



Monitoring Tree Migration in the Eastern United States

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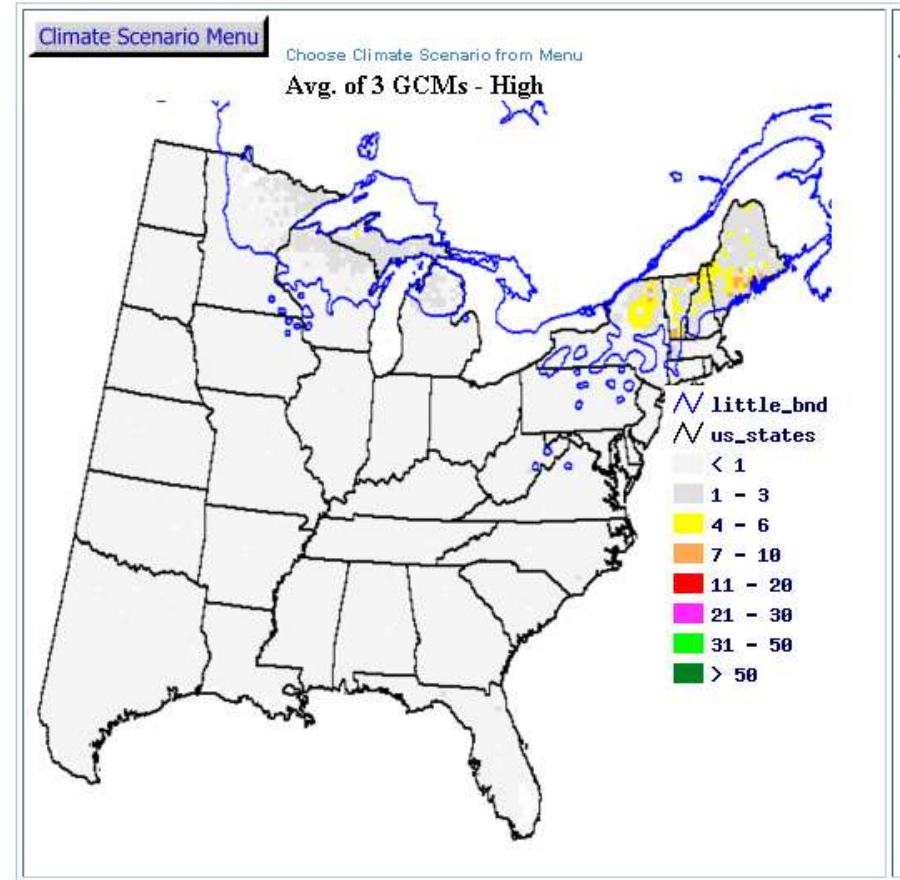
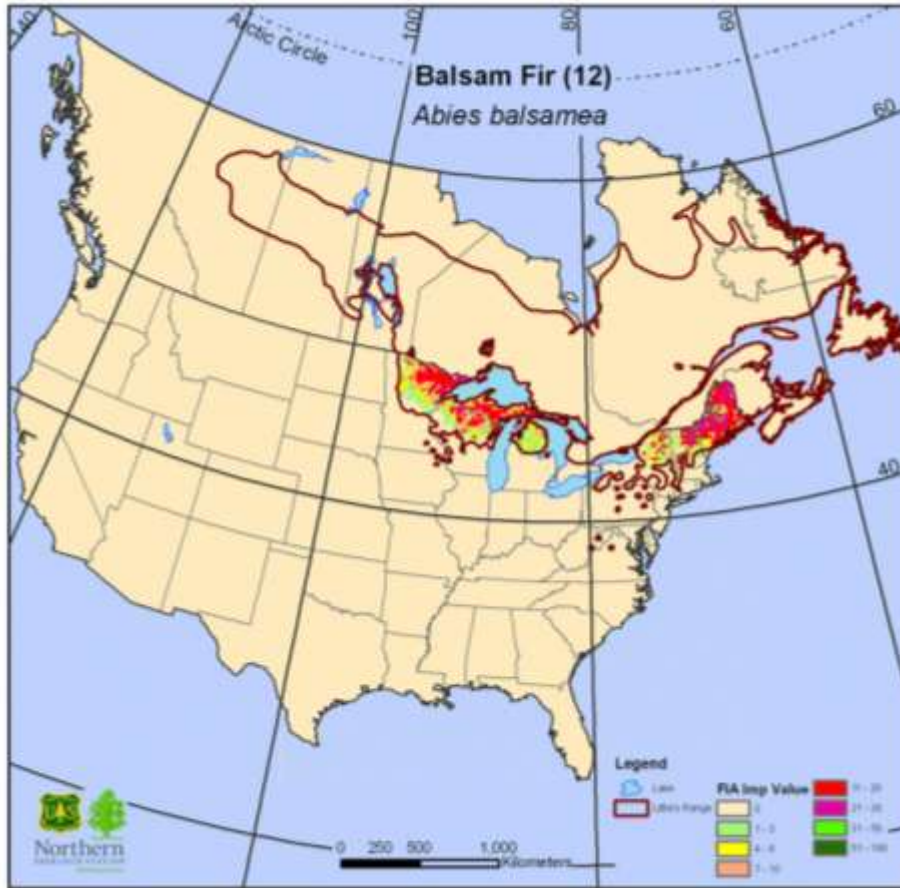


Climate Change Impacts to Forests

- Forest fires
- Pest outbreaks
- Floods/droughts
- Wind disturbances
- Lack of pollinators
- Tree species migration?



