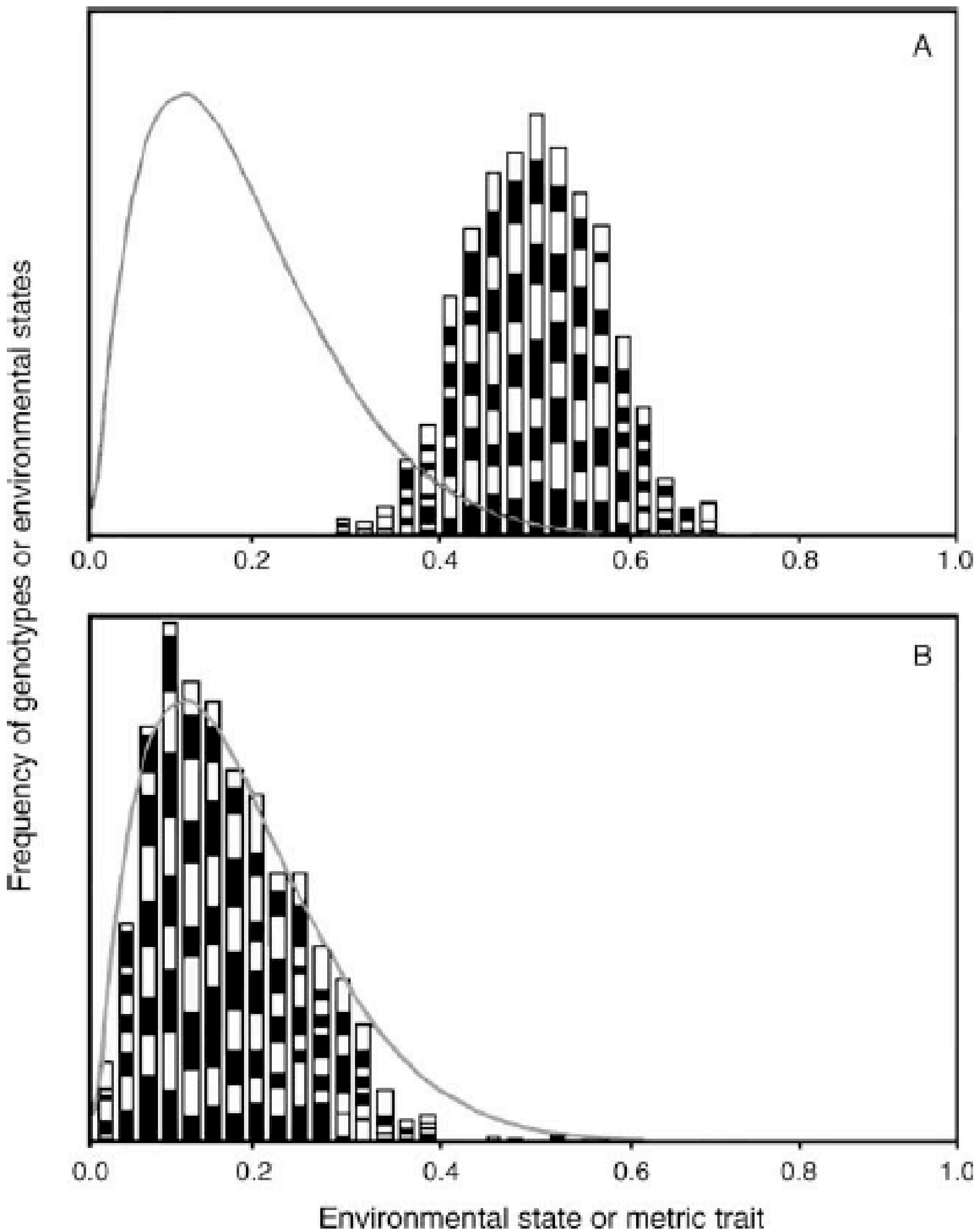

Reich et al. 1997 PNAS




Low diversity community:
- Interspecific competition dominates
- Neighbor interactions are consistent
- Directional selection can occur
- Character displacement is common
- Result is trait divergence

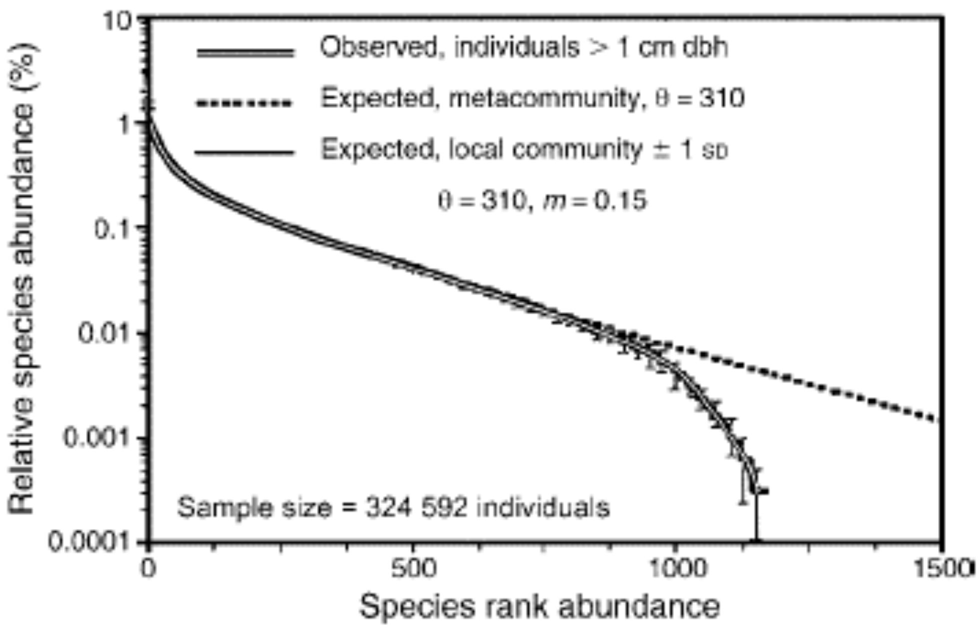
High diversity community:
- Diffuse competition dominates
- Neighbor interactions are inconsistent
- Directional selection is rare
- Character displacement is uncommon
- Result is trait convergence

Hubbell 2006 Ecology




Evolution of trait convergence through drift. This process requires dispersal limitation.

Hubbell 2006 Ecology

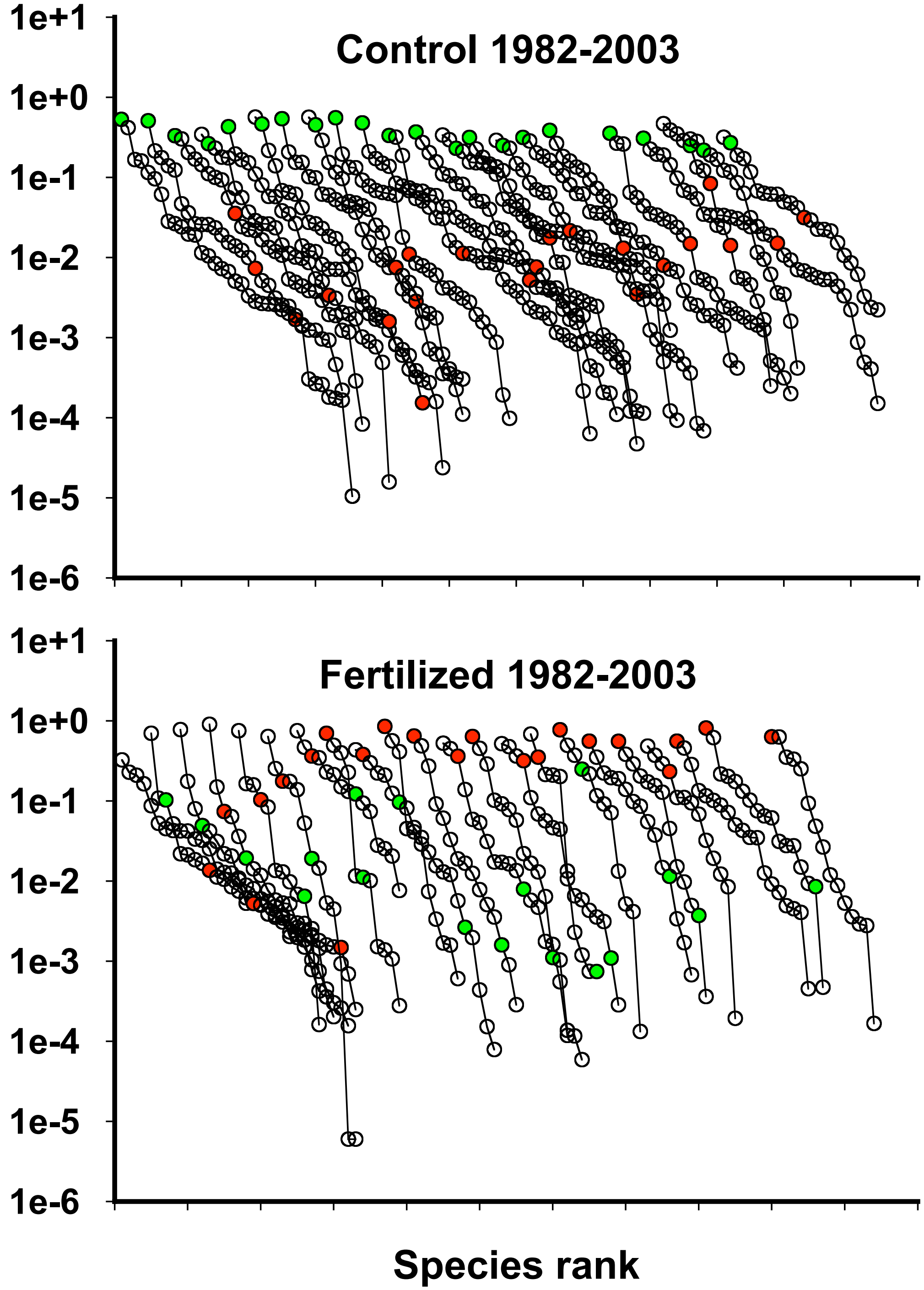



Neutral model and curve fitting:

- the metapopulation model overestimates abundance of rare species

- the neutral model fits the distribution well ($r^2$=0.996)

