

# Assessing the future Northern Forest through the lens of seedling survival and sapling recruitment

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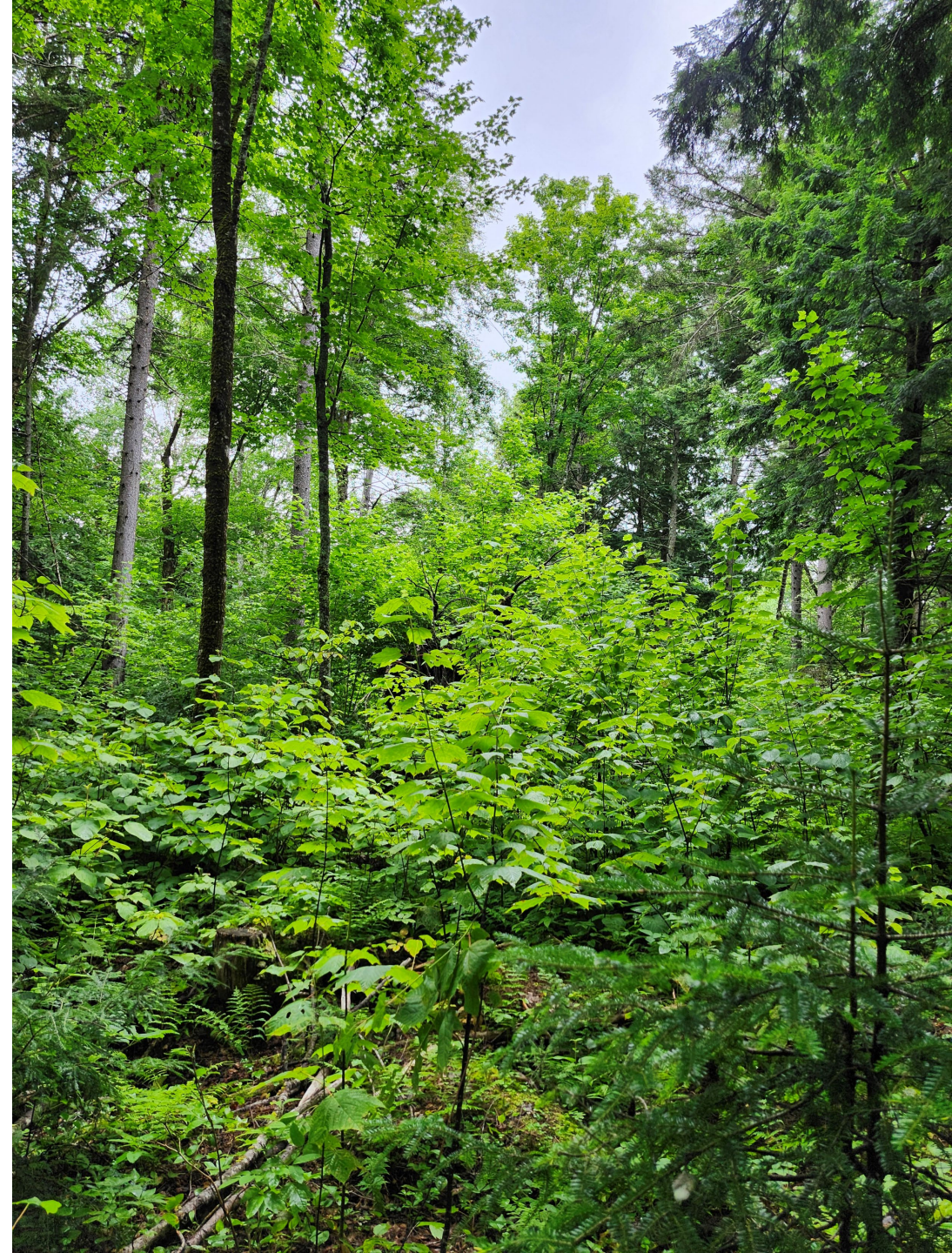
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<sup>4</sup>Current affiliation: CTrees



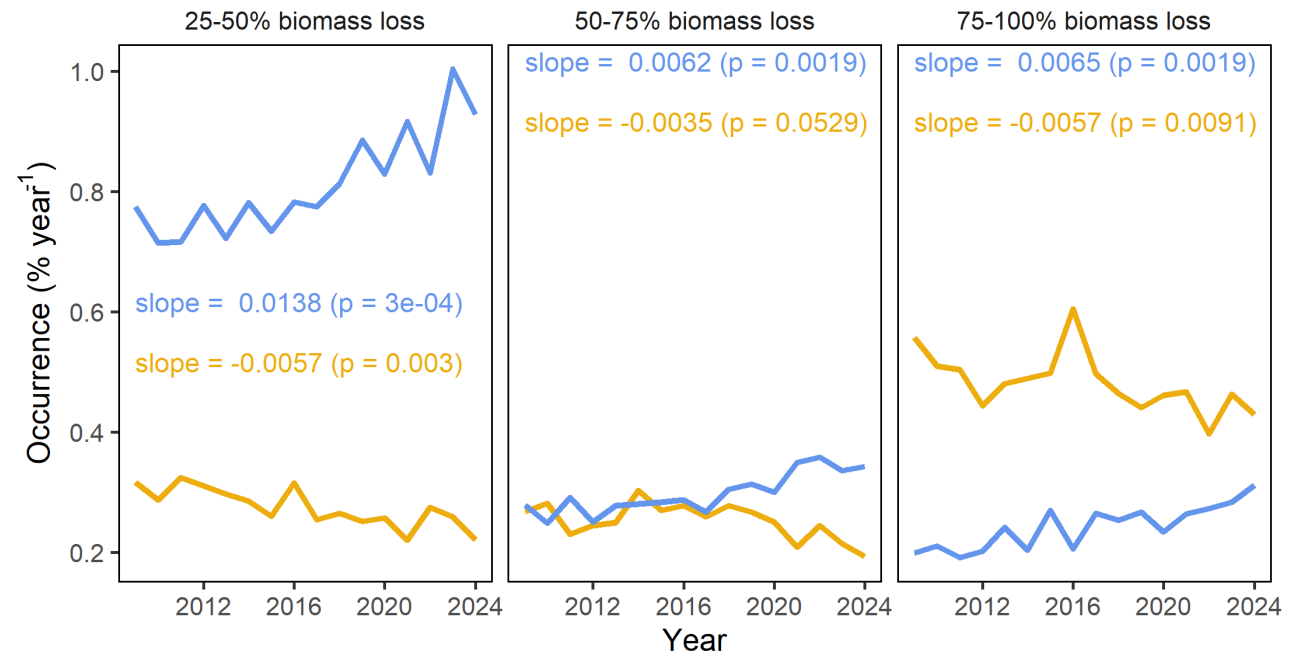
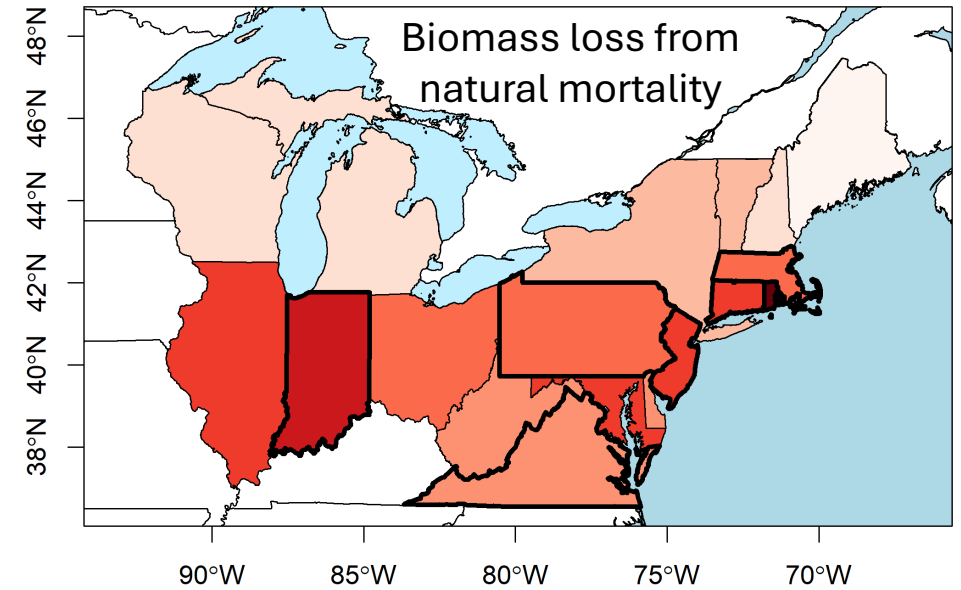
# Forest resilience

