

# Ecological Principles for Natural Resource Management

- Objectives
  - Basic ecological principles that are important for understanding natural resources and their management
    - Plant and ecosystem focus

# Ecological Principles for Natural Resource Management

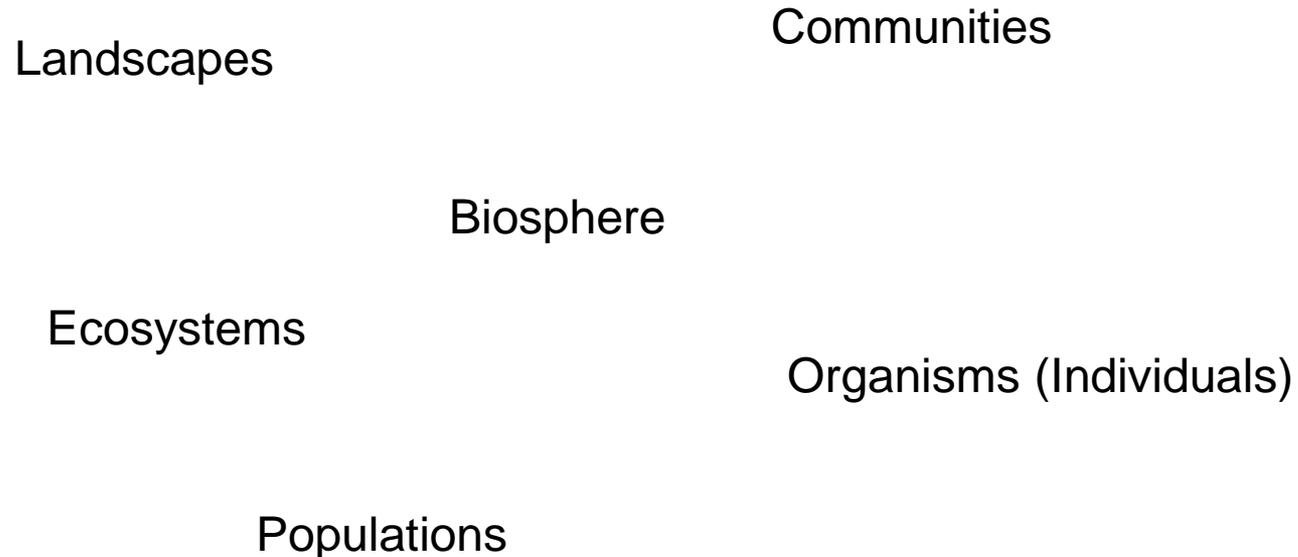
- Definitions
  - *Natural resources*
  - *Natural resource management*
    - *Renewable vs. nonrenewable*
    - *Sustainable vs. non-sustainable*

# Ecological Principles for Natural Resource Management

- Definitions
  - *Ecology*
  - *Ecological Hierarchy*

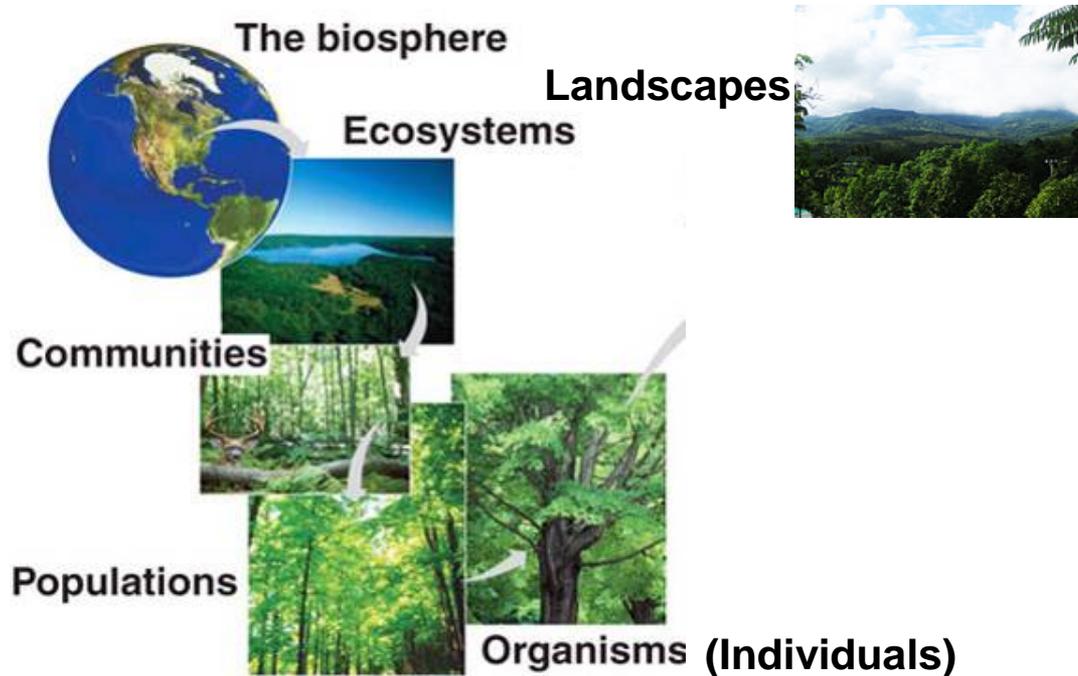
# Ecological Principles for Natural Resource Management

- Ecological Hierarchy



# Ecological Principles for Natural Resource Management

- Ecological Hierarchy



# Ecological Principles for Natural Resource Management

- Definitions
  - *Ecosystem ecology*
  - *Ecosystem*
    - *Biotic components*
    - *Abiotic components*
    - *Ecosystem Attributes*

# Ecological Principles for Natural Resource Management

## • Spatial scales of Ecosystems

a) Global ecosystem

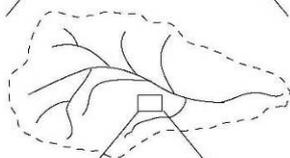
5,000 km



How does carbon loss from plowed soils influence global climate?

b) Watershed

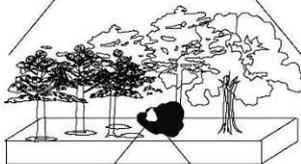
10 km



How does deforestation influence the water supply to neighboring towns?

c) Forest ecosystem

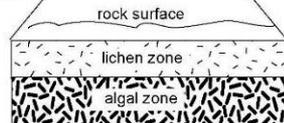
1 km



How does acid rain influence forest productivity?

d) Endolithic ecosystem

1 mm

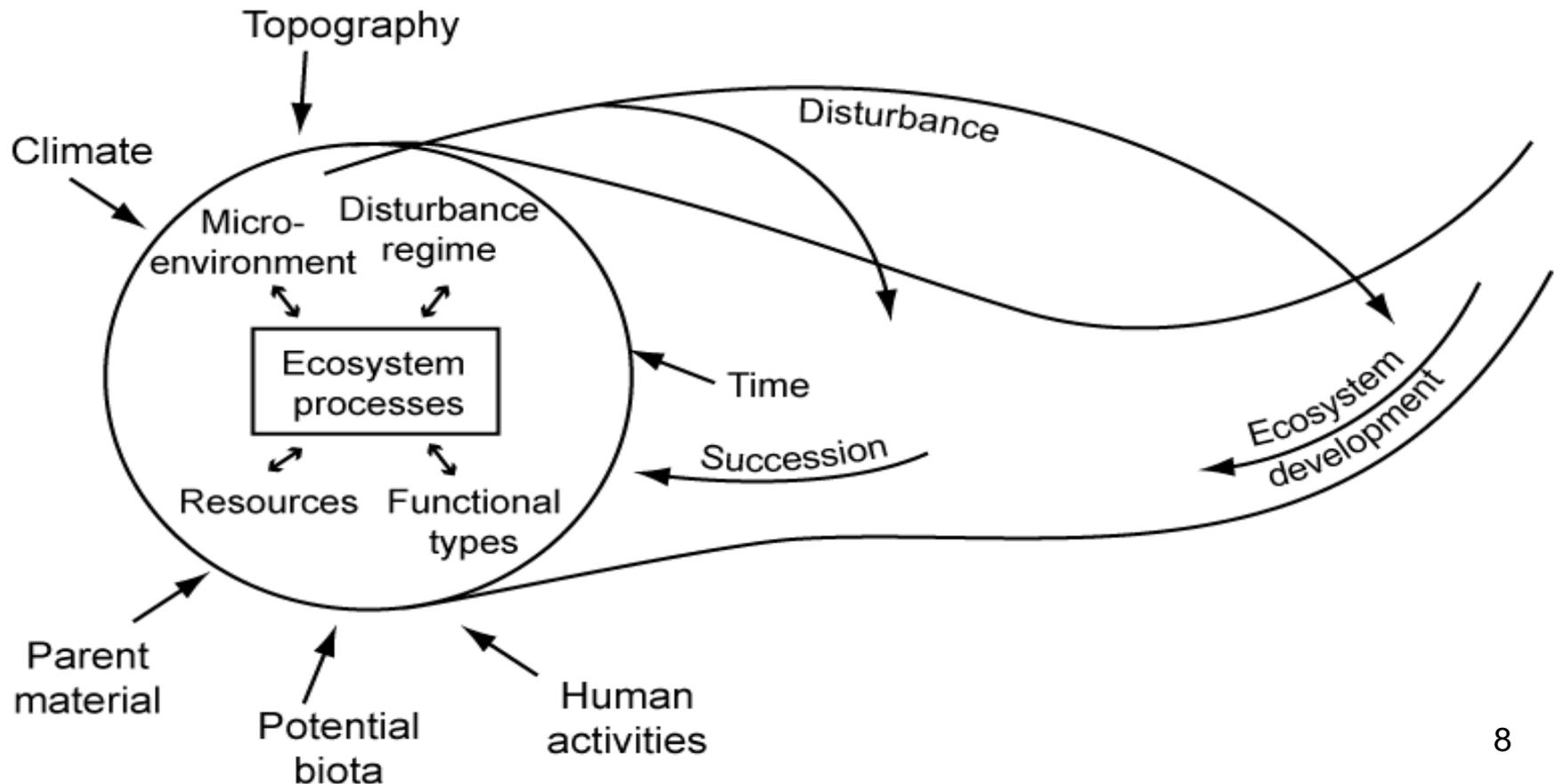


What are the biological controls over rock weathering?



# Ecological Principles for Natural Resource Management

- Ecosystem (& Soil) Development & Processes



# Ecological Principles for Natural Resource Management

- Climate - Solar Radiation

- Earth's solar energy budget

- Over a year, Inputs  $\approx$  Outputs

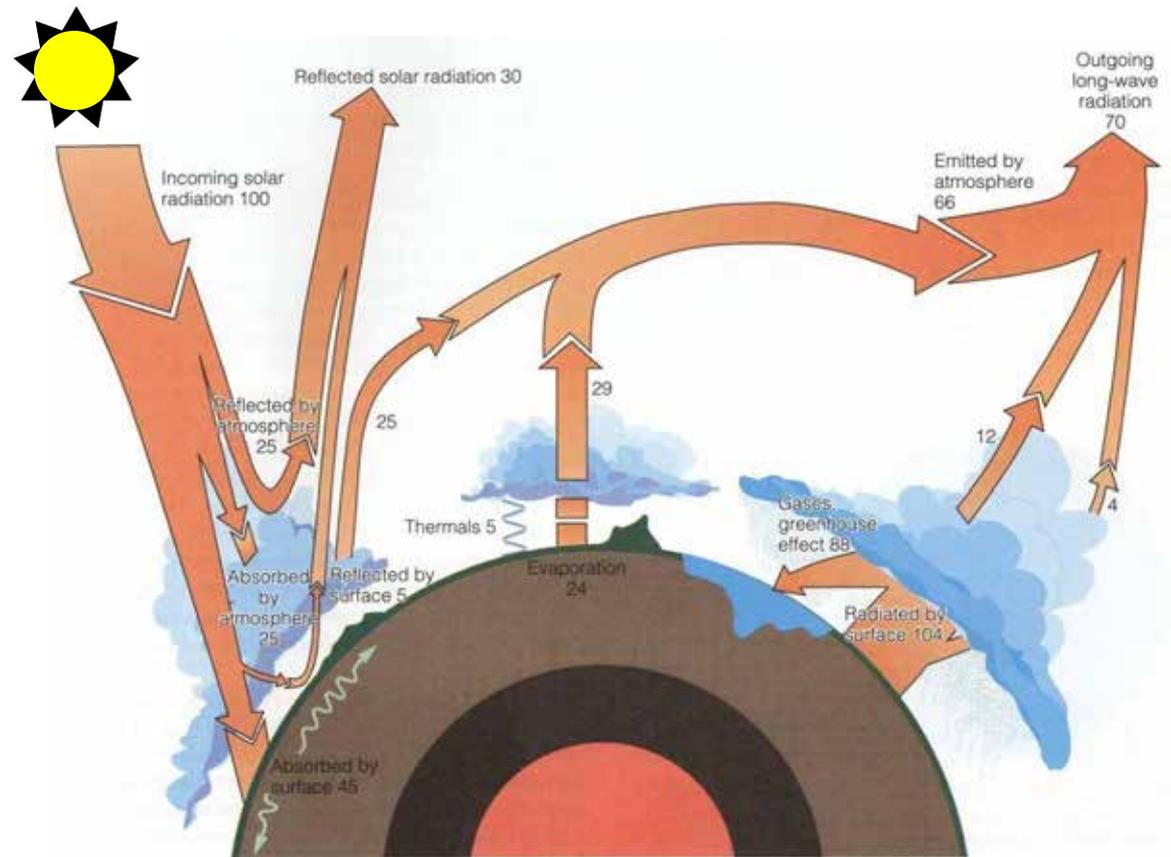
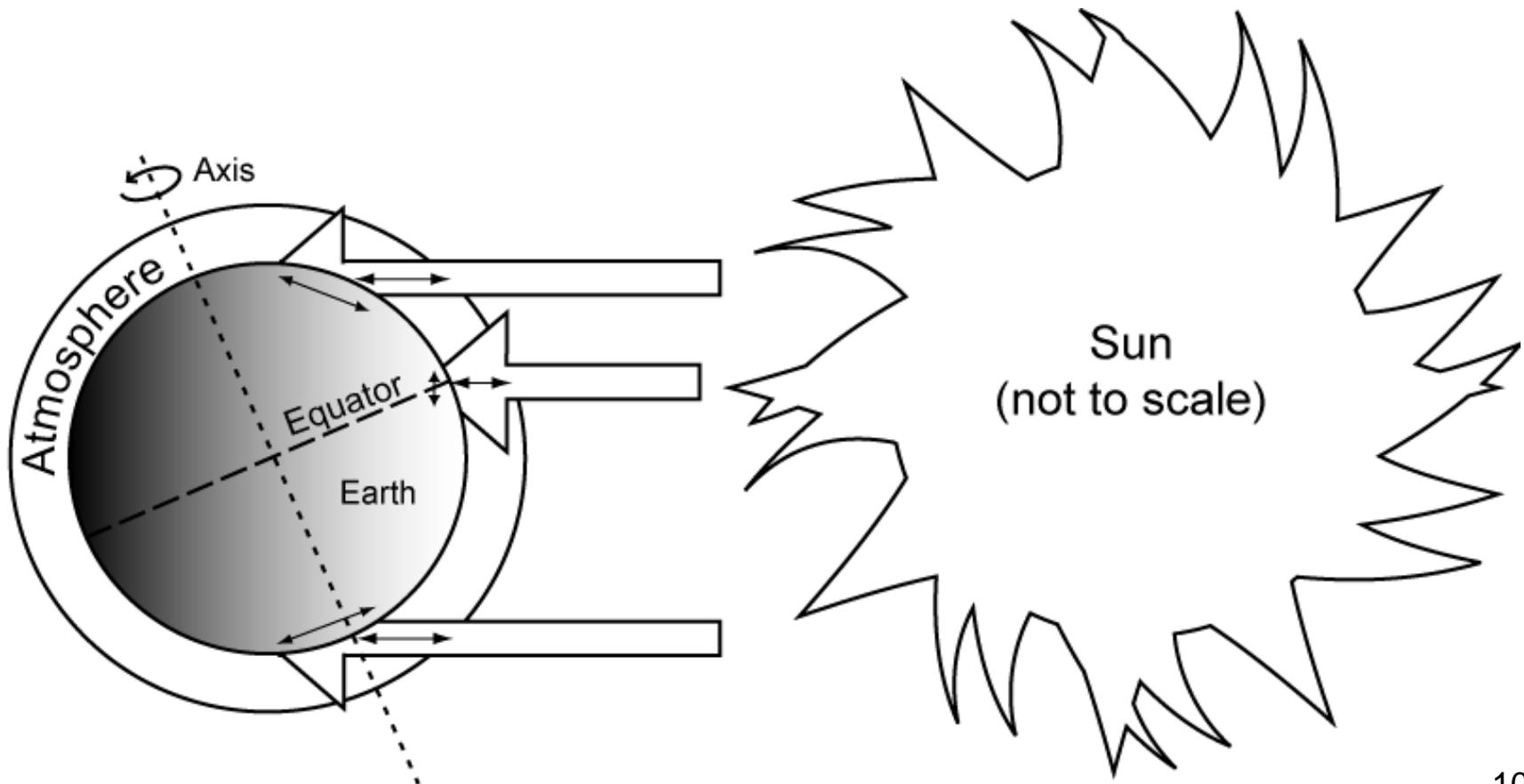


Figure 4.1 Disposition of solar energy reaching Earth's atmosphere.

