THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Potential effects of future climate change on the oak resource

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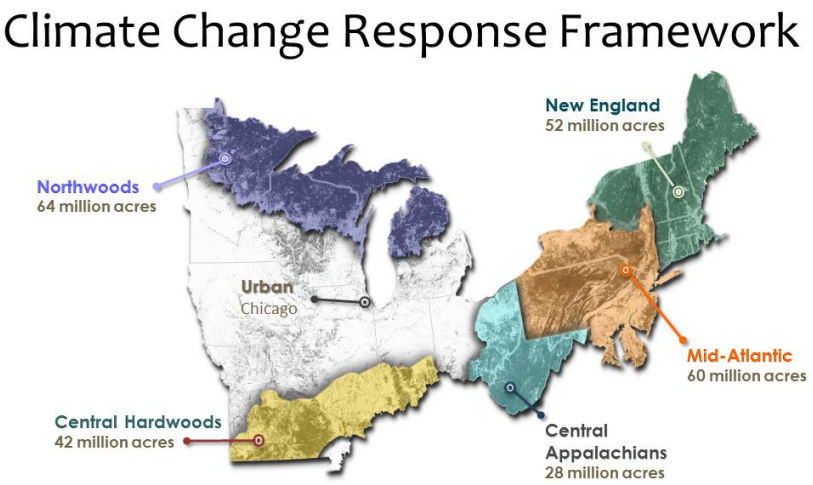
Major contributions by Louis Iverson, Matthew Peters, Anantha Prasad, (NRS-Delaware)

The setting

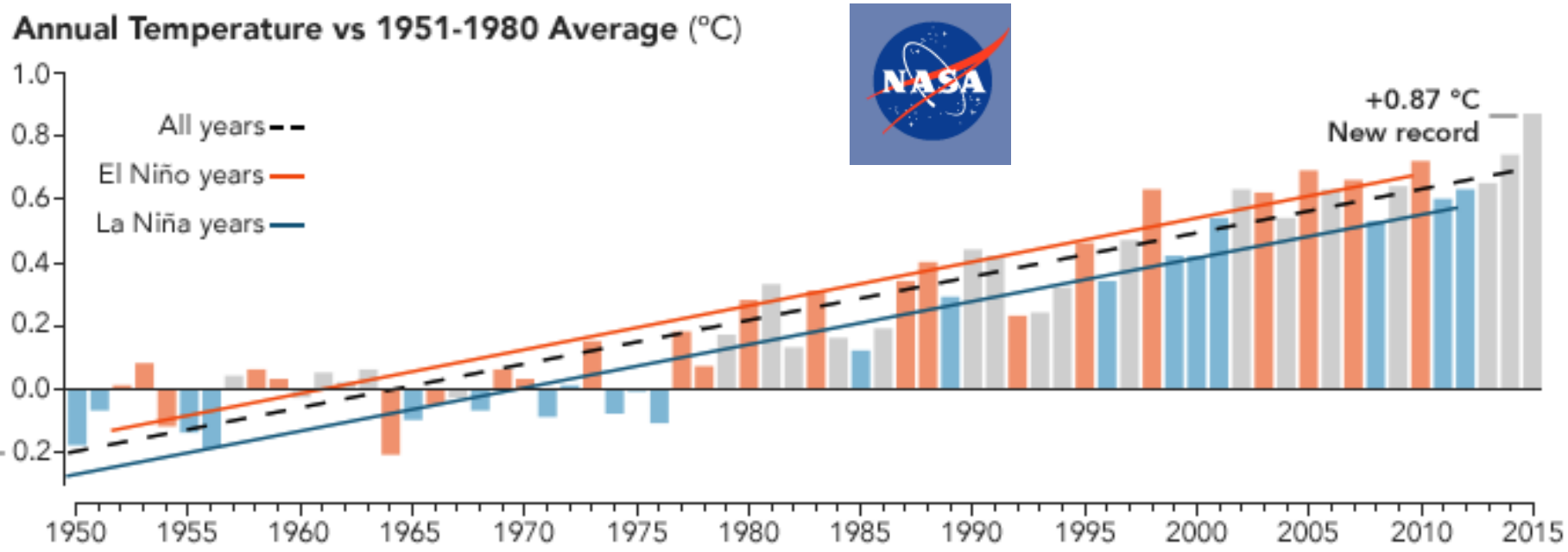
The reason

- Climate is changing and species are responding
- Understanding habitat dynamics with change provides a basis for considering how we keep species competitive now (e.g. oaks)

How these data Are being used



Evidence of Climate Change: A continuing and intensifying trend with more records falling

