

Forest Production Ecology

- Objectives

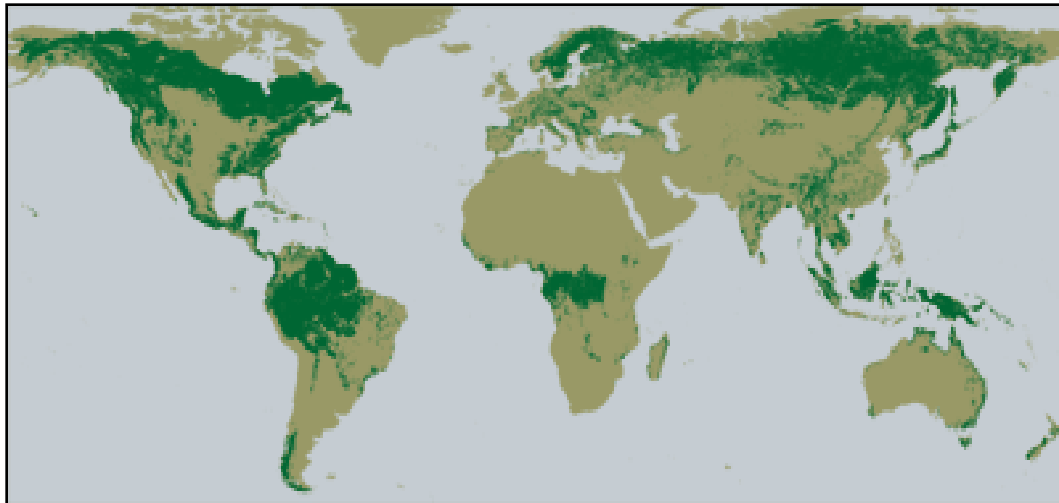
- Overview of production ecology in forests
 - C cycling
 - Primary productivity

“... ecologists and ecosystem managers are unlikely to achieve desired management objectives unless they are familiar with the distribution and movements of energy that are responsible for the character and productivity of ecosystems under their management (Kimmins 2004).

- First, thoughts and insights from the reading assignment

Forest Production Ecology

- Forest Ecosystems
 - Importance to global C cycling



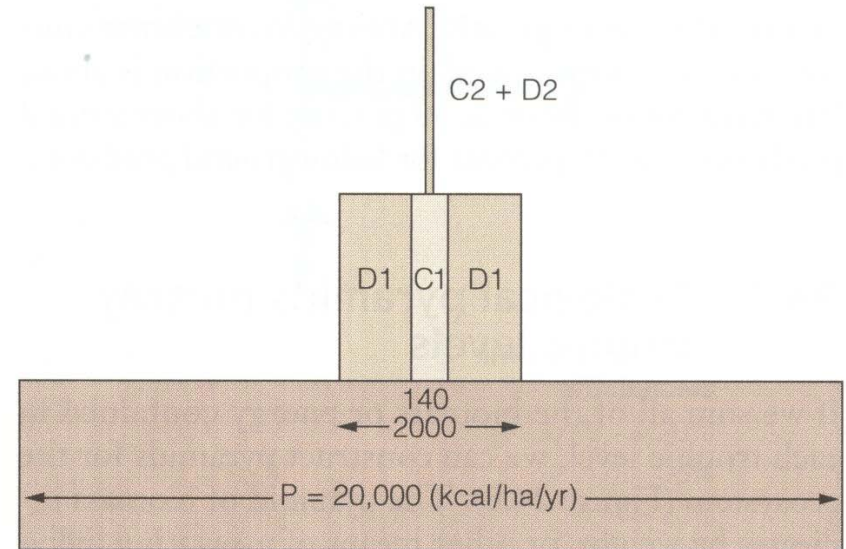
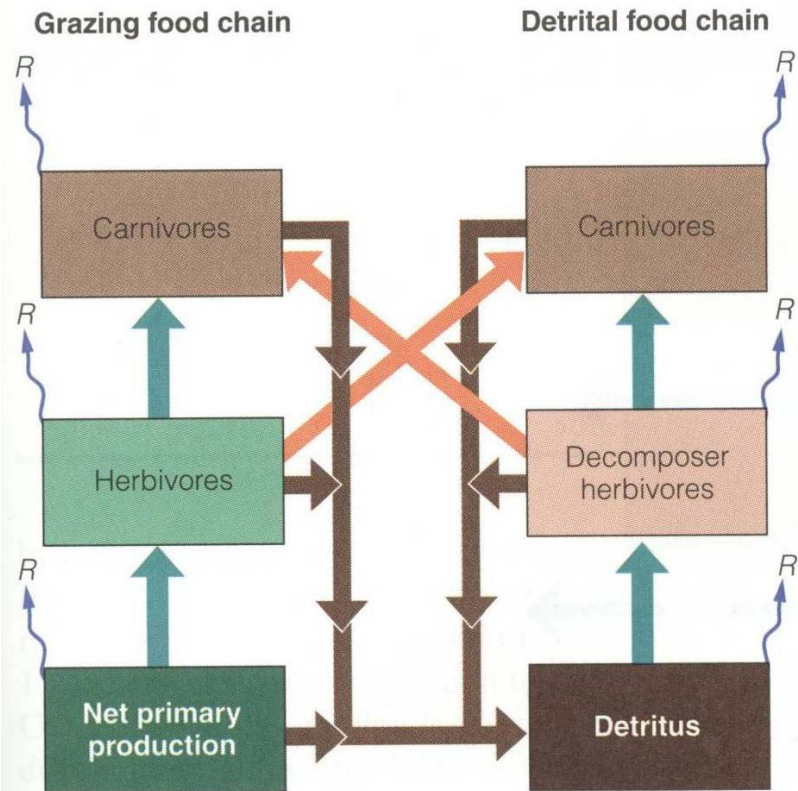
Forest Production Ecology

