Climate change adaptation and mitigation considerations

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Outline

- Forest carbon 101
- Influence of silvicultural treatments on carbon dynamics
- Adaptation considerations in light of global change
- Tradeoffs and challenges


Forest carbon 101

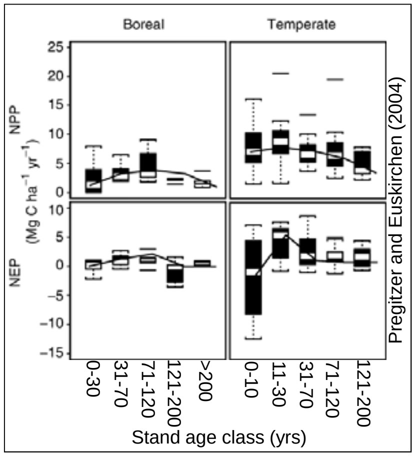
Carbon terminology

- Basic components associated with carbon accounting
  - **Carbon pool**-a reservoir having the capacity to accumulate or lose carbon over time (e.g., soils, aboveground biomass)
  - **Carbon stocks**-measured, estimated, or modeled quantity of carbon held in a particular pool
  - **Carbon sequestration**-the removal of atmospheric carbon with subsequent storage in carbon pools (such as oceans, forests or soils)
  - **Additionality**-carbon storage that is above and beyond what would have happened in a "business as usual" scenario



Patterns in forest carbon dynamics

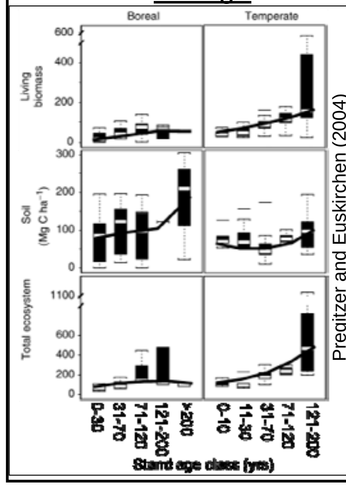
- Carbon <u>sequestration</u> rates over stand development



- Younger forests generally sequester carbon at higher rate
- Greater overall release of carbon from young forests due to respiration (higher decomposition rates)

Patterns in forest carbon dynamics

- Carbon <u>storage</u> over stand development



- The size of carbon pools **increase** with stand age
  - Larger live trees
  - Accumulation of dead material
  - Soil organic matter

Forest Carbon Fun Fact

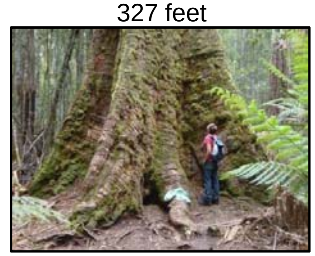
Where are the most carbon-dense forests in the world?

Australia (*Eucalyptus regnans*)

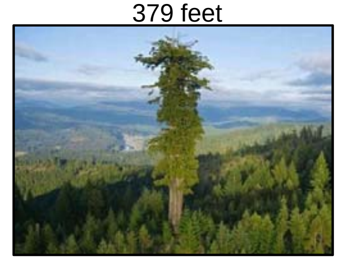
Forest Carbon Fun Fact

- **Total aboveground biomass** (total mass of trees in a given area) is a function of tree size and wood density (typically expressed as **specific gravity)**
  - *Eucalyptus regnans* specific gravity = 0.49 g/cm^3
  - *Coast redwood* specific gravity = 0.36 g/cm^3