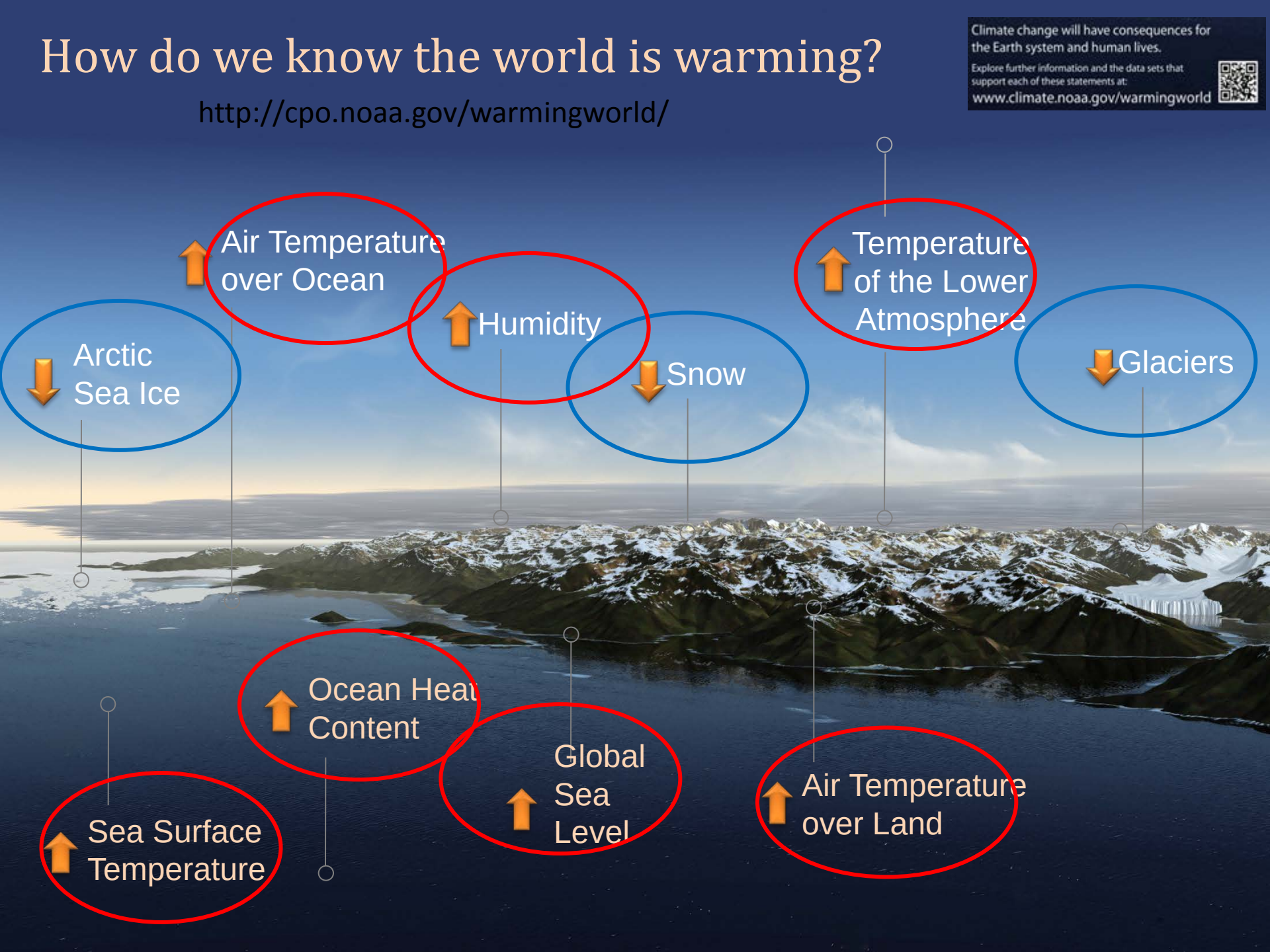


How do we know the world is warming?

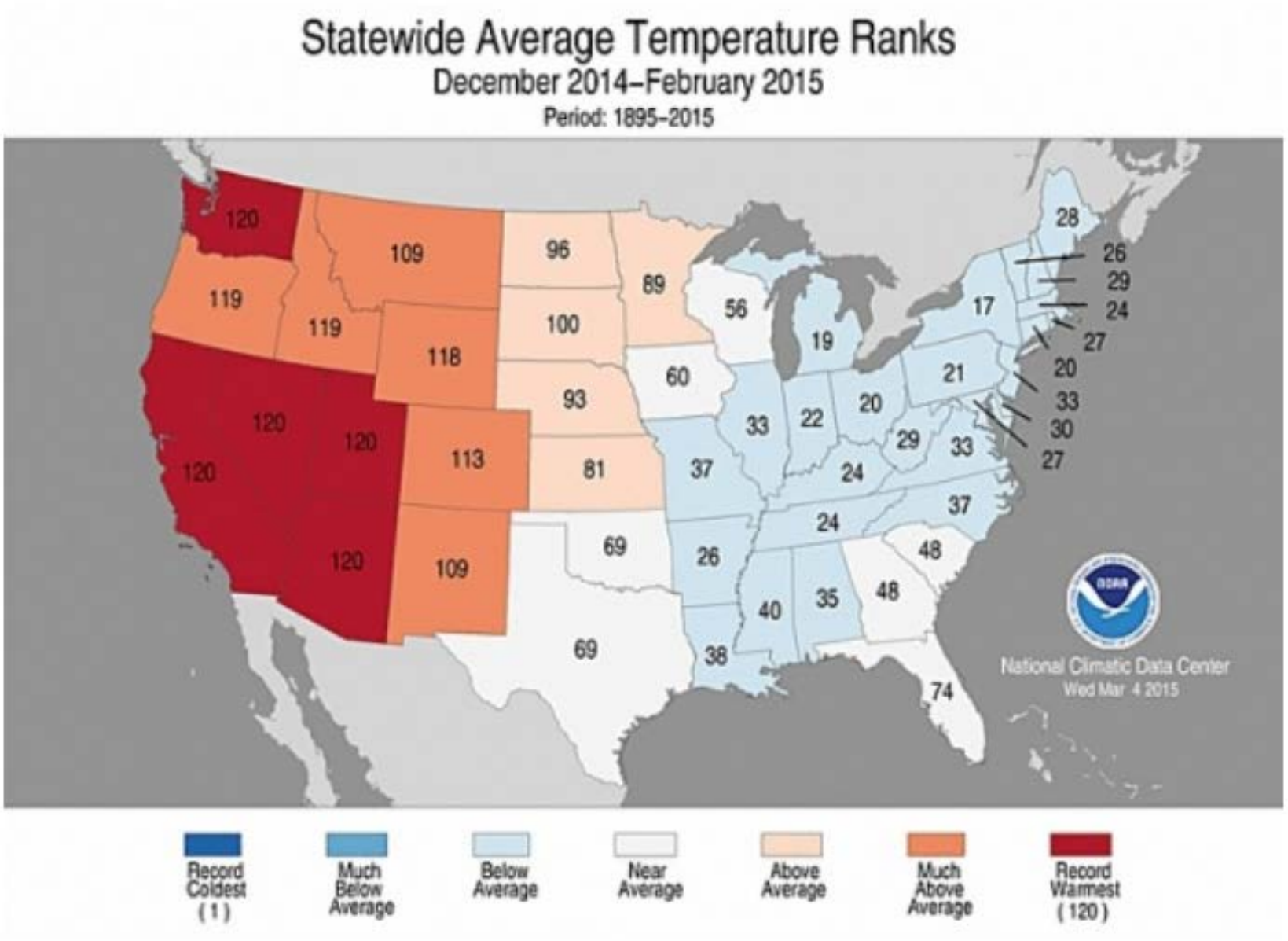
http://cpo.noaa.gov/warmingworld/

Climate change will have consequences for the Earth system and human lives.