- Trophic Structure and Dynamics
 - Autotrophs (Producers)
 - Photoautotrophs
 - Chemoautotrophs
 - Heterotrophs (Consumers and Decomposers)
 - Herbivores
 - Carnivores
 - Omnivores
 - Saprotrophs



Forest Production Ecology

- Trophic Structure and Dynamics



(b)

Forest Production Ecology

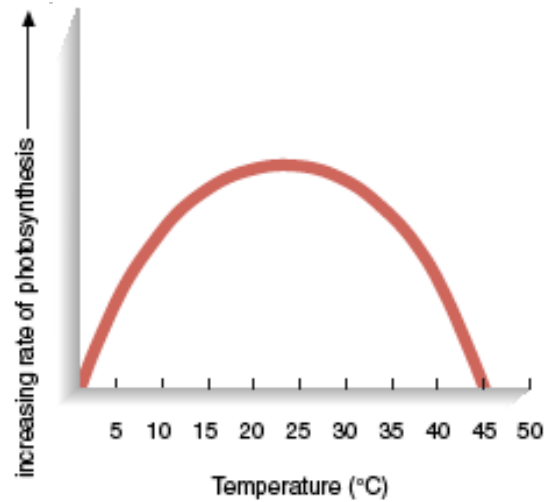
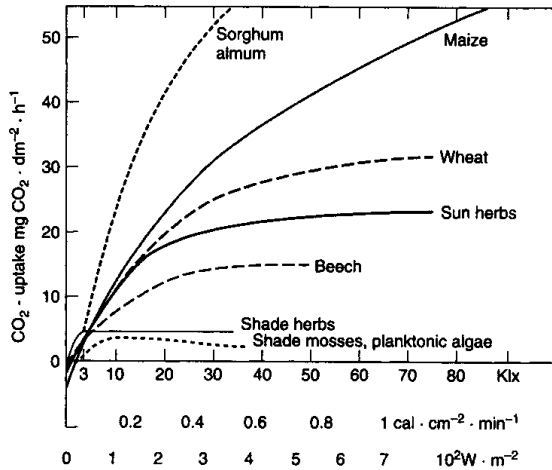
- Tree Carbon Balance
 - Gross photosynthesis
 - Respiration (Dark)

 - Net Photosynthesis
 - Gross Photo. – Resp. = Net Photosynthesis
 - C available for growth and maintenance

Forest Production Ecology

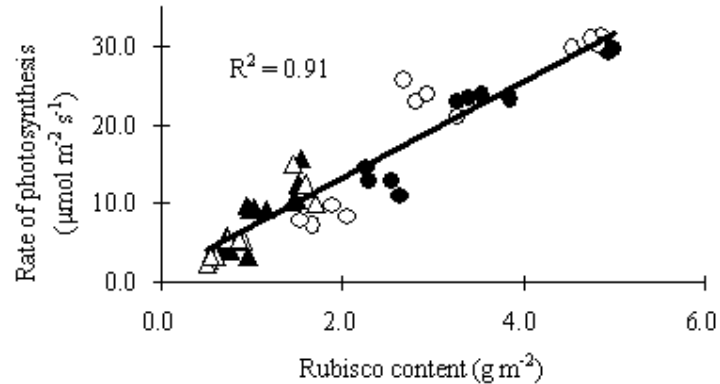
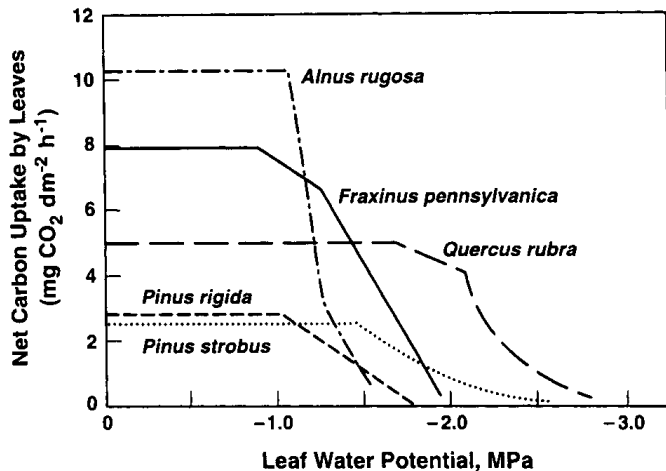
- Tree Carbon Balance - Net Photosynthesis

