Density Management Strategies for Enhancing Carbon Sequestration in U.S. Working Forests

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Justification

Density management will continue to be a method to achieve goals for a variety of objectives

PCT/CT are useful to have in our toolbox

Commodity production, Crop tree release, C sequestration, Stand composition, Forest health, Wildlife habitat, Aesthetics, Structure, etc.

Justification

Little is known about the causal factors of the magnitude and duration of response

f (tree size, light, water, nutrient availability, competition)

How much? What is the threshold?

Justification

Tree-ring isotopes* and Site Water Availability (light and water)

Novel tools of quantifying potential water use efficiency and a *promising solution* to site-specific density management regimes

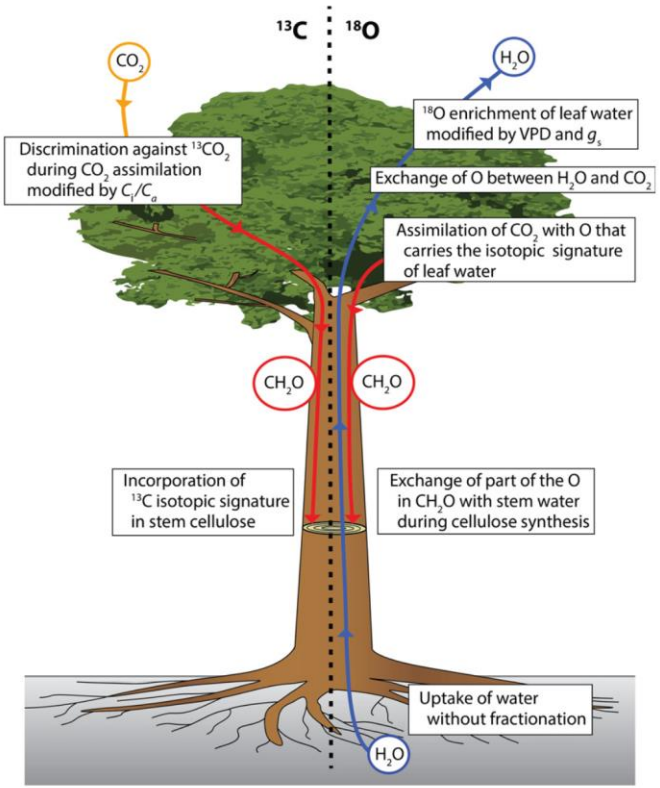
*Atoms that do not decay, C^{13} and O^{18}

If resources are not limiting, trees are "picky" and don't utilize the heavier isotopes of C and O

As resources become limiting, trees will "use what is available"

If light limited, drop in ^{13}C, if water limited, drop in ^{18}O

This is recorded in the tree ring tissue each growing season



van der Sleen et al. (2017)

Use of isotopes are common in agricultural settings, and some forestry applications

Thinning trials in *P. ponderosa* in N. California

N fertilization in Douglas-fir in the Pacific Northwest

Site water availability, leaf area, and productivity

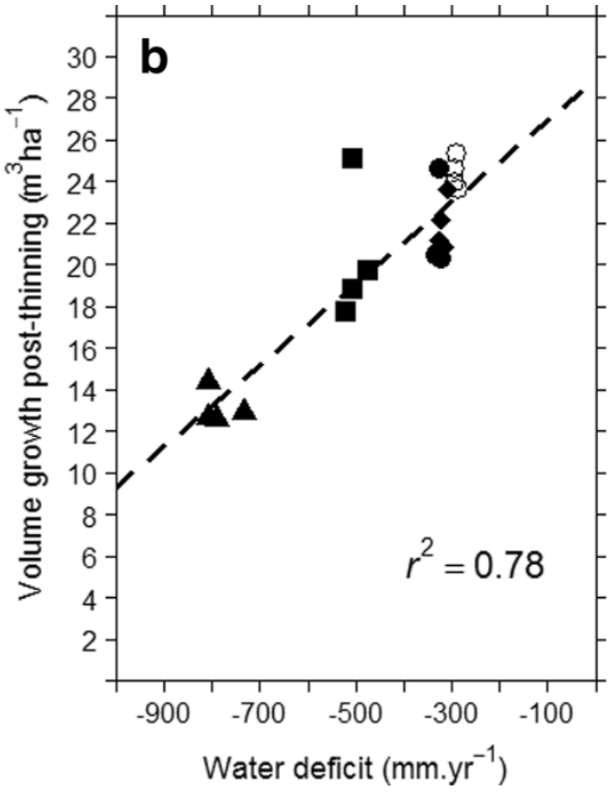
Continued success in application of SWA estimators (WD/WDI)