Explore further information and the data sets that support each of these statements at:
www.climate.noaa.gov/warmingworld



Extremes are becoming more common



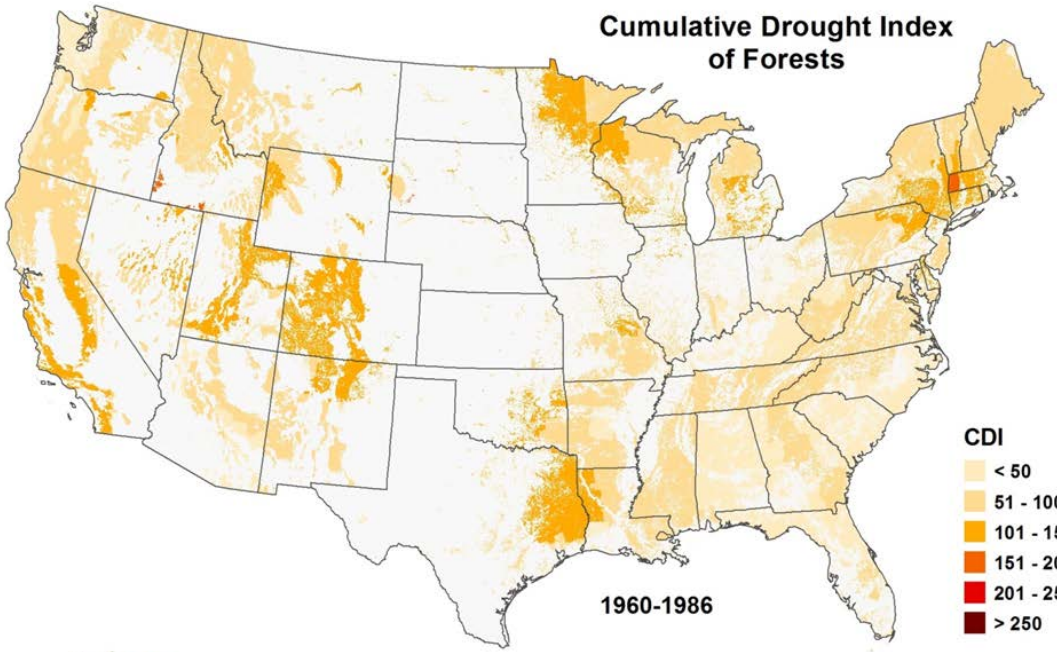
Bring in snow for the Iditarod in Anchorage

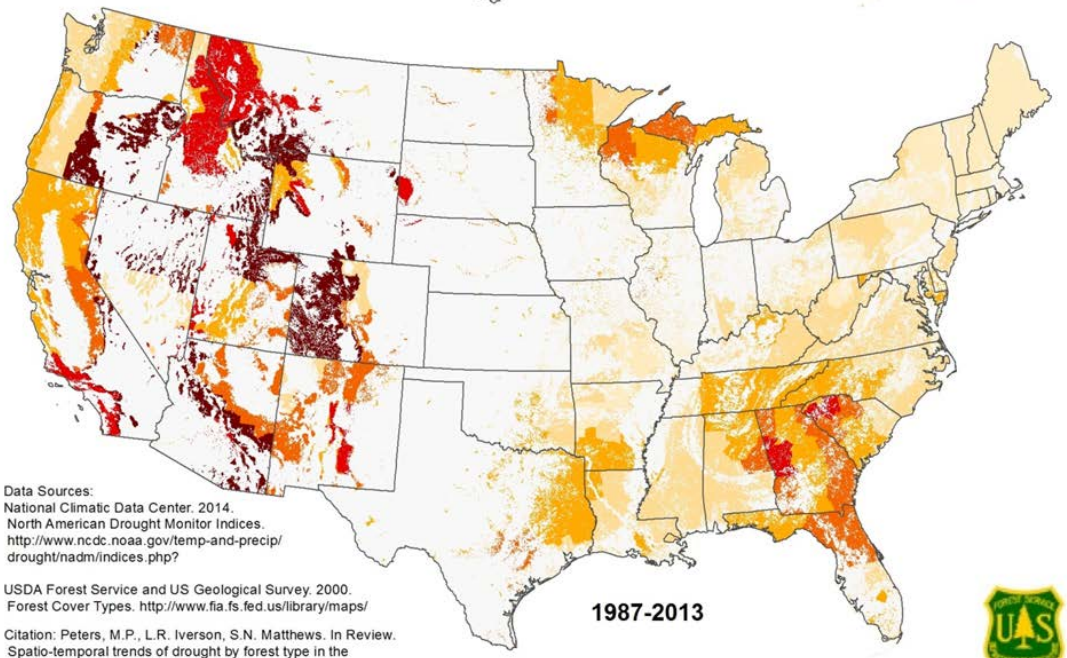
Snow is trucked in on March 7, 2015, for the ceremonial Iditarod start in Anchorage, Alaska.

Photo by David Hulen/Twitter

--While in Boston, where to put it?

Cumulative Drought Index of Forests





Data Sources:
National Climatic Data Center. 2014.
North American Drought Monitor Indices.
http://www.ncdc.noaa.gov/temp-and-precip/drought/nadm/indices.php?

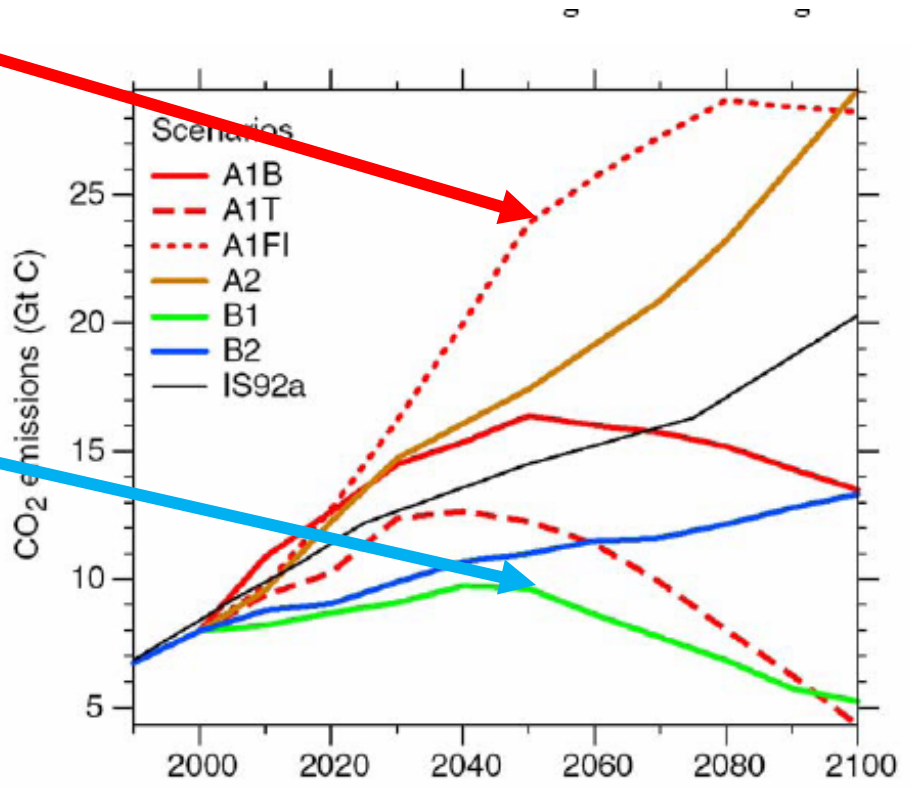
USDA Forest Service and US Geological Survey. 2000.
Forest Cover Types. http://www.fia.fs.fed.us/library/maps/

