Technische Universität München

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Directing structural development can improve the functional response diversity of forests to climate change in northeastern North America

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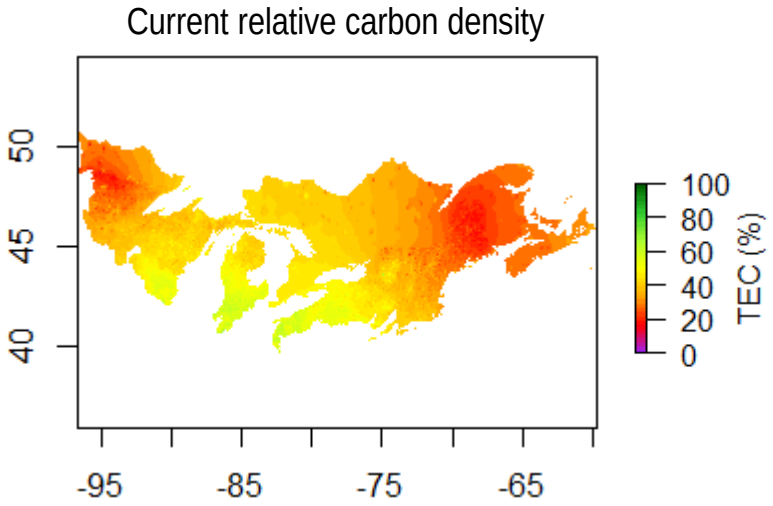
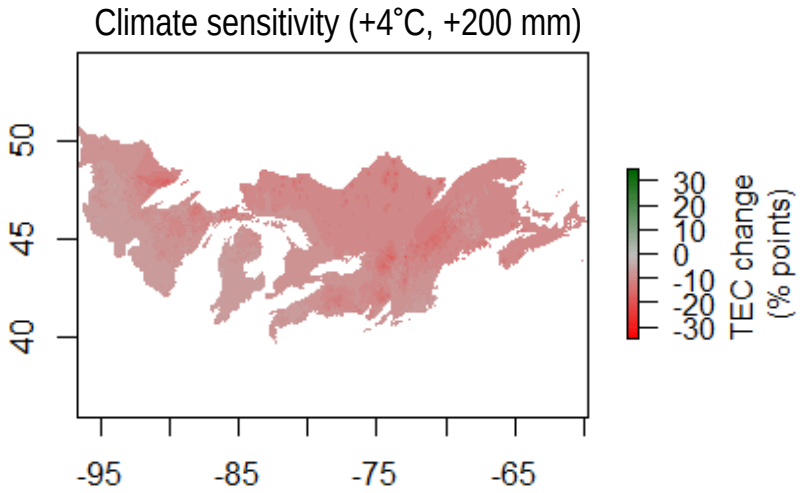
Decreasing ecosystem services supply