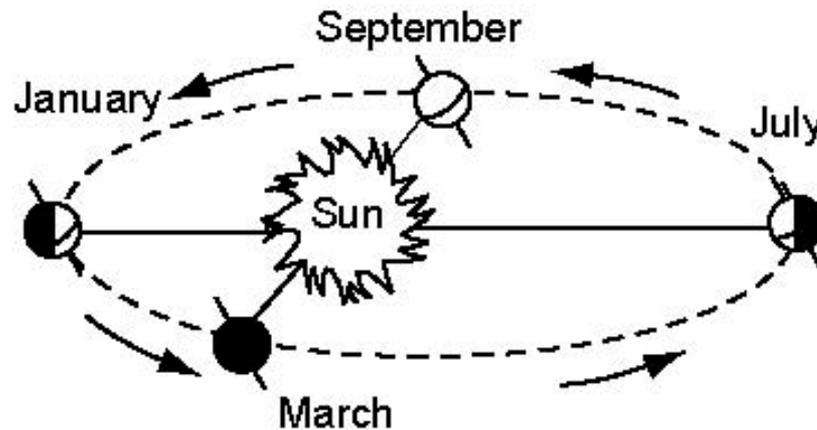
# Ecological Principles for Natural Resource Management

- Climate - Solar Radiation



# Ecological Principles for Natural Resource Management

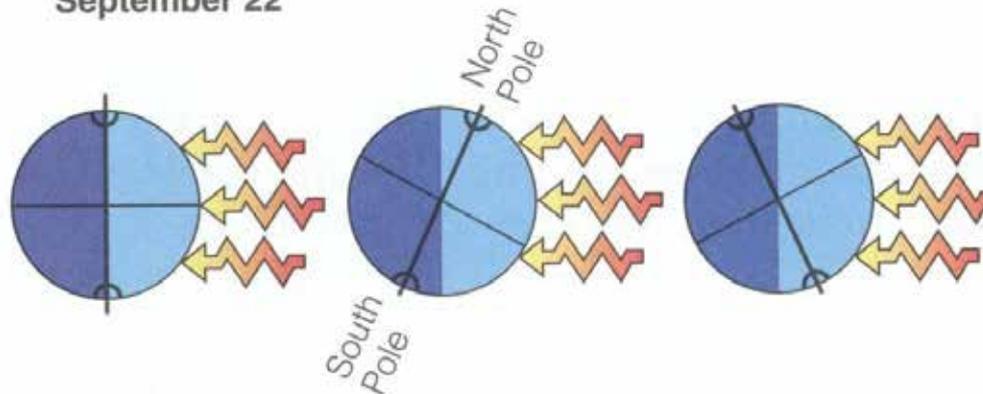
- Climate - Solar Radiation



(a) March 21 or  
September 22

(b) June 22

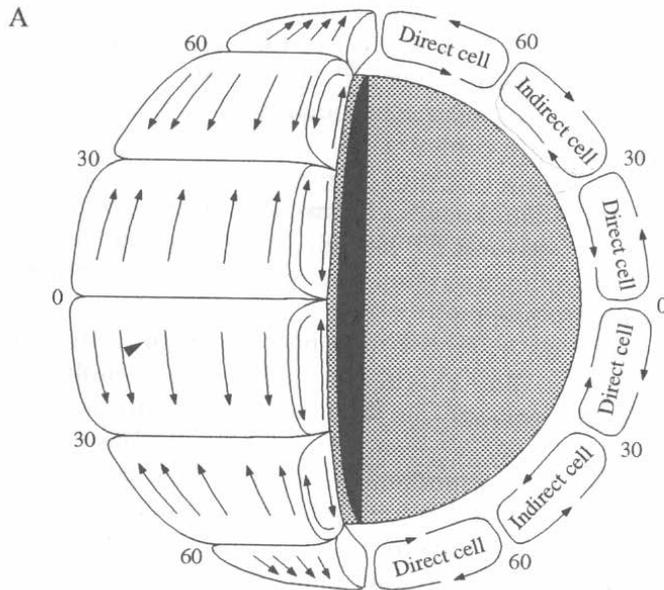
(c) December 22



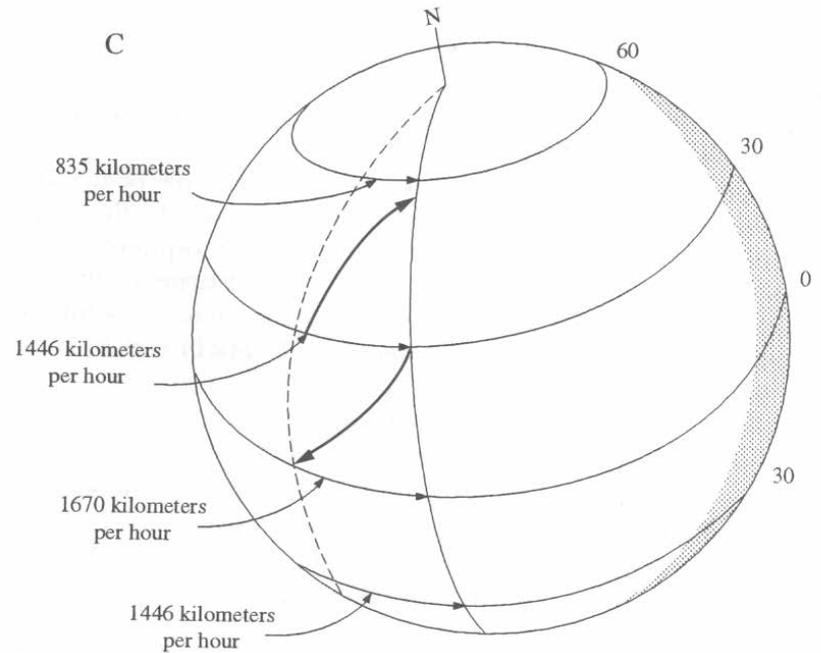
# Ecological Principles for Natural Resource Management

- Climate - Solar Radiation

Hadley Cell Circulation

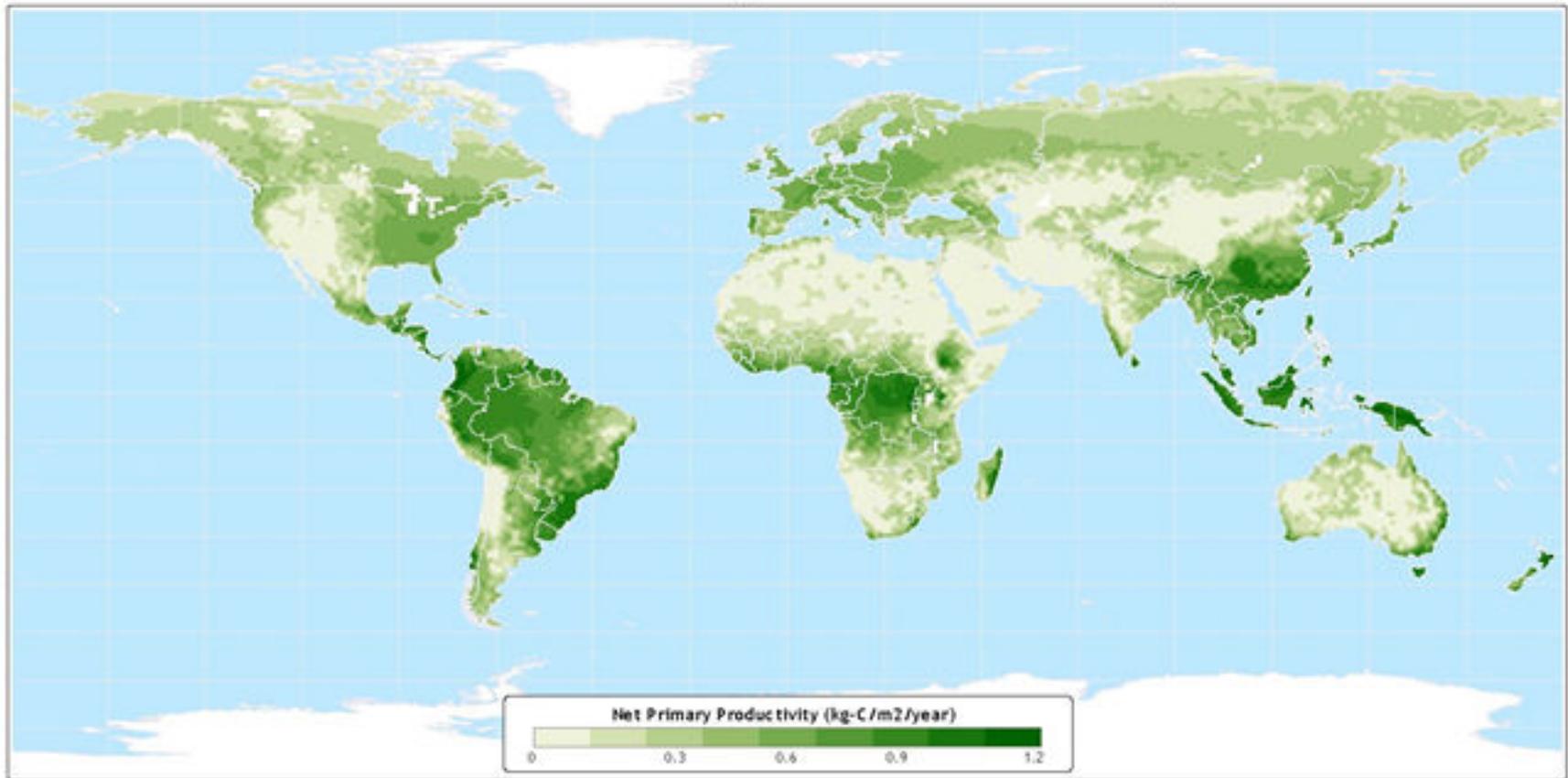


Coriolis Effect



Where is productivity highest? Lowest?  
What are the latitudinal patterns? Other patterns?

## Net Primary Productivity

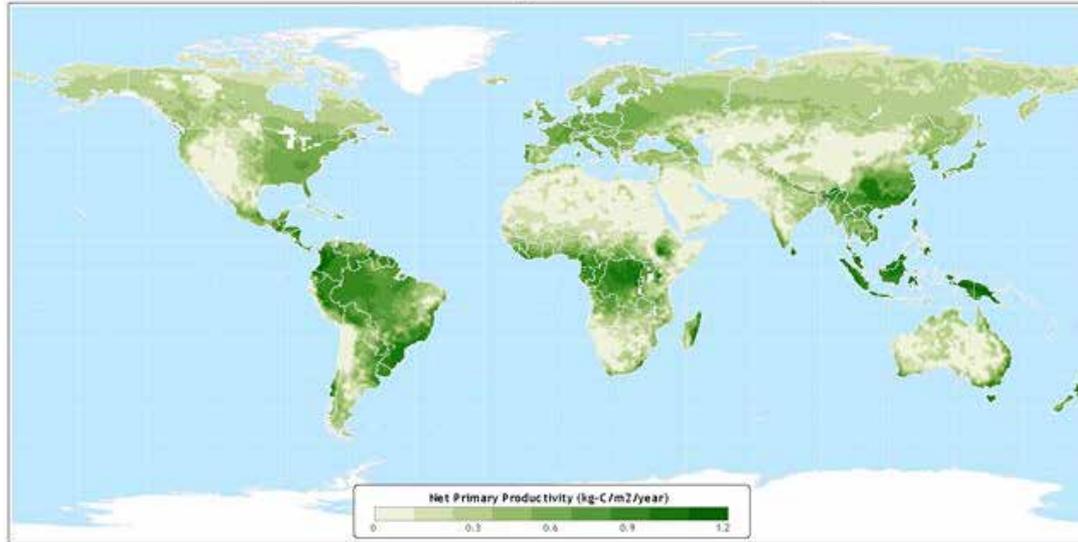


Data taken from: IBIS Simulation  
(Kucharik, et al. 2000)  
(Foley, et al. 1996)

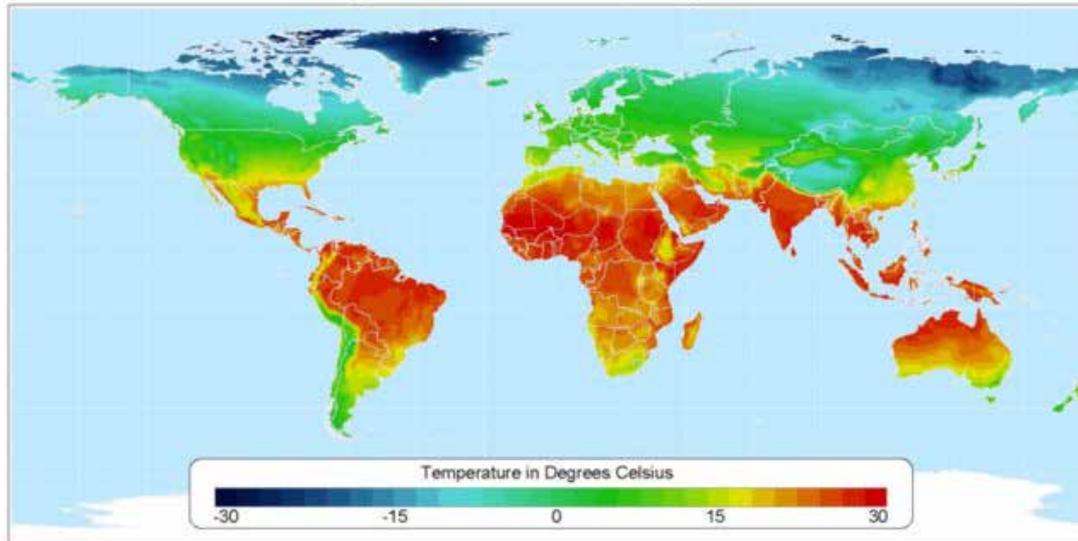
**Atlas of the Biosphere**  
Center for Sustainability and the Global Environment  
University of Wisconsin - Madison