Citation: Peters, M.P., L.R. Iverson, S.N. Matthews. In Review.
Spatio-temporal trends of drought by forest type in the Conterminous United States, 1960-2013

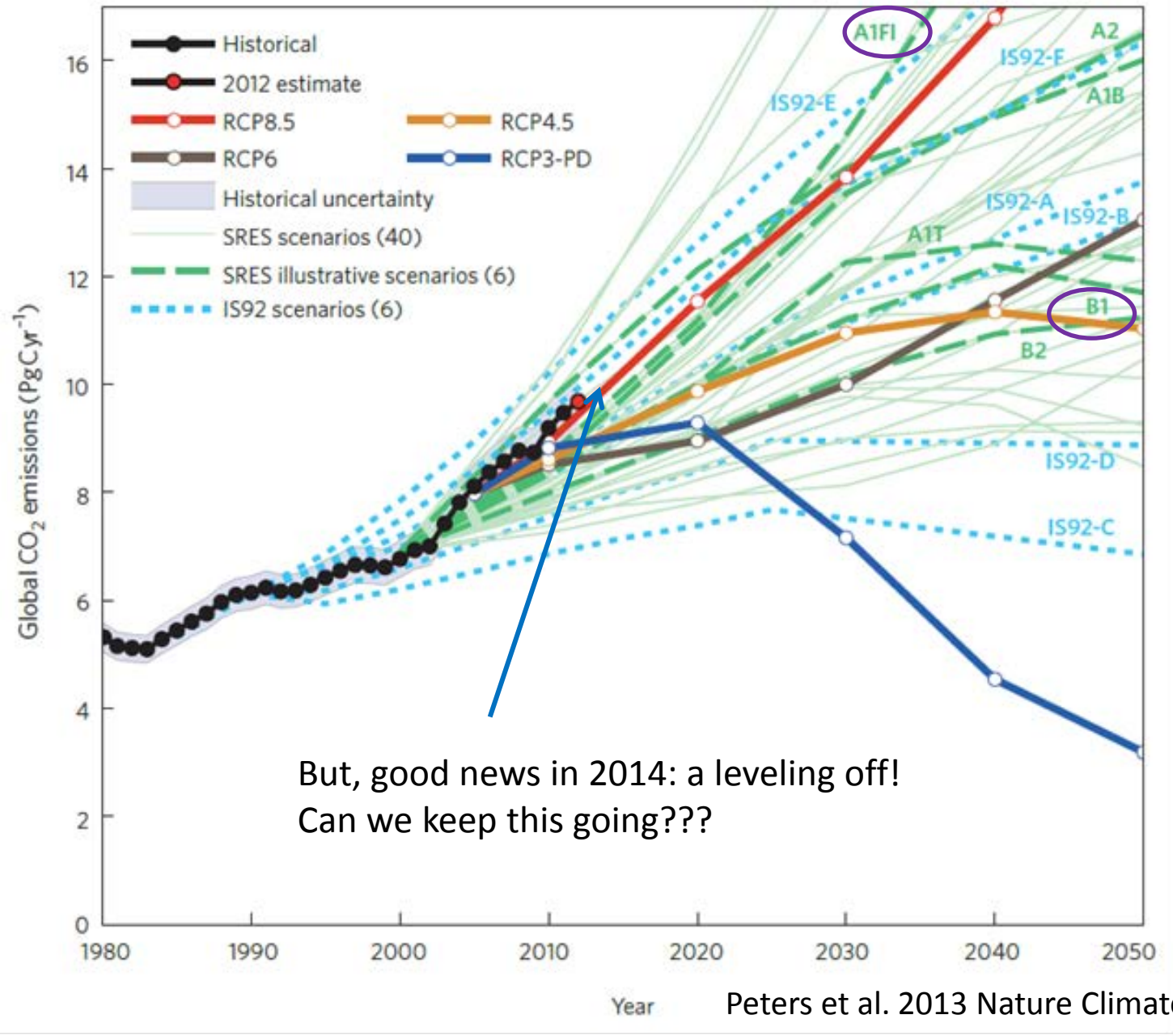
The Future Climate

Emissions of CO2 – range of scenarios over next 100 years

- A1fi (high)-fossil fuel intensive until later century
- B1 (low)-shift to resource efficient technology



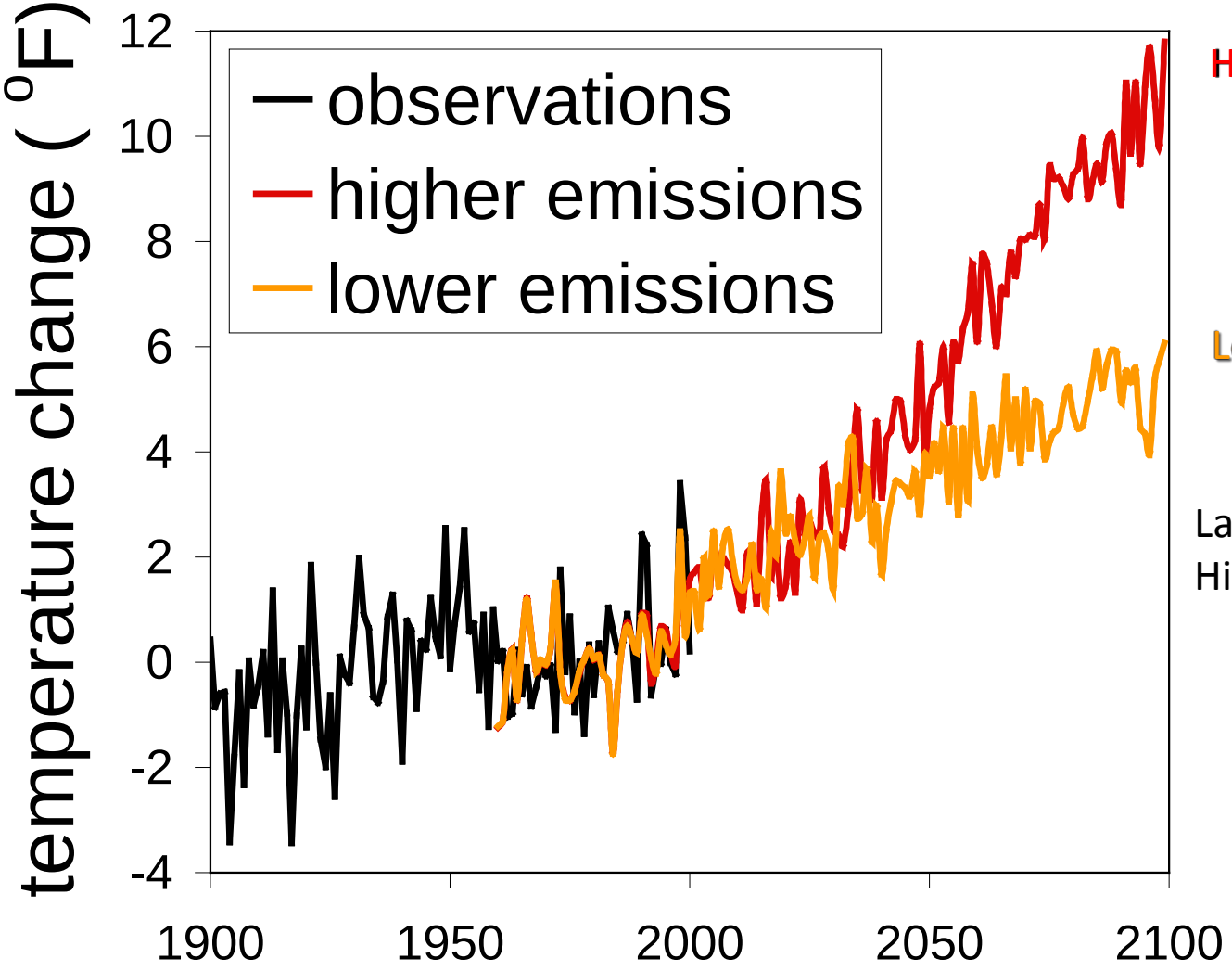
Past and potential future trends in annual CO2 emissions