Predicting thinning response in Radiata pine in Chile
(Ojeda et al. 2018)

Dominant height and leaf area in loblolly pine in the SE
(Koirala et al. 2021; Kinane et al. 2022)

Diameter increment in white spruce in Maine
(Premer, unpublished)

Total volume of Eucalyptus in Brazil
(Scolforo et al. 2019)



A continuous composite variable that is compatible across regions

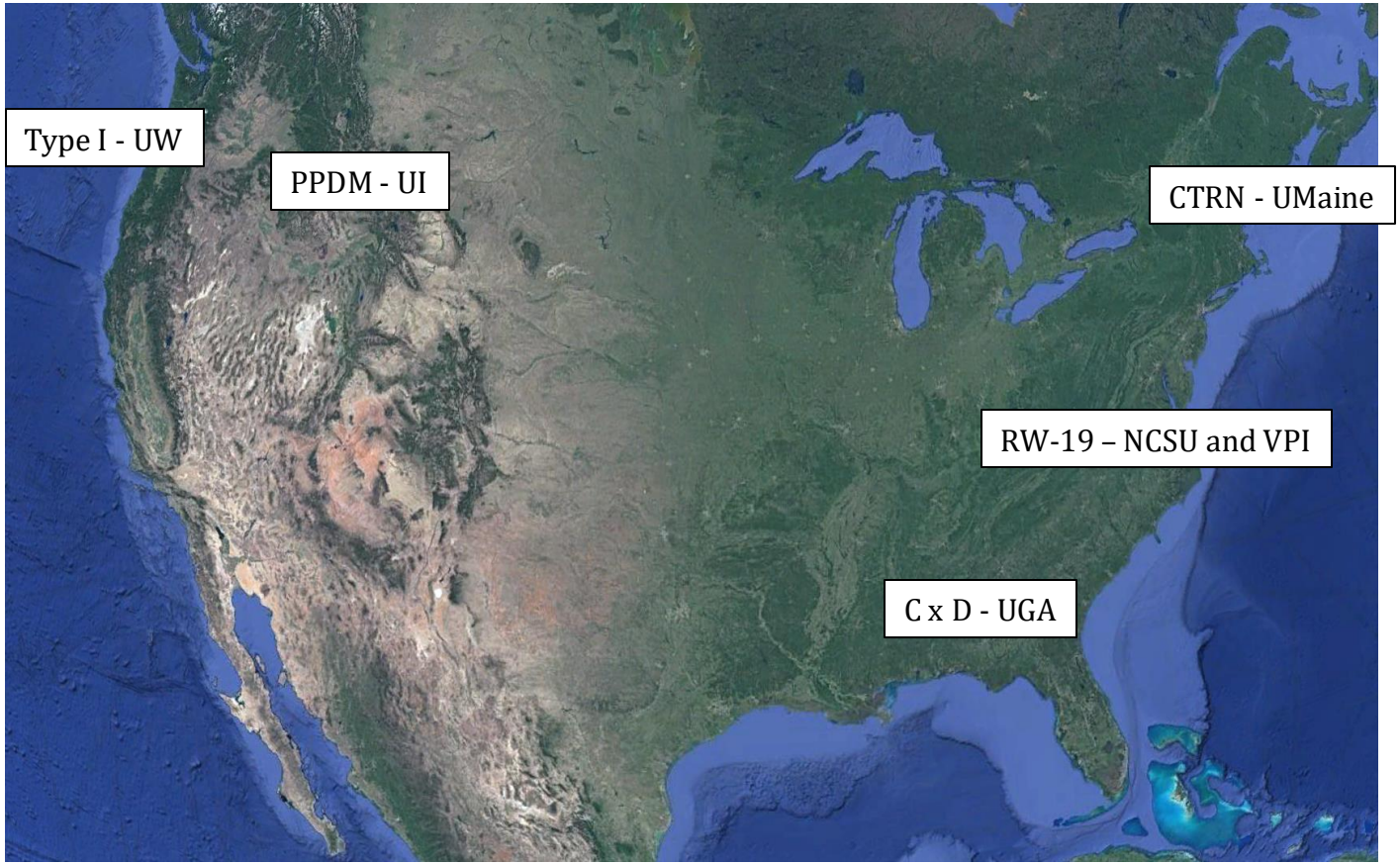
Project objectives

1. Quantify the causal mechanisms of stem growth response (or lack of) to variations in thinning intensity, timing, and site variables through sampling and analysis of tree ring stable isotopes ($\delta^{13}C$ and $\delta^{18}O$) with regional long-term datasets

2. Link remote sensing composite estimates of productivity, (e.g., cumulative monthly timesteps of water availability) with thresholds of thinning response across the hydrologic gradient of sites and patterns in stable isotopes

3. Develop cross-regional silvicultural thinning guidelines and geospatial tools of estimated treatment priority and response to aid decision support in commercial forest operations.

Each working forest region has an intact experimental thinning network



