Sapling recruitment as an indicator of carbon resiliency in forests of the northern US

Lucas B. Harris, University of Vermont
Christopher W. Woodall, USDA Forest Service
Anthony W. D'Amato, University of Vermont

Tree regeneration

- Widespread concern:
  - Low abundance
  - Undesirable composition
- Complex reasons for inadequate regeneration
  - Climate change, over-browsing, pests and pathogens, disturbance regimes
- Carbon implications?

Wildfires and climate change push low-elevation forests across a critical climate threshold for tree regeneration

Kimberley T. Davis[a,1], Solomon Z. Dobrowski[b], Philip E. Higuera[a], Zachary A. Holden[c], Thomas T. Veblen[d], Monica T. Rother[d,e], Sean A. Parks[f], Anna Sala[g], and Marco P. Maneta[h]

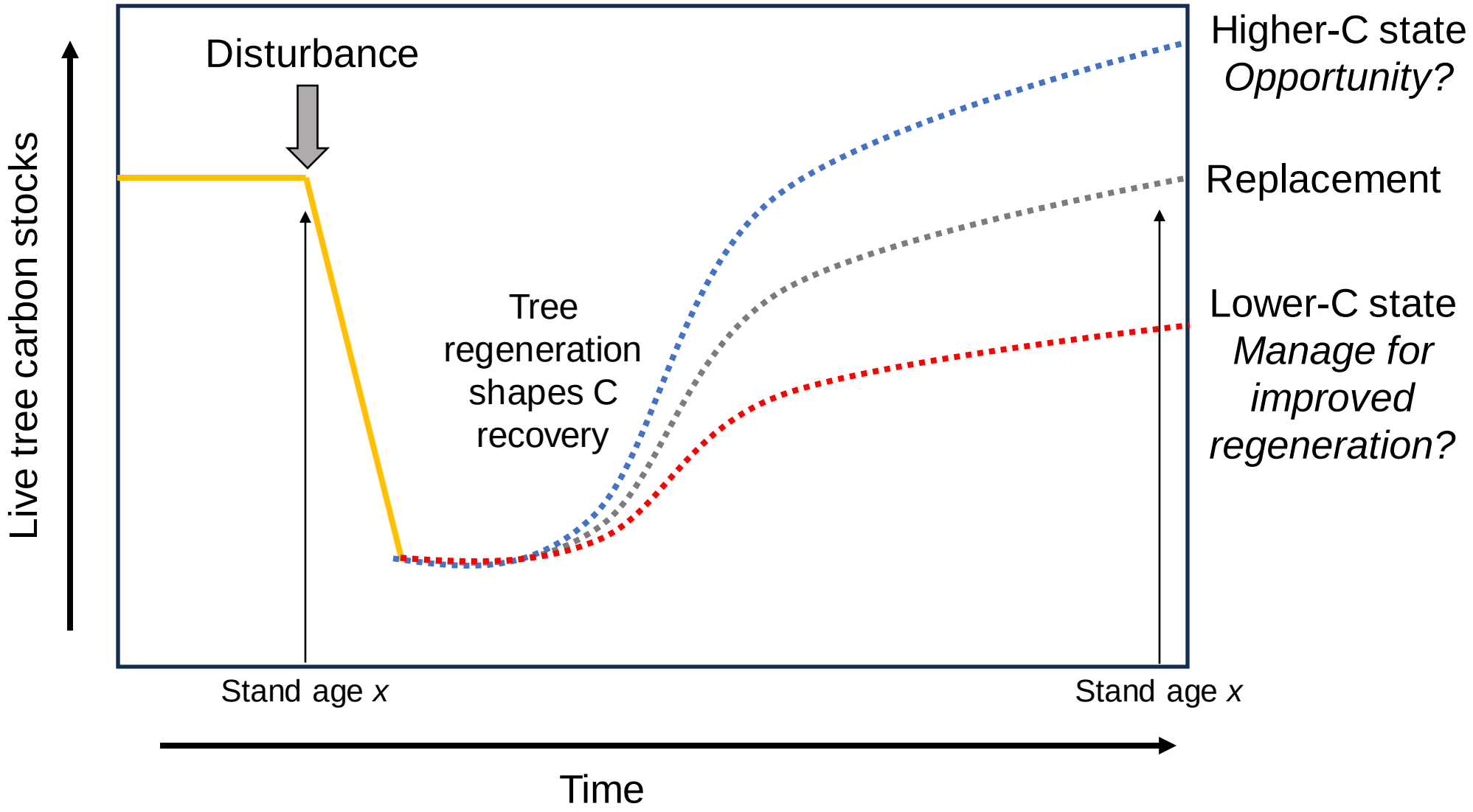
RESEARCH ARTICLE

Journal of Applied Ecology

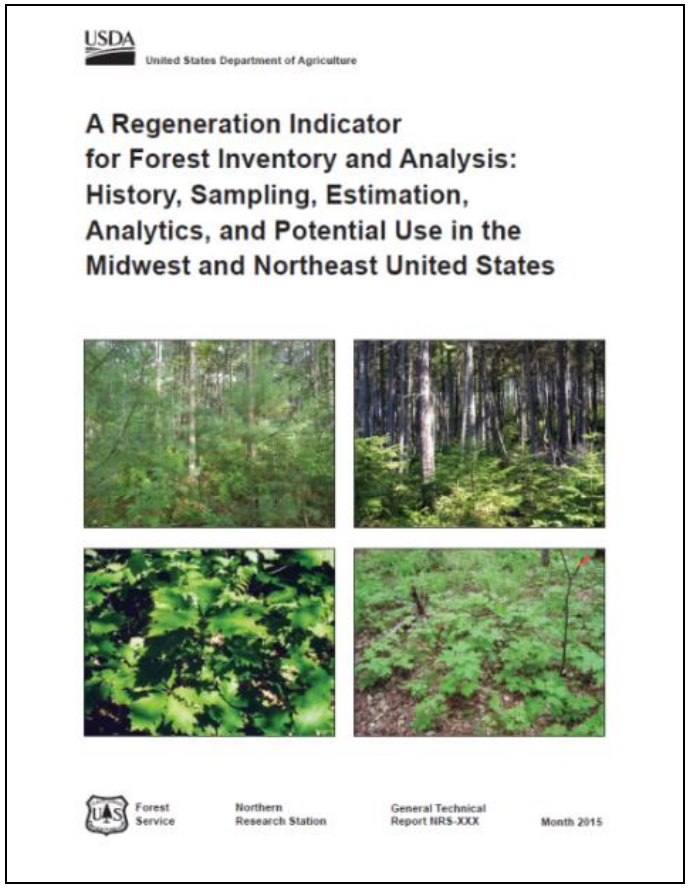
Compounding human stressors cause major regeneration debt in over half of eastern US forests