327 feet



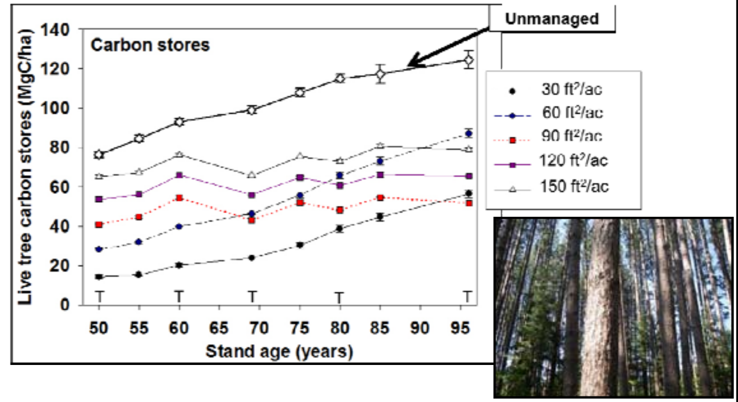
379 feet



Silviculture and forest carbon

Silviculture and forest carbon

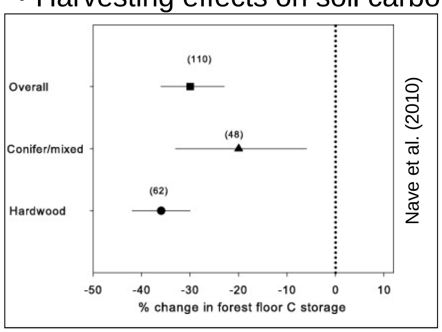
- Harvesting effects on live-tree carbon stores



As with stocking, any harvest disturbance reduces live-tree carbon storage below the maximum potential amount for a site

Silviculture and forest carbon

- Harvesting effects on soil carbon



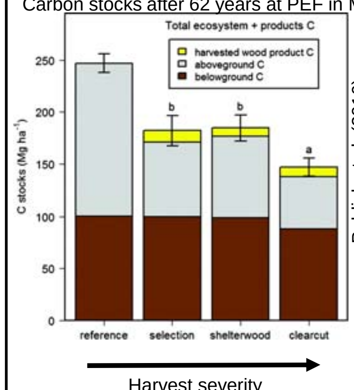
Nave et al. (2010)

- Harvesting has little appreciable impact on mineral soil carbon (unless BMPs aren't followed)
- Primary soil impacts are on forest floor (20-36% loss)

Silviculture and forest carbon

- Harvesting effects on total ecosystem carbon

Carbon stocks after 62 years at PEF in Maine



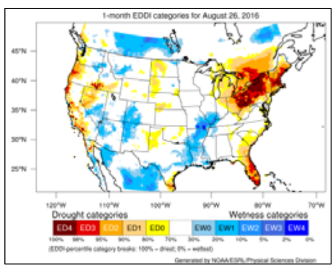
Puhlick et al. (2016)

- Aboveground carbon stocks (i.e., live trees) are most influenced by silviculture
- As severity of regeneration harvest increases, on-site carbon benefits decrease

Forest carbon: take home points

- Silvicultural systems that promote and maintain high levels of stocking provide greatest carbon benefit over time
  - Two-aged and uneven-aged methods (e.g., irregular shelterwoods, selection methods)
  - Promotion of stratified, mixed species stands
  - Extended rotations
- Application of structural retention regardless of method can offset carbon losses from site (large live trees, coarse woody debris)
- Silviculture matters, but keeping forests forests is most critical step for sustaining carbon benefits

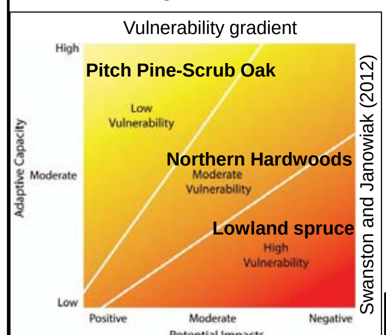

Silviculture and Forest Adaptation






Silviculture and forest adaptation

- Assessing current and future vulnerability



- What are potential impacts of climate change and other stressors (invasives) on given stand?
- Are there species or site characteristics that provide ability to respond to change in positive ways?

Take a few minutes and plot a couple of forest types for the areas you work in

www.forestadaptation.org

Silviculture and forest adaptation

- Main adaptation options
  - **Resistance**-ability to withstand change and maintain normal functioning
  - **Resilience**-capacity to recover from disturbance or change and return to normal functioning
  - **Transition (response)**-actively accommodate change to encourage adaptive response

