Predicted & Observed Changes in Sugar Maple-Dominated Northern Hardwoods

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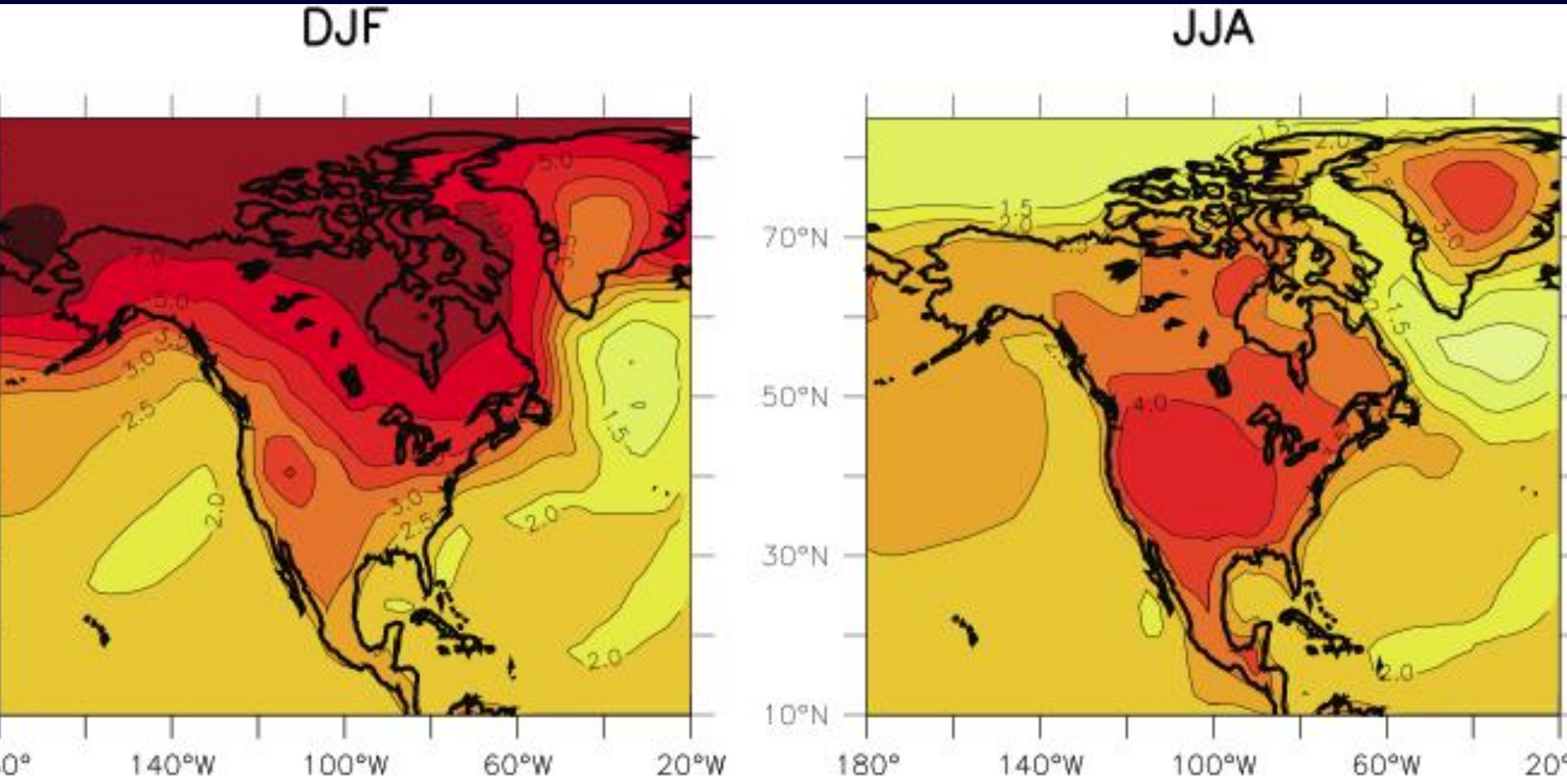
How much climatic change for Lake States?

1. General consensus predictions are for warmer conditions with precipitation changing little
2. Extreme weather events are also predicted to increase in frequency
3. Various model do differ in their specific predictions

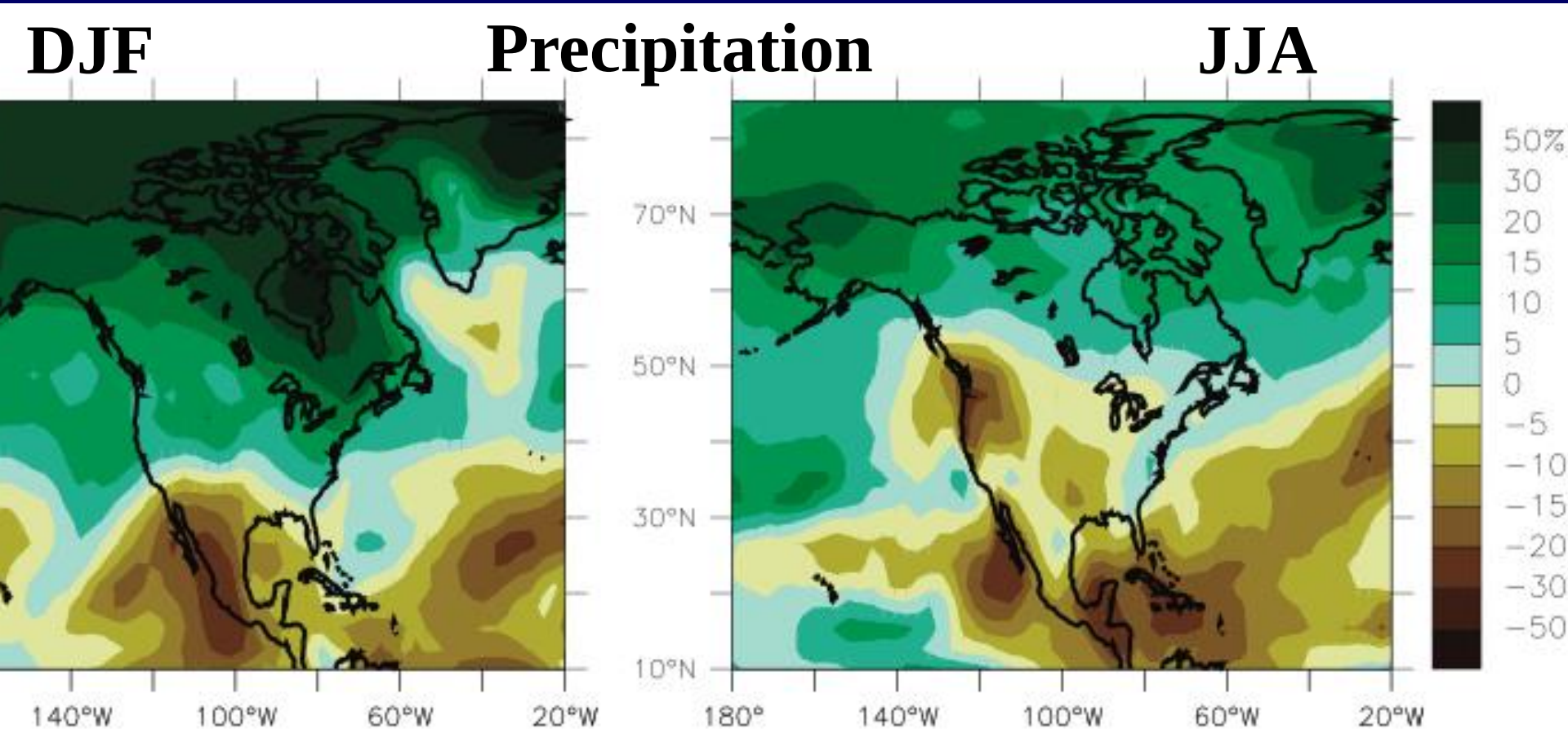
How much climatic change?



IPCC 4th Assessment, MMD-A1B simulation

change from 1980-1999 to 2080-2099 (Christensen et al. 2007)

How much climatic change?



IPCC 4th Assessment, MMD-A1B simulation

change from 1980-1999 to 2080-2099 (Christensen et al. 2007)

IPCC 4th Assessment Predictions for NE US (A2, B1 and A1B scenarios, multimodel)

2080 to 2099 vs 1980 to 1999

- 3.5 ºC in mean annual temperature (3 to 5.5 ºC)
- 4.1 ºC in summer temperature by 2080 to 2099 for the region
- slight increase in mean annual precipitation (range of -3 to +15%)
- Possible slight decrease in mid-summer precipitation

IPCC 4th Assessment Predictions for NE US and Lake States

(A2, B1 and A1B scenarios, multimodel)

2011 to 2030 vs 1980 to 1999

- 1.0 to 1.5 ^{o}C increase

2046 to 2055 vs 1980 to 1999

- 1.5 to 3.0 ^{o}C increase

Changes in geographic ranges

a. **Bioclimatic envelopes for today's range are often used to predict future range**

b. **Climate Change Tree Atlas makes predictions based on 38 environmental variables**

   http://www.nrs.fs.fed.us/atlas/tree/tree_atlas.html

c. **This approach does not take into account effects of future CO_2 concentrations**

d. **Predicted suitable areas do not mean the species will exist there in the future.**