Light



Temperature

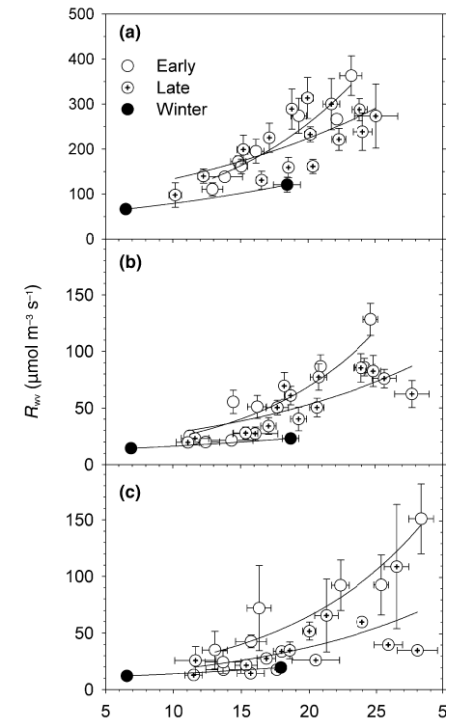
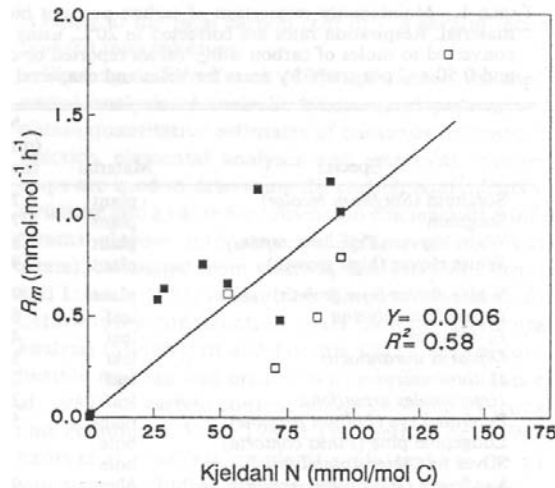
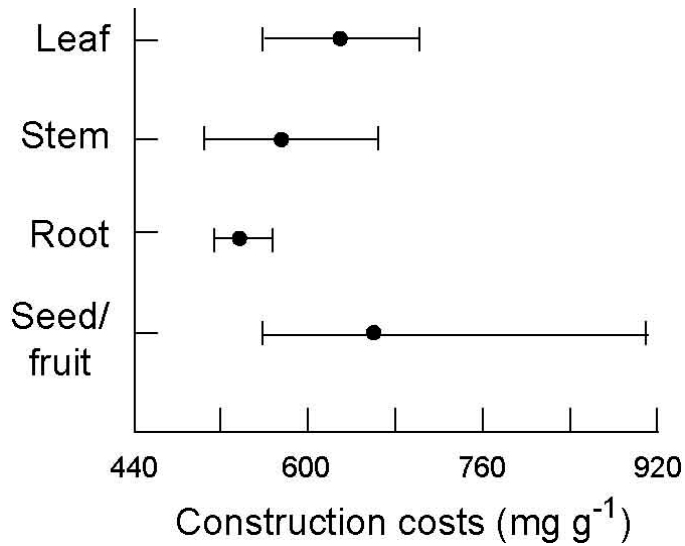
H₂O



Nutrients

Forest Production Ecology

- Tree Carbon Balance - Respiration



Forest Production Ecology

- Tree Carbon Balance - Allocation

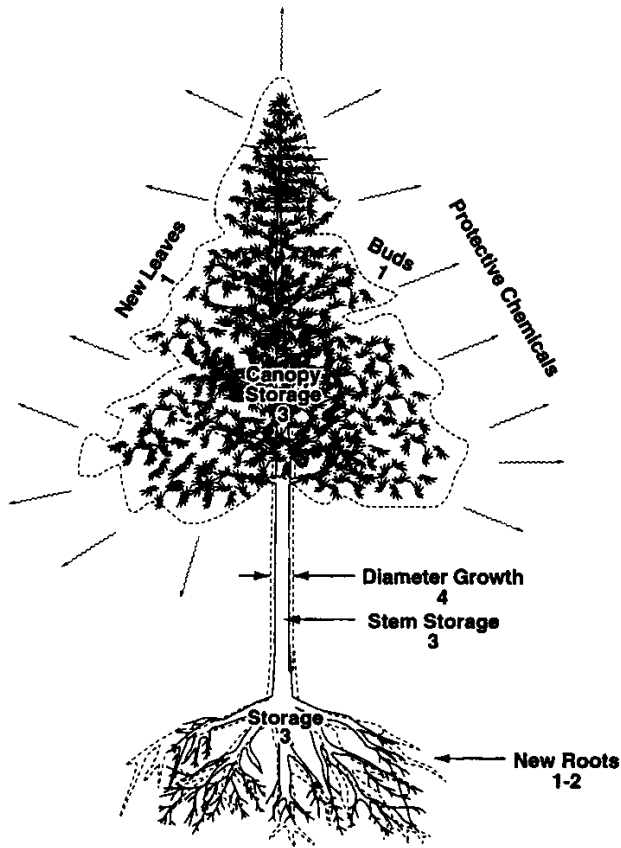


Table 18.3 The carbon budget of a 14-year-old Scots pine tree.

	Assimilation g C year ⁻¹	Allocation	Percent of Total
Net Photosynthesis	1723		
Growth			
Current Needles		286	16.6
Branch Axes		132	7.7
Stem		145	8.4
Roots		960	55.6
Total Growth		1523	88.4
Construction and Maintenance Respiration			
Stem		49	2.8
Branch Axes		15	0.9
Roots		109	6.3
Total Respiration		173	10.0
Growth + Respiration		1696	98.5
Unaccounted Net Photosynthesis		27	1.5
TOTAL		1723	100.0

Source: After Agren et al., 1980.