Tree Species Migration Simulations



<http://www.nrs.fs.fed.us/atlas/>

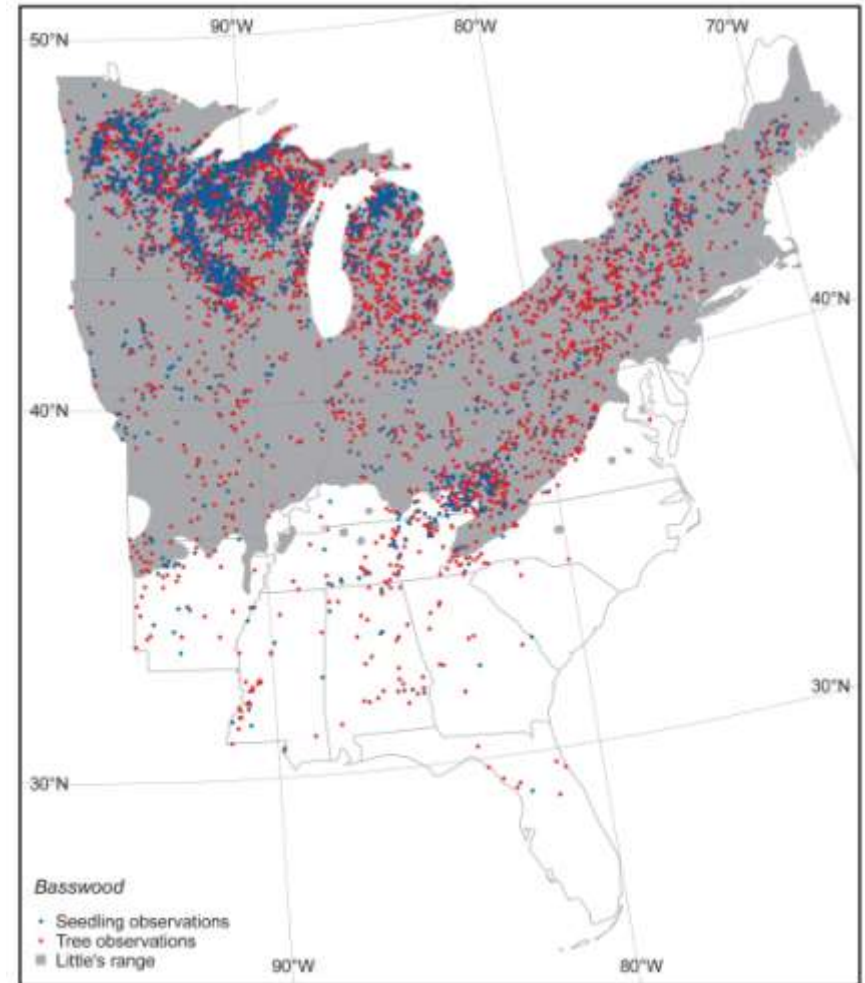
Can We Detect Tree Migration Now?



- Only Simulate Tree Migration
- Empirical Evidence?
- Forest Inventory since 1930's
- Can We Use 70+ years worth of inventories?

Forest Inventory Hurdles

- Prior to 1999 –
Periodic Inventories
- Different sample
designs by state by
year
- Post 1999 – Annual
Inventories



Basswood (*Tilia americana*)