- Tree regeneration critical to forest recovery
  - Traditionally, not a strong focus in the Northeast
- Longtime understanding: natural mortality/disturbance rates are low
  - When stands are disturbed or harvested, natural regeneration is sufficient





# Disturbance is increasing

- We analyzed live tree biomass loss from 2004-2024 using forest inventory (FIA) plots
- High and increasing tree mortality in southern New England and the Mid-Atlantic
  - Not yet in the Northern Forest region

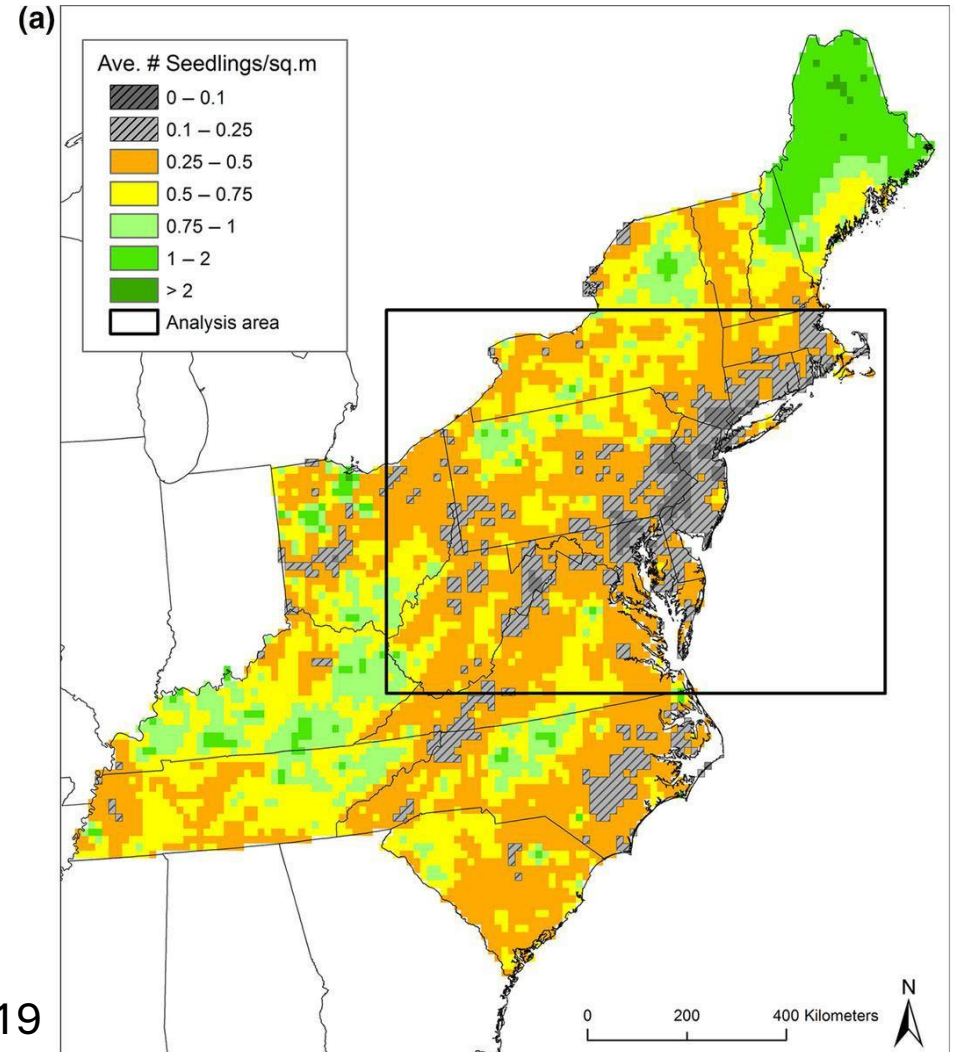


Harris et al., *in review*

Cause  Harvesting  Natural mortality

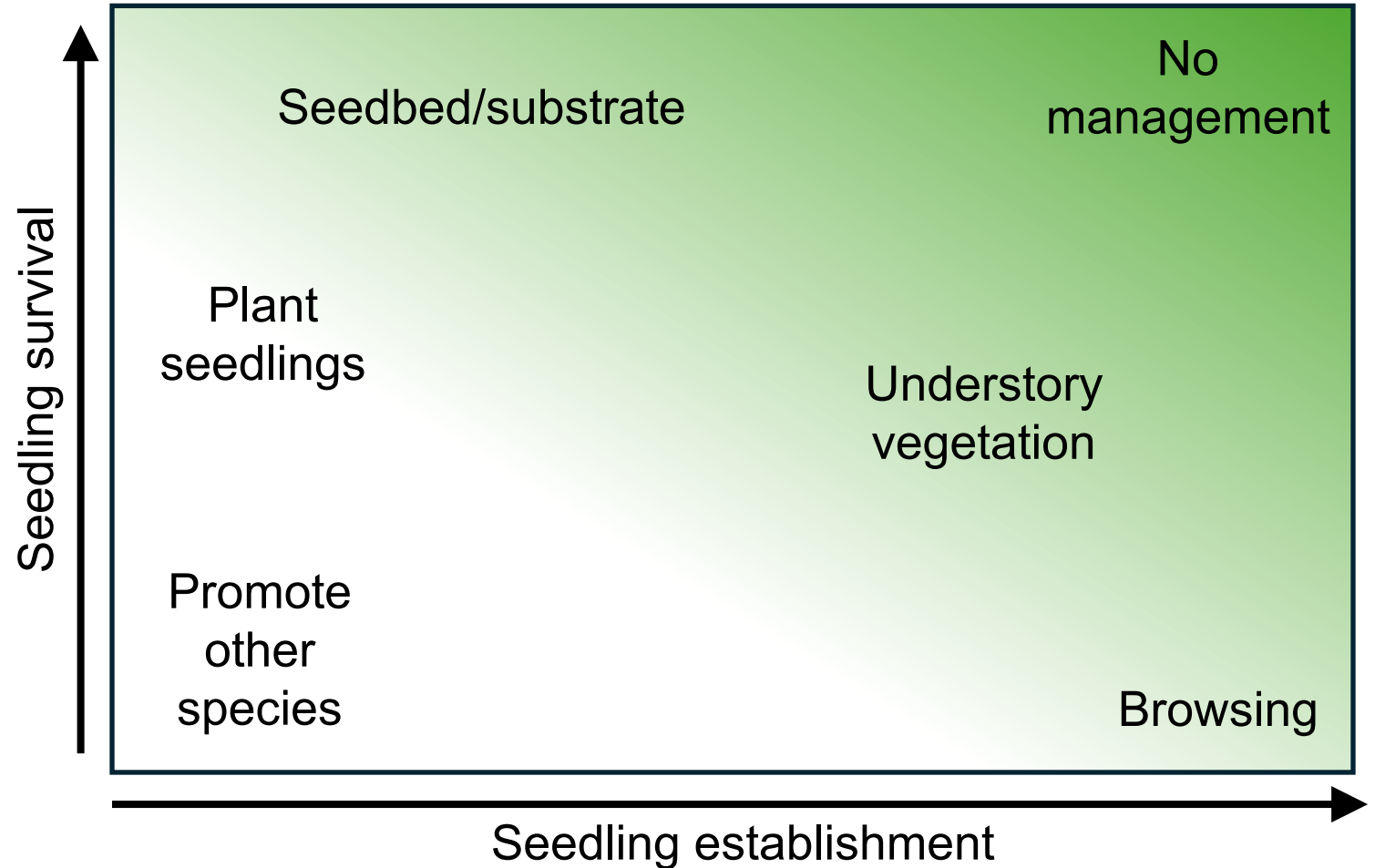
# Is tree regeneration in trouble?

