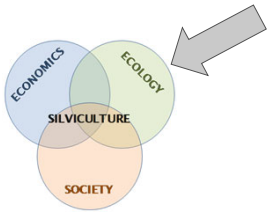
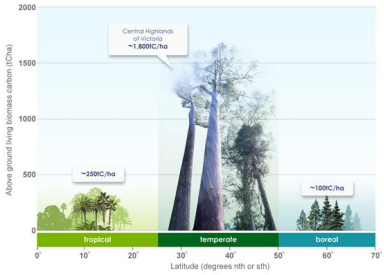
Role of Stand Dynamics in Silviculture

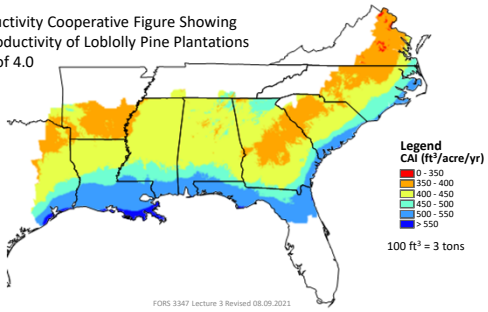


Understanding Forest Ecophysiology



This is why ecophysiology is important

Forest Productivity Cooperative Figure Showing Potential Productivity of Loblolly Pine Plantations with an LAI of 4.0



What Makes a Tree

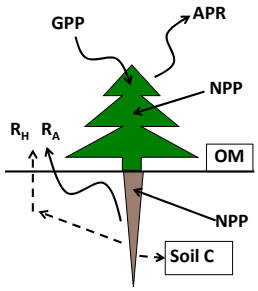
Element	Symbol	% Plant Dry Mass	Source
Carbon	C	45	Atmosphere
Oxygen	O	45	Water, Atmosphere
Hydrogen	H	6	Water
Nitrogen	N	1.5	Soil
Potassium	K	1.0	Soil
Calcium	Ca	0.5	Soil
Magnesium	Mg	0.3	Soil
Phosphorus	P	0.2	Soil
Sulfur	S	0.1	Soil

Pools vs. Flux

- Pool: Stored C
  - Biomass: Leaves, branches, stem, tap root, coarse roots, fine roots
  - Litter layer, soil C
- Fluxes: C moving from one pool to another
  - Respiration: Maintenance, growth
  - Photosynthesis
  - Litter fall, branches pruning, etc.
  - Decomposition

Carbon Balance

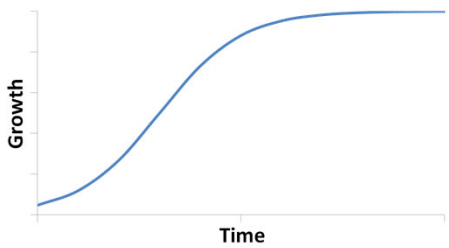
- **GPP**: **G**ross **P**rimary **P**roduction = All C fixed by photosynthesis
- **APR**: **A**boveground **P**lant **R**espiration
- **F_S**: Soil CO_2 efflux = combined respiration from plant and biota
- **Soil C**: Stable carbon fixed in soil
- **NPP**: **N**et **P**rimary **P**roduction = Carbon fixed as biomass (GPP – Respiratory fluxes)
- **NEP**: **N**et **E**cosystem **P**roduction = Carbon fixed in ecosystem (NPP + Soil C)



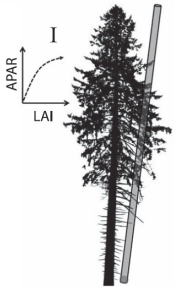
More on Carbon Balance

- GPP, **NPP**, **NEP**, F_S, APR, Soil C:
  - Are all expressed on annual basis (per year)
  - Most can be difficult to measure
  - But they explain GROWTH **(NPP)**
  - NEP gives you CARBON SEQUESTRATION
  - Others help you figure out NPP & NEP

Carbon Balance & Growth

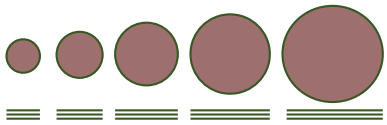


Canopy Depth



Binkley, D., et al. Light absorption and use efficiency in forests: Why patterns differ for trees and stands. Forest Ecol. Manage. (2011), doi:10.1016/j.foreco.2011.11.002

Live Tissue



dbh *(feet)*	Circumference *(feet)*	New Live Tissue *(in)*	*(in^2)*	Butt Log Live Tissue *(in^3)*
1	3.1	0.04	0.13	24.1
2	6.3	0.04	0.25	48.3
3	9.4	0.04	0.38	72.4
4	12.6	0.04	0.50	96.5
5	15.7	0.04	0.63	120.6
6	18.8	0.04	0.75	144.8