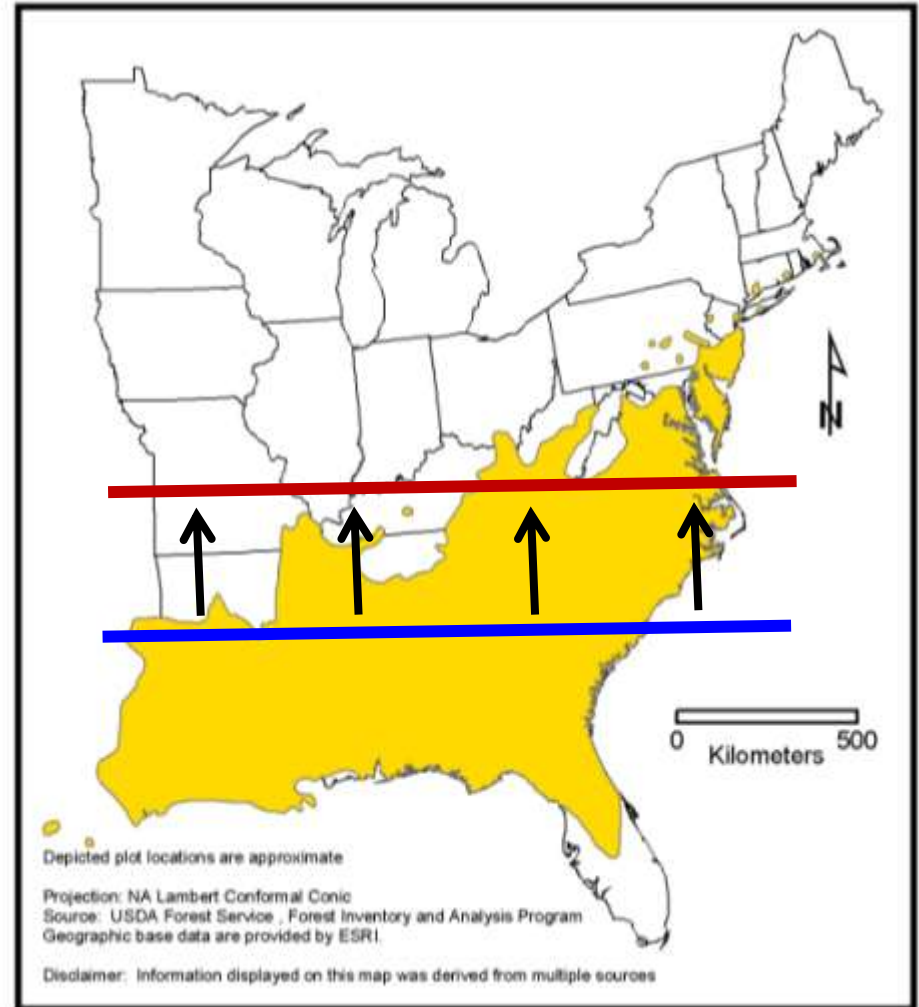
Tracking Tree Seedlings



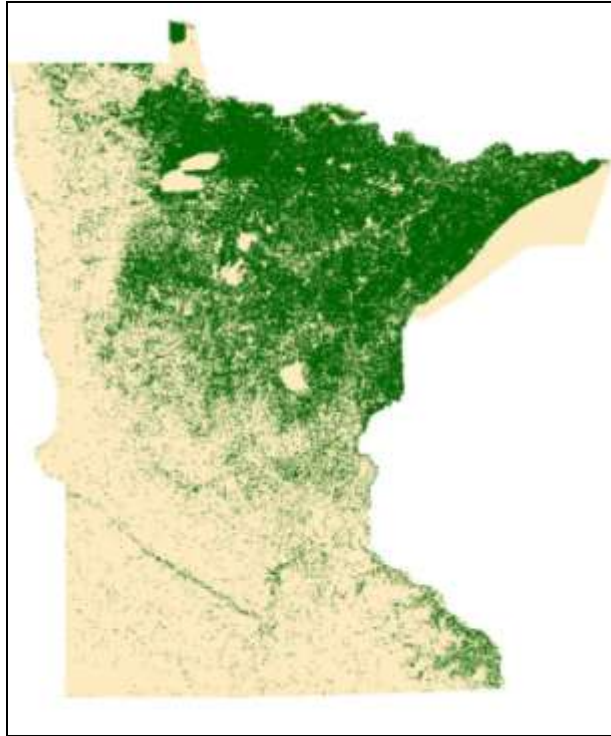
- Trees don't move
- Seedlings survive/die in different locations
- Seedlings may be indicators of climate change effects

Study Objectives

Compare locations/attributes of tree seedlings to tree biomass (d.b.h. > 2.54 cm) for dozens tree species in eastern United States



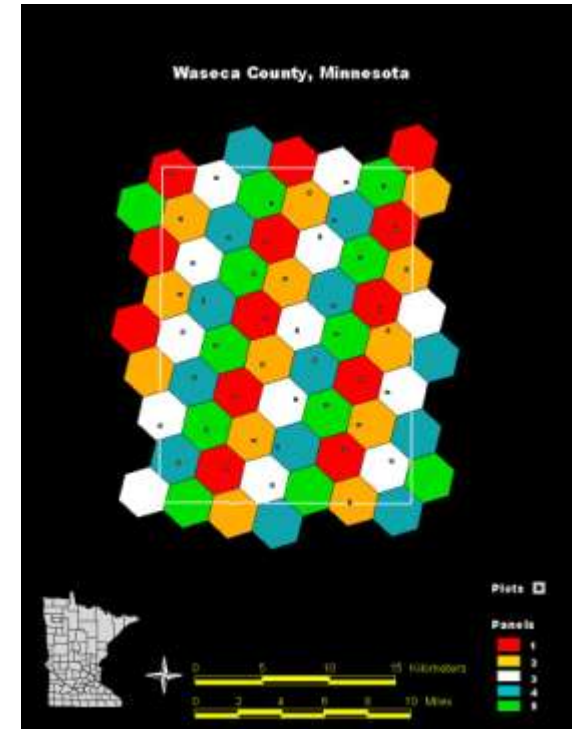
FIA Annual Inventory



Forest/Non-Forest



Inter-penetrating Panels



Sample 20 percent/year

Methods/Data

- 15 northern, 15 southern species, and 10 general species
- Sensitivity analysis: 50 species
- Over 65,000 observations
- Biomass = Mg/ha with d.b.h. $>$ 2.54 cm
- Seedlings = trees/ha with d.b.h. $<$ 2.54 cm

Methods/Data

Northern

Balsam Fir
Tamarack
Black Spruce
Red Pine
Northern White Cedar
Sugar Maple
Yellow Birch
Paper Birch
Black Ash
Balsam Poplar
Bigtooth Aspen
Quaking Aspen
Northern Pin Oak
Northern Red Oak
American Basswood

