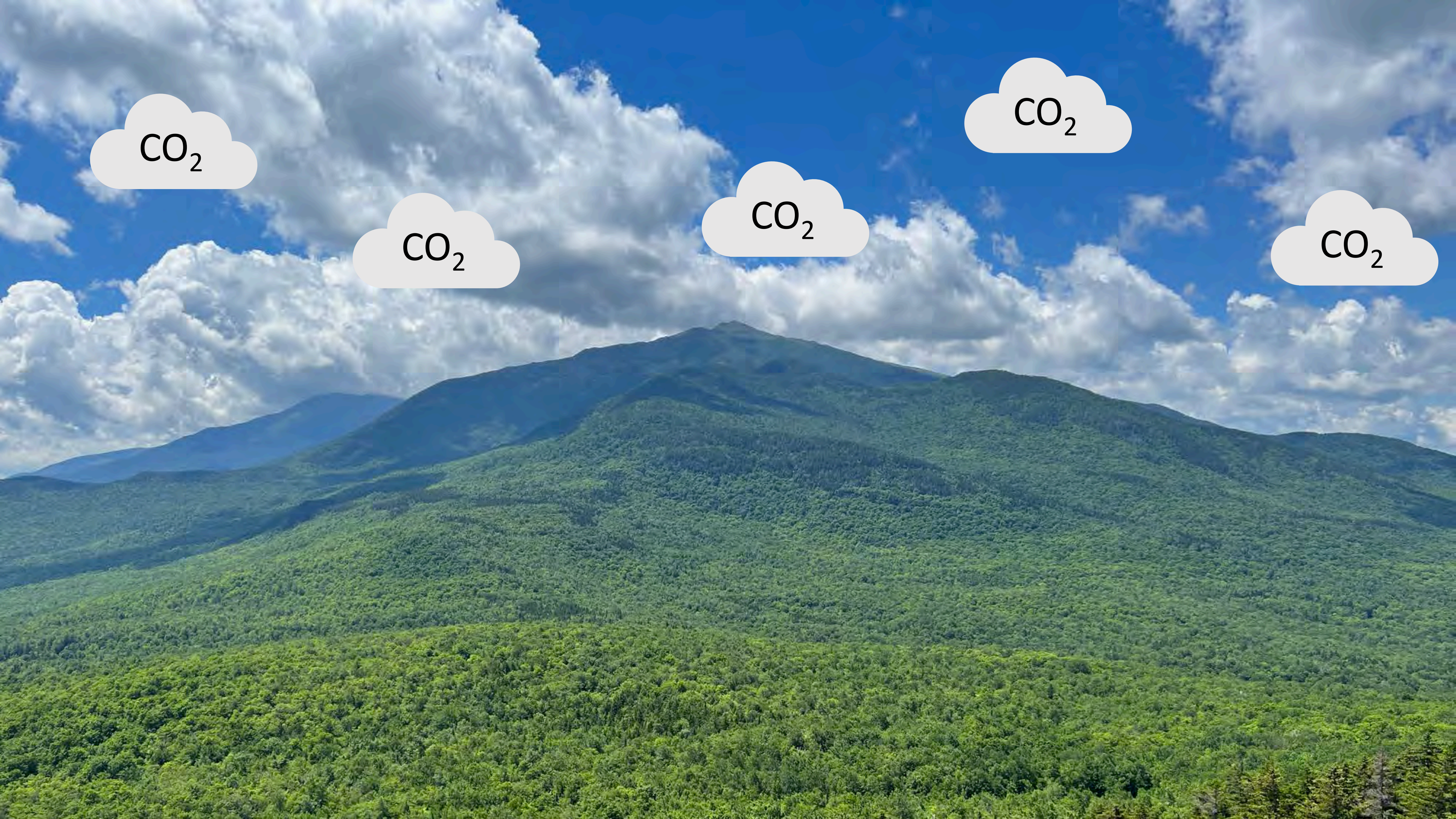
2023 EASTERN OLD-GROWTH FOREST CONFERENCE

Understanding carbon storage and sequestration in old forests

Ali Kosiba

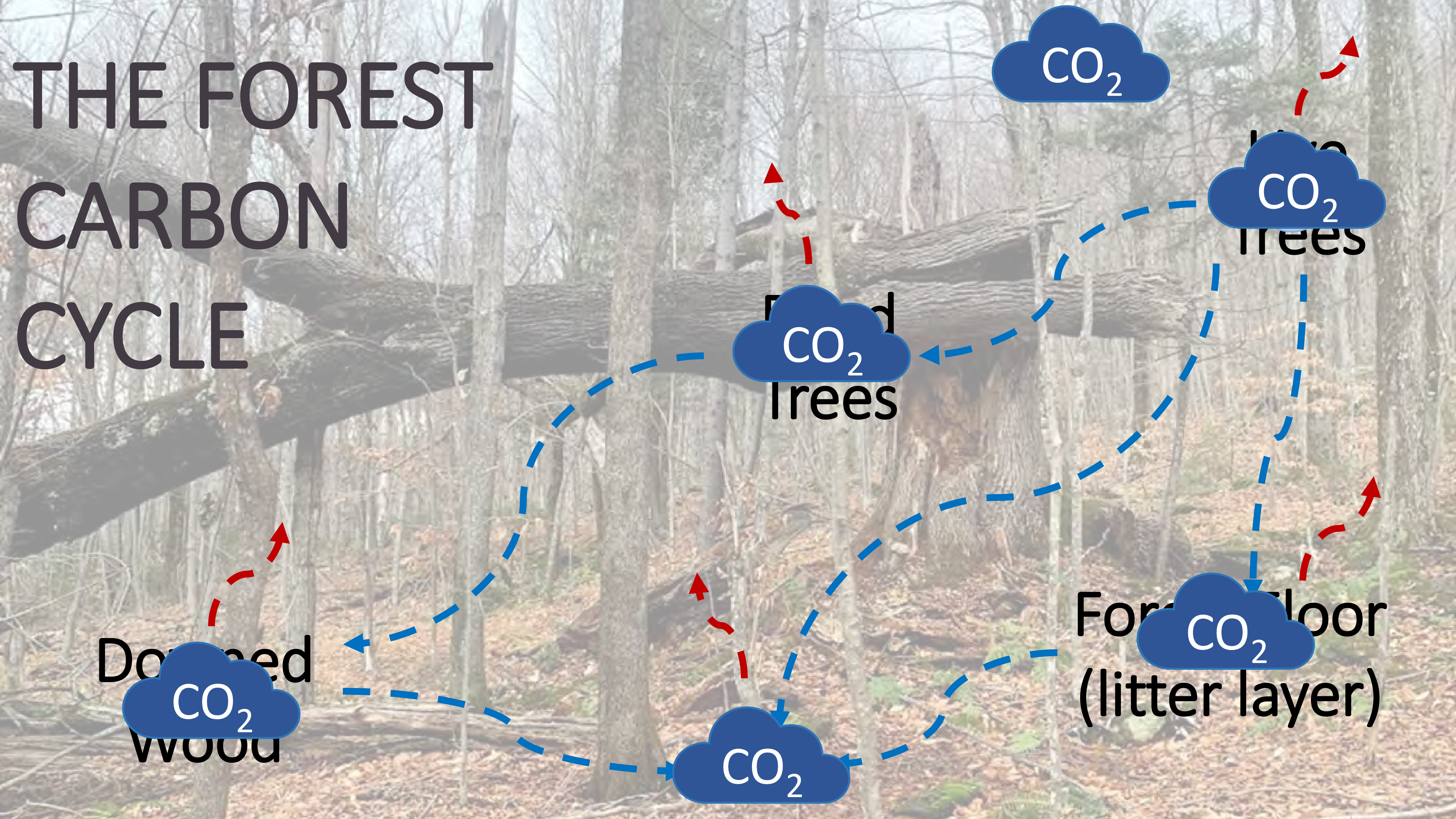
Extension Assistant Professor

THE UNIVERSITY OF VERMONT
EXTENSION
FORESTRY


CO_2
CO_2
CO_2
CO_2
CO_2


HALF
of the dry weight of wood is carbon that was removed from the atmosphere by the growing tree

THE FOREST CARBON CYCLE



Carbon Sequestration

the process of taking CO_2 from the atmosphere and storing it

Carbon Storage

total the amount of carbon in an entity

(e.g., tree, acre of forest, cord of wood)

Carbon Emissions

the process of releasing CO_2 back to the atmosphere

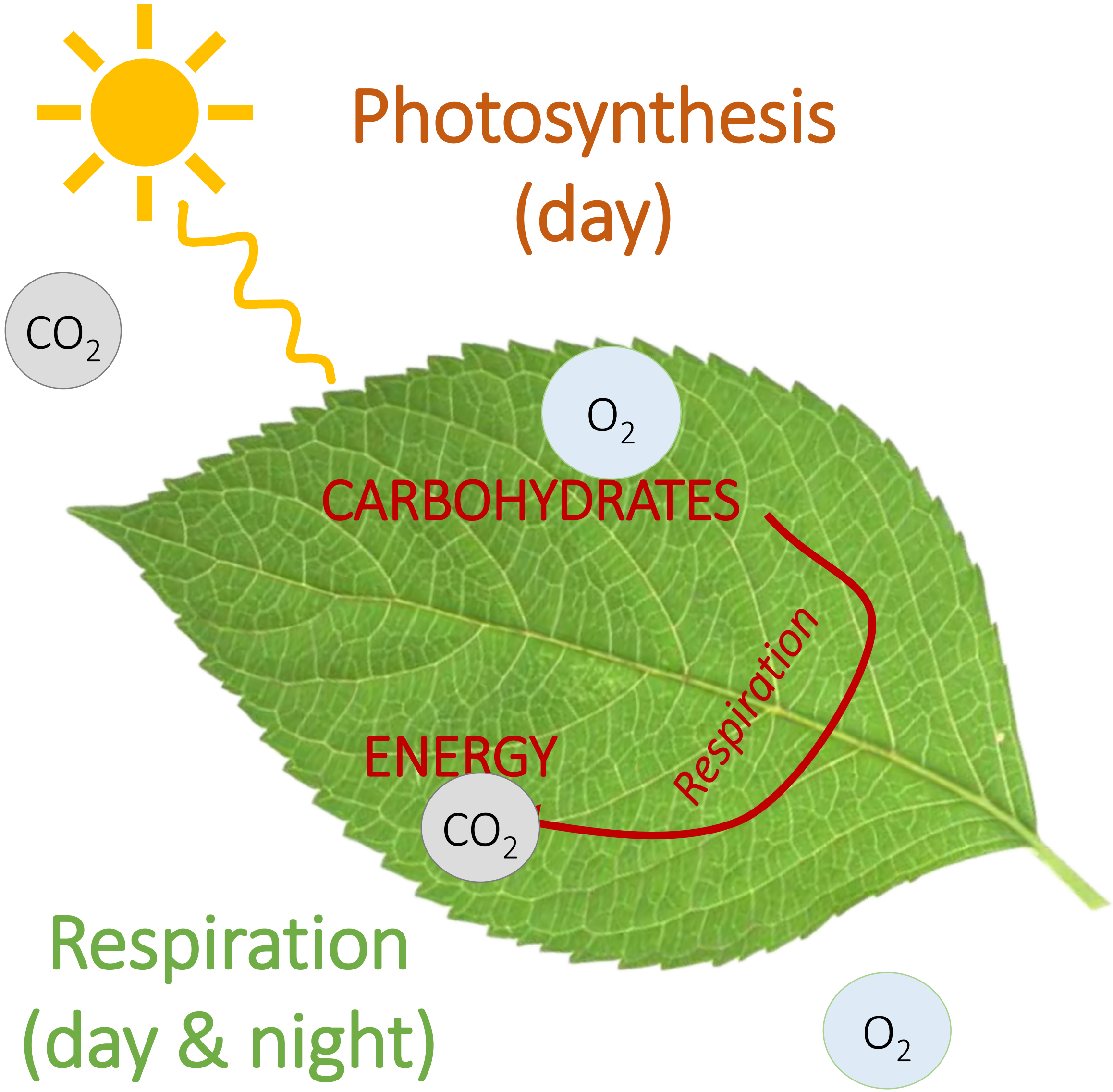
(via respiration, decomposition, combustion)

Carbon Flux

the net change in carbon storage

- positive = net emissions
- negative = net sequestration

Trees take in CO_2, use the carbon to make carbohydrates for energy and to grow, and release the oxygen