# How do temperature patterns compare with those of NPP?

## Net Primary Productivity

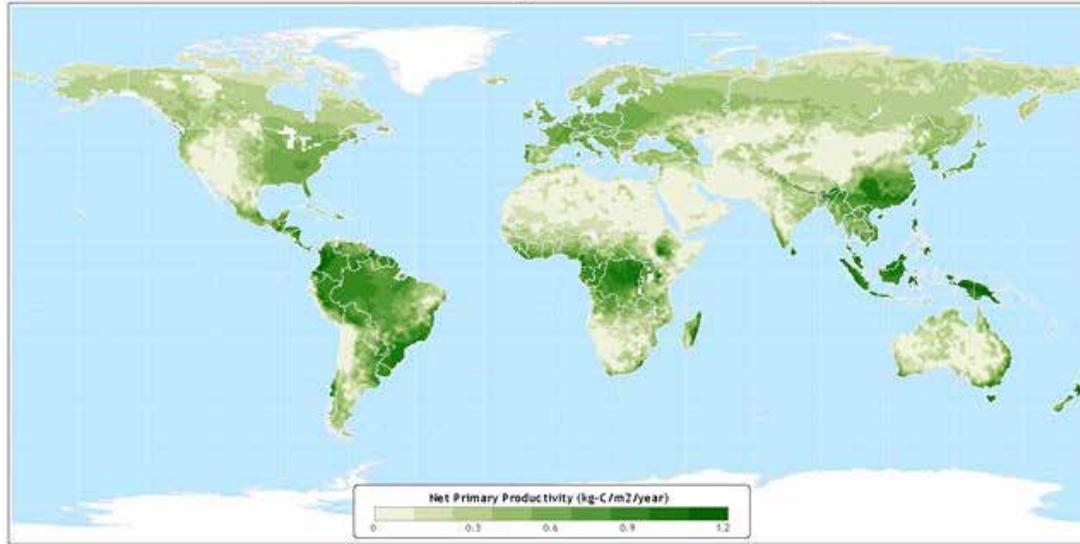


## Average Annual Temperature

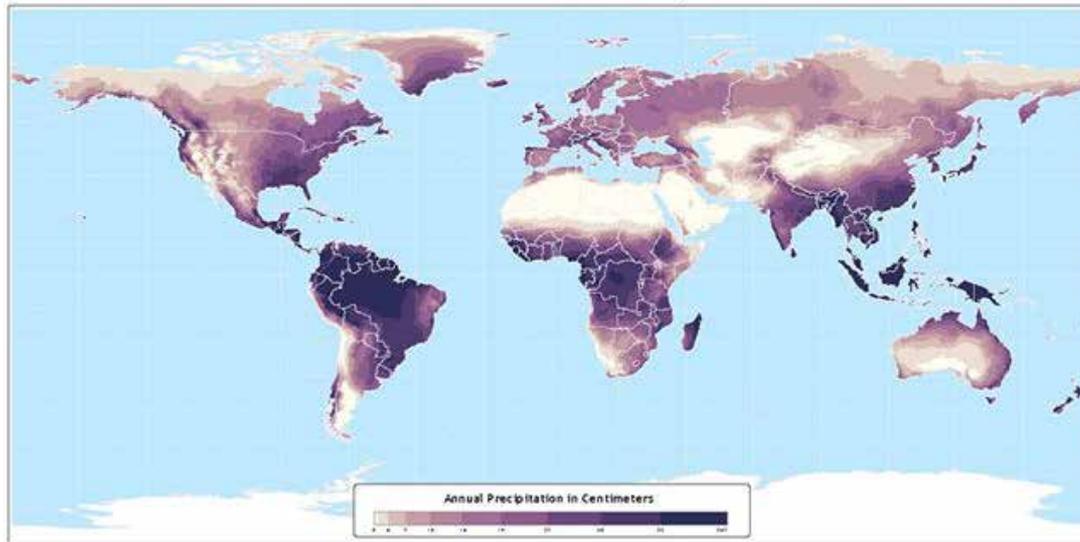


# How do precipitation patterns compare with those of NPP?

## Net Primary Productivity

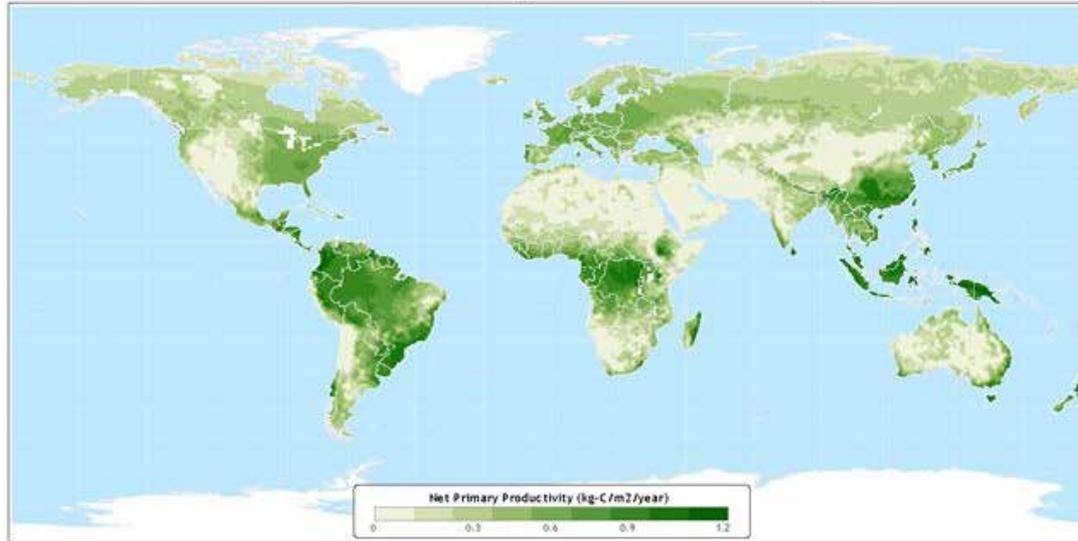


## Annual Total Precipitation

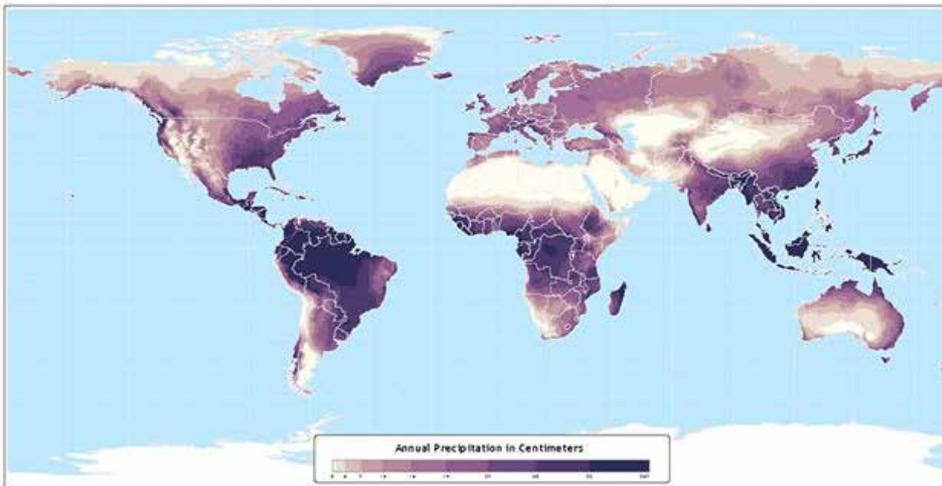


# Is temperature or precipitation a better predictor of NPP?

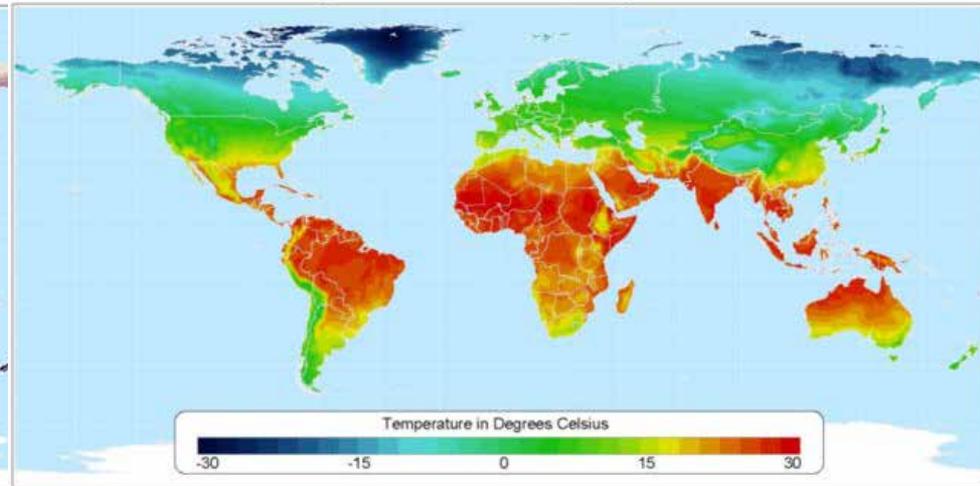
## Net Primary Productivity



## Annual Total Precipitation

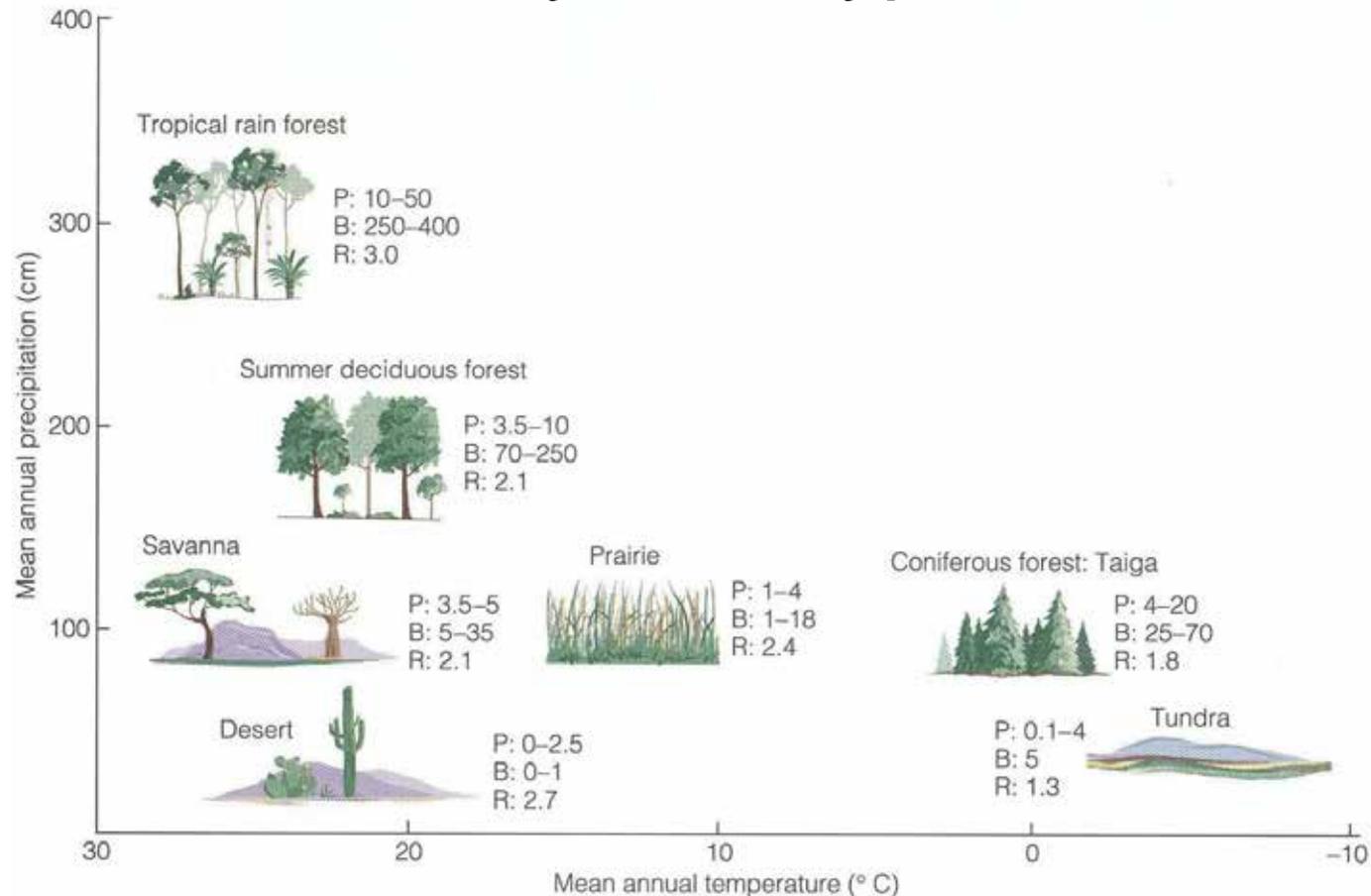


## Average Annual Temperature



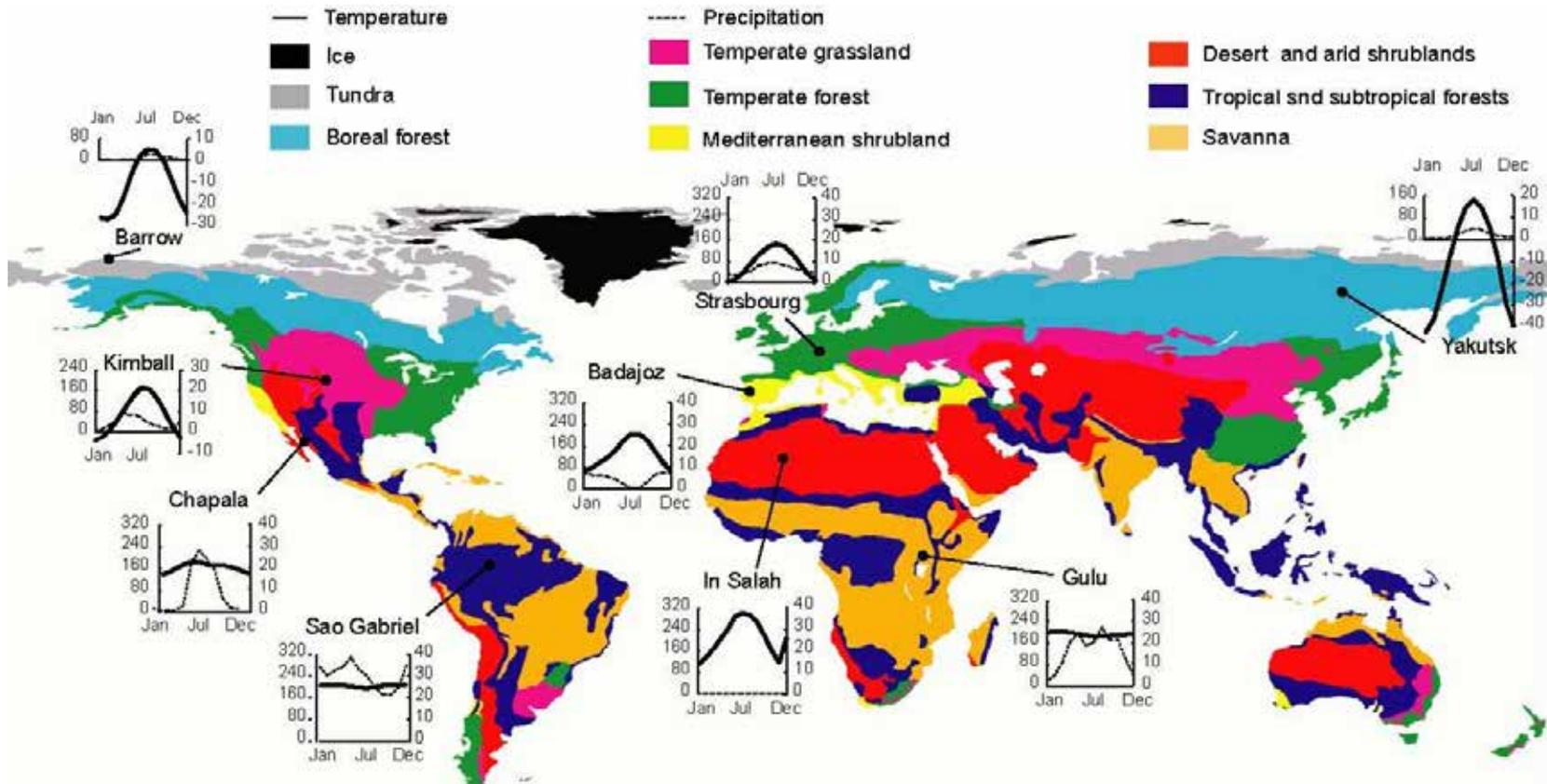
# Ecological Principles for Natural Resource Management

- Climate - Ecosystem Types



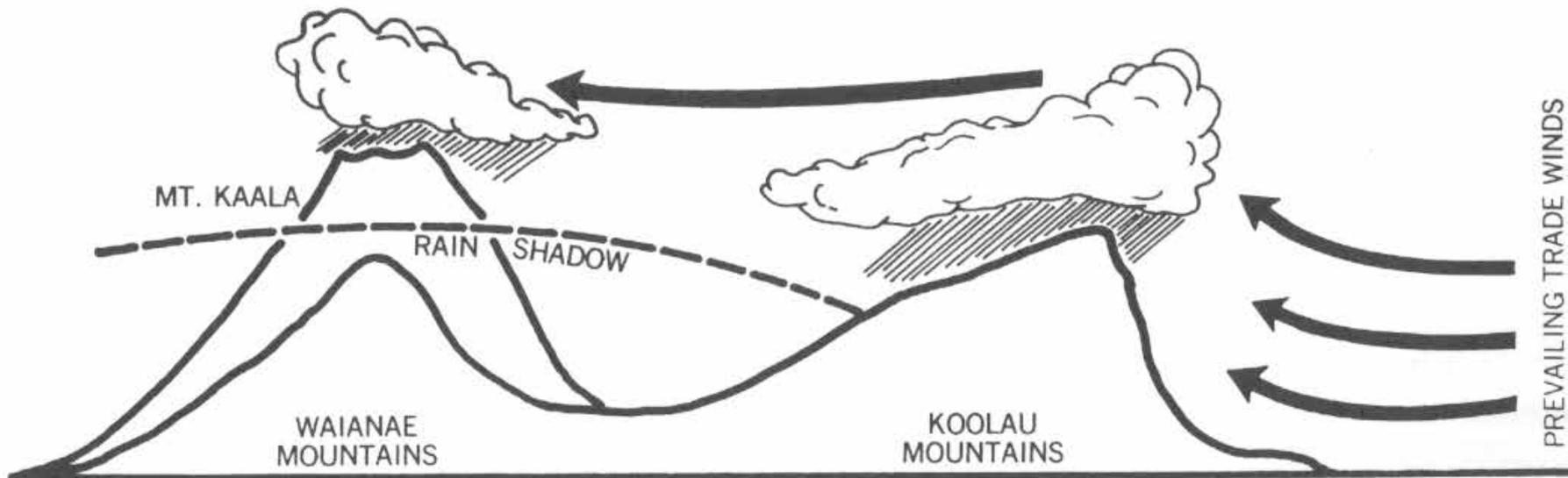
# Ecological Principles for Natural Resource Management

- Climate - Global Biome Types



# Ecological Principles for Natural Resource Management

- Regional Climate - Orographic Effect
  - Oahu



# Life Zone Map of O'ahu

Based on the World Life Zone System of L. R. Holdridge

TROPICAL SCIENCE CENTER  
 Geographic Information System Unit  
 San Jose, Costa Rica  
 July 2001  
 sig@cct.or.cr



