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USDA United States Department of Agriculture

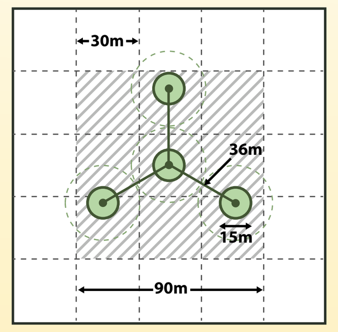
Combining National Forest Inventory Data with Soil Drainage Index to Assess Forest Health Vulnerability

BACKGROUND AND HYPOTHESES

- Assessing the health of America's forests is central to the mission of Forest Health Protection to foster resilient and adaptive ecosystems
- Depressed growth and higher mortality, resulting from physiological stress, compromises long-term forest health
- Drought/disturbance causes physiological stress, but can be exacerbated by site variables, such as soil and topography
- Previous work defined ranges based on geographic, bioclimatic, basal area (BA) distributions
- Goal: define margins and interiors based on **soil drainage index**, examine mortality and **growth rates over time**
- Hypotheses:
  - Mortality in range margins > interiors
  - Growth in range margins < interiors

METHODS

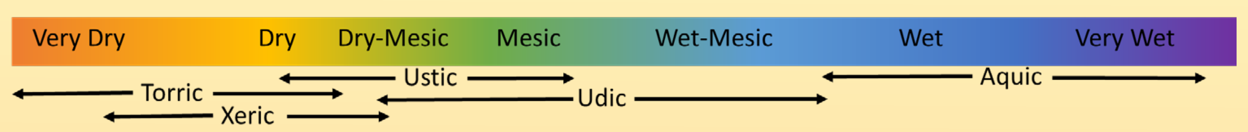
Response Variables: Tree Mortality and Growth



- Forest Inventory and Analysis (FIA) database
- Subplot remeasurements allow calculation of mortality and growth rates at time steps of 5-10 years
- Change in live and dead basal area over time were assessed for:
  - Dominant and co-dominant crown classes only
  - Untreated and undisturbed subplots only
  - Most recent remeasurement only
- Mortality was from any cause (fire, insect, disease, suppression/competition)
- **Mortality rate = Newly dead basal area/total basal area per year**
- **Growth rate = average tree basal area increase per year**

Range-defining Variable: Soil Drainage Index

- Taxonomy-based index of soil wetness (Schaetzl et al. 2009)
- Major contributors: soil moisture regime, natural soil drainage class, subgroup modifiers (texture, shallowness to bedrock, etc.), slope gradient
- Soil taxonomy data obtained from SSURGO, gaps filled with National Forest System survey data and modeled DI values (Krist et al. 2014)
- DI classed into 8 classes and assigned to each FIA subplot



Statistical Analysis

- Defined tree range margins/interiors based on distribution of FIA subplots among DI classes for each species (**Figure 1**)
- Mean mortality and growth calculated for margins vs interiors for each species
- Significant increase in mortality or decline in growth in margins vs interiors for each species tested using randomization tests (n=1000) at the P <= 0.05 level