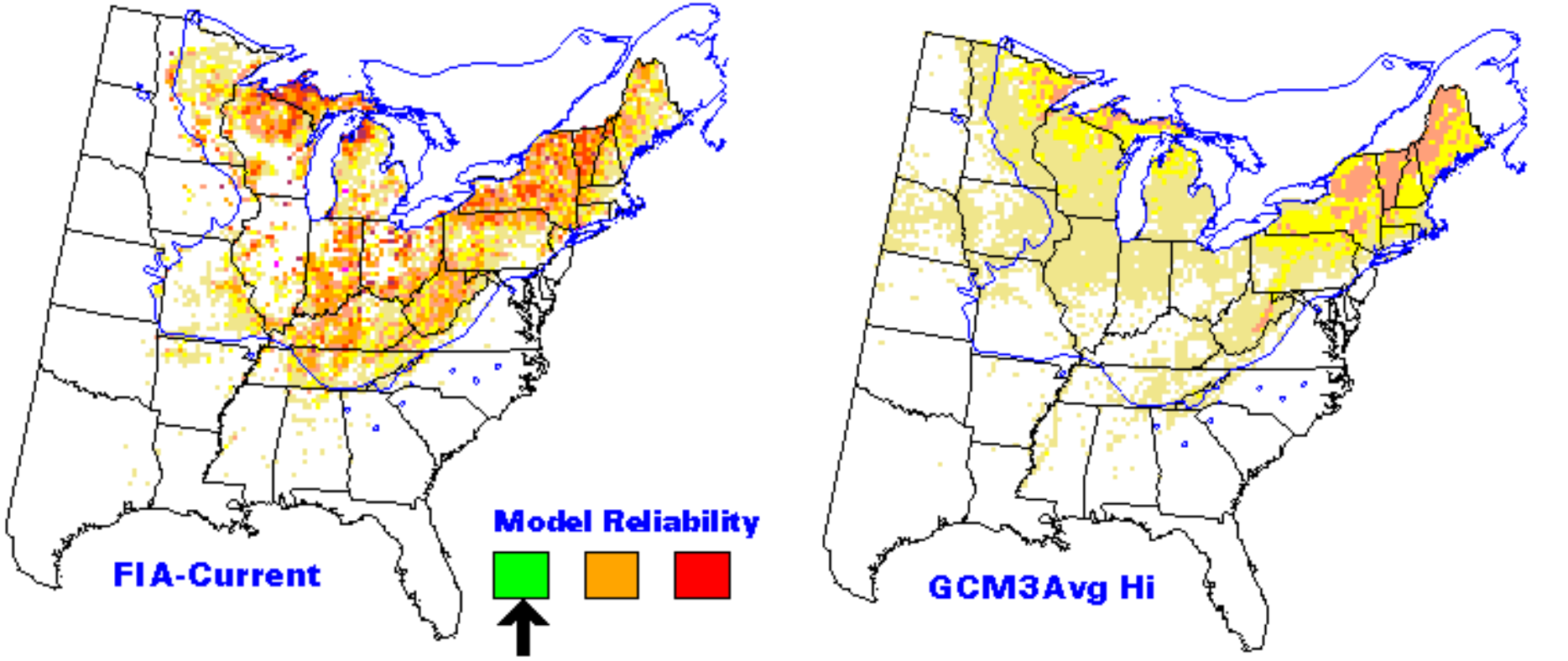
   - **historical high for migration rates is about 1 km/yr (some say much less), and fragmented landscapes will likely further limit migration**

Predicted Range of Sugar Maple Habitat in 2100

Average of 3 Global Climate Models

(Climate Change Tree Atlas -climatic envelope model)

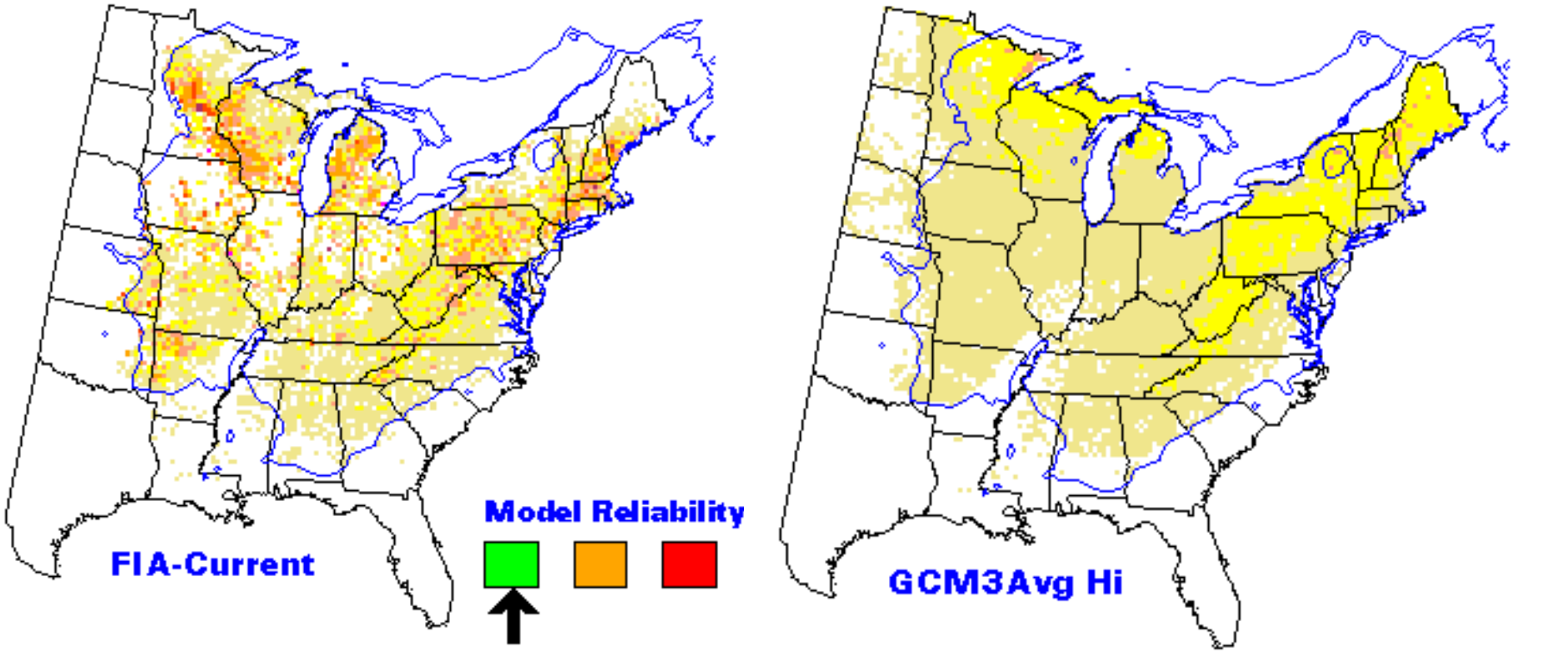
(Imp. Val. = importance value = proportion of basal area)



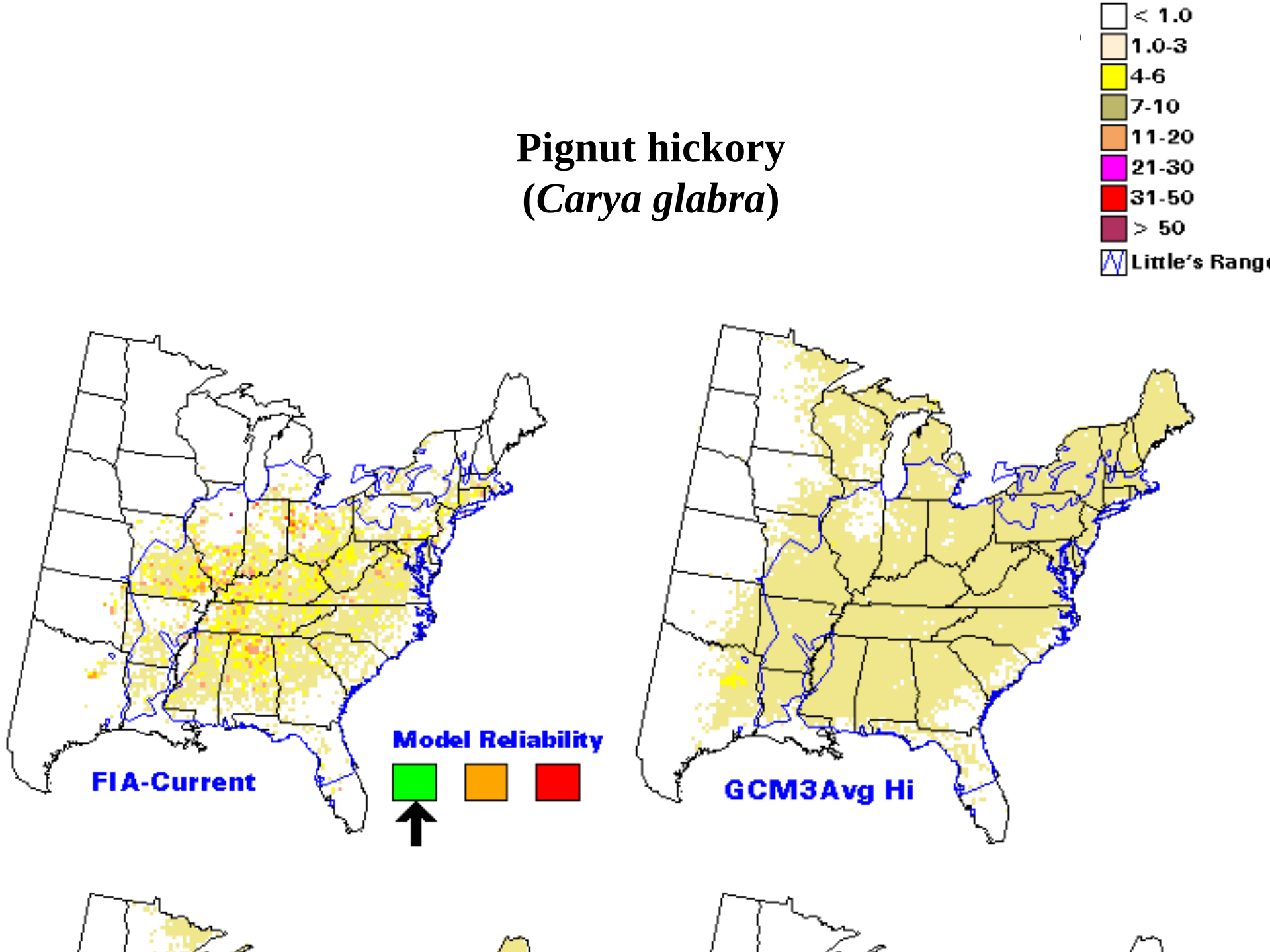
Source: http://www.nrs.fs.fed.us/atlas/tree/tree_atlas.html

(see also Iverson and Prasad 1998, 2001, 2002, Iverson et al. 2008)