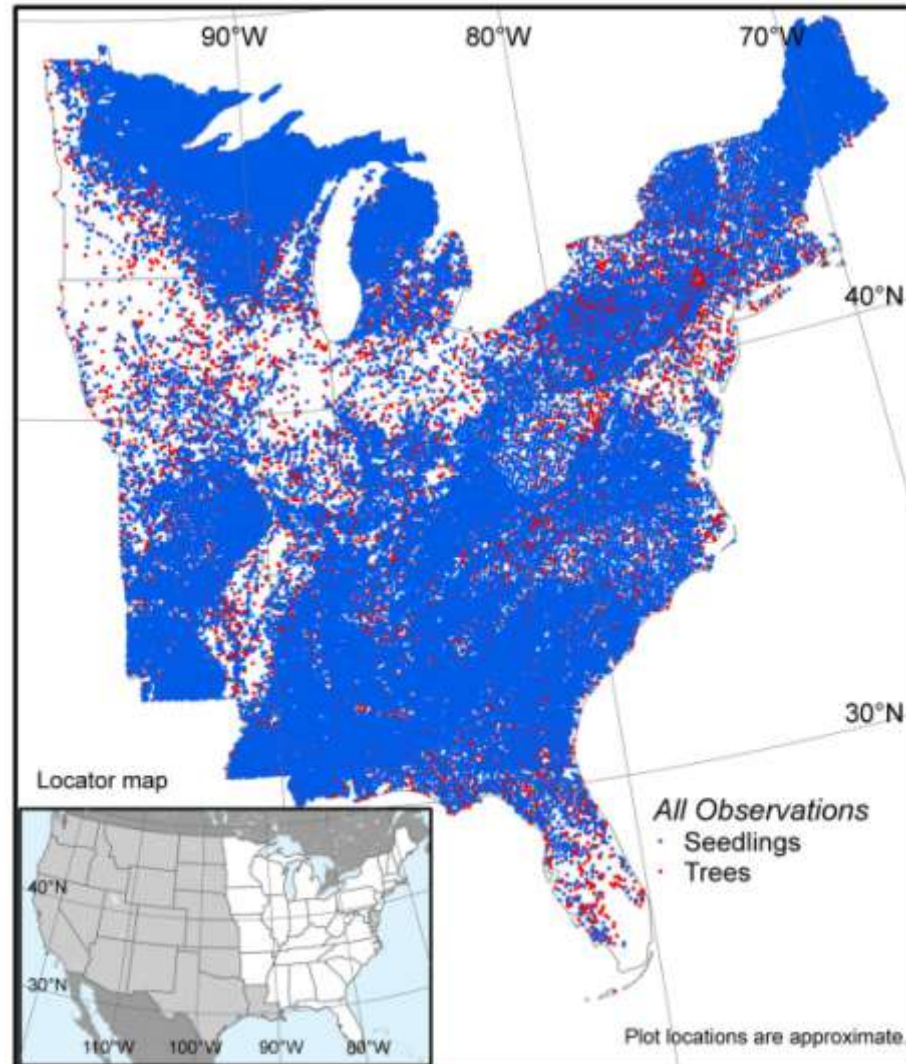
Southern

Shortleaf Pine
Slash Pine
Loblolly Pine
Baldcypress
Flowering Dogwood
American Holly
Sweetgum
Yellow-poplar
Southern Magnolia
Sweetbay
Southern Red Oak
Laurel Oak
Blackjack Oak
Post Oak
Sassafras

General

Eastern Redcedar
Eastern White Pine
Boxelder
Red Maple
Silver Maple
Bitternut Hickory
Green Ash
Eastern Hophornbeam
White Oak
American Elm