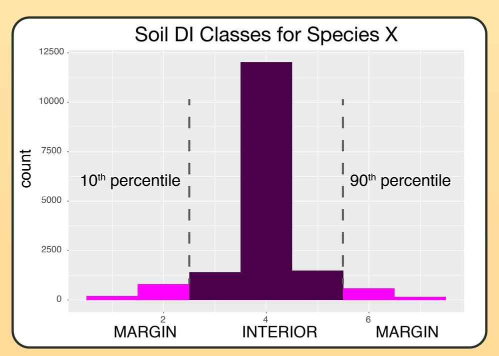
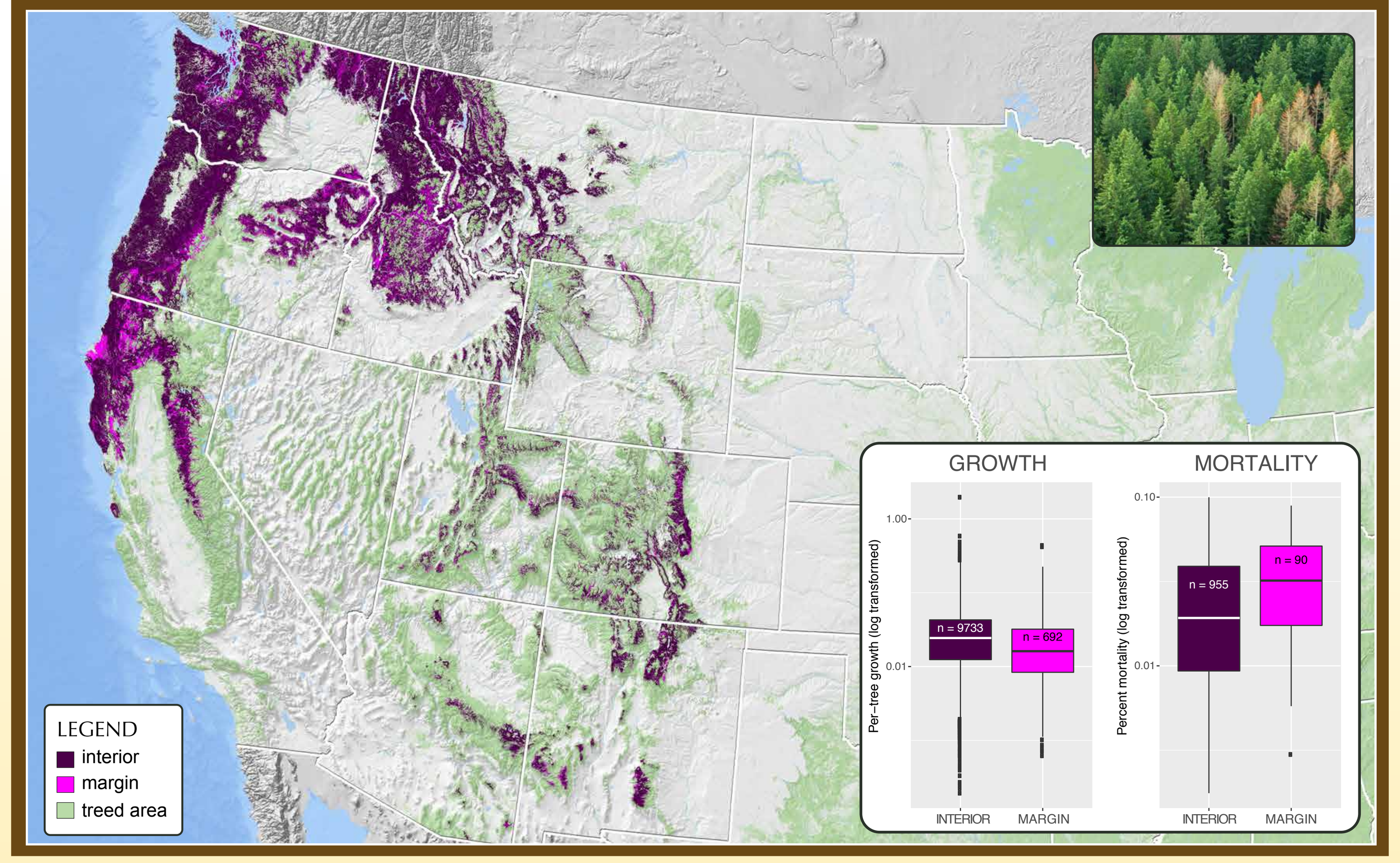