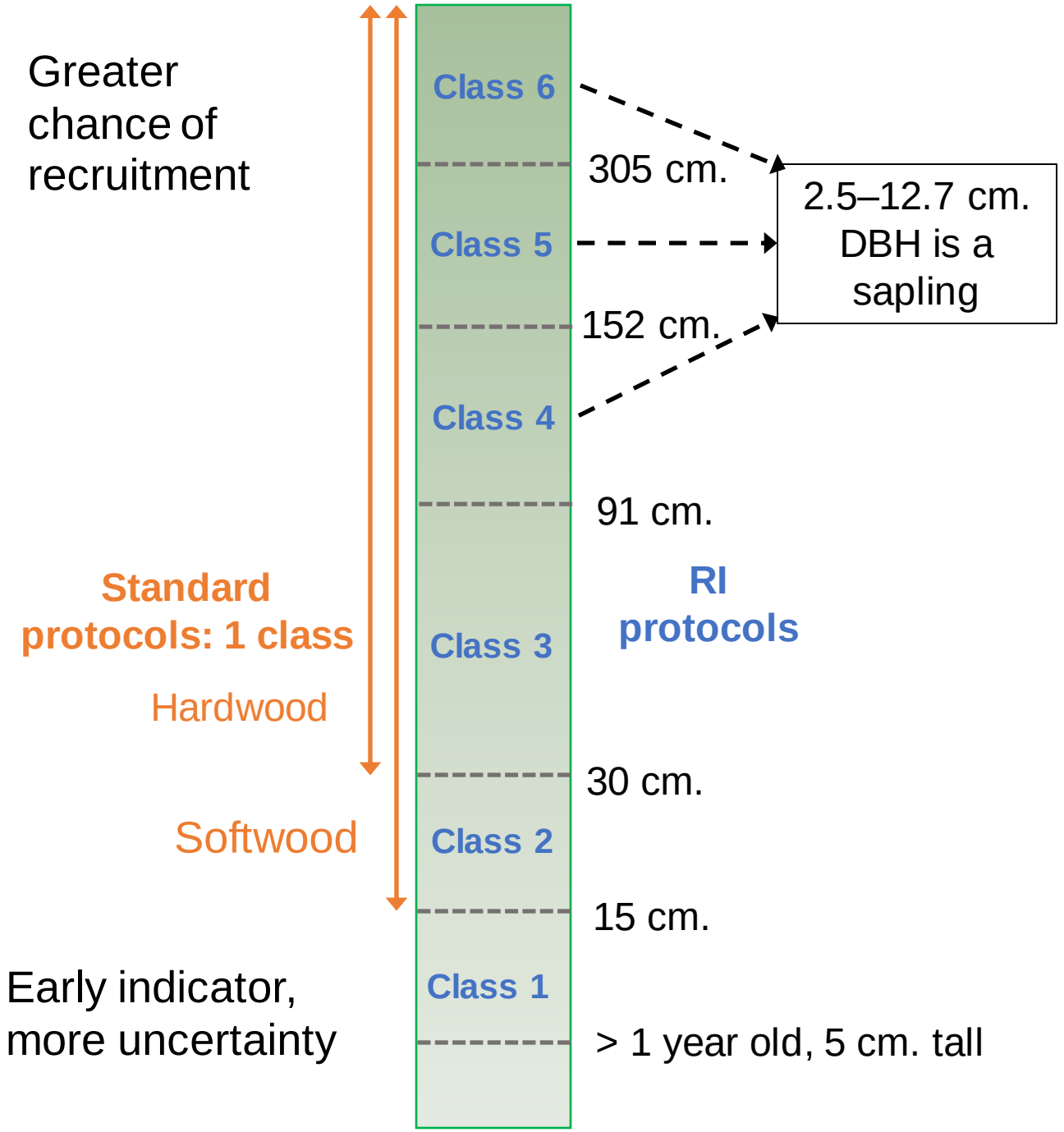
Kathryn M. Miller[1,2] | Brian J. McGill[2]