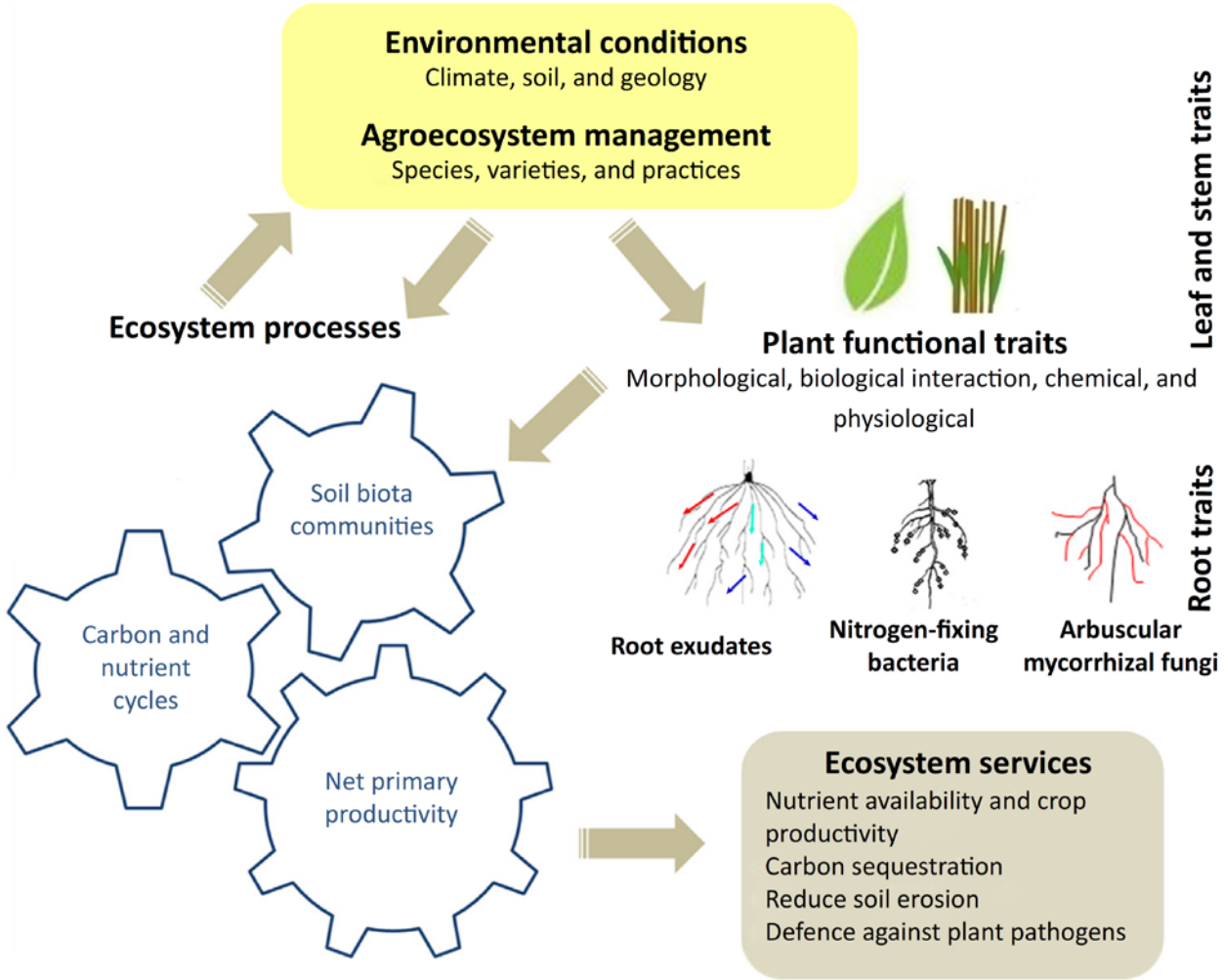




Climate change challenges the objectives of forest management in northeastern North America

Thom et al. (2019)

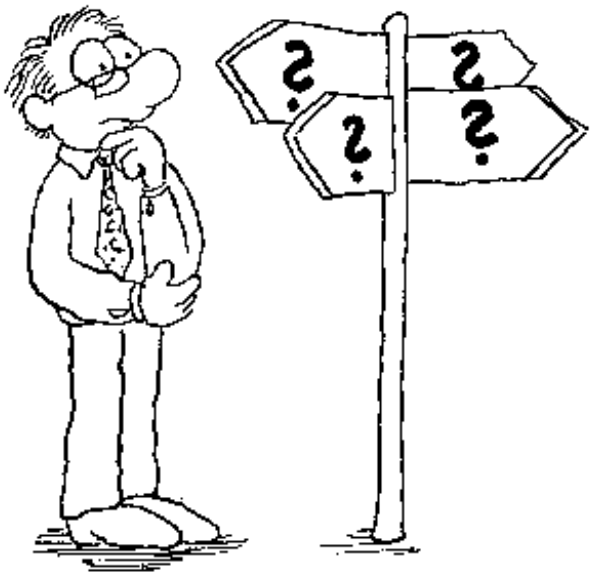
Ecosystem response depends on functional trait diversity



Faucon et al. (2017)

Challenges for forest management

- Increasing functional diversity is a promising, yet not well-understood strategy to increase adaptive capacity
  - Which regions are poor in functional diversity?
  - What drives functional diversity?
  - How sensitive is functional diversity to climate change?