Project approach – three pronged

Tree physiologic processes

Tree-ring isotopes

Stand dynamics

Competitive metrics

stem maps

Remote sensing data, soil samples

Site productivity and hydrologic flux

Methods

Project approach – three pronged

Tree physiologic processes

Tree-ring isotopes

2023-2024 6 CTRN (UM)

- 1 Thinned Plot and 1 Control Plot per installation
  - Core 40 trees per installation, 1 per diameter distribution quintile
  - 20 of each species (RS, BF)
  - Core samples will be processed pre-harvest, and 5-10-15-20 years post treatment (5 samples per tree)
  - Lab processing at UMaine and Columbia University

2024 6 SMC Type I (UW), 6 RW-19 (NCSU)

- 1 Thinned Plot and 1 Control Plot per installation
  - Core 20 trees per installation, 1 per diameter distribution quintile

2025 6 C x D (UGA), 6 PPDM (UI)

- 1 Thinned Plot and 1 Control Plot per installation
  - Core 20 trees per installation, 1 per diameter distribution quintile

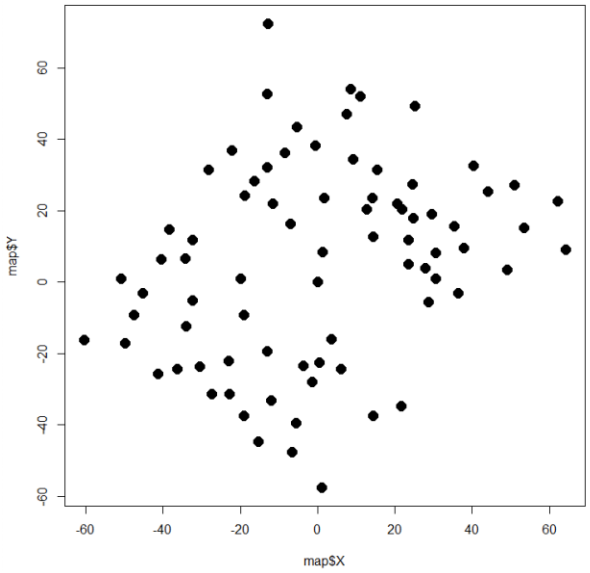
Methods

Project approach – three pronged

Stand dynamics

Integrate records from long-term databases

- Stand structure
- Competitive metrics
  (spatially explicit tree neighborhoods)