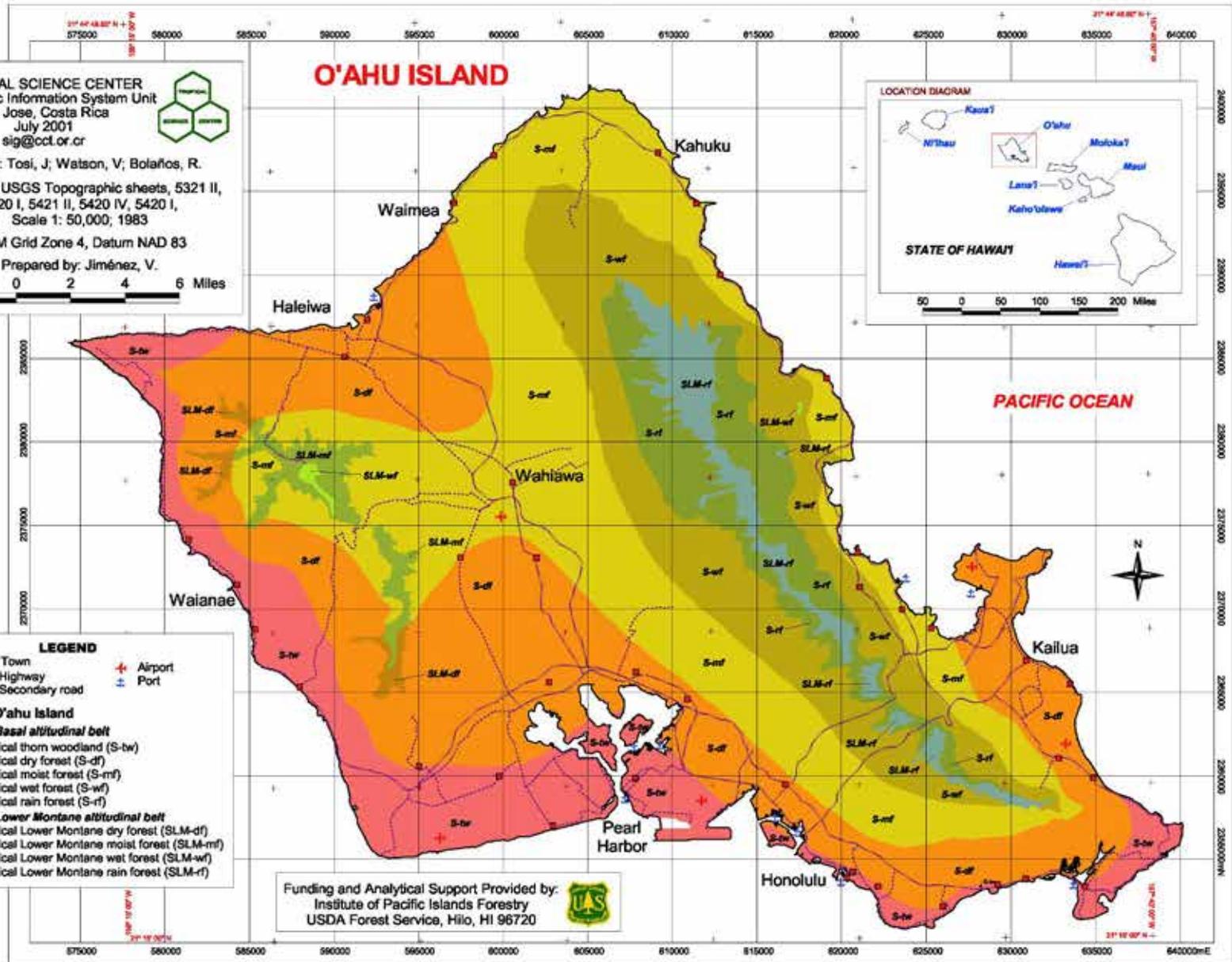
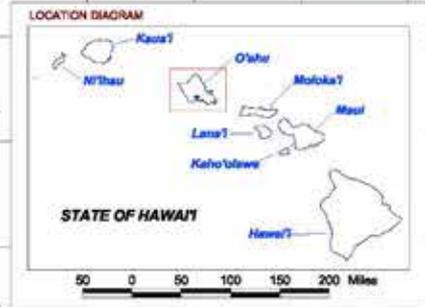
Author: Tosi, J; Watson, V; Bolaños, R.

Based on USGS Topographic sheets, 5321 II,  
 5320 I, 5421 II, 5420 IV, 5420 I,  
 Scale 1: 50,000, 1983

UTM Grid Zone 4, Datum NAD 83

Prepared by: Jiménez, V.

2 0 2 4 6 Miles



**LEGEND**

- Town
- + Airport
- + Port
- Highway
- Secondary road

**Life Zone O'ahu Island**

**Subtropical Basal altitudinal belt**

- Subtropical thorn woodland (S-tw)
- Subtropical dry forest (S-df)
- Subtropical moist forest (S-mf)
- Subtropical wet forest (S-wf)
- Subtropical rain forest (S-rf)

**Subtropical Lower Montane altitudinal belt**

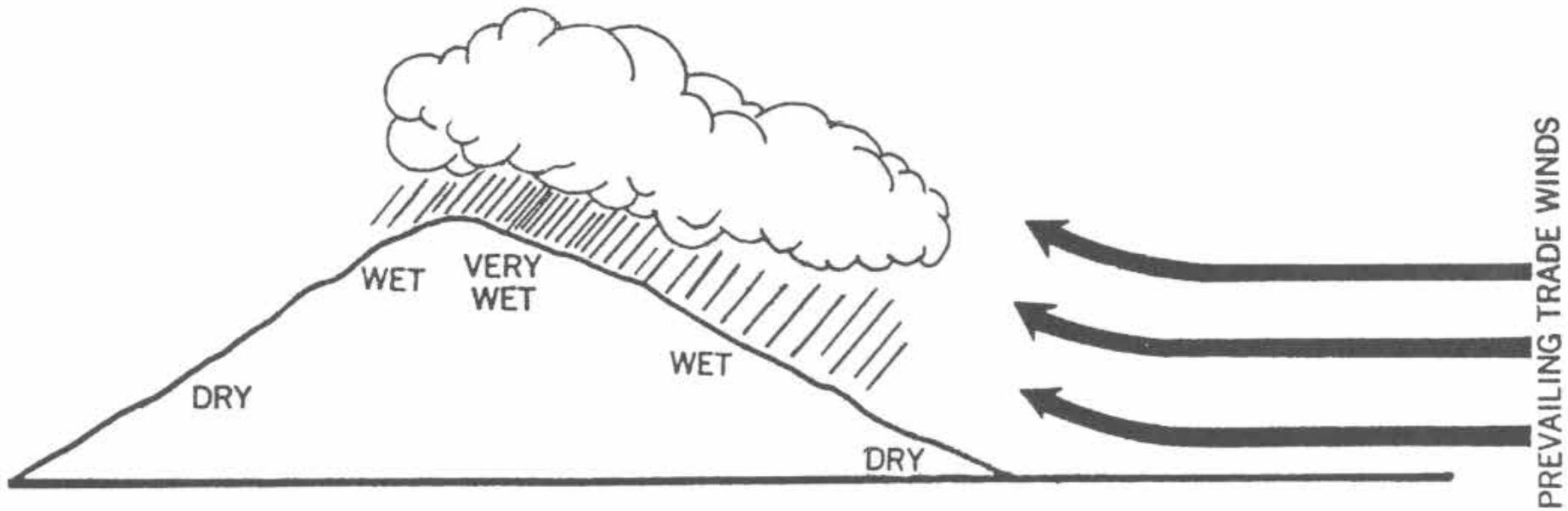
- Subtropical Lower Montane dry forest (SLM-df)
- Subtropical Lower Montane moist forest (SLM-mf)
- Subtropical Lower Montane wet forest (SLM-wf)
- Subtropical Lower Montane rain forest (SLM-rf)

Funding and Analytical Support Provided by:  
 Institute of Pacific Islands Forestry  
 USDA Forest Service, Hilo, HI 96720



# Ecological Principles for Natural Resource Management

- Regional Climate - Orographic Effect  
– Hawaii



# Ecological Principles for Natural Resource Management

- Regional Climate - Orographic Effect



Leeward

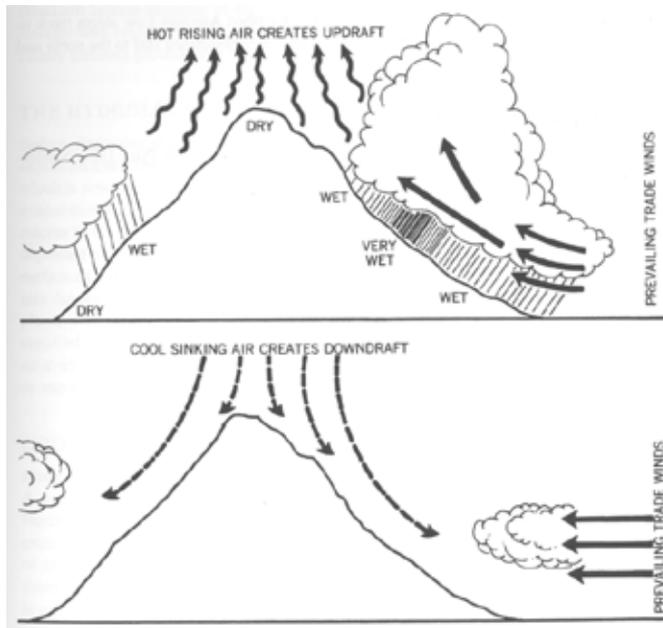


Windward

# Ecological Principles for Natural Resource Management

- Local Climate - Elevation & Aspect

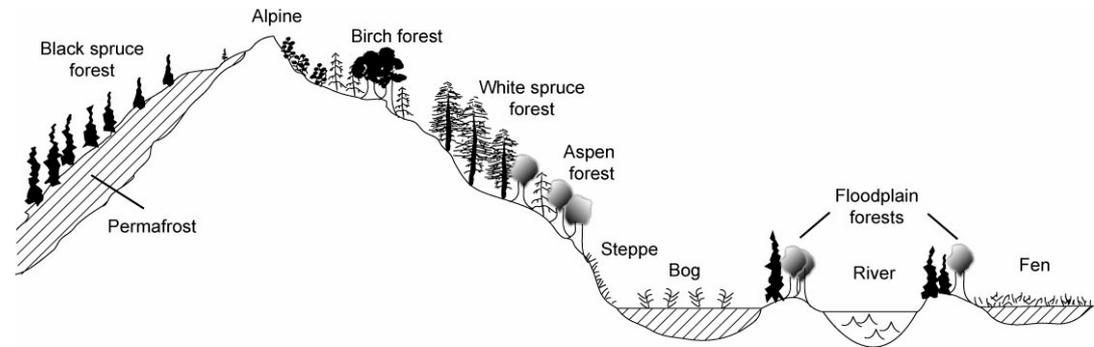
## Elevation



N

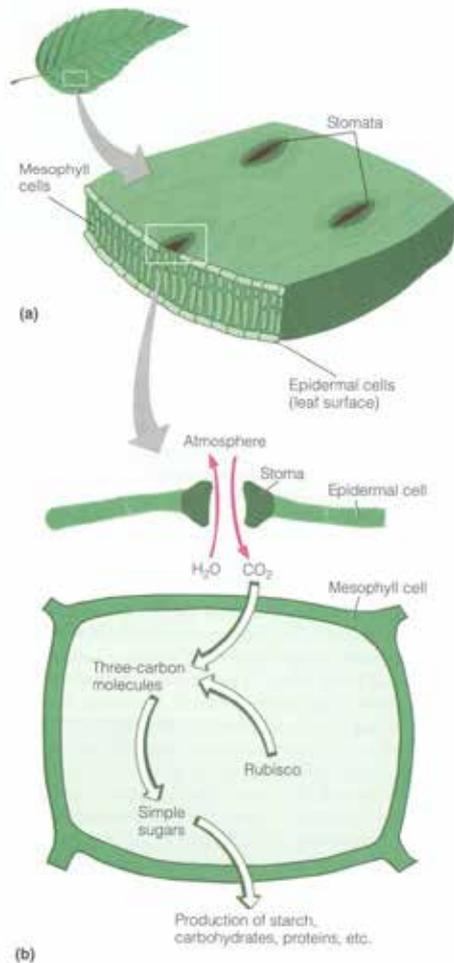
Aspect

S



# Ecological Principles for Natural Resource Management

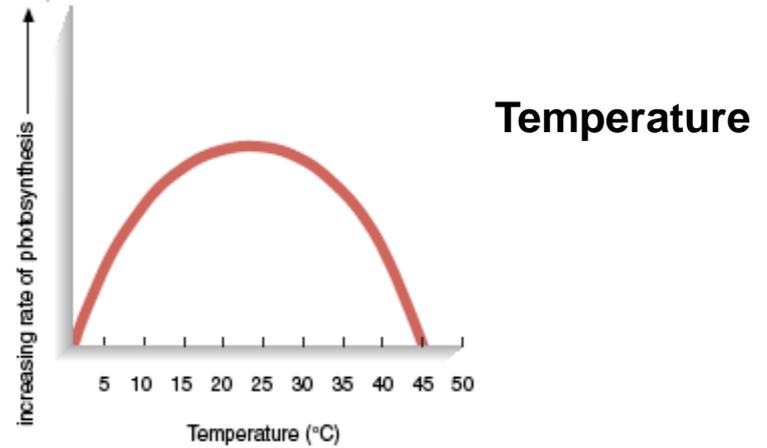
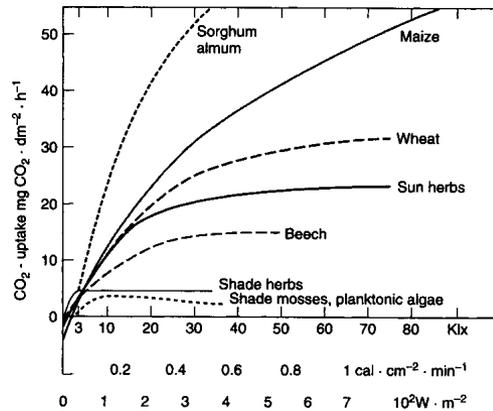
- Solar Radiation - Photosynthesis



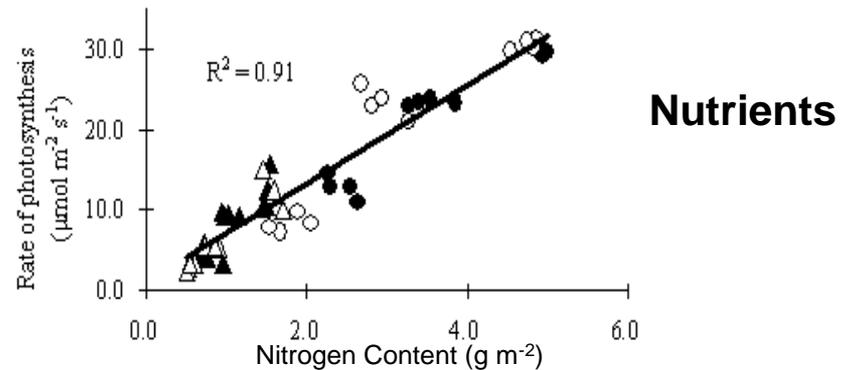
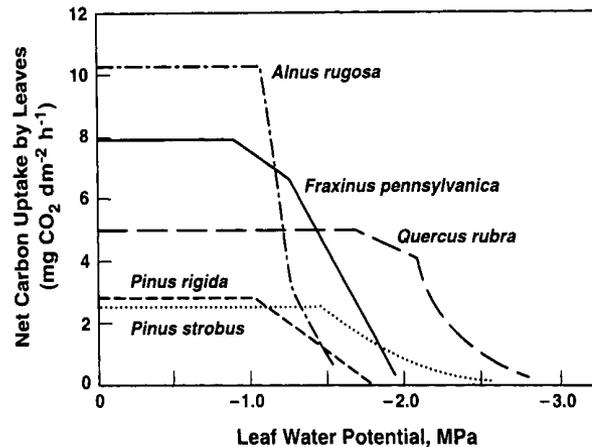
# Ecological Principles for Natural Resource Management

