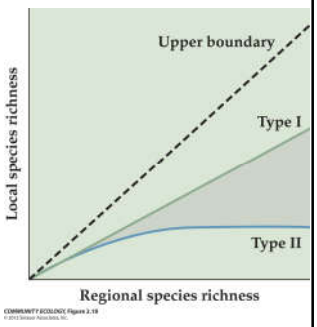
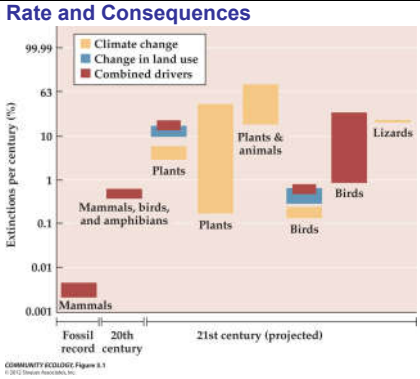
Are communities saturated?

- Species area relationships appear driven by extinction-colonization equilibrium.
- Thus, there are predictable relationships between regional (gamma) diversity and local (alpha) diversity.
- **Saturation** – there is a maximum alpha diversity regardless of gamma diversity.
- Alternatively, there may be no limit to alpha diversity and it could increase linearly with gamma diversity.



Extinction Rate and Consequences



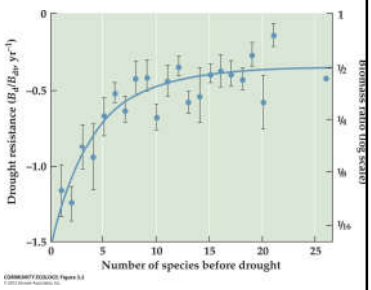
- Extinction rates are known to be variable through time (mass extinctions in the fossil record)
- Data suggests we are in or approaching a mass extinction period
- So?

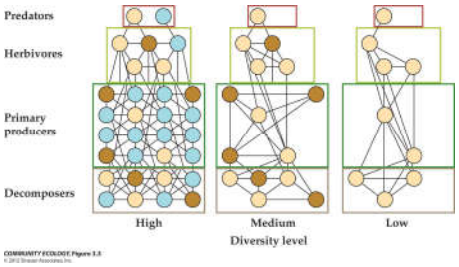
Community Emergent Properties

- **Diversity - #** "species", relative abundances, other measures of diversity.
- **Trophic structure –** number of trophic levels, food web structure
- **Species composition**
  - What species occur in a region and why?
- **Productivity –** Primary productivity and energy transfer through ecosystem
- **Nutrient cycling and/or use**
- **Stability**
  - **Resistance, Resilience – response to environmental change**
    - Is the community resistant to change (do we observe the same species through time)?
    - Is the community resilient (if disturbed, does the community return to pre-disturbance conditions)?
- **Patterns of colonization and extinction**
  - What species persist or disappear from a community?

How Will Emergent Properties Change With Diversity?

- For most metrics, ecosystem function (**emergent properties**) seems to be correlated with diversity.
- Field experiments demonstrate drought resistance (loss of biomass during drought compared to normal conditions) increases with diversity.
- Why?

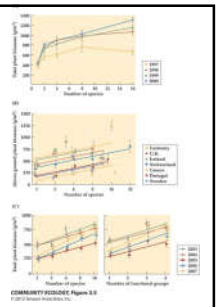


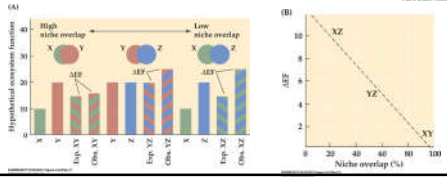


Experimental Food webs demonstrate higher diversity yields greater plant biomass.

Diversity and Productivity

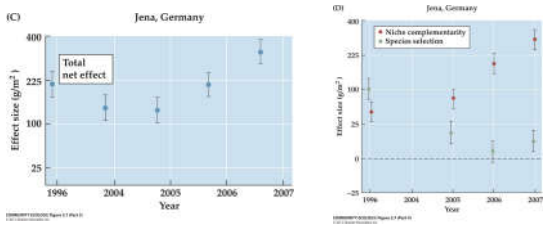
- We talked before about productivity explaining (to some degree) latitudinal diversity gradients. So, no surprise that diversity and productivity are related. But, how might diversity increase productivity?
- Within a site, or among sites, diversity and productivity related.
- Coexisting species expected to have low niche overlap (Gause's Principle).