Resilience and carbon replacement

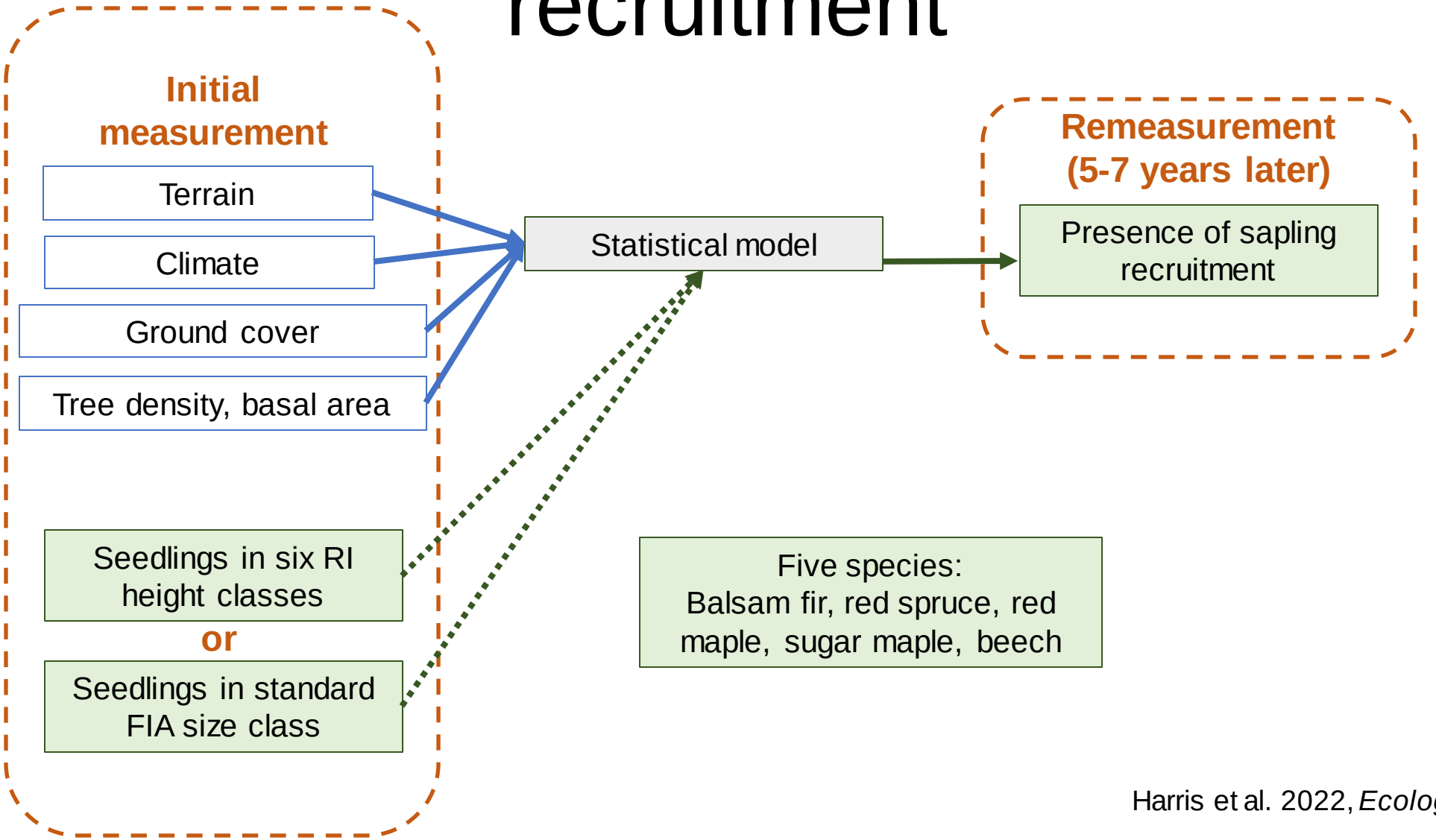


FIA's Regeneration Indicator





One approach: Predict sapling recruitment



Harris et al. 2022, *Ecological Indicators*

Regeneration and C trajectories

- Stand-based models widely used to model change in C stocks over time
  - But, regeneration is either represented coarsely or needs to be specified manually (case in point: FVS)
  - Regeneration = a major uncertainty in predicting C trajectories

Contents lists available at SciVerse ScienceDirect

Ecological Modelling

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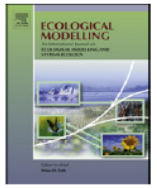


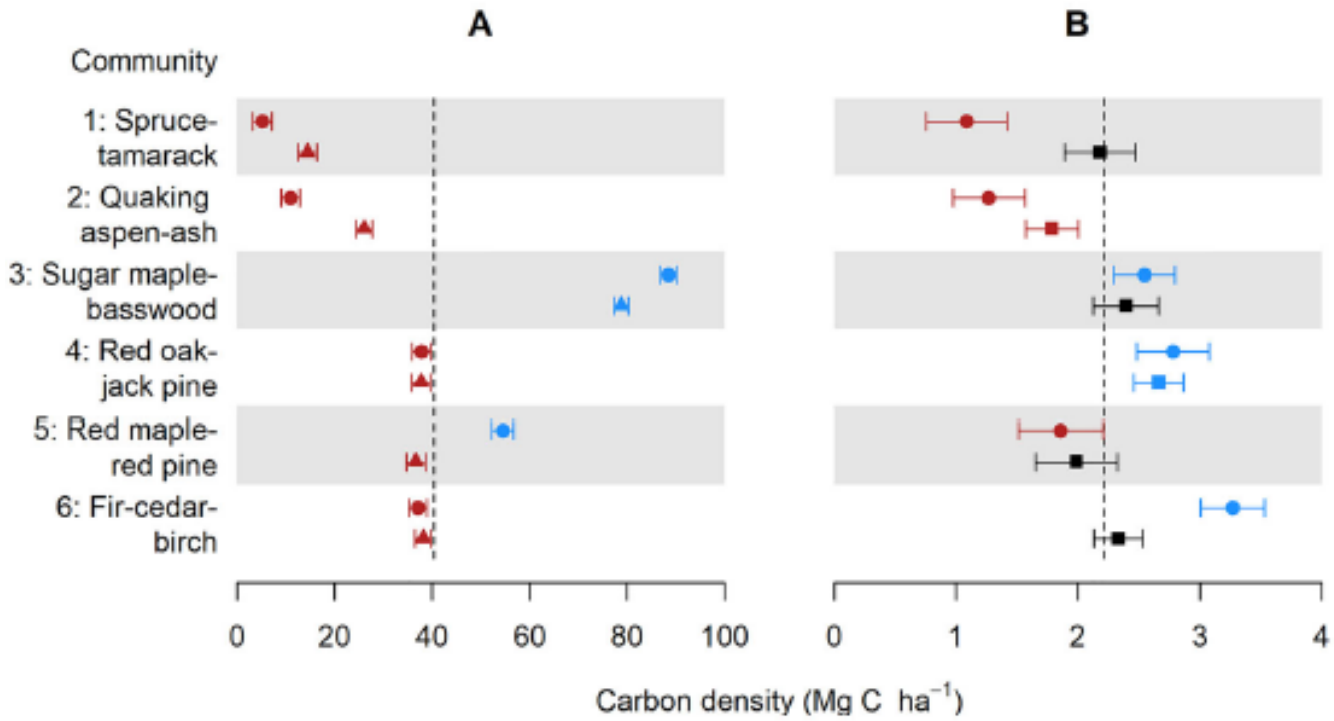
Filling the gap: A compositional gap regeneration model for managed northern hardwood forests