- Widespread regeneration challenges in eastern North American forests
  - Low seedling and sapling abundance
  - Dissimilarity with overstory
- Regeneration is relatively better in the Northern Forest

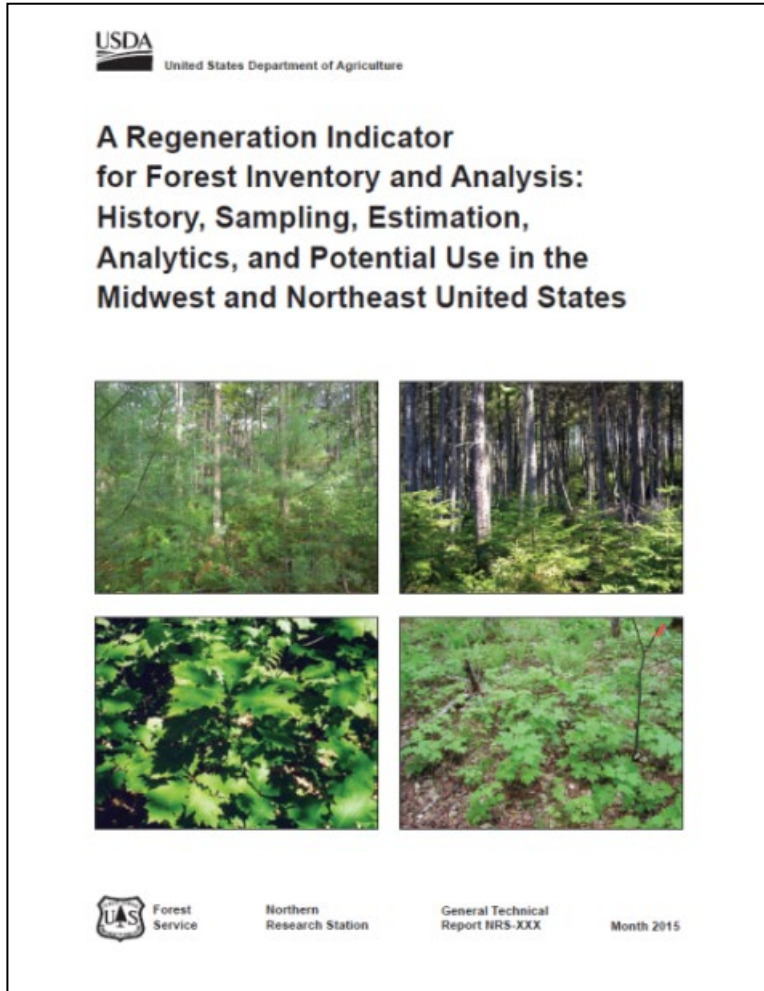


# Big picture: When and how to intervene?

- Regeneration bottlenecks: what stage?
  - Seeds: fecundity and dispersal
  - Establishment and early survival
  - **Small seedling to sapling recruitment**
- Determines which management strategies are most effective