Methods/Data



Seedlings versus Biomass Mean Lats



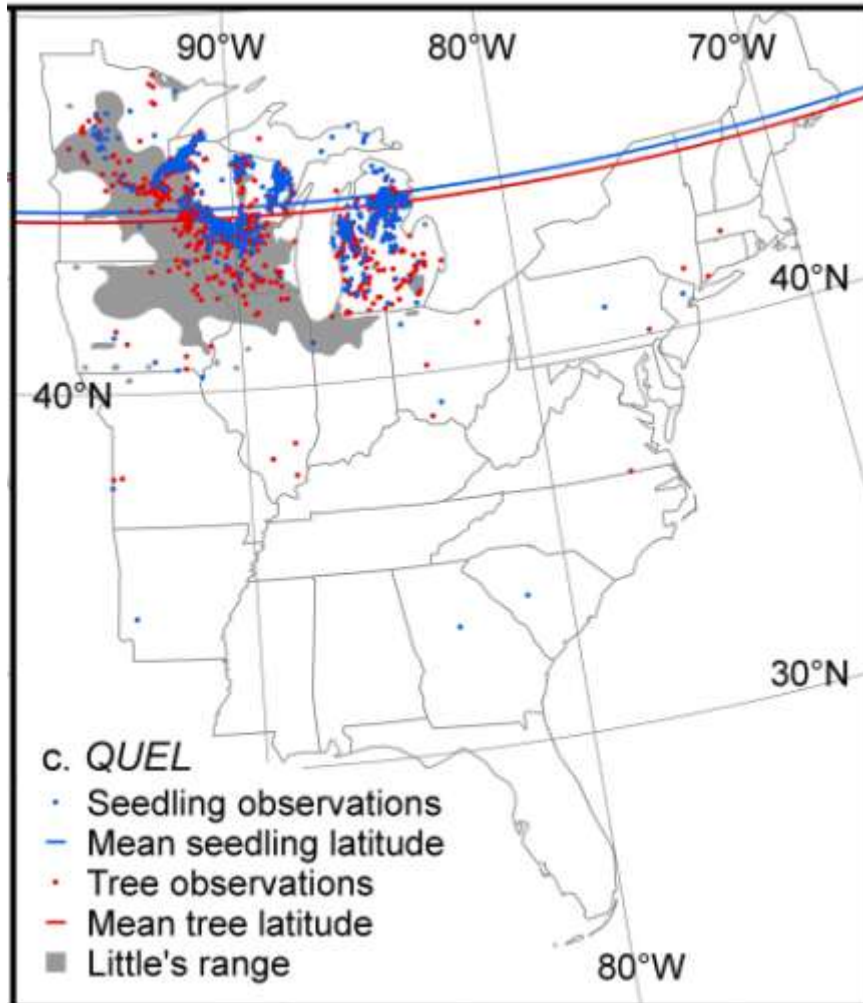
Versus



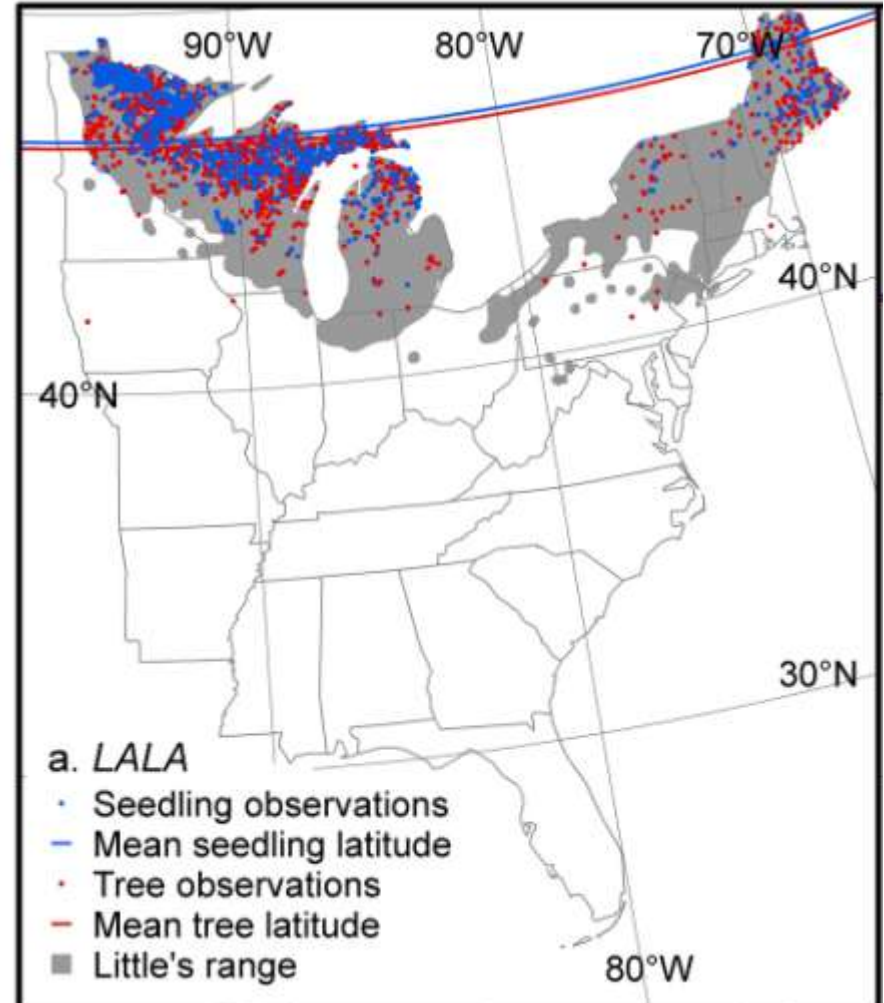
Seedlings versus Biomass Mean Lats

- Northern Species
 - 11 species shift north
 - 1 species shift south
 - 20 km shift north
- Southern Species
 - 5 species shift north
 - 6 species shift south
 - 3 km shift south
- General Species
 - 1 species shift north
 - 9 species shift south
 - 42 km shift south

Seedlings versus Biomass Mean Lats

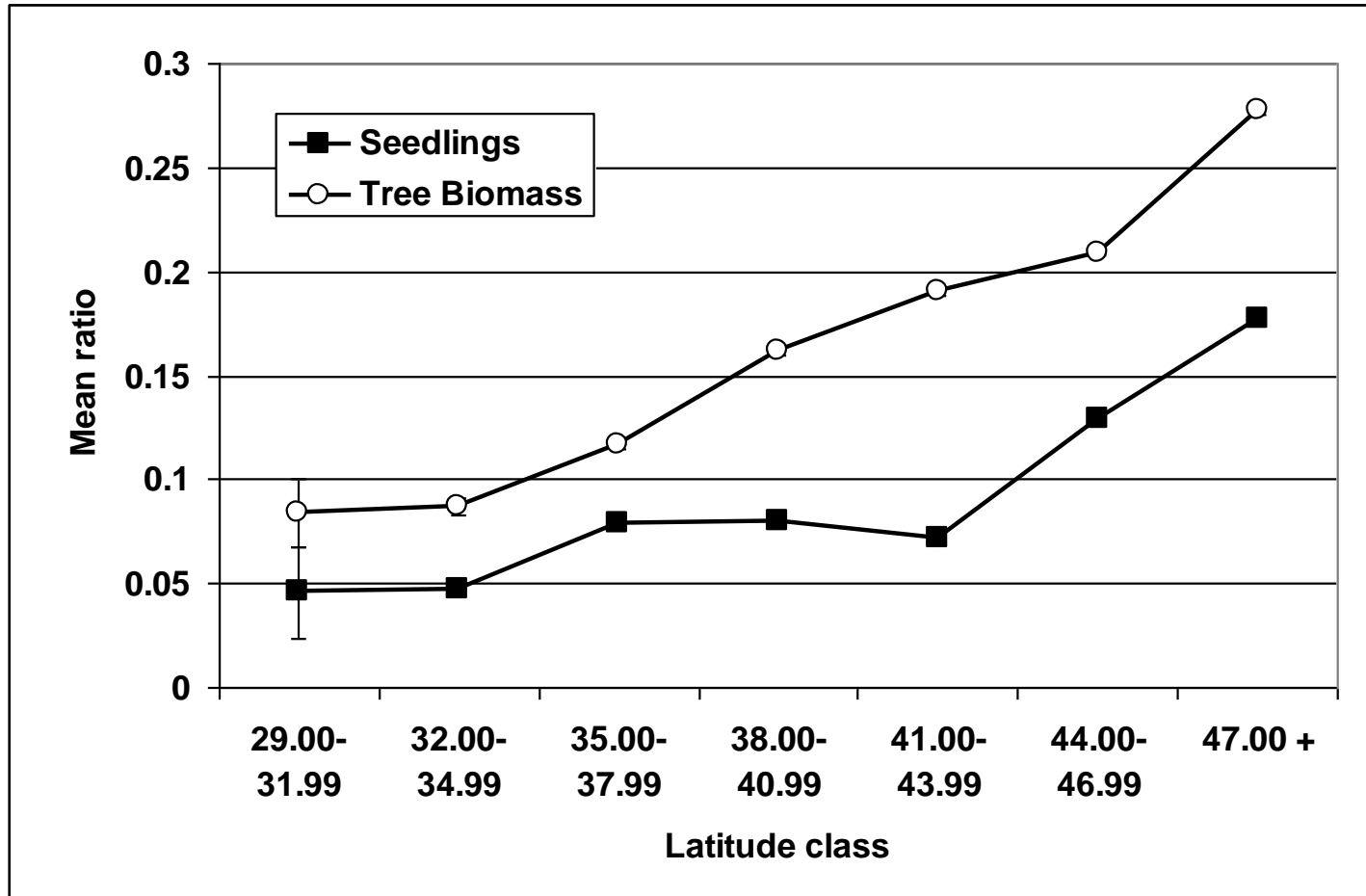


Northern Pin Oak (*Quercus ellipsoidalis*)