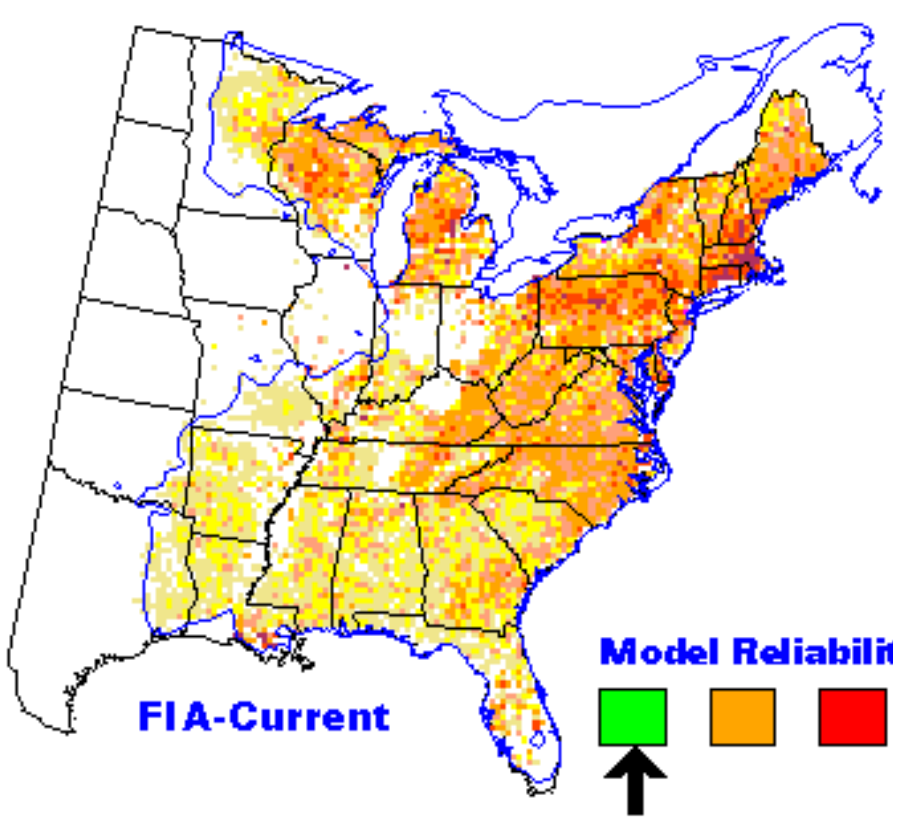
Northern red oak
(*Quercus rubra*)

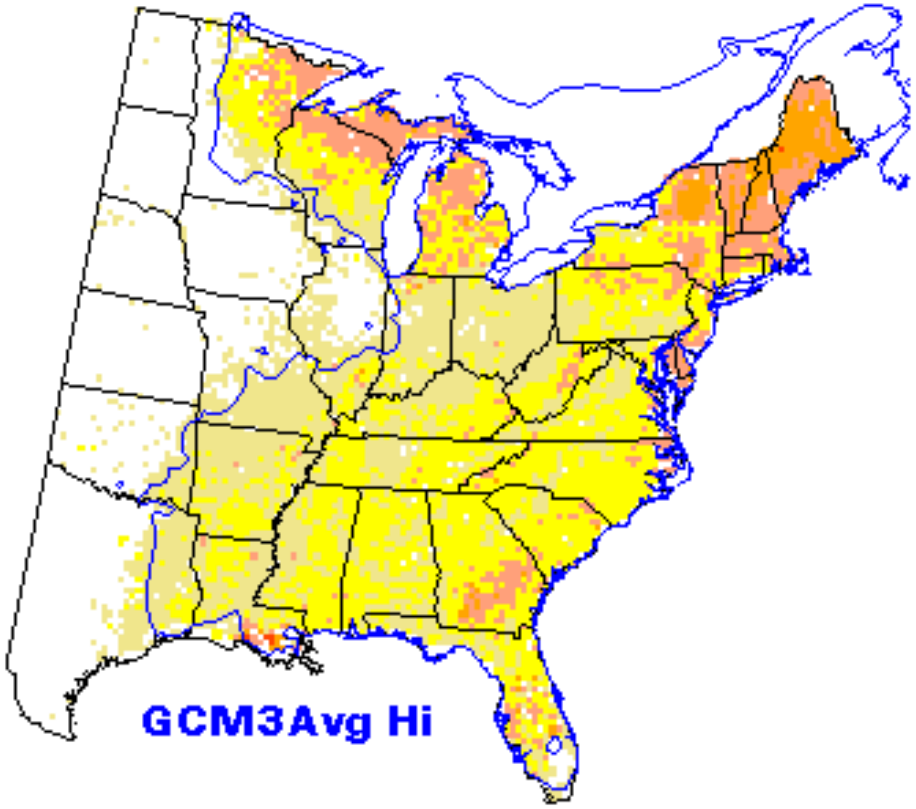


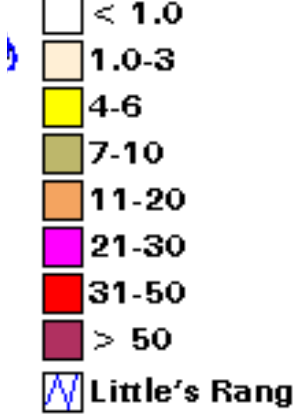
Pignut hickory
(*Carya glabra*)



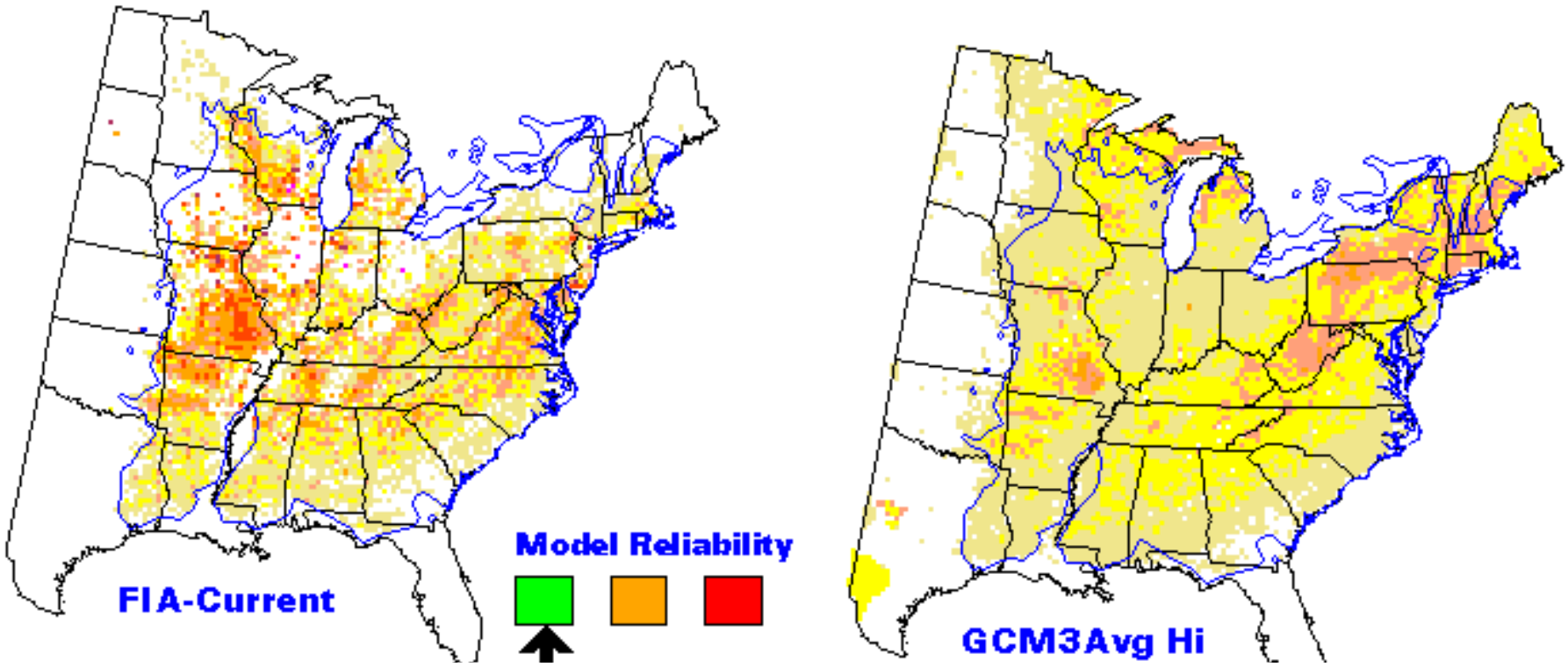
Red maple
(*Acer rubrum*)







White oak
(*Quercus alba*)



Predictions of suitable habitat – not necessarily where it will be!

Does not take into account migration rates (<1 km/yr or maybe <<1 km/yr).

Many "no analog" combinations (temp & moisture – but also CO_2, sun angle, O_3 etc.)

Does not take into account future CO_2 concentrations

What can we learn from these predictions of suitable habitat

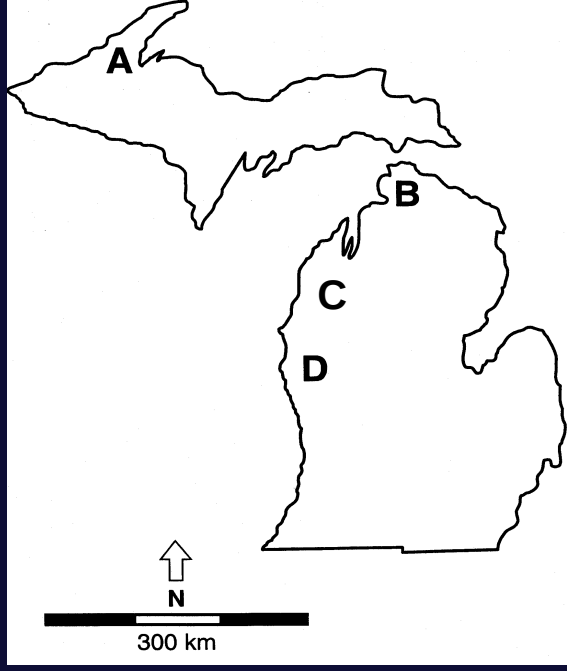
- Identify species at a given location that might perform better in the future and thus should be favored today
- Method will be of most utility for areas with large number of species
- Realize it is just one tool and it doesn't predict future C balance or productivity
- Existing species being less competitive in the future does not mean they won't grow

Fundamental vs. Realized niche

- **trees often are capable of growing in warmer (and cooler) climates than they currently do, but are limited by competition from species better suited to the warmer (or cooler) climate**
- **if the competitors are not present and don't migrate rapidly under global warming, the species will continue to exist in a climate that currently doesn't support it**
- **in many locations some mixture of today's species will still be there, with possible shifts in dominance**