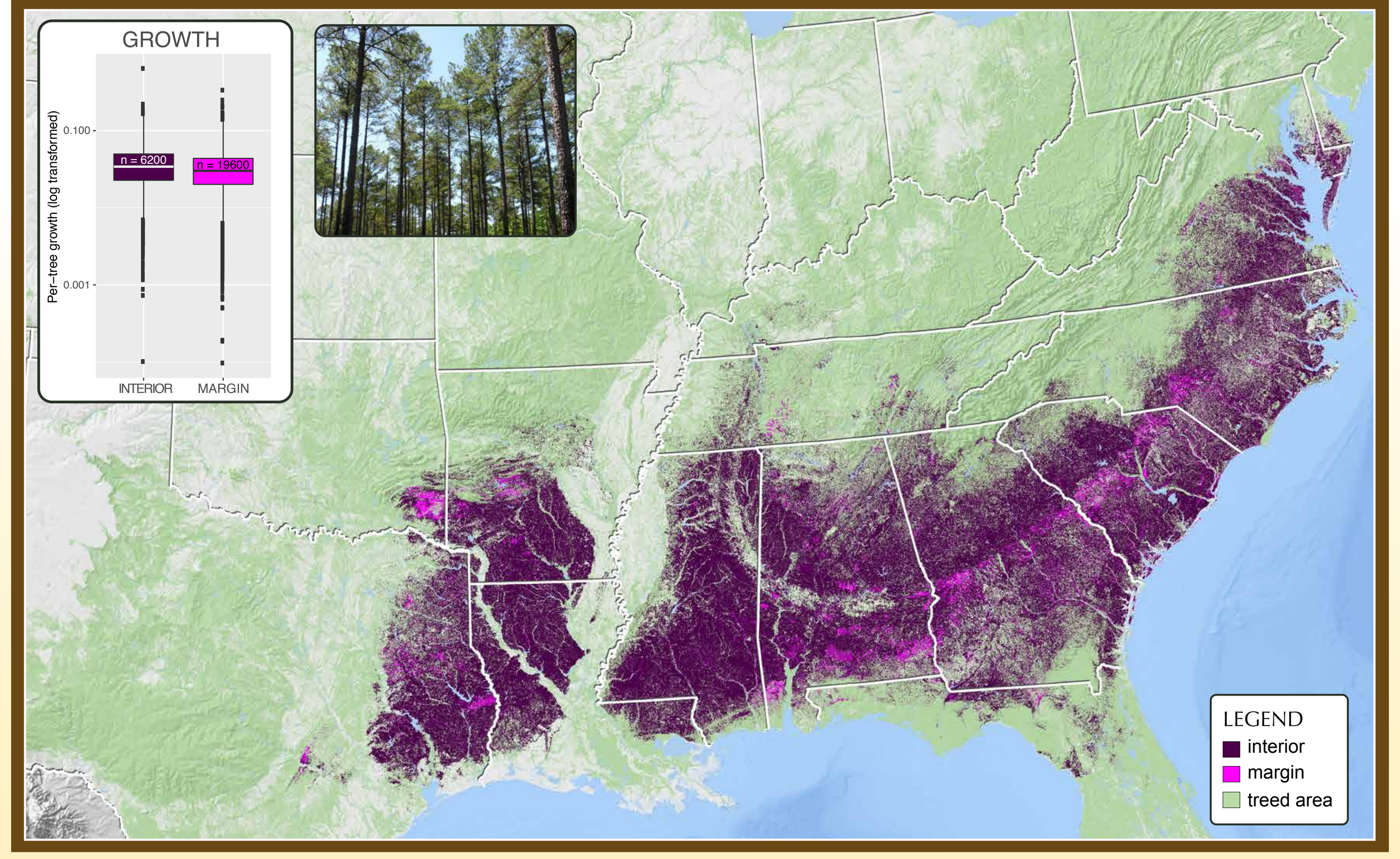
Figure 1. Example distribution of species presence according to DI class.

