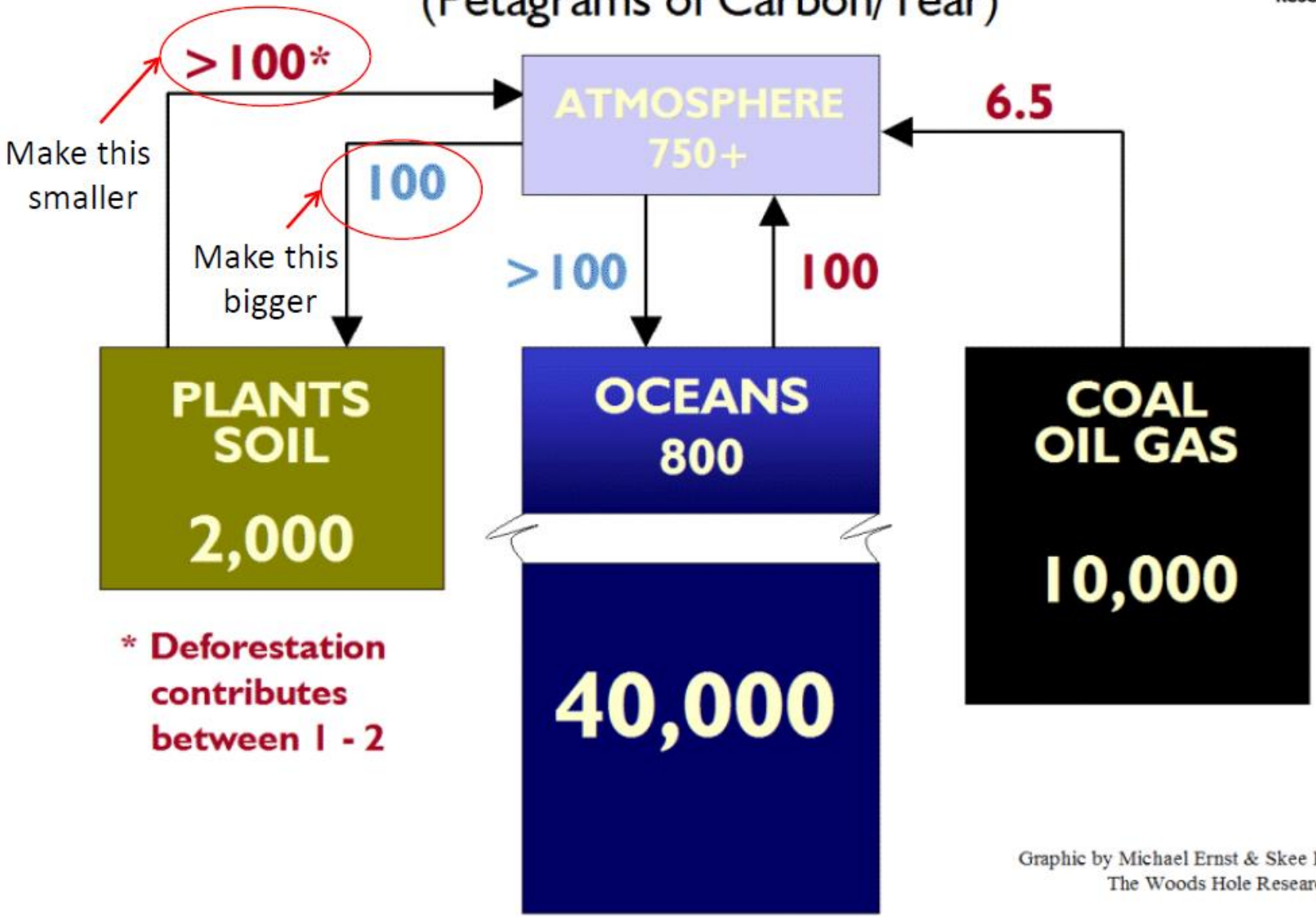
Forest Management and Carbon

Global Flows of Carbon

(Petagrams of Carbon/Year)

The Woods Hole Research Center



Graphic by Michael Ernst & Skee Houghton
The Woods Hole Research Center

Carbon Storage

- Refers to the amount of carbon held on a long-term basis within a biological organism (e.g., tree).

Wood has carbon as its primary component

- About 50% of tree biomass (dry weight) is carbon.
- About 20% of total tree carbon is stored in the roots.

Growth Rate Matters!

- Every pound of CO_2 captured equates to 0.27 pounds of carbon
- Every pound of tree growth (dry weight) extracts 1.85 pounds of CO_2

- Mg/ha = 0.45 tons/acre

Growth rate matters, and Carbon not just in bole

Biomass in components of 13-year-old stand receiving fertilization (Fert) and complete competition control (Herb) and a stand receiving non treatment (Control)

	Fert+Herb		Control	
Litter layer	39.4 Mg/ha	17%	17.8 Mg/ha	17%
Foliage	7.6 Mg/ha	3%	3.5 Mg/ha	3%
Branch	14.0 Mg/ha	6%	11.3 Mg/ha	11%
Bark	22.8 Mg/ha	10%	10.2 Mg/ha	10%
Wood	148.0 Mg/ha	63%	62.5 Mg/ha	60%
Total	232 Mg/ha ~115 Mg/ha C		105 Mg/ha ~ 53 Mg/ha C	

Mineral soil had ~ 50 Mg/ha carbon in upper 50 cm and did not differ among treatments

Will, R.E et al. 2006. Forest Ecology and Management 227:155-168.