James D.A. Millington[a,*], Michael B. Walters[b,c], Megan S. Matonis[d], Jianguo Liu[b]

[a] Department of Geography, King's College London, Strand, London WC2R 2LS, UK
[b] Center for Systems Integration and Sustainability, Department of Fisheries and Wildlife, Michigan State University, USA
[c] Department of Forestry, Michigan State University, USA
[d] Department of Forest and Rangeland Stewardship, Colorado State University, USA

C and tree species composition

- Surprisingly little empirical work on:
  1) How species composition affects C stocks/sequestration
  2) What regeneration composition implies for future C stocks



Ecosystems
https://doi.org/10.1007/s10021-022-00765-6

ECOSYSTEMS

Shifting Forests and Carbon: Linking Community Composition and Aboveground Carbon Attributes

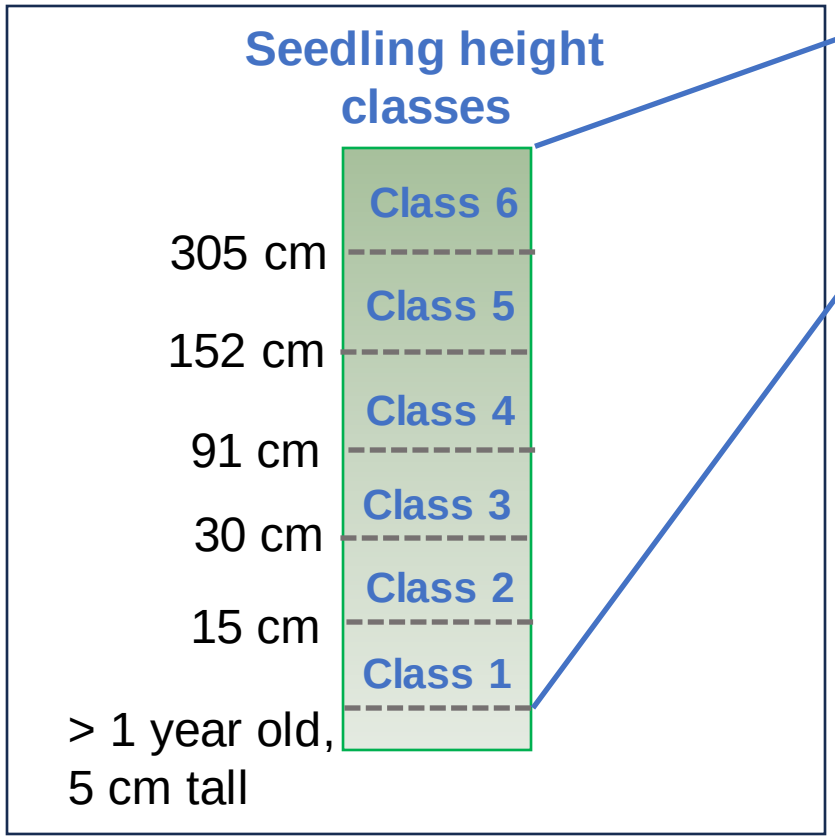
Jonathan Knott,[1]* Grant Domke,[1] Christopher Woodall,[2] Brian Walters,[1] Michael Jenkins,[3] and Songlin Fei[3]

Circles = trees
Triangles = seedlings

Goals

- Explore carbon replacement concept using FIA's Regeneration Indicator
  - What do seedlings suggest about future forest C across the northern US?
  - Under what conditions (forest type, physiographic and geographic setting) do seedlings suggest greater vs. lesser C stocks?

Approach



Sapling recruitment models (Harris et al. 2022)
Sapling: 2.5–12.6 cm diameter at breast height

