

# Community effects on ecosystem processes

CMM Chap. 12

## I. Introduction

### A. The context –

1. CIORPT
2. Loss of biodiversity
3. Species invasions

### B. What is biodiversity?

### C. What is ecosystem functioning?

## II. Organism effects on ecosystem processes

### A. Community determinants

### B. Functional determinants: interactive controls

## III. Effects of diversity on ecosystem processes

### A. Magnitudes of processes

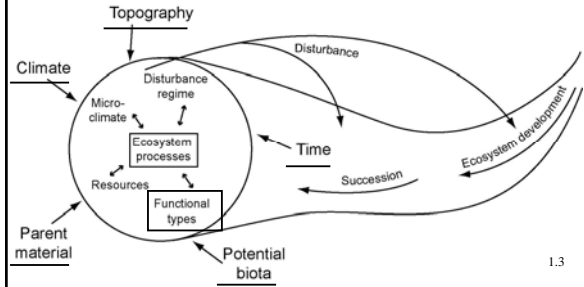
### B. Stability of processes

### C. Synthesis

Powerpoint modified from Chapin (<http://www.faculty.ucsf.edu/ffsc/>)

## A.1. State factors and interactive controls:

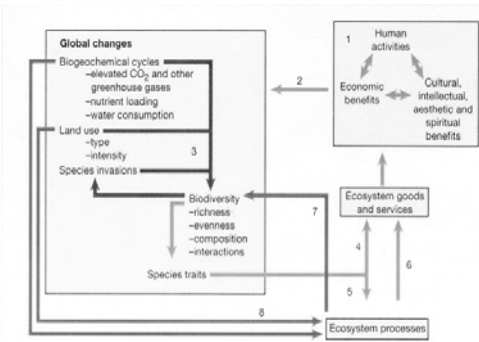
Species effects on interactive controls determine ecosystem consequences



1.3

How will changing biodiversity affect ecosystem functioning?

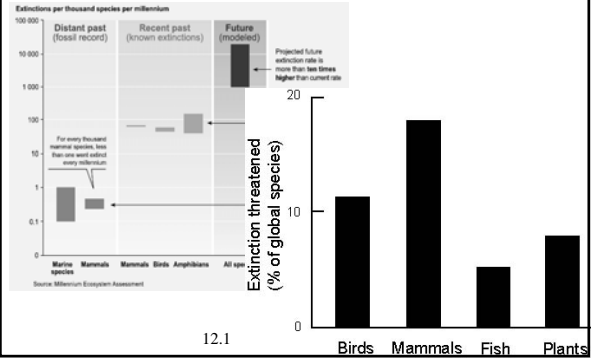
## 2. The context: altered biodiversity



Chapin et al. 2000

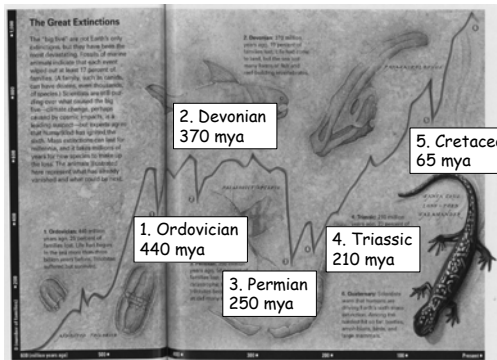
## 2a. Loss of Global Biodiversity:

Current extinction rates are 10-100 fold higher than past



12.1

## The "Sixth Extinction"?



National Geographic 1999

## 2b. Loss of Regional Biodiversity:

Problems can occur long before species go extinct.