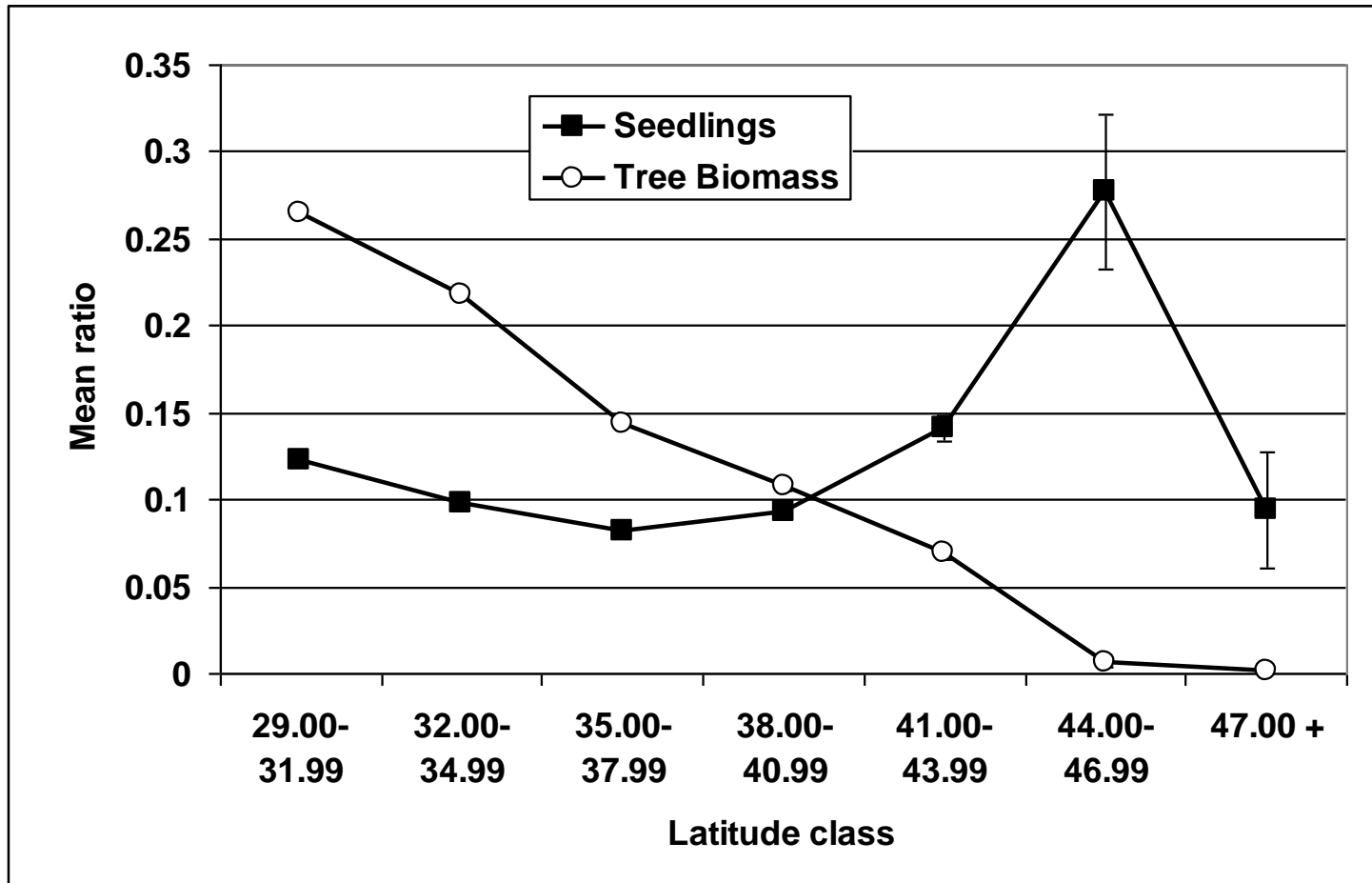
Tamarack (*Larix laricina*)

Ratios of Seedlings and Biomass



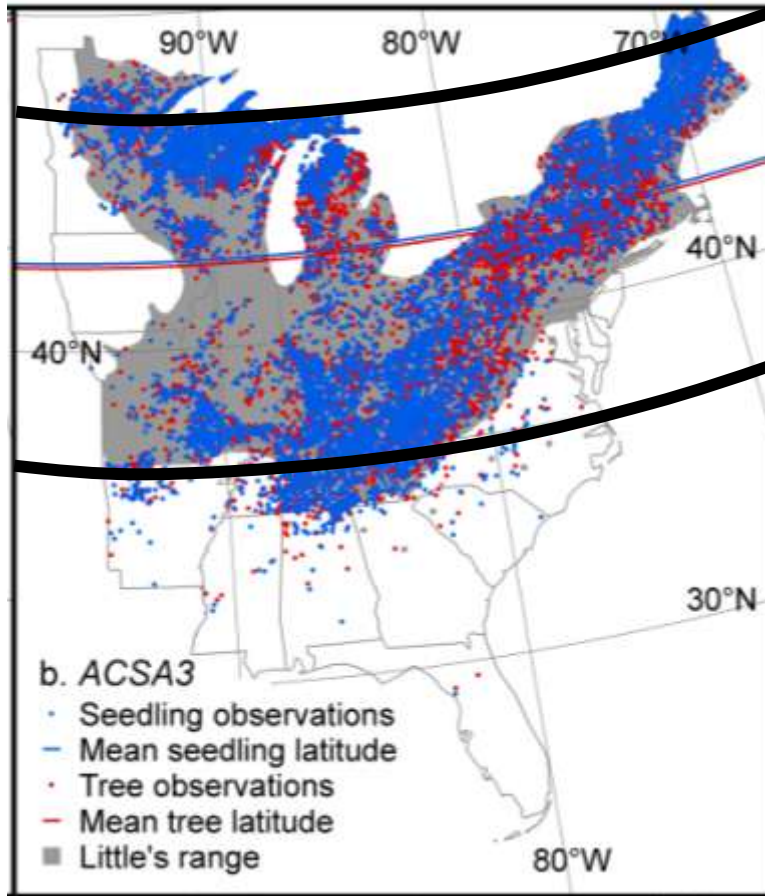
Northern

Ratios of Seedlings and Biomass



Southern

Outer Range Ratios



Sugar Maple (*Acer saccharum*)

90th and 10th
percentile of
tree biomass

Outer Range Ratios

- Northern Species
 - On average 3.5 x more seedlings relative to biomass above 90th latitude
- Southern and General Species
 - Ratios of biomass and seedlings similar in outer ranges