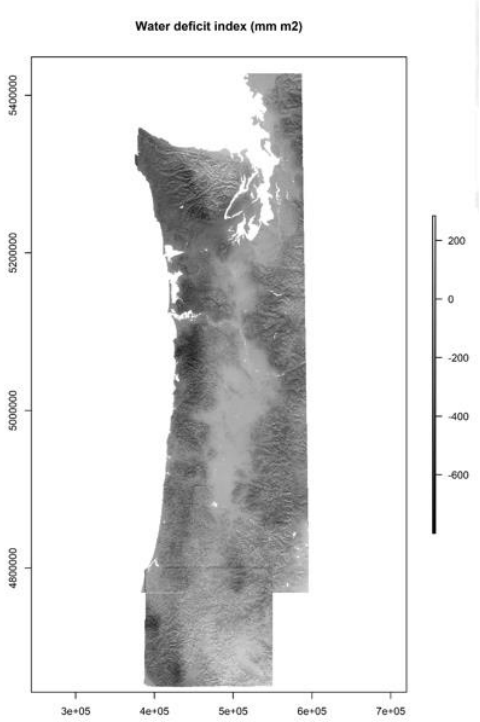


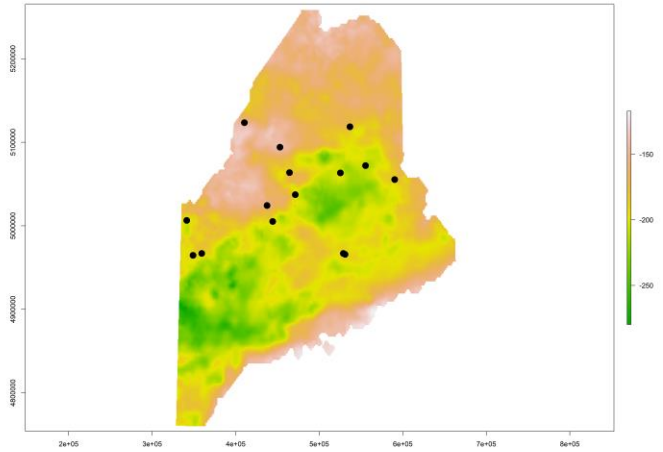
Methods

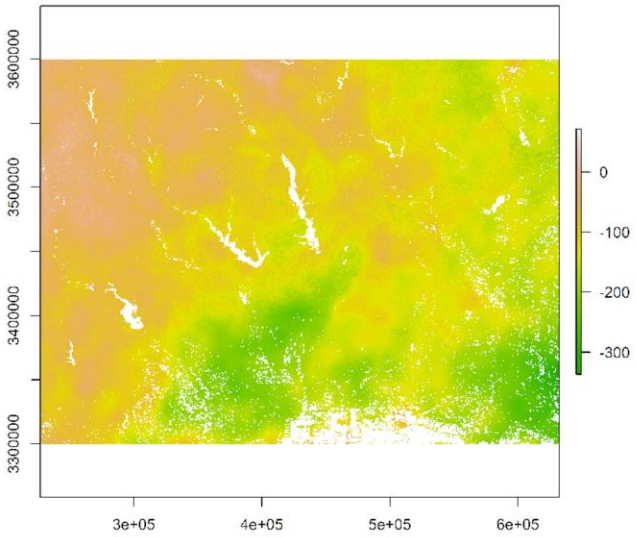
Project approach – three pronged

Site hydrologic flux

Remote sensing data, soil samples



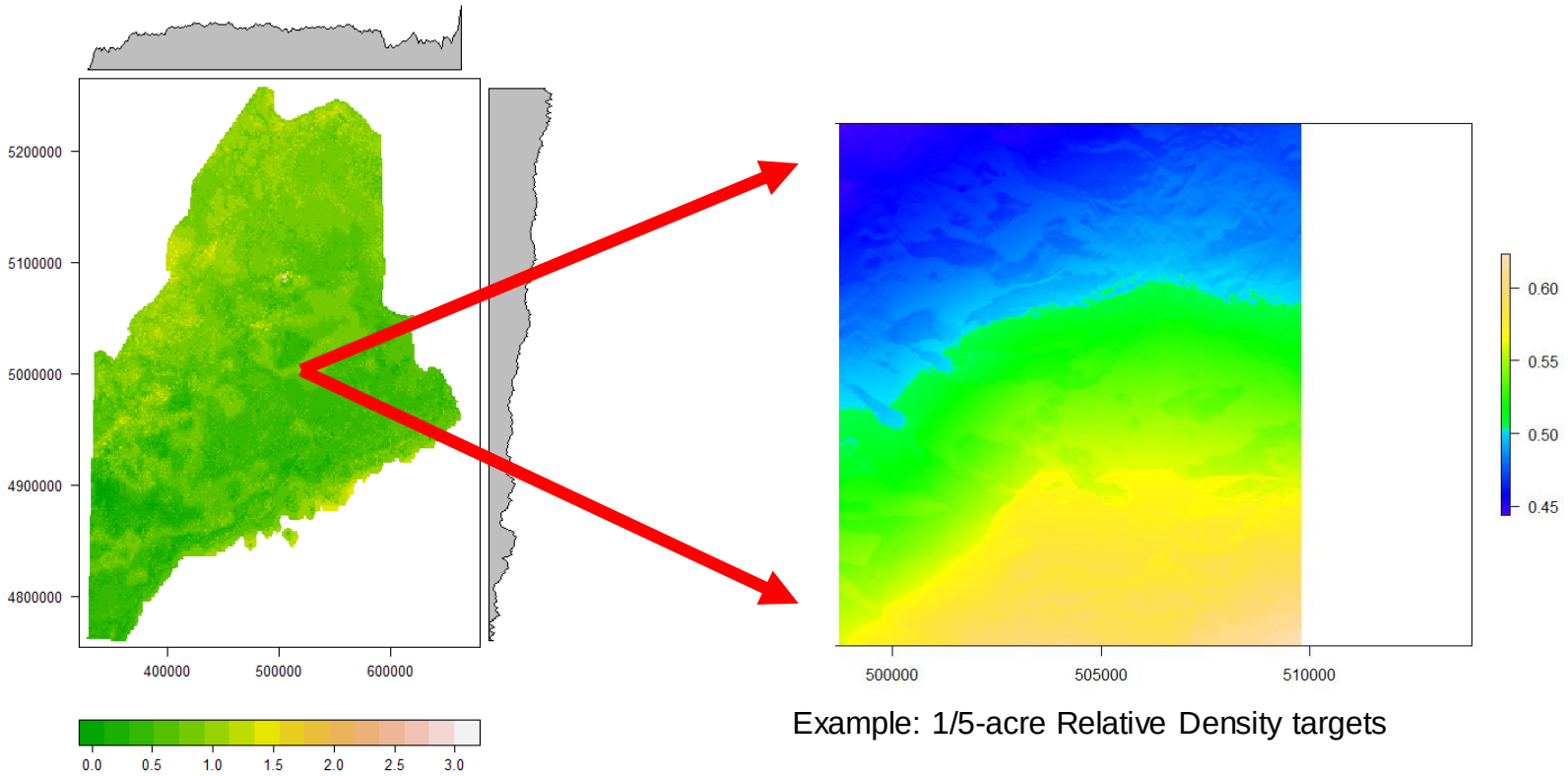




Evapotranspiration demand at a user-defined monthly time-step (cumulative since thinning)

Integration of processes across the tree, stand, and site scales

…C based forest management - *when does tree slow down pulling C from atmosphere*?



Example: 1/5-acre Relative Density targets

$$\Delta^{13}C = f(\text{Species}, \sum \text{WDI}_{t2\text{-}t1}, \text{CompInd}, \text{DBH})$$

Deliverables

Final report integrating cross-regional findings for C-oriented management guidelines in U.S. working forests

Integration of long-term and cross-regional cooperative datasets and geospatial layers for analysis and collaborative extension

Four publications submitted to peer-reviewed journals that reflect project objectives

Partial support for 2 MSc students with original thesis works

Presentation of findings at 2 national meetings (2024 and 2026)

Company Benefits

Silvicultural guidelines and geospatial tools of treatment priority and response

Towards site-specific silviculture – "*should I open the stand up a bit more?...*"

Leveraging long-term, cooperative dataset with emerging technologies

Quantifying C sequestration and tools for C based management

The approach can be extended to a variety of applications

Summary

- Density management will continue to be a useful tool in our toolbox – but more research is needed to optimize treatments
- Using new technology while leveraging long-term datasets to develop site-specific thinning regimes has tremendous value
- C based forest management
- This approach can be extended to other areas of future research
  (M/CSP, nutrition, tree improvement, species migration)

Thank you. Questions/Comments/Criticisms?

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