But, good news in 2014: a leveling off!
Can we keep this going???

Peters et al. 2013 Nature Climate Change

Rising Temperatures in Eastern US
(it matters what humans decide to do!)



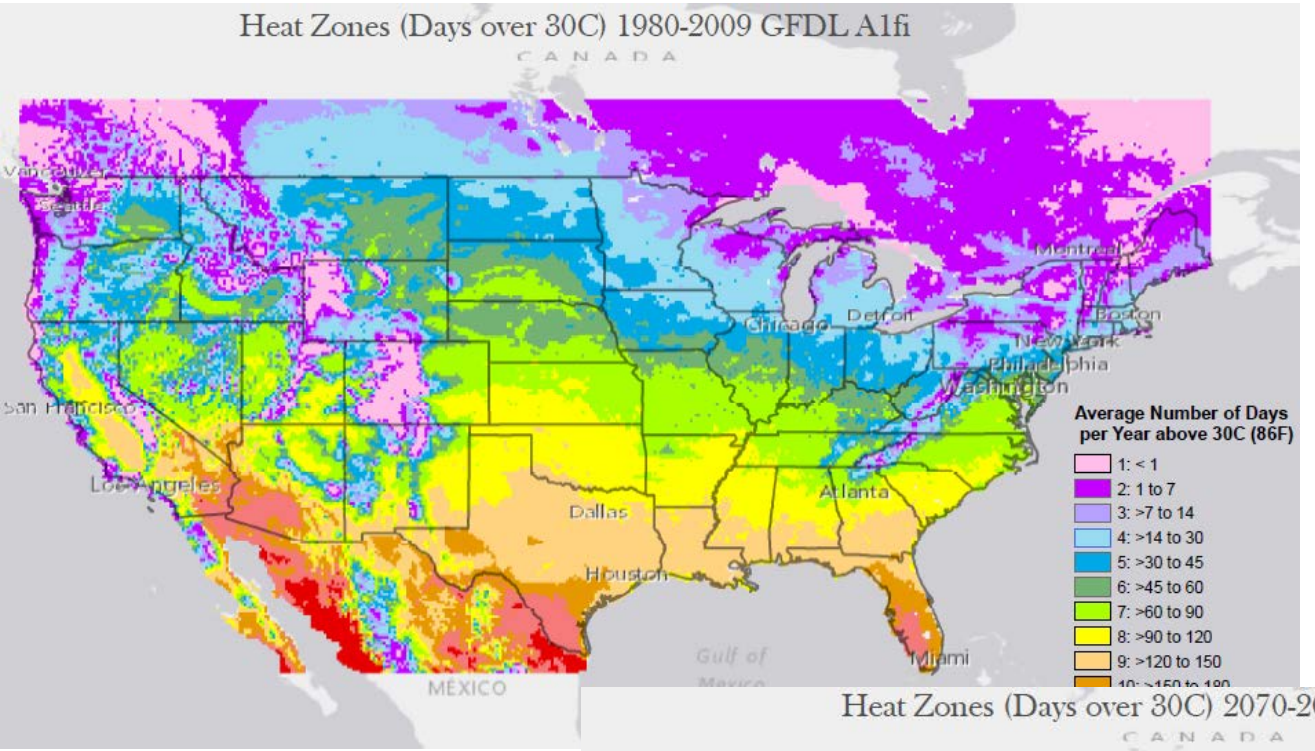
Higher: 3.6 – 7.0 ºC

Hadley A1Fi

Lower:2.0 – 3.6ºC

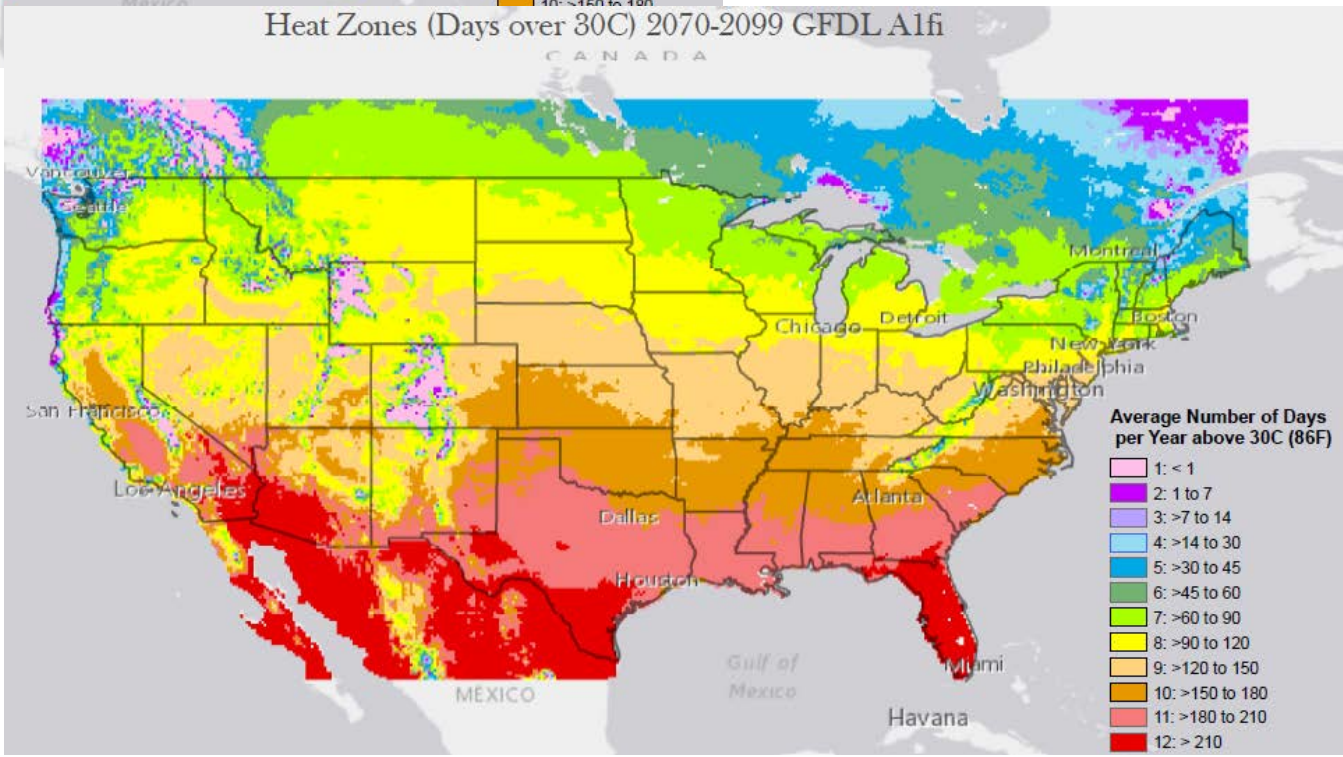
PCM B1