Objectives

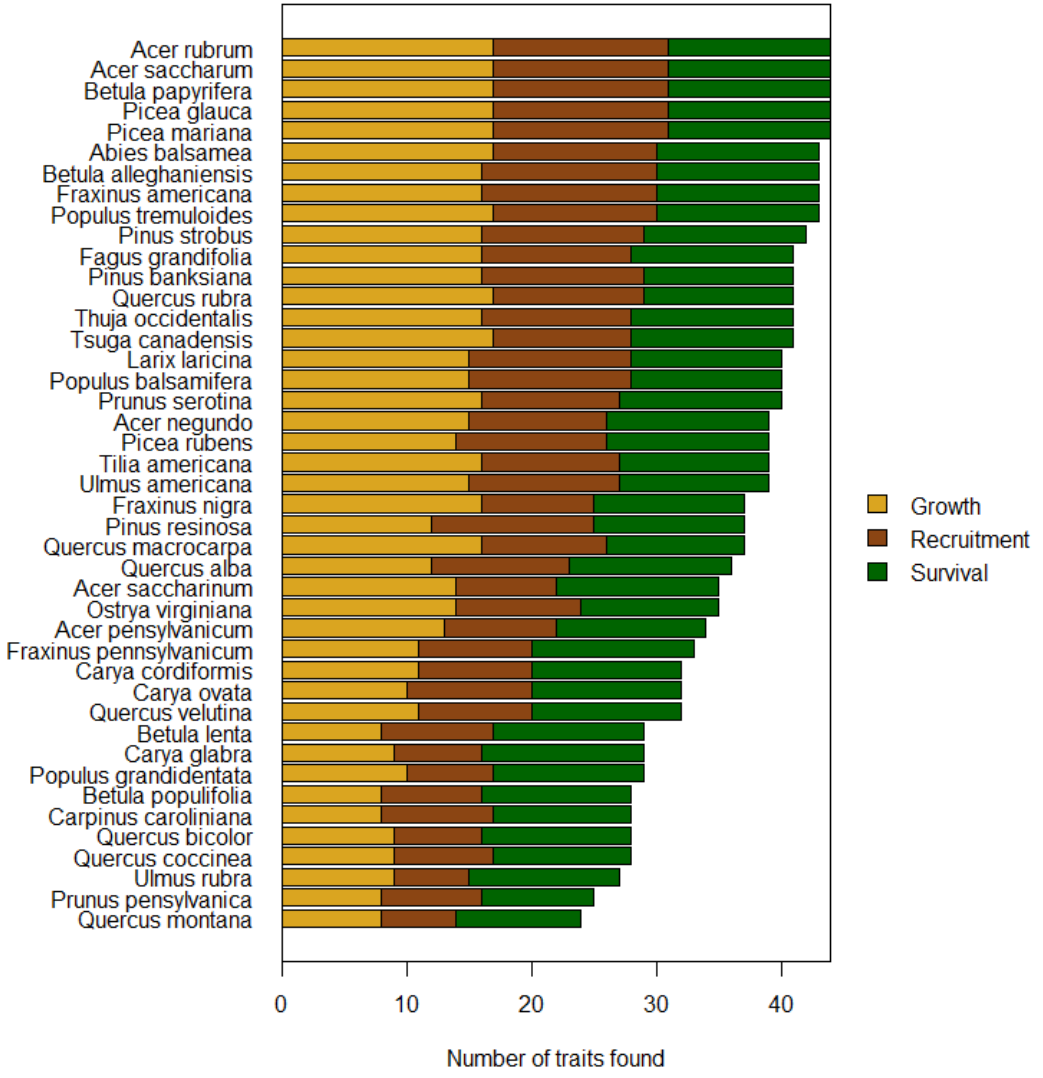
1. Map the current functional trait diversity distribution throughout northeastern North America

2. Analyze the functional diversity drivers

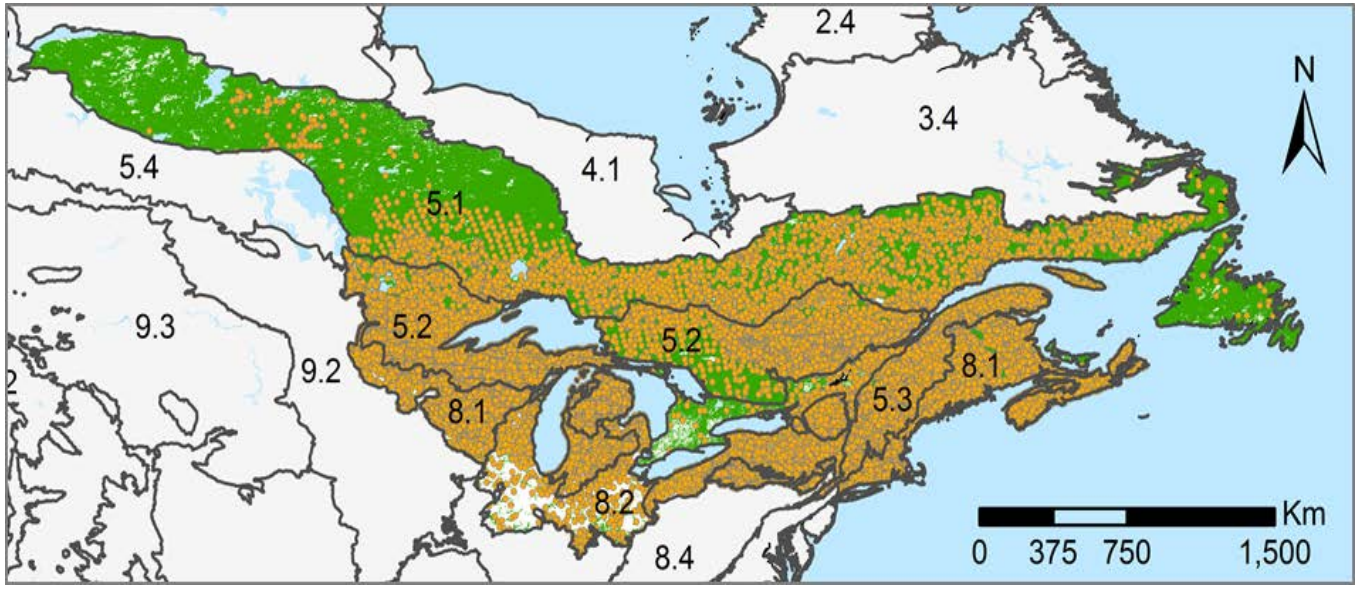
3. Test the sensitivity of functional diversity to projected increases in temperature and precipitation

Functional trait data

- Literature and database review for growth, recruitment, and survival traits
- In total 1570 traits of 43 NE North American tree species found