- Photosynthesis

Light



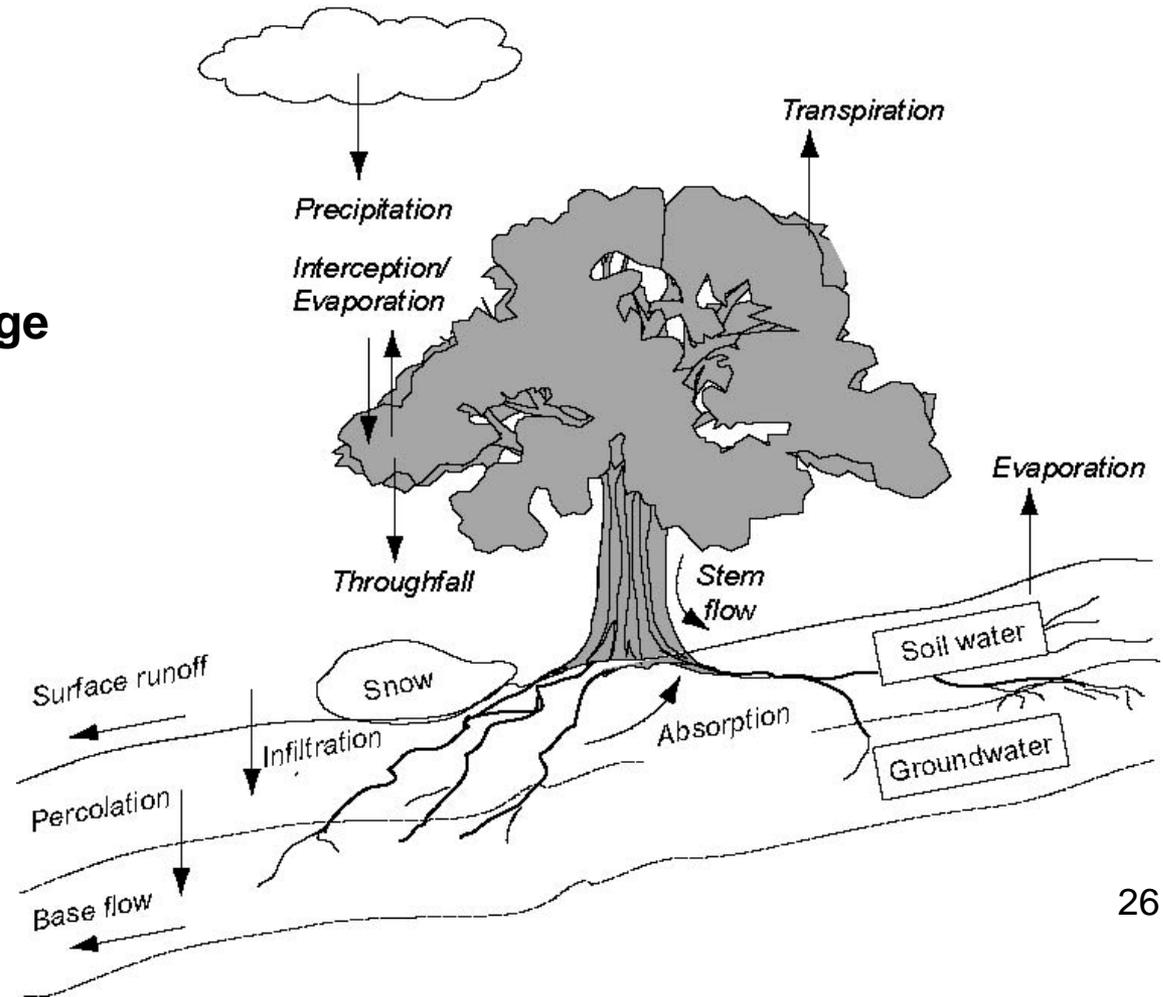
H<sub>2</sub>O



# Ecological Principles for Natural Resource Management

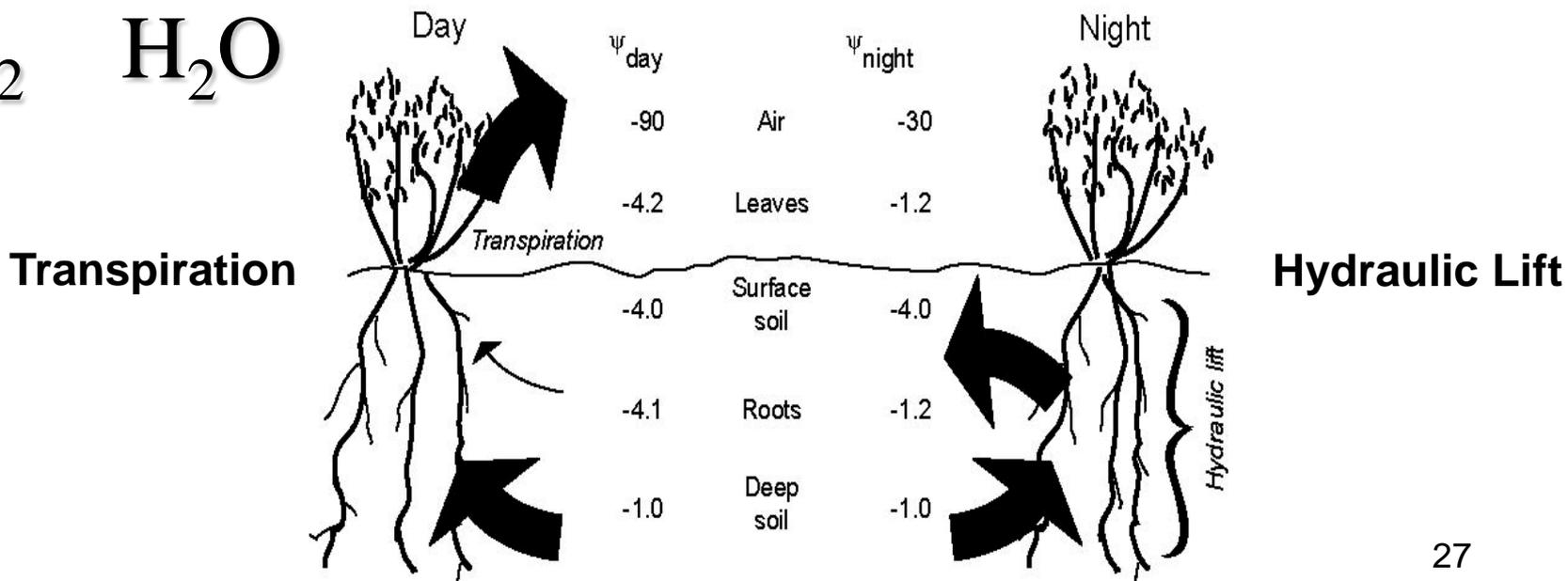
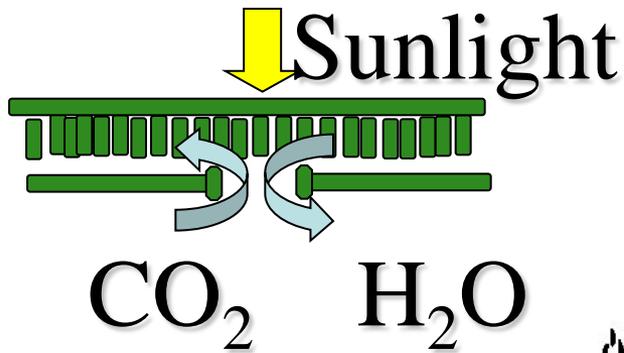
- Ecosystem Water Budget

Inputs - Outputs =  $\Delta$ Storage



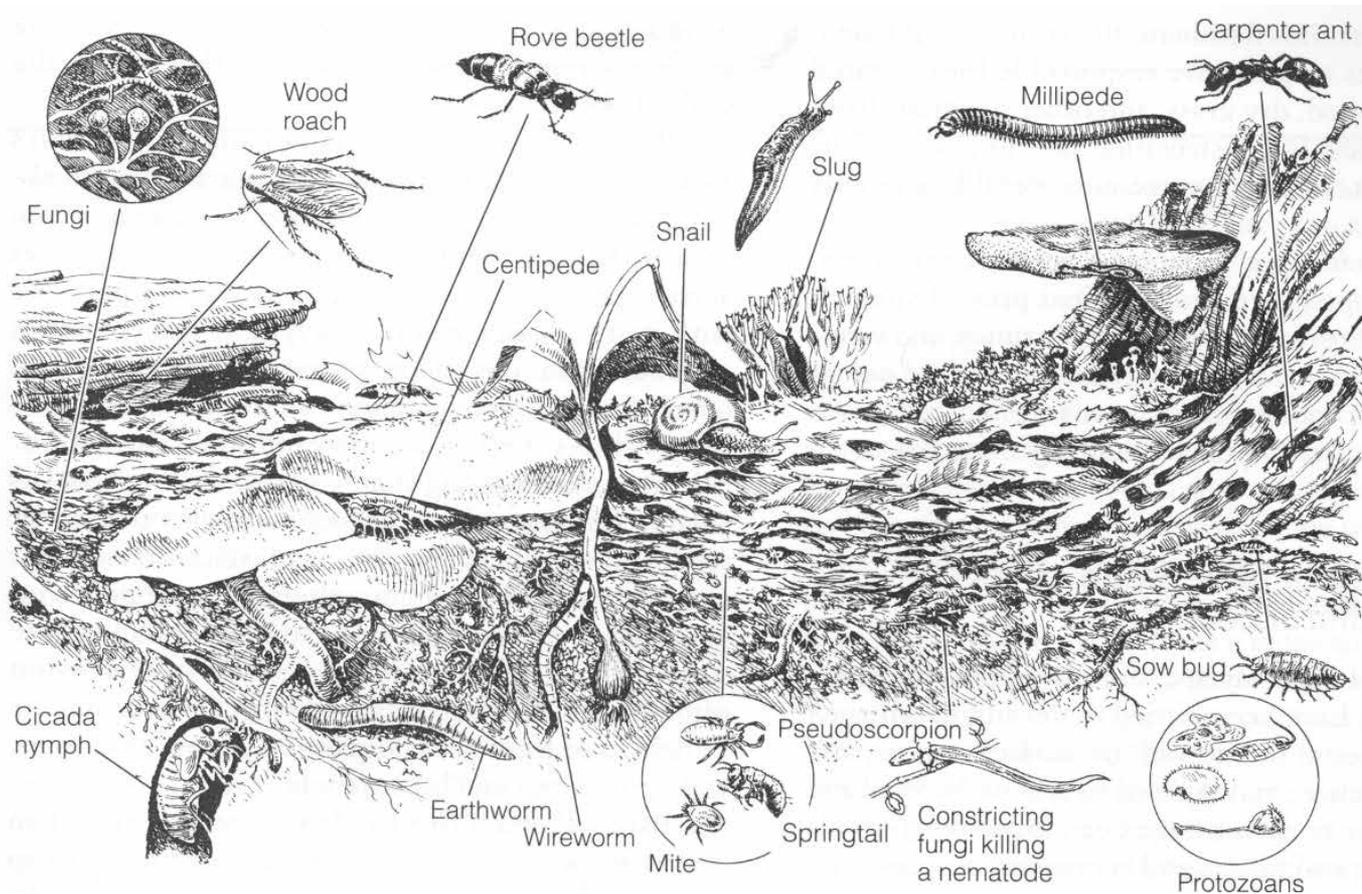
# Ecological Principles for Natural Resource Management

- Water Budget - Transpiration



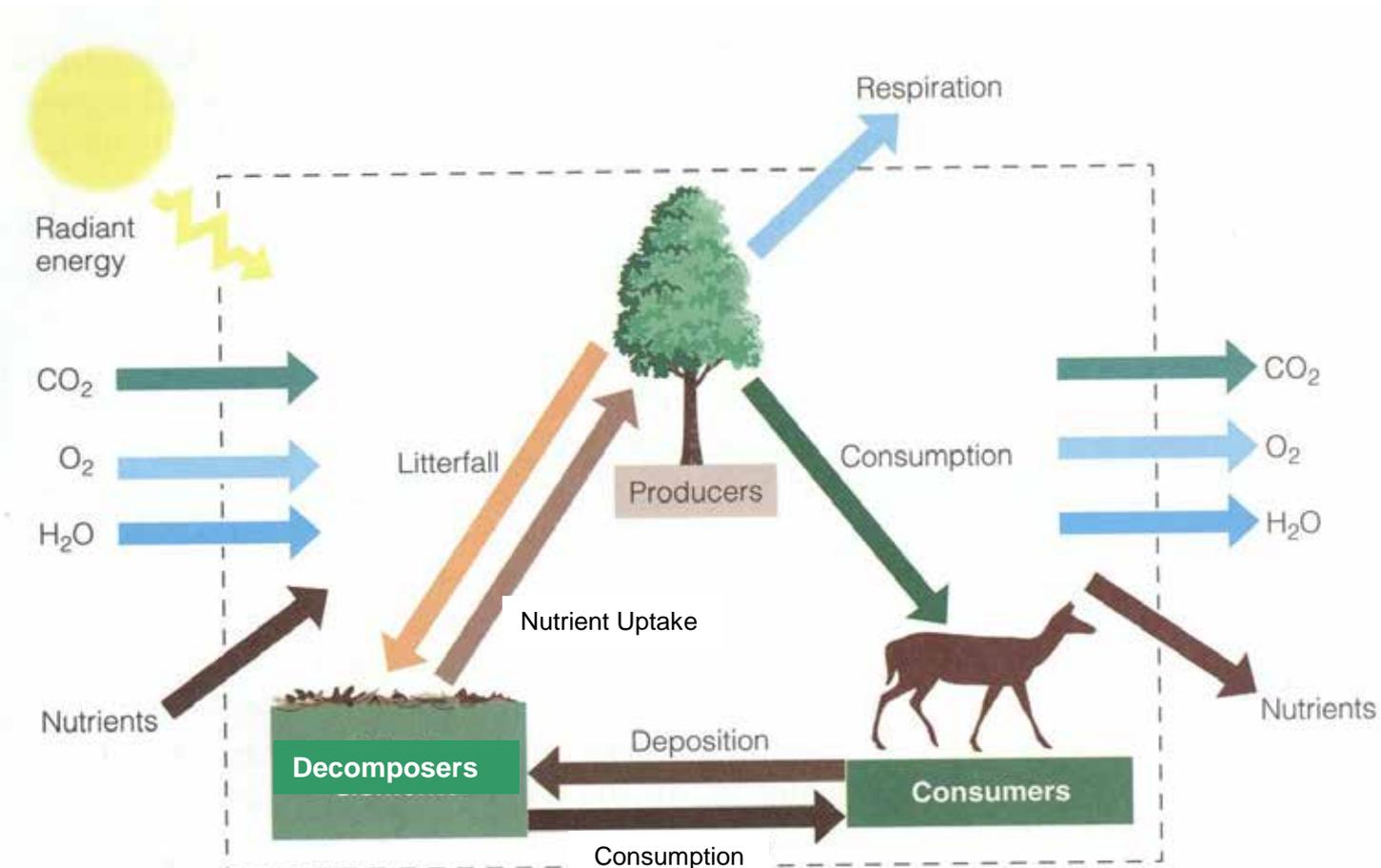
# Ecological Principles for Natural Resource Management

- Soils - So much more than dirt!