Managing Forests For Carbon

Focusing on plantations

1. Highly productive so most potential
2. Flexible in management approaches
3. Economically viable to manage
4. More growth has potential to increase profit and increase carbon storage

Pine Plantations in southeastern USA have been increasing

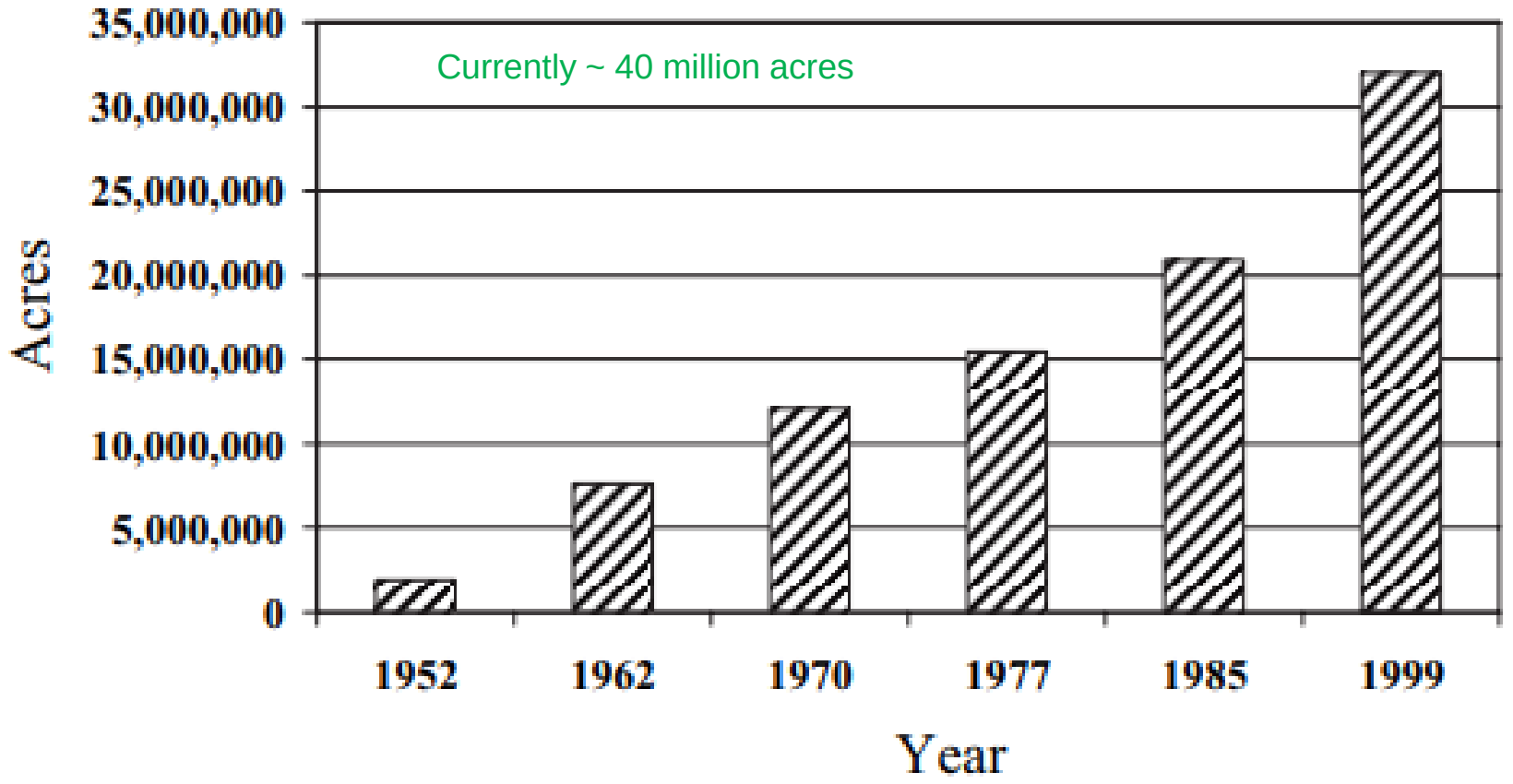


Figure 1. Number of acres of pine plantations in the southern United States from 1952 to 1999.

Fox, Jokela, and Allen. 2007. The development of pine plantation silviculture in the southern United States. Journal of Forestry 105: 337-347

About 1 million acres of loblolly pine plantation in south-eastern Oklahoma

Supports a multi-billion dollar per year industry

Google earth

Forestry Practices that Increase Carbon Storage

General Categories

1. Establishing trees (reforestation or afforestation)
2. Lengthening rotation ages
3. Modifying management practices
4. Preserving existing forest land
5. Improved utilization