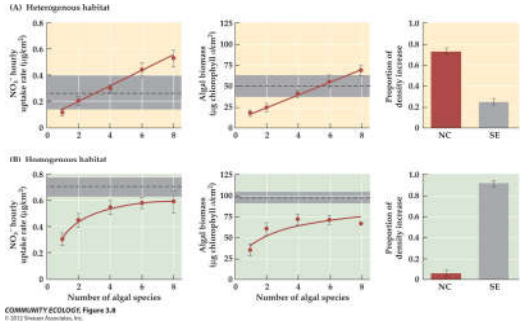
Diversity Productivity Mechanisms

- **Niche Complimentarity** – Species complement each other by all utilizing different resources. The more species, the greater proportion of resources used.
- **Species Selection (Sampling Effect)** – Diverse communities are more likely to contain productive species.
- Some support for both, patterns change over time:



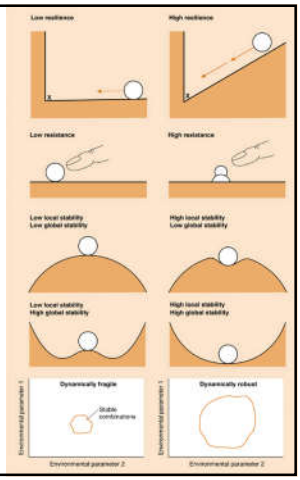
Diversity Productivity Mechanisms

- If more diverse communities feature species with complimentary niches, we expect more efficient resource use at higher diversity. More available niche space is filled, more efficient use.



Stability

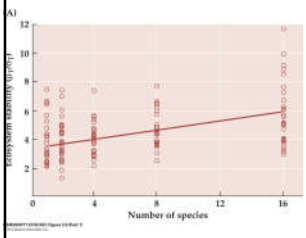
- How do emergent properties of communities respond to disturbance?
  - Resistance
  - Resilience
  - Local and global stability
  - Dynamically fragile
  - Dynamically robust
- How does diversity relate to stability?



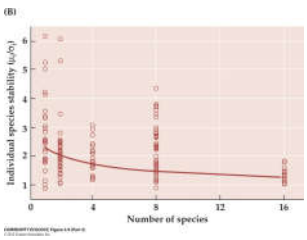
Diversity Stability Relationships (Tillman 1994)

- Stability in any community emergent property increases with diversity
- Individual species stability decreases
- **Insurance hypothesis (aka. Portfolio effect)**

"...the balance of relatively simple communities of plants and animals is more easily upset than that of richer ones"
C. Elton (1958, p. 145).

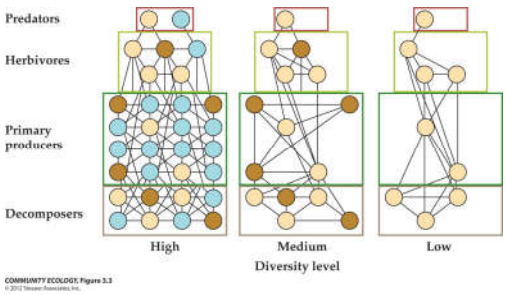


Overall community stability (total plant biomass/variance) **increases** with diversity.



Individual species stability **decreases** with diversity.

- Diversity itself may not be as important as the number of species interactions.



Evidence for diversity-stability

- Evidence
  - Mathematical models predict low S = low stability
  - Small island (low S) habitats are more susceptible to invasion
  - Cultivated or monoculture habitat is more susceptible to invasion or disturbance
  - Diverse tropical systems less invasible and/or more stable
  - Pesticide use (reducing diversity or links among species) increases variation in pest populations.
- Still somewhat controversial…

Models of stability (May 1972)

Constructed model food webs, varying diversity and complexity and measuring stability. Found that stability only occurred if:

$$B(SC)^{\frac{1}{2}} < 1$$

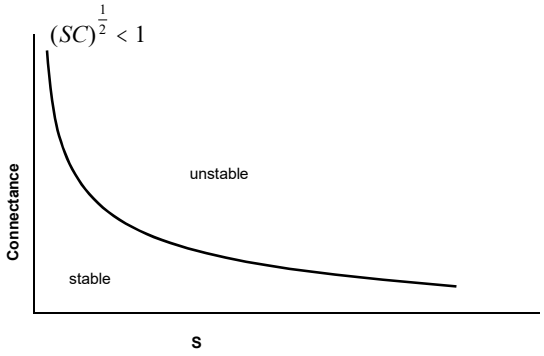
- β = strength of species interactions, assumed a constant, impossible to measure.
- S = # species
- C = connectance – proportion of total number of possible species connections.

$$(SC)^{\frac{1}{2}} < 1$$

For a stable community, as S increases, C must decrease and vice versa.