Community data and drivers



- Five boreal and temperate ecoregions with ca. 2.8 Mio km² forest cover
- > 48,000 permanent sample plots
- 25 explanatory variables related to forest structure, climate, topography, soils, and stewardship

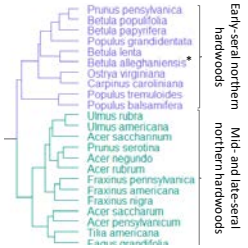
Functional diversity analysis

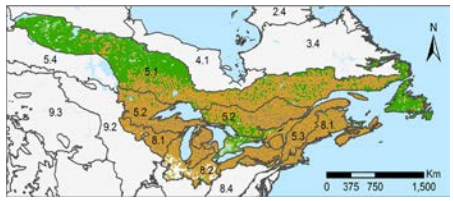
Functional distance of tree species

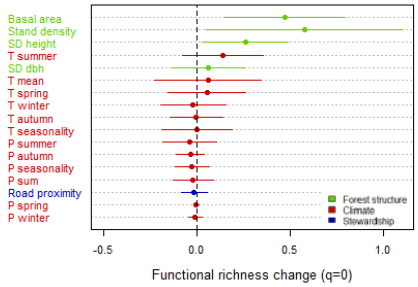
Functional diversity at each inventory plot

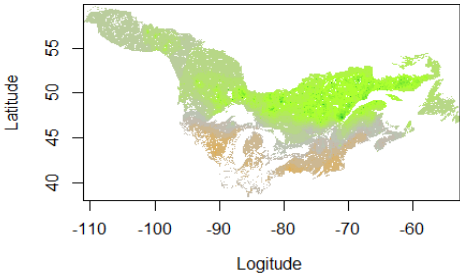
90 non-parametric models to test functional diversity drivers

Climate sensitivity analysis (+4°C, +200mm)



