Forest Carbon and Resilience

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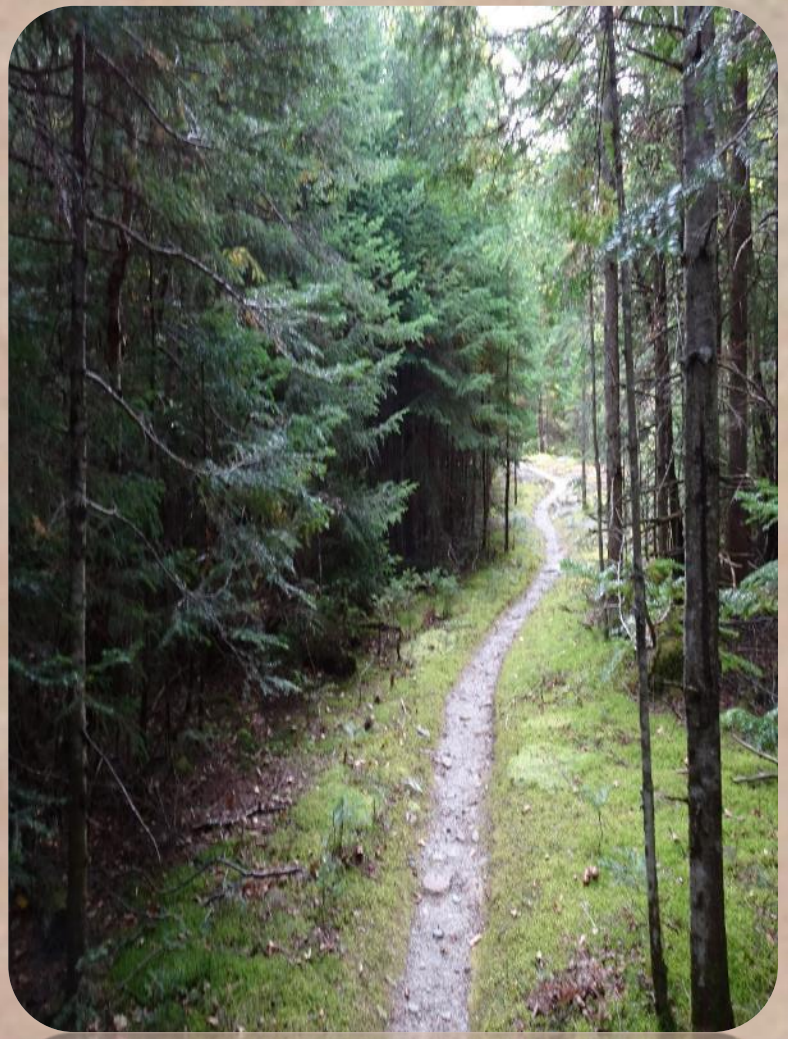
Trail Map

- Carbon basics
- Stocks and rates
- The Big Picture – health and resilience
- Changing the Frame
- Points to Ponder



Forest Carbon Basics

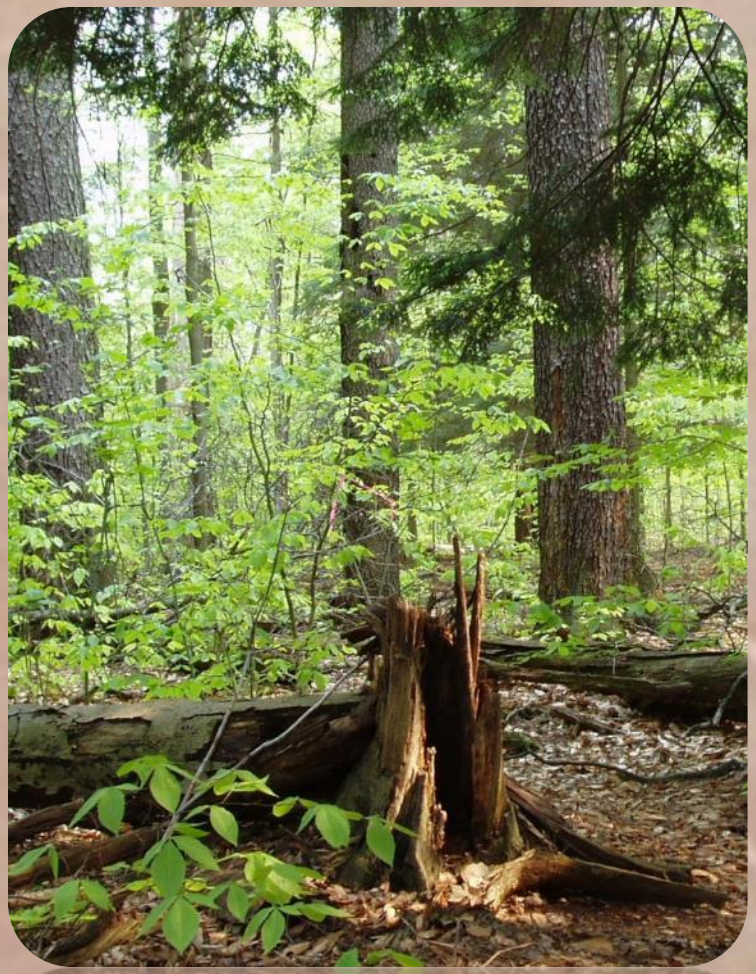
Carbon Sequestration 101

- During photosynthesis, plants use carbon dioxide (CO_2) from the atmosphere to make sugars, wood, etc.
  - Plant tissues are about 50% carbon (C)
- This carbon is temporarily removed from the atmosphere
  - This slows the rate of CO_2 accumulation
- US forests are currently a carbon sink – they are storing CO_2 (offset about 10% of GHG emissions)