Hubbell 2006 Ecology

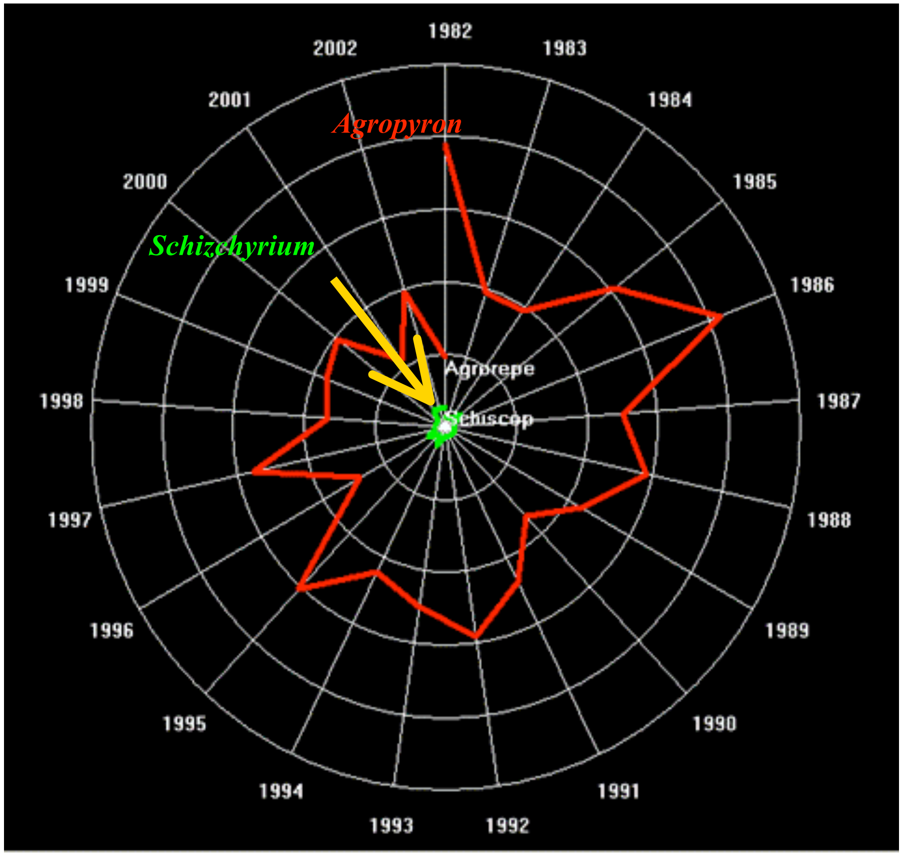


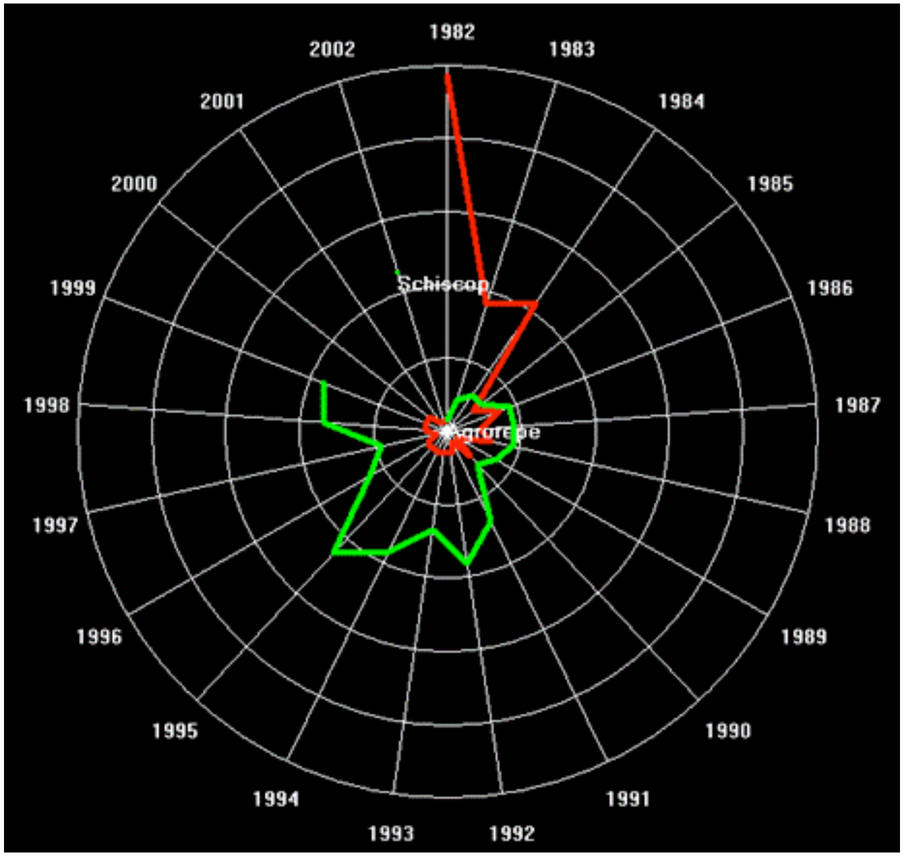

Collins et al. in review

Species abundance distributions did not differ in control vs. N fertilized plots despite considerable change in species ordering and a decrease in species richness. Therefore, curve-fitting is a weak test of neutral theory.

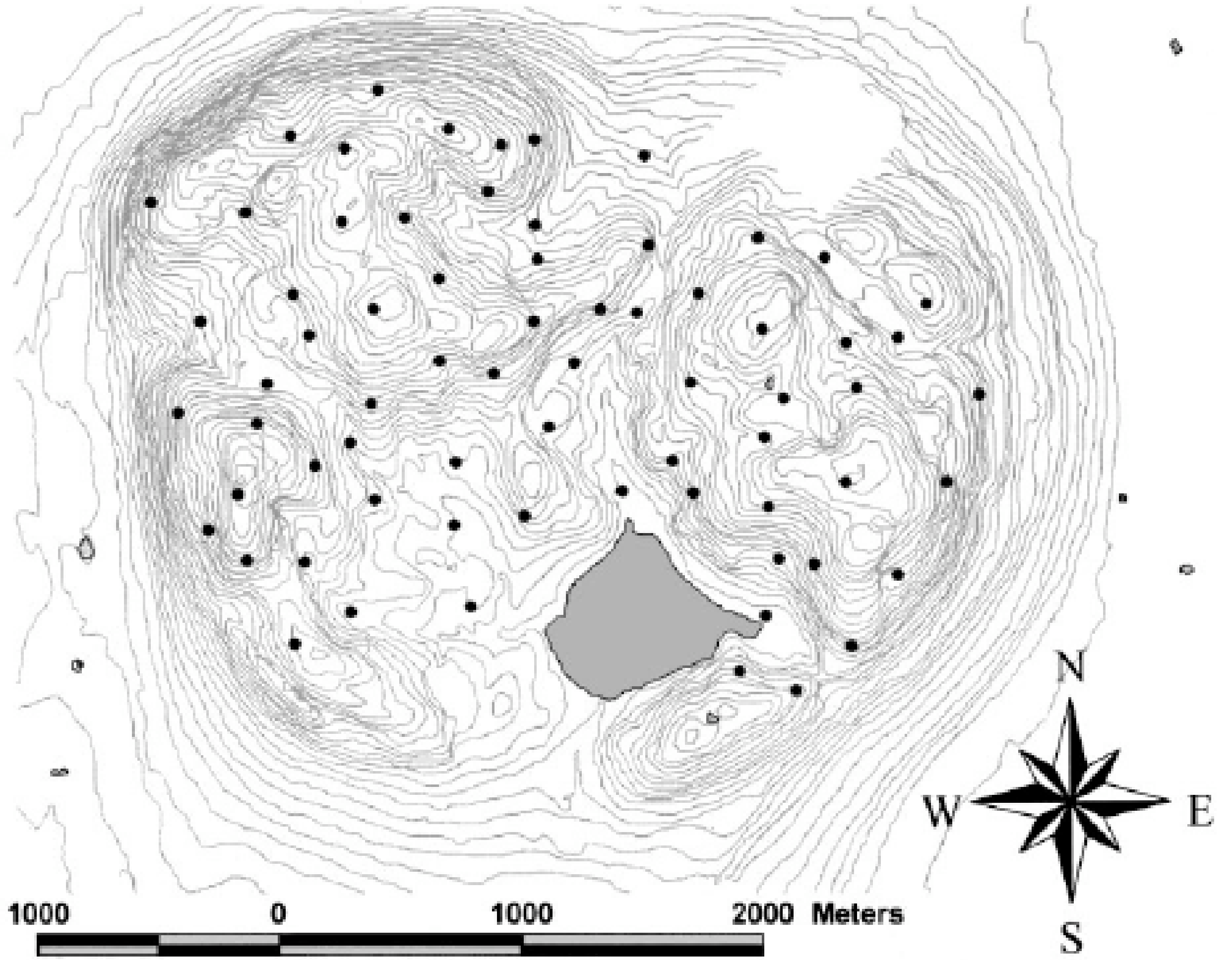
Collins et al. in review

Significant changes occurred in two grass species with N fertilization. The dominant perennial C4 bunchgrass, little bluestem, decreased over time whereas the non-native annual C3 grass, western wheatgrass, increased.