Forest carbon data may be presented as CARBON atoms and other times as CARBON DIOXIDE molecules

- CO_2 is 3.67 x heavier than carbon
- To convert from carbon → CO_2 multiply by 3.67
- Both carbon and CO_2 are measured by thier mass




Emissions of CO_2 can result from disturbances and other stressors

Carbon sink = net absorber of CO_2

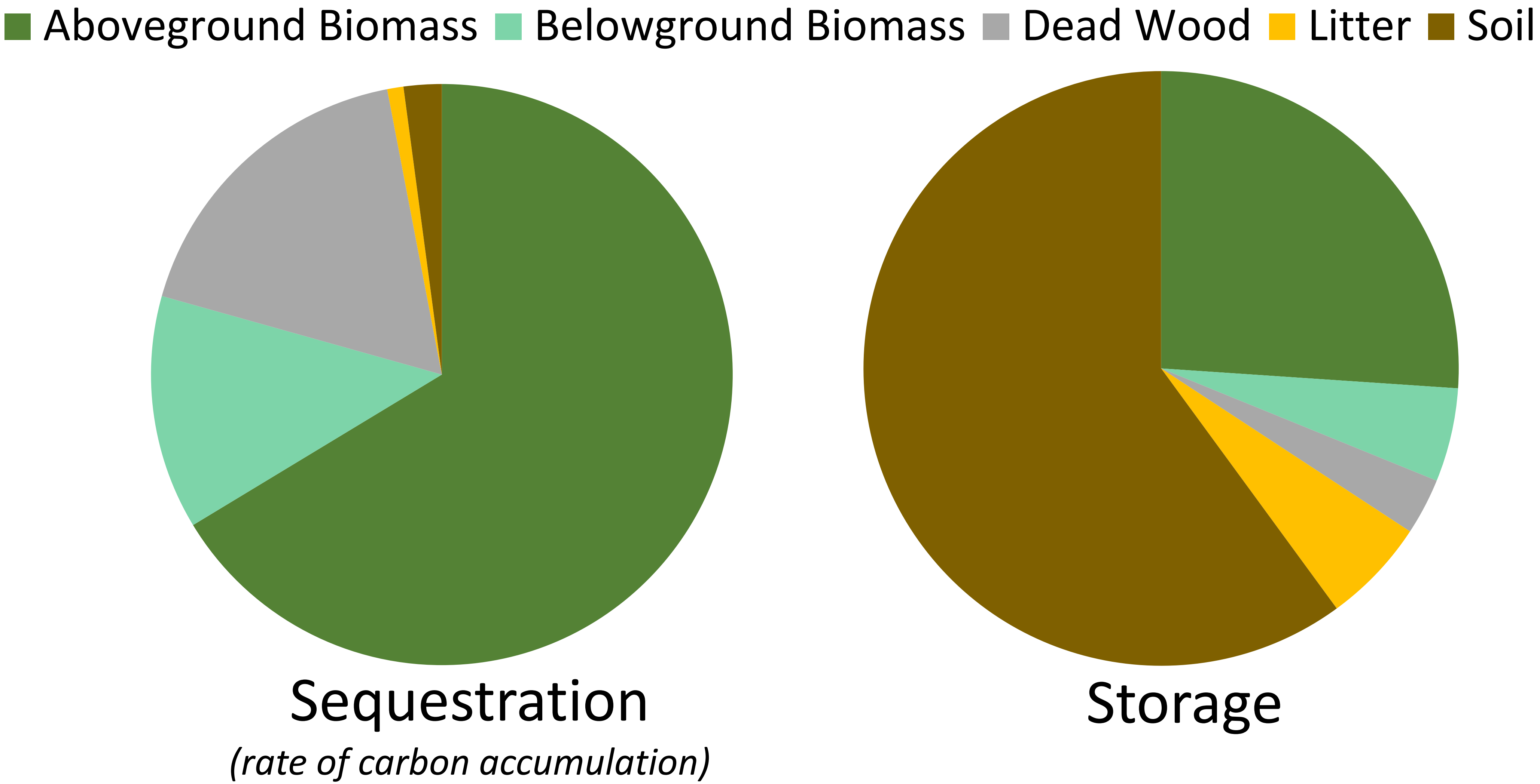
Sequestration > Emissions

Carbon source = net emitter of CO_2

Sequestration < Emissions

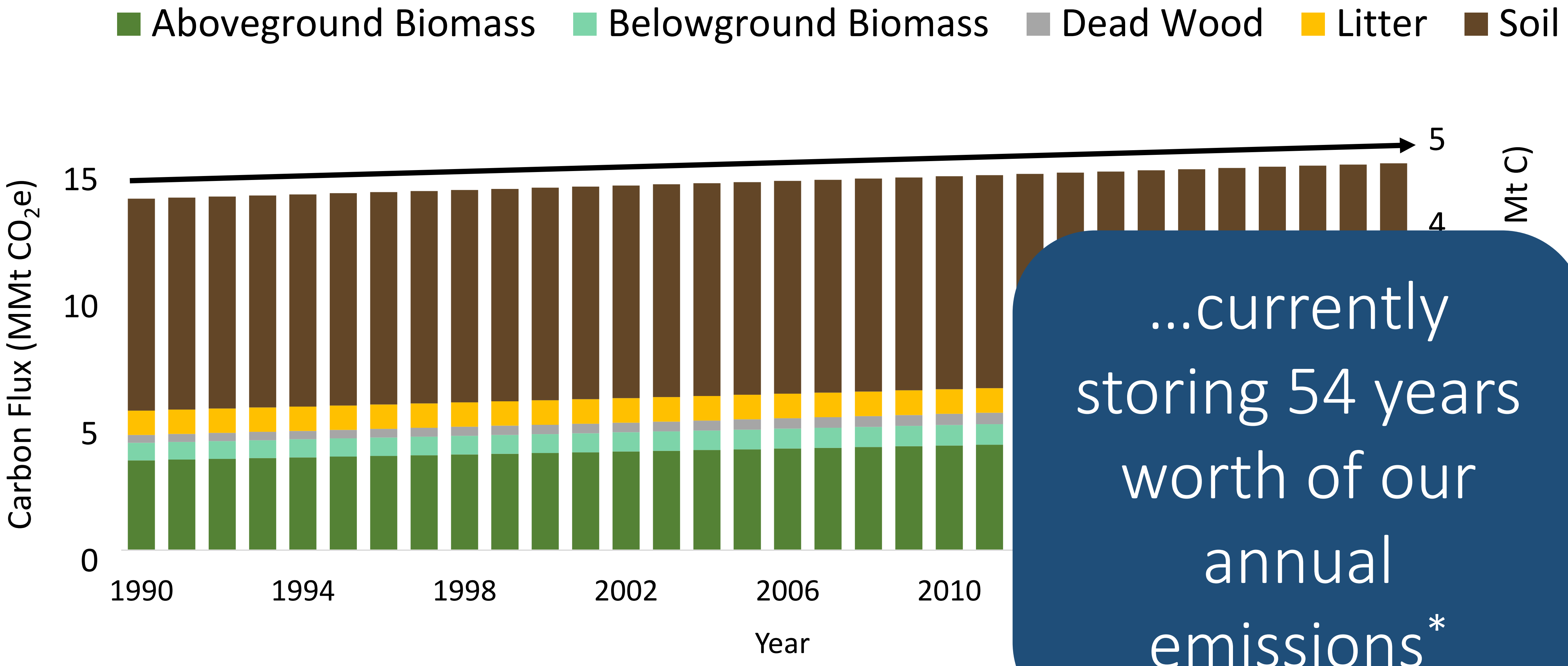
The importance of time and space

Forest carbon pools accumulate at different rates and store different amounts of carbon



Data : Walters et al. (2023), data from 2020/2021 averaged for the 7-state region

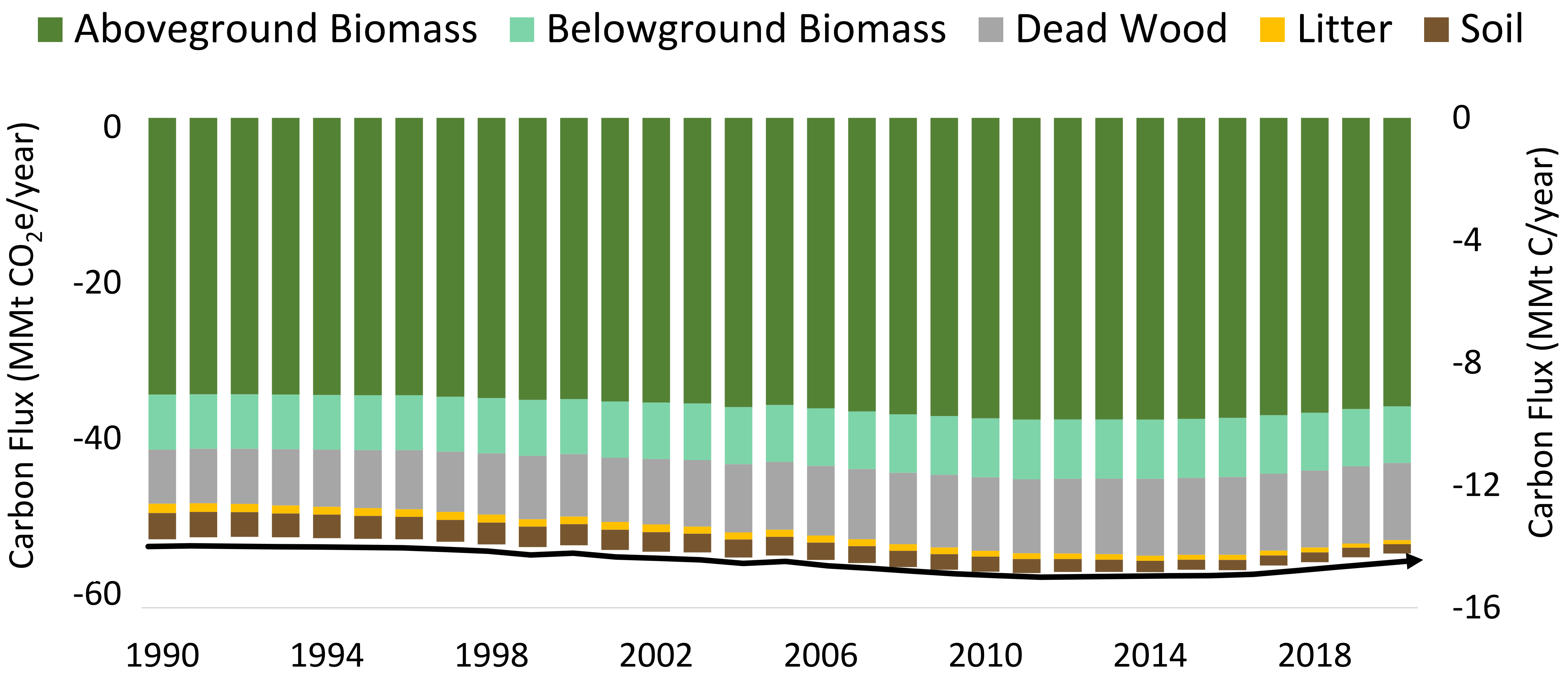
Currently, the region's forests are a carbon sink