Major Greenhouse Gases

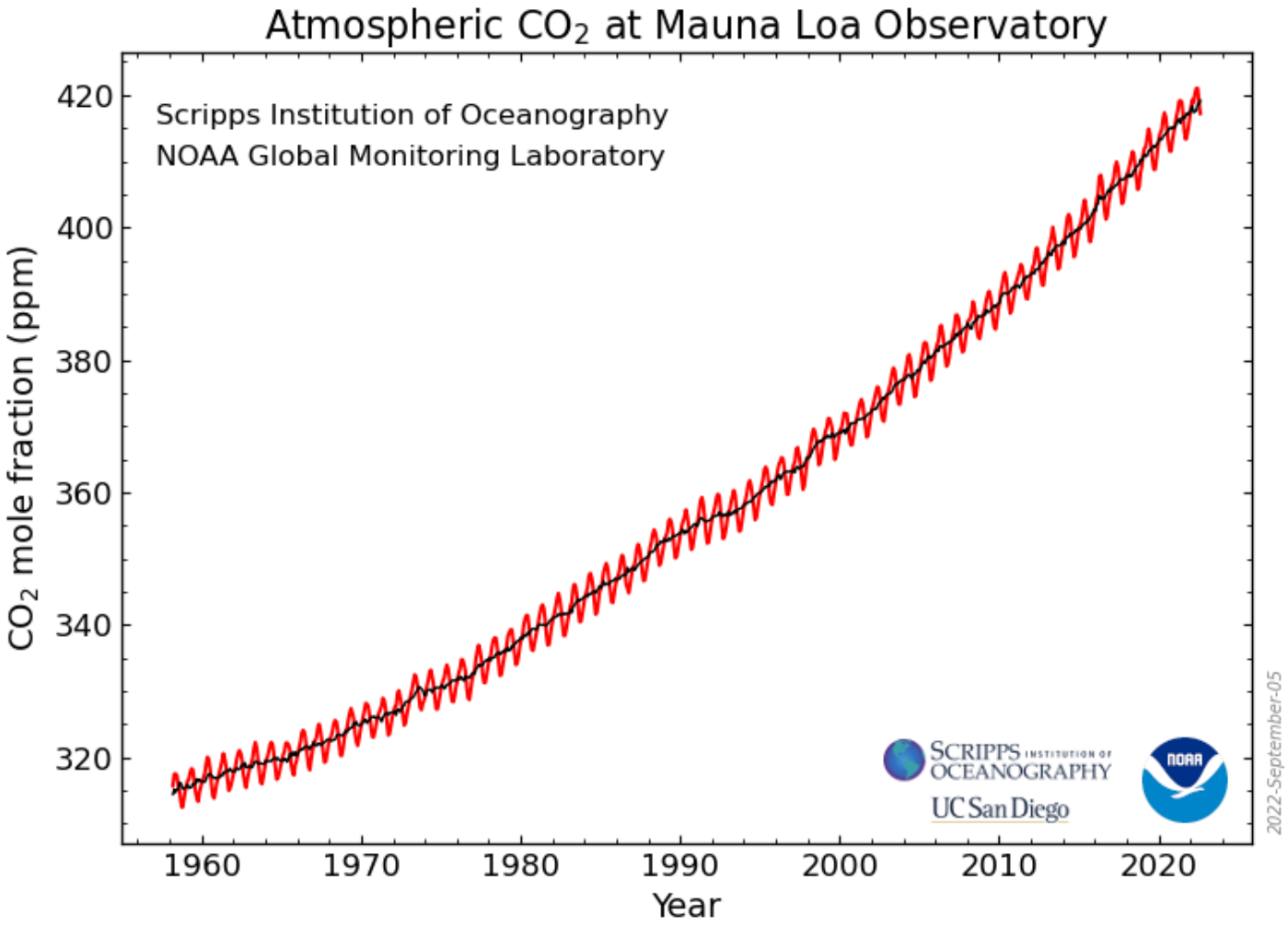
- Carbon Dioxide (CO_2)
  - Uptake by plants, emission from respiration and fire
- Methane (CH_4) – GWP = 28
  - Uptake by soils, emission from fire
- Nitrous Oxide (N_2O) – GWP = 265
  - Emission from soils and fire
- Water vapor
  - Transpiration
- Carbon monoxide (CO) – GWP = 1.9
  - Emission from fire
- Sulfur hexafluoride, CFCs, other chlorinated hydrocarbons