Forest Production Ecology

- Forest Carbon Balance - Biomass

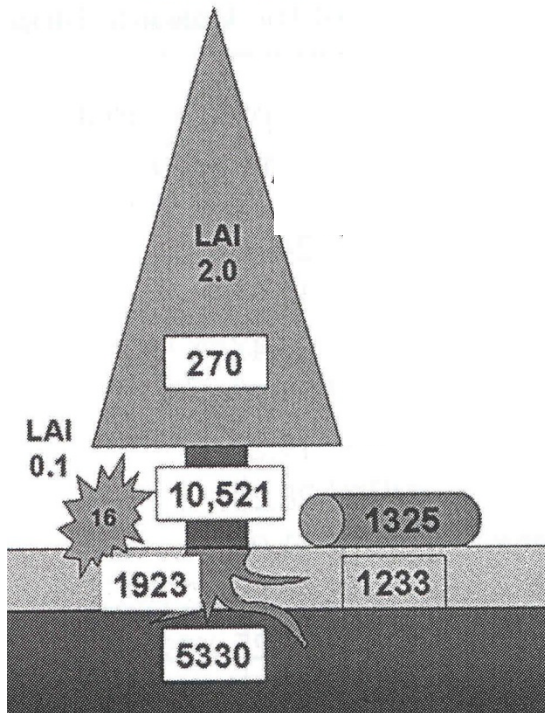
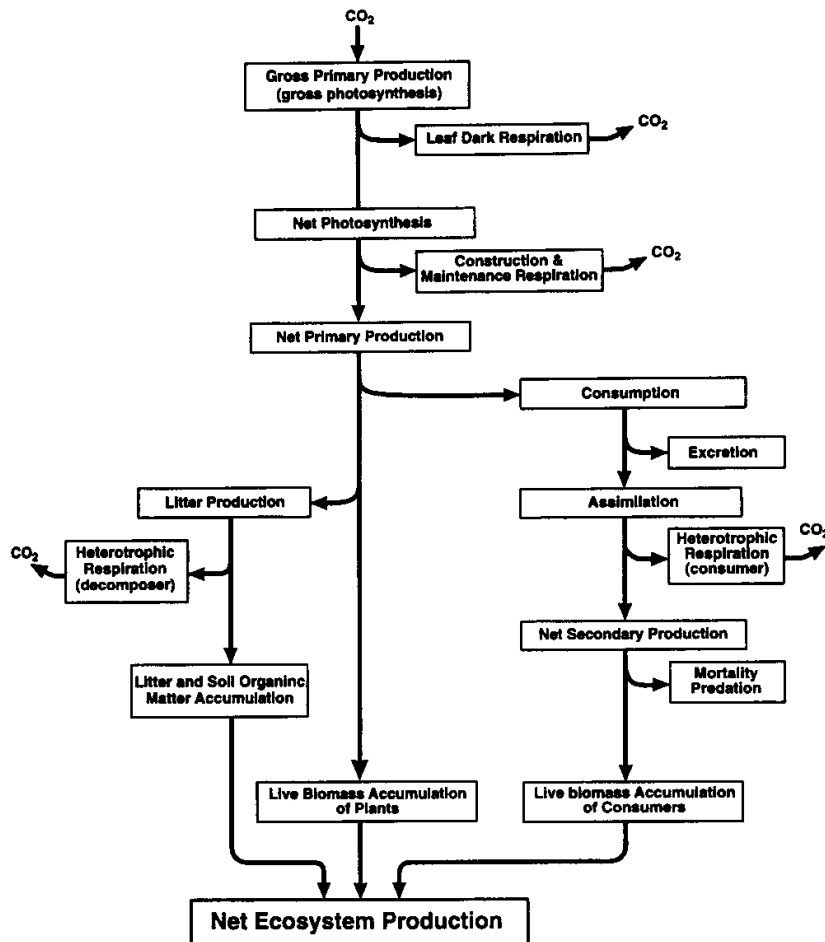


Table 18.5 The distribution of biomass in selected boreal, temperate, and tropical forest ecosystems.

	Boreal	Temperate		Wet Tropical
Location	Alaska USA	Washington USA	New Hampshire USA	Amazon Brazil
Overstory				
Dominant Species	black spruce	Douglas-fir	sugar maple -beech	mixed species ¹
Age (yrs)	95	60	55	mature
Biomass Pools	Mg ha⁻¹			
Overstory	50	410	165	990
Woody Debris	—	9	29	18
Forest Floor	76	15	48	7
Mineral Soil	152	119	173	250
Heterotroph	<1	<1	<4	<1
Total	278	553	419	1265

Forest Production Ecology

- Forest Carbon Balance - Energy Flow



$$GPP = \Sigma \text{Photosynthesis}$$

$$NPP = GPP - R_A$$

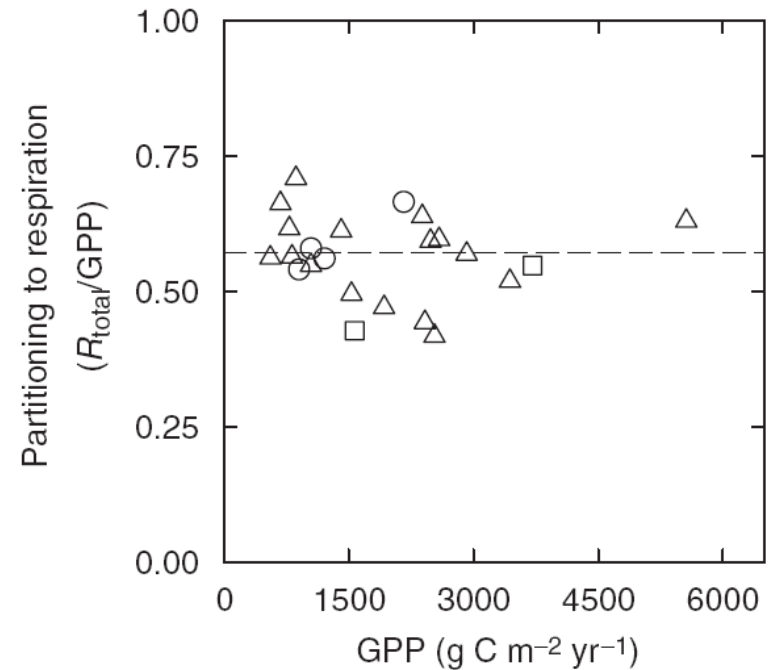
$$NEP = GPP - (R_A + R_H)$$

Forest Production Ecology

- Forest Carbon Balance - Allocation

Table 18.6 Estimates of total plant (R_A), construction (R_C), and maintenance (R_M) respiration in relationship to gross (GPP) and net primary productivity (NPP) in forest and grassland ecosystems.