…currently storing 54 years worth of our annual emissions*

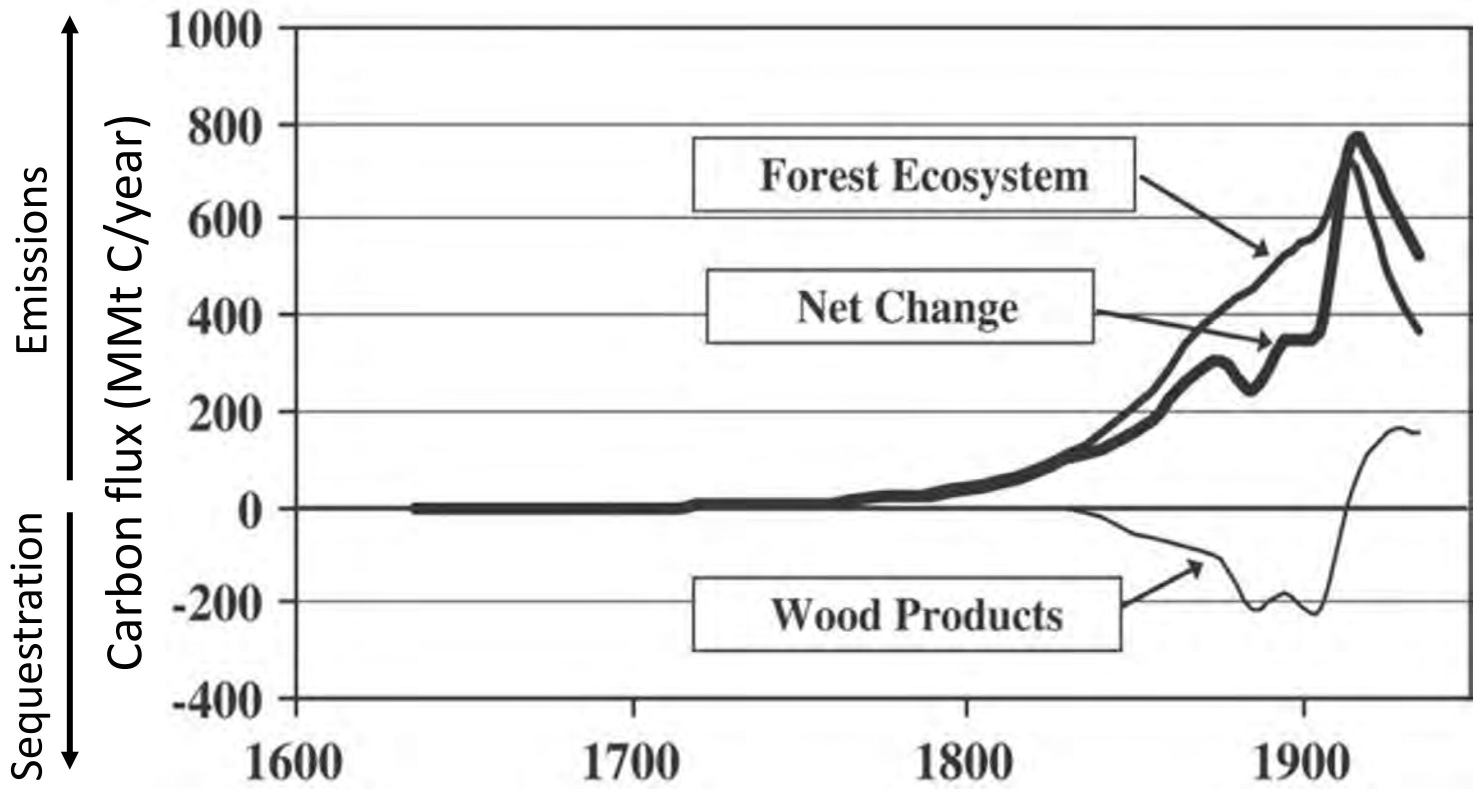
Data source: Walters et al. (2023) – Carbon in forests remaining forests for New England and New York. *based on GHG emissions and forest sequestration rates in 2021

In 2021, the region's forests sequestered ~14% of annual anthropogenic emissions



Data source: Walters et al. (2023) – Carbon in forests remaining forests for New England and New York. *based on GHG emissions and forest sequestration rates in 2021

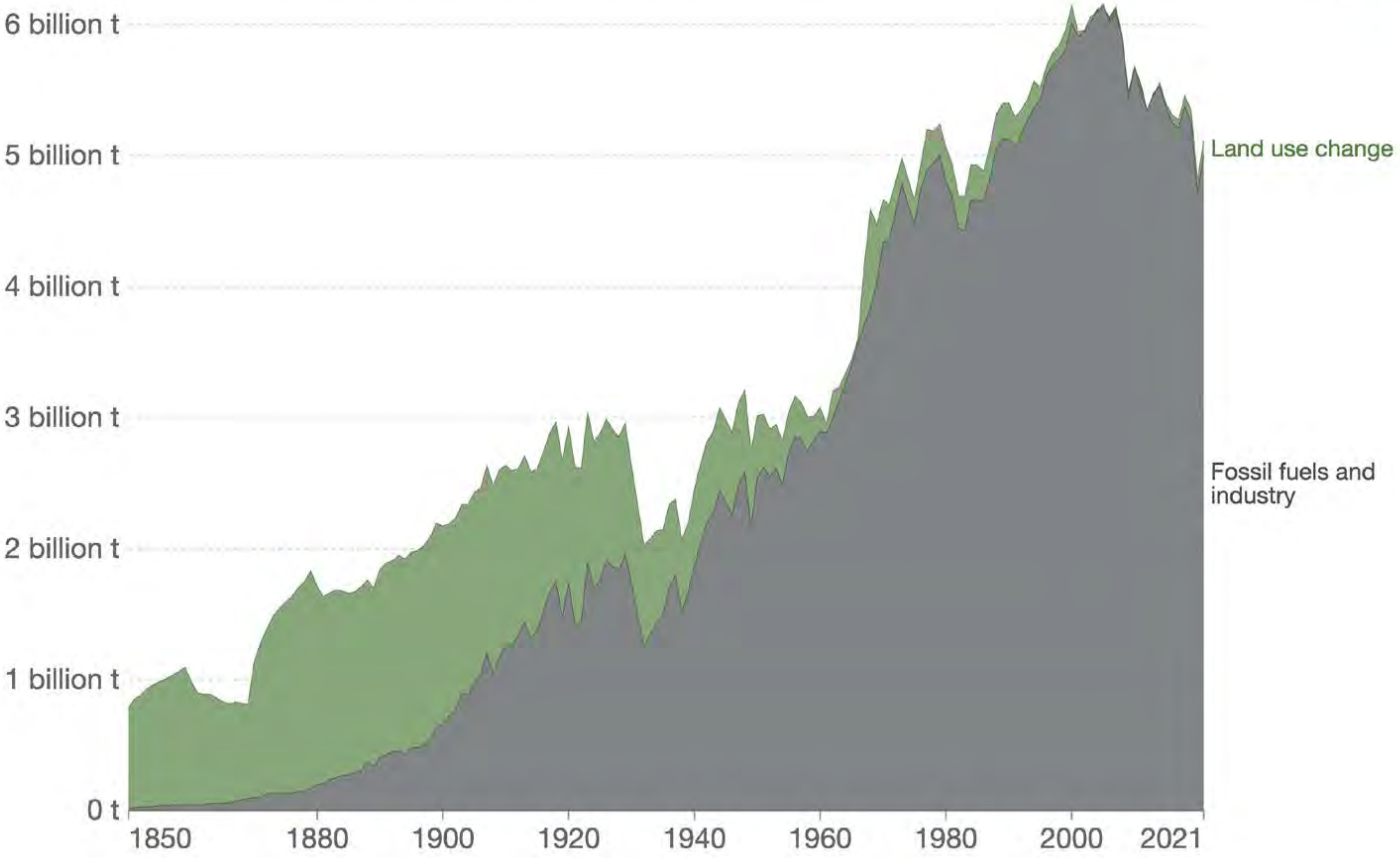
Widespread timber harvesting and land clearing lead to a large pulse of carbon emissions in the 19th century