The Forest Carbon Equation



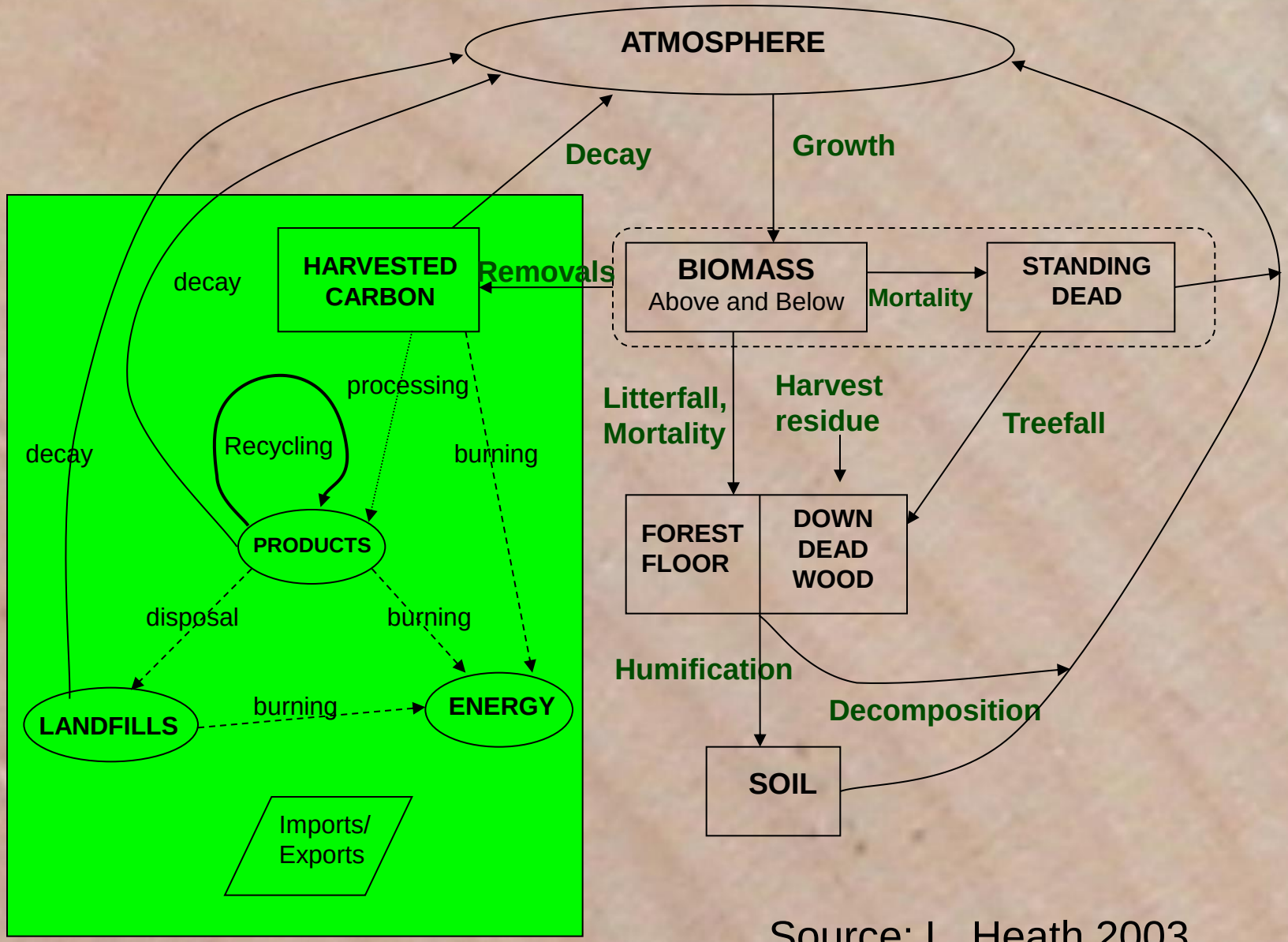
- Any given forest can be a *carbon source OR a carbon sink* (or change back and forth)
- Depends on variables like:
  - Age class distribution
  - Forest health/disturbance history
  - Management practices
  - Weather
- Overall, US forests are acting as a carbon sink