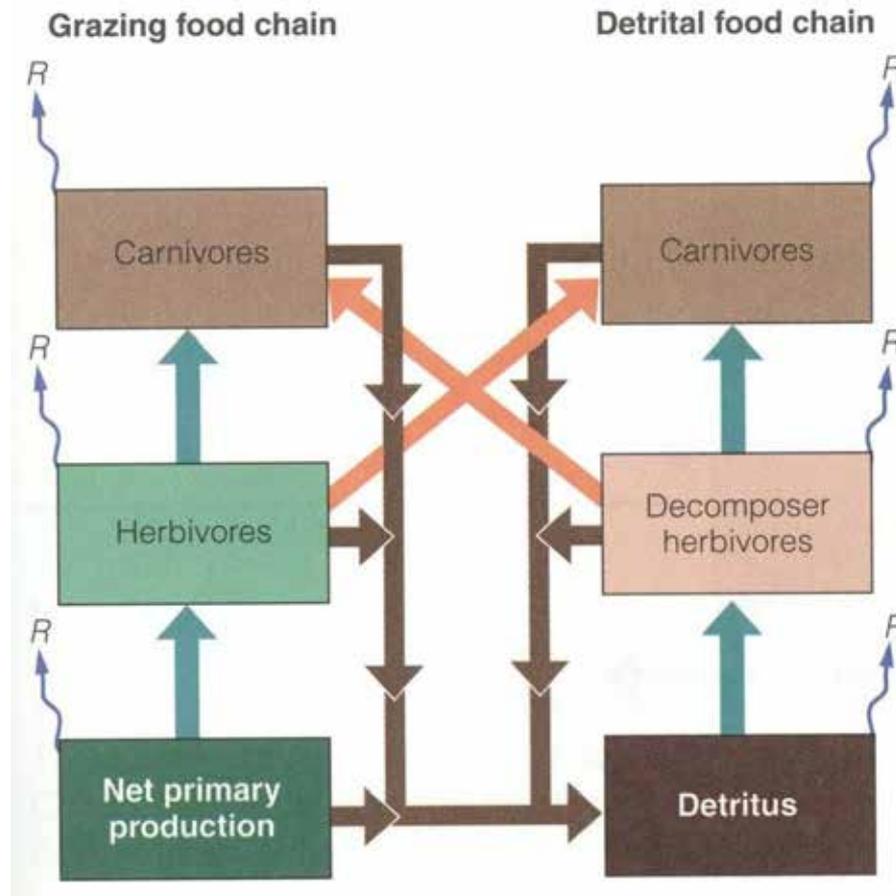
# Ecological Principles for Natural Resource Management

- Carbon Cycling - Energy cycling



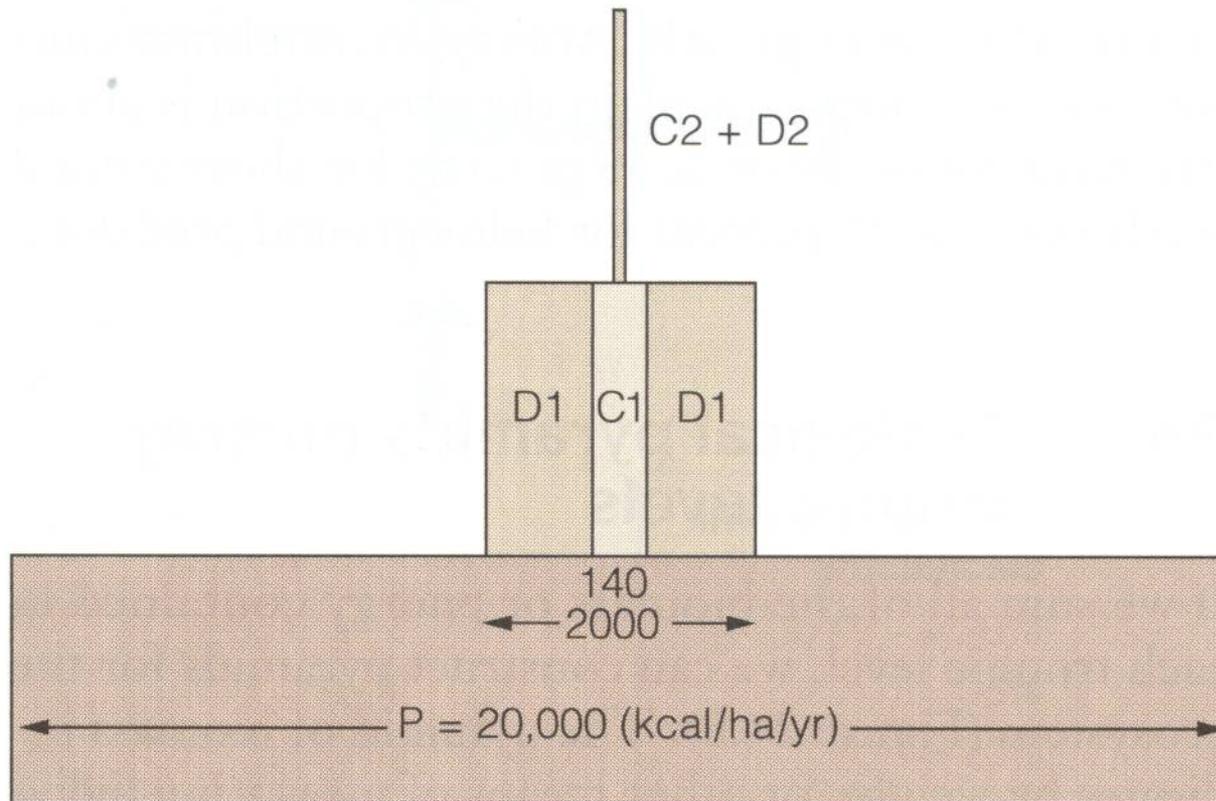
# Ecological Principles for Natural Resource Management

- Carbon Cycling - Trophic Chains



# Ecological Principles for Natural Resource Management

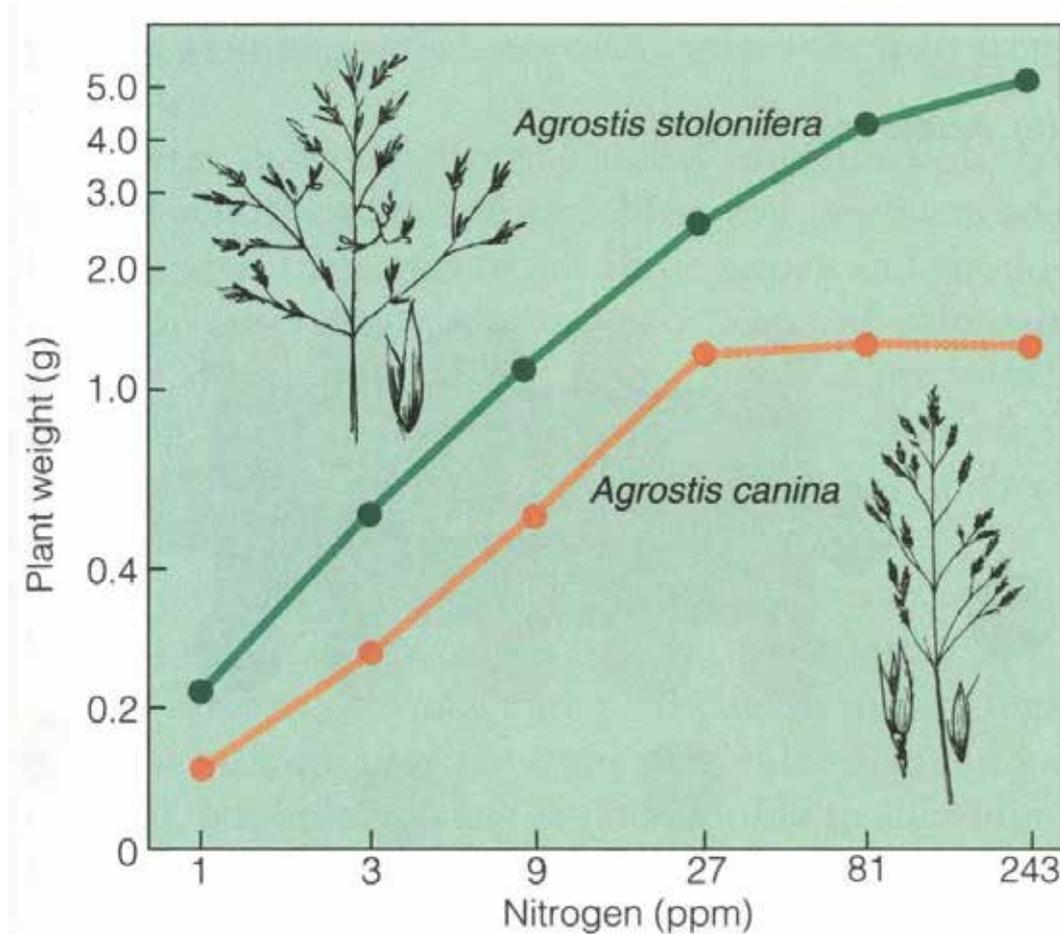
- Carbon Cycling - Trophic Pyramid



(b)

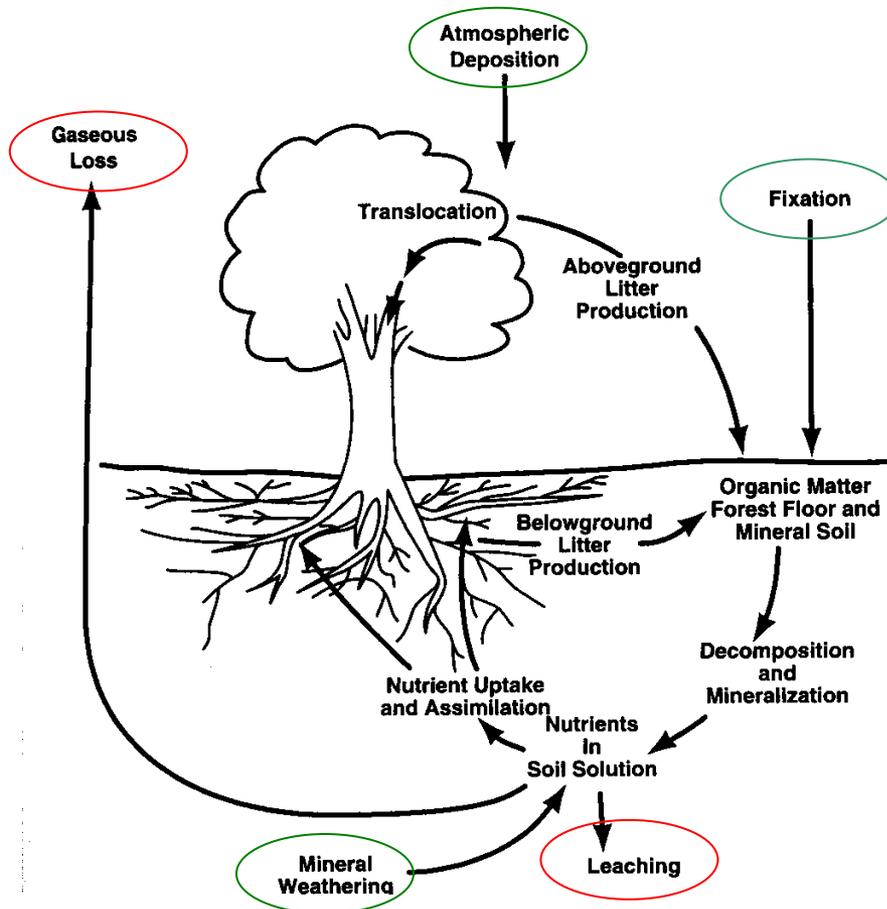
# Ecological Principles for Natural Resource Management

- Nutrient Cycling & Uptake



# Ecological Principles for Natural Resource Management

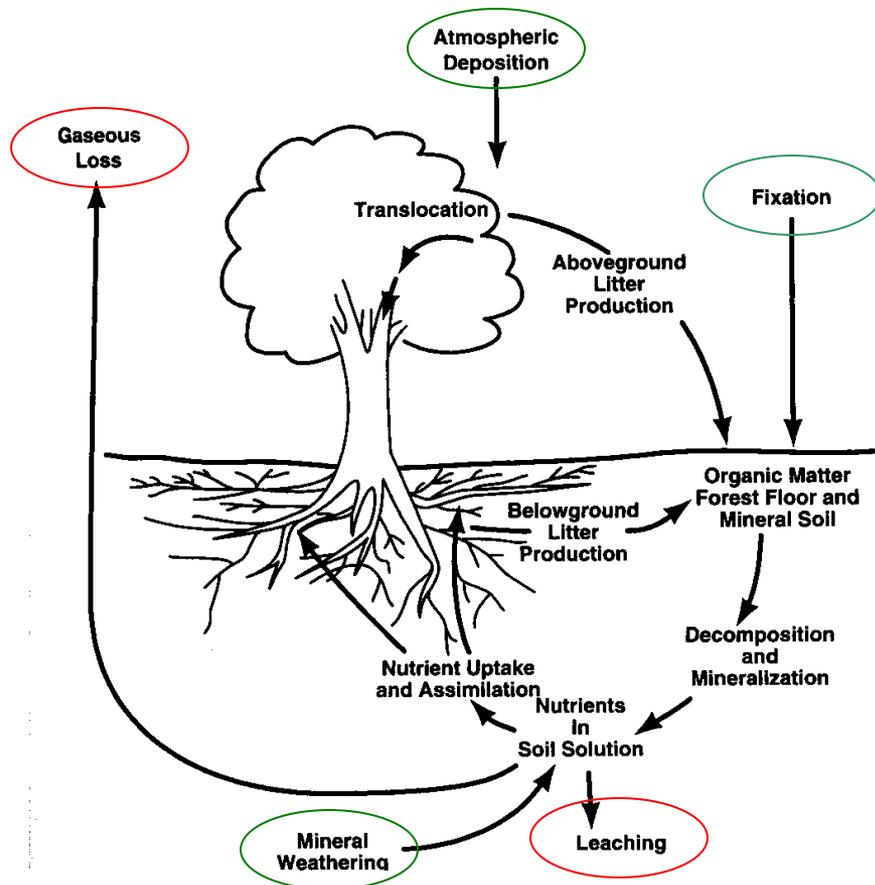
- Nutrient Cycling & Uptake



$$\text{Inputs} - \text{Outputs} = \text{DS}$$

# Ecological Principles for Natural Resource Management

- Nutrient Cycling & Uptake



$$\text{Inputs} - \text{Outputs} = \text{DS}$$

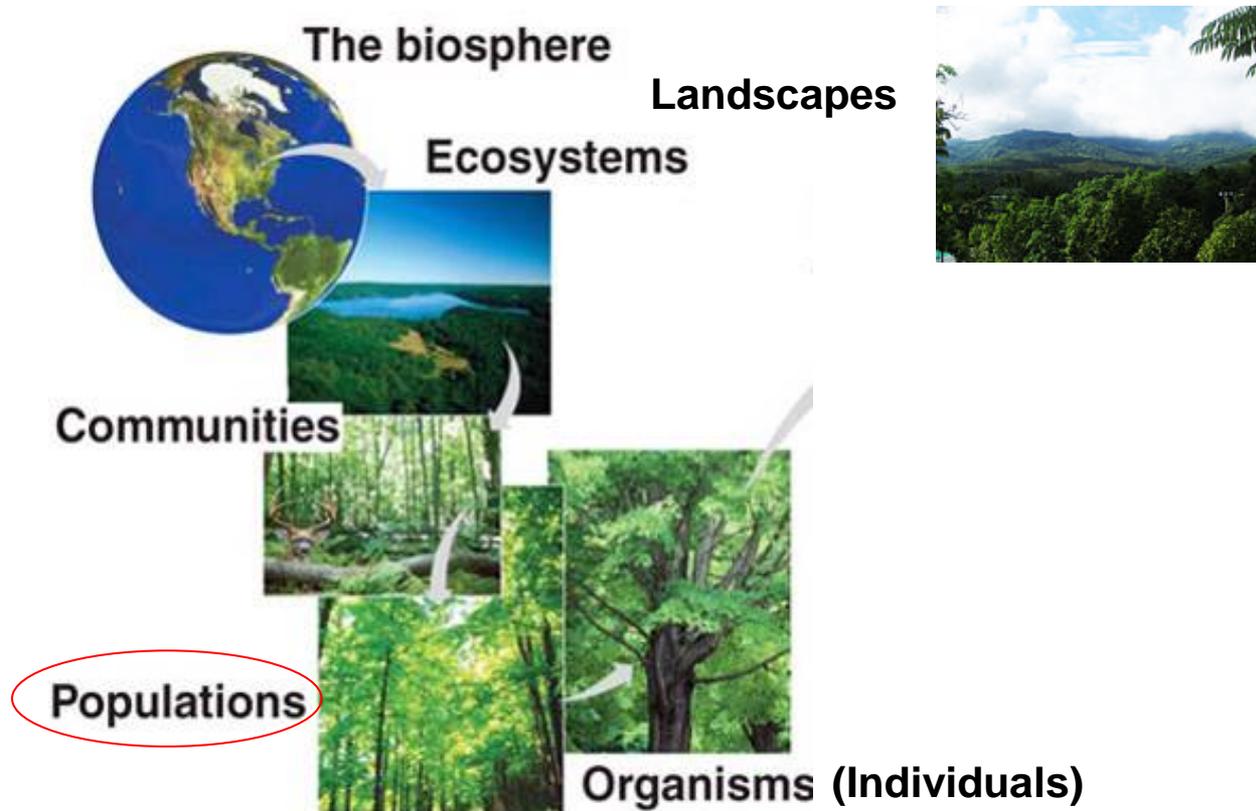
Table 7.1. Major Sources of Nutrients that Are Absorbed by Plants<sup>a</sup>.