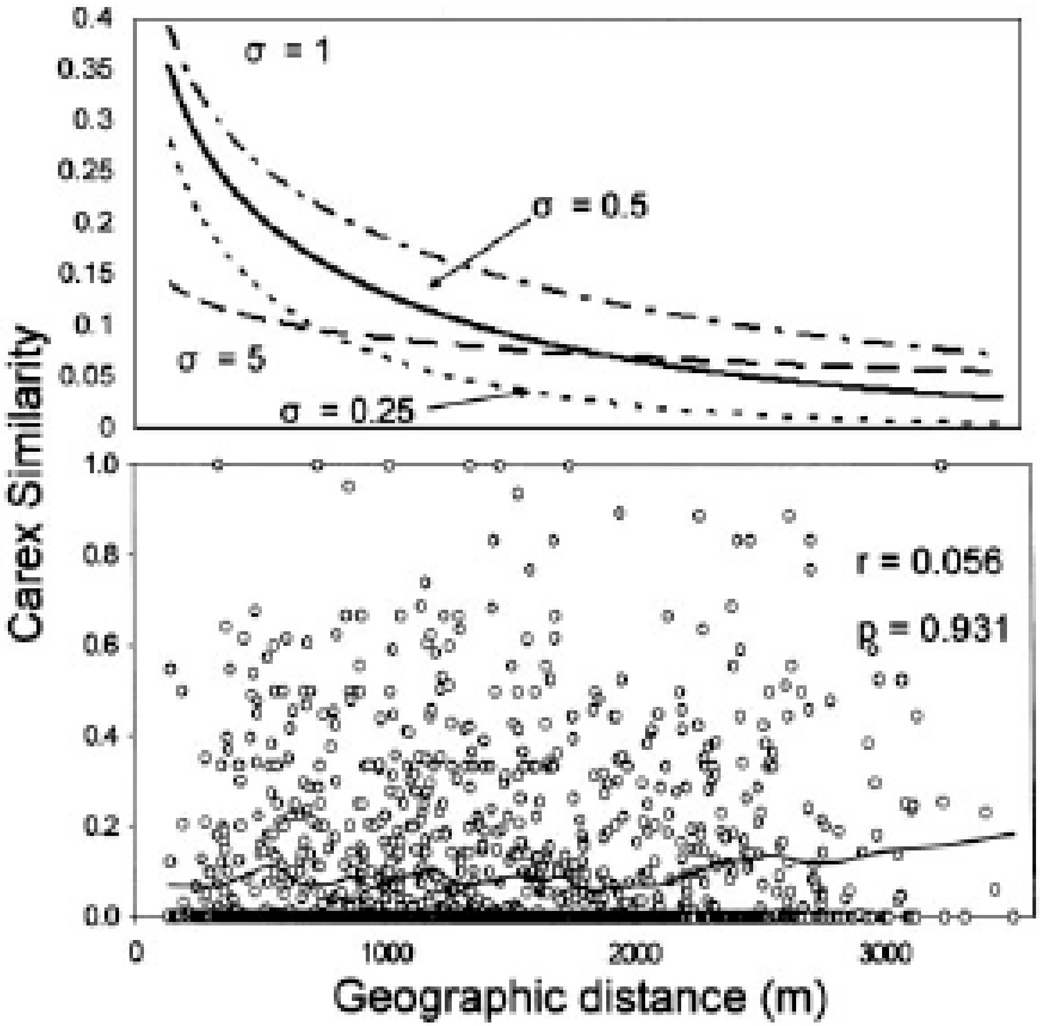


Distribution of sampling points for understory vegetation (individuals < 1.5 m tall) in an old growth forest in Canada.

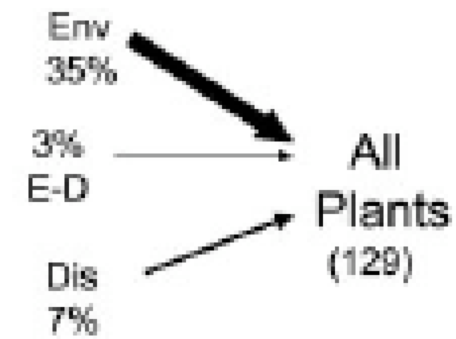


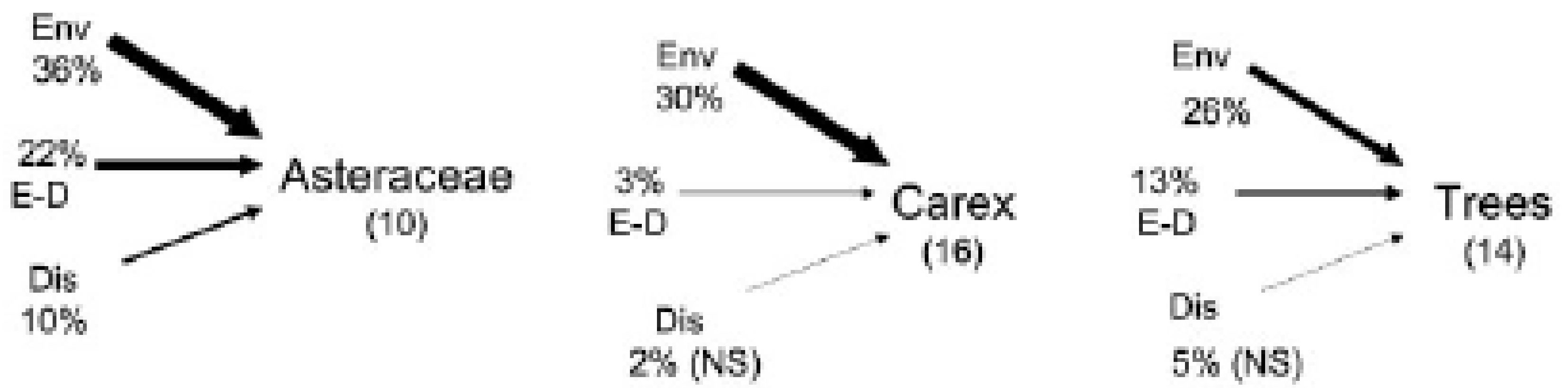

Gilbert and Lechowicz 2004 PNAS



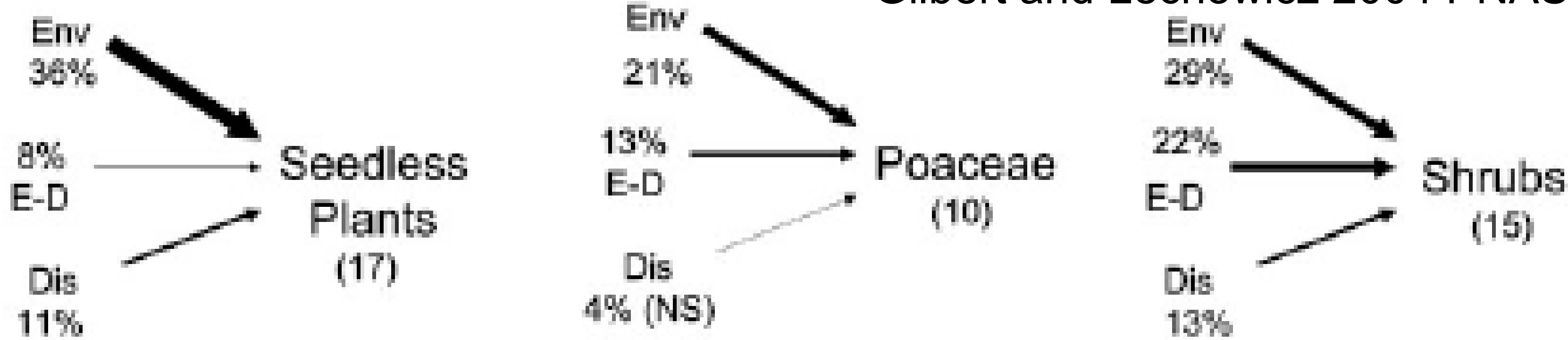

Analysis of distance decay, or similarity of species composition with increasing distances between sample points. Model output predicts pattern of distance decay (top). Empirical data shows no pattern of distance decay, as would be expected from a neutral model.

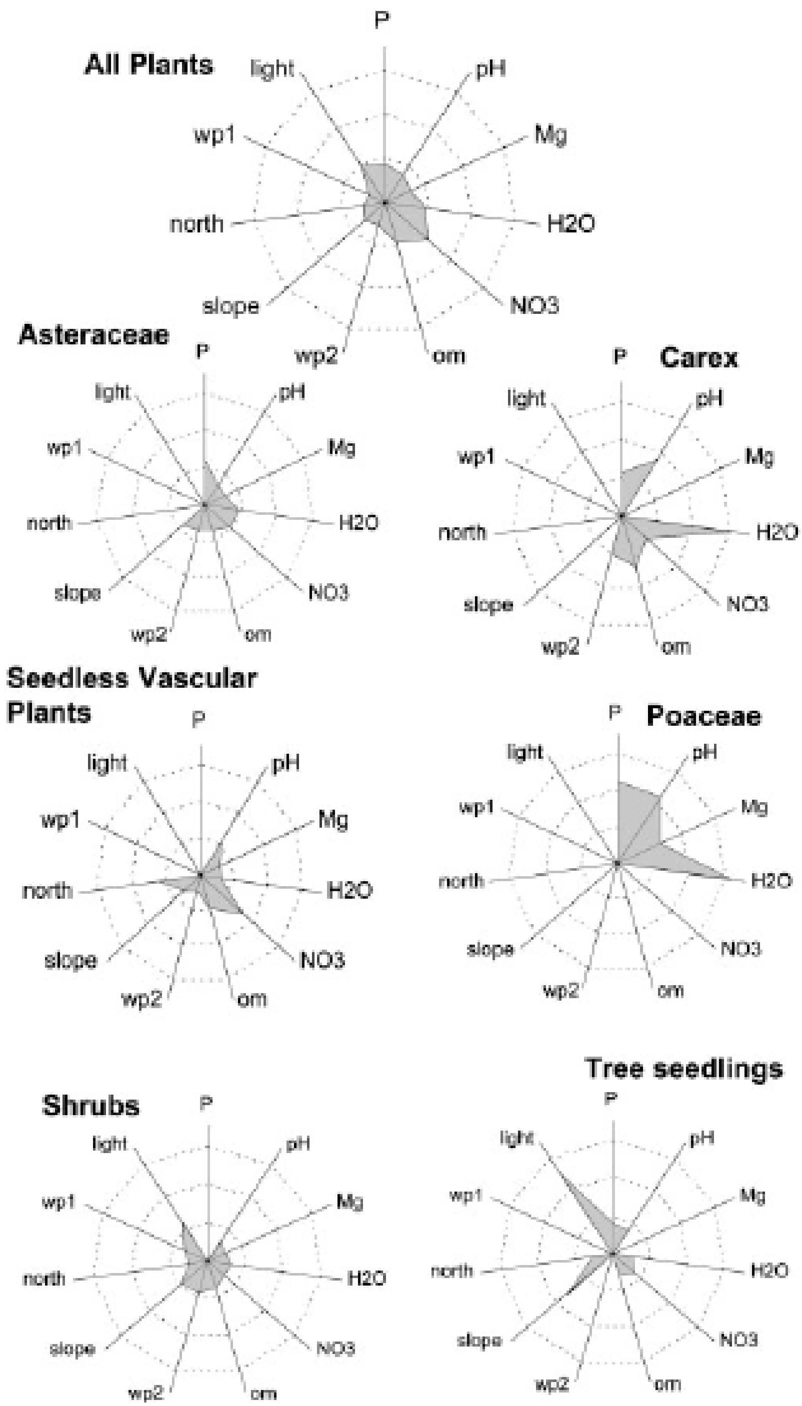
In all cases, environmental variables explained a greater proportion of variance in species distribution than did distance, implying strong niche-based responses to species distributions.