Forestry Practices that Increase Carbon Storage

1. Establishing trees through afforestation or reforestation

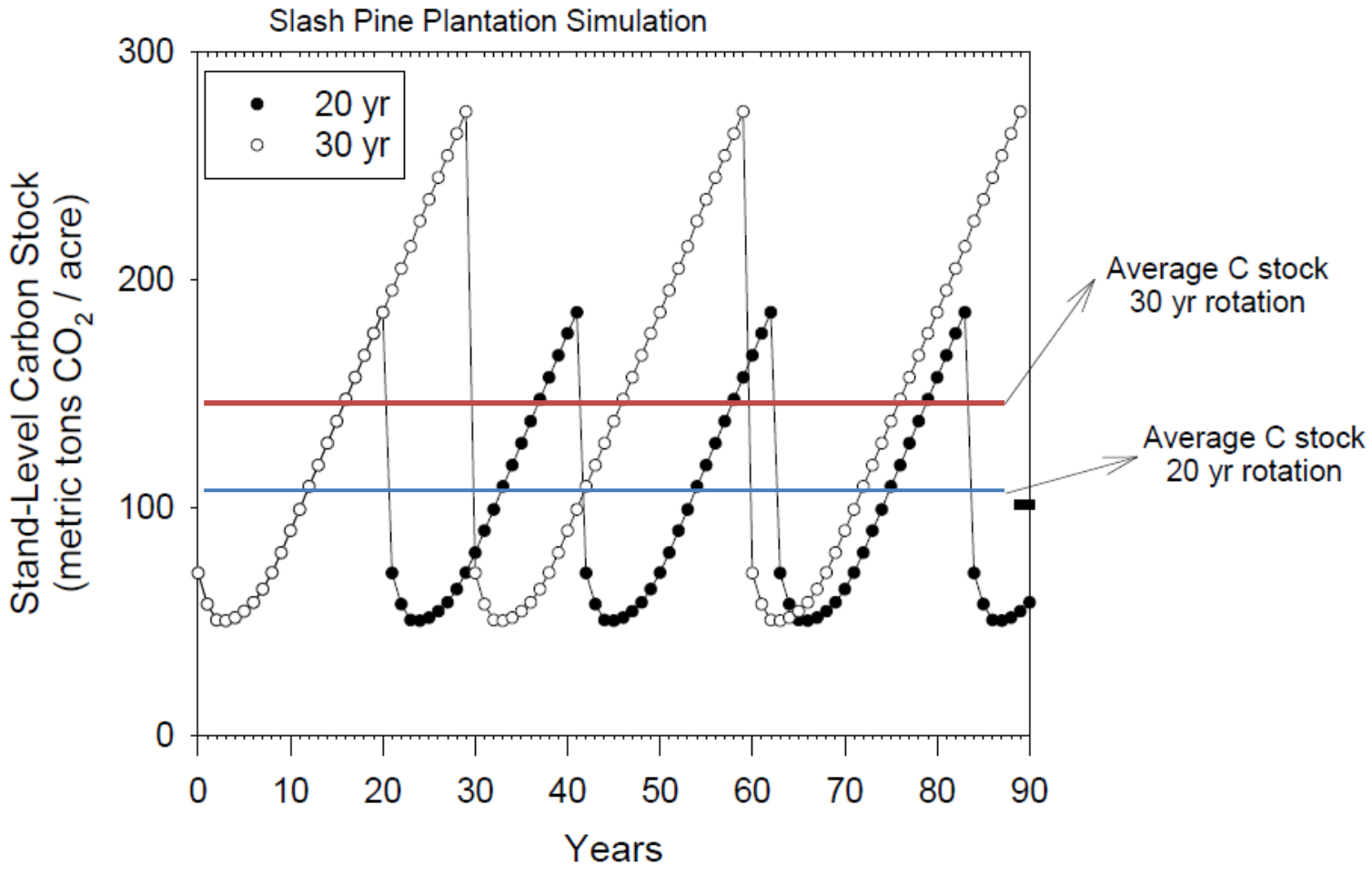
    - Straightforward approach
    - *Some* trees are better than *no* trees!
    - Orders of magnitude more carbon in aboveground
    - Soils?
    - Disturbance?

Forestry Practices that Increase Carbon Storage

2. Lengthening Rotation Ages

- Even if growth rates slow with older stands, the average amount of carbon stored over a longer rotation increases

Increase carbon density of existing forests - Rotation Age



Martin and Cropper, unpublished

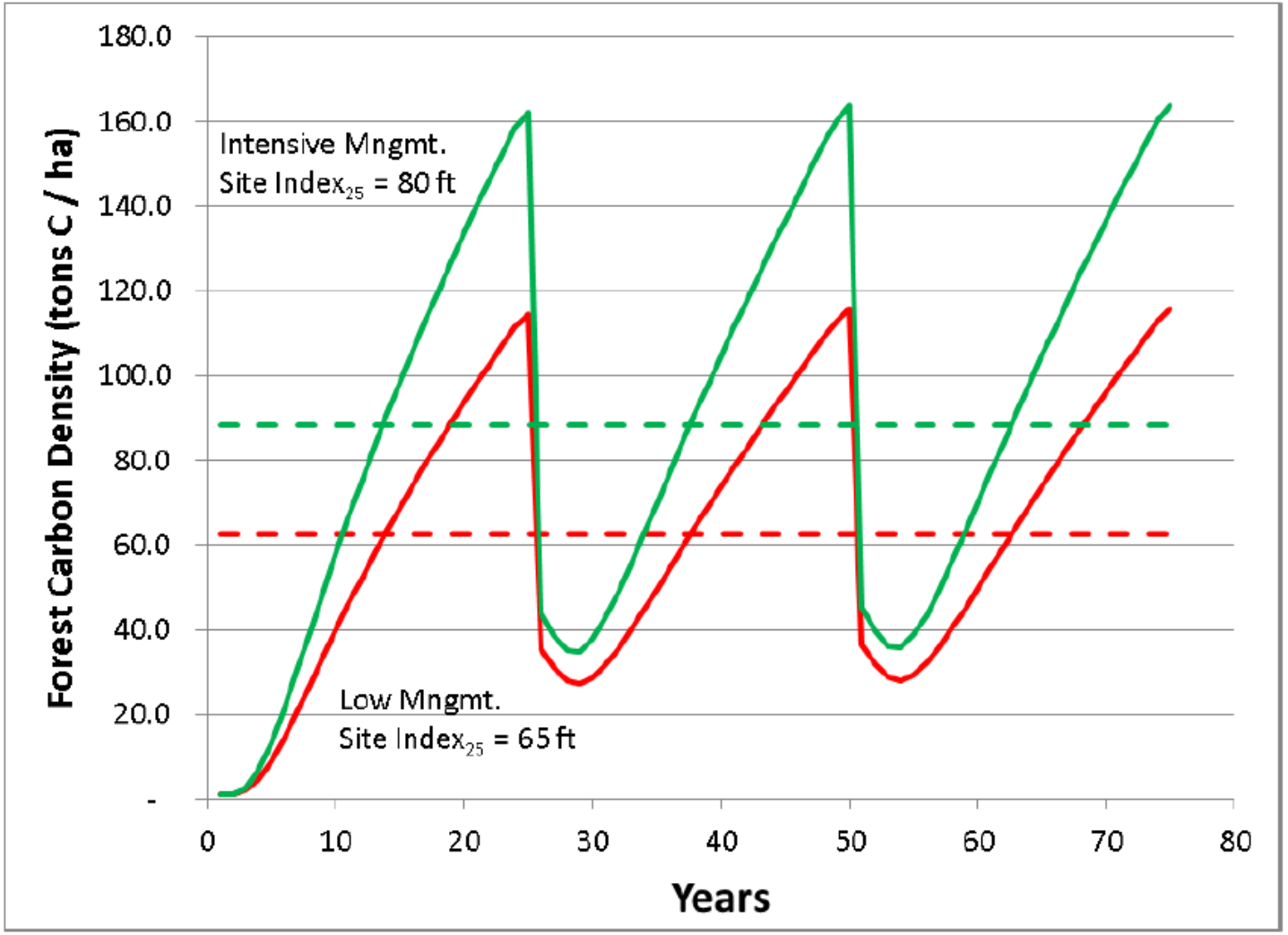
Forestry Practices that Increase Carbon Storage