Nutrient	Source of plant nutrient (% of total)		
	Deposition/fixation	Weathering	Recycling
Temperate forest (Hubbard Brook)			
Nitrogen	7	0	93
Phosphorus	1	< 10	> 89
Potassium	2	10	88
Calcium	4	31	65
Tundra (Barrow)			
Nitrogen	4	0	96
Phosphorus	4	< 1	96

<sup>a</sup> Data from (Whittaker et al. 1979, Chapin et al. 1980b)

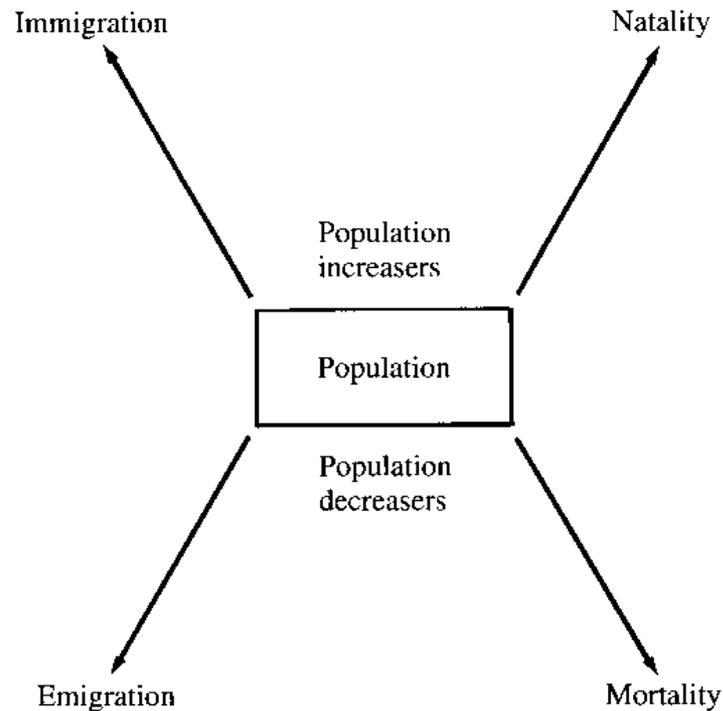
# Ecological Principles for Natural Resource Management

- Ecological Hierarchy - Populations



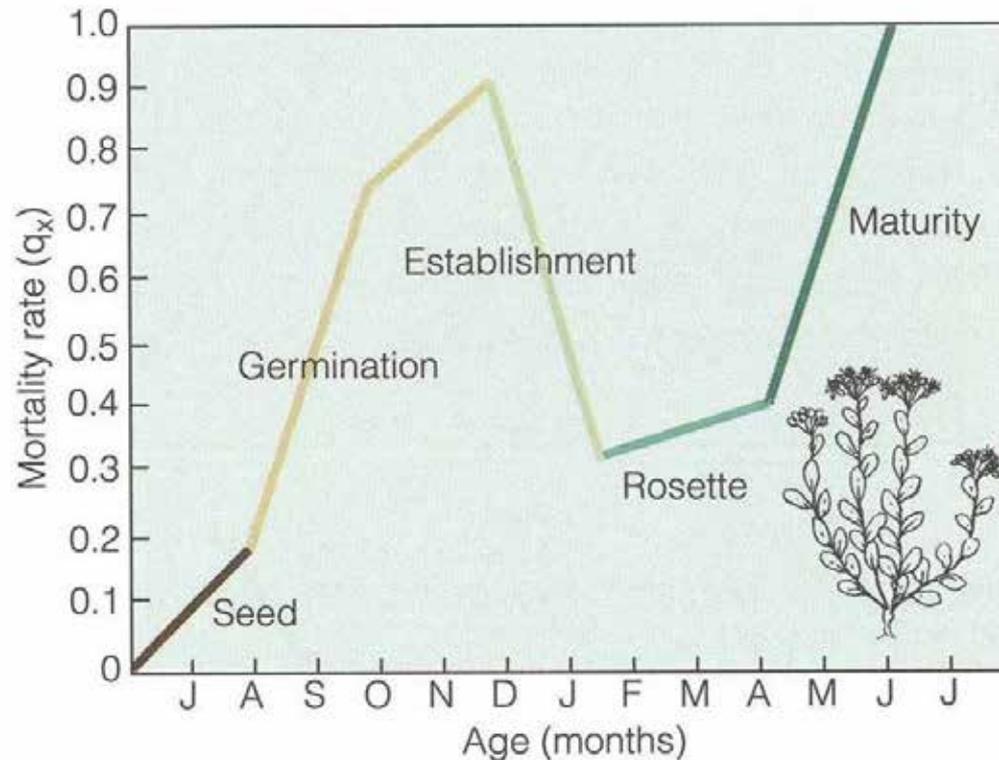
# Ecological Principles for Natural Resource Management

- Populations - Size



# Ecological Principles for Natural Resource Management

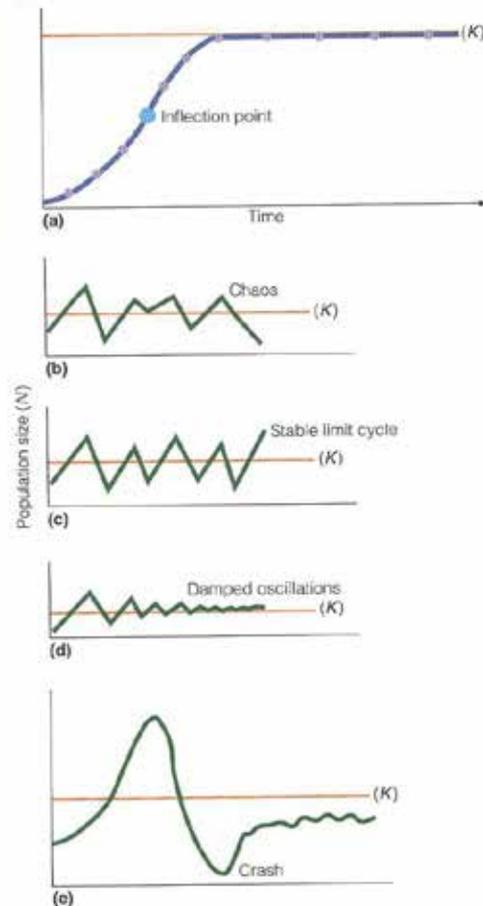
- Populations - Size



(b)

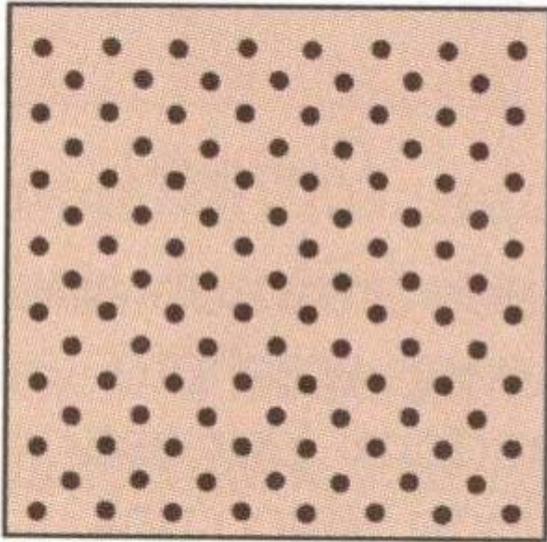
# Ecological Principles for Natural Resource Management

- Populations - Growth Rate

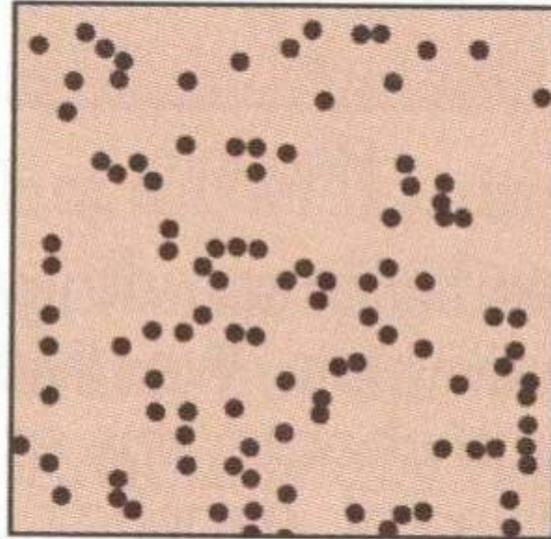


# Ecological Principles for Natural Resource Management

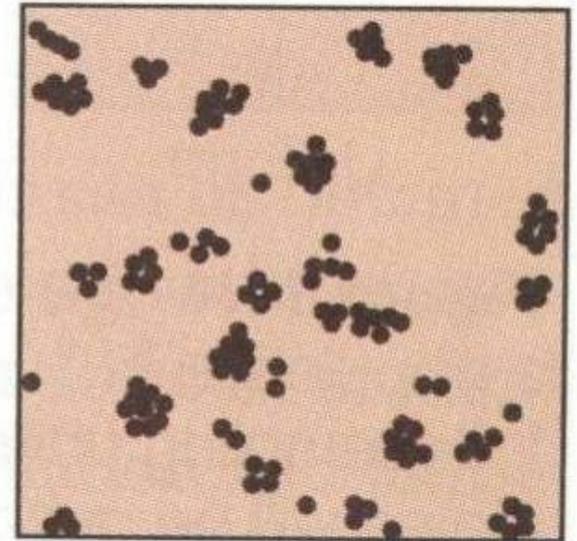
- Populations - Distribution



Uniform



Random

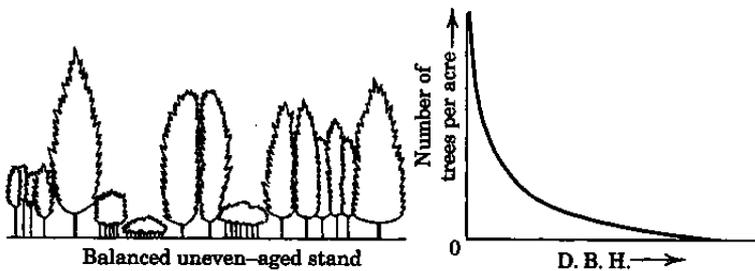
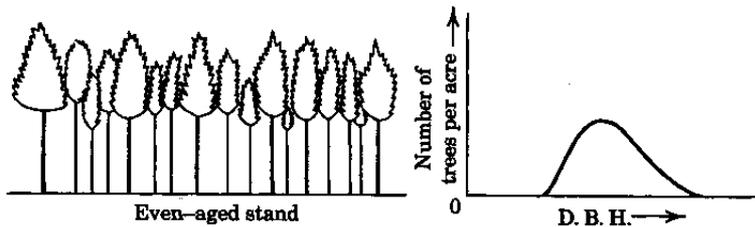


Clumped

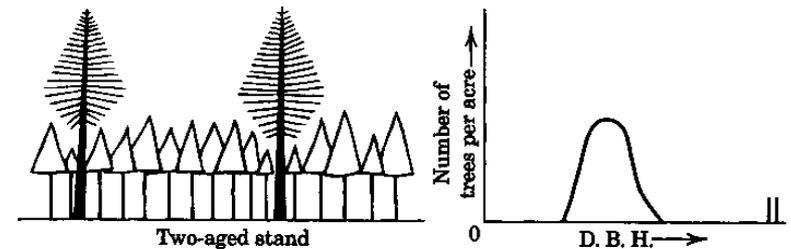
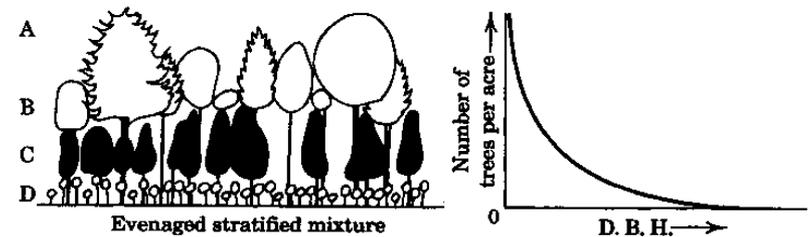
# Ecological Principles for Natural Resource Management

- Populations - Structure

## Single Species

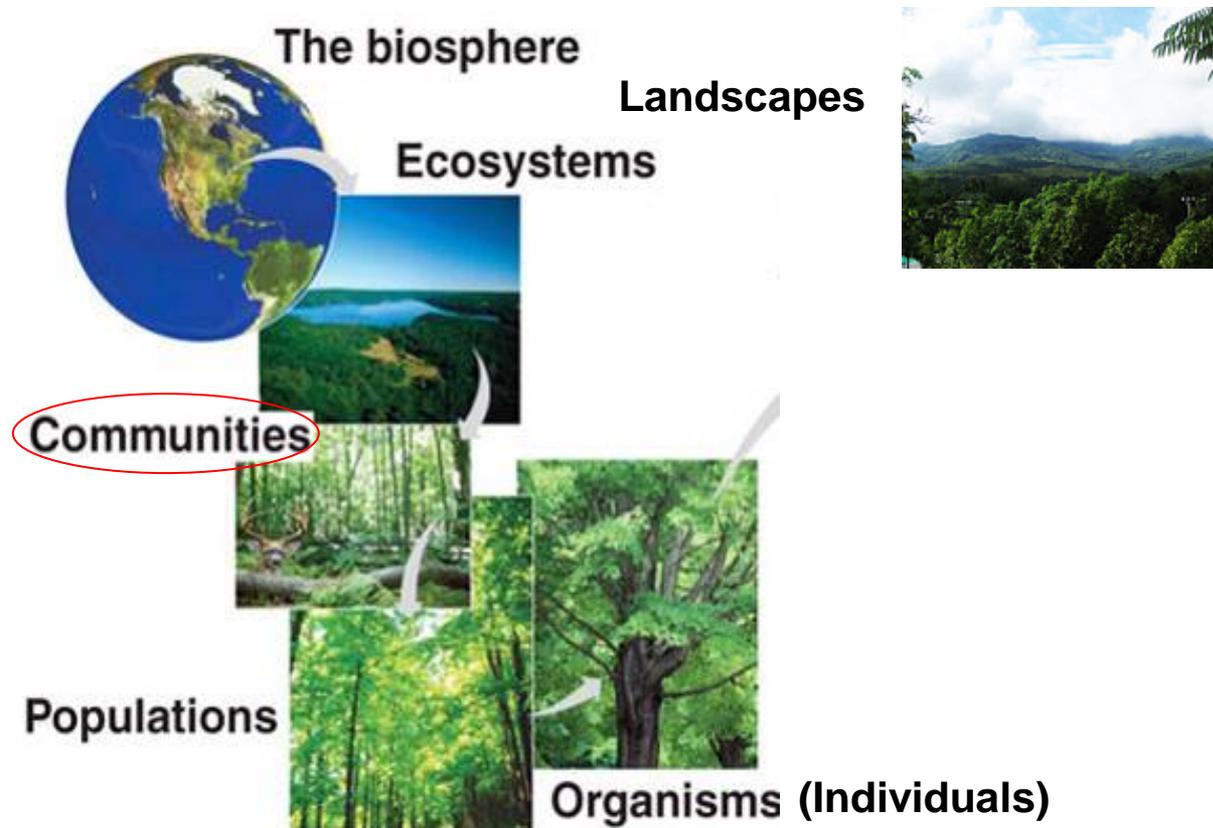


## Mixed Species



# Ecological Principles for Natural Resource Management

- Ecological Hierarchy - Communities



# Ecological Principles for Natural Resource Management

- Communities - Interspecific Interactions

*Table 15-2* Types of Interspecific Interactions

Category of Interaction	Type of Interaction	Effect on	
		Species A	Species B
Symbiosis	Mutualism	+	+
	Commensalism	+	0
Antagonism	Exploitation		
	physical	+	-
	parasitism	+	-
	predation	+	-
	Antibiosis, including allelopathy	+	-
	Competition	-	-

# Ecological Principles for Natural Resource Management

- Communities - Mutualism (+ , +)

N-fixation  
(root nodule)



Mycorrhizae



Lichens

# Ecological Principles for Natural Resource Management

- Communities - Commensalism (+ , 0)



Epiphyte



Facilitation

# Ecological Principles for Natural Resource Management

- Communities - Parasitism (+ , -)



*Korthalsella* sp.  
(HI Mistletoe)



# Ecological Principles for Natural Resource Management

- Communities - Predation (+ , -)



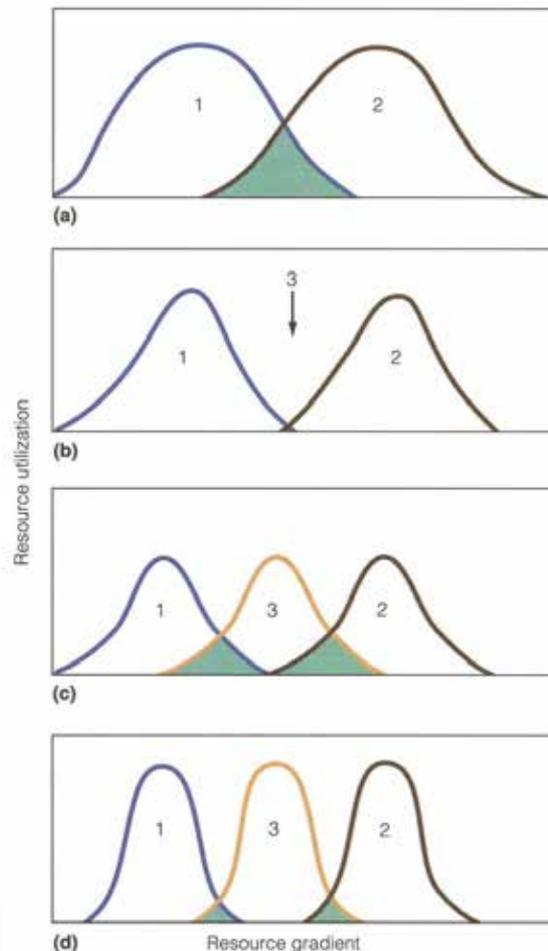
# Ecological Principles for Natural Resource Management

- Communities - Competition (- , -)