Large difference between High and Low emissions!



Annual Days over 86F

GFDL A1Fi represents a hot and dry scenario accompanying high emissions (harsh)



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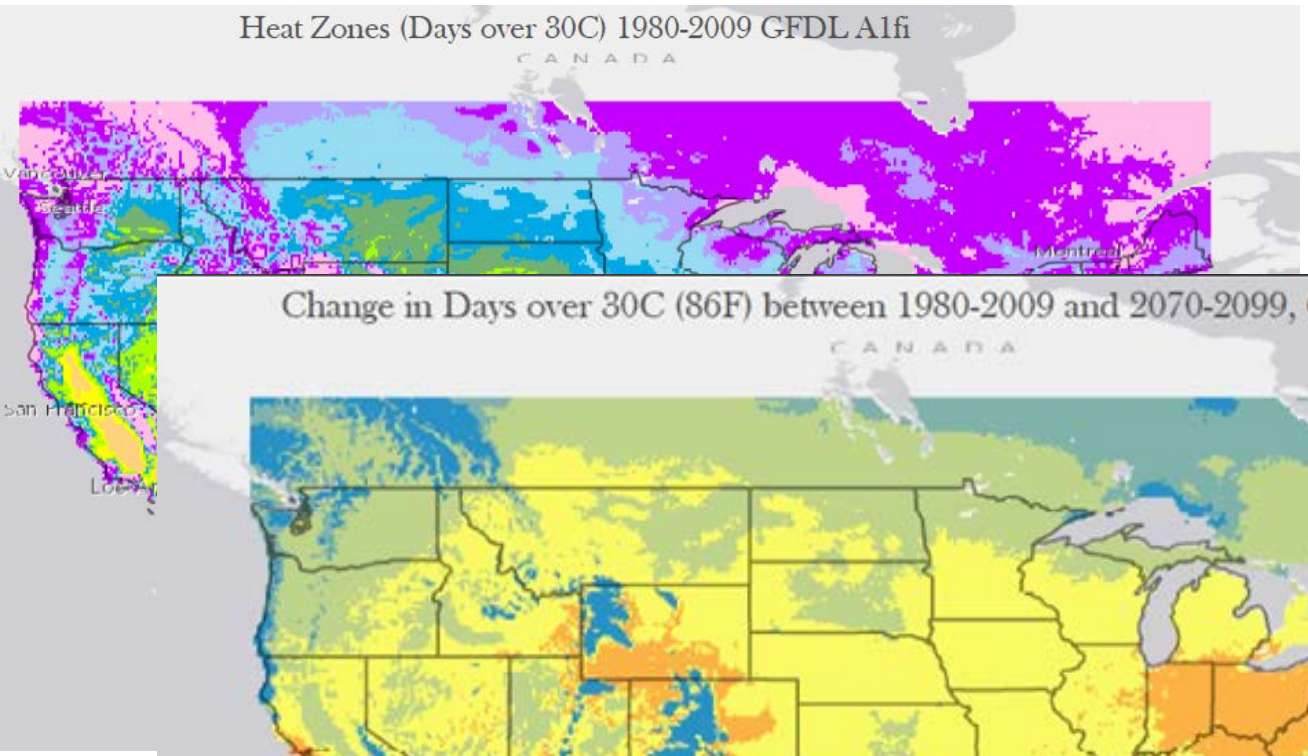
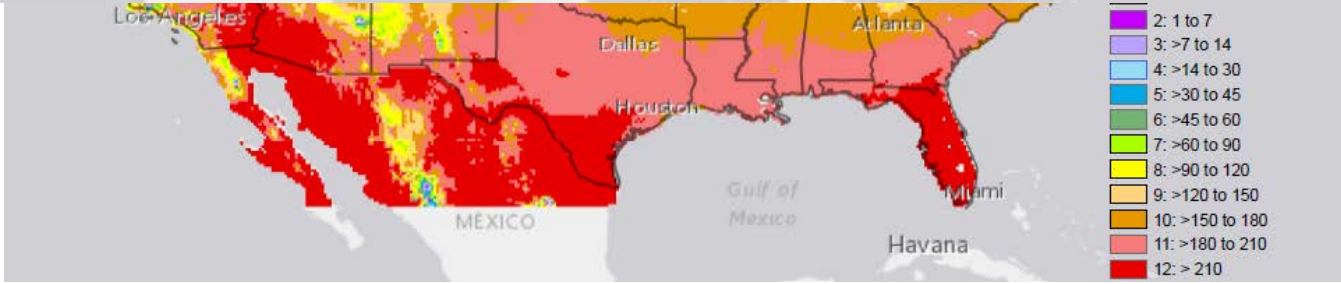
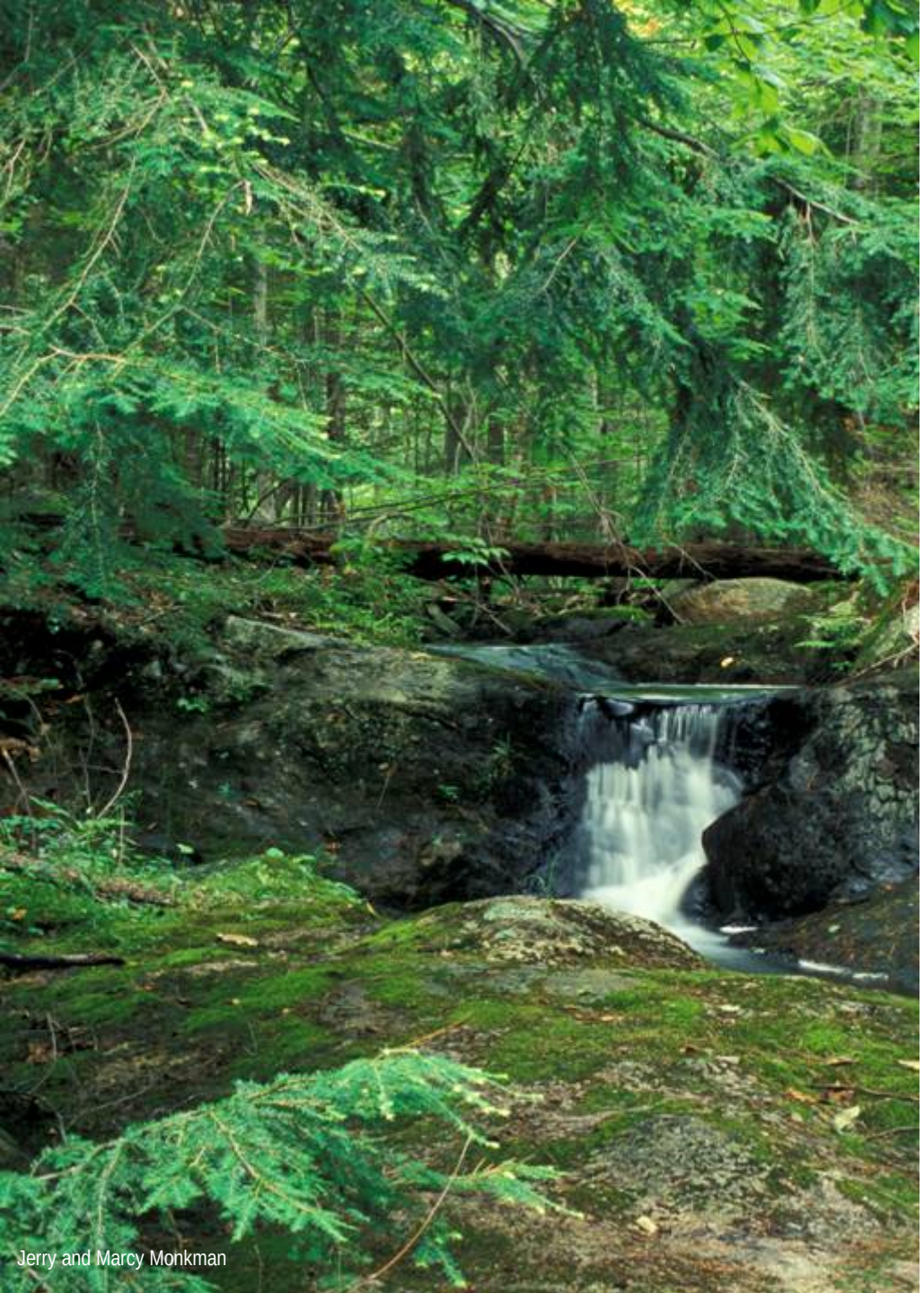