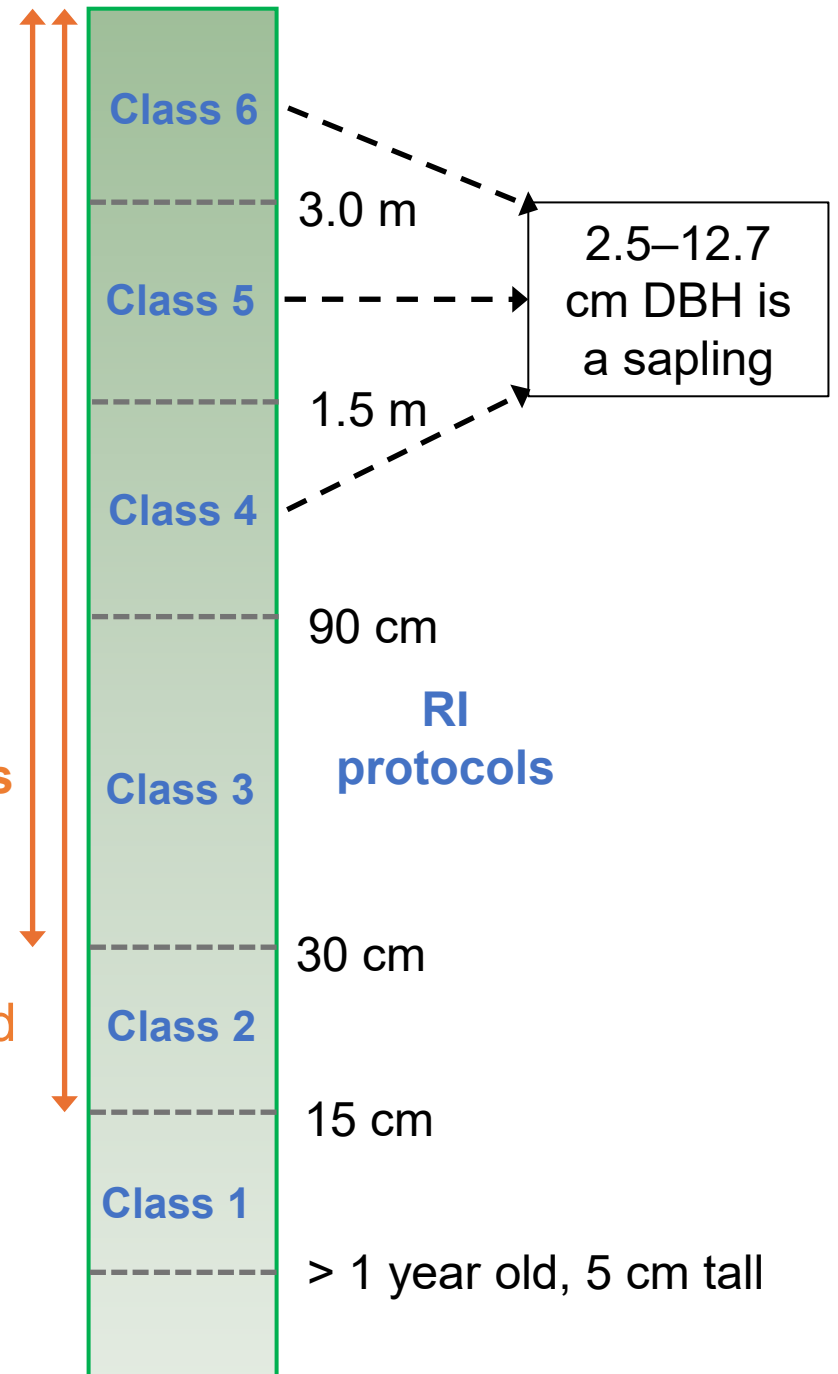
# FIA's Regeneration Indicator



Standard protocols: 1 class

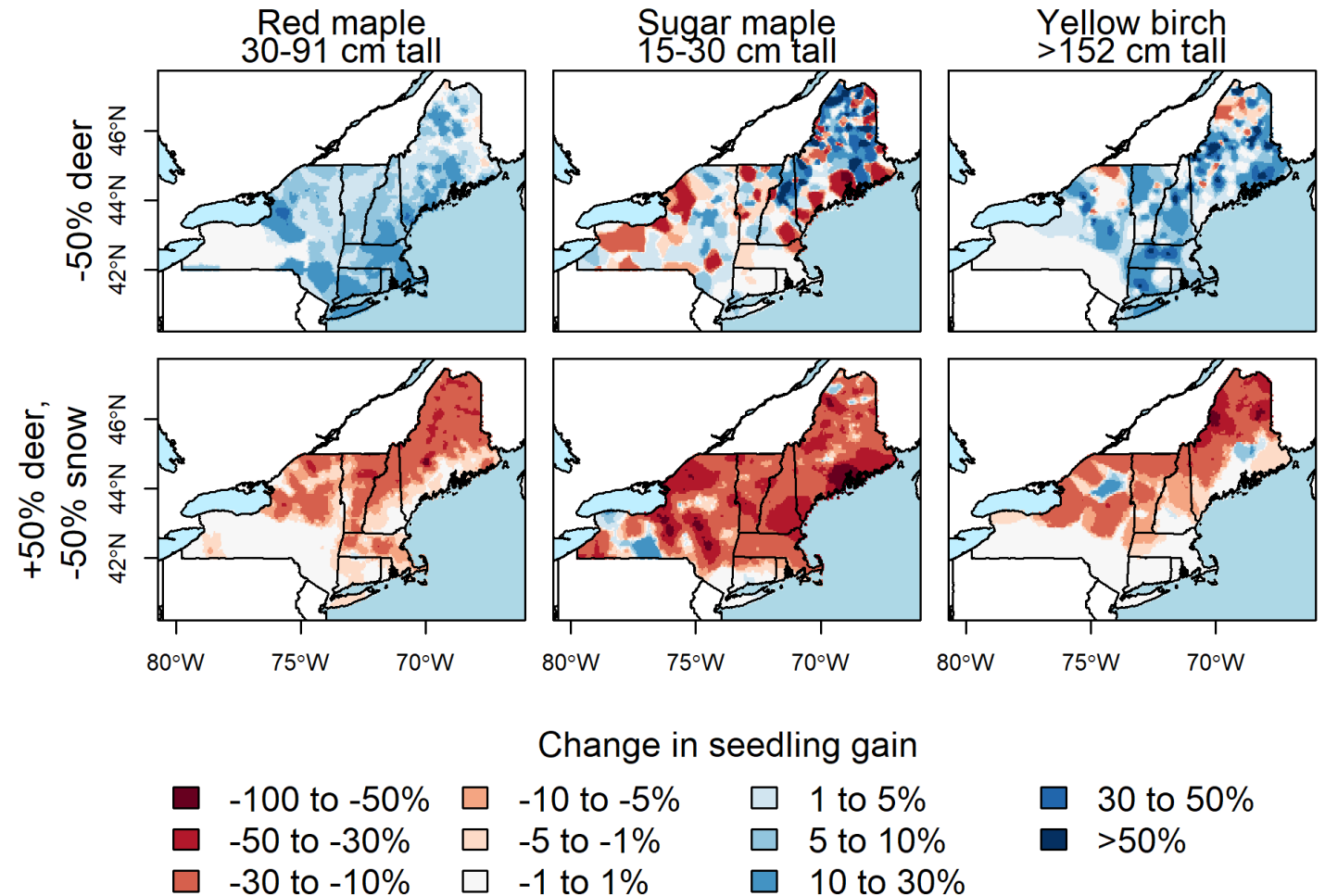
Hardwood

Softwood



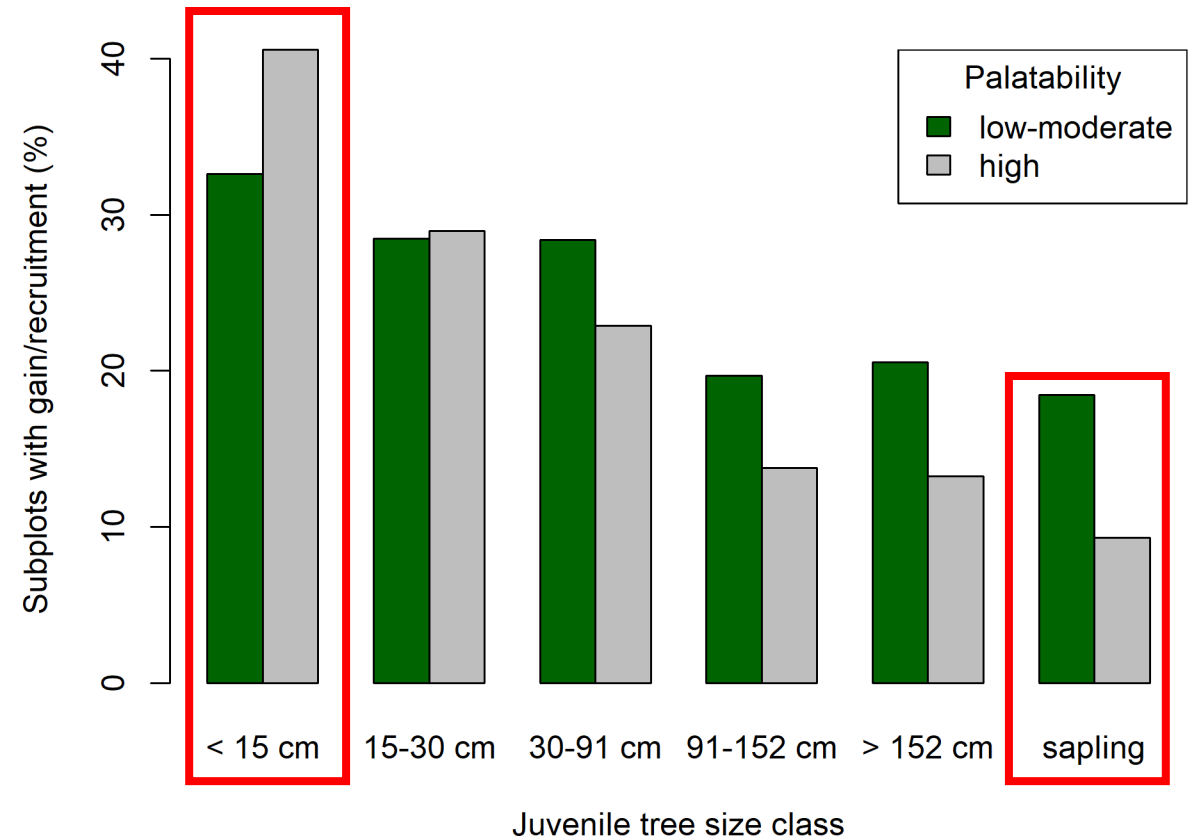
# Deer browse impacts by seedling height