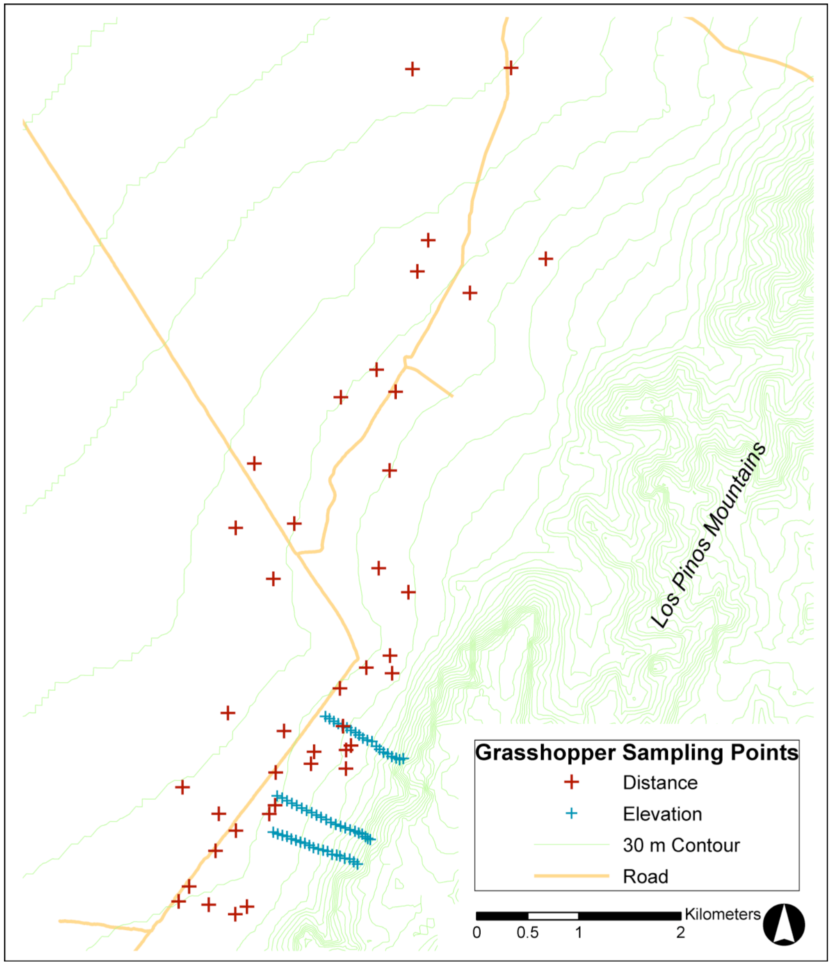

Gilbert and Lechowicz 2004 PNAS

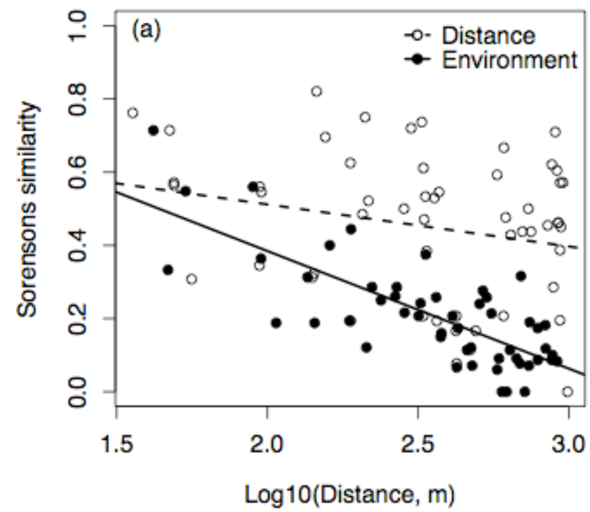





Partial contribution of environmental variables to the distribution of different species groups. Again, these show clear patterns of niche differentiation among species groups.