Modeling Impacts on Suitable Habitats for Tree (and Bird) Species in the Eastern US – An Atlas

sugar maple (*Acer saccharum*)

Model Reliability: High

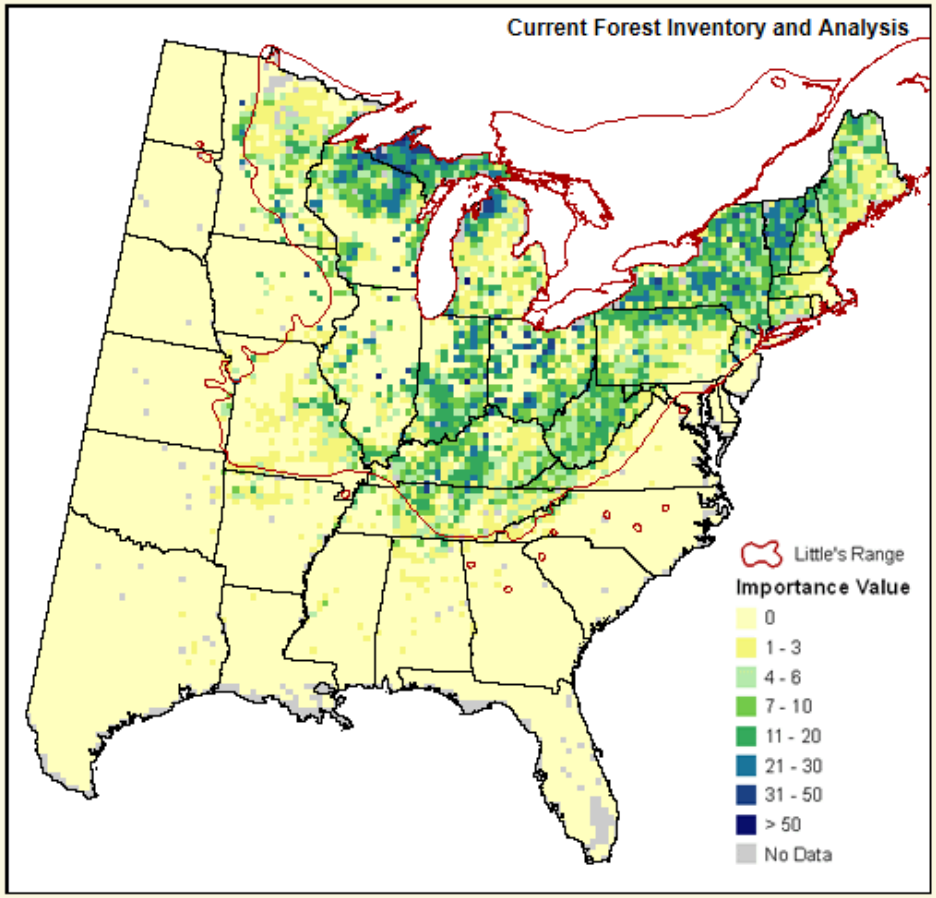
Current Distribution | Projected Future Habitat | Predictor Maps

Current Distribution Maps for sugar maple

Help »

Current Forest Inventory and Analysis

Compare Two Species



Potential Changes in Abundance and Range (Future)

GCM SCENARIO	% Area Occ	Ave IV	Sum IV	Future/Current IV
Actual FIA	31.8	8.6	26,735	NA

Cautions & Model Info

Notice:

This is an updated version of the Climate Change Tree Atlas. You can view the previous sugar maple page, or browse the previous Tree Atlas.