- Reducing deer browse would have widespread benefits
- Less snowy winters will impact seedlings through increased browsing
  - Especially farther north



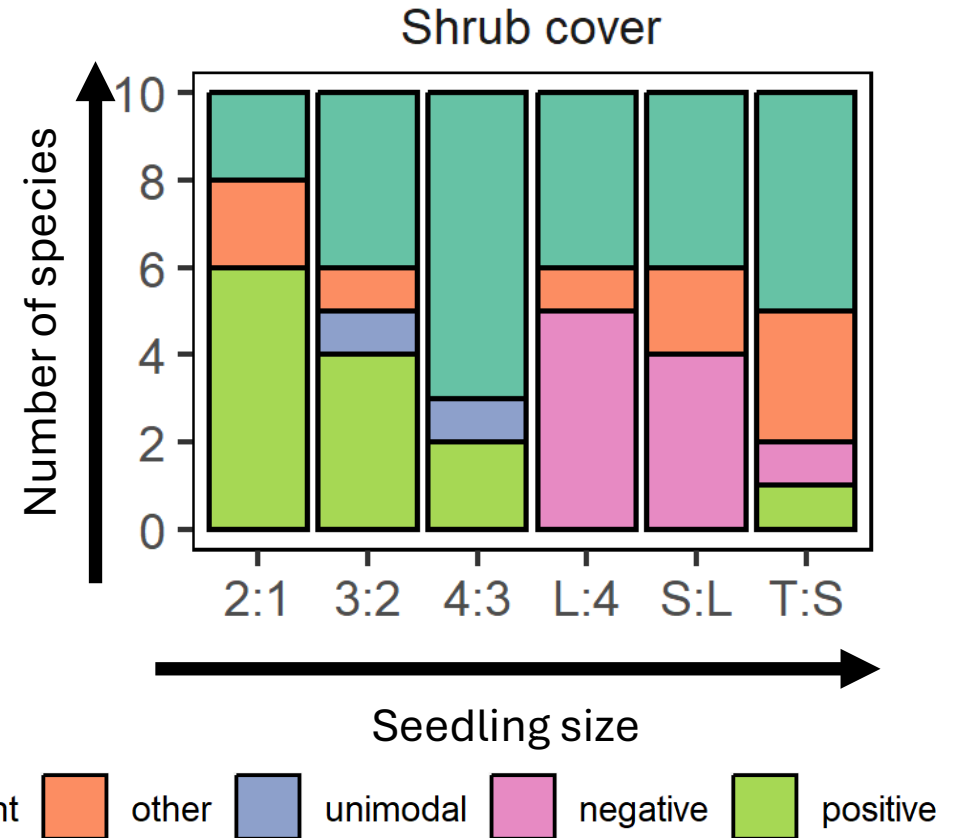
# Deer and the seedling to sapling pipeline

- Highly palatable species show more gains in abundance than unpalatable species as small seedlings...
- But sapling recruitment is half as likely



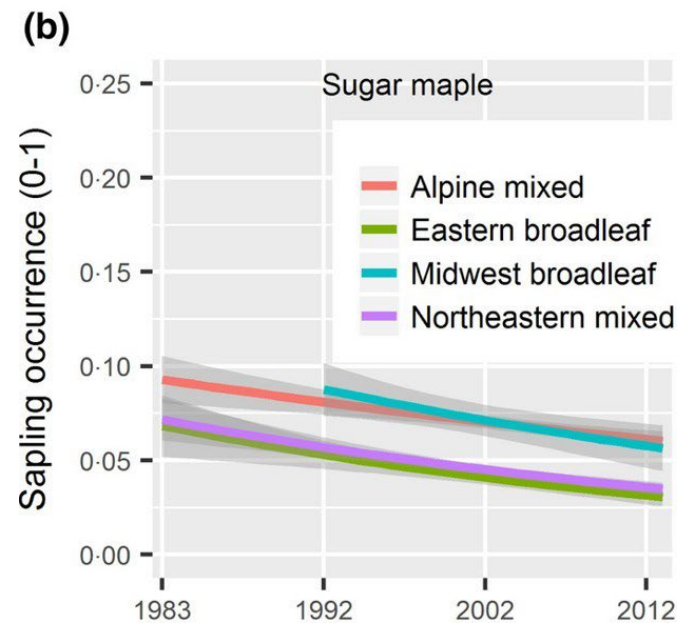
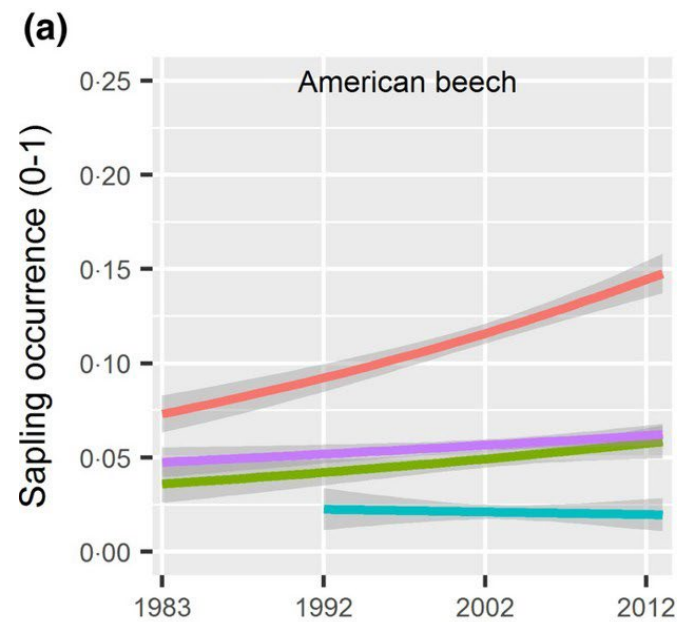
# Deer and shrubs

- Shrubs tend to increase survival of small seedlings, but decrease survival of large seedlings
  - Protection from herbivory?