© National Geographic Magazine 2007

### 3. Introductions of exotic species

- Washington examples (to name just a few):



Cheatgrass (*Bromus tectorum*) (eastern WA)  
<http://www.cabrnr.unr.edu/CABNR/Newsletter/FallStory.aspx?StoryID=41>



*Spartina alterniflora* (reed grass) in Gray's Harbor  
<http://www.cabrnr.unr.edu/CABNR/Newsletter/FallStory.aspx?StoryID=41>



European Green crab (*Carcinus maenas*)  
[http://maashay.mit.edu/exoticspecies/exoticmaps/images/carcinus\\_big.jpg](http://maashay.mit.edu/exoticspecies/exoticmaps/images/carcinus_big.jpg)

- Shifts in species can be difficult, expensive, or impossible to reverse.



Reed canary grass, Whatcom County

Not all introduced species become problems in their new habitat, but those that do can cause extensive ecological and economic damage.

- Introductions
- Establishment
- Invasions
- Noxious pests

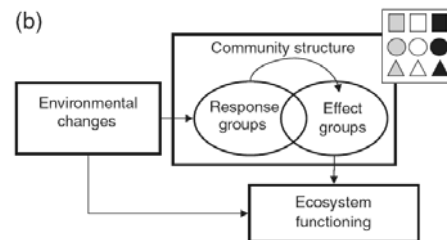
### B. What is biodiversity?

- Genetic
- Species
- Functional groups
  - Effect
  - Response
- Community types
- Ecosystem arrangement on the landscape

### Salmon - Genetic diversity maintains local adaptation



Functional group diversity: Need to understand how responses link to effects on processes.



Suding *et al.* 2008

### Understanding interactions

Bay checkerspot

Cows are good?!

Plantago erecta

Invasive grasses

L. Gonzalez photos 2005

D. Hooper photos 2005

### Ecosystem distribution matters for some services

- Wetlands & riparian buffers:
- Flood control,
- Nutrient filtration

<http://extension.umd.edu/environment/index.cfm>

### C. What is ecosystem functioning?

- Ecosystem properties (non-qualitative) (production, nutrient cycling, energy flux, etc.)
- Ecosystem goods – (“Provisioning services”) directly marketable
- Ecosystem services – benefit human endeavor, but harder to quantify in economic terms
  - Regulating: pollination, pest control, water purification, maintenance of soil fertility, climate regulation, etc.;
  - Cultural: recreational, educational, spiritual, etc.

### II. Organism effects on ecosystem processes

#### A. Community context

### Impact of organisms on ecosystems depends on:

A. Effect of species number

B. Effect of species abundance

C. Effect of species type

D. Species interactions

### B. Functional Effect Traits

Global changes

Biodiversity

Species traits

Abiotic process controls

Disturbance regimes

Climatic variables

Direct biotic processing

Ecosystem processes

Ecosystem goods and services

Human benefits

3a

3b

3c

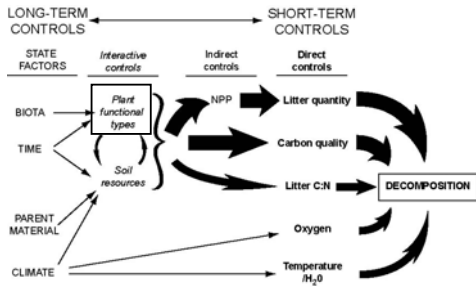
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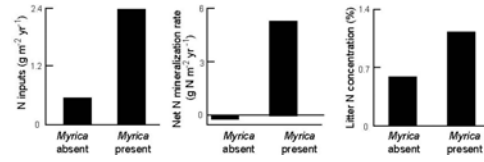
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Chapin et al. 2000

Species effects are an important interactive control  
Affect most ecosystem processes