Michigan Gradient

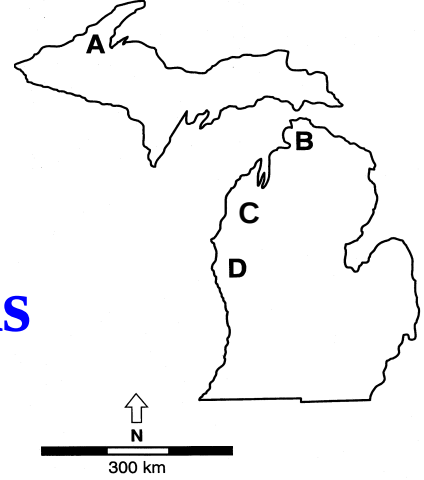
Four northern hardwood forests in Michigan

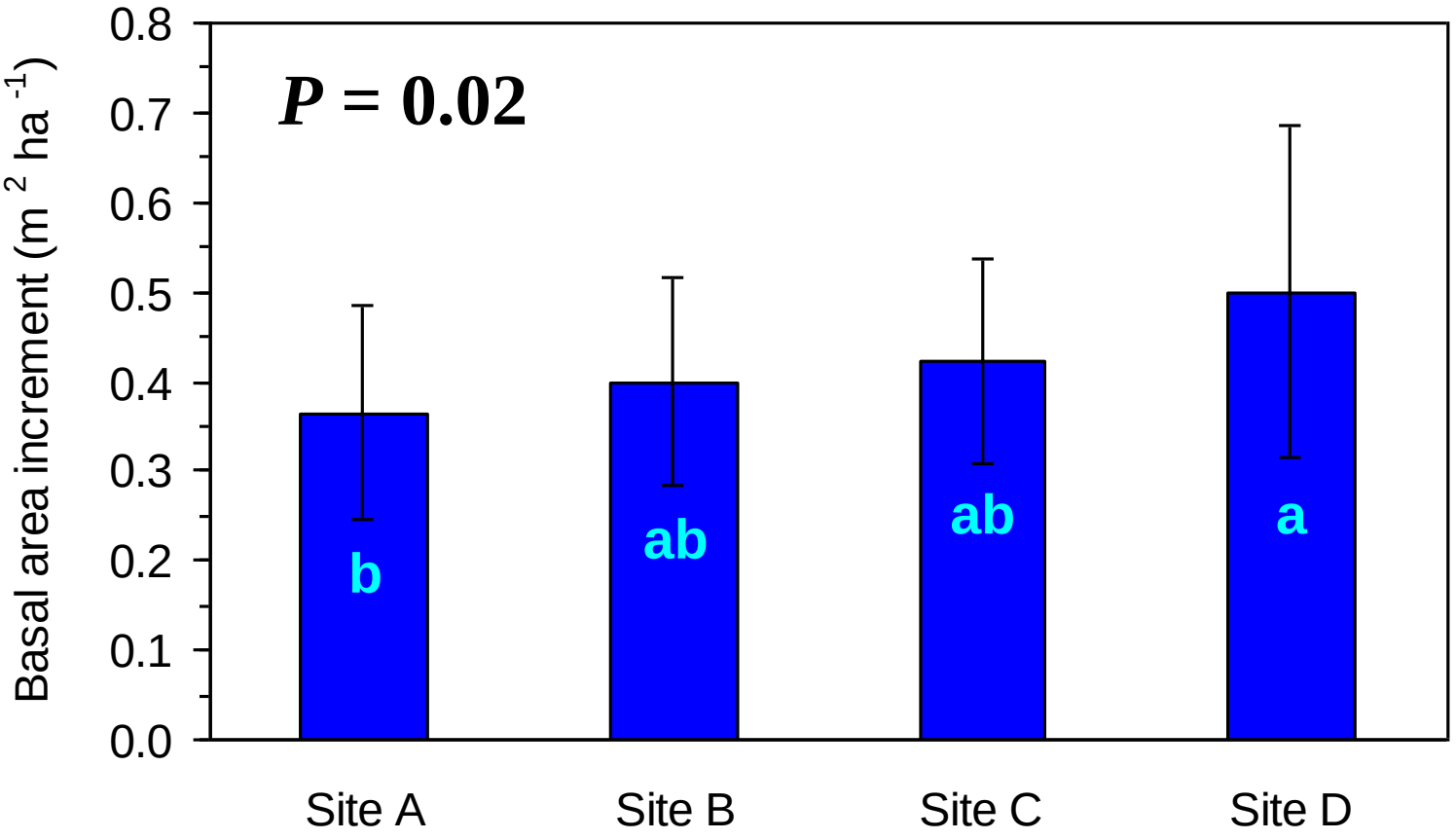


Since 1988, we have measured:

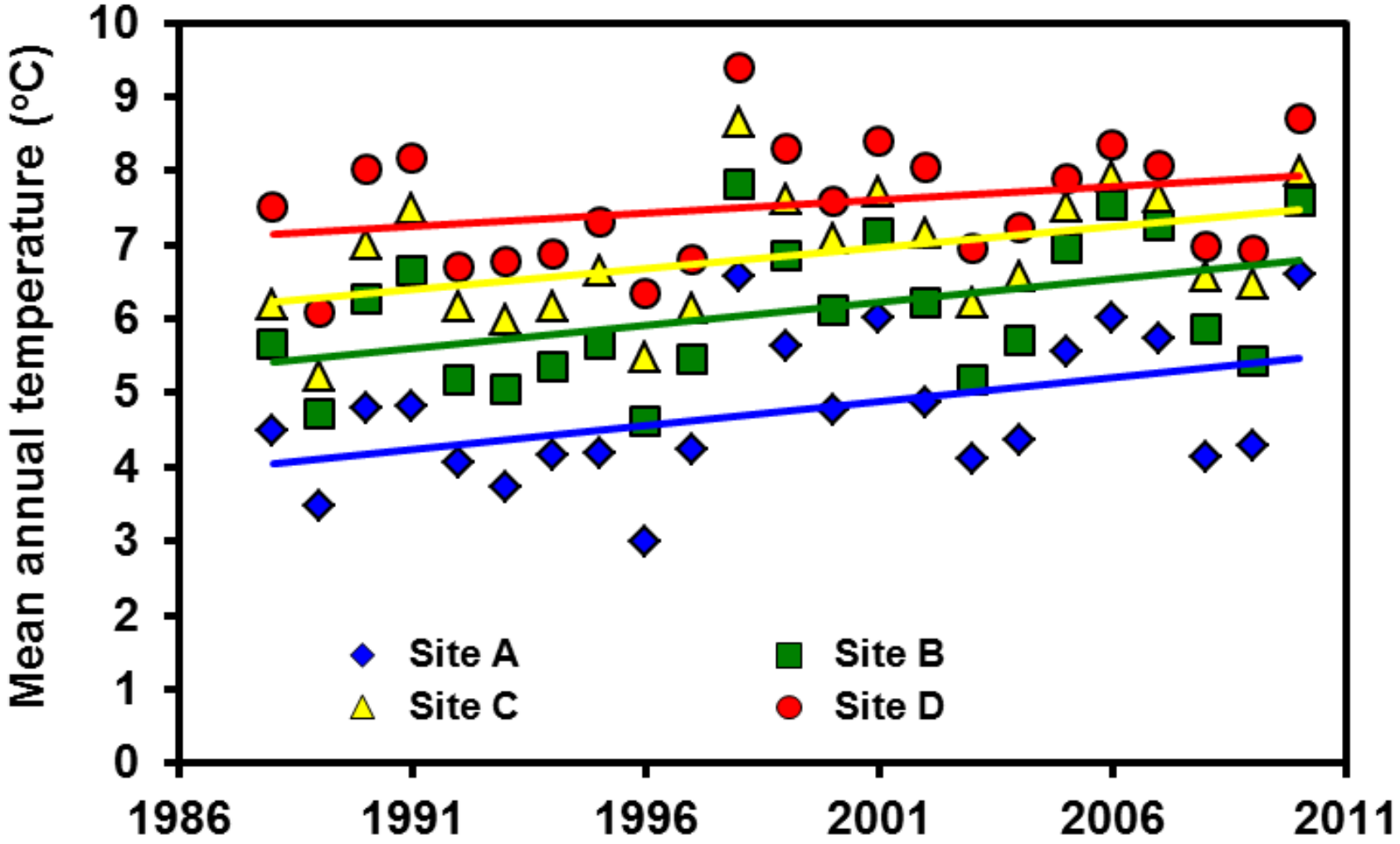
- Annual diameter increment
- Tree heights every 5 to 6 years
- Air and soil temperature (30 min intervals)
- Ambient precipitation and soil moisture
- Length of leaf display

- **greater tree growth where annual climate is warmer (5 ºF from A to D)**
- **due to longer growing season (about 3 weeks from A to D)**
- **will individual locations respond similarly to warming?**