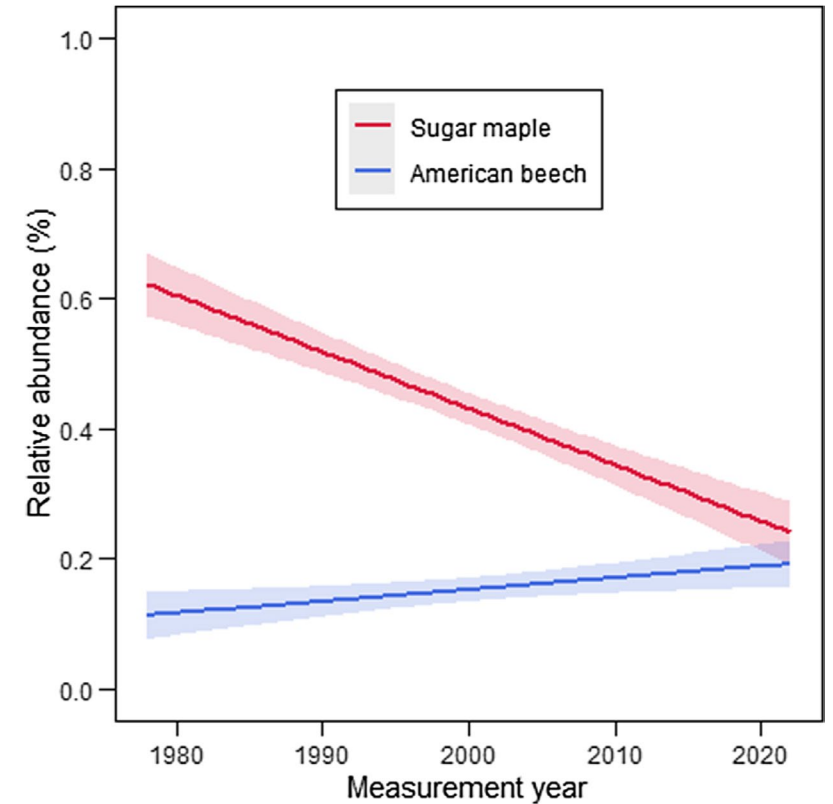


# Regeneration trends

- Trends since 1980's:
  - ↑ in American beech (*Fagus grandifolia*)
  - ↓ in sugar maple (*Acer saccharum*)
- Beech outcompetes maple given abundant deer, acidic soils



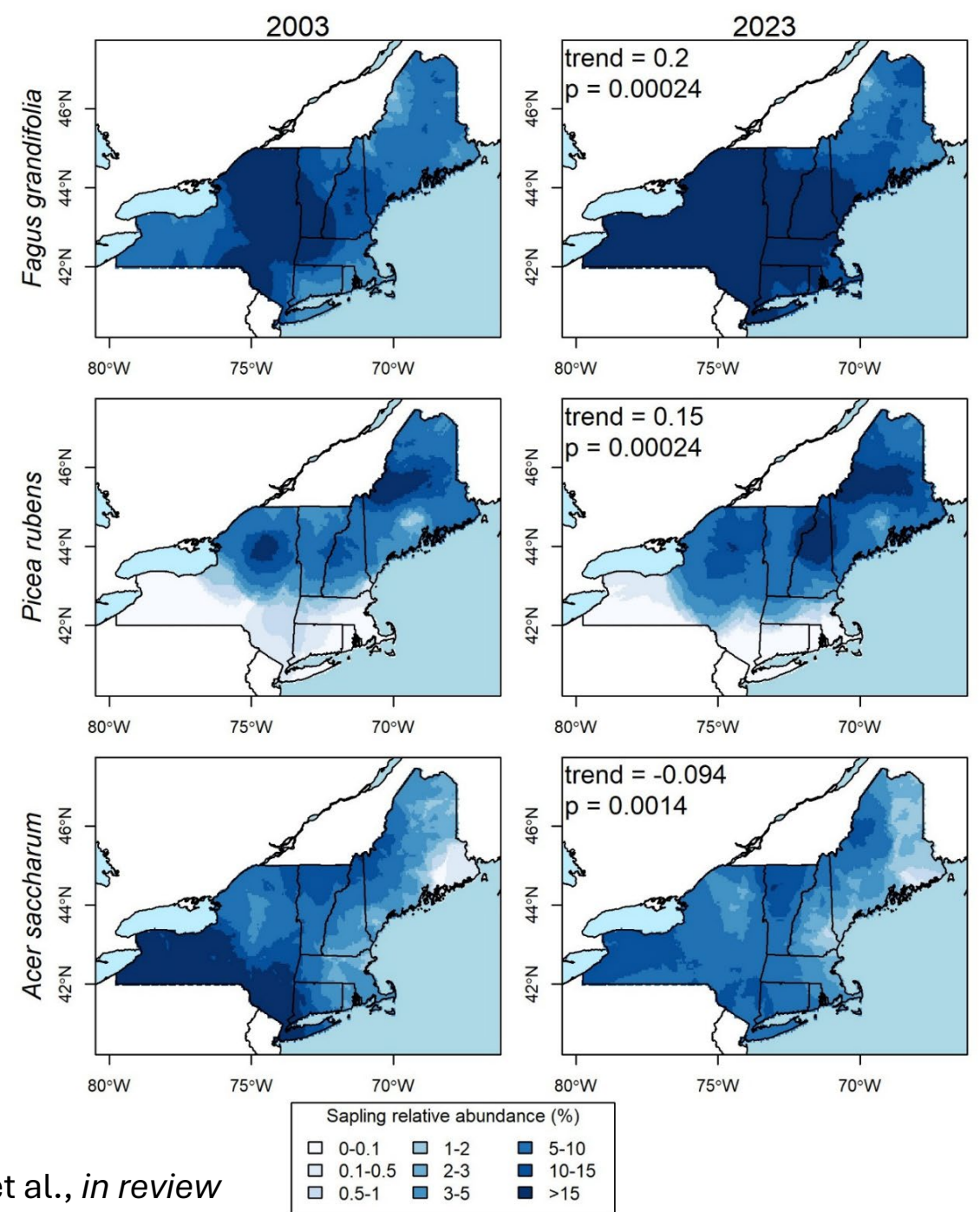
Bose et al. 2017, *Journal of Applied Ecology*



Gauthier 2025, *Ecology and Evolution*

# Species-level changes

- Sapling abundance:
  - Increases in beech and red spruce
  - Decrease in sugar maple
- Sapling recruitment:
  - ~50% decrease in balsam fir recruitment
  - Decrease for red maple in northern areas

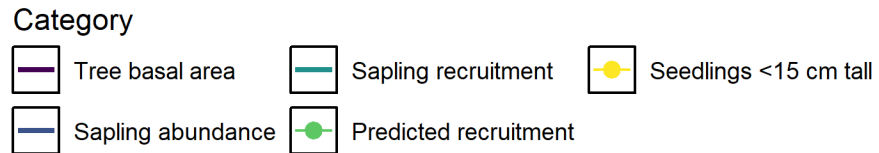
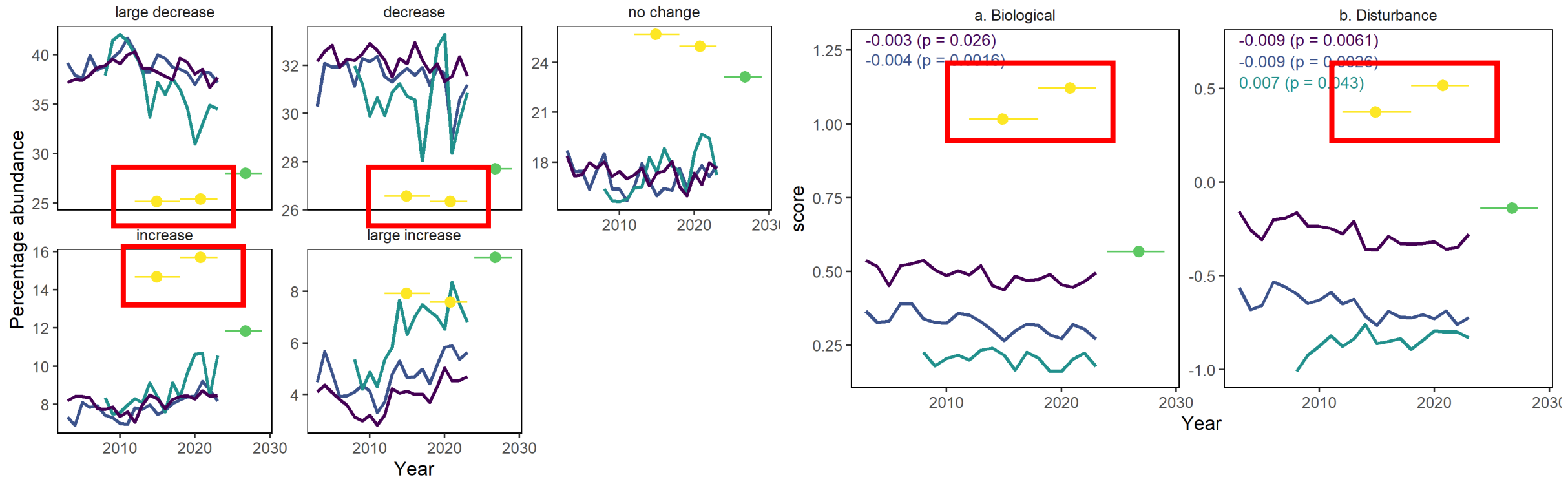