Probability of sapling recruitment by species

Live tree C by species

Ordination
Representing species composition

Other factors
Including stand age, physiography, geography

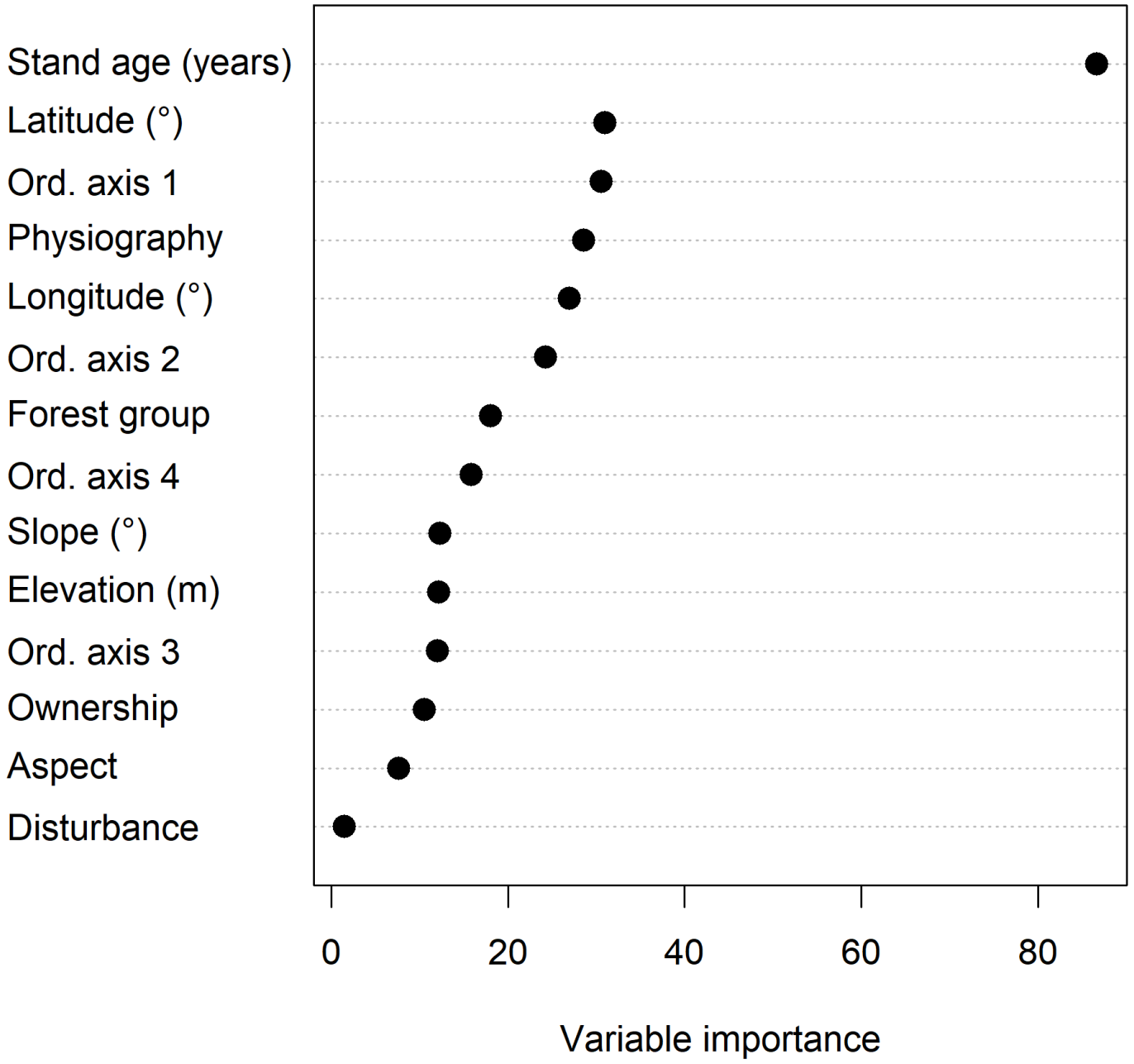
Models of live tree C and total tree C

Difference in predicted C stocks from seedling vs. tree composition
Over a sequence of stand ages

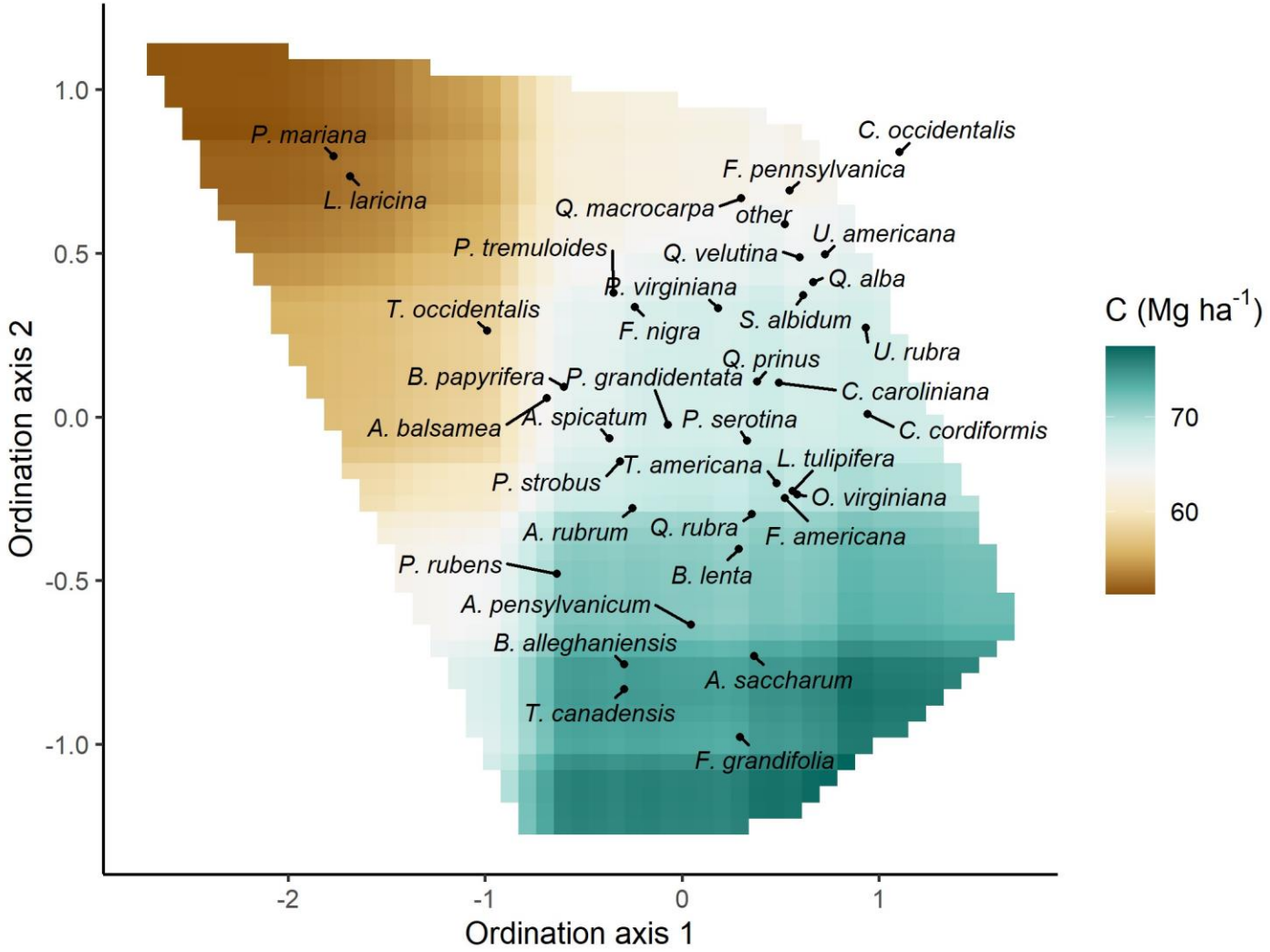
Within 5 Mg C ha-1: replacement
Seedlings imply greater C: gain
Trees imply greater C: loss
Under what conditions is C replacement potential better and worse?