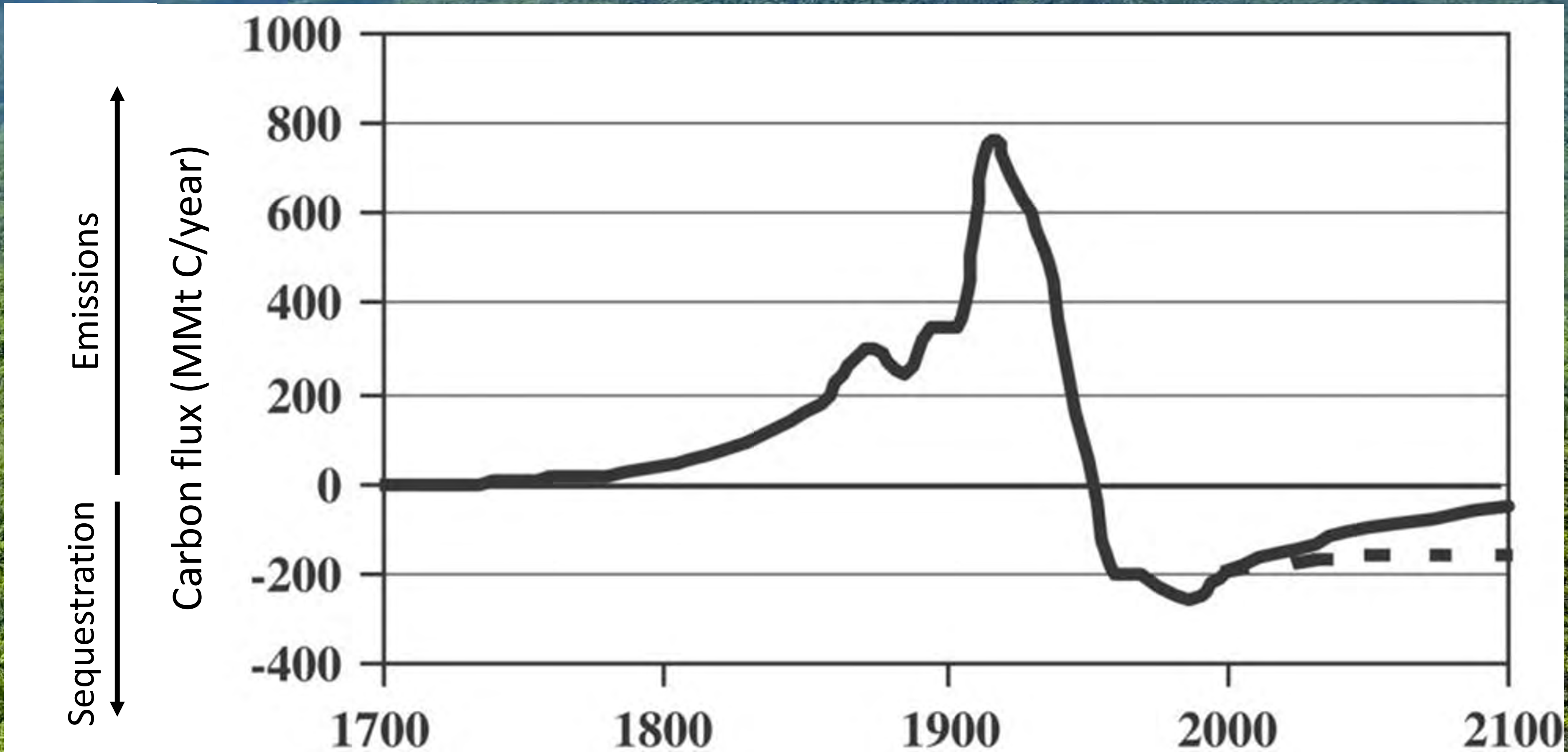
Source: Birdsey et al. 2006

Photo: Harvard Forest

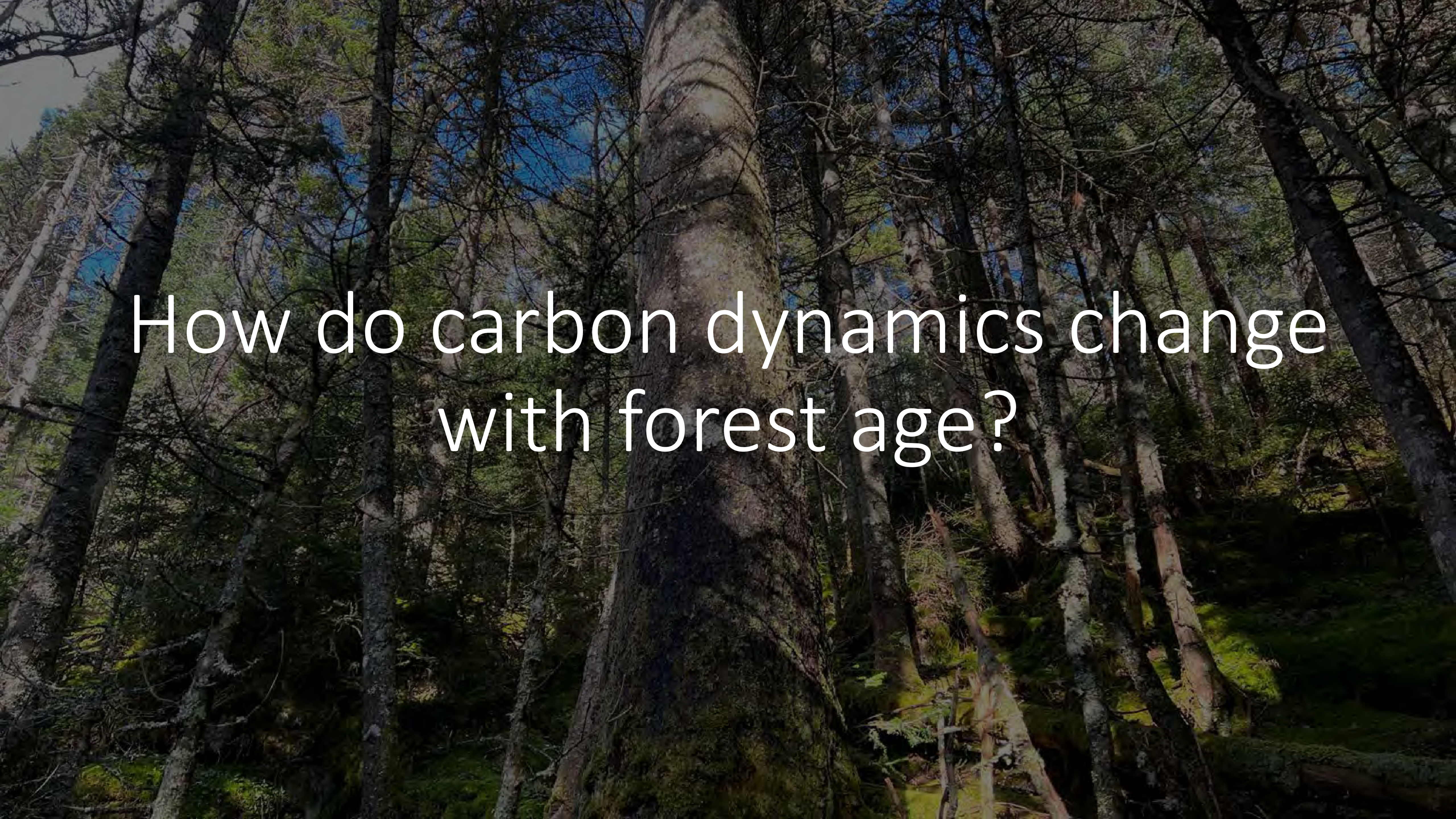
U.S. CO_2 emissions from fossil fuels and land use change



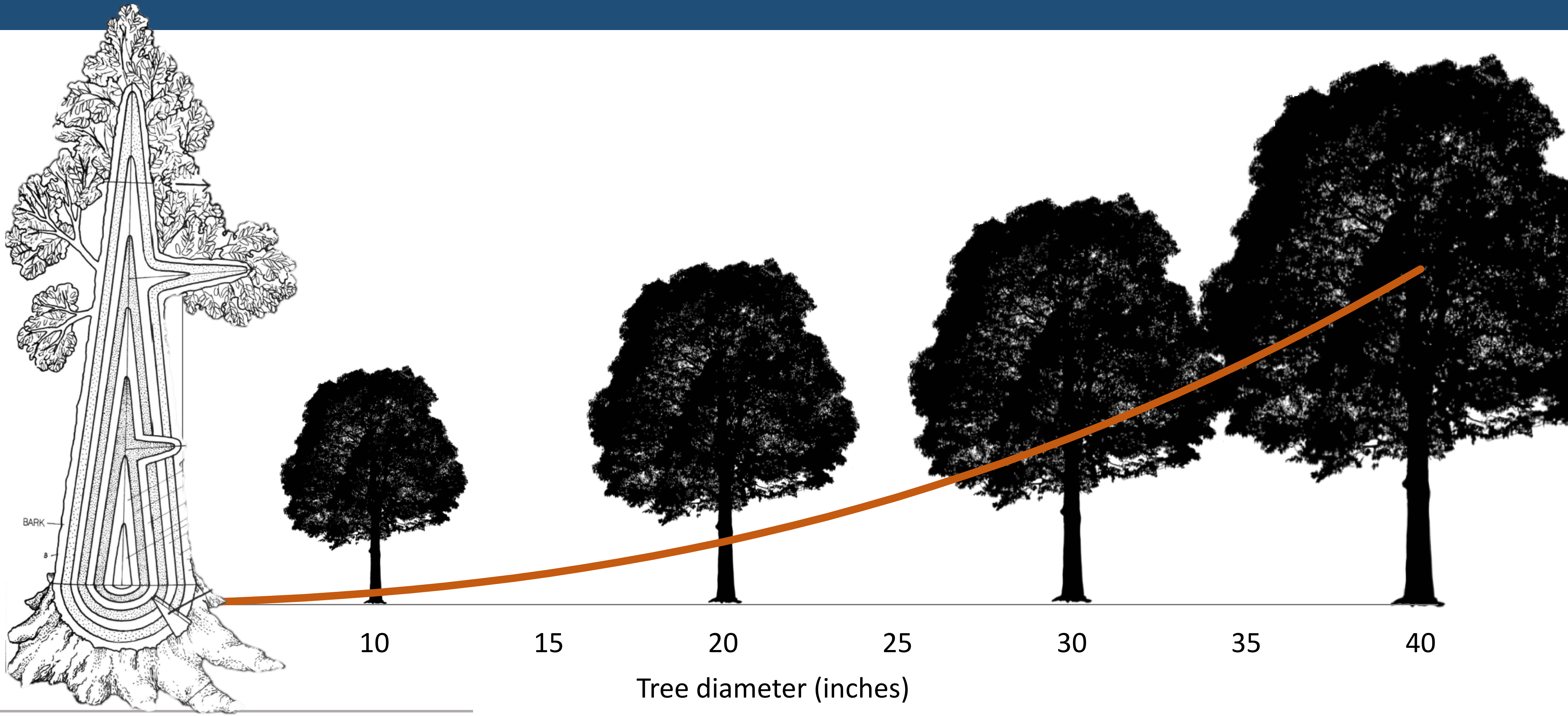
We're now in a period of forest regrowth and net carbon sequestration



Source: Birdsey et al. 2006


How do carbon dynamics change
with forest age?

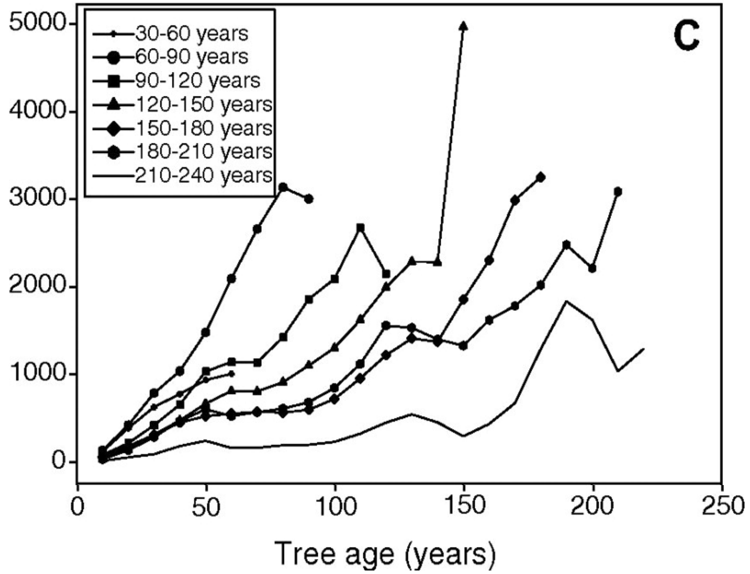
Larger trees store more carbon



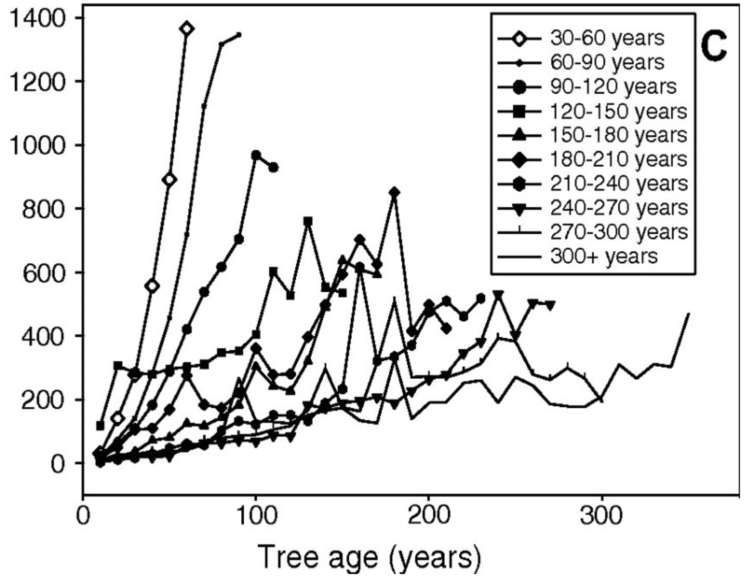
Data: Jenkins et al. (2003) for sugar maple (*Acer saccharum*)

Old trees continue to sequester carbon, but the rate can vary considerably by species, location, and longevity