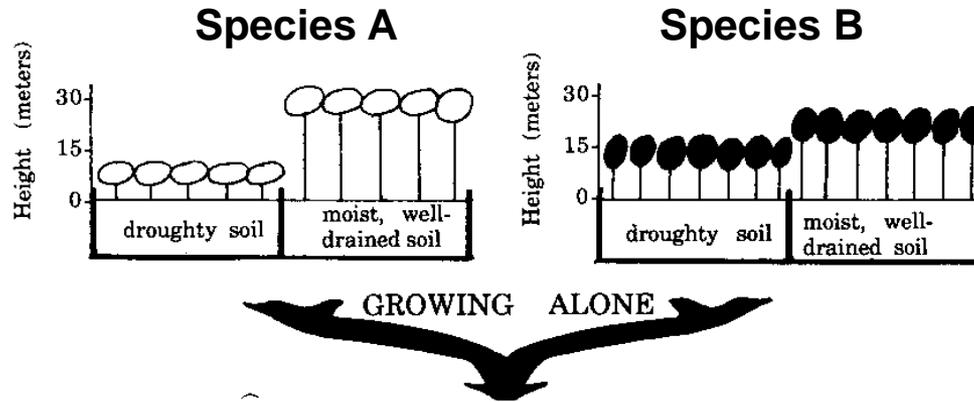
# Ecological Principles for Natural Resource Management

- Communities - Competition (Niche)



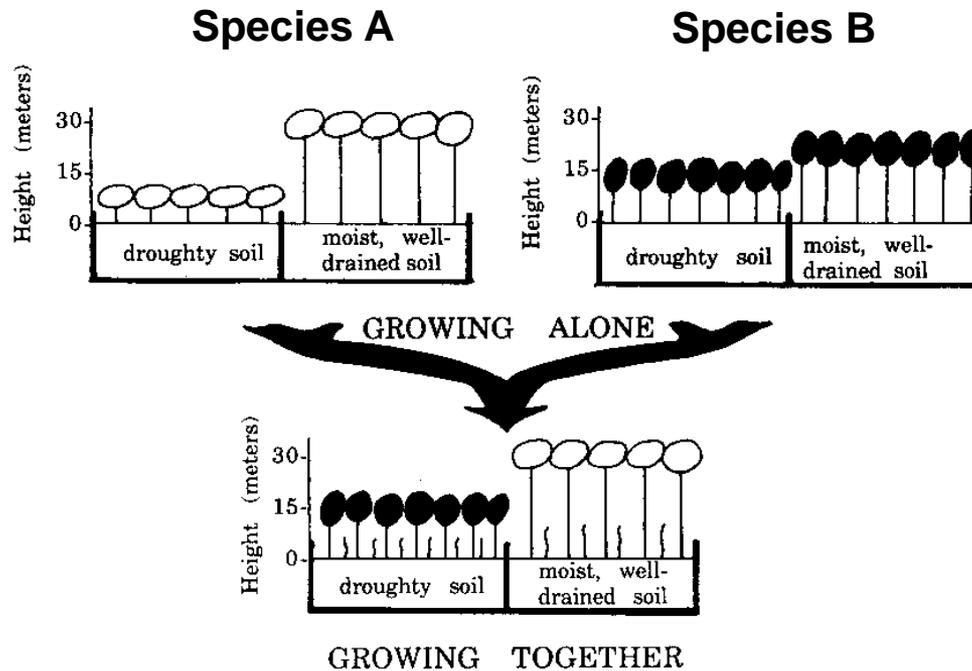
# Ecological Principles for Natural Resource Management

- Communities - Competitive Exclusion



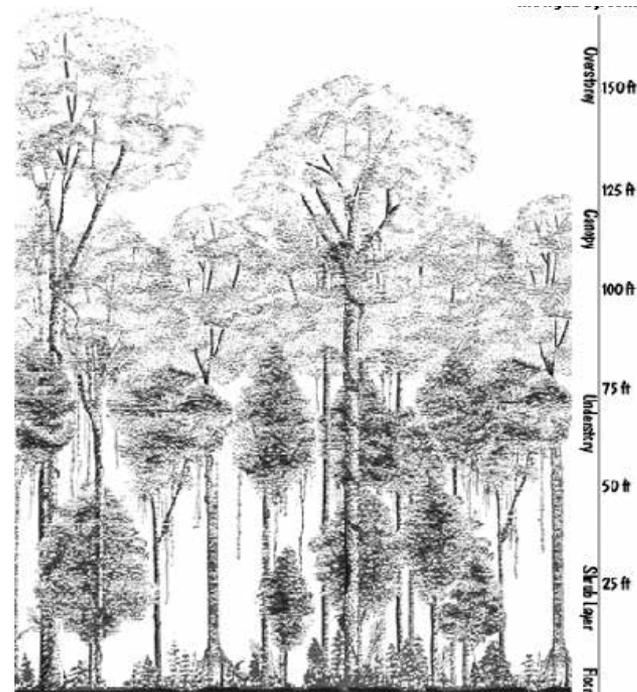
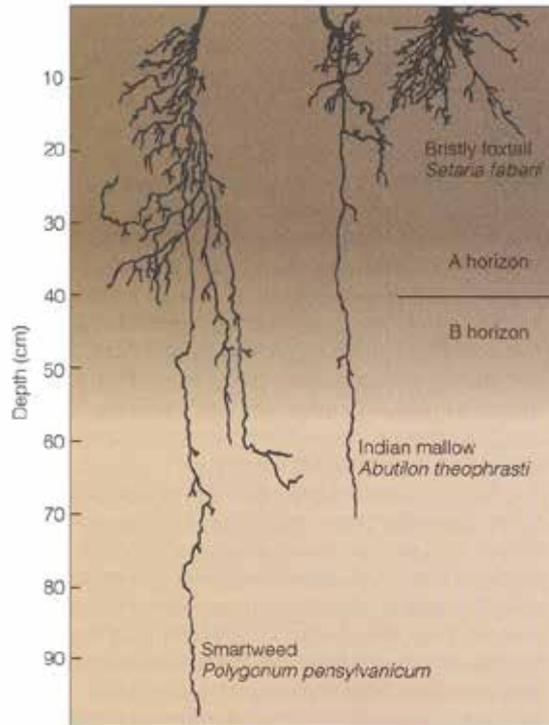
# Ecological Principles for Natural Resource Management

- Communities - Competitive Exclusion



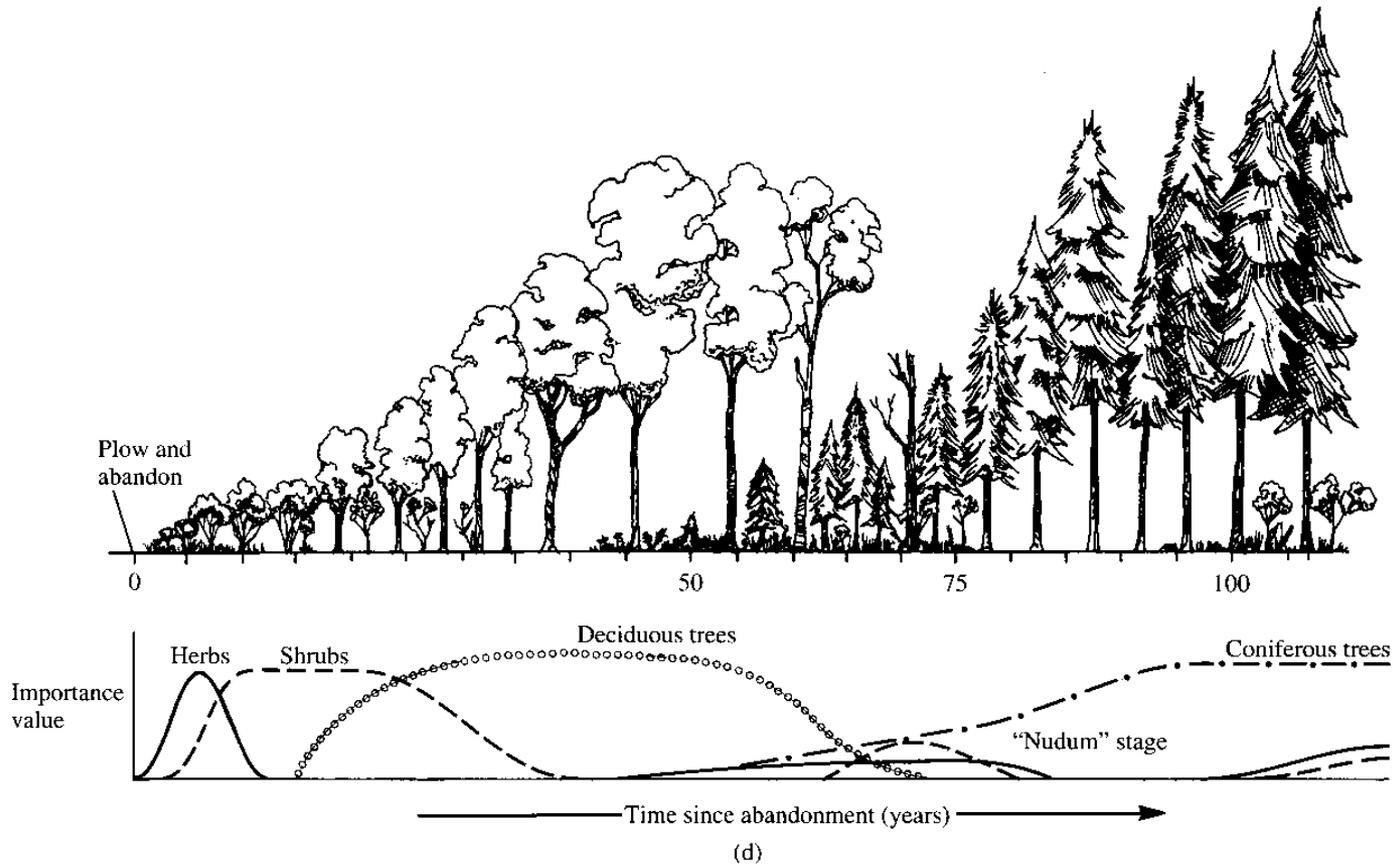
# Ecological Principles for Natural Resource Management

- Communities - Resource Partitioning



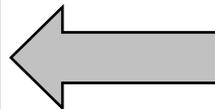
# Ecological Principles for Natural Resource Management

- Communities - Ecological Succession



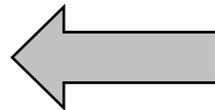
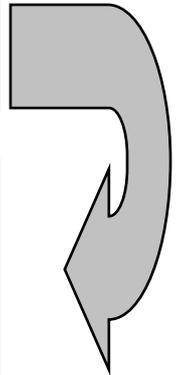
# Ecological Principles for Natural Resource Management

## Primary Succession



# Ecological Principles for Natural Resource Management

## Secondary Succession



# Ecological Principles for Natural Resource Management

- Communities - Disturbances (Fire)



# Ecological Principles for Natural Resource Management

- Communities - Disturbances (Wind)



# Ecological Principles for Natural Resource Management

- Communities - Disturbances (DIPs)



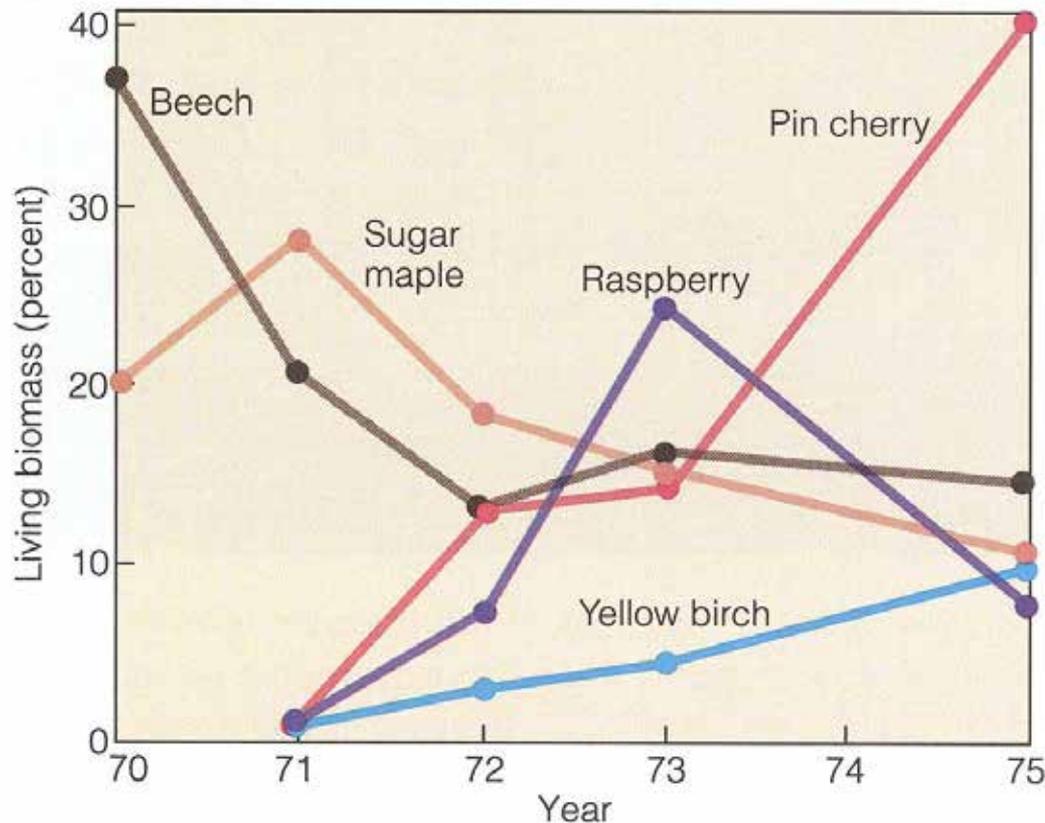
# Ecological Principles for Natural Resource Management

- Communities - Disturbances (Humans)



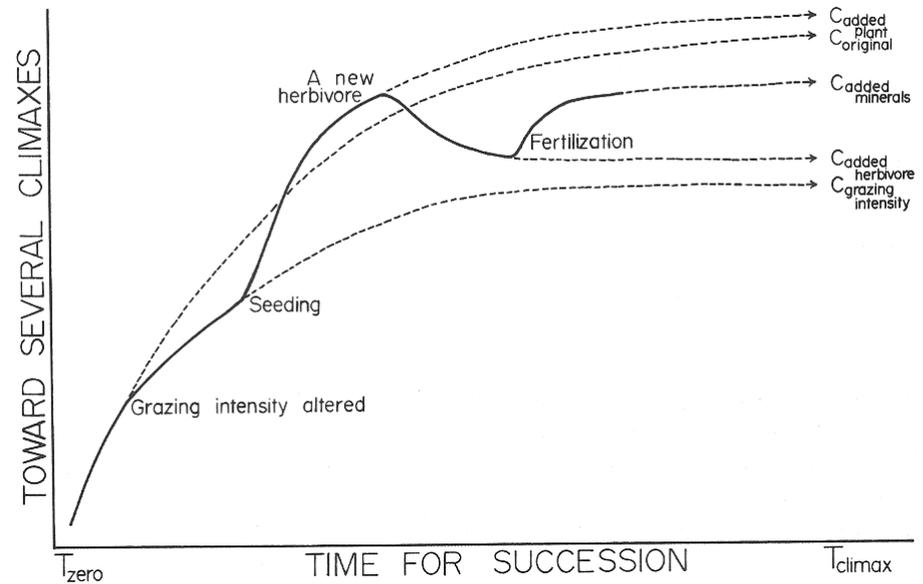
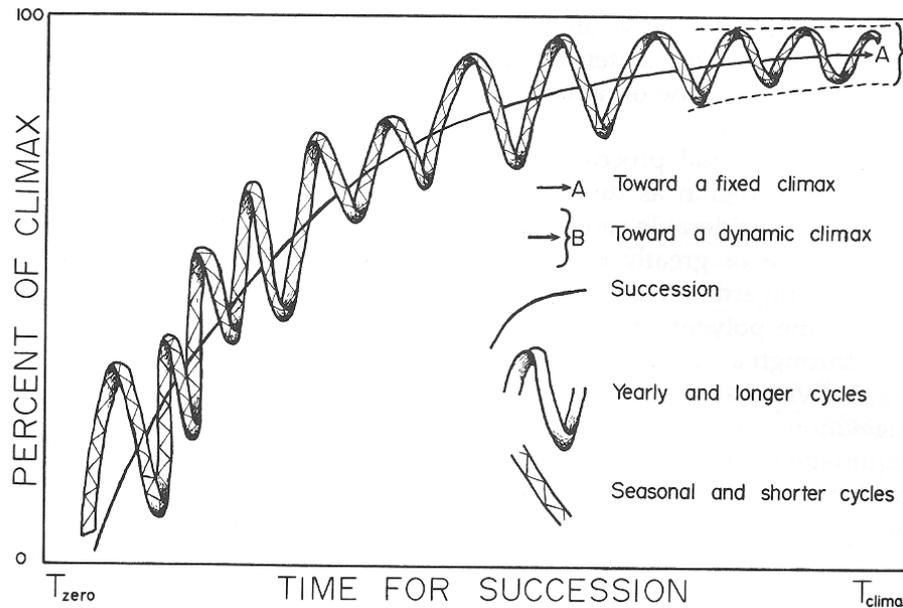
# Ecological Principles for Natural Resource Management

- Communities - Ecological Succession



# Ecological Principles for Natural Resource Management

- Communities - Ecological Succession



# Ecological Principles for Natural Resource Management

- Ecology Matters
  - Natural resource management = the application of ecological principles to the management of natural resources
  - To manage biota, you have to understand ecology