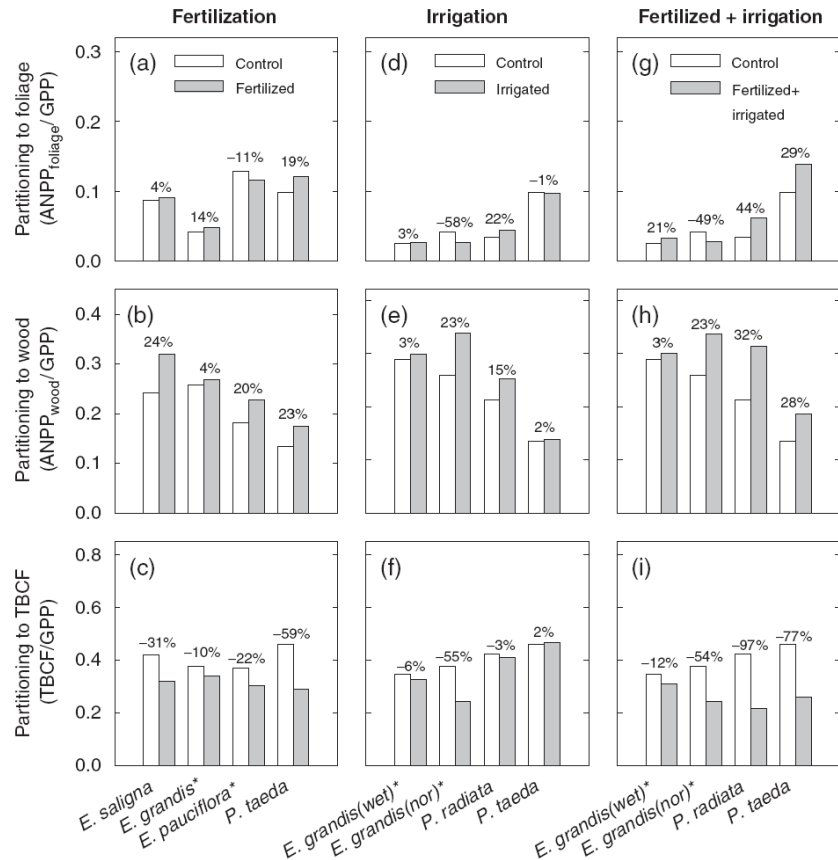
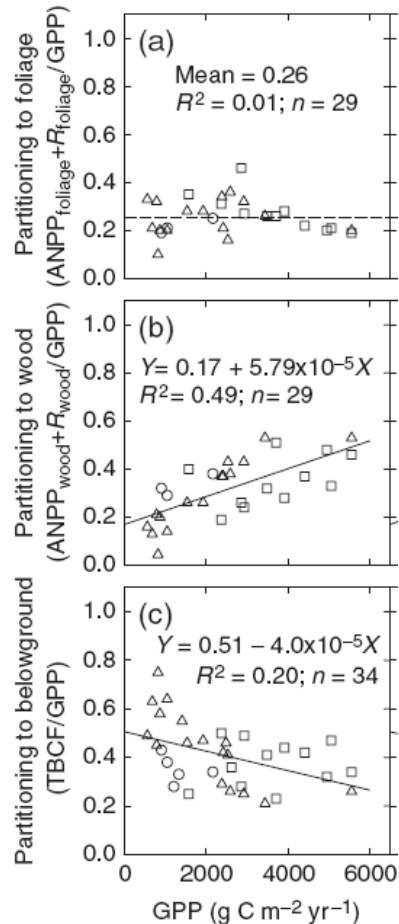
Ecosystem	Plant Biomass (Mg C ha ⁻¹)	GPP	NPP	R_A	R_C	R_M	R_A/GPP	R_M/R_A
		Mg C ha ⁻¹ y ⁻¹						
Forest								
deciduous	88	21.7	7.3	14.4	1.8	12.6	0.66	0.88
oak-pine	71	12.8	6.0	6.8	1.5	5.3	0.53	0.78
Grassland								
tallgrass	8	9.5	3.7	5.8	0.9	4.9	0.61	0.84
shortgrass	-	1.5	0.7	0.8	0.2	0.6	0.53	0.75



(Litton et al. 2007)

Forest Production Ecology

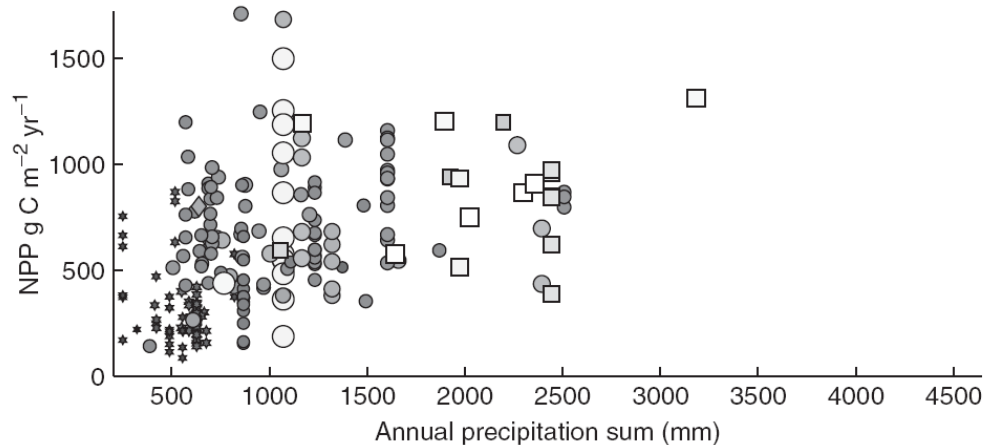
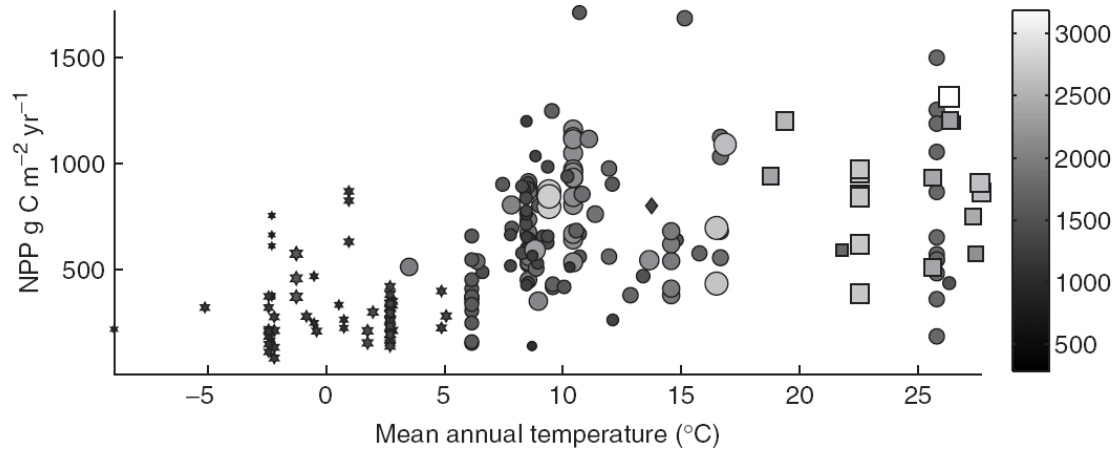
- Forest Carbon Balance - Allocation



