Biodiversity at local scales

Reading assignment: GSF Ch. 13

Also see Mack et al. "Biotic Invasions: Causes, Epidemiology, Global Consequences and Control" (optional)

Biodiversity at Local Scales

- Differing abundances of different species may result from variable competitive ability (fitness) among species, or from stochastic factors
- Patterns of commonness and rarity are scale-dependent and may shift over time
- Common species are called "dominants"
- Most species are not common

Three aspects of species distributions (Rabinowitz, 1981)

- Geographic range (wide/narrow)
- Habitat specificity (broad/restricted)
- Local abundance (somewhere large vs. everywhere small)

TABLE 13.1 A scheme for describing eight categories of commonness and rarity based on three traits

Geographic range		Wide		Narrow	
Habitat specificity		Broad	Restricted	Broad	Restricted
Local abundance	Somewhere large	Common	Predictable (habitat specialists)	Unlikely	Endemic
	Everywhere small	Sparse		Unlikely	Rare on all counts

Source: Rabinowitz 1981.

Why are species common?

- Ecological generalists: wide habitat tolerance; broad fundamental niches
- Common species are “superior organisms,” more competitive for resources
- This theory has been partially supported, but maybe common species happen to be well adapted to commonly found environmental conditions
- See Table 13.2

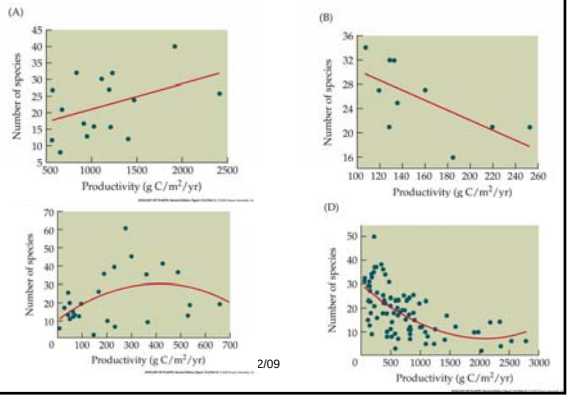
Why are species rare?

- Classic explanation is that species tend to be ecologically specialized
  - Low abundance
  - Small geographic ranges (endemism)
  - Rare species can efficiently exploit their specialized niche
- Lack of dispersal (spatial and temporal barriers)
- Historical accidents
- See Table 13.2

Why do some areas have high species diversity?

- As productivity (or resources, or area) increases, the number of species should, too
- Assumes that more productivity is driven by more energy in the system, which would support more individuals (or species)
- “Paradox of Enrichment:” at high productivity, some individuals (species) outcompete others if they get bigger or take up more space, leading to lower diversity

The relationship between productivity and diversity is very scale dependent



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Does disturbance promote diversity?

- Gaps in temperate and tropical forests are important in maintaining diversity
  - Stochastic events lead to species coexistence
- Intermediate disturbance hypothesis
  - Competitive exclusion reduces diversity at low levels of disturbance
  - Recolonization may be too slow at high levels of disturbance
  - Recent review showed marginal support for this idea (Fig. 13.10)

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Does increased biodiversity increase ecosystem stability?

- What is stability?
- If stability is reduced variability, there is some evidence for a relationship (Fig. 13.12)

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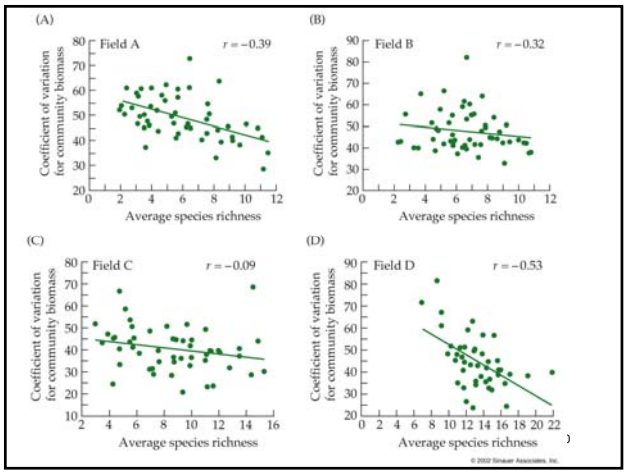


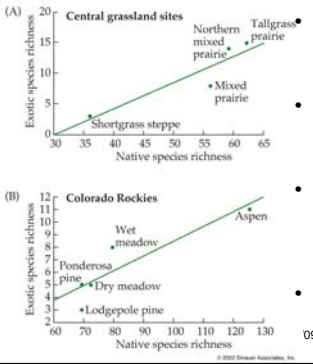
Why are species invasive?

- Invasive species expand their ranges rapidly outside their native habitat
  - May be "weedy" or "ruderal" but not always
  - May be native to the region but more often exotic
- Most invasive species have been introduced by people (2000-3000 species in US, last 100 years)
- Strategies for spreading
  - Lots of seeds, wind dispersal
  - Rhizomes
  - For pines, reproduction at a young age, small seeds and large, frequent seed crops
  - Rapid growth; lack of natural predators or pathogens
- Invaders may alter ecosystem properties in a way that increases their success (feedback)

Ecosystem Conditions leading to Invasion

- Empty niches (Elton 1958)
  - Species-poor communities have more ecological "space" for invaders
  - Evidence is mixed!
- Disturbance
  - Increases resource availability and niche space
- Unused resources
  - Dalmatian toadflax, tap-rooted forb, invades prairie after wet springs; few other species make use of deep soil moisture

What is the role of empty niches in invasion?



- Dominant paradigm says that species-poor areas are susceptible to invasion
- Species-rich communities may have higher rate of invasive species (Fig. 13.5)
- S. African fynbos, New Zealand beech forests, and Great Plains grasslands show similar patterns
- Are species-rich areas more fertile?

What is the role of disturbance in invasion?

More work needs to be done on specific mechanisms driving disturbance-invasion cycles

- soil surface conditions, microclimate
- water infiltration rates
- competition
- natural enemies
- resource (nutrient) availability
- feedbacks: kochia and cheatgrass increase N cycling rates

Phases of invasion

- Lag phase; many introduced species disappear
- Population increases slowly
- Often multiple introductions of the same species occur over time and space
- Invasion (log) phase; rapid population increase in number and area
- Eventually the population and area stabilizes (may take centuries)

Phases of invasion

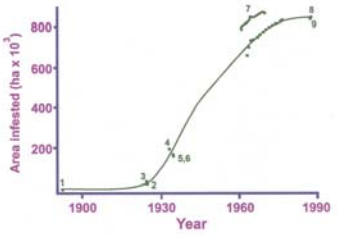


Figure 2 - Many invaders occupy new ranges at an accelerating rate with pronounced "lag" and "log" phases of proliferation and spread. This initial slow rate of range occupation may be indistinguishable from the rate of spread displayed by non-invasive (but nevertheless non-indigenous) species in a new range, thus hampering the early identification of future invaders. Terrestrial plant invasions most commonly illustrate this pattern (e.g. the spread of *Opuntia aurantiaca* in South Africa) (Moran and Zimmerman 1991 and sources [numbers 1-9] therein). By contrast, invaders in other taxonomic groups may show no lag in range expansion and rapidly occupy new range upon entry.

Mack et al. 2000