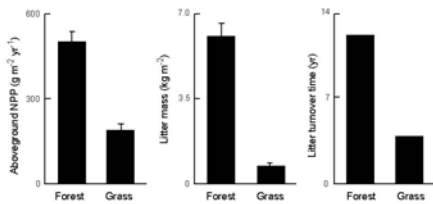


1. Species effects on resource supply:  
Invasion of exotic N fixer augments N cycling



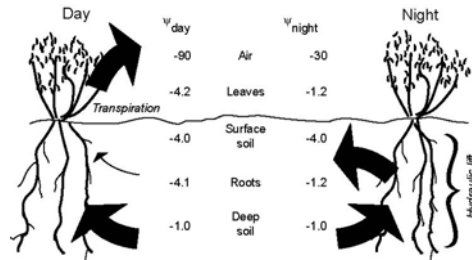
*Myrica faya* is a N-fixing exotic tree in Hawaii

Deep-rooted species access more resources  
Enhanced NPP  
Alters ecosystem structure and functioning



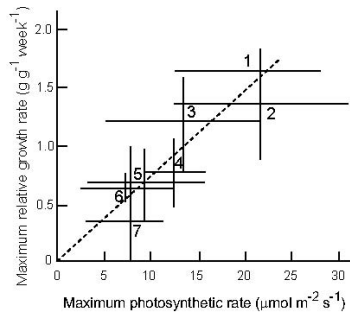
Native perennial bunch grasses of Calif. Have been replaced either by European annual grasses or by deep-rooted *Eucalyptus* trees that can access more water and nutrients

Deep-rooted species access more water  
Augments water available to support  
NPP

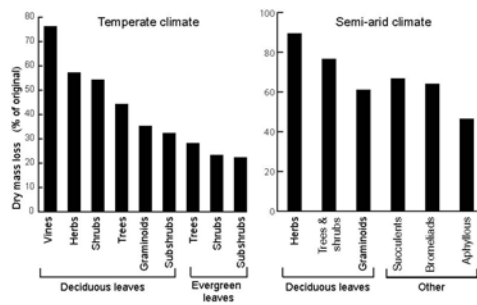


Relative growth rate is key trait with strong ecosystem impacts

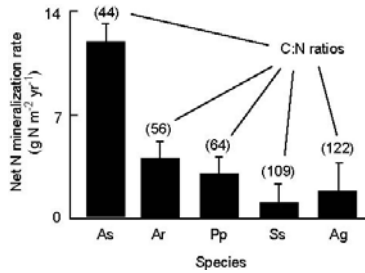
Determines NPP  
Influences nutrient requirement and litter quality



Plant species differ predictably in litter quality  
High-resource-adapted leaves decompose quickly  
Enhance nutrient cycling rates

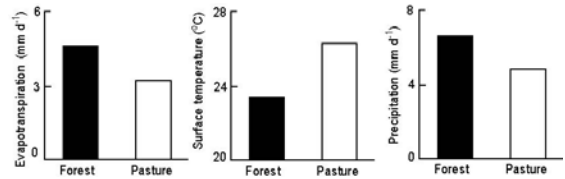


Species effects on nitrogen mineralization  
Associated with differences in litter quality



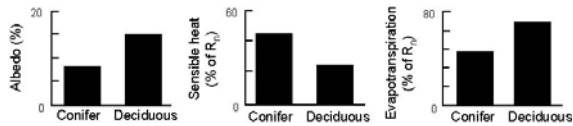
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2. Species effects on climate  
a. in tropical forests



Climate changes predicted for the Amazon Basin if rain forests were replaced by pasture.

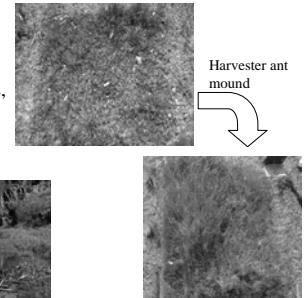
2. Species effects on climate  
b. in boreal forest



3. Species effects on disturbance

a. Many animals are ecosystem engineers

- Soil disturbance (worms, gophers, ants)
- Landscape disturbance (beavers)