(Litton et al. 2007)

Forest Production Ecology

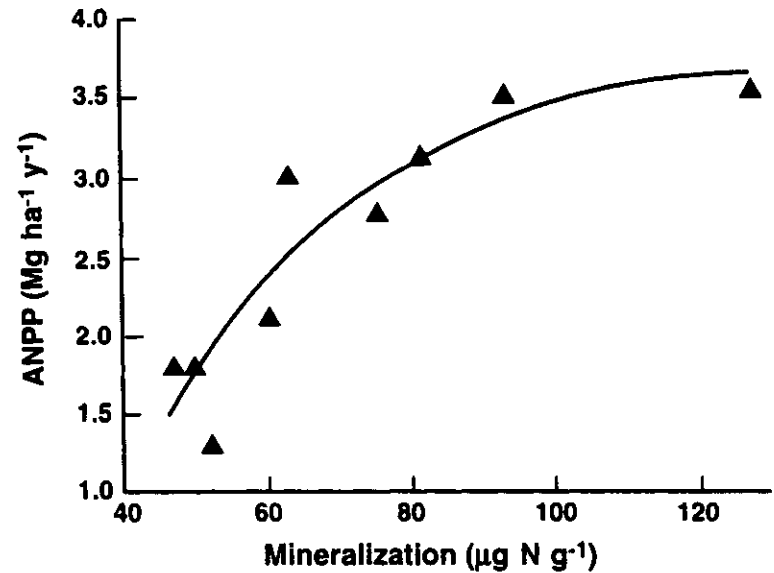
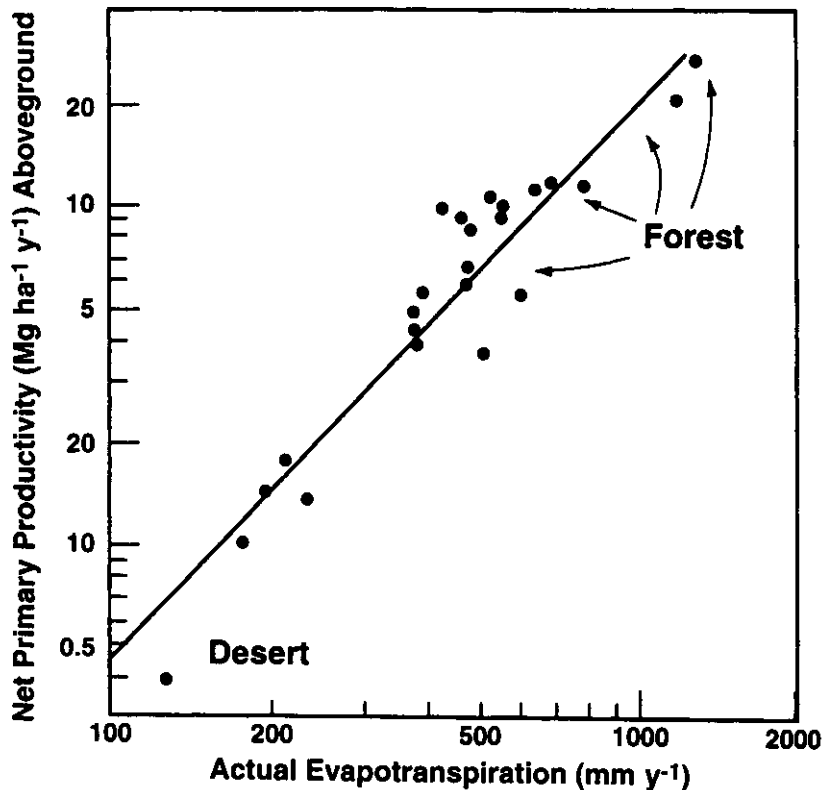
- Forest Carbon Balance - Climate



(Luyssaert et al. 2007)