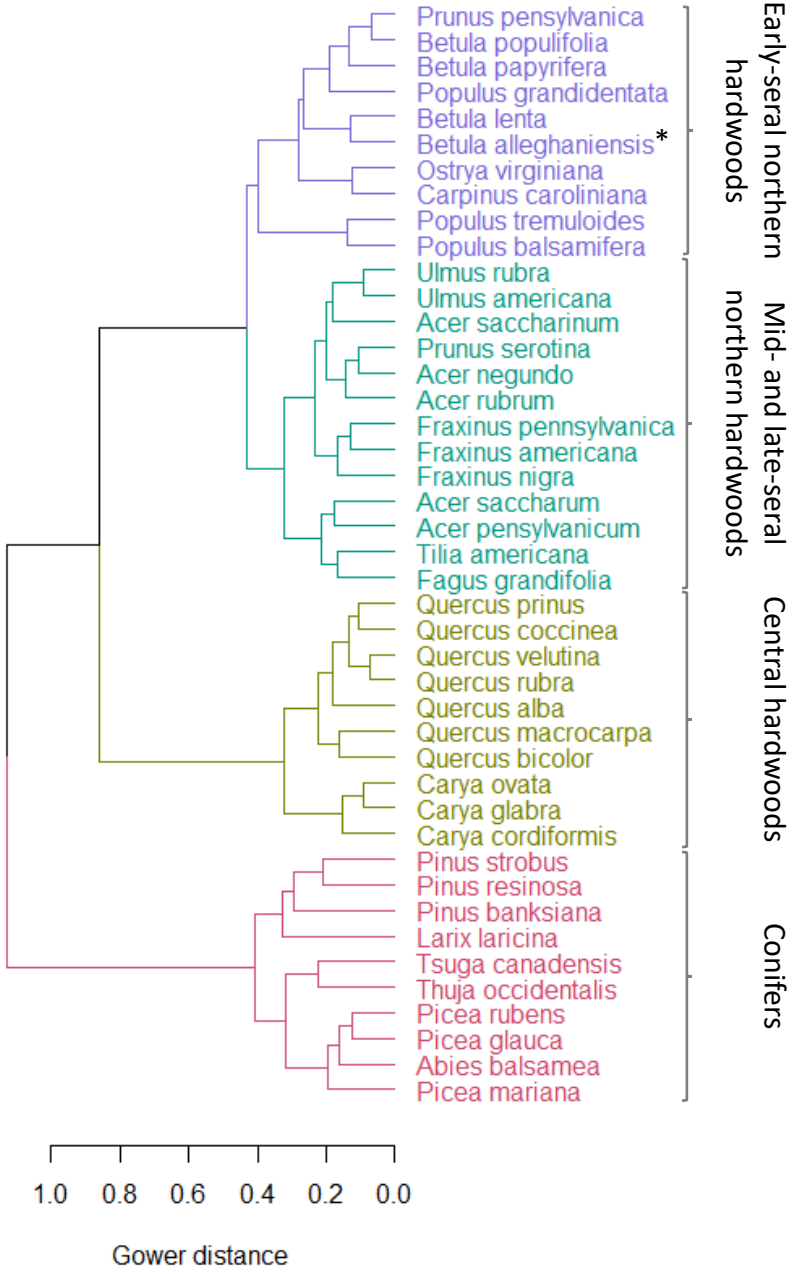






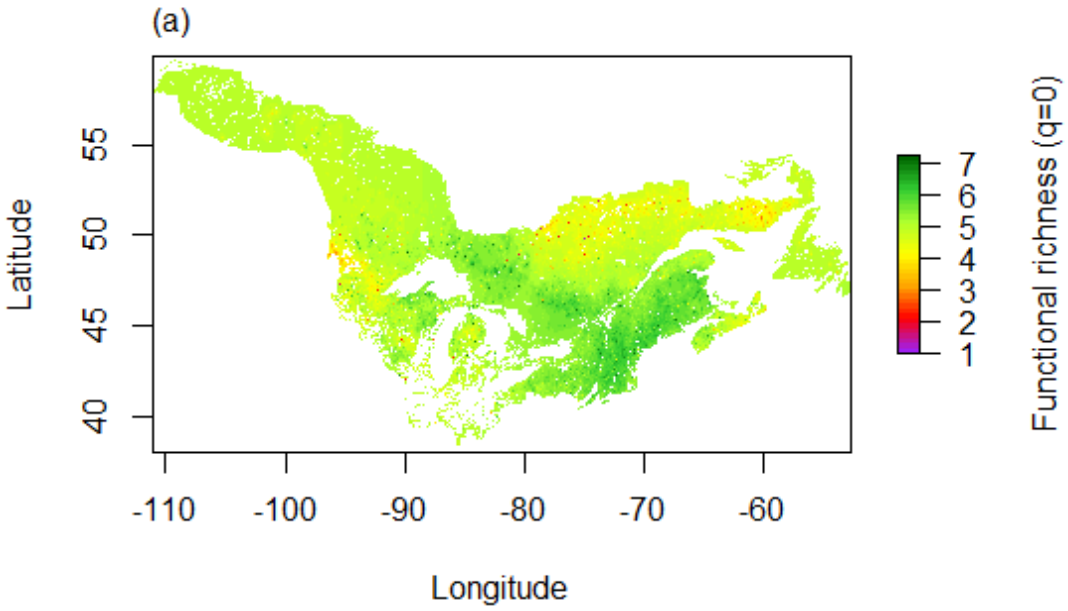
Functional distance among tree species of northeastern North America

- Four distinct functional groups:
  - (i) early-seral northern hardwoods
  - (ii) mid- and late-seral northern hardwoods
  - (iii) central hardwoods
  - (iv) conifers
- Biggest difference between northern hardwoods and conifers

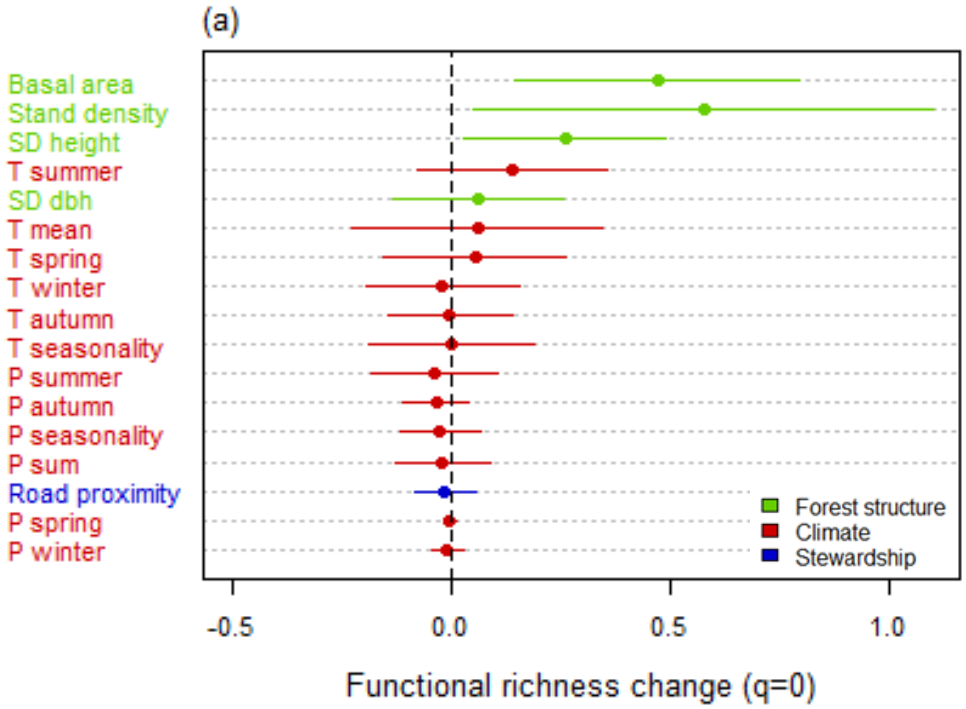


Functional diversity distributions

- Highest functional diversity in temperature forests and the ecotone east and northeast of the Great Lakes
- Low functional diversity northeastern boreal forest and the ecotone west of the Great Lakes