# Sapling trends $\neq$ small seedling trends

Species	Small seedlings, Time 1	Small seedlings, Time 2	Sapling trend
American beech	279 stems ha <sup>-1</sup>	278 stems ha <sup>-1</sup>	Increasing
Sugar maple	1532 stems ha <sup>-1</sup>	2196 stems ha <sup>-1</sup>	Decreasing
Eastern white pine	238 stems ha <sup>-1</sup>	240 stems ha <sup>-1</sup>	Decreasing
Black cherry	93 stems ha <sup>-1</sup>	133 stems ha <sup>-1</sup>	Decreasing

- Recent trends in sapling layer seem not to be driven by seedling establishment and early survival
  - Survival and growth of mid-sized to large seedlings is key to understanding sapling trends

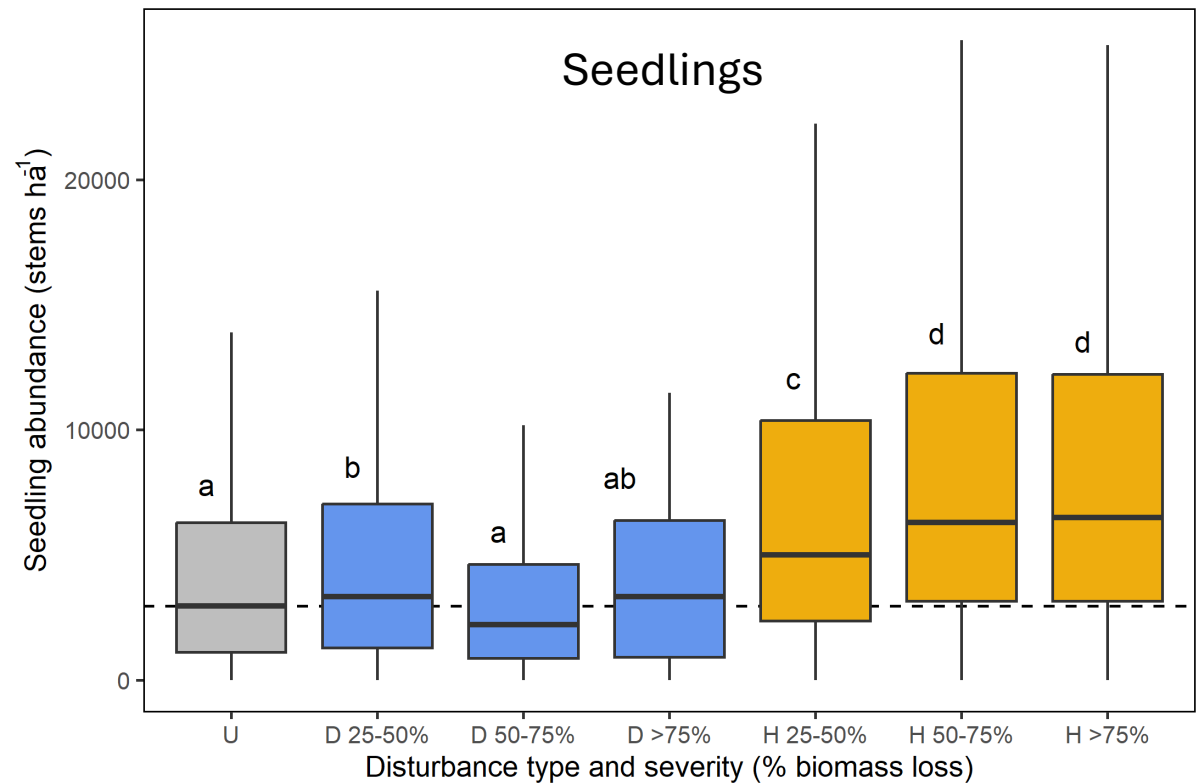
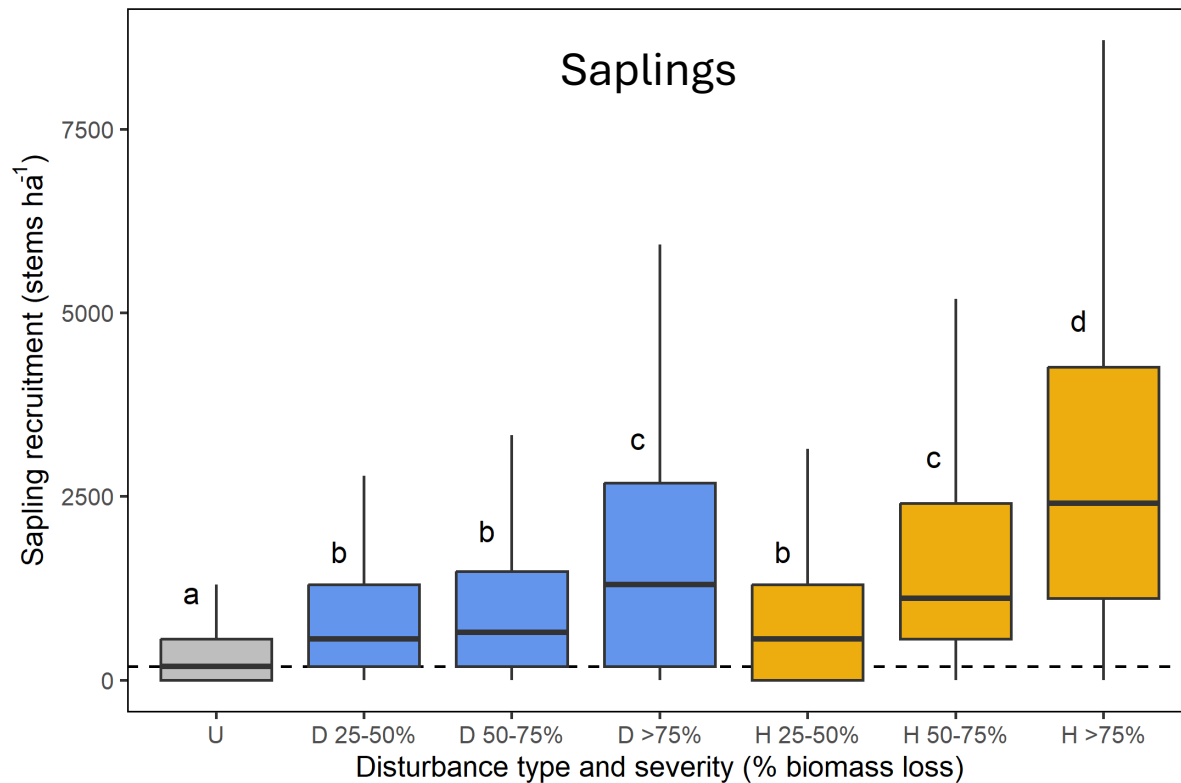
# Small seedling vs. sapling composition