Atmospheric CO_2



Forest Carbon Pools

The Forest Carbon Cycle



Source: L. Heath 2003

Key Forest Carbon Pools

Live biomass

Dead trees

Products

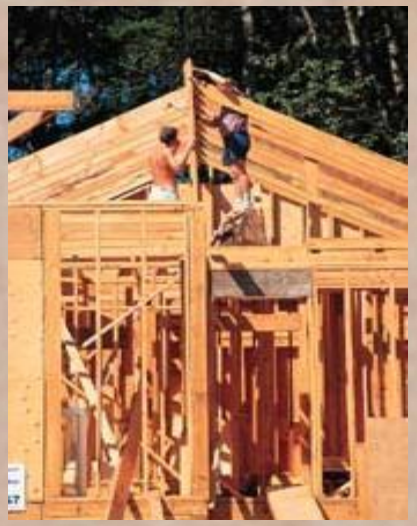
Soils

Forest floor

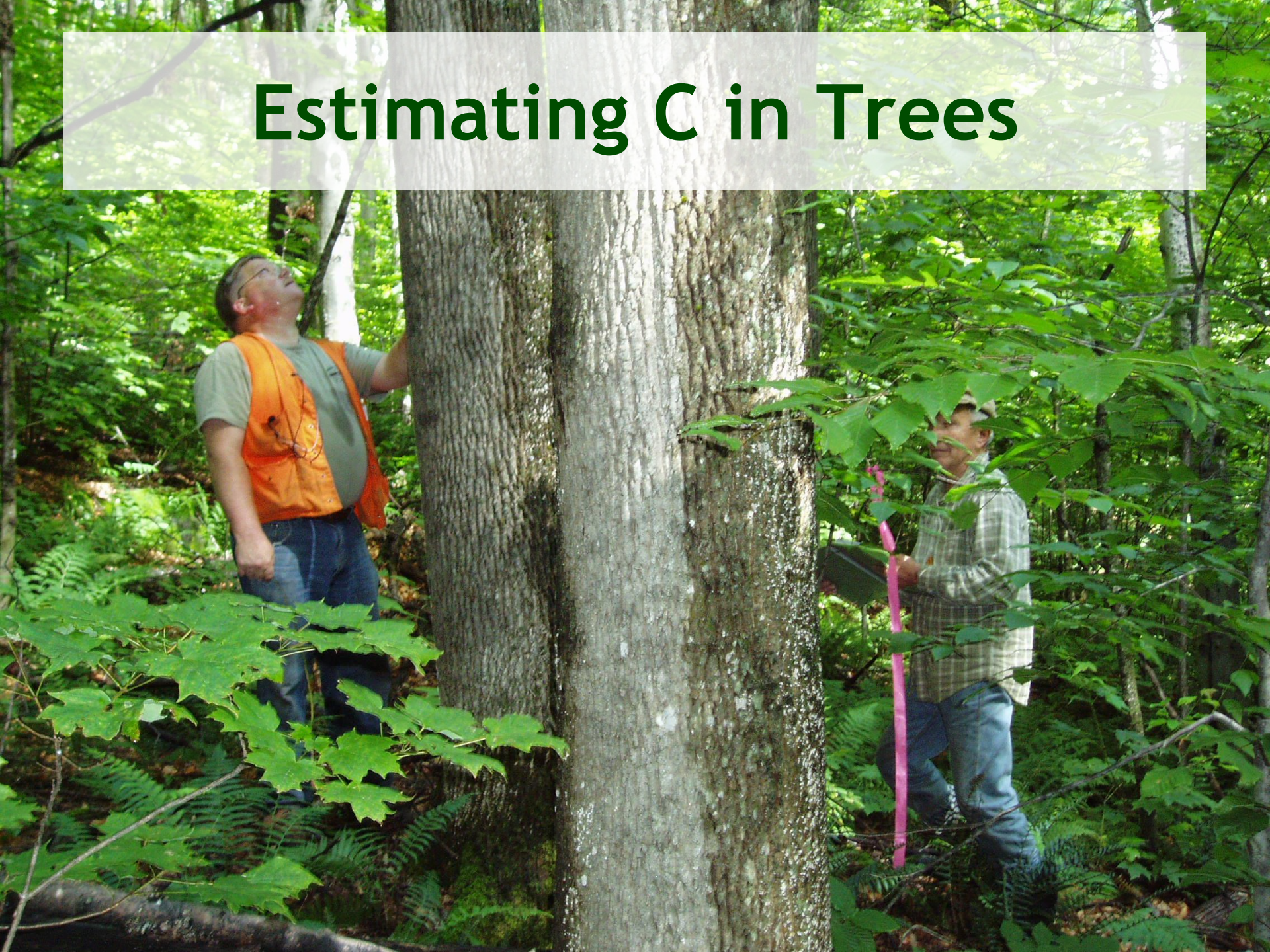
Woody debris

The Role of Wood Products

- Harvested C is turned into products, but some waste is landfilled or burned for energy
- Products go different places over time – pulp often to a landfill, sawtimber into longer lived products
- Product end use affects size and duration of this sink



Estimating C in Trees



How do we estimate C in trees?

- We use standard forest measurements
- There are a few ways to get there:
  - Volume based approach: start with merchantable volume and apply scaling factors to get to total volume and then biomass (BEF = Biomass Expansion Factor)
  - Biomass based approach: using DBH (and sometimes height) calculate biomass of each stem using species/region specific equations (these are called biomass or allometric equations)

Ways to express C estimates

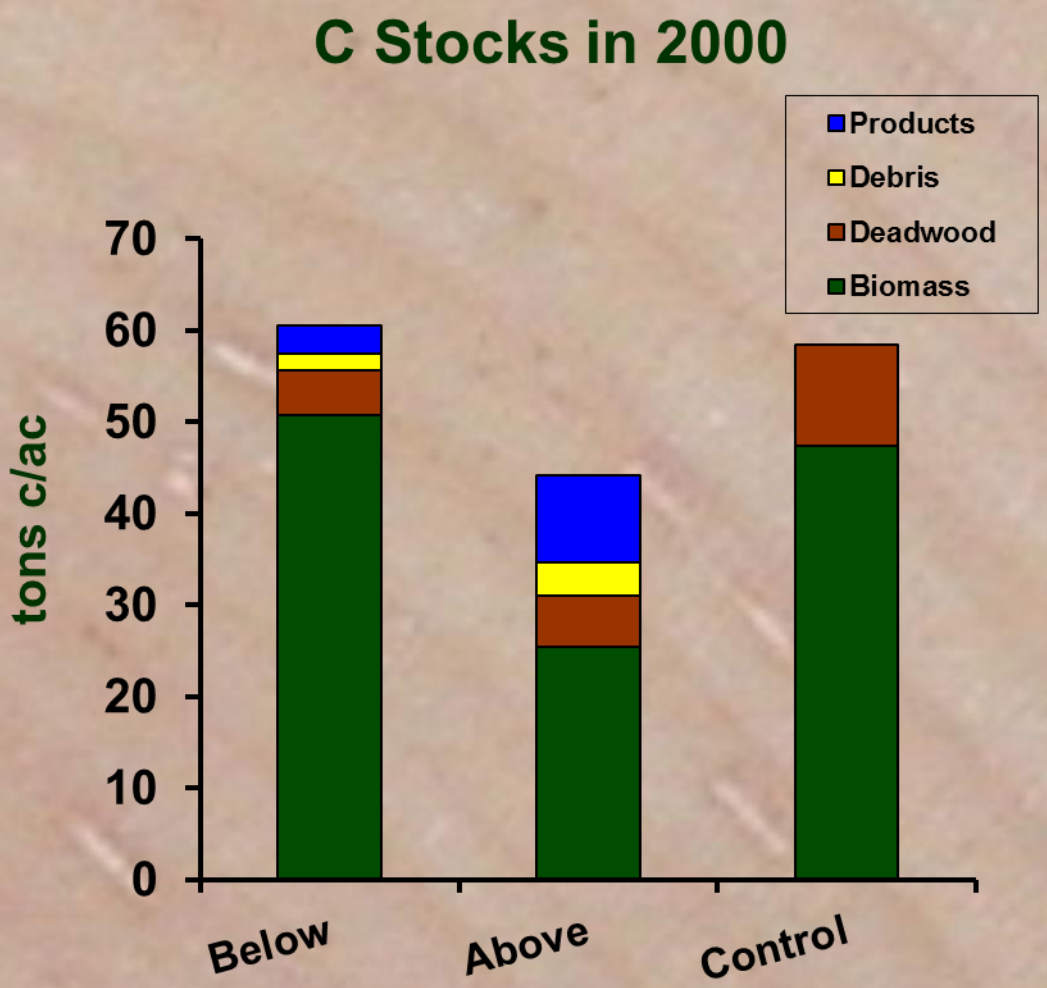
- Stock: amount of carbon in a stand/forest/state/etc. at a point in time
  - Can be expressed as a total (tons, metric tons) or as carbon per unit area (tons/ac, mt/ha)
- Net change: difference in C stock between 2 points in time (total or per area)
- Rate: average annual change = net change/# of years between measurements
  - Expressed as tons/ac/yr or mt/ha/yr