Predicting C stocks

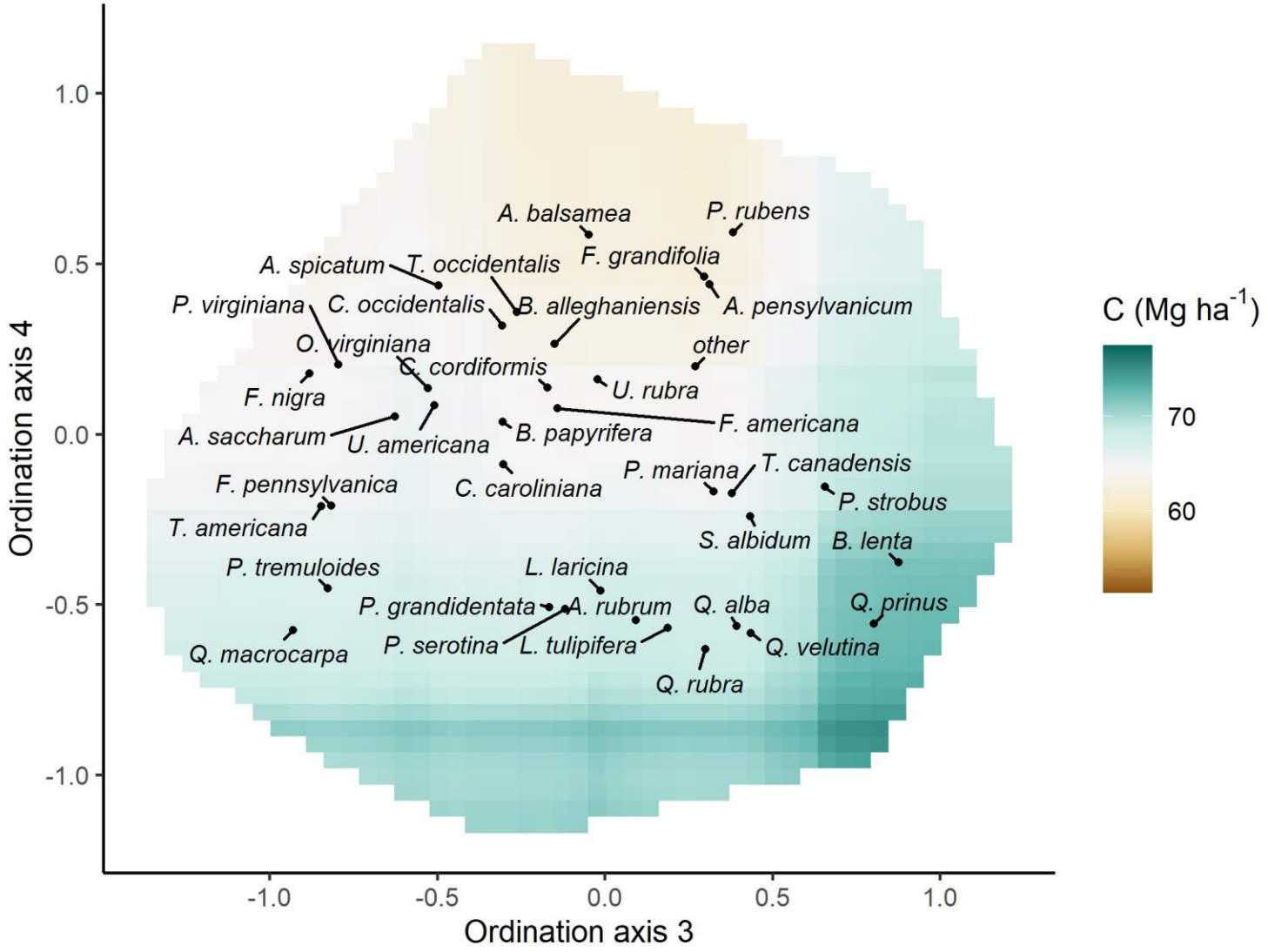
- Species composition (ordination axis scores) was important
- Models of live tree C and total C (live trees, snags and downed woody material) highly similar
  - Live C: 42% variance explained
  - Total C: 37%