Small seedlings < 15 cm high: lower climate vulnerability, greater resilience to disturbance and pests

# Regeneration response to disturbance

- Response to natural disturbance and harvesting
  - Median = 14 years post-disturbance

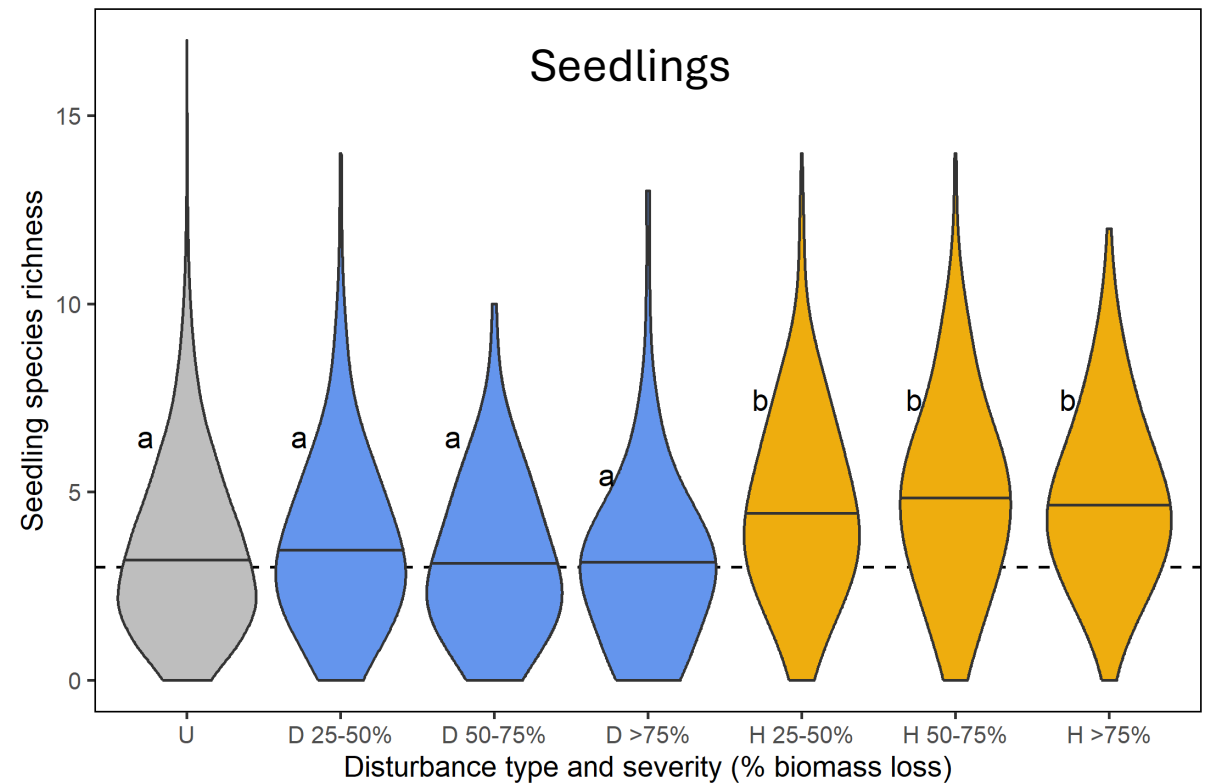
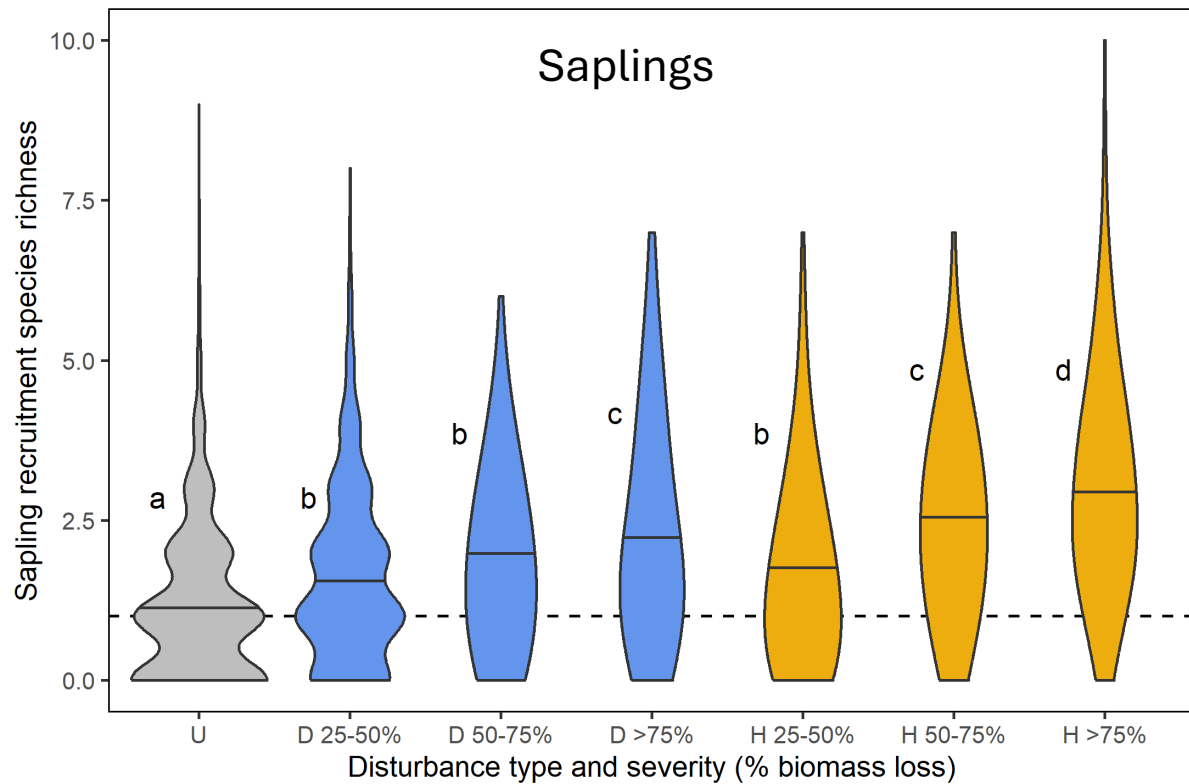


Category Undisturbed Disturbance (natural) Harvesting

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# Disturbance response: species richness

- More robust response to harvests than natural disturbance



Category  Undisturbed  Disturbance (natural)  Harvesting

Category  Undisturbed  Disturbance (natural)  Harvesting

# Conclusions

- Regeneration will be crucial as mortality and disturbance increase
- Bottlenecks in the seedling to sapling recruitment pipeline shape regeneration patterns
- Favorable composition of small seedling layer suggests opportunity to manage for improved natural regeneration



# Thank you!

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