Canopy versus Live Tissue

$$\frac{\text{Canopy} = \text{Photosynthesis} = \textbf{Carbon Gained}}{\text{Live Tissue} = \text{Respiration} = \textbf{Carbon Lost}}$$

$$\text{IF } \frac{\text{Carbon Gained}}{\text{Carbon Lost}} = 1 \quad \textbf{Growth = 0}$$

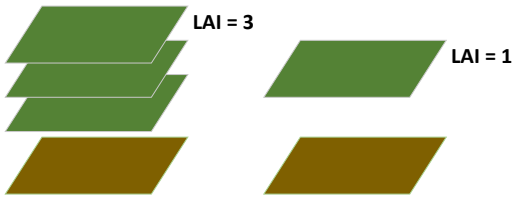
Carbon Budget of World Forests

	Mixed Hardwoods (US)	Southern Pine (US)	Subalpine Conifers (Japan)	Beech (Denmark)	Rain Forest (Africa)	Doug-fir (US)
Biomass	175	141	318	---	---	870
GPP	43	77	38	24	54	161
NPP	15	36	10	14	14	11
RA	29	41	28	10	40	150
RH	13	14	7	14	14	8
RE	42	55	34	24	54	158
NEP	1	22	4	0	0	3
RA / GPP	67%	53%	71%	43%	77%	93%
NEP / GPP	2%	29%	11%	---	---	2%

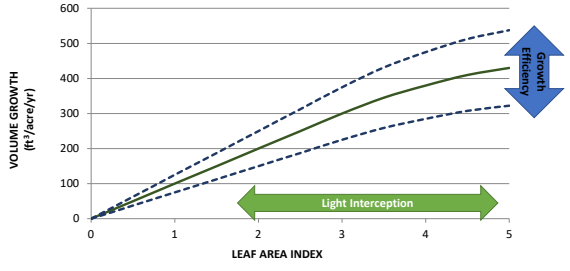
Biomass: *Mg / ha* **Rates:** *Mg / ha / yr* **Source:** *Waring & Schlesinger*

Quantifying Canopy: Leaf Area Index (LAI)

- unit area leaf / unit area ground

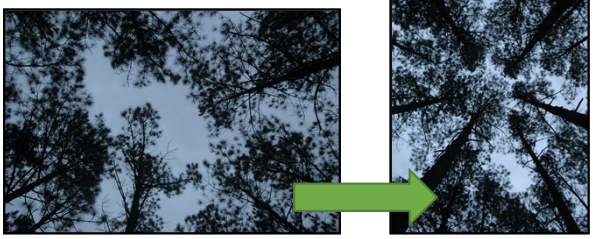


Why is LAI Important?



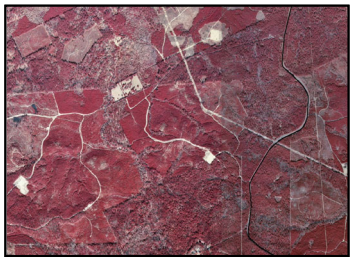
Reproduced from Fox et al. SOUTH. J. APPL. FOR. 31(1) 2007

LAI Application: Fertilizer

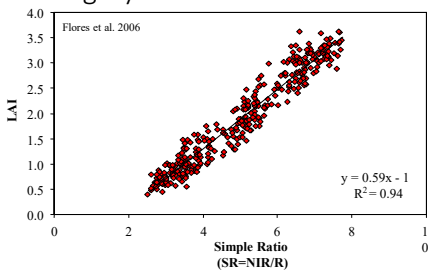


Leaf Area Index: Measuring

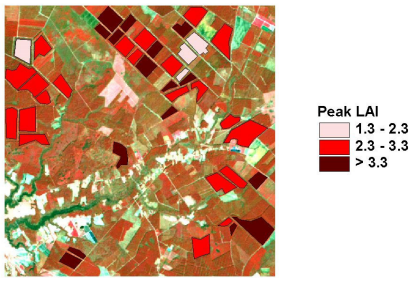
LandSat Image of East Texas



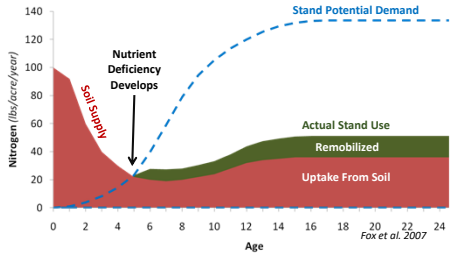
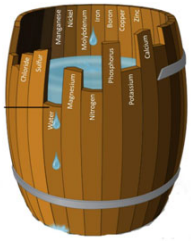
Remote Sensing Estimation of LAI Using Landsat Imagery



Estimated Stand Peak LAI



Stand Initiation: No Nutrient Limitation



Stand Initiation:
Liebig's Law of the Minimum