About sugar maple

Family: Aceraceae
Guild: persistent, slow-growing understory tolerant
Functional Lifeform: large deciduous tree

- Life History and Disturbance Response
- Silvics Manual
- Photos of sugar maple in USDA Plants Database
- View current and modeled sugar maple distributions in Google Earth (219 KB)

Download Google Earth for free

Climate Change Adaptability

Summary of Predicted Changes

Range and Niche Maps

Predictor Analysis

Search for Trees & Birds:

Enter a common or scientific name

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

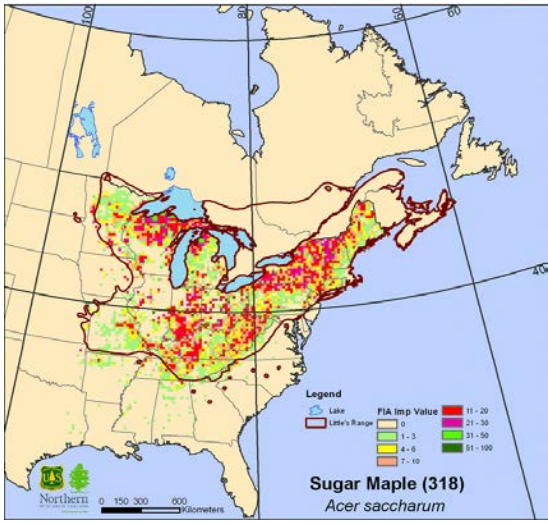
Atlas ingredients: methods and terminologies

Modelled responses

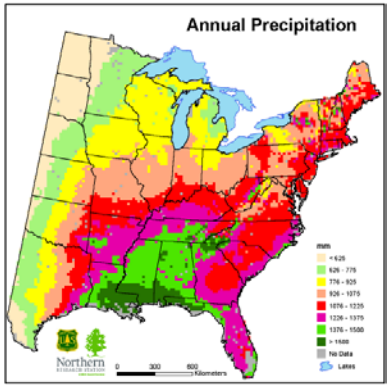
Forest Inventory and Analysis (FIA)
- Eastern US extent (37 states)
- 134 tree taxa
- > 100,000 plots
- ~ 3 million tree records

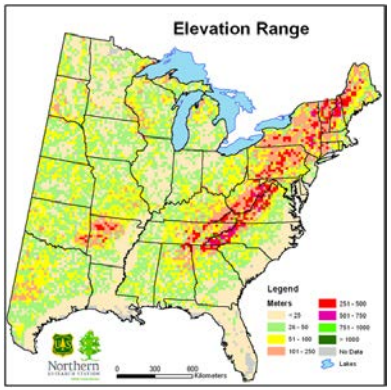
Importance value (IV)
for 134 tree species
(Range: 0-100)
(IV=0 => species absent
IV=100 => only species present)

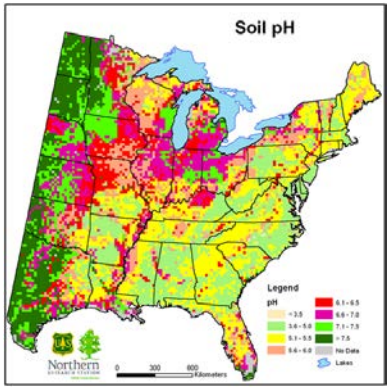
Abundance & Little's Range Maps



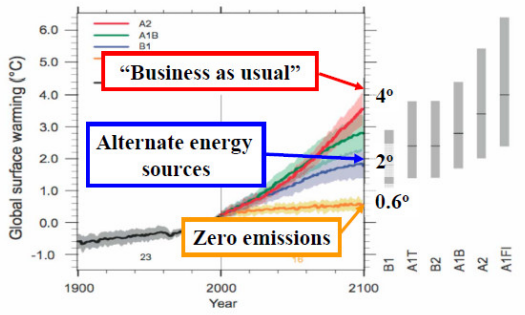
- Predictor variables
  - For tree models based on climate, elevation, soil properties, soil class
- Method: Random Forest regression based
- Models 20-km resolution







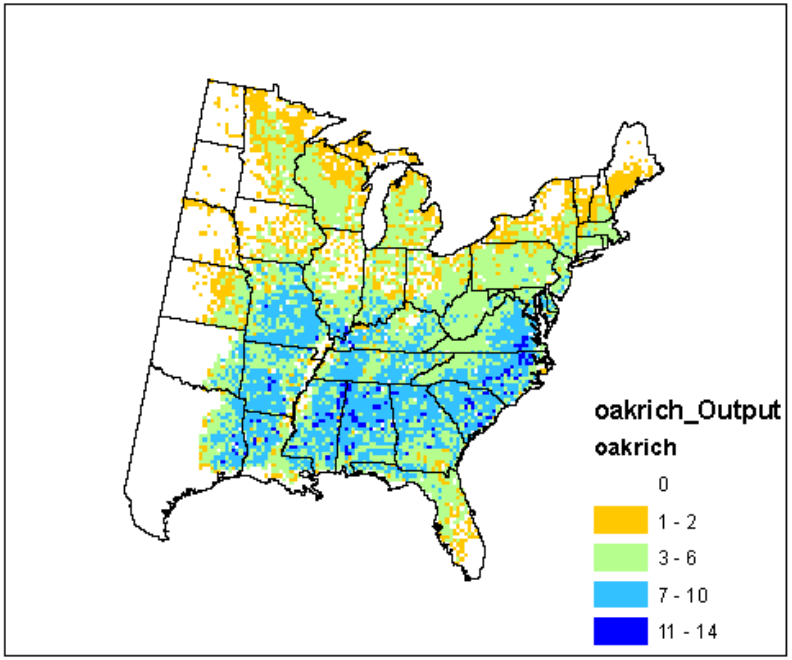
Earth is expected to warm by at least 2-4° C by 2100[11]