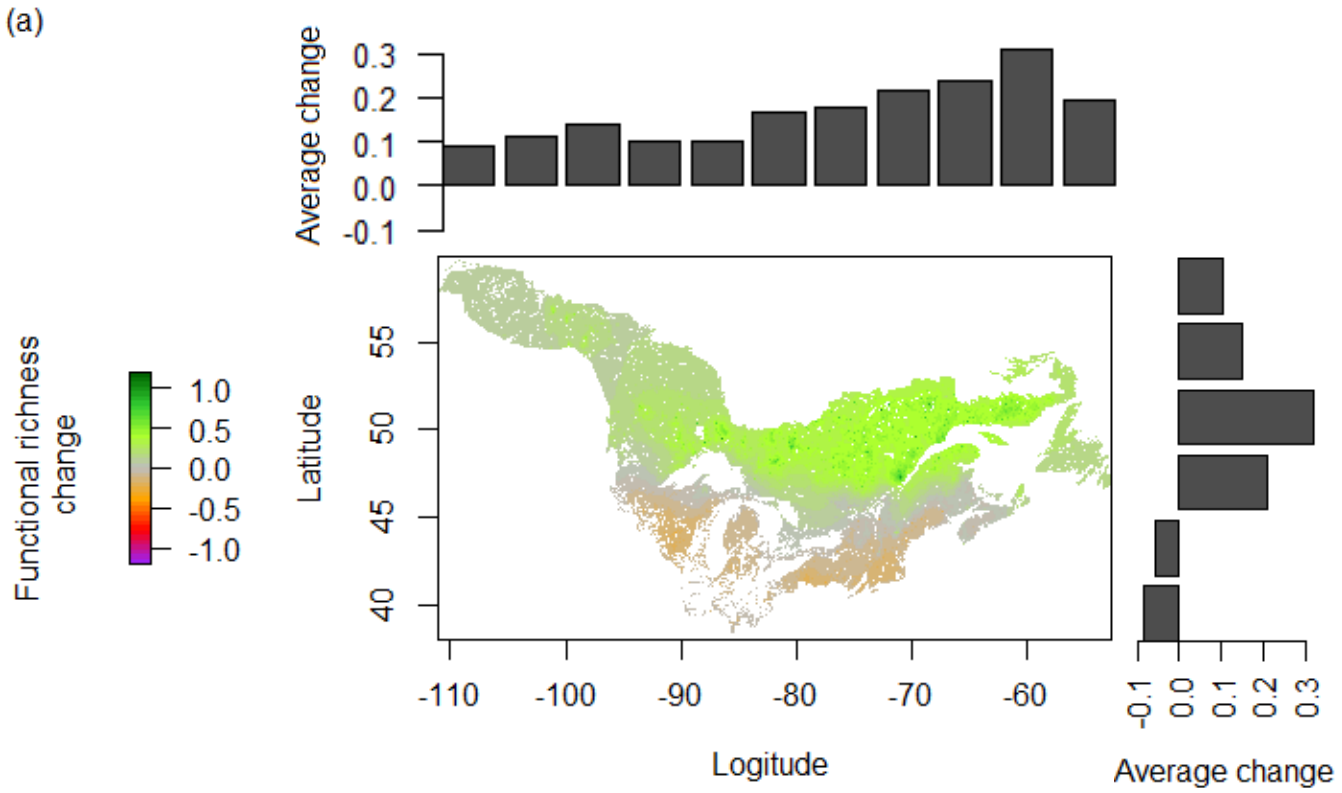


Functional diversity drivers



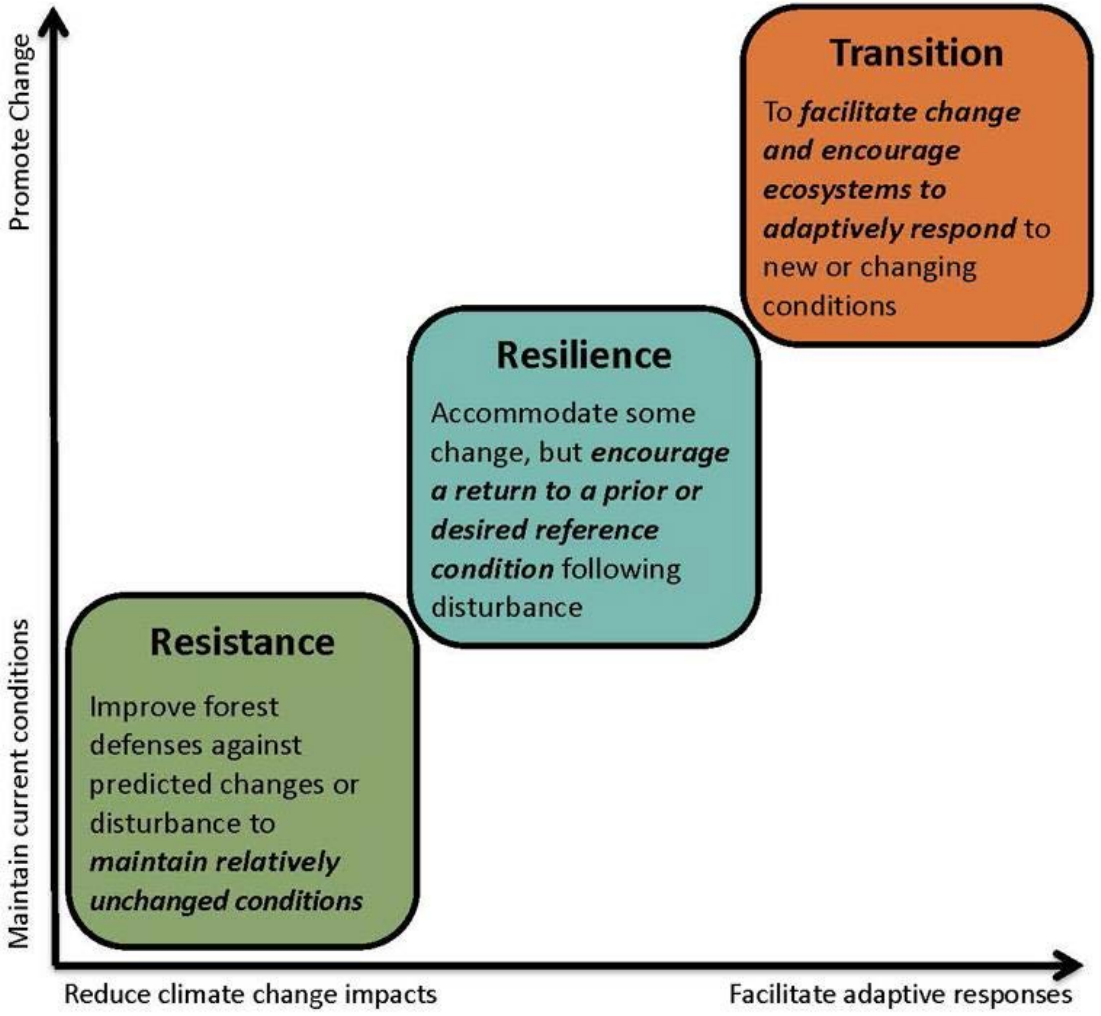
- Strong positive association between functional diversity and forest structure
- Climate of secondary importance with varying positive and negative responses

Climate sensitivity



- Increasing functional diversity in boreal forests
- Decreasing functional diversity in temperate forests

Adaptive silviculture for climate change