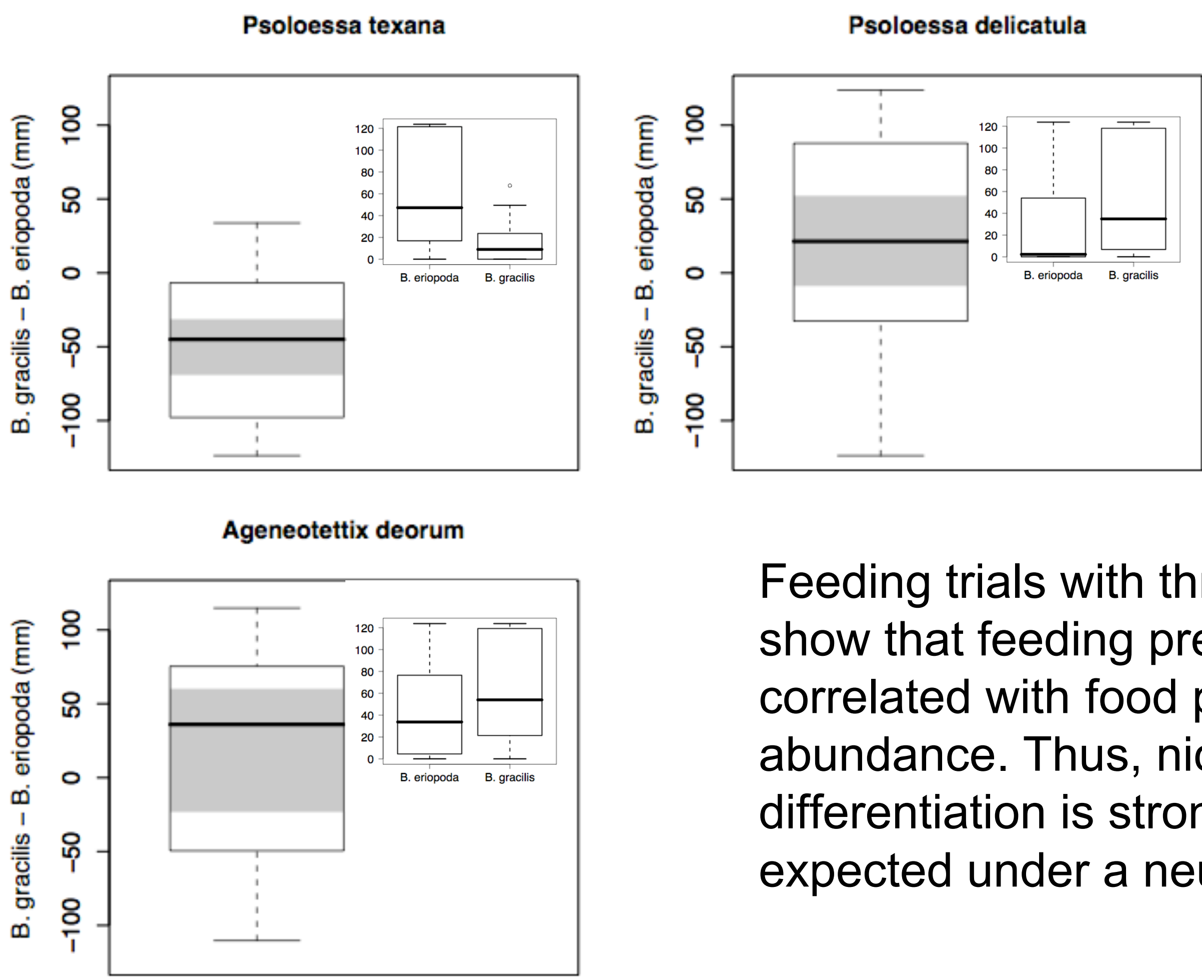
Gilbert and Lechowicz 2004 PNAS



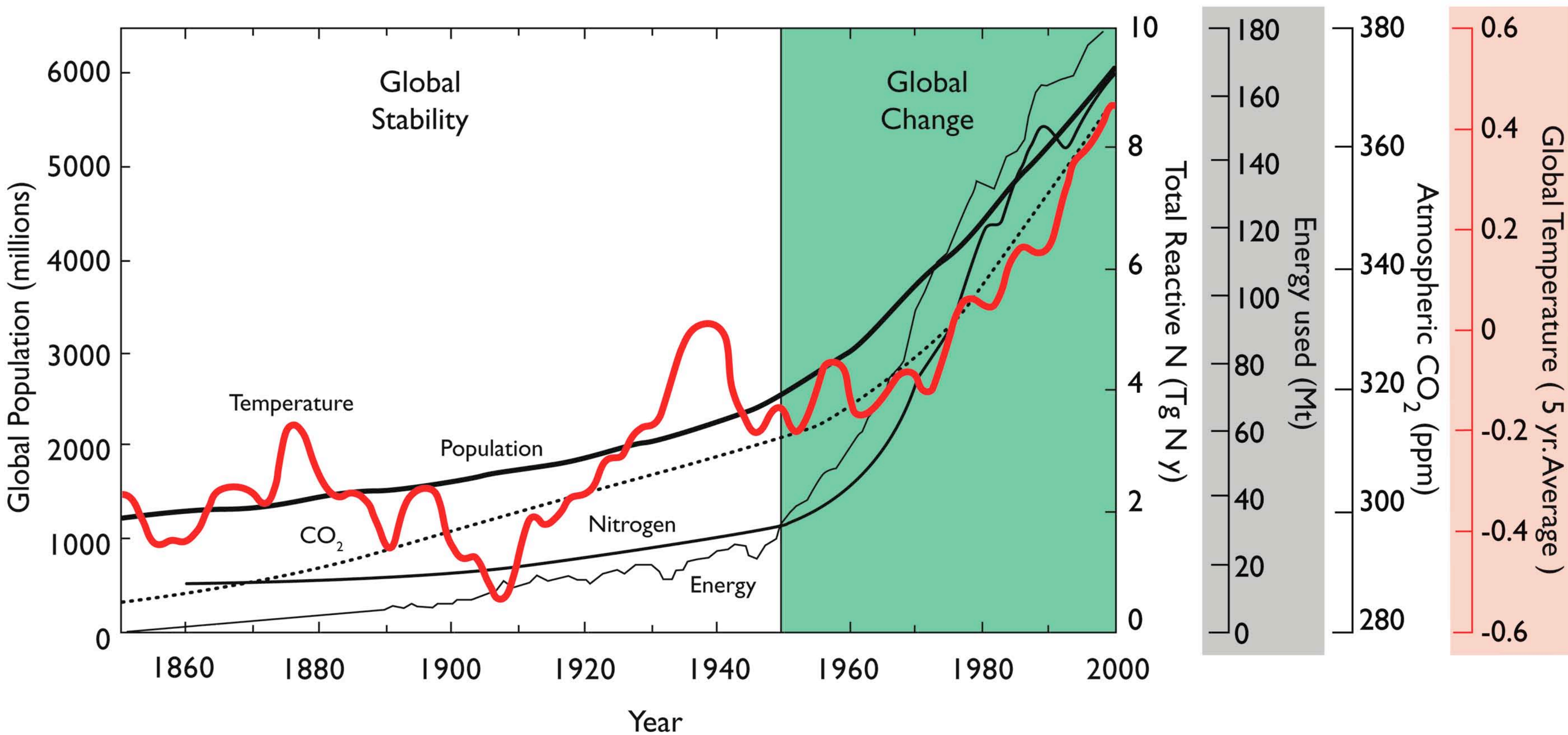

Sampling design and distance decay results for grasshopper species at the Sevilleta. Distance decay does occur across the homogeneous desert grassland transect, but distance decay is much stronger across the elevation gradient suggesting niche differentiation.

Romenger et al. in prep




Feeding trials with three common species show that feeding preferences are well correlated with food plant distribution and abundance. Thus, niche-based differentiation is stronger than would be expected under a neutral model.

Romenger et al. in prep




Smith et al. submitted (almost)

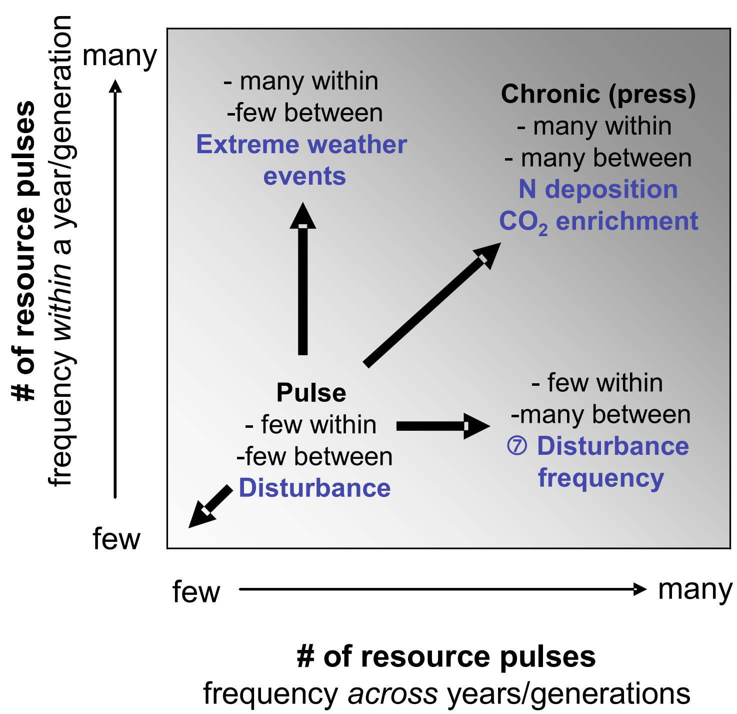
# DISTURBANCE REGIME

**Press factor** – variable or driver that is applied continuously at rates ranging from low to high (e.g., atmospheric nitrogen deposition, elevated CO2). Includes changes in rates (increases, decreases) relative to some historical baseline.

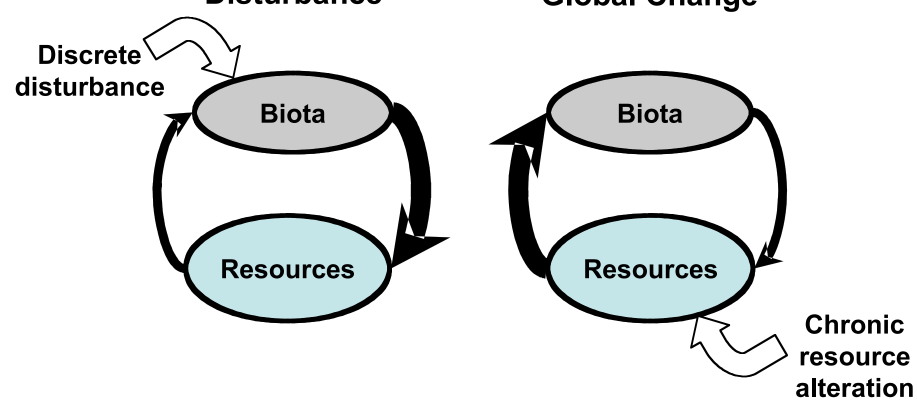
**Pulse factor** – variable or driver that is applied once or at periodic intervals (e.g., fire, extreme climatic events). Includes changes in the size, magnitude and frequency at which pulses occur.

Concept from Bender et al. 1984. Perturbation experiments in community ecology: Theory and practice. Ecology 65(1):1-13.

B.

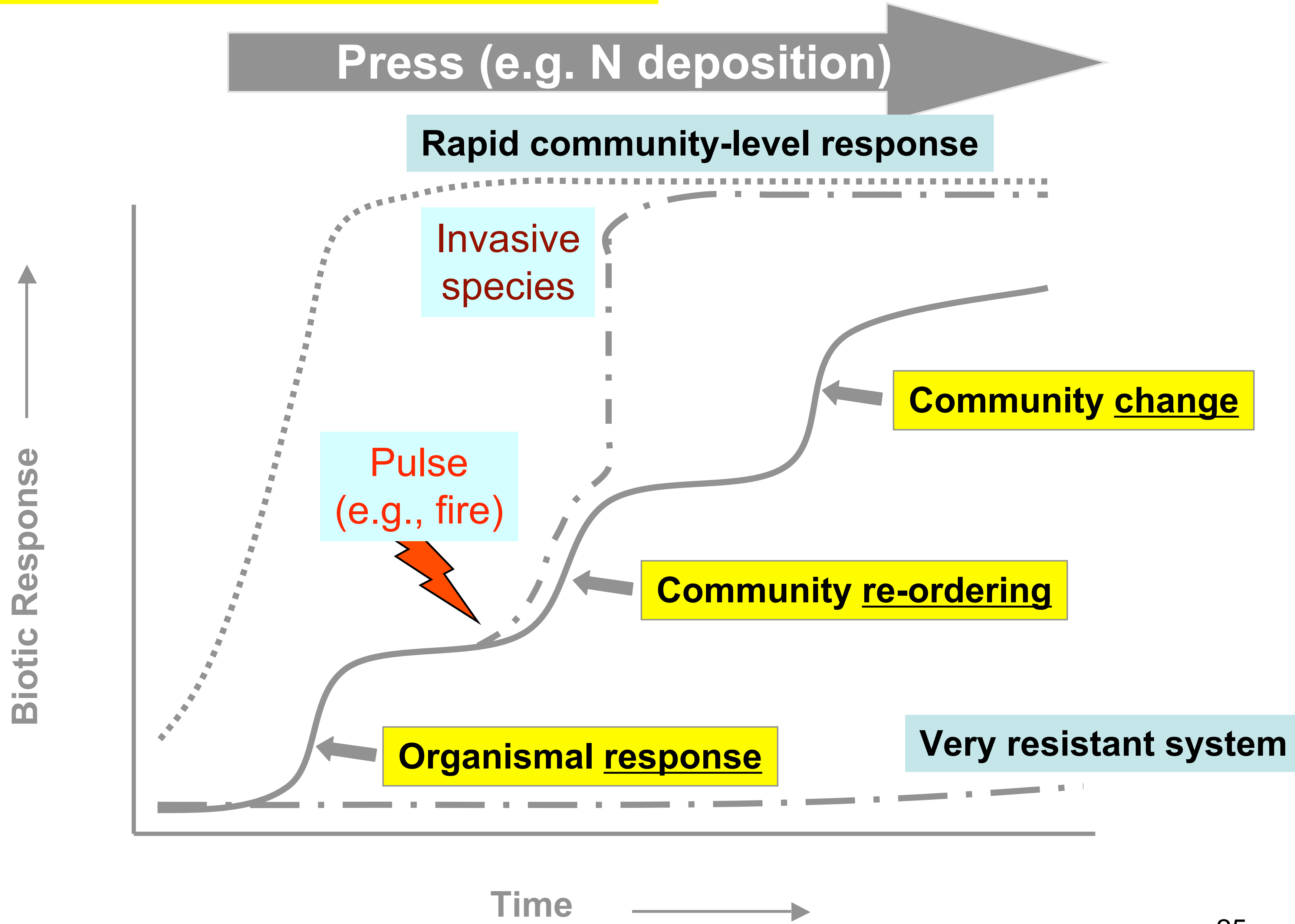



A.