A note about units

- There are many units used!
  - Forestry in the US uses English units: tons, acres, cubic feet
  - Forestry outside the US uses metric units: metric tons (tonnes), hectares, cubic meters
  - Science is metric or SI units (eg megagrams)
- CO_2e: carbon dioxide equivalents
  - Often used when talking about offsets, expresses values in terms of carbon dioxide, not carbon
  - Often used with atmospheric sign convention where negative values = CO_2 uptake and positive values = CO_2 emissions

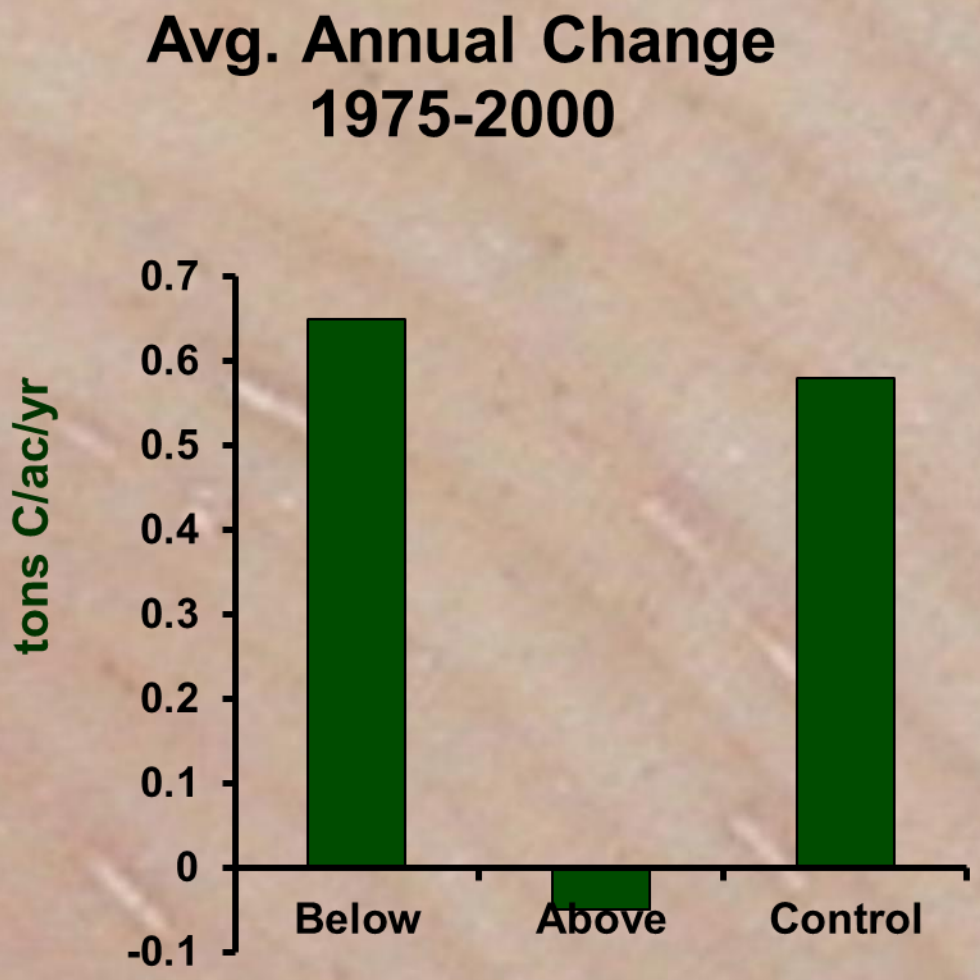
Warning: Soapbox moment ahead….Stocks vs Rates