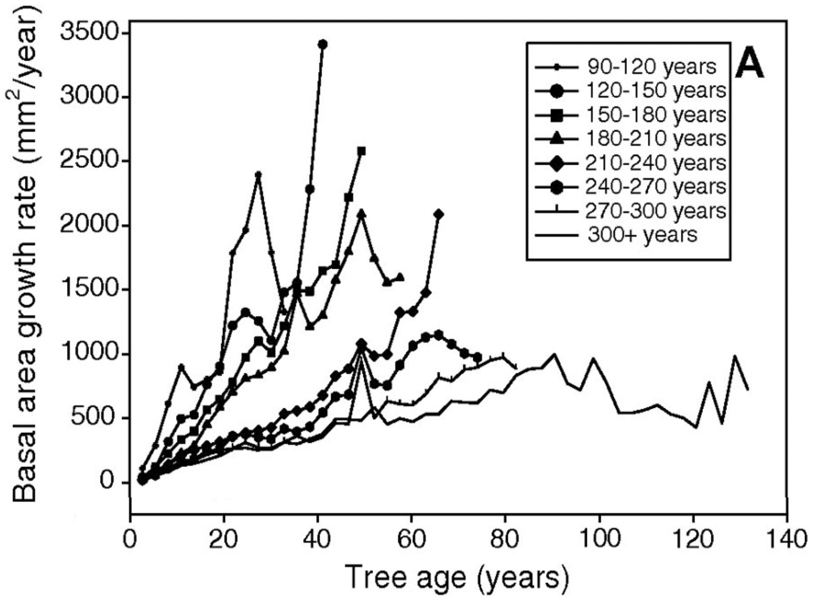
Red oak



Pitch pine



Eastern hemlock

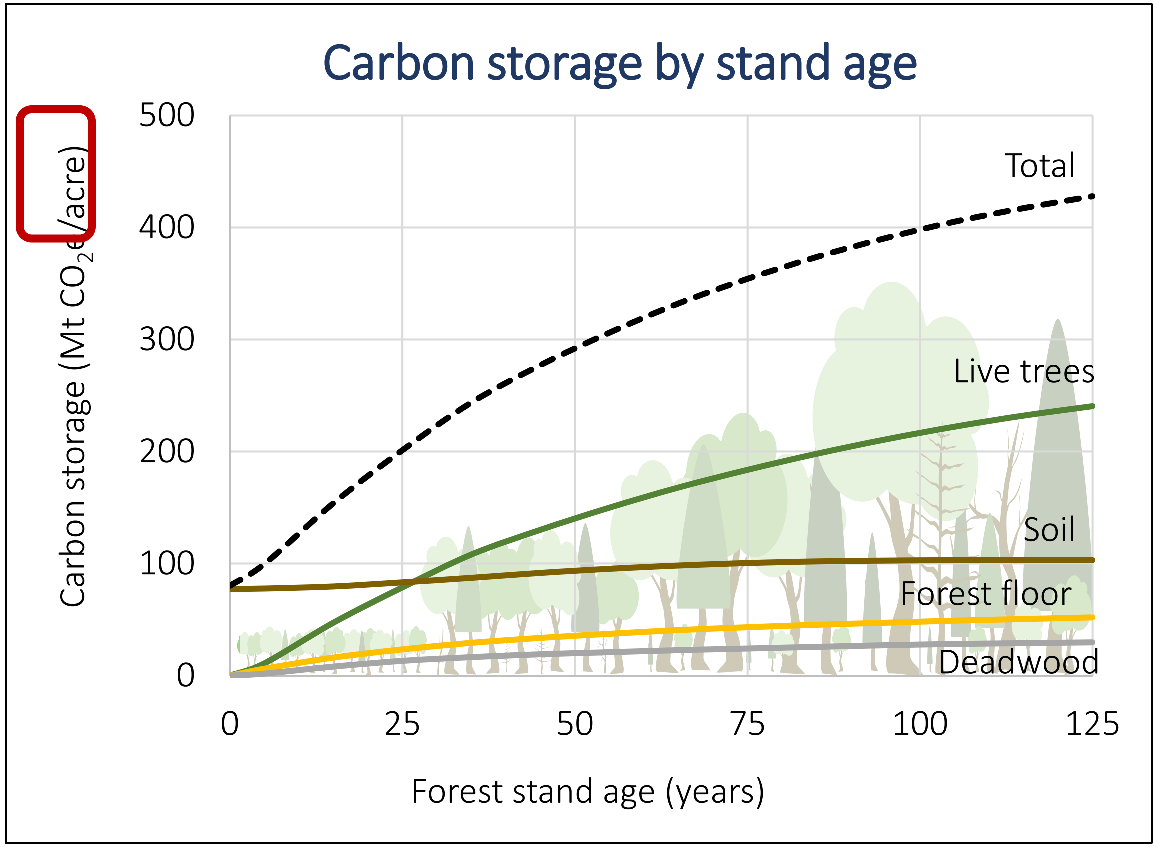


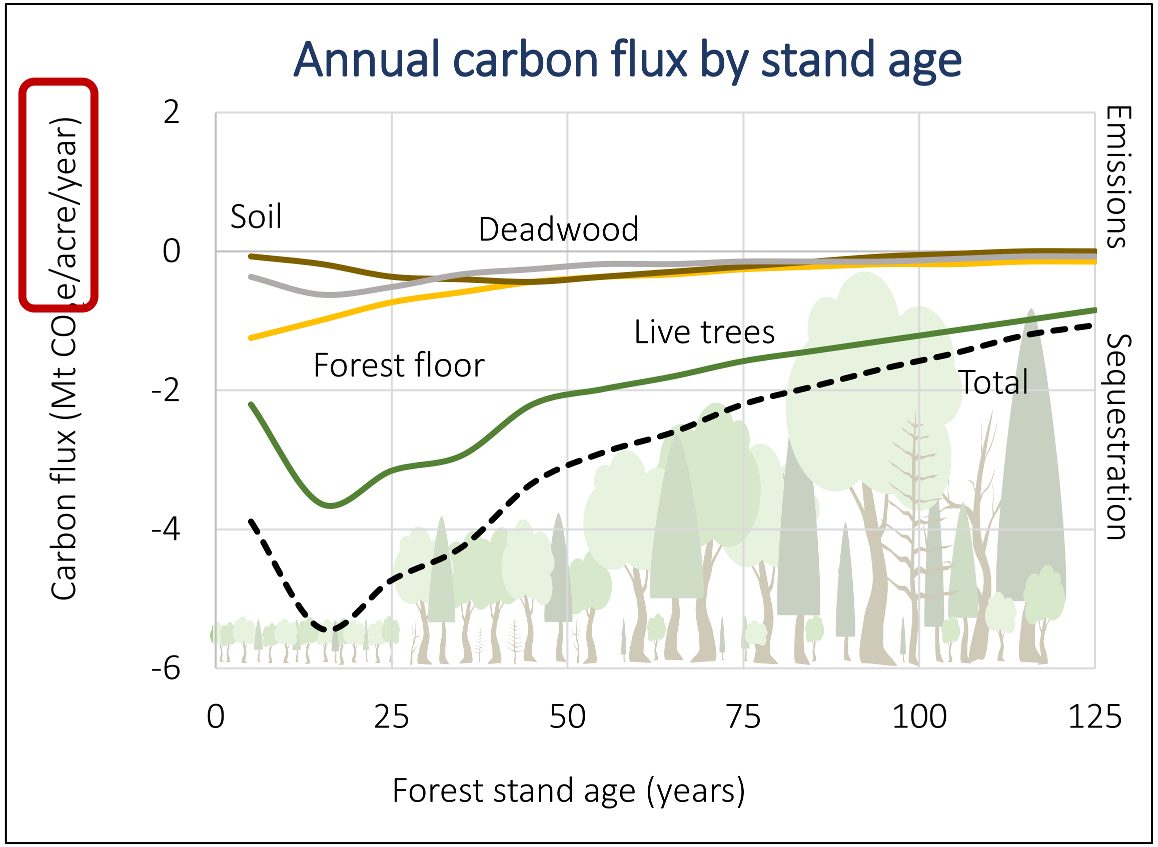
→ Inverse relationship between growth rate and longevity

Trees in the oldest age classes grew at the slowest rate throughout their life

Source: Johnson and Abrams (2009)

In a forest, carbon continues to accumulate, but at a slower rate over time



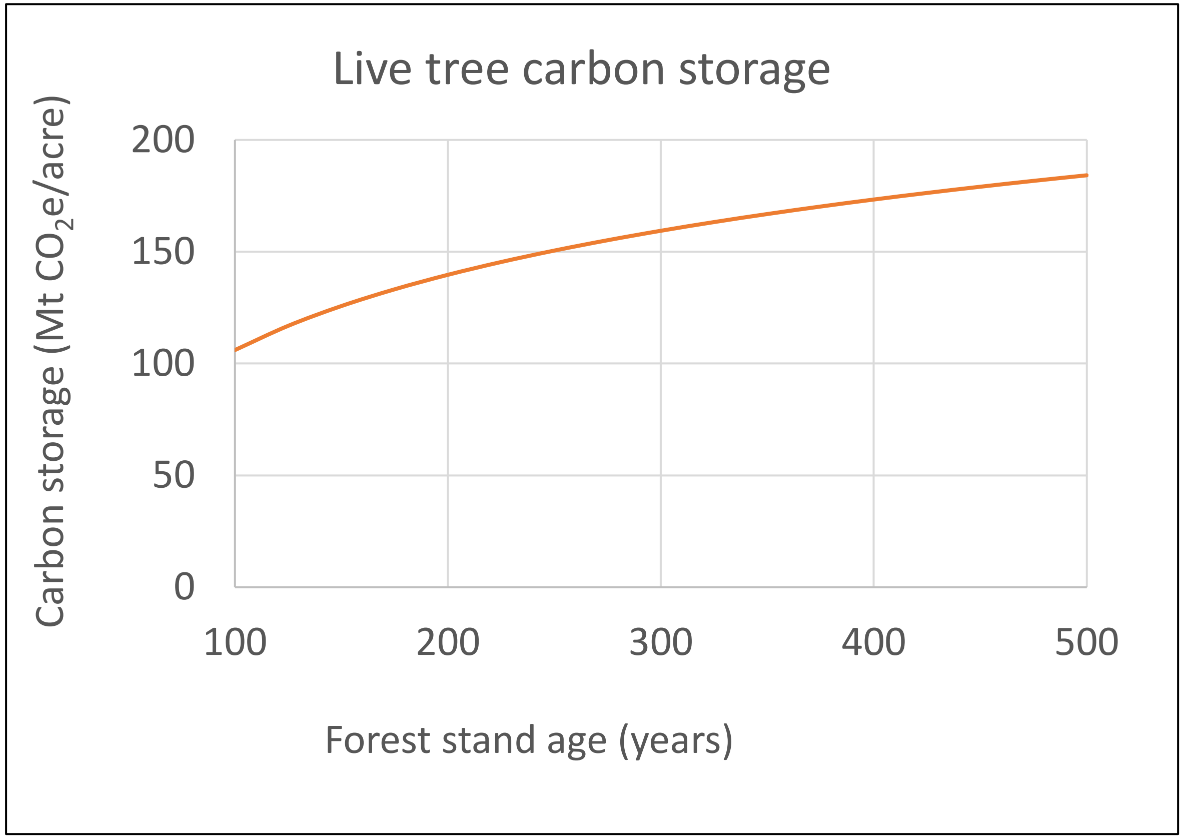


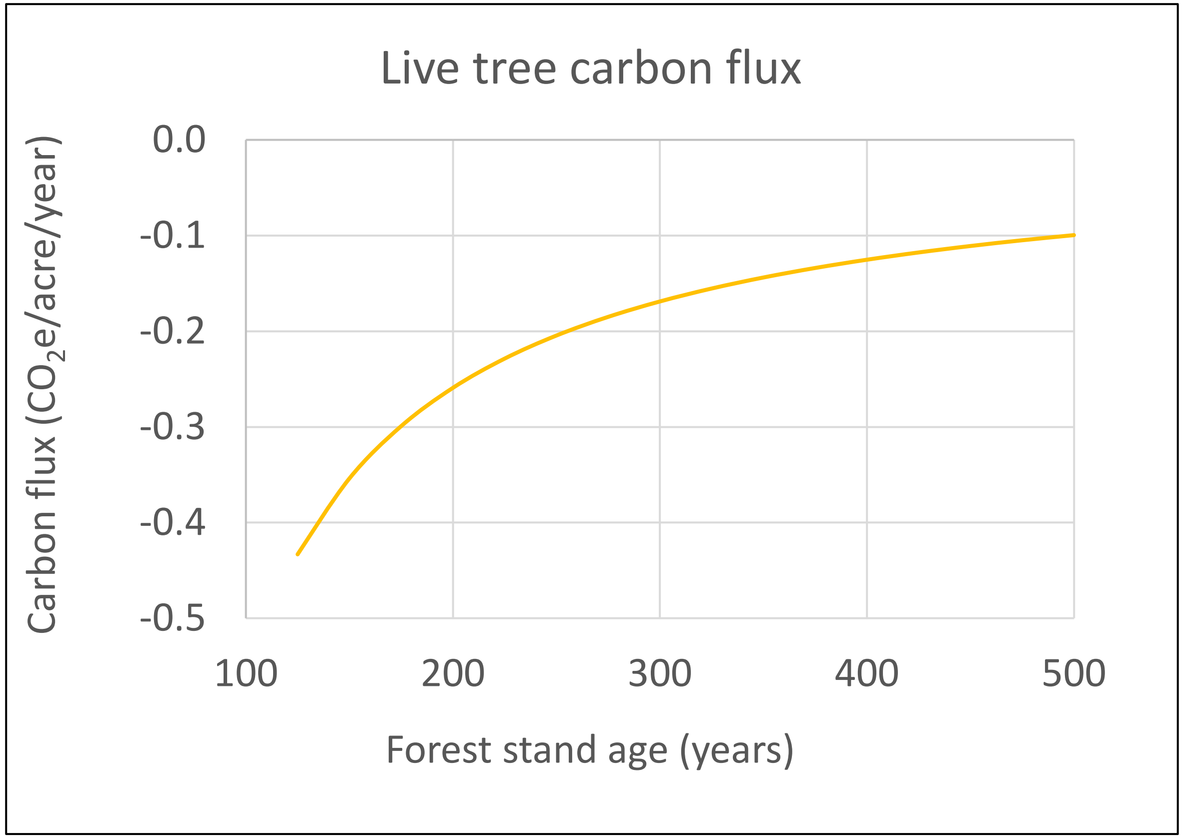
Data: Smith et al. 2006 - carbon stocks and fluxes following afforestation for maple-beech-birch forest

The oldest forests often have more carbon stored in the soils and deadwood, too

Source: Thom et al. (2019)

Data from 20 forest stands suggest that trees in old forests can remain a net carbon sink