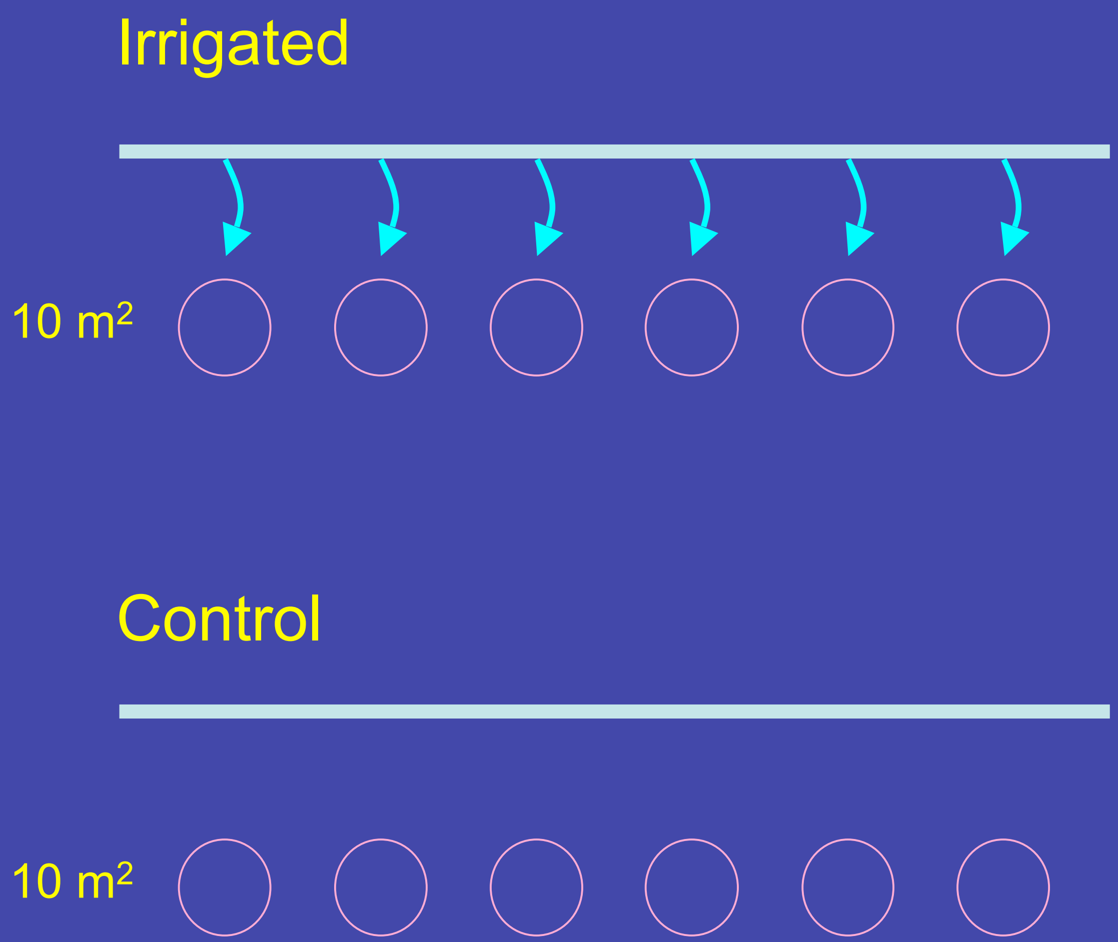

Smith et al. submitted (almost)

# *System Response Trajectories*



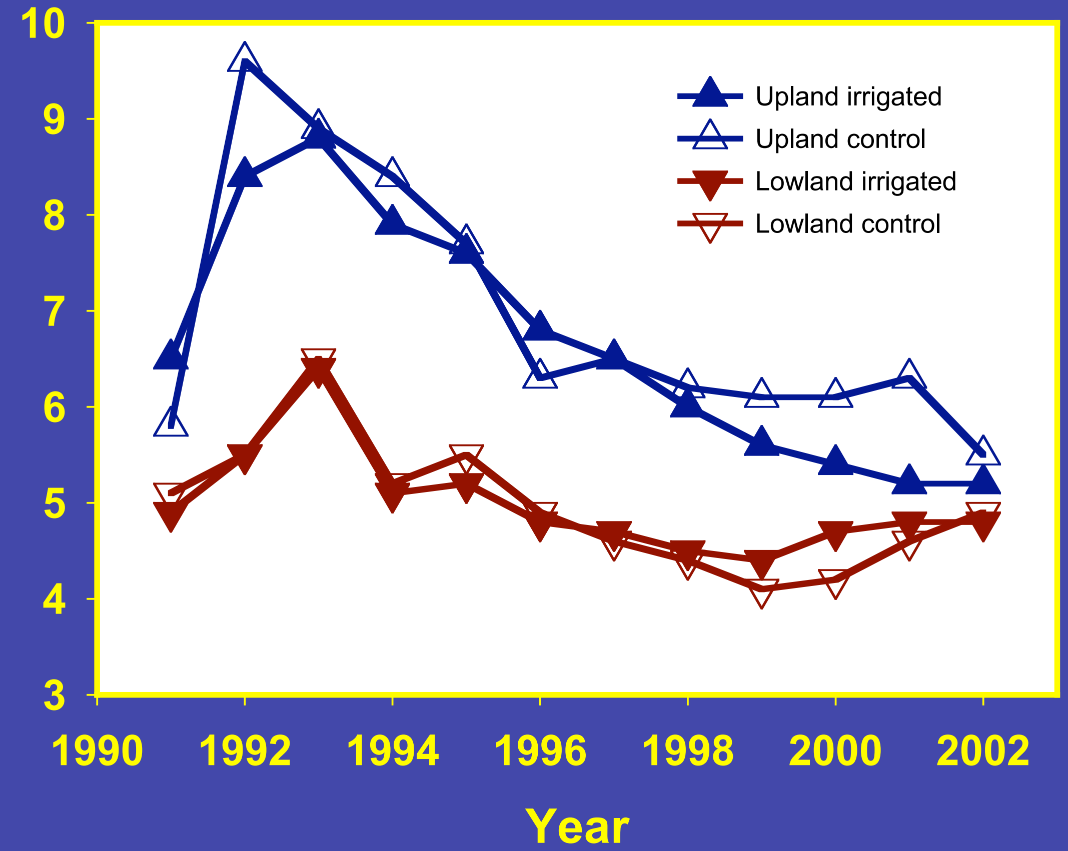

Smith et al. submitted (almost)

# Irrigation transects



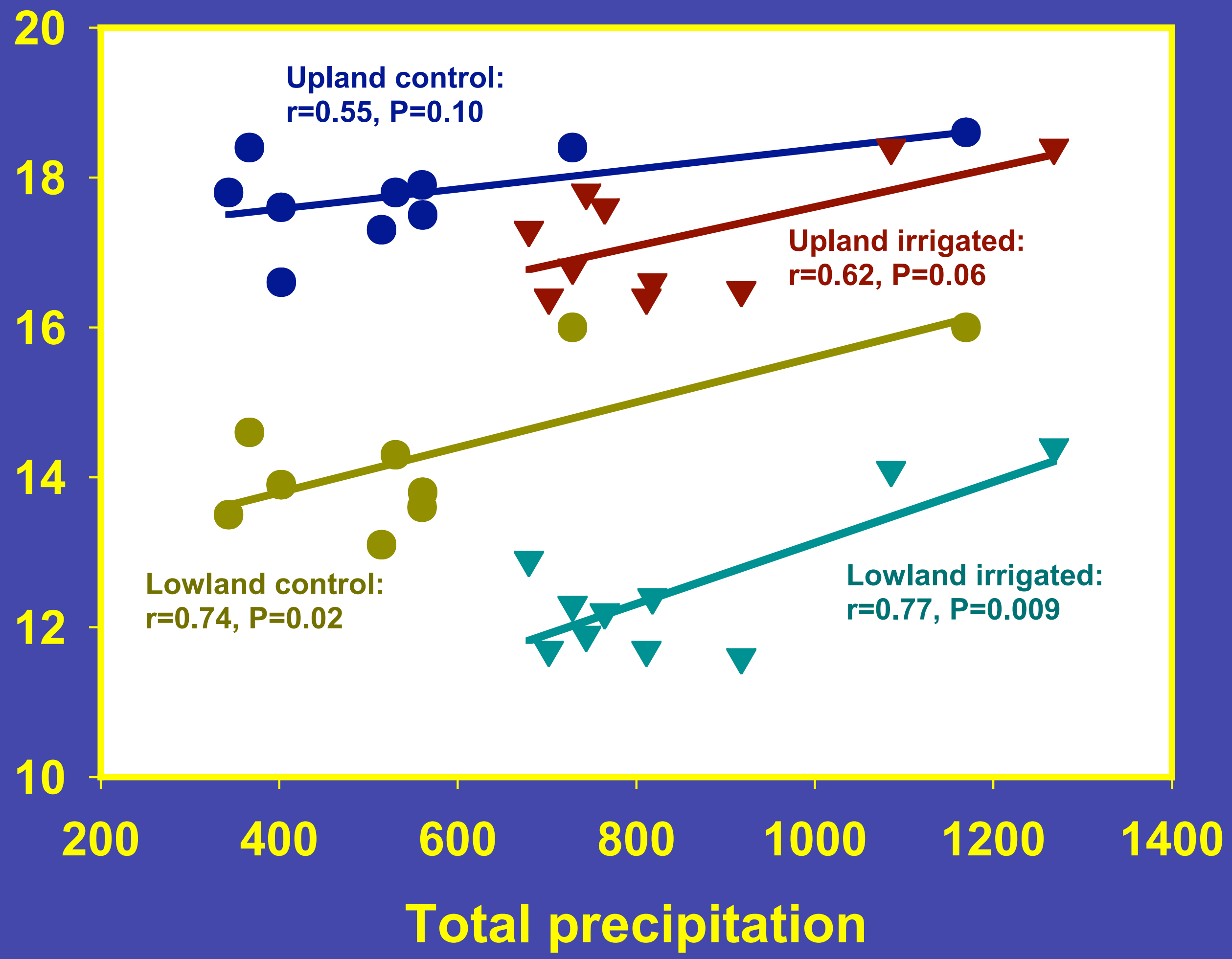

Vegetation was sampled from 1991-2002 in 31 permanently located 10-$m^2$ quadrats along two irrigated and two control transects