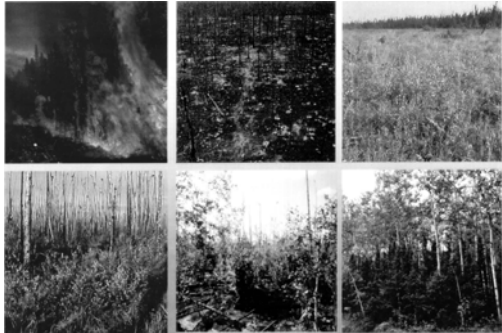
3. Species effects on disturbance

b. Plants influence disturbance

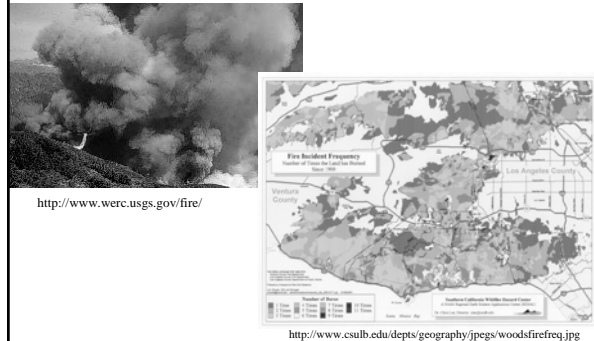
- Decrease: Stabilize soils (e.g., sand dunes)
- Increase: Fire probability



Boreal conifer forests are born to burn  
 After fire are replaced by less flammable deciduous forests  
 (effect and response functional groups differ)



### Fire in California chaparral (effect and response groups the same)



### Fire in Hawaiian woodlands (effects of invasive grasses)



- *Schizachrium scoparium* is an invasive grass that both promotes fire and resprouts quickly after burning.  
 - Effect and response groups are the same → positive feedback.  
 - Native Hawaiian shrubs and trees are not adapted to frequent fire and are eliminated.

## III. Effects of species diversity

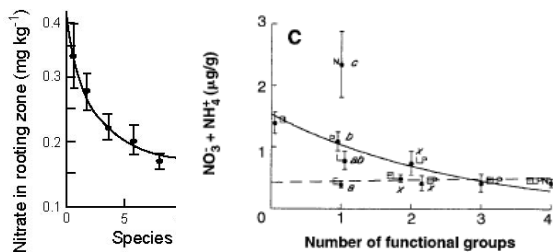
### A. Magnitudes of processes

1. Enhance efficiency of resource use
2. Primary productivity
3. Mechanisms

### B. Stability of ecosystem processes

### C. Synthesis

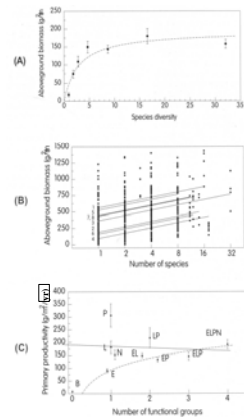
1. Efficiency of resource capture/retention
  - greater plant species richness led to lower pool sizes of available N
  - from greater plant uptake?



12.8

Hooper & Vitousek 1997

## 2. Responses of Primary Productivity to Changing Plant Diversity



Tilman et al. 1996

Hector et al. 2001

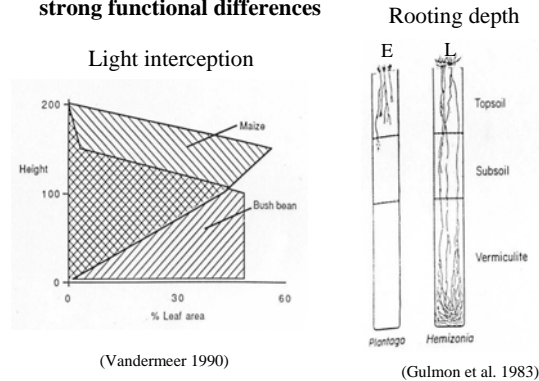
Figure from Inchausti 2001

Hooper and Vitousek 1997

### 3. Mechanisms of diversity effects

- Complementarity - niche differentiation that leads to greater overall resource use in more diverse communities.