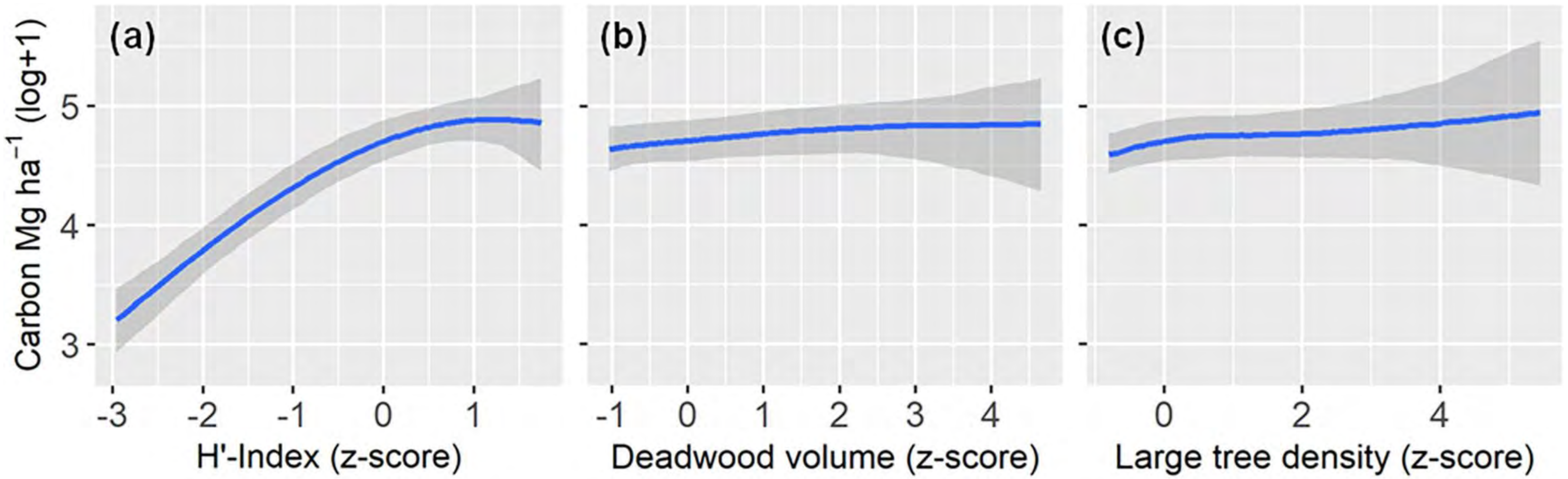


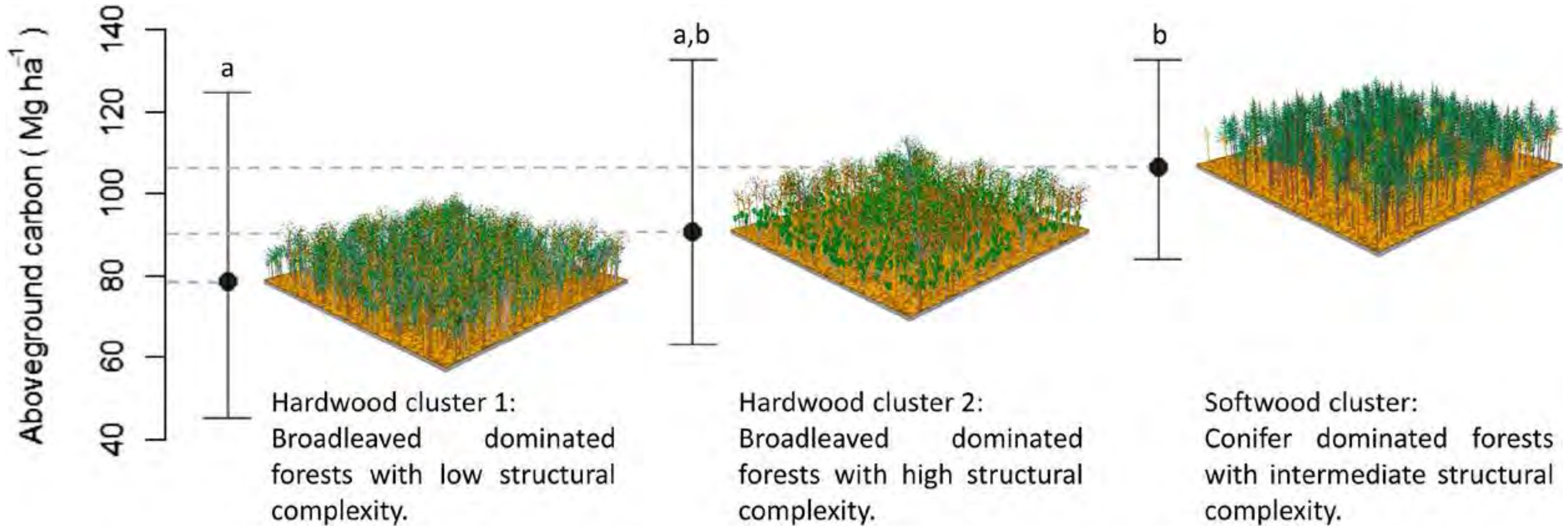


Data source: Keeton et al. (2011)

Carbon storage in a forest is strongly related with greater structural complexity and species diversity

H'-Index:
measure of variability in tree size and height and number of species



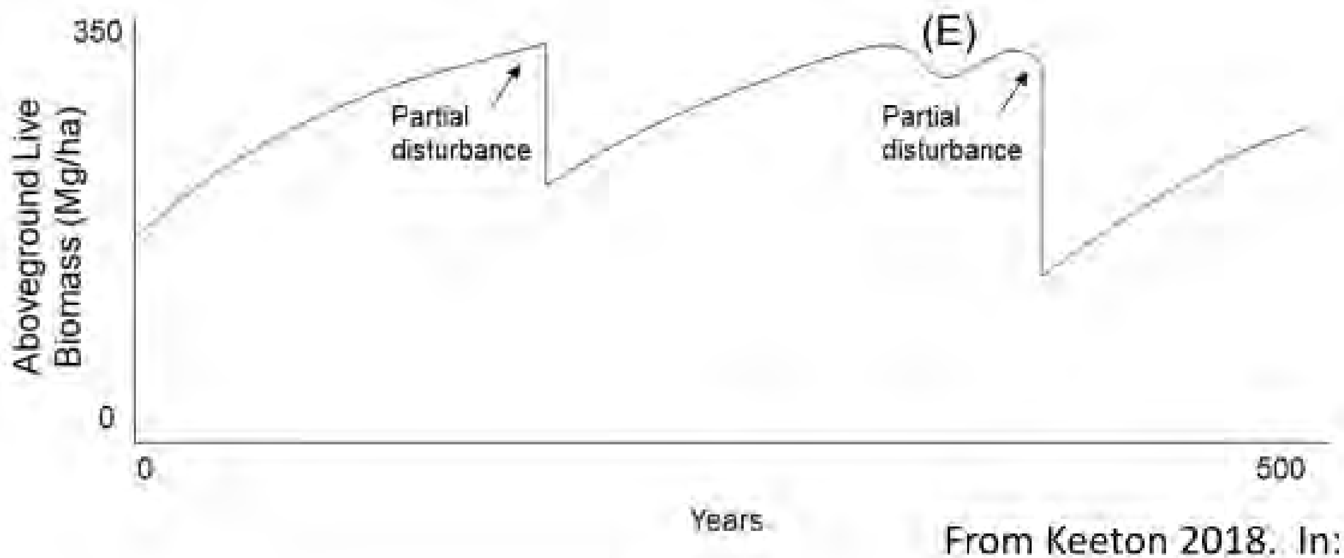


Structural complexity:
the horizontal and vertical distribution of layers in a forest (trees, shrubs, ground cover, deadwood, etc.)

Source: Thom and Keeton (2019, 2020)

While older forests typically store more carbon, there are many trajectories that a forest can follow

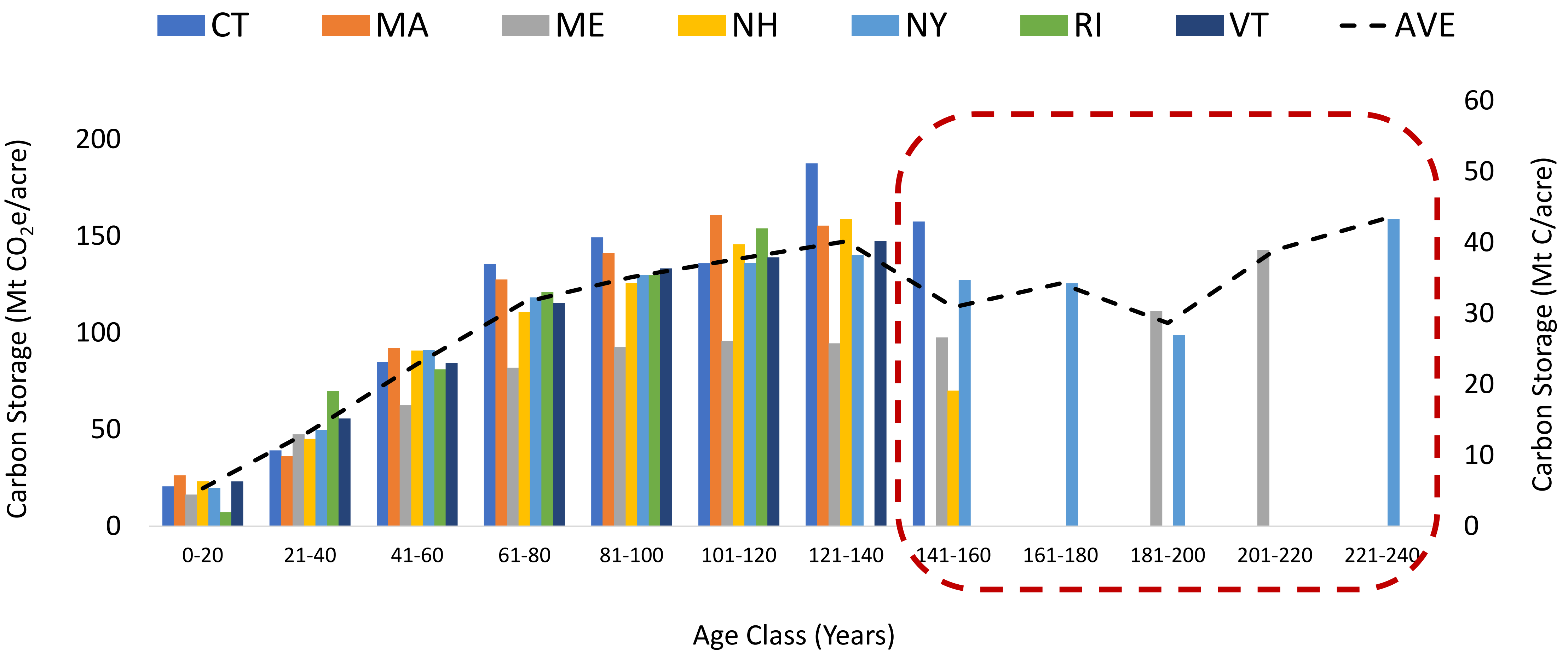
Forest dynamics are driven by disturbances of varying intensities



From Keeton 2018. In: Barton and Keeton, Island Press

We don't know how the carbon dynamics of an individual stand fluctuates over centuries

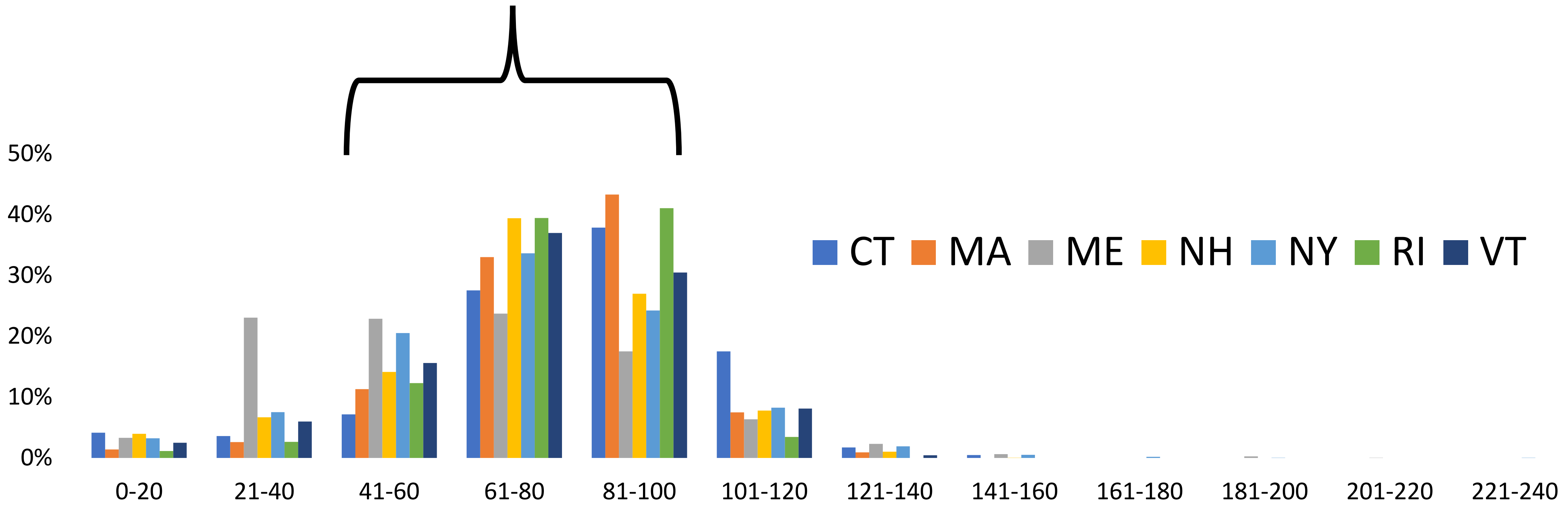
To understand age-related trends, chronosequences are created from forest plots