# Precipitation effects on species diversity




**Irrigation had no significant effect on species diversity in upland or lowland prairie**

# Precipitation effects on species richness over time



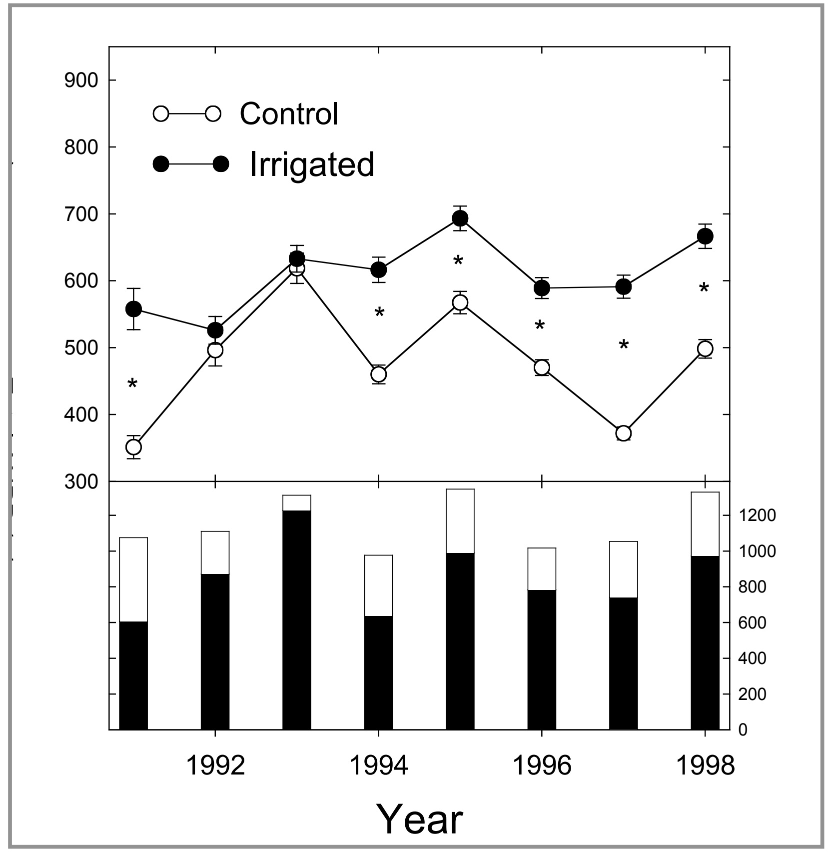

- Species richness increases with increasing total precipitation
- The response is stronger in lowland compared to upland soils

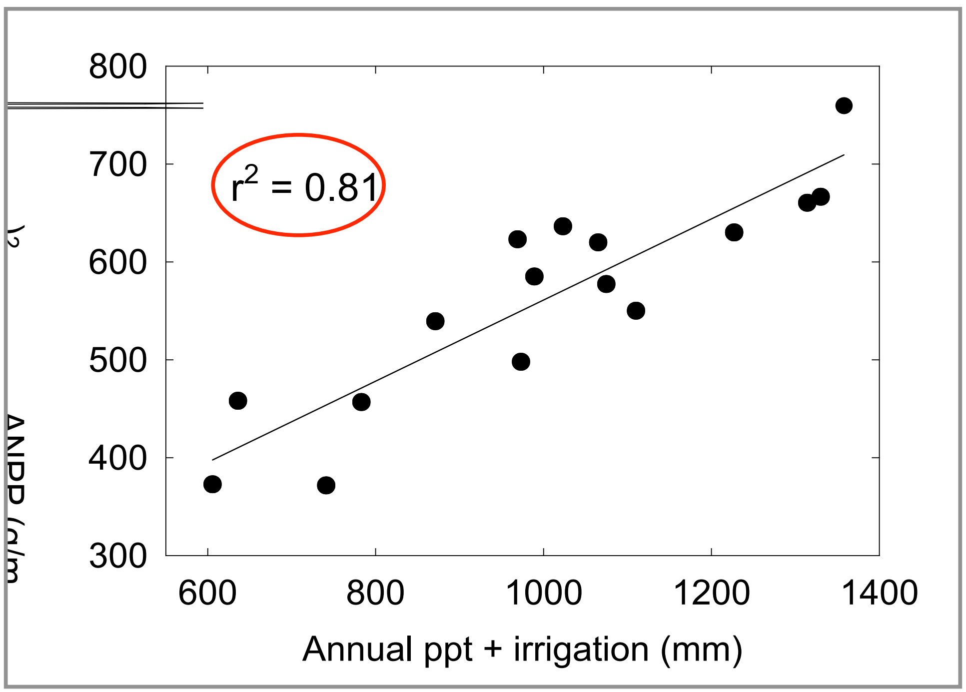
# Konza Prairie Long-term Irrigation Transect Study

- Treatments initiated in 1991
- Supplemental water added during the growing season to replicate 140 m transects (paired with control transects)
- Designed to meet plant water demand and minimize intra-annual variability in soil water deficits

# Summary of the first eight years…

- Water availability limited ANPP 6 out of 8 years
- Irrigation increased ANPP by ~25% (physiological response)



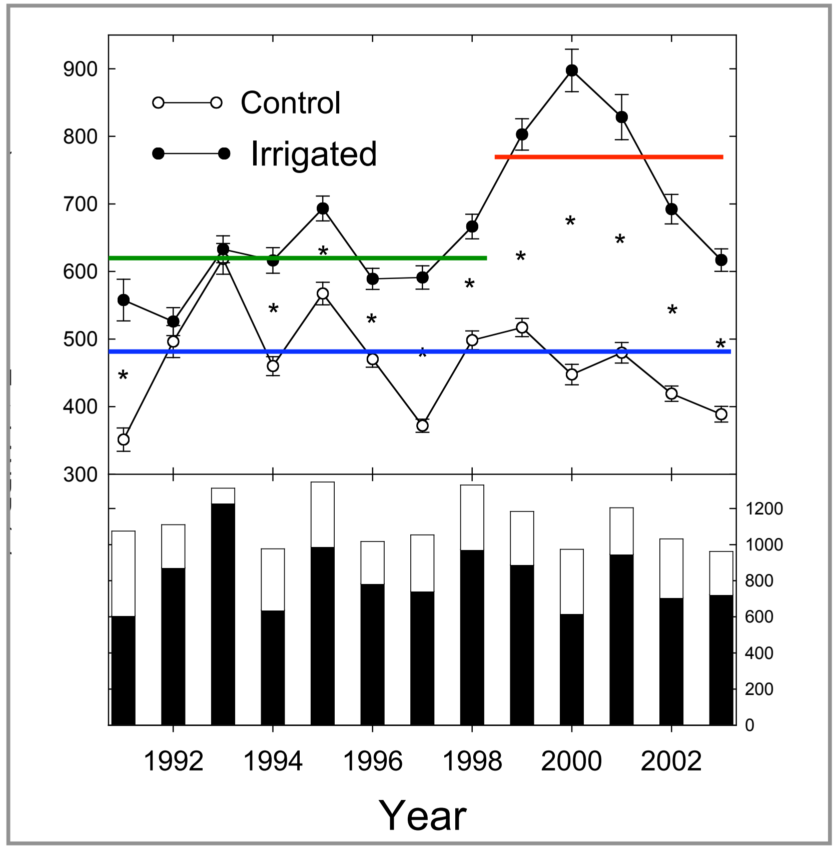

- Good fit between ANPP and ppt amount and when variability is removed and range extended

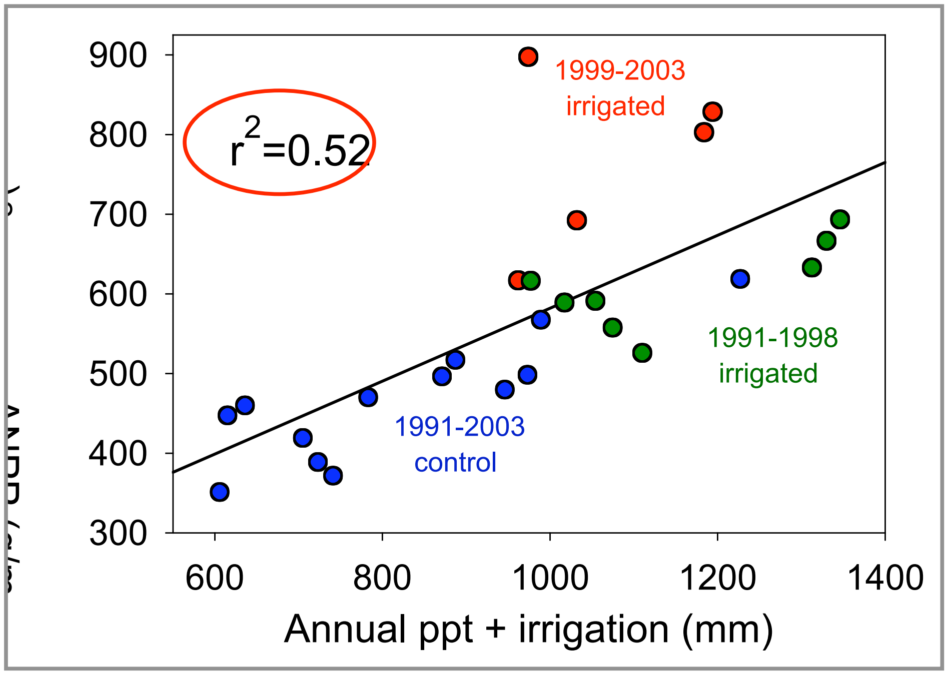


Knapp et al. 2001 Ecosystems

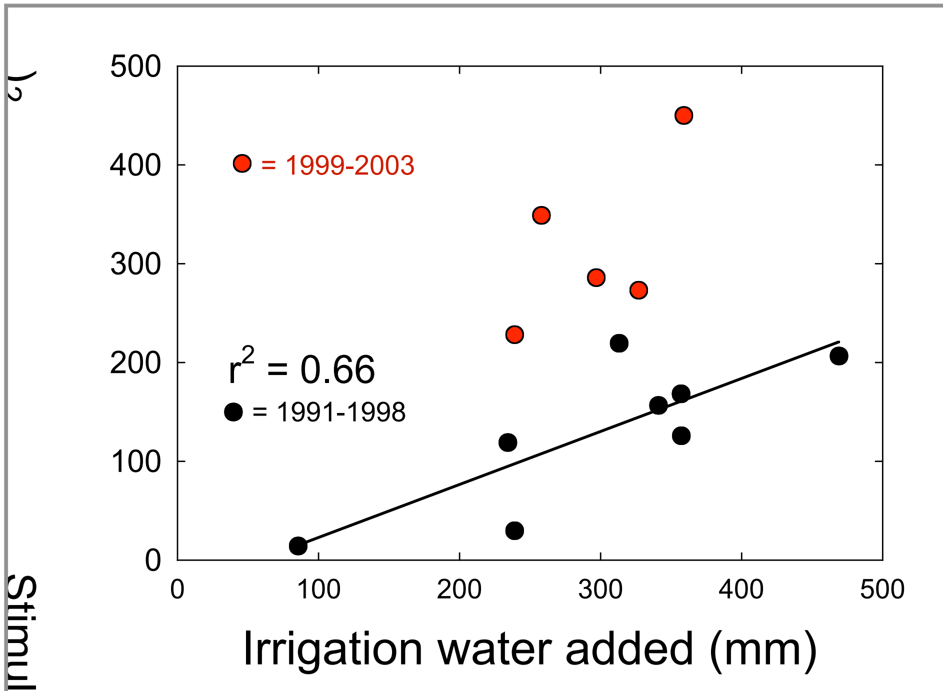
# But then we continued the experiment…

- Mean increase in ANPP for the next five years was 70%
- Driven by responses of grasses