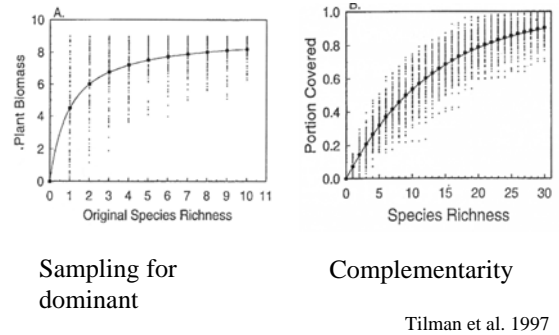
### Complementarity in plants with strong functional differences



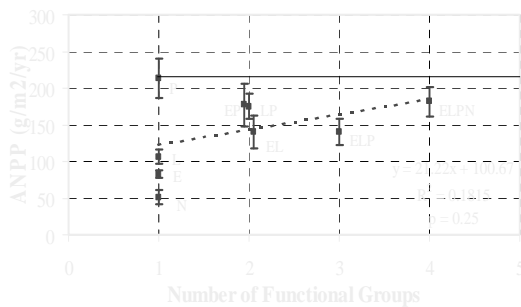
### 3. Mechanisms of diversity effects

- Complementarity - niche differentiation that leads to greater overall resource use in more diverse communities.
- Sampling - statistical probability of choosing a highly productive species.