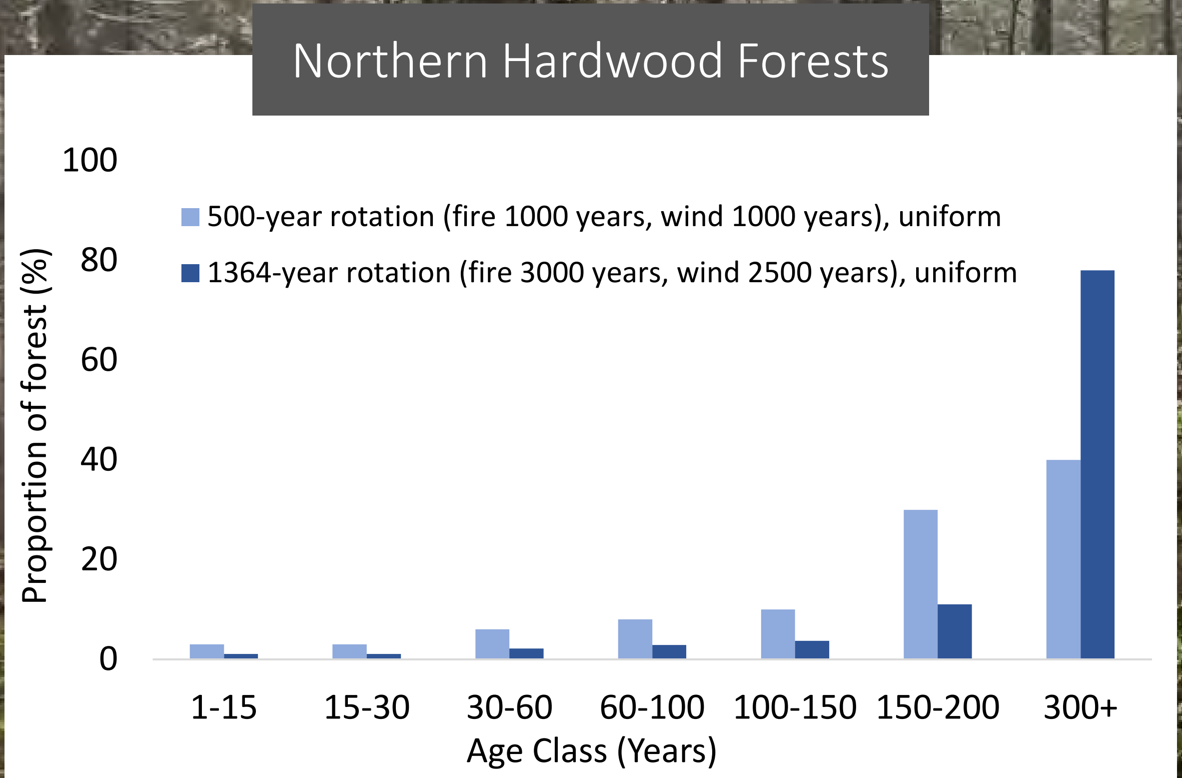
Data source: USFS Forest Inventory and Analysis EvaliDator

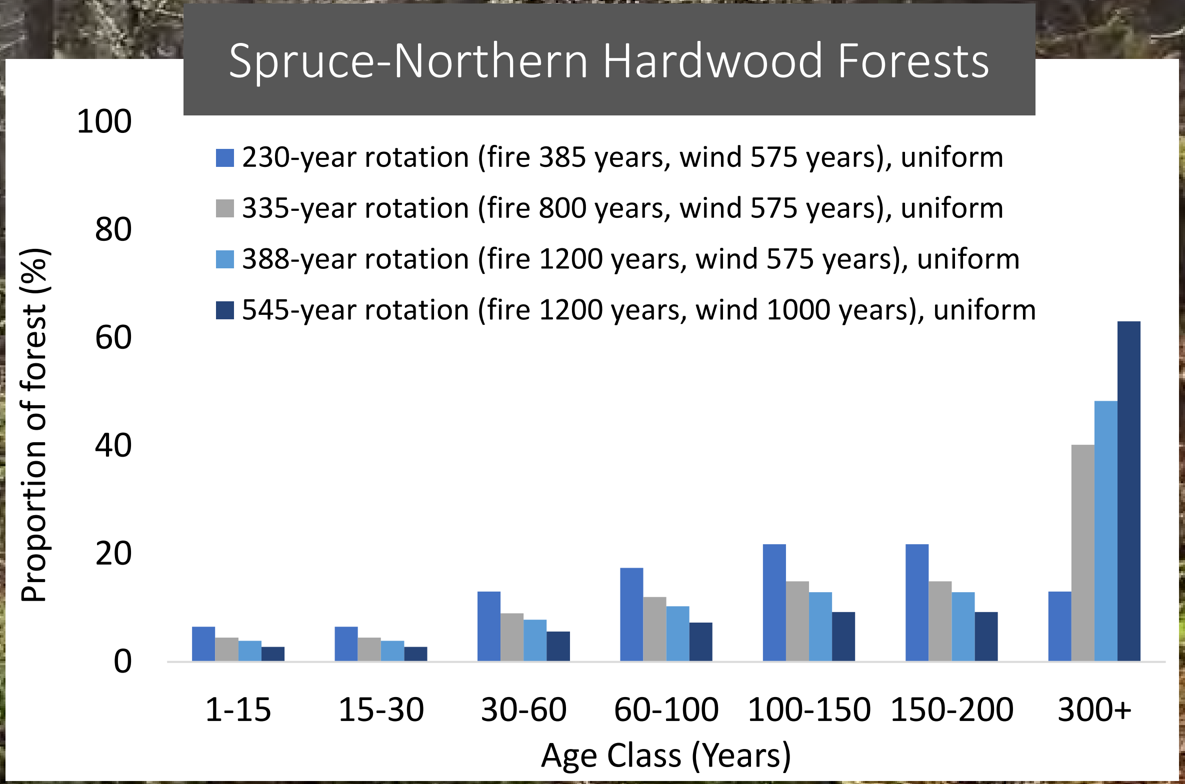
Historical land use across the region altered the age distribution of forests

74% of region's forests between 40-100 years old



Historicaly, much more of the forested landscape would be in old age classes



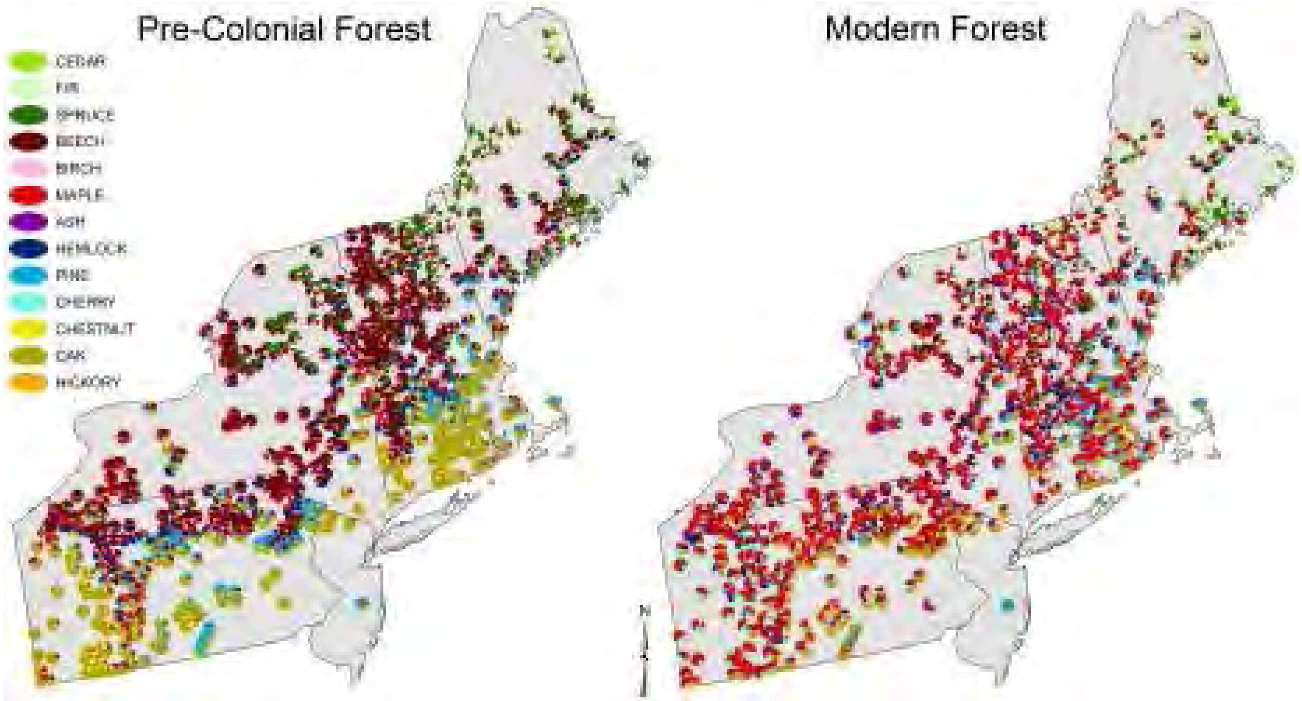


Source: Lorimer and White (2003)

Because of the region's land use history

- True old growth forests are rare
- Forests are in various stages of recovery depending on the intensity of and time since human disturbance
- "Old forests" can have a variety of conditions

Land use history altered the species composition, structure, and condition of forests we have today

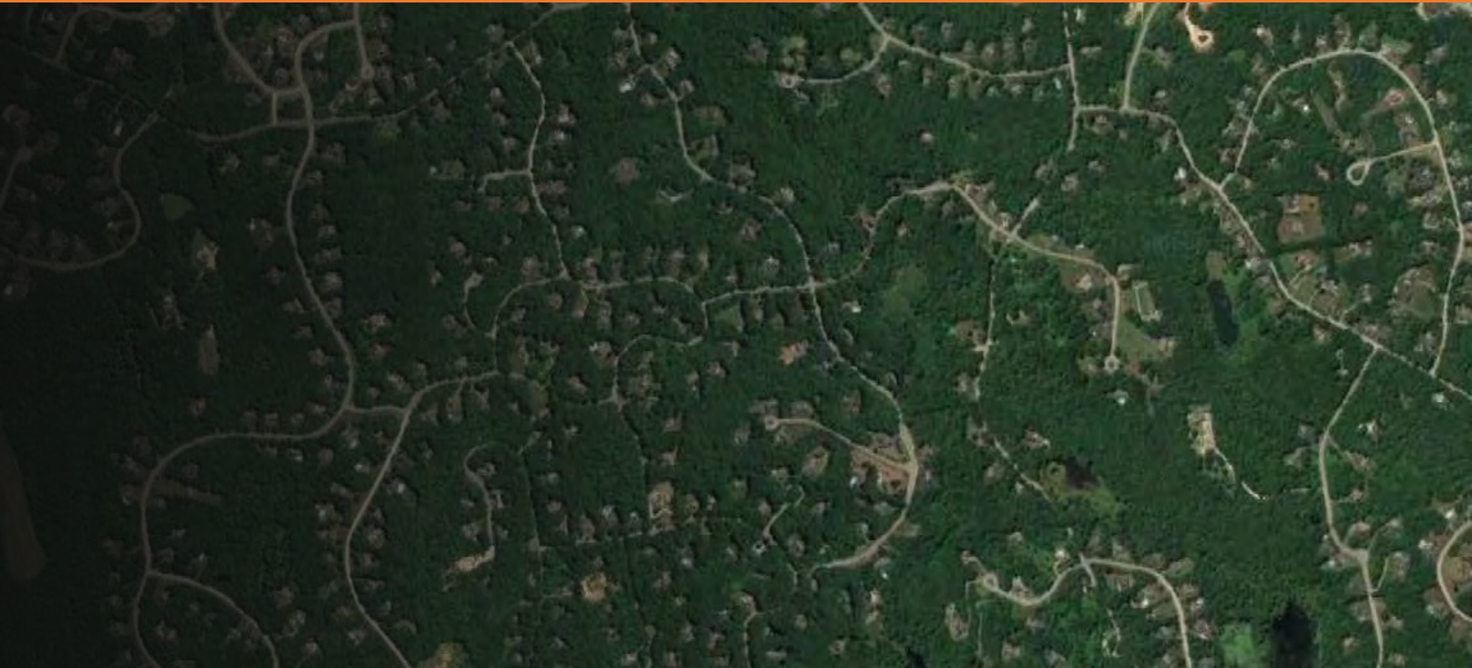


Source: Thompson et al. (2013)