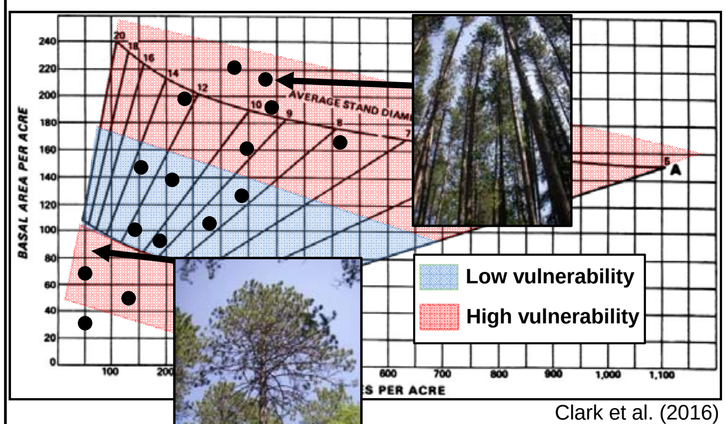


Silviculture and forest adaptation

- Resistance approaches
  - Primary focus is minimizing vulnerability to future stressors
    - Thinning to increase vigor and water availability
    - Fuel reduction treatments
    - Invasives control (release and site preparation)


Silviculture and forest adaptation

- Thinning and drought resistance

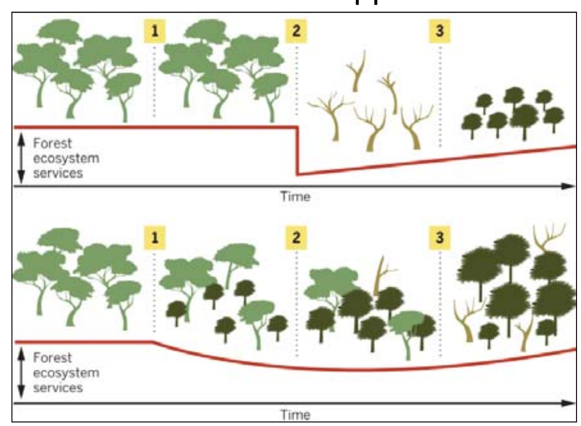


Clark et al. (2016)