Standing Stocks vs. Rates



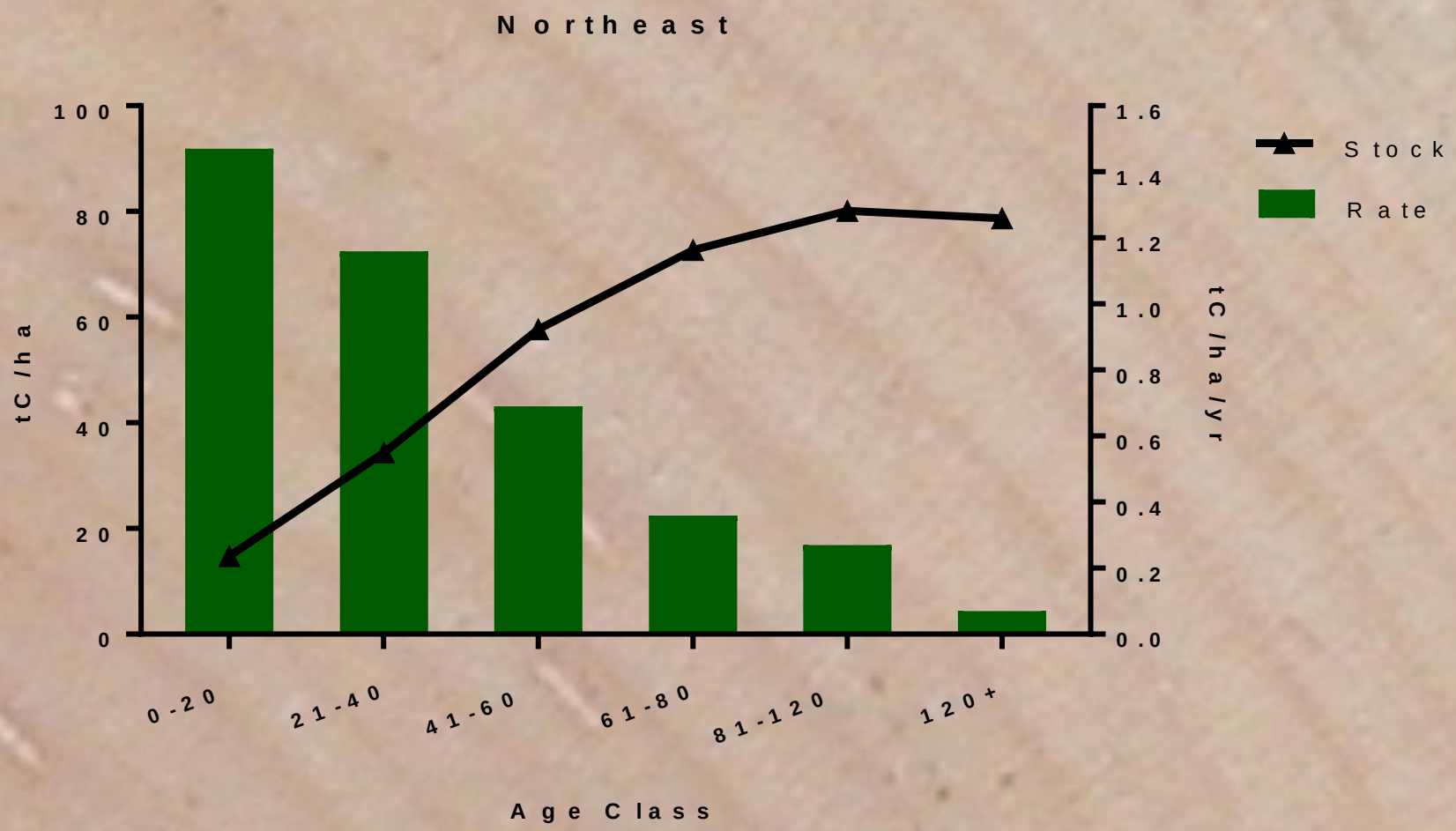
- Stocks give a snapshot in time
  - Carbon in the "bank"
- Can be expressed per acre or for total land area
- If areas had different initial conditions, it won't be explicitly shown in the numbers