Many forests face novel stressors, such as invasive insects, diseases, and plants

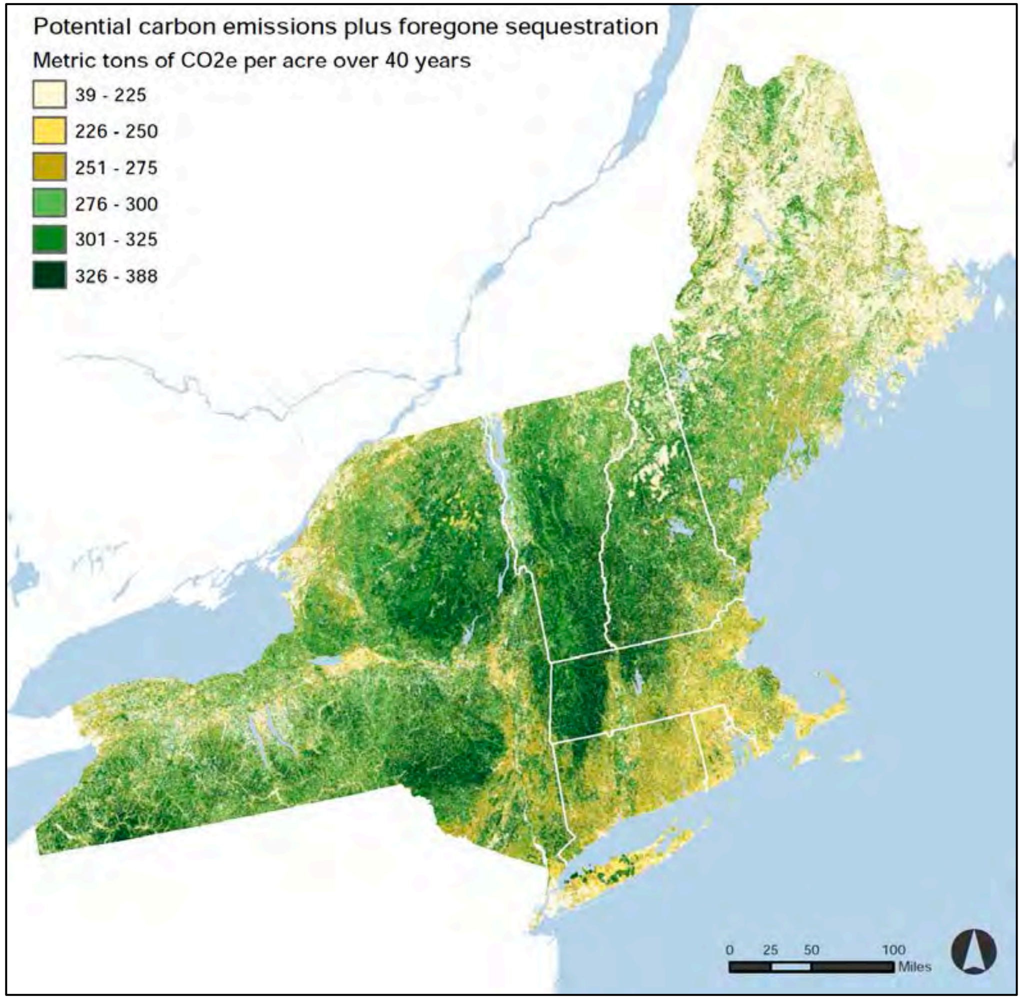
The region is now experiencing a second wave of forest loss

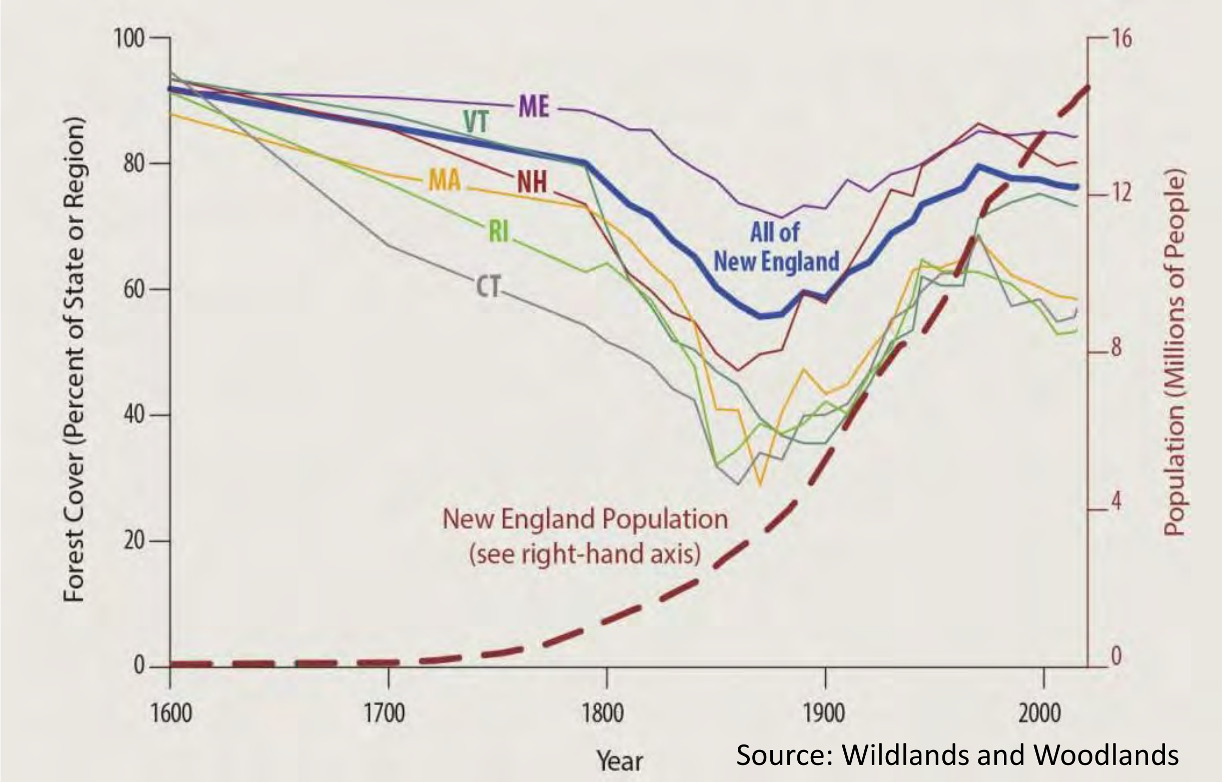
Regionwide, we’re losing >20,000 acres of forest per year



Data source: Walters et al. (2023), 7-state region

When we lose forests to other land uses, we emit stored carbon and lose out on future carbon sequestration





Source: Williams et al. (2021)

What can we do to enhance the mitigation power of the region's forests?

What can we do to enhance the mitigation power of the region’s forests?

Reduce forest loss to other land uses (deforestation)

Create new forests by allowing natural regeneration to occur or by planting (riparian buffers, field edges)

Be strategic about how we manage forests

- Continue to protect old-growth forests
- Create reserves where appropriate
- Improve forest management to be ecologically-informed and restorative

Reduce resource needs, reuse more, improve resource efficiency, and use the least GHG intensive materials

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The portfolio approach

By adopting these pathways, the region's forests could sequester the equivalent of 21% of 2020 emissions (compared to 14% currently)

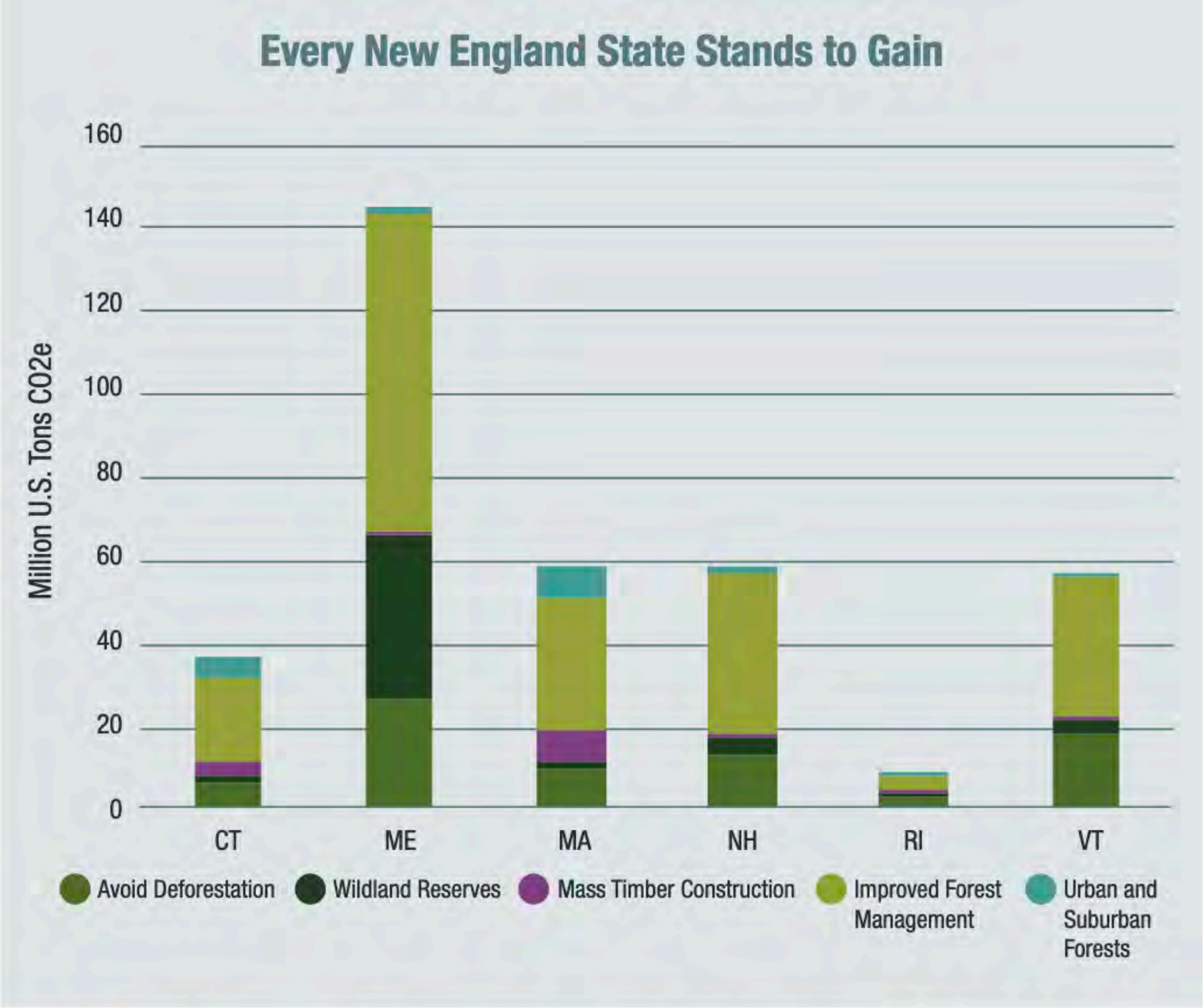

Figure 2: Additional CO2e sequestered above the BAU scenario in each New England state by 2050. Estimates shown are associated with the adoption of each pathway at its middle tier. See Figure 3 for estimates of low and high tiers.

Source: Meyer et al. 2022. New England's Climate Imperative: Our Forests as a Natural Climate Solution. Highstead Foundation Report.

Adjust active forest management to

- Increase species diversity
- Enhance structural complexity
- Restore ecological functions
- And provide local, renewable resources

Ali Kosiba
Alexandra.Kosiba@uvm.edu

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