3. Modifying Management Practices for CO_2

- Generally speaking involves anything that increases growth rate.
- Examples include genetic improvement, thinning, competition control, fertilization, etc.

Must increase productivity over current practices (additionality)

Increase carbon density of existing forests - Management Intensity



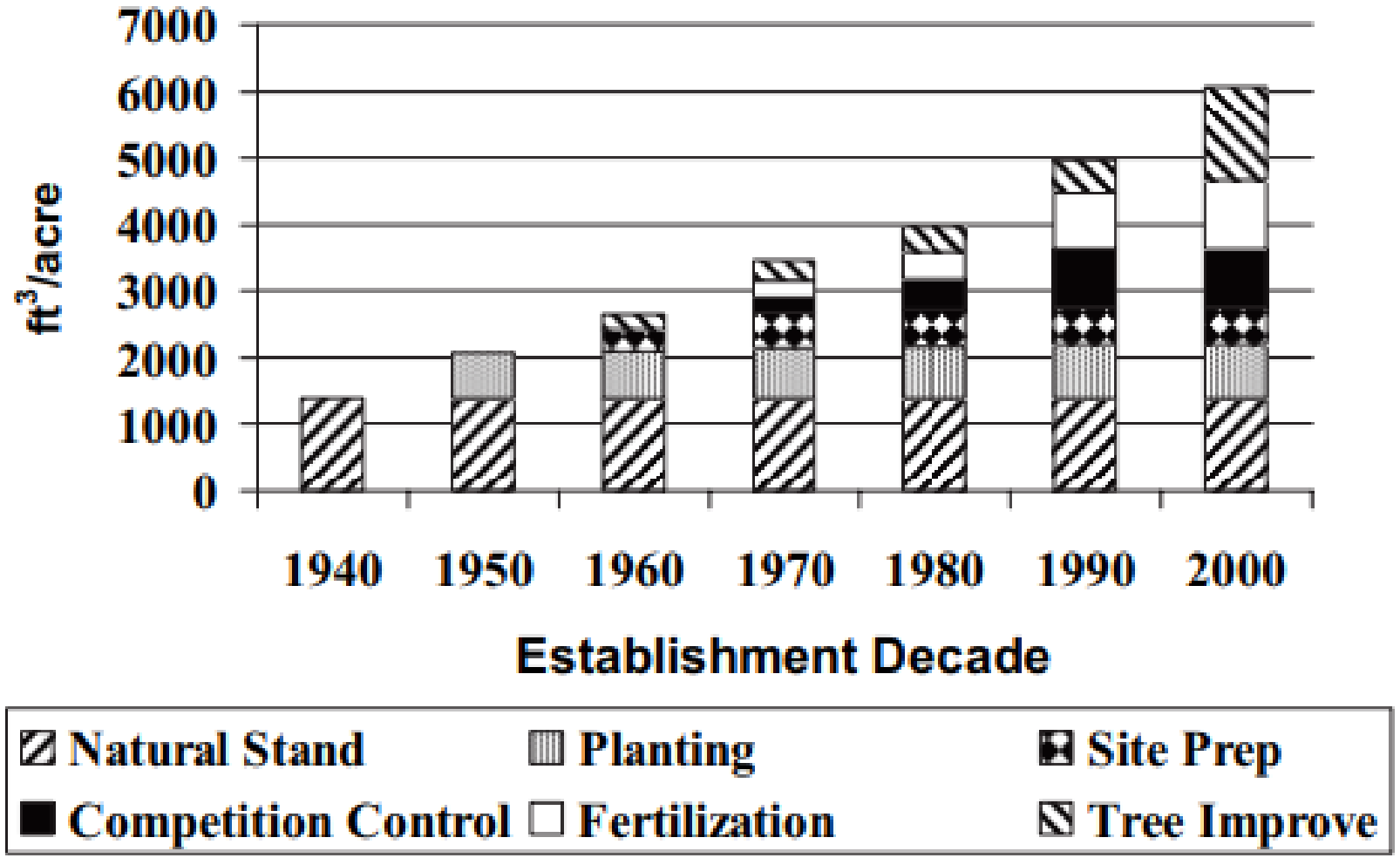


Figure 2. Estimated total yield and contributions of individual silvicultural practices to productivity of pine plantations in the southern United States from 1940 to 2000.