Standing Stocks vs. Rates

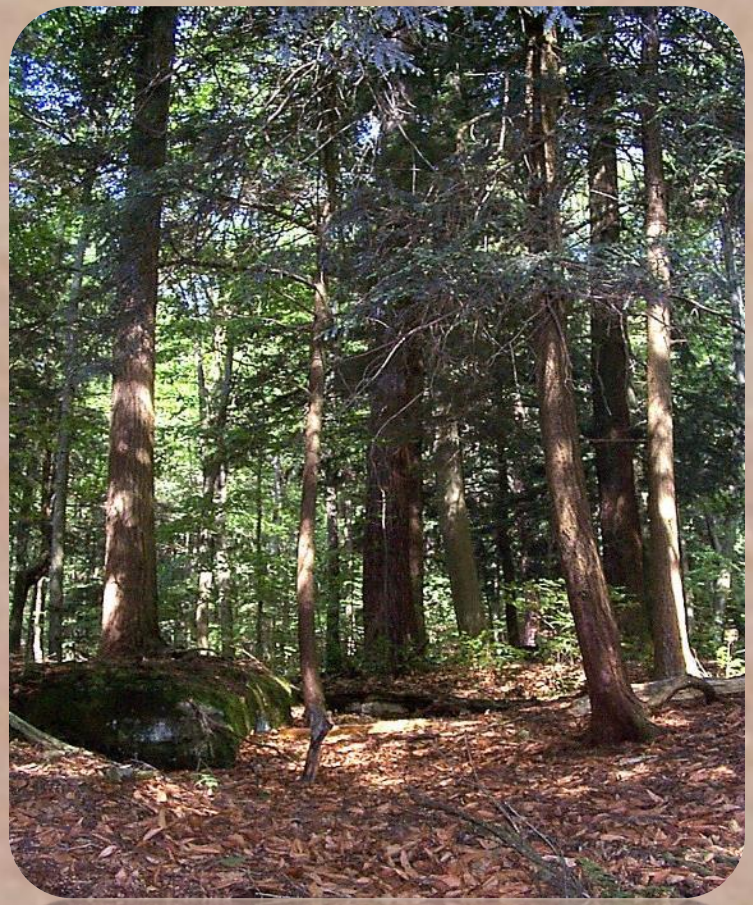


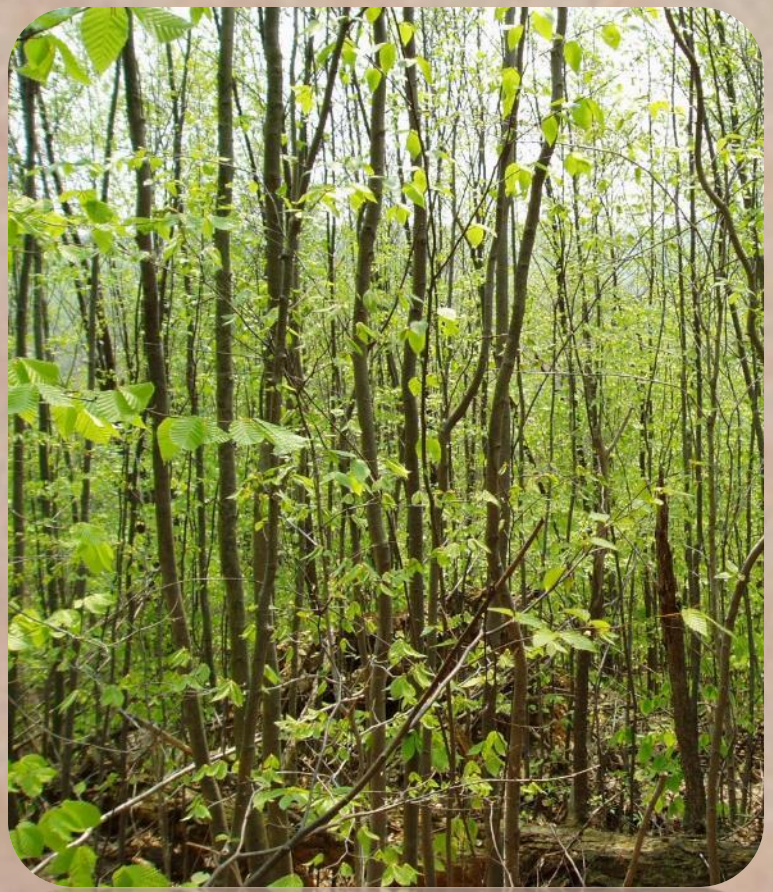
- Average annual change shows rate of change
  - "Interest" earned on C in the bank
- Useful for comparing areas, treatments, etc.
  - Comparing **rate** of change, not total change

From FIA data….



So, another good reason to plan for a range of age classes across the landscape…..





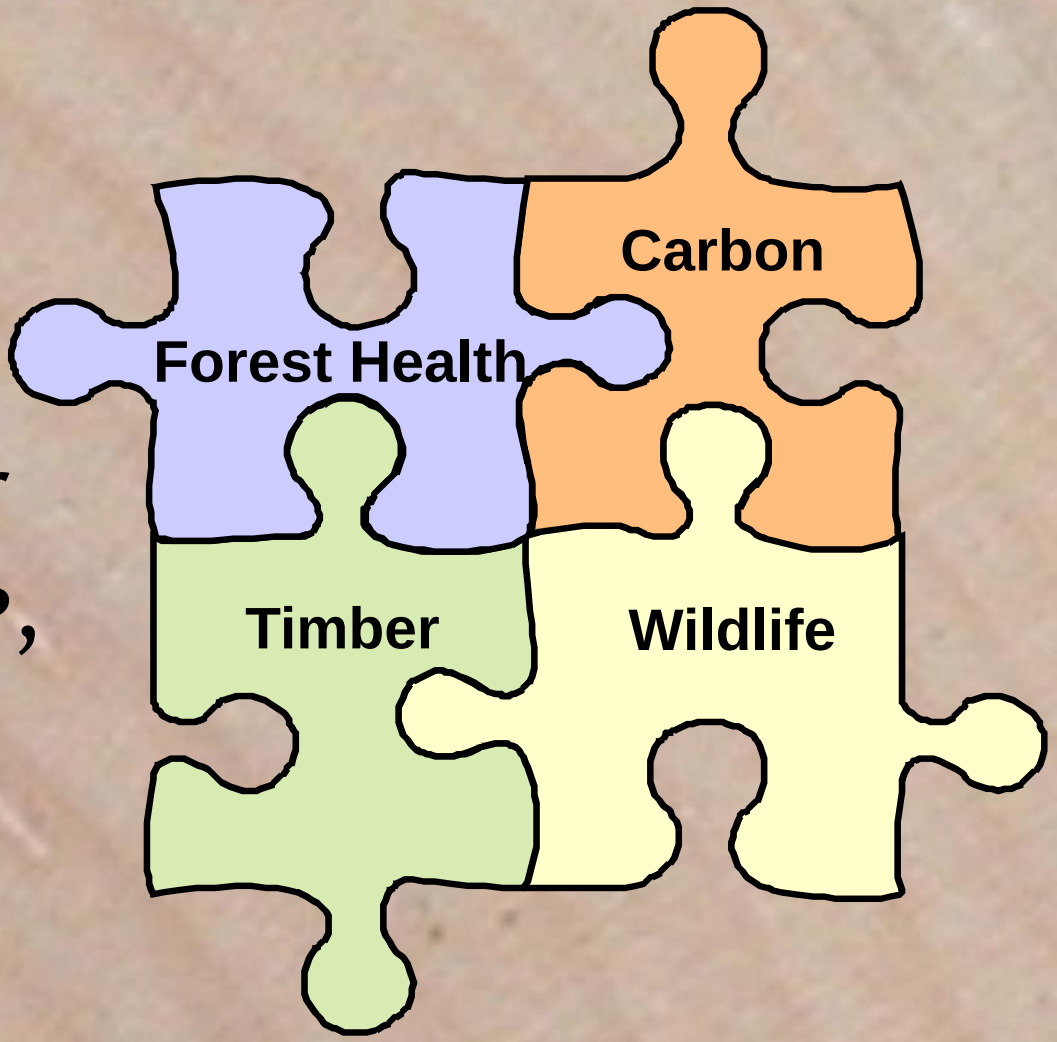
The Big Picture

How do carbon and climate fit into the management picture?

- Carbon is 50% of the dry weight of biomass
- Carbon isn't mysterious or different, it's just another lens for viewing forests
- What we know about forest growth and yield applies to carbon!
- We calculate carbon using data from standard forest inventory measurements *(and you can, too!)*

Carbon is a piece of the management puzzle

- Think carbon **AND** x, not carbon **OR** x
- Tradeoffs over the ***landscape***, not project/ stand scale



Changing the Frame

Assembling the puzzle

- How do we think about forest management in the context of a changing climate?
- What about more frequent and interacting stressors?
- What about the role of silviculture and management treatments?
- How do we think about tradeoffs?

Quiz:

- What is the definition of resilience in the context of ecology and forestry?