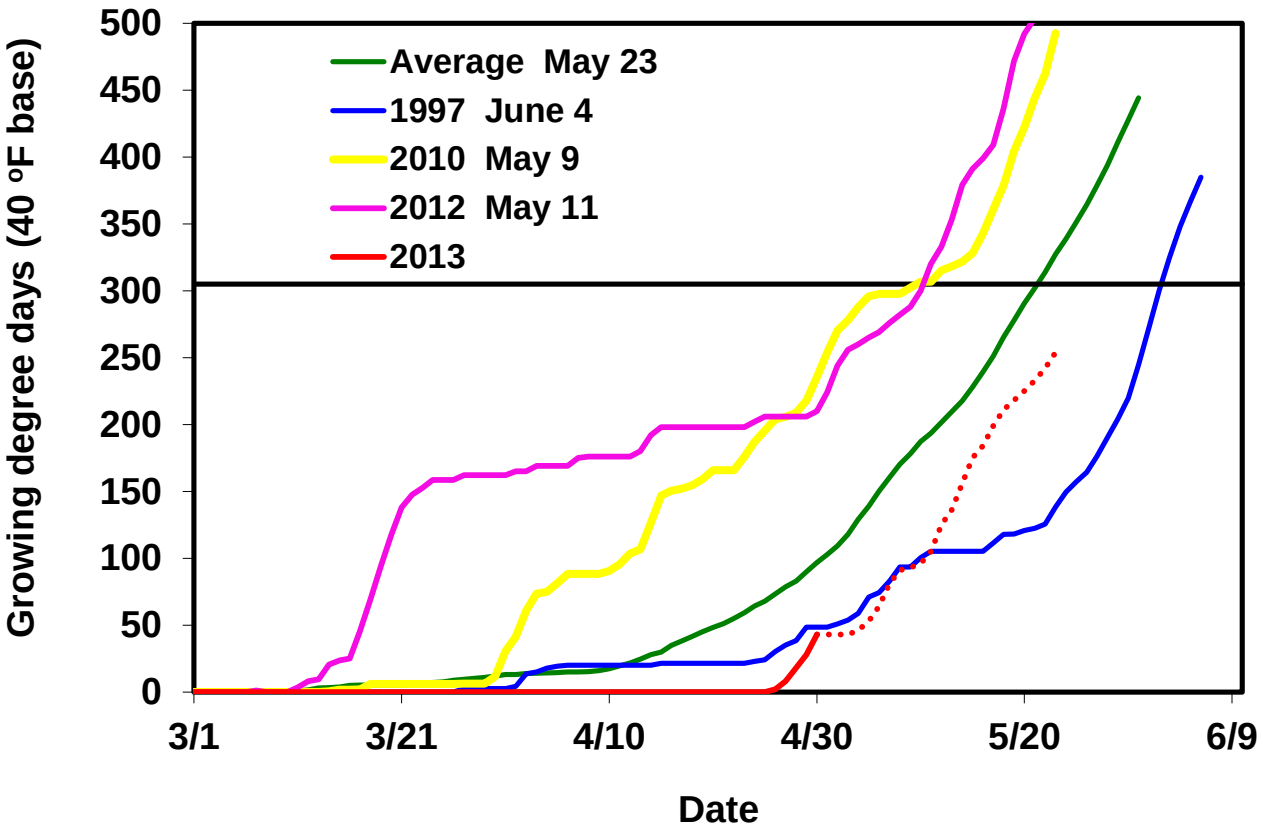




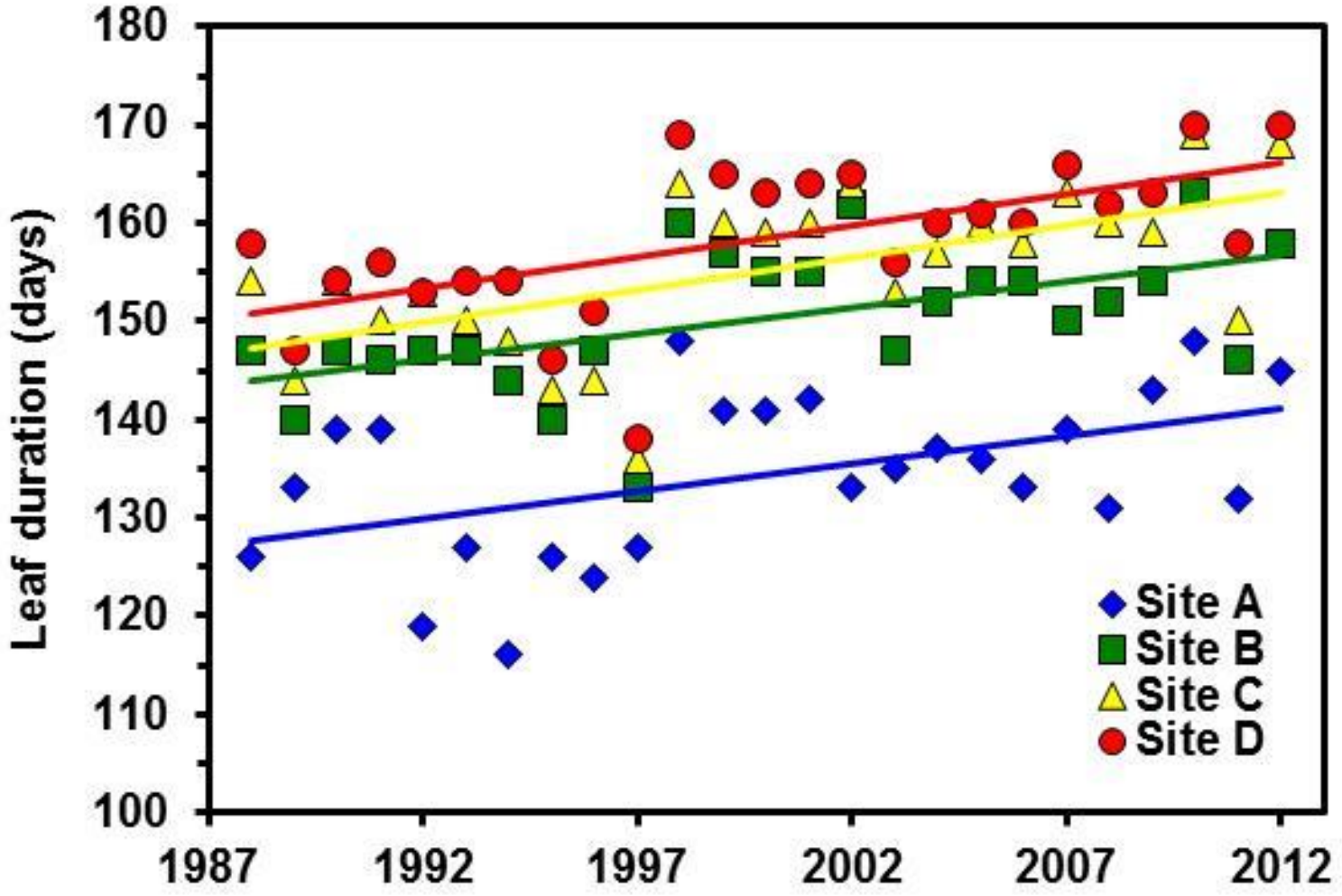
Mean annual temperature increased by 1.3 ºC during the 20+ year period



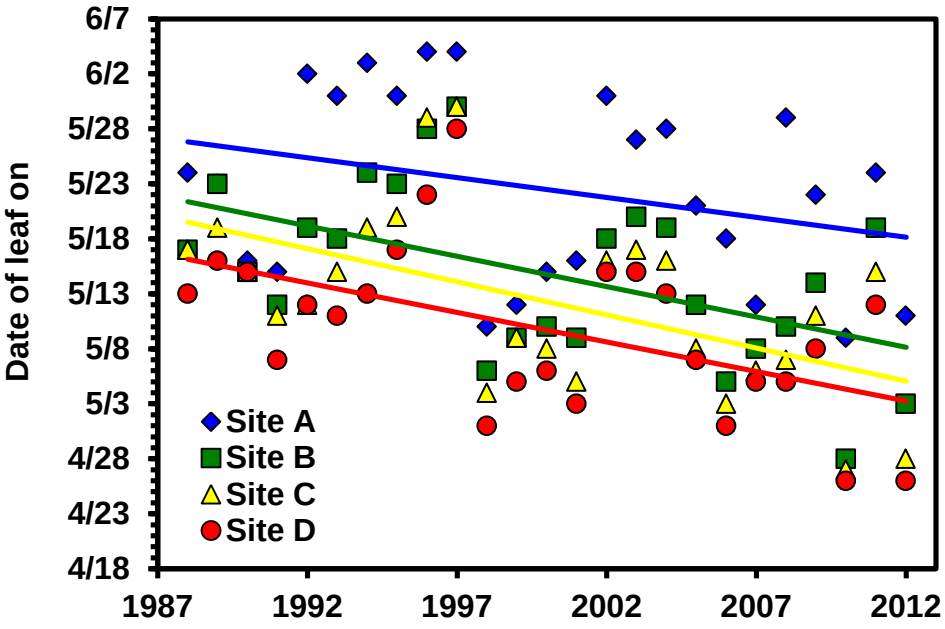
Bud-burst and leaf expansion are highly dependent on temperature (can track with GDD)