Millar et al. (2007); https://www.adaptivesilviculture.org/

Adaptive silviculture based on functional traits

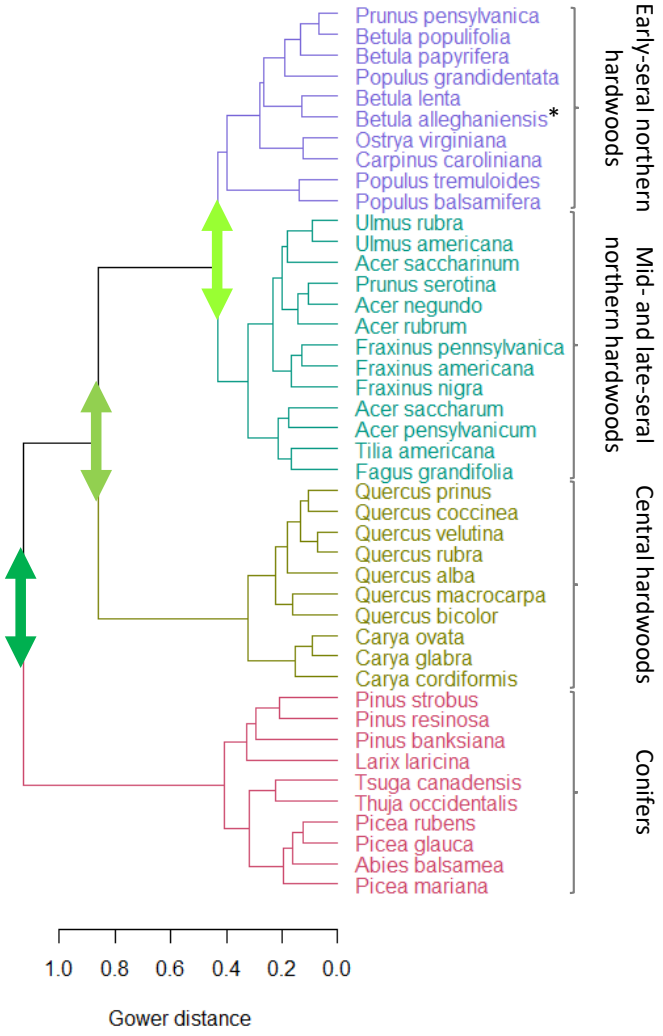
- Resistance: mixing species with high disturbance tolerance
  - Drought: Jack pine, Oaks, Hickories
  - Fire: Shagbark hickory, Balsam poplar, Quaking aspen
  - Wind: White Ash, Hickories, Scarlet oak
  - Biotic disturbances: American larch, Eastern white pine, White oak