RESULTS

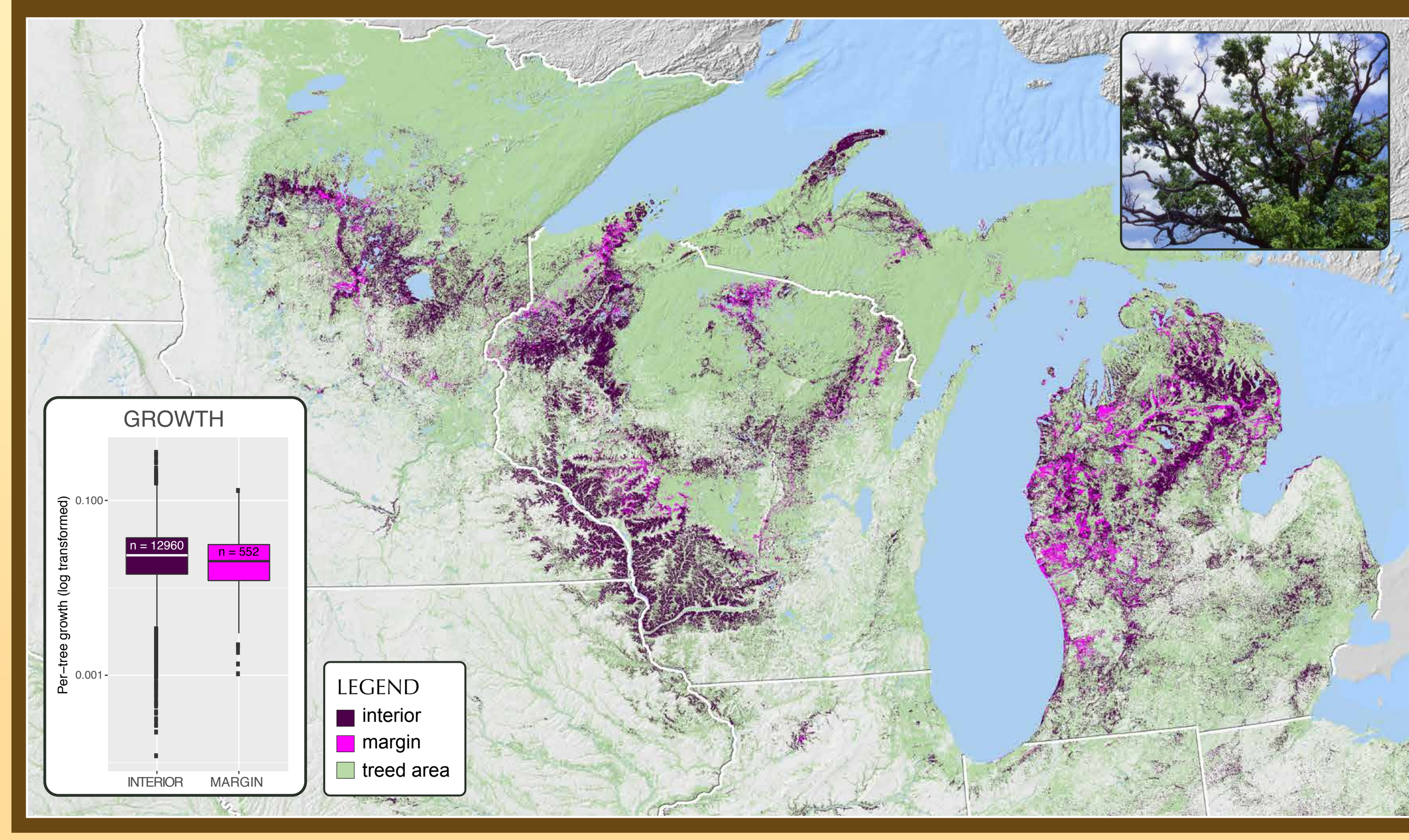
Douglas-fir (***Psuedotsuga menziesii***) showed significantly higher mortality and lower growth in places with a very dry soil drainage index. Identifying these margins could help predict areas at risk for future mortality.