Thinned and unthinned red pine in response to extreme drought

Silviculture and forest adaptation

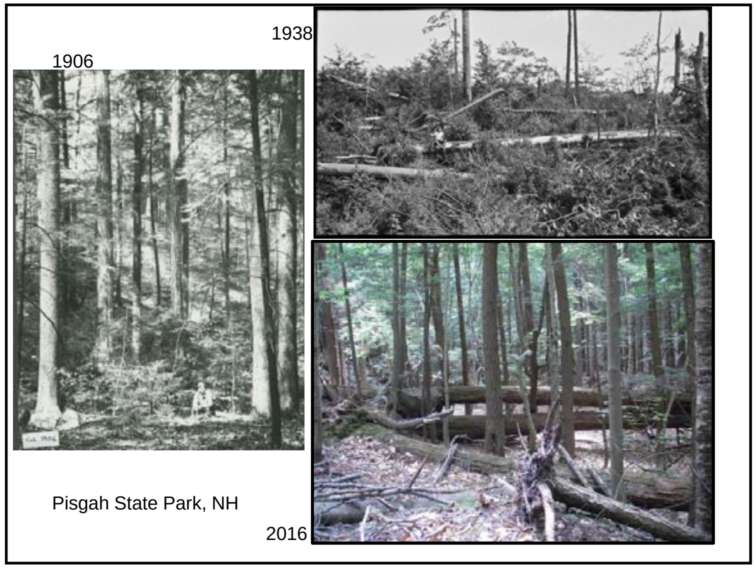
- Resilience and transition approaches

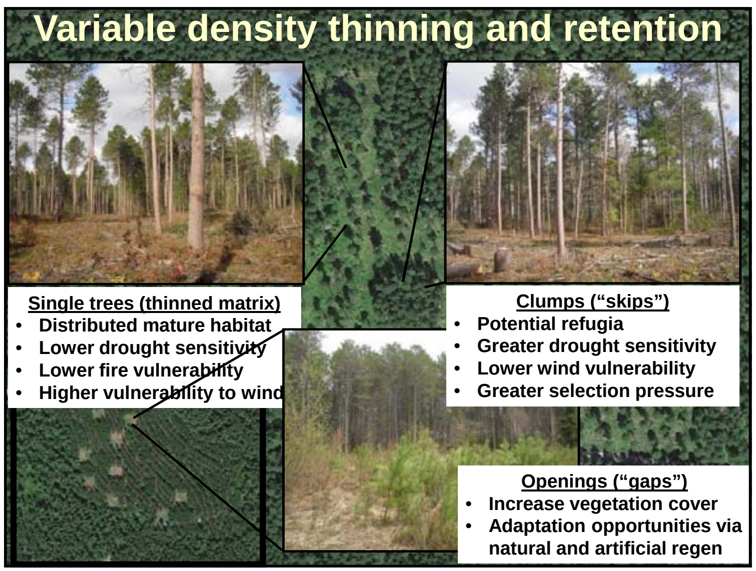


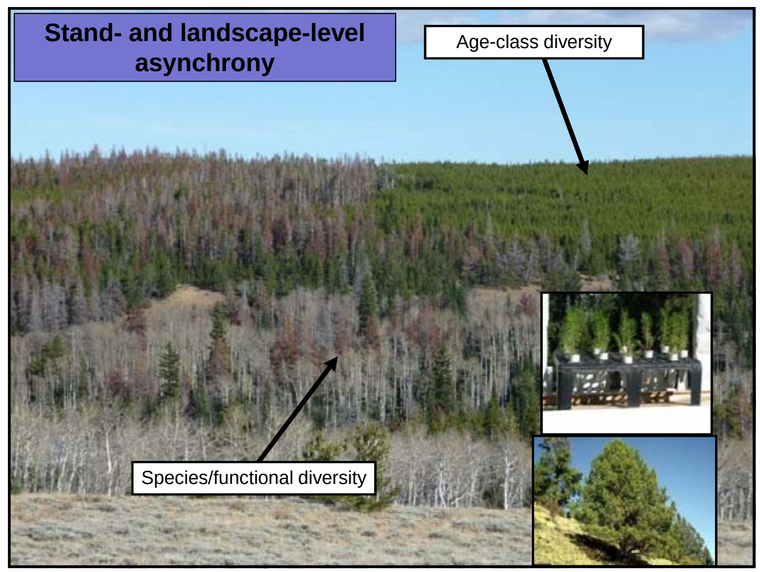
Millar et al. (2007)

Silviculture and forest adaptation

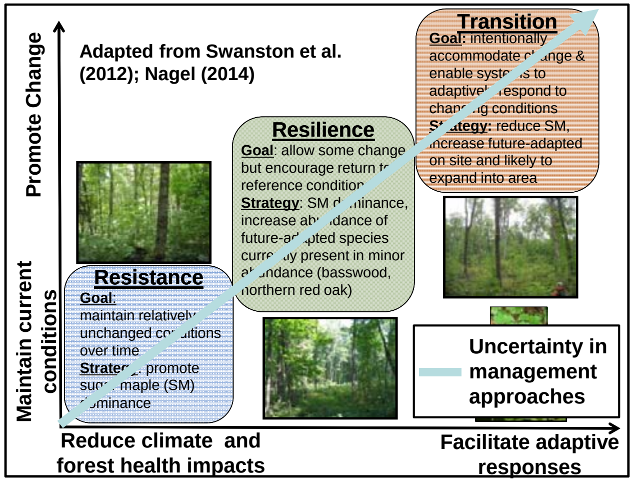
- Resilience and transition approaches
  - Focus on increasing levels of response diversity and ecosystem complexity
    - **Response diversity**-diversity in reproductive mechanisms, sensitivity to environmental conditions, stressors (insects, disease, fire)
    - Greater species and structural diversity at stand- and landscape-scales provides more pathways for recovery







Silviculture and forest adaptation



Tradeoffs and Challenges

Tradeoffs and challenges

- Maximizing adaptation and mitigation potential on same site may prove difficult
  - Mitigation strategies will always trend towards high stocking, low levels of disturbance
    - May increase vulnerability to future stressors
  - Most species projected to do well under future climate are shade intolerant or intermediate (e.g., red oak, bitternut hickory, black cherry)


Tradeoffs and challenges

- Uncertainty about future conditions places renewed emphasis on "options forestry"
  - Balance between retaining structural and compositional legacy of present stand with focus on promoting multiple options to respond to emerging conditions
  - Focus on regeneration methods that accommodate greatest range of species while maintaining mature structure
    - Group/patch selection, irregular shelterwoods, two-aged variants
  - Lack of future options should trigger need for investment in regeneration




THANKS!