- Resilience: mixing species with high recovery speed
  - Resprouting ability: Poplars, Cherries
  - Fast juvenile growth: Big toothed aspen, Sugar maple
  - Serotiny: Jack pine
  - Species with high photosynthesis rate under current and future conditions

- Transition
  - Assisted migration of species with better adapted traits

Mix species of different functional groups

- Different seral stages
- Northern and Central hardwoods
- Broadleaved and coniferous species



Foster structural diversity as surrogate for functional diversity

Complex forest structure provides niches for a diversity of species

Conclusions

- Forest structure is more important than climate for functional diversity
- Functional diversity is lowest in boreal forests and may decrease in temperate forests under climate change
- Directing structural development can improve the functional response diversity of forests to climate change in northeastern North America without requiring knowledge in functional ecology

Thank you!

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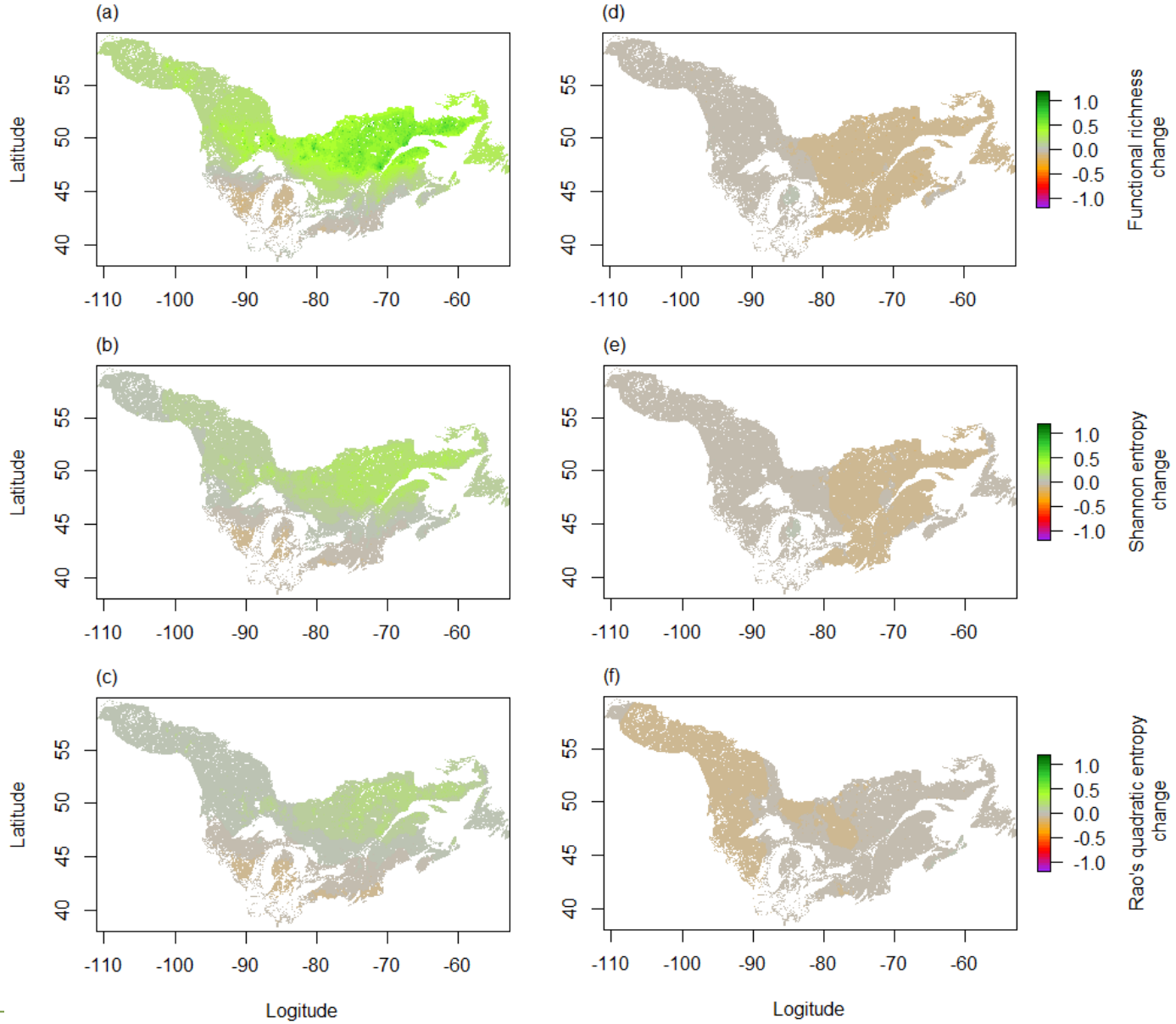
Climate sensitivity



Managing structural diversity as surrogate for functional diversity

- High basal area, concentrated on large trees
- Rich understory
- Variation in heights and diameter

→ e.g., irregular shelterwood systems, variable retention harvesting, modified group selection approaches