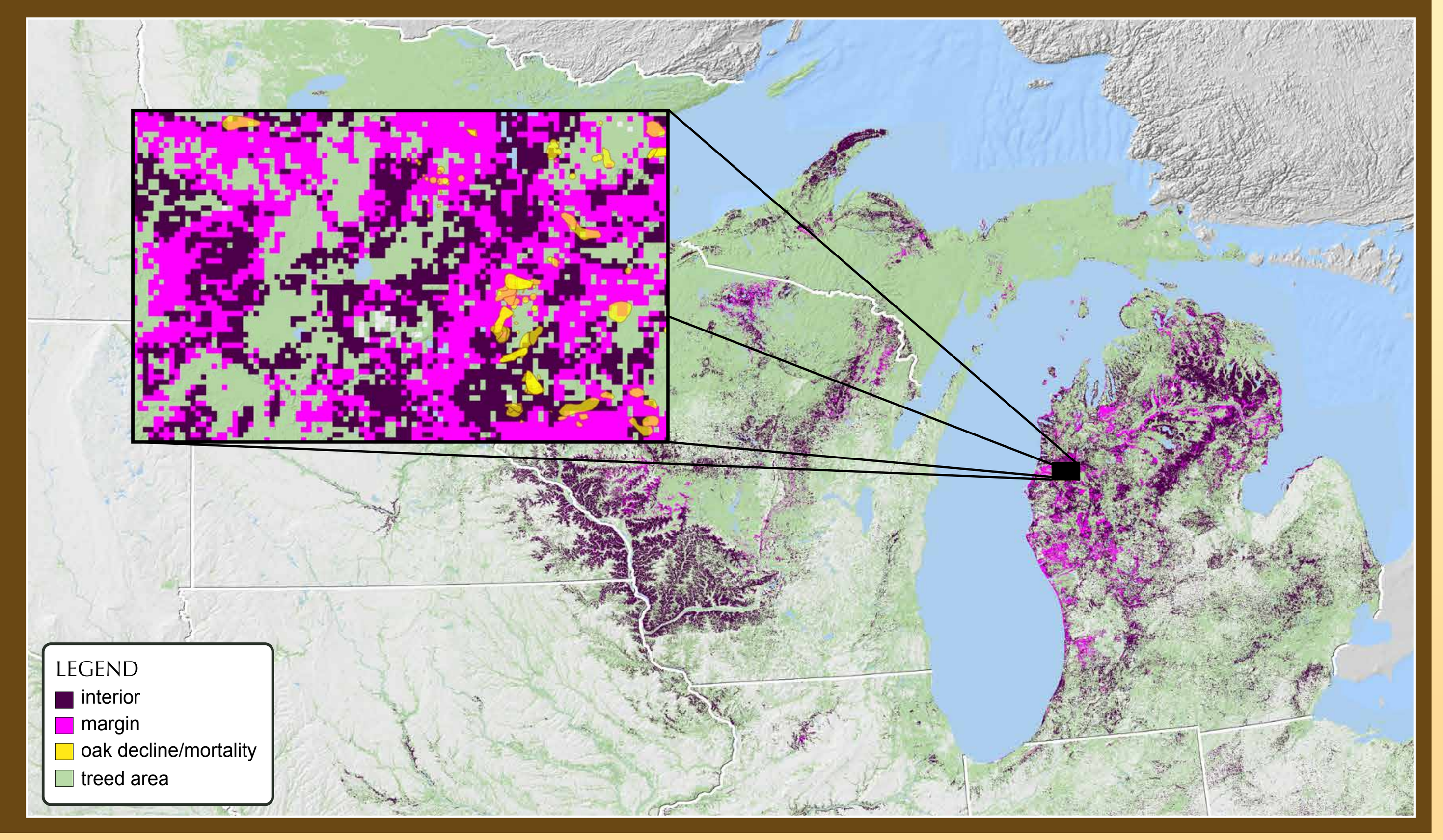
Loblolly Pine (***Pinus taeda***) showed significantly lower growth in places with soil drainage index from very dry to dry-mesic. Slow growth can reduce productivity and affect rotation lengths for this economically-important timber species. Identifying these margins could help mangers plan where to plant and thin.



Northern Red Oak (***Quercus rubra***) had significantly lower growth in places with a very dry soil drainage index. Identifying these margins could help managers better plan where to prioritize planting and thinning for timber management.



Slow growth can be a warning signal for oak decline – much of oak decline and oak mortality detected by aerial survey falls within the DI margins.



CONCLUSIONS AND NEXT STEPS

- Different species are sensitive to margins defined in different ways
- Growth differences in margins vs interiors were more pronounced than mortality differences (**Table 1**)

Table 1. Number of species in each group with significantly different mortality or growth (soil DI only) in the margin as defined by each variable (either one or both tails of the distribution).

		Geography	Elevation	BA	Climate	Soil DI	
	n	Mortality*				Mortality‡	Growth
Ash	8	1	3	4	5	0	2
Beech	1	0	1	0	1	0	1
Elm	7	1	1	3	2	0	1
Fir	10	1	1	1	1	0	2
Hemlock	3	2	1	1	1	0	1
Larch	4	0	3	0	1	0	1
Maple	10	2	3	7	6	1	2
Oak	46	5	11	25	12	6	17
Pine	36	7	12	17	10	5	10
Spruce	8	0	2	3	1	3	4

*Mortality defined as cumulative dead basal area divided by total basal area. Margin defined as below 5th or above 95th percentiles.
‡Mortality defined as recent (since last measurement) dead basal area divided by total basal area, only considering dominant or co-dominant crown classes. Margin defined as below 10th or above 90th percentiles.

- Resulting margin vs interior maps defined from DI can provide guidance for various forest management goals, such as assisted migration, replanting for maximum carbon sequestration, and post-disturbance restoration
- Low growth precedes drought-induced mortality (Hülsmann et al. 2018). But, fast-growing stands can also be targets for insects and diseases. This likely introduces noise to mortality-growth trends in the margins vs interior
- Future work will build upon this concept to generate forest health projections in a multivariate framework, starting with an interactive web application that allows exploration of forest growth and mortality trends with soil, climate, and topographic variables while filtering by management and disturbance history, stand density, region, and species (**Figure 2**)

Figure 2. Screenshot of FHAAST web application under development using the R Shiny package.

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