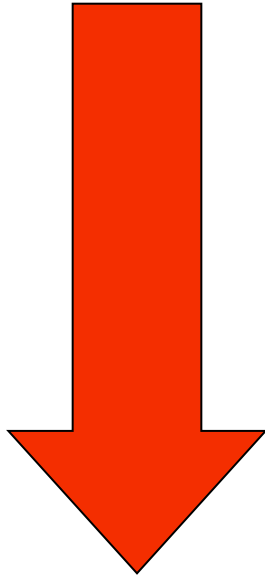
Northern Pin Oak

- 90th LAT=46.0377
 - Mean Biomass = 9.24 tonnes/ha
 - Mean Seedlings = 1526 ha
- 10th LAT=42.9388
 - Mean Biomass = 17.51 tonnes/ha
 - Mean Seedlings = 118 ha

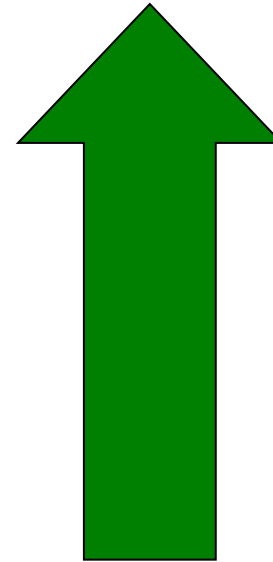


Quercus ellipsoidalis

Northern Pin Oak



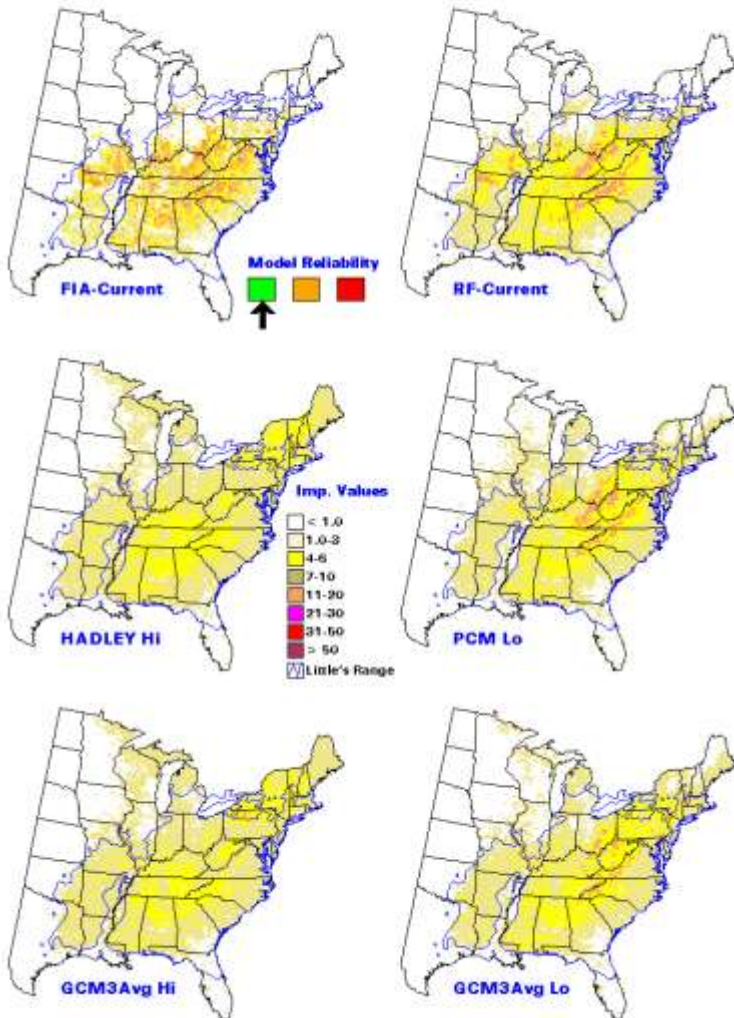
1/2 the Biomass
(seed source)



13x the Seedlings

Sensitivity to Species Lists

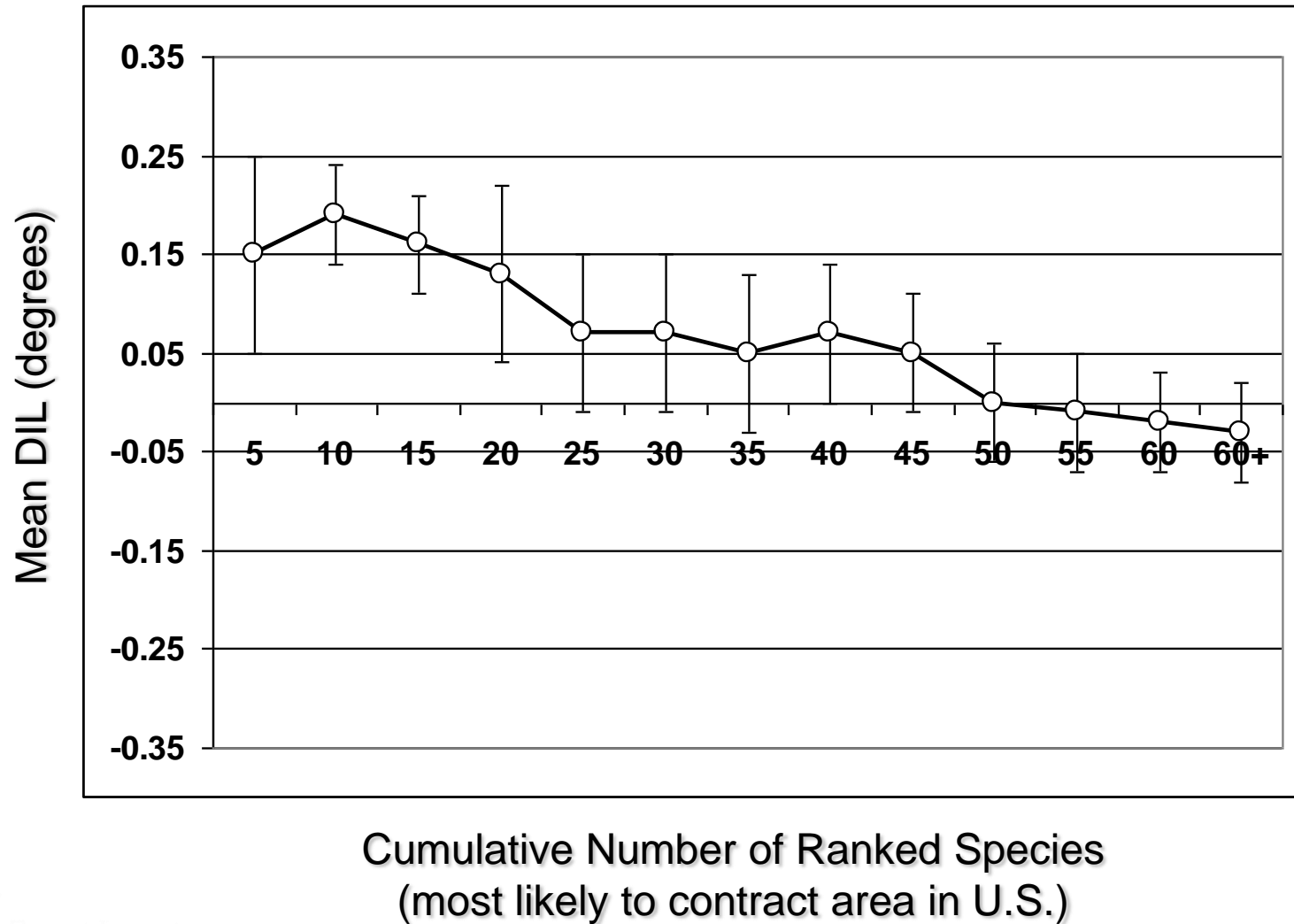
flowering dogwood - *Cornus florida* - (491)