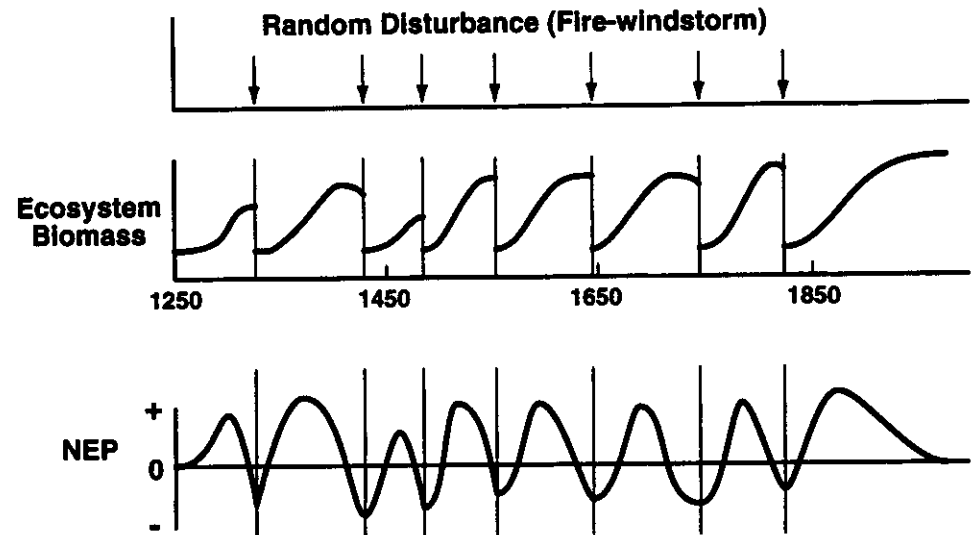
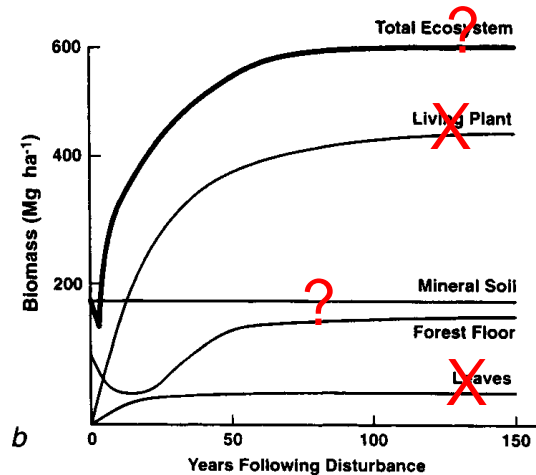
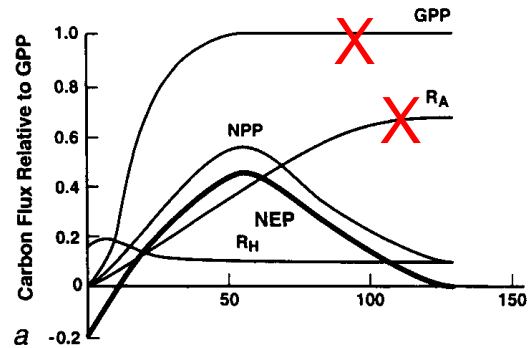
Forest Production Ecology

- Forest Carbon Balance - Climate



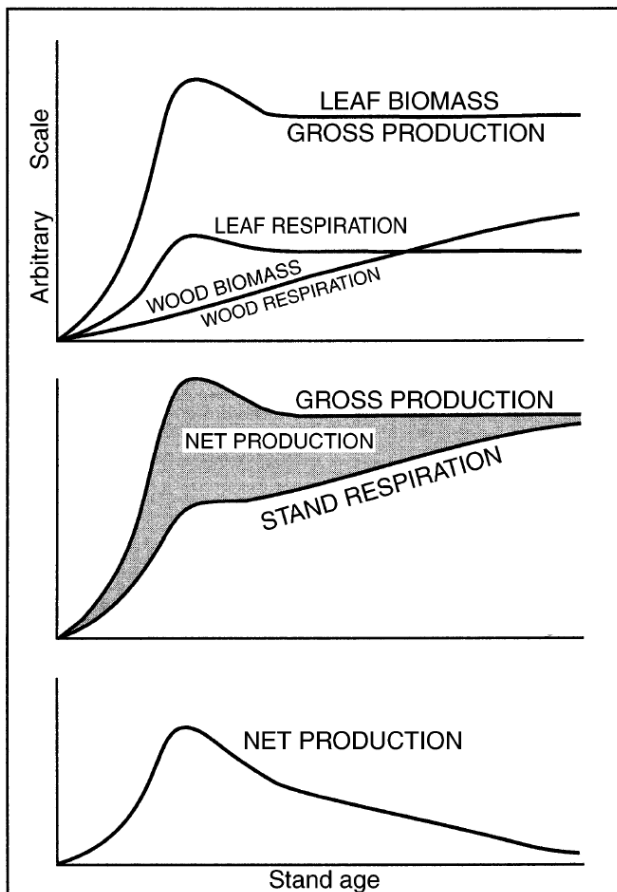
Forest Production Ecology

- Forest Carbon Balance - Ecosystem Development



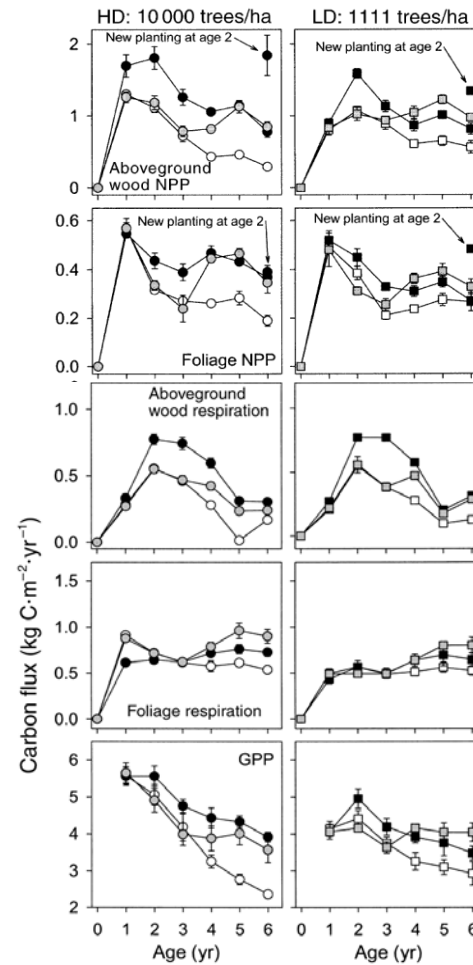
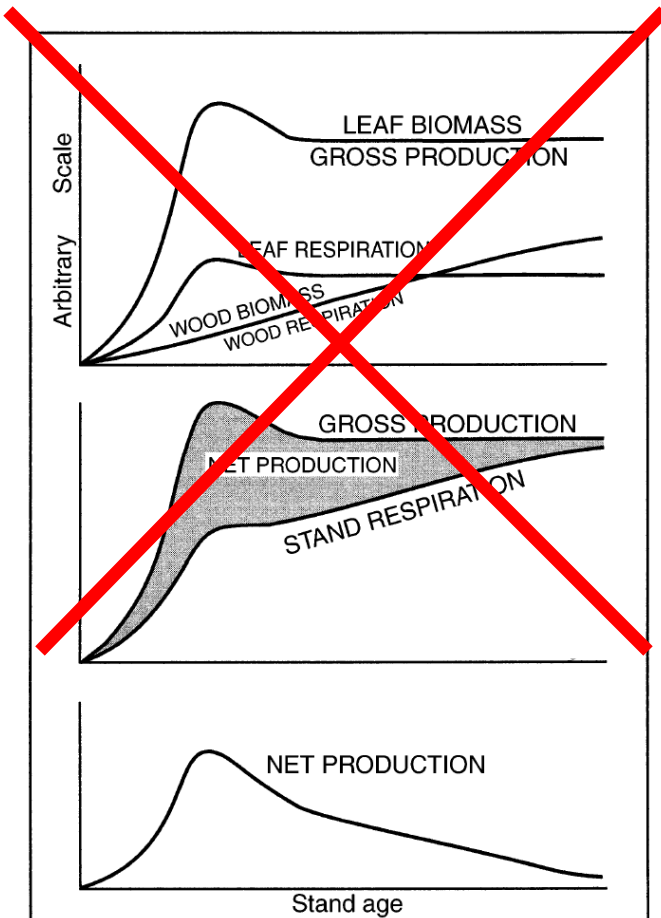
Forest Production Ecology