Species composition and carbon

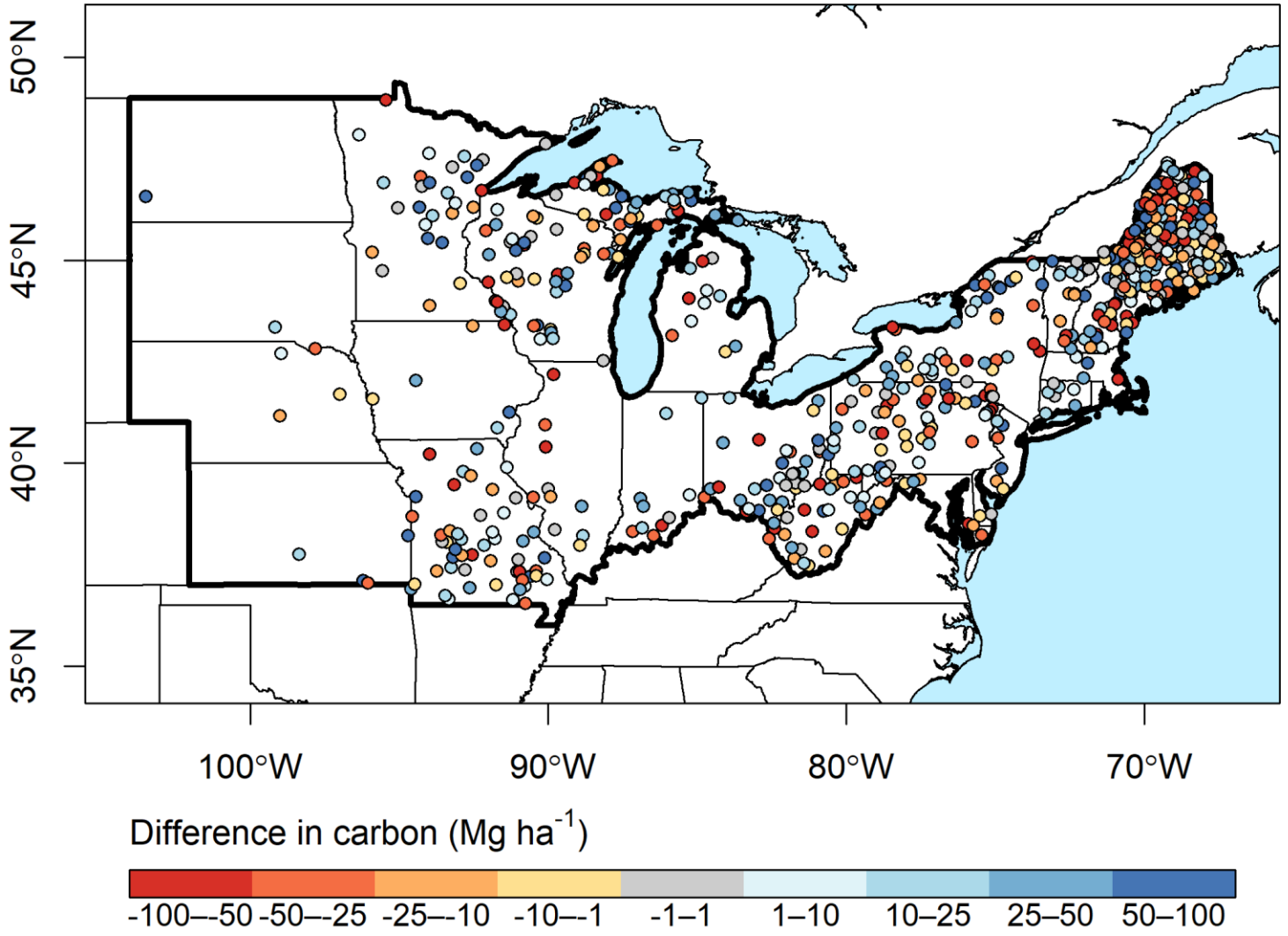


Species composition and carbon (part 2)



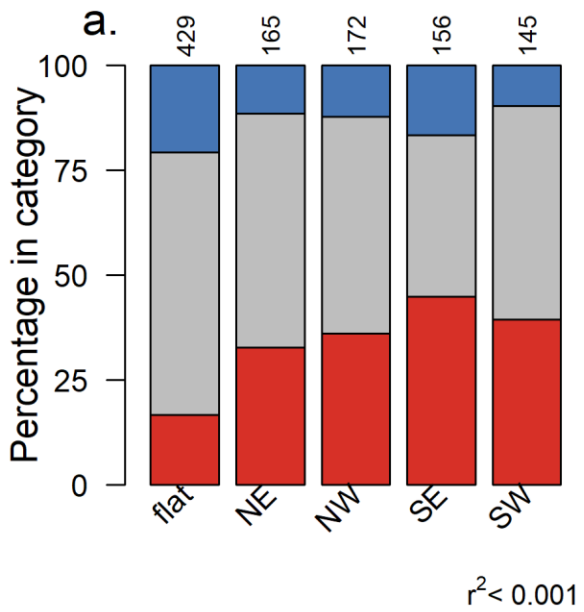
Seedlings and C stocks

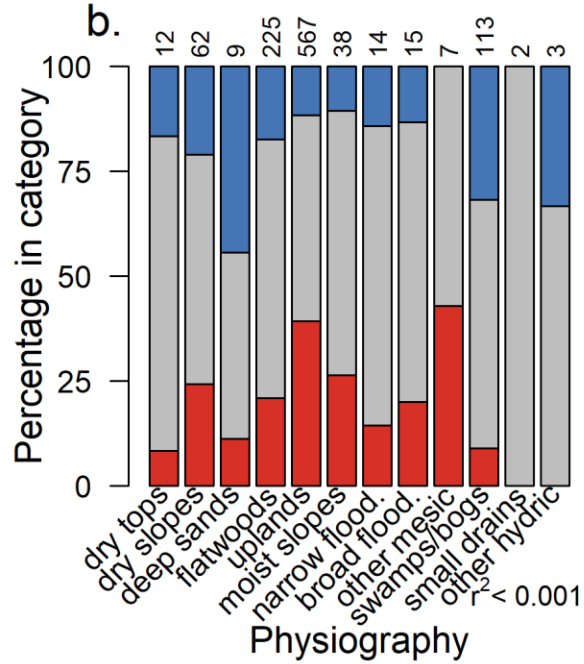
- Predict C stocks at 100 years based on tree vs. seedling composition
- Blues (reds): seedlings imply greater (lesser) C stocks