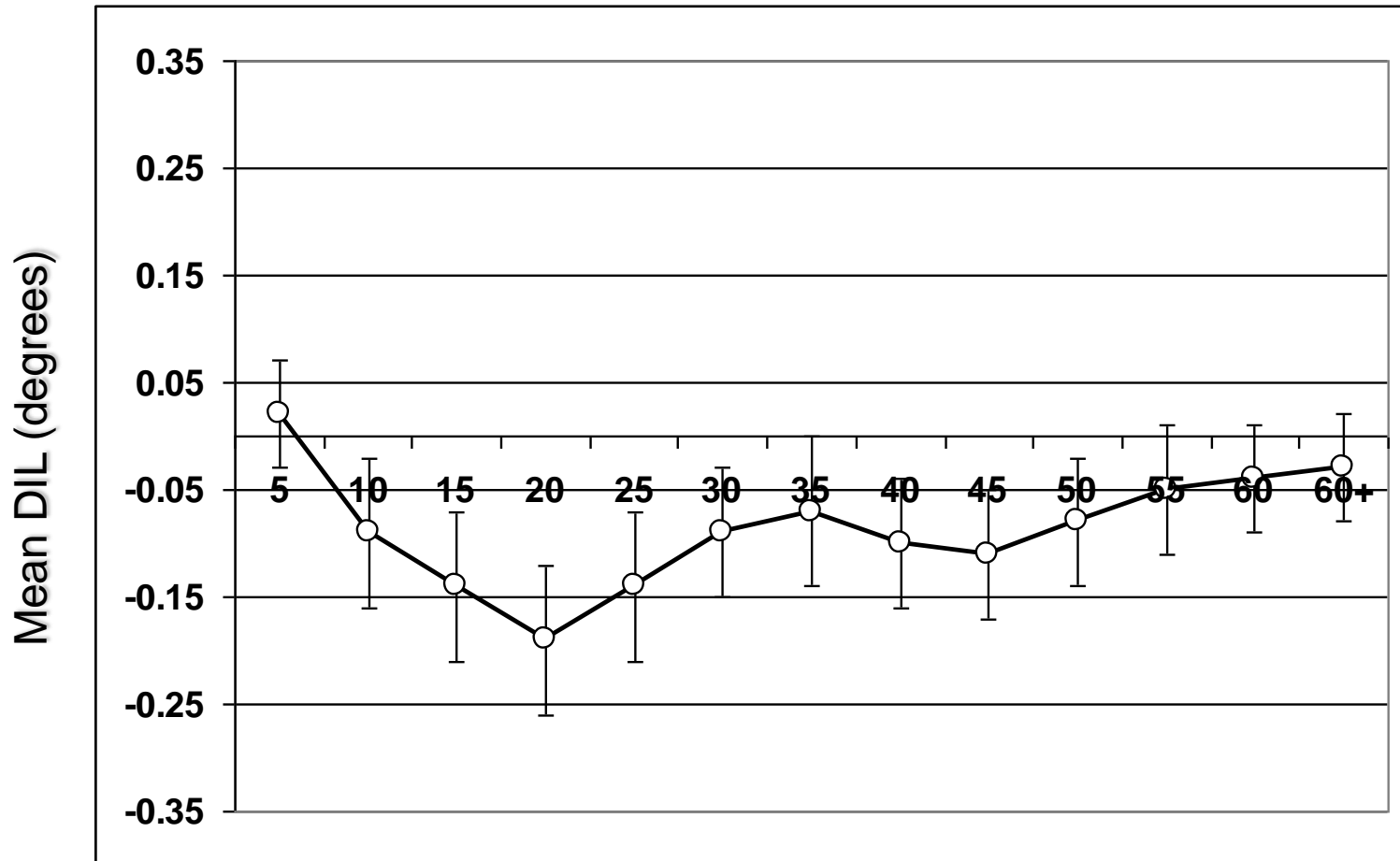
Rank species:

Modeled Future Habitat
Iverson et al.
Hadley Low Emission

Sensitivity to Species Lists



Sensitivity to Species Lists



Cumulative Number of Ranked Species
(most likely to expand area within U.S.)

Indicator Caveats

- Study species selection is subjective
- Latitude as a surrogate for temperature
- Seedling survival/mortality varies
- Varying stand dynamics/management over range of latitude
- True tree ranges not contained by conterminous U.S. – censoring issues
- Mast periodicity

Conclusions

- Northern species moving northward
- General species expanding southward
- Seedlings more prevalent in northern edge of ranges
- Some species demonstrating 100 km/century migration rates
- Must maintain monitoring

Further Questions?

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