- Age-related decline in forest productivity



Forest Production Ecology

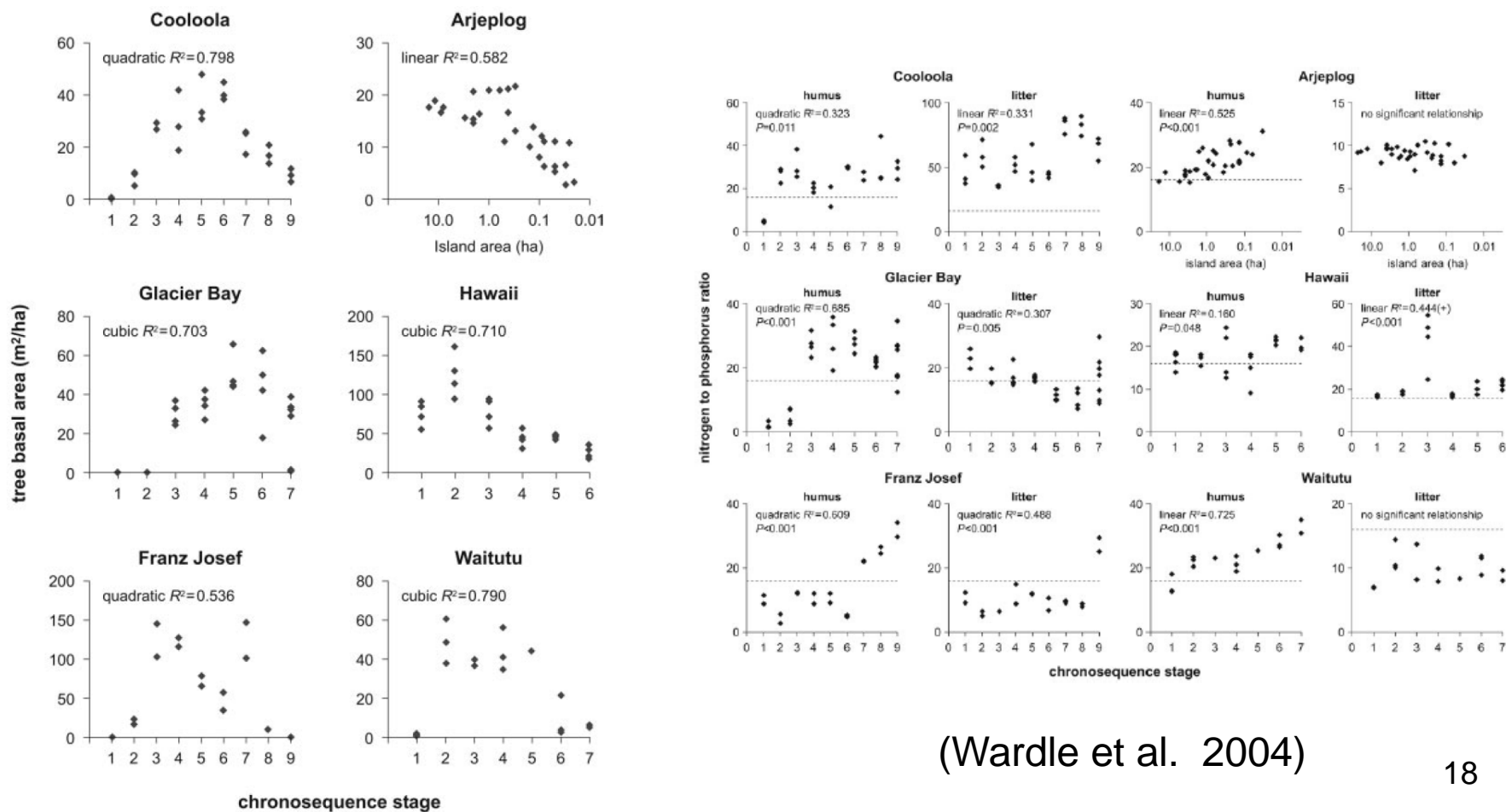
- Age-related decline in forest productivity



(Ryan et al. 2004)

Forest Production Ecology

- Ecosystem Retrogression



(Wardle et al. 2004)

Forest Production Ecology

- Forest Management

- Production forestry = manipulating energy (i.e., C) flows
- Maximize NPP (by maximizing GPP)
 - GPP is controlled primarily by leaf area (LAI)
 - LAI is primarily controlled by water and nutrient availability (within a given climate); belowground resources
 - Importance of good soil conservation practices
- Manipulate C allocation (typically to wood)
- Bioenergy
 - Utilization of the stored energy in biomass

To understand ecosystems we have to understand the ecology of organic matter production and storage... (Kimmins 2004)