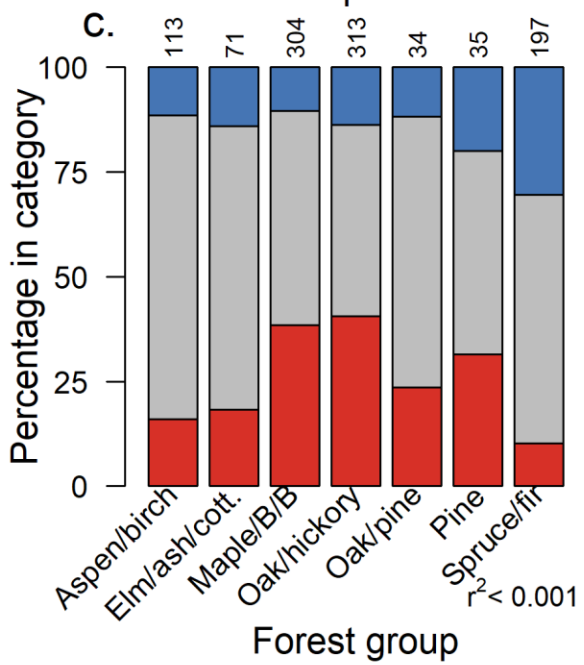


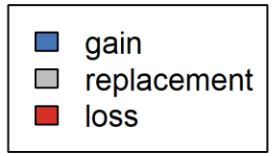
Effects on C replacement

- Outlook is worst in maple/beech/birch and oak/hickory, best in spruce/fir
- C loss more likely in uplands and on hillslopes



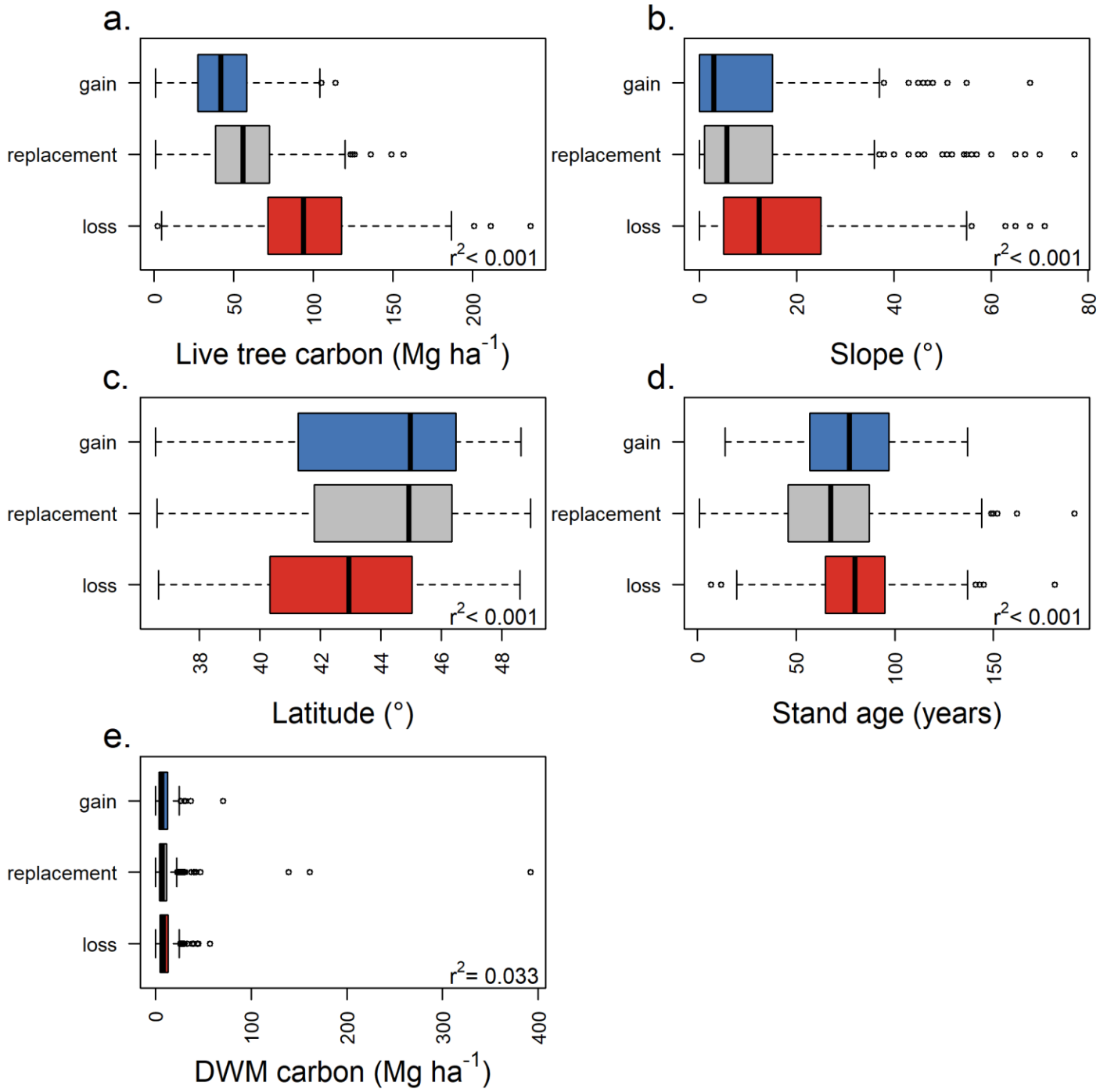






Effects on C replacement

- Plots standing to lose C based on seedlings:
  - Steeper slopes
  - Farther south
  - Stands currently with greater C stocks



C replacement: interpretation

- Poor C replacement prospects in oak/hickory and maple/beech/birch
  - Each has long-discussed problems with regeneration
  - Shifts away from sugar maple and oaks would reduce C stocks
- Tradeoffs between C and other values
  - What is good for C, may be bad from an ecological perspective

Conclusions

- “C replacement” is a useful way to look at regeneration patterns
- Improved regeneration assessments can guide management
  - Where and how to manage for improved natural regeneration?
  - Where does tree planting have the greatest benefit?
- These methods are not limited to assessing C
  - Could examine resilience to climate change, functional traits, and more

Thank you!

- FIA program and field crews
- Department of Interior Northeast and Midwest Climate Adaptation Science Centers
- Jonathan Knott and Melissa Pastore