- "***the capacity of a natural community or ecosystem to maintain or regain normal function and development following disturbance***" **-From the Dictionary of Forestry**

Resilience as a Frame

- Traditionally, we think of managing for an objective or set of objectives
- Given that stressors on forests are increasing and interacting…
  - Why not consider managing for forest health and resilience as our framework?
  - Managing for health and resilience maintains the ability of forests to provide a variety of benefits

Managing for resilience

- Think in terms of optimal stocking level for the long term
- Diverse mix of species and age classes across the landscape
- Setting up forests to better handle multiple stressors/disturbances

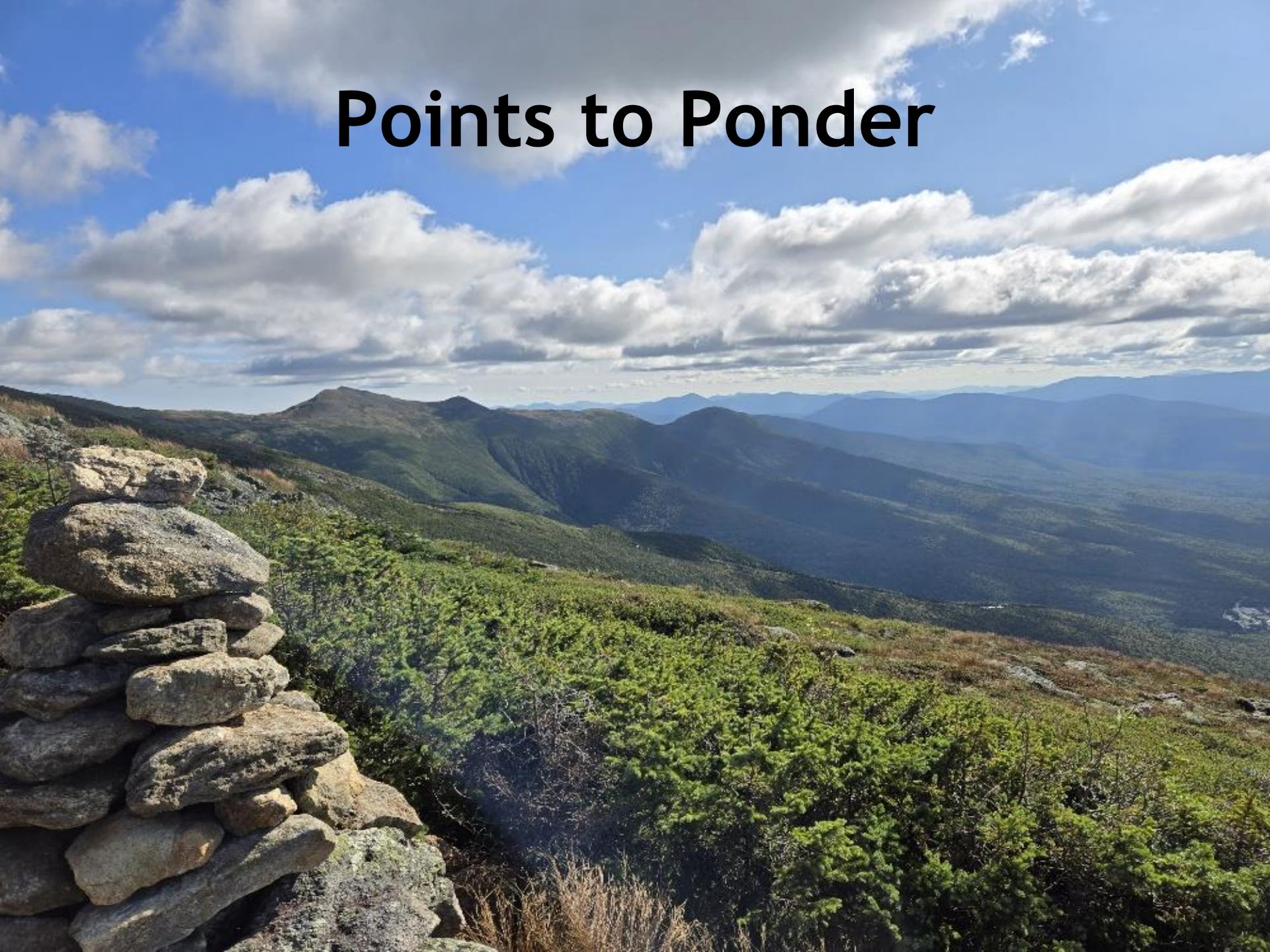
Key ingredient for resilience: mix of age classes

- We often think of species diversity, but age classes are important, too
- C “in the bank” and C “earning interest”
- Some age classes are more prone to some types of disturbance
  - Diversity as a bet-hedging strategy
- Diversity also important for wildlife objectives (think about forest structure)

Managing for the AND

- A mix of species and age classes across the landscape at an appropriate stocking level is a good prescription for:
  - Sustainable timber production
  - Wildlife habitat
  - Forest health
  - AND carbon and climate
- Silviculture is the tool we use to shape forest characteristics

Points to Ponder



Remember…

- Resilience is the ability of a system to continue to maintain key processes and functions in the face of change
- A healthy and diverse forest is more likely to continue to provide multiple benefits, including climate benefits
- Examining management actions through a resilience lens is a useful tool when planning – serves multiple objectives

Take homes

- Consider maintaining forest carbon long-term rather than maximizing stock
  - Think stocks AND uptake rates
- Managing for diverse and healthy forests promotes resilience *(and the carbon sink)*
- Forests are not a guaranteed carbon sink, they can also be a carbon source
- A diverse mix of species and age classes across the landscape at an appropriate stocking level = recipe for resilience


What is the best way to manage for forest carbon?


Making sure this….

Doesn’t become this….

Questions?