Models of stability (May 1972)

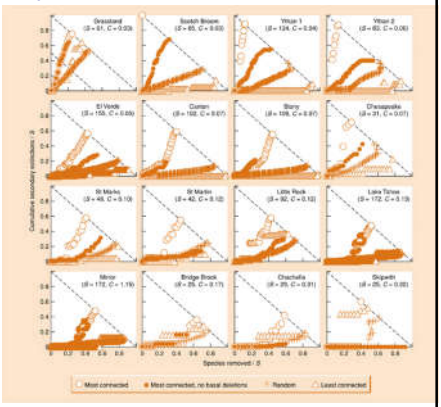
$$(SC)^{\frac{1}{2}} < 1$$



Increased diversity and/or complexity decrease stability. More diversity communities are only stable if connectance is low. Low diversity systems require high connectance to be stable.

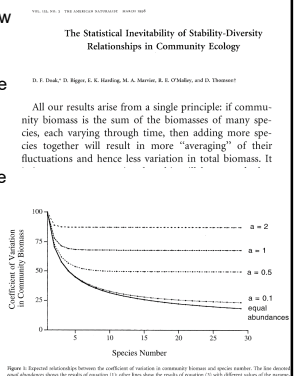
Criticism of May (1972)

- Constructed food webs at random
  - Resulted in some unrealistic links
  - Assumed all species linked similarly (no strong interactors)
- Are strong interactors more important than weak ones?



Criticisms of diversity-stability

- Monocultures and human altered ecosystems are not in equilibrium. Low diversity equilibrium systems are not invasible.
- High diversity tropical systems may be less stable than assumed, large fluctuations may go unnoticed.
- Islands are a special case.
- Diversity-stability relationships may be a mathematical inevitability.



The Statistical Inevitability of Stability-Diversity Relationships in Community Ecology

All our results arise from a single principle: if community biomass is the sum of the biomasses of many species, each varying through time, then adding more species together will result in more "averaging" of their fluctuations and hence less variation in total biomass. It

Functional Diversity

- The focus should not be on taxonomic diversity but on the functional roles played by species.
- **Functional redundancy** – two species can play the same role, loss of one does not change ecosystem function (stabilizing)
- **Functional insurance** – differences in species response (ie. Functional diversity) to disturbance buffer ecosystems against change (stabilizing effect).
- **Phylogenetic diversity** may be more important than **species diversity**. More distantly related taxa more likely to provide functional insurance.

The contribution of species richness and composition to bacterial services

Thomas Bell[1], Jonathan A. Newman[2], Bernard W. Silverman[3], Sarah L. Turner[2] & Andrew K. Lilley[2]

Figure 1 | The relationship between species richness and ecosystem functioning. Illustration of how the complementarity mechanism and the selection mechanism alter the shape of the relationship between species richness and some measure of ecosystem functioning. If all species contribute approximately equally to ecosystem functioning, species effects are (1) additive if the species are completely complementary (black line) or (2) decelerating if the species are to some extent functionally redundant (light grey line). If the same pool of species now contains a few species that, when present in a given mixture, are able to attain maximum ecosystem functioning, the shape of the curve will also be decelerating (dark grey line).

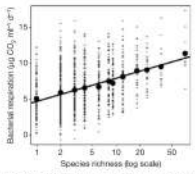


Figure 2 | Relationship between manipulated species richness (*R*) and ecosystem functioning (*F*) over 28 days. *F* represents the mean daily rate of bacterial community respiration. Each data point (denoted by a dash) is the mean of two replicates with identical species composition ($n = 687$). Filled circles are the means at each level of species richness ($F = 1.21 \ln(R) + 4.98$, $R^2 = 0.12$).

- Diminishing returns of ecosystem function with increased diversity.
- Suggests functional redundancy and that species are not complementary