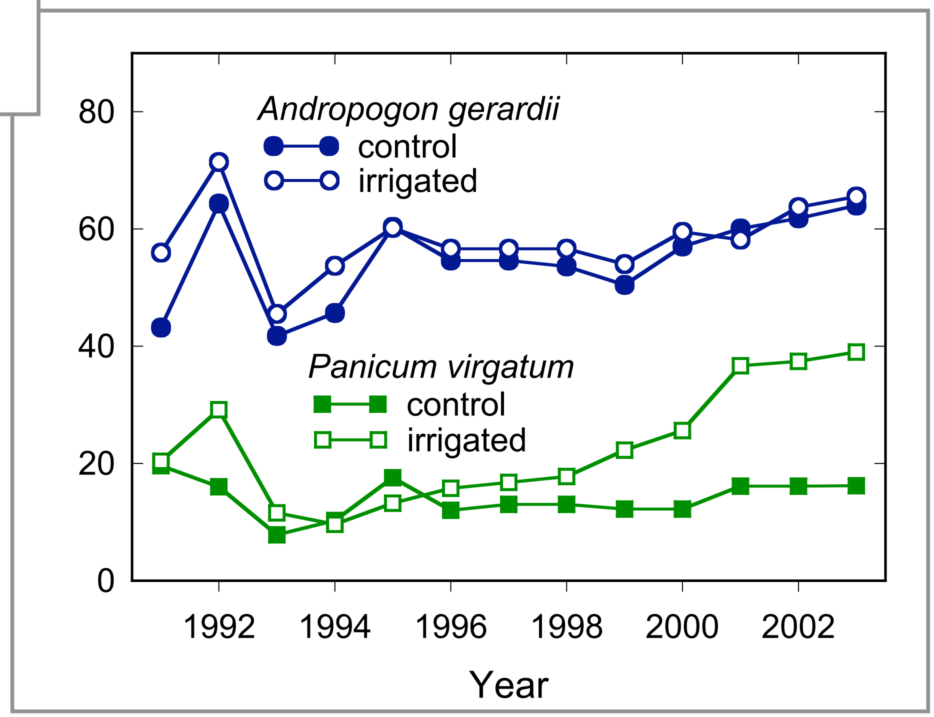




Changing relationship between ANPP and precipitation after long-term increase?




What would change the relationship between ANPP and precipitation?

- May be related to species changes (increased cover of *Panicum virgatum*) – **Community response**



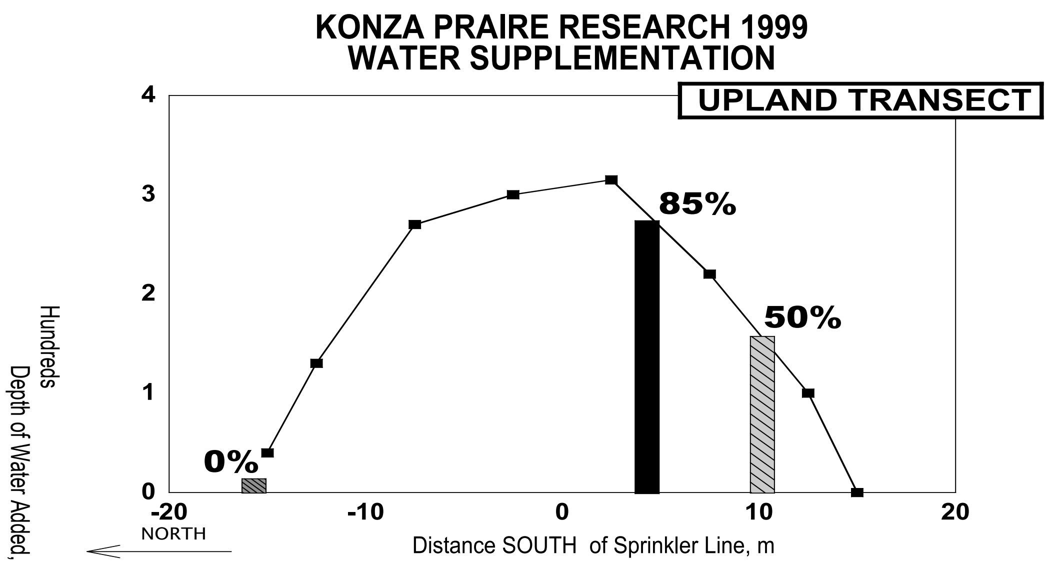
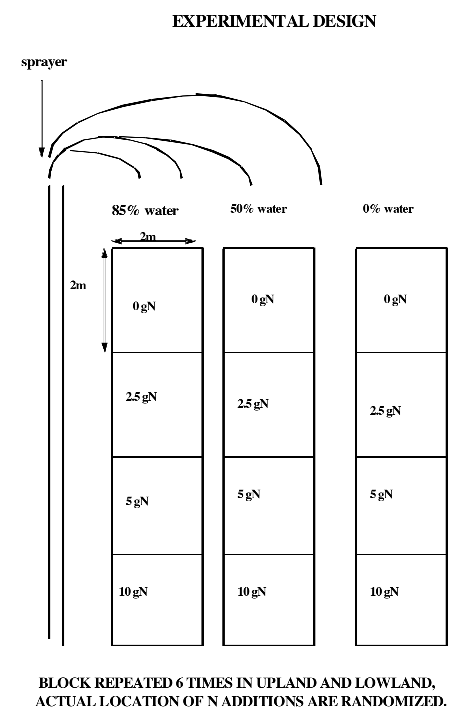
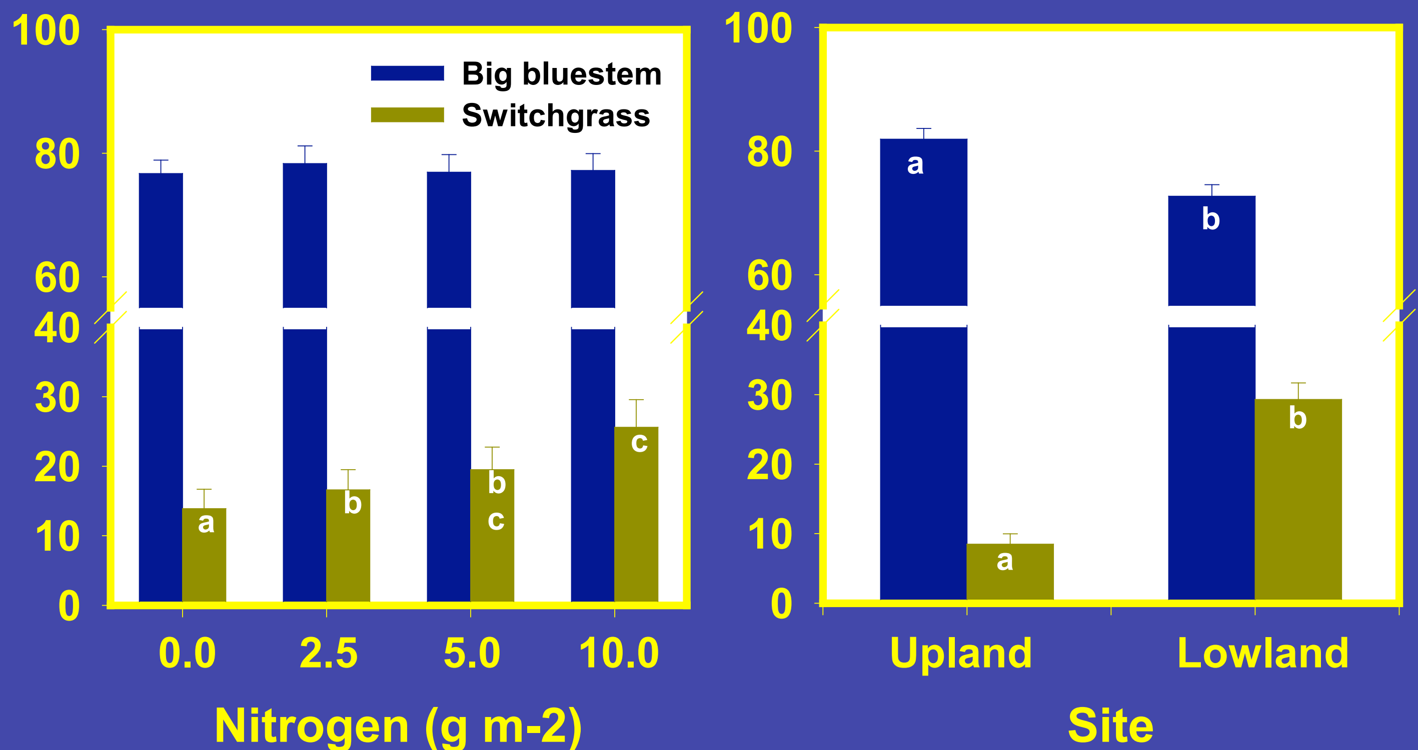



**Fig. 6.** 0 on the x-axis refers to the position of the sprinkler line. Bars indicate water supplementation used in this experiment (in mm water) and as % of control.



# Treatment effects on dominant grasses




•Resource addition alters species interactions
•Strength of response is context dependent

# Simple model of resource augmentation response (global change)