Fox, Jokela, and Allen. 2007. The development of pine plantation silviculture in the southern United States. Journal of Forestry 105: 337-347


UGA140

Pine plantation silviculture

- Clearcut
- Site preparation (physical)
- Site preparation (chemical)
- Plant site
- Herbaceous weed control
- Hardwood release?
- Thin
- Fertilize (some stands)
- Thin (multiple thinnings on better sites)
- Clearcut

Clearcut

Site preparation (physical)

- Bedding or ripping usually done the summer following clearcutting
- Match best method to site conditions while considering cost

Site preparation (chemical)

- Site prep; Herbicides used to kill competing vegetation before planting

Planting currently in SE OK

- Plant late January to mid March (usually hand planted)
- Typical planting between 500 and 700 trees per acre
- Genetically improved seedlings, level of genetic improvement continually improving

Herbaceous Weed Control

- Herbicides used to kill herbaceous competition usually during first year

Hardwood release prescriptions (if needed)

- Herbicide used to kill competing hardwoods, typically mid-rotation

Thinning

- Reducing number of trees to increase growth rate of residual trees and maintain forest health
- Harvested wood sold for mostly lower value pulpwood as well as some smaller sawtimer.

Mid-rotation fertilization

- Usually age 8 to 18 years old, often following thinning
- Common prescription is 200 lbs/acre N and 25 lbs/acre P

Clearcut

- Final harvest and begin cycle again
- Around age 25-30

Increasing Growth (and carbon)

- Aggressive site preparation
- Aggressive use of herbicides
- Plant the best genetics
- Fertilize
- Thin multiple times
  - Increase growth of residual trees
  - Increase utilization
- All these increase vigor and resistance to insects

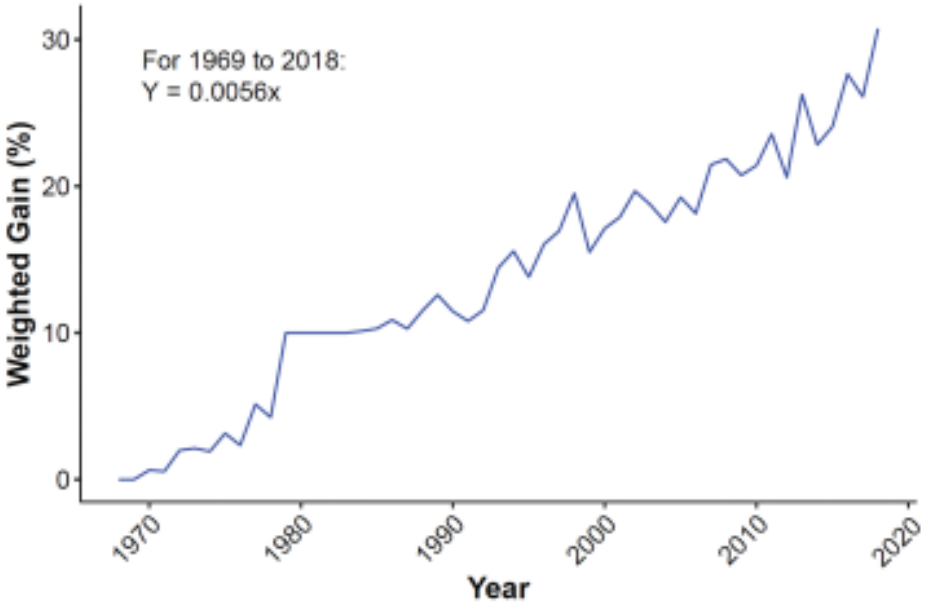


Figure 1. Estimates of genetic gain deployed in the last 50 years in loblolly pine plantations established with germplasm derived from the North Carolina State University Cooperative Tree Improvement Program. In the first 14 years, only first-generation seedlings were planted, and until 1979, there were not enough seedlings available to plant all acres. The genetic gain each year is weighted by the number of first-, second-, and third-cycle seedlings and full-sib seedlings that were available for planting. The yearly fluctuations are due to the variability in the availability of seedlings of different genetic gain levels and differences in the acreage of plantations established each year. As genetically better seedlings became available, the gains increased by 0.56% per year over the 50-year period (the slope of the trend line, not shown). Over the last 7 to 10 years, the gains increased by 0.91% to 1.25% per year.