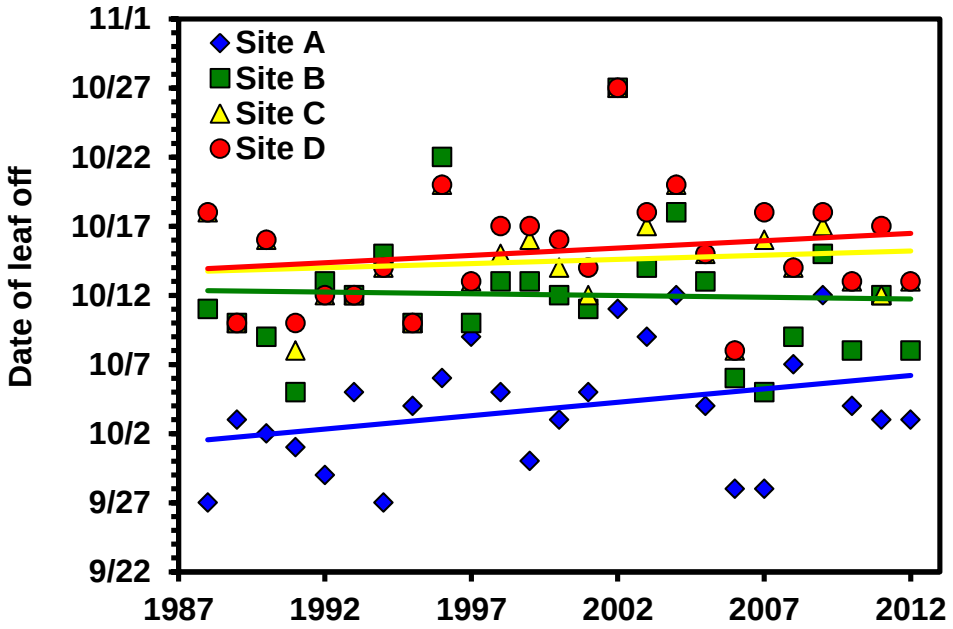


Average duration of leaf display increased by 13.8 days during the study period

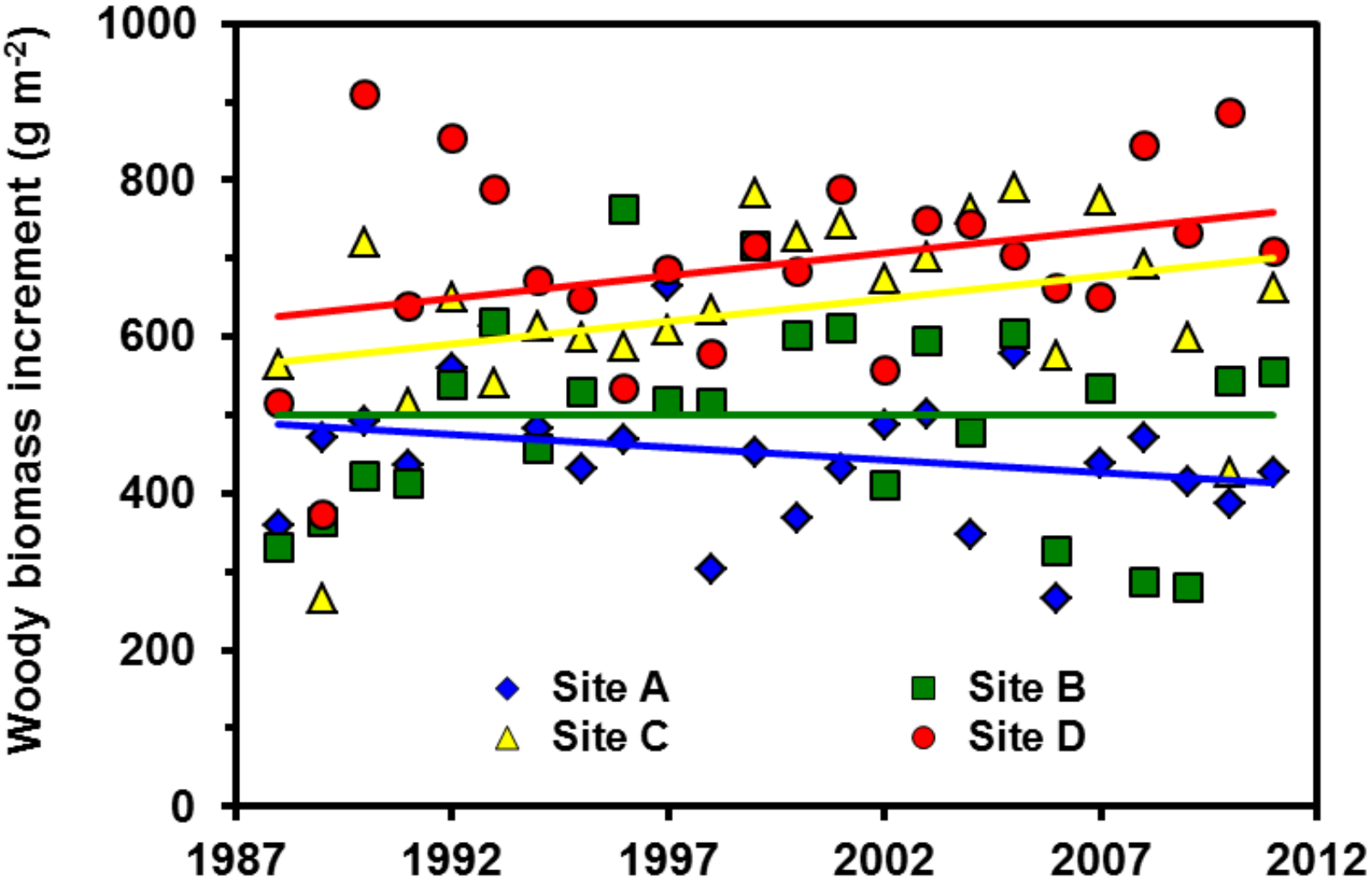


This change was due to both earlier leaf display in the spring and longer leaf retention in the fall

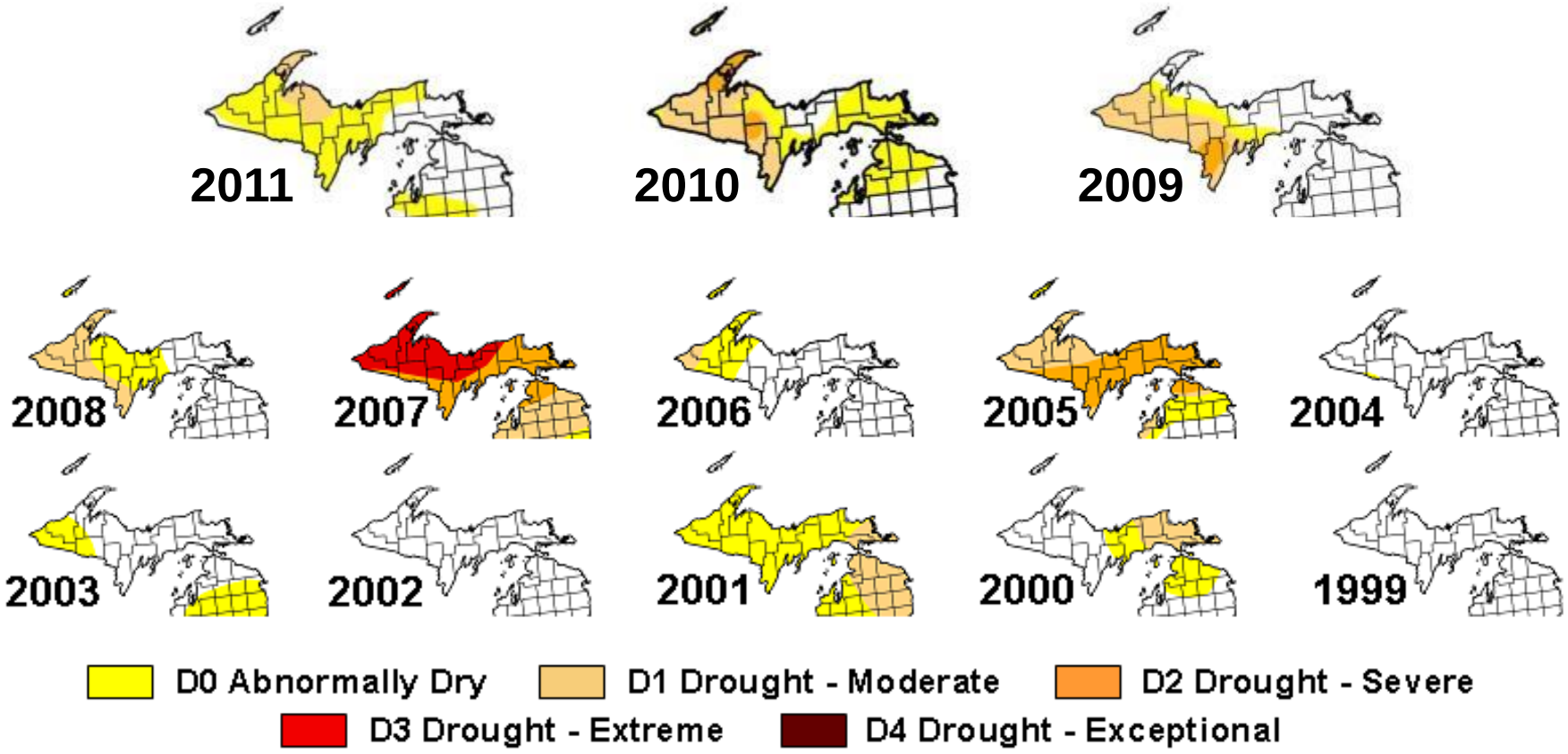




Averaged across sites, aboveground biomass increment increased significantly during the 20+ year study, but results varied by location