### Detecting complementarity

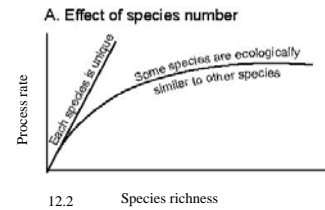


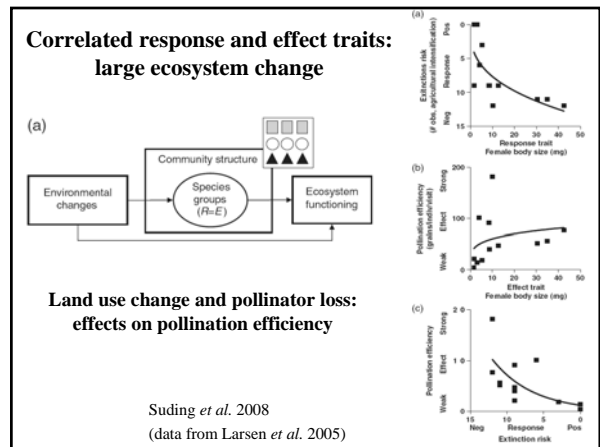
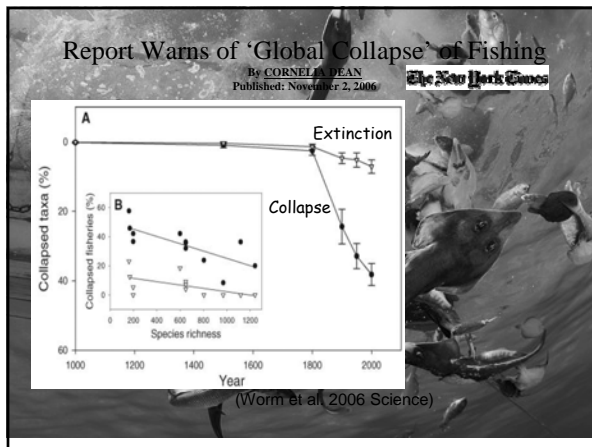
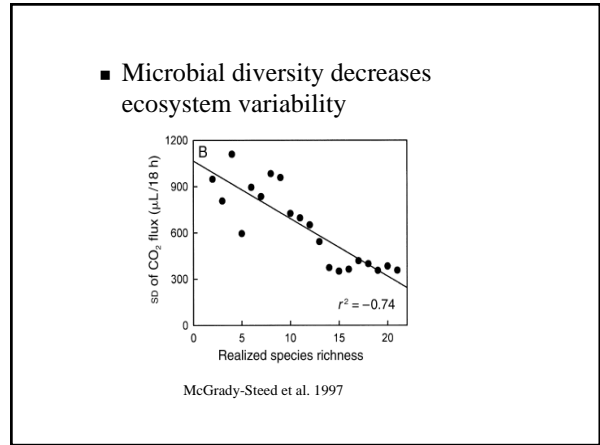
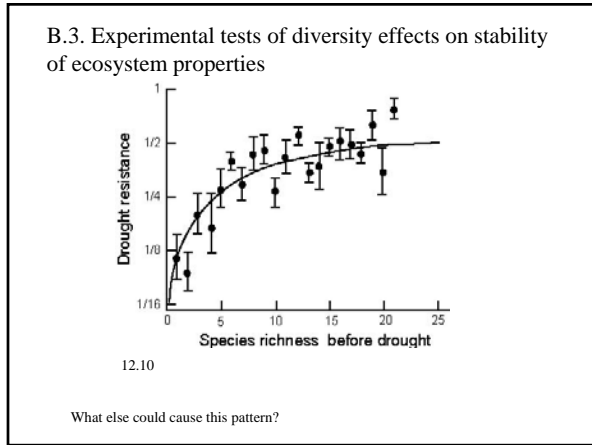
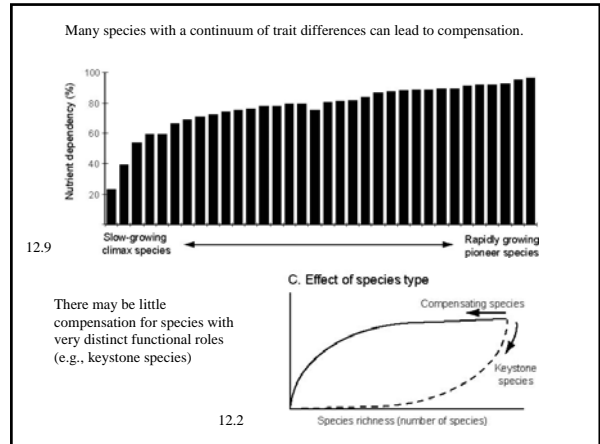
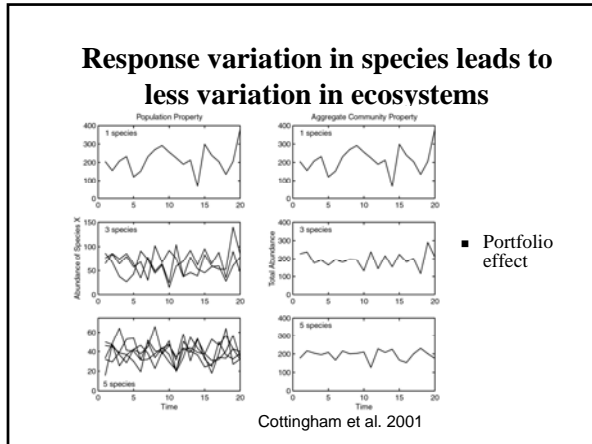
### Aboveground Productivity 1999



### B. Stability of ecosystem properties

1. Different kinds of stability
  - a. Resistance
  - b. Resilience
2. Mechanisms of diversity effects
  - a. Compensation







## **C. Synthesis of diversity effects**

- Figure from Field 1996
  - One year/one site
  - Zone accessible to intensive management
  - + site to site variation
  - + year to year variation
  - + different successional stages
  - Without knowledge of exact functional roles

## **Summary**

- Differences in species functional traits can influence ecosystem properties (effect and response groups)
- Direct effects and effects on interactive controls (climate, disturbance, resource availability)
- Diversity effects
  - Magnitudes of processes
  - Stability of processes
  - Understanding mechanisms needs critical evaluation of alternative hypotheses.