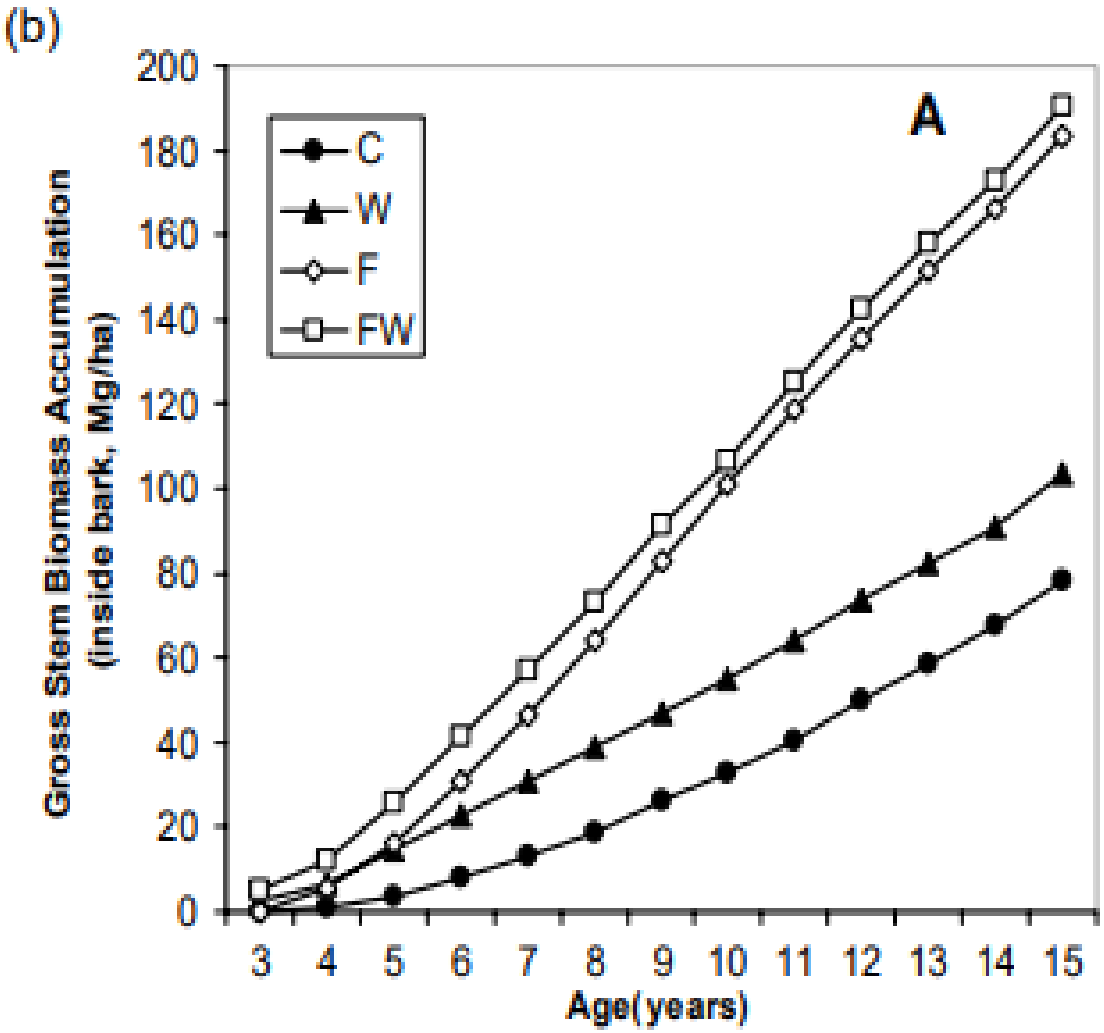
McKeand et al. 2021. Journal of Forestry 119:62-72

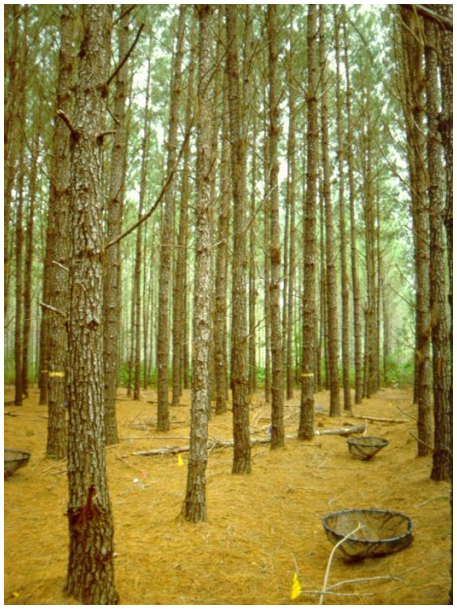
Often, herbicide use is an essential step