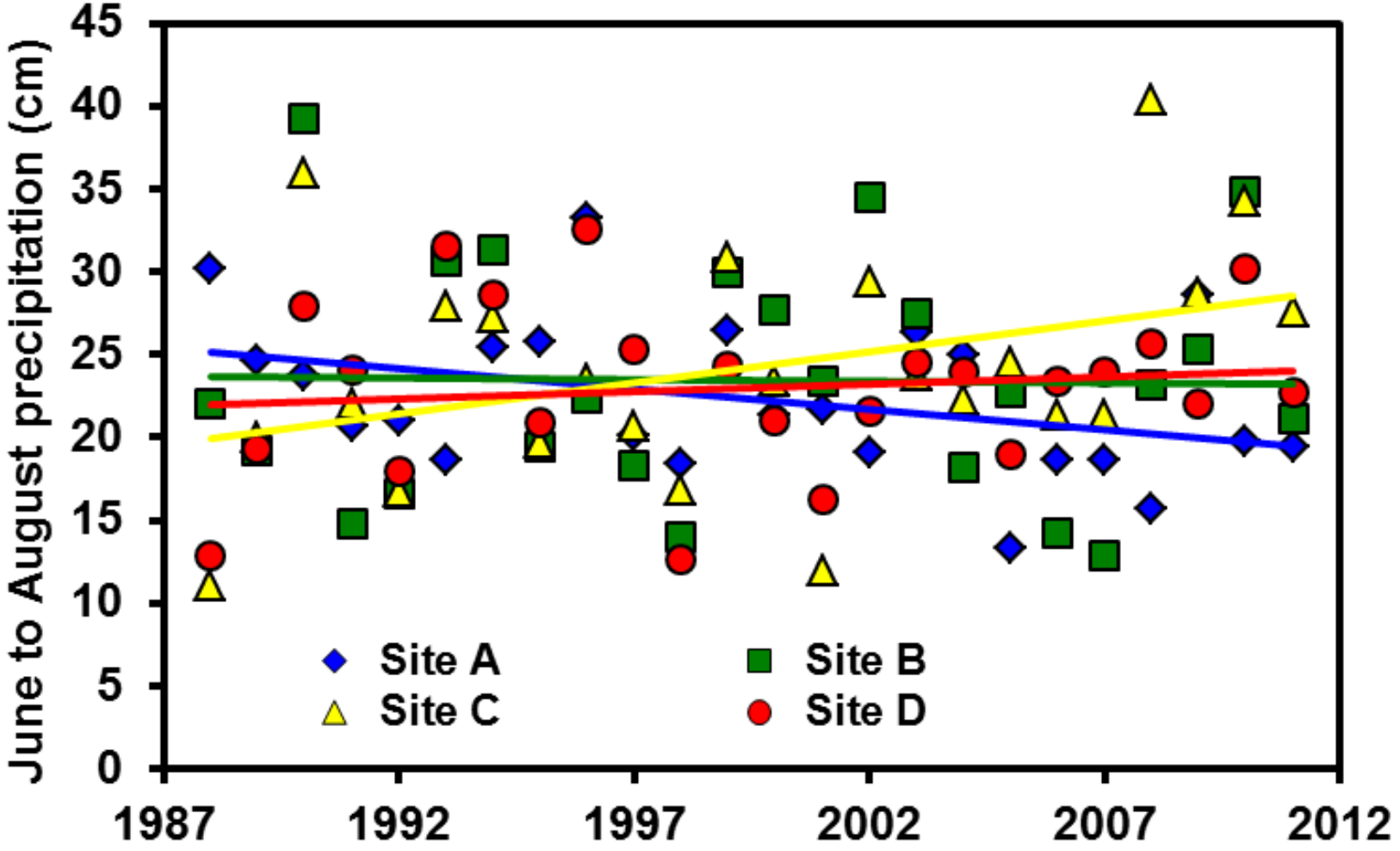


Late August/Early September Drought Index

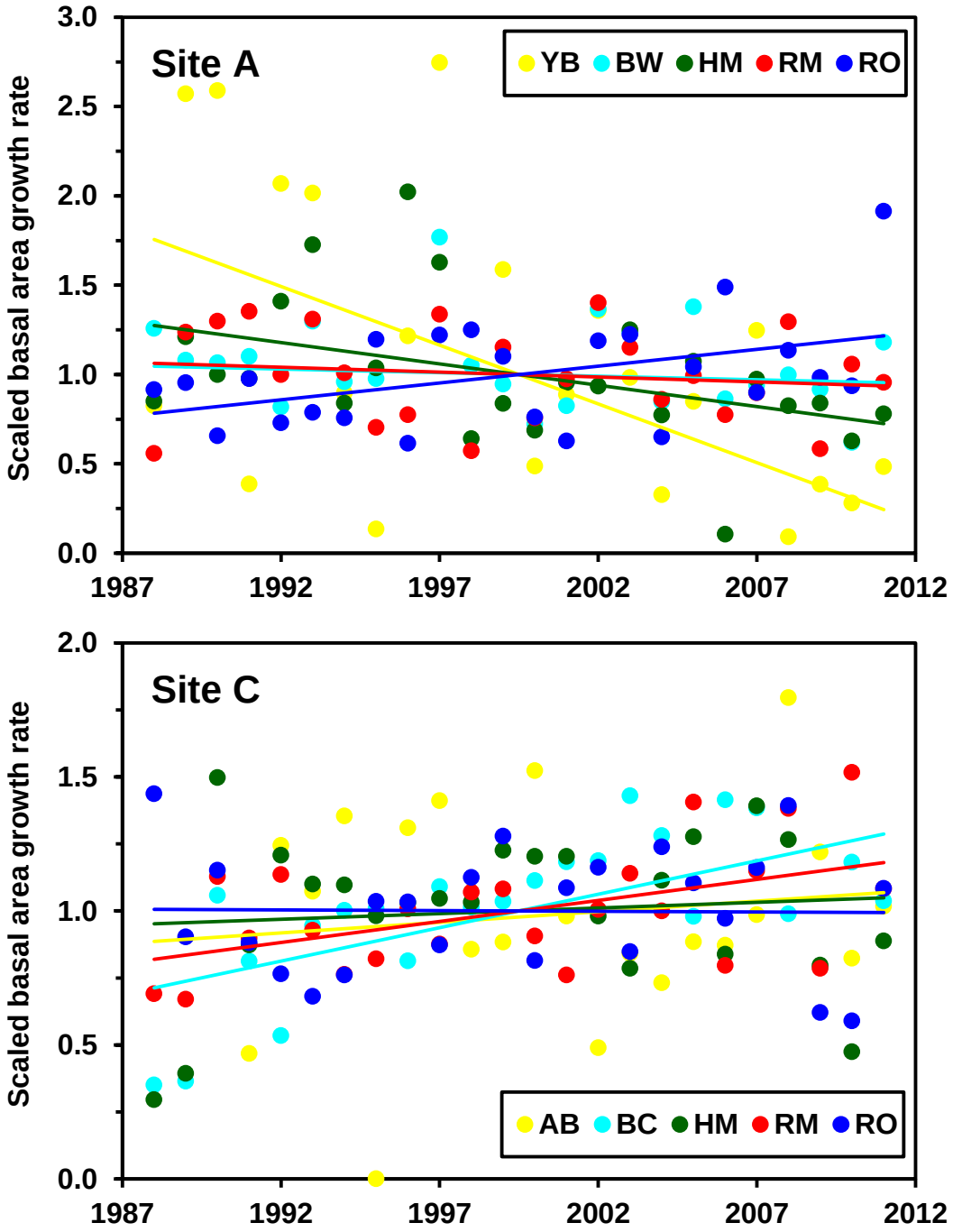


http://droughtmonitor.unl.edu/archive.html

The neutral to declining trend in woody biomass increment at Site A may be due to increasing drought occurrence during the later years of the study



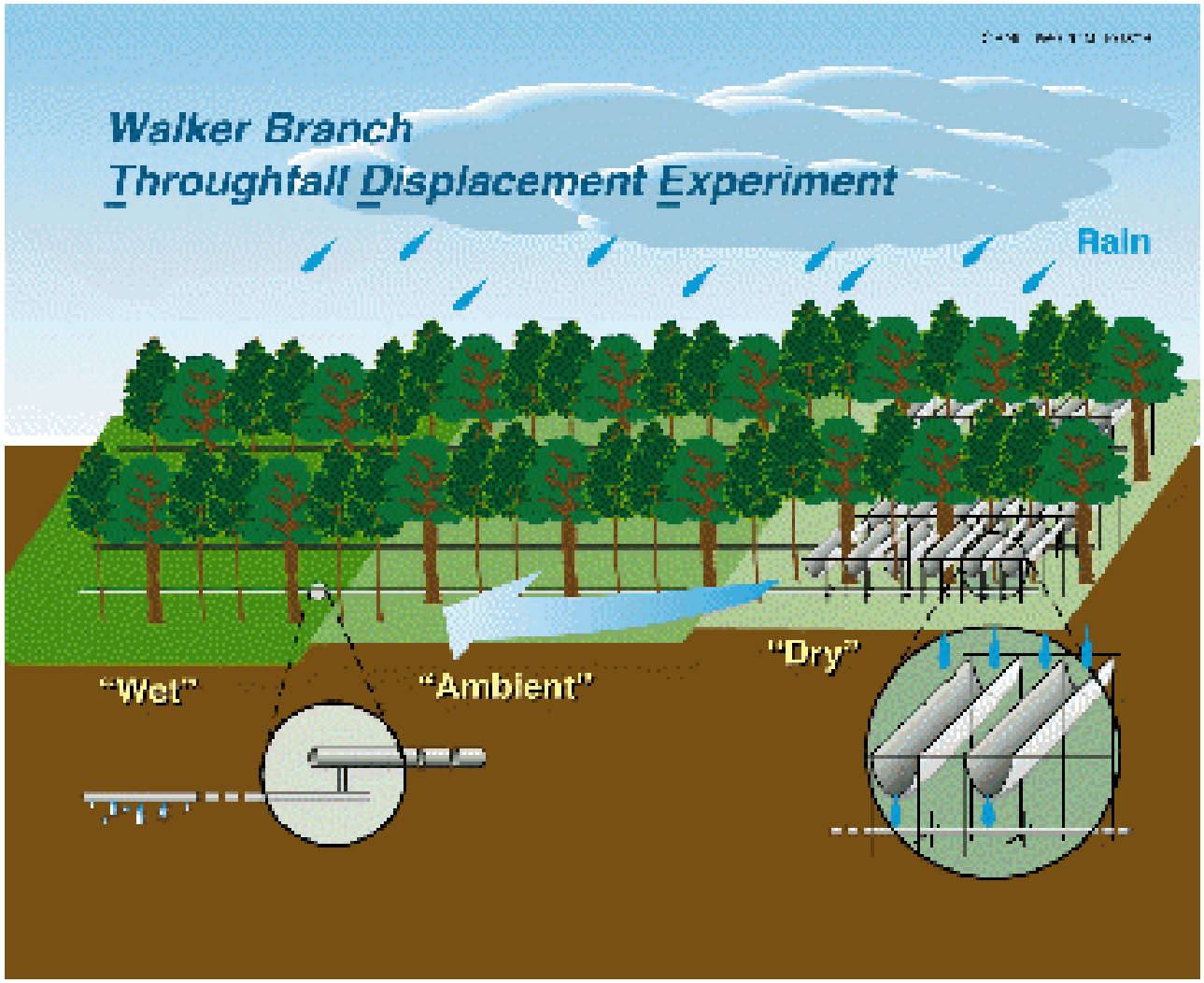
Species have responded differently



Climatic Change & Productivity

- Longer growing seasons associated with climatic warming may initially result in greater productivity in northern hardwood forests for which moisture availability is adequate
- Predicting future precipitation regimes and understanding their influence is critical to predicting future forest productivity
- Need to improve the physiological basis used to model tree and ecosystem carbon balance and productivity
- Species will respond differently

Can trees find more water if needed?