Five-year-old plantation in SE OK with strip not receiving HWC

Photo courtesy of Ed Hurliman

Fertilization and competition control on growth



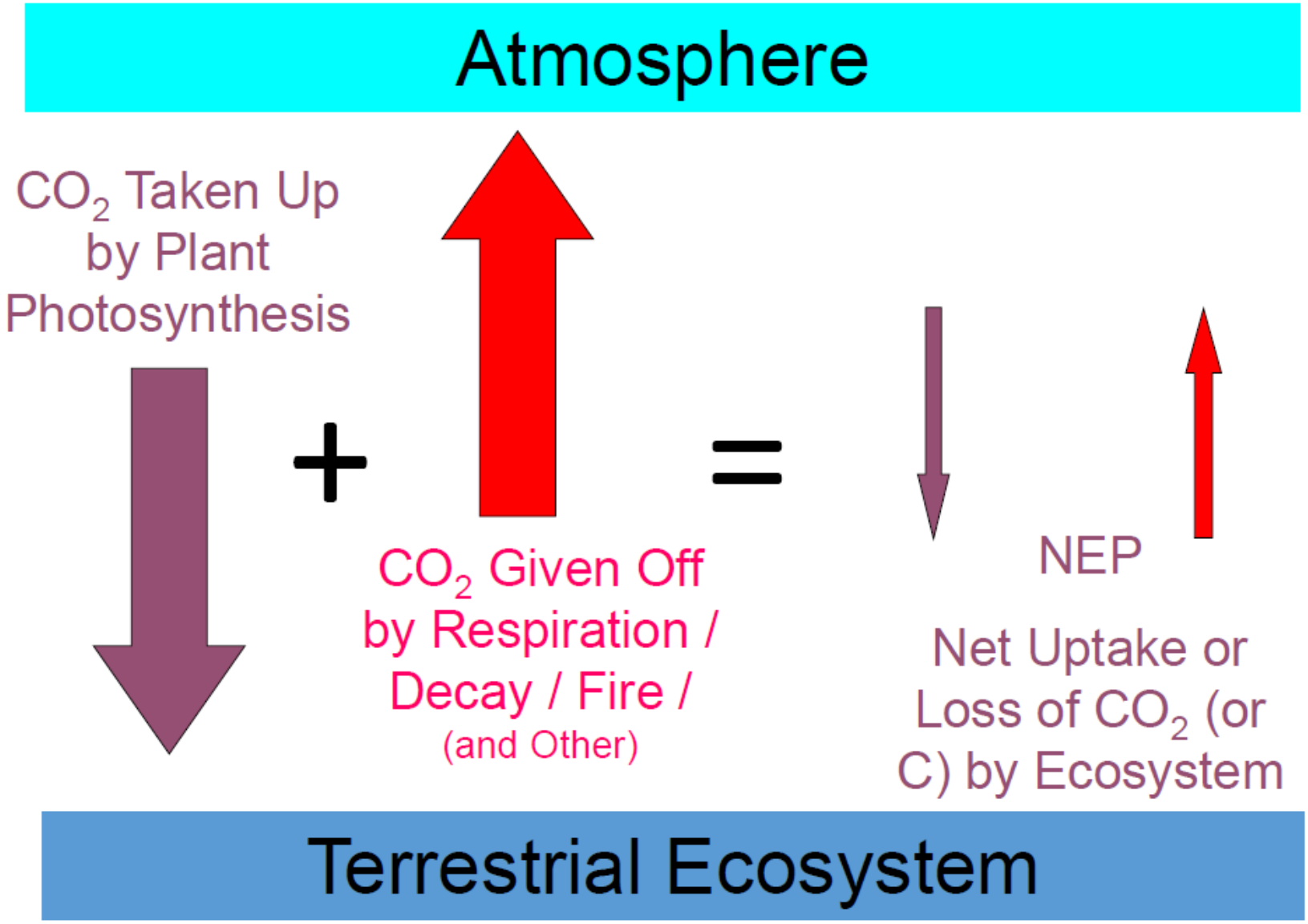


Stem biomass accumulation in loblolly pine in southern GA

Borders, Will, et al. 2004. Forest Ecology and Management 192:21-37

Ultimately, it is carbon in the ecosystem rather than carbon in the trees only

- Soils
- Litter layer
- Microbes decompose organic carbon and release CO_2 back to atmosphere
- Fire


Atmosphere
CO_2 Taken Up by Plant Photosynthesis
+
CO_2 Given Off by Respiration / Decay / Fire / (and Other)
=
NEP
Net Uptake or Loss of CO_2 (or C) by Ecosystem
Terrestrial Ecosystem

Global Flows of Carbon

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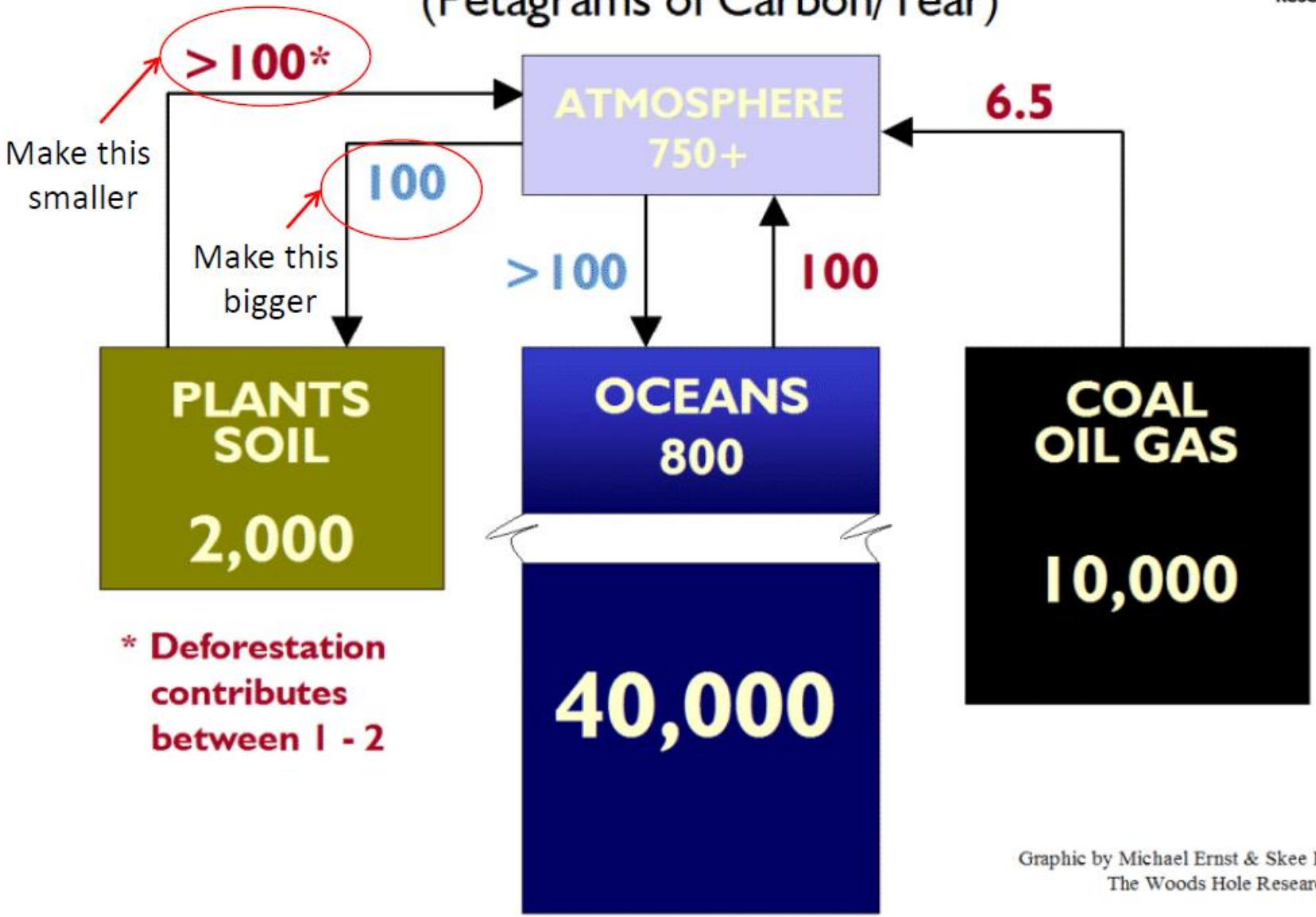

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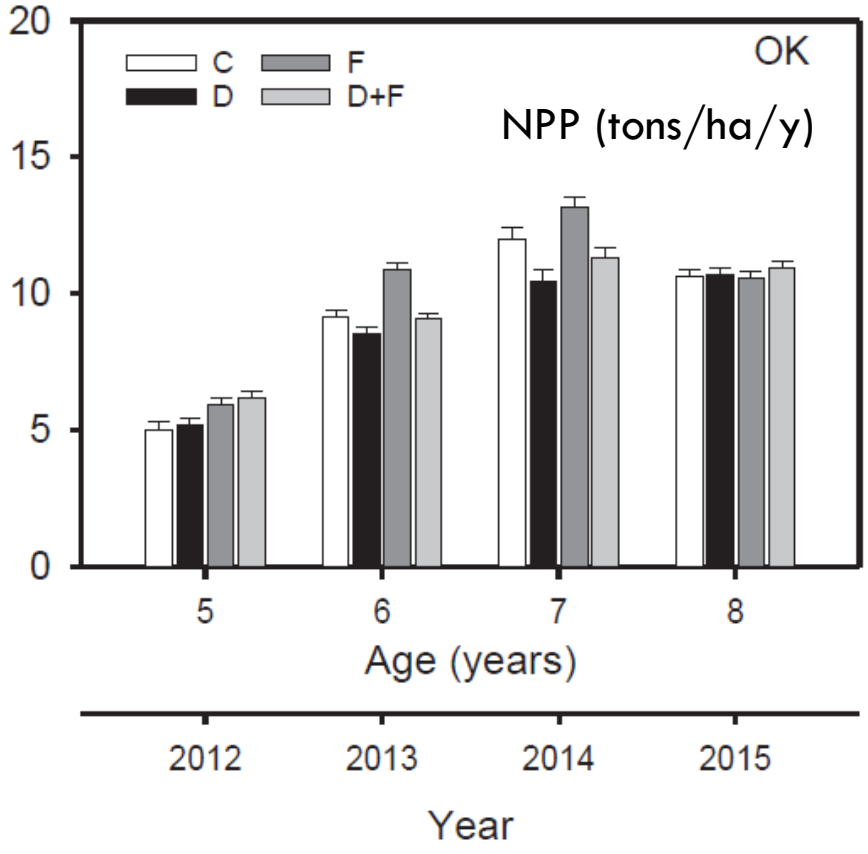
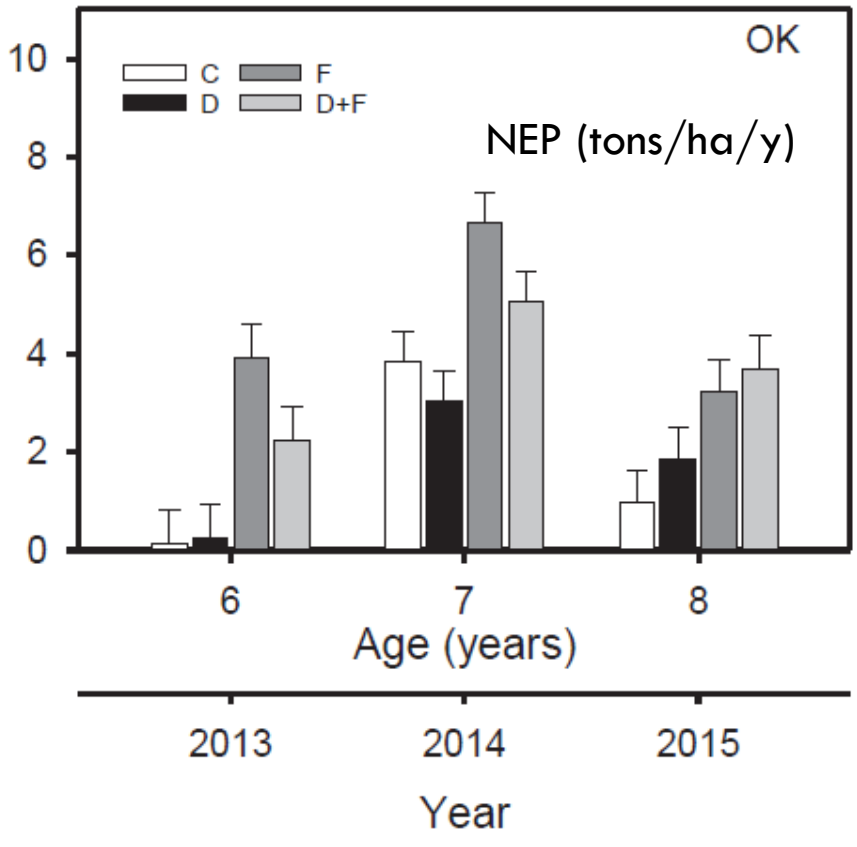
Carbon gain in Oklahoma pine plantations

- Its more than just tree growth, carbon flux for the soil matters
- Fertilization increases tree growth and reduces soil carbon loss





We can grow trees faster and store more carbon, but……

- What is considered additionality?
- How can it be monetized?