Oak and yellow-poplar

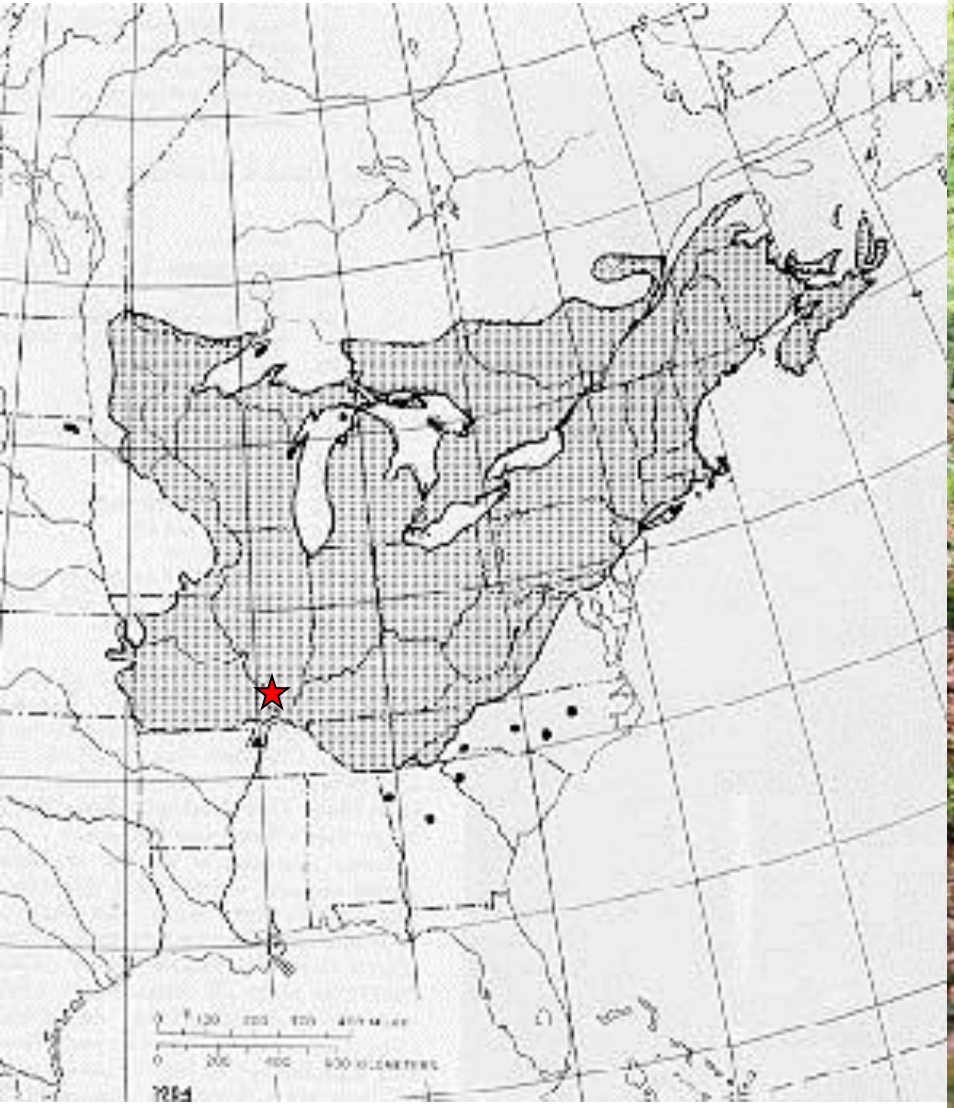
30% of rain removed from dry treatment and placed in wet treatment

Growth of large trees was not affected by treatments!

(Hanson et al. 2001)

Native Range of Sugar Maple

http://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/acer/saccharum.htm



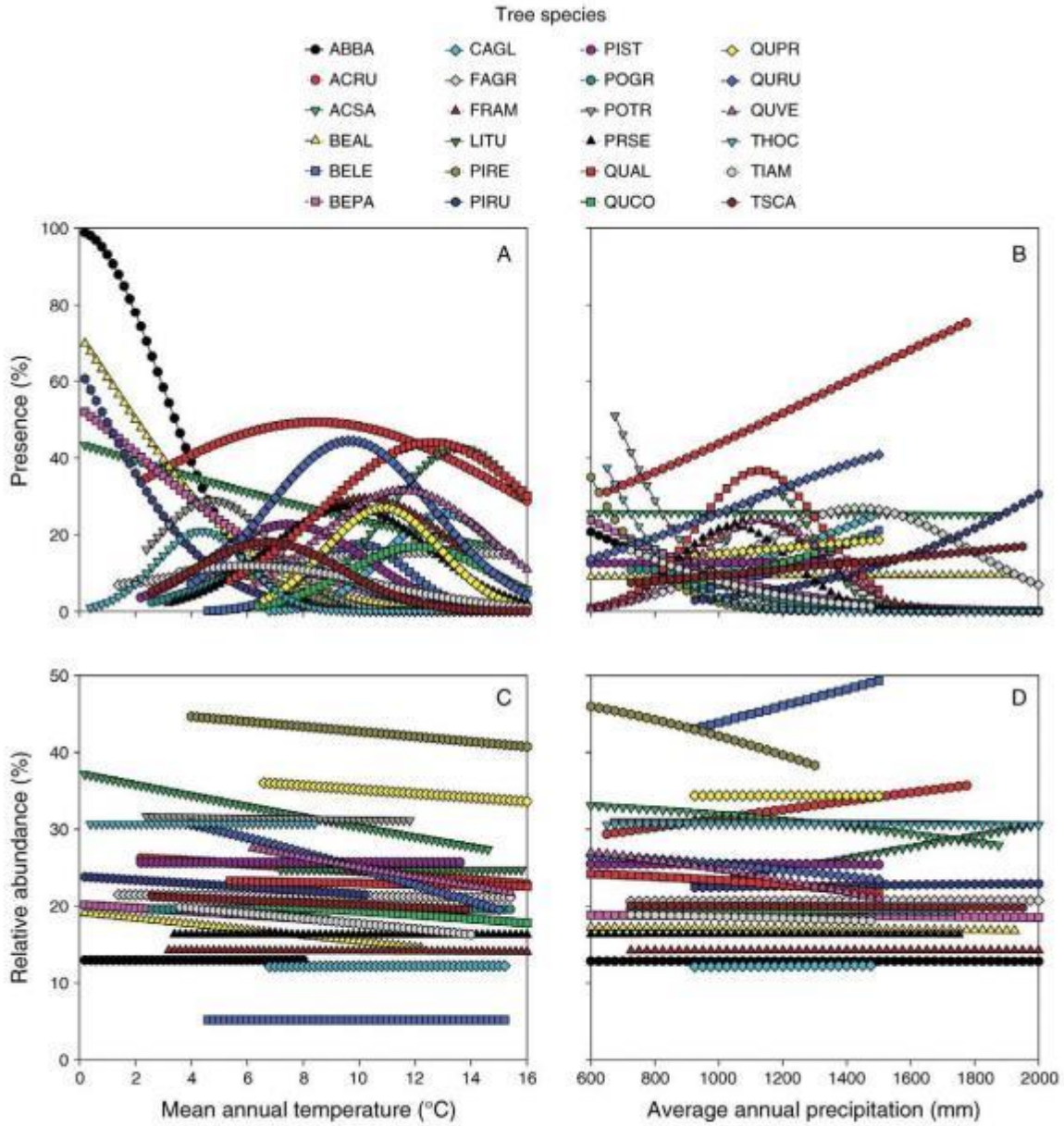
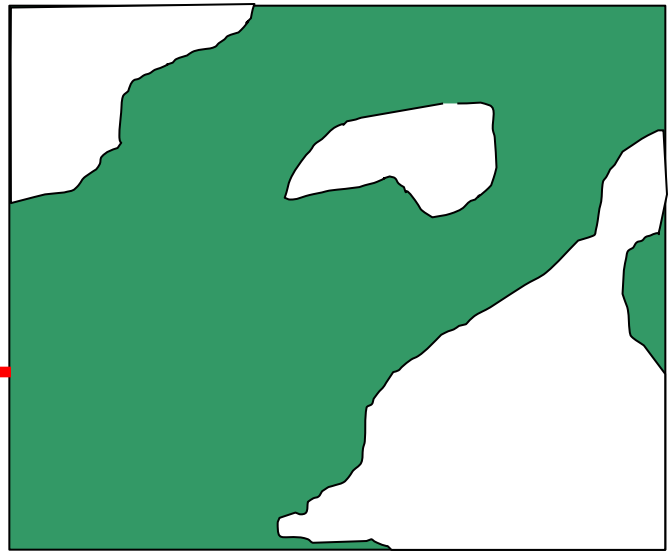


FIG. 1. (A, B) Predicted variation in frequency (presence, the percentage of plots in which the species occurs) and (C, D) relative abundance (percentage of aboveground biomass, when present) for adult trees of the 24 study species, as a function of annual mean temperature and annual precipitation. Maximum-likelihood estimates and two-unit support intervals for the parameters of all of the functions are given in Appendix B. Species abbreviations consist of the first two letters of the genus and specific epithet. The full species names are listed in Table 1.

Sugar maple, 60% of basal area

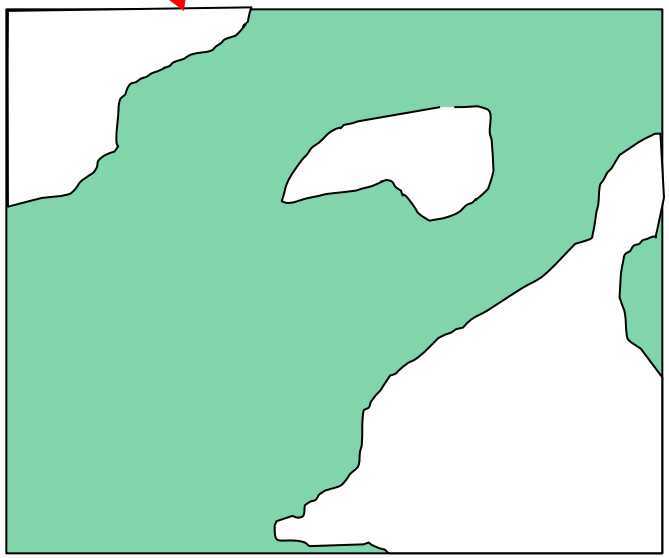
Climate change prediction: sugar maple importance decreases to 30%

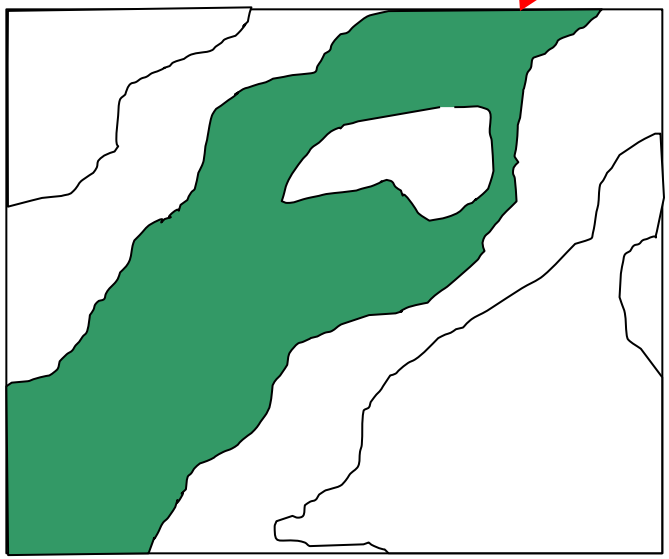
How will this happen?



SM is lost from half of its sites, but stays close to 60% basal area in remaining suitable habitats

SM basal area declines by 1/2 wherever it was found?





Fundamental vs. Realized niche

- **if a species declines in an area, it is not likely to be a general overall decline throughout the area, but rather a reduction in the number of suitable locations that are within the species niche (i.e. it will continue to do well in some sites and just about disappear from others)**
- **managers need to know where in the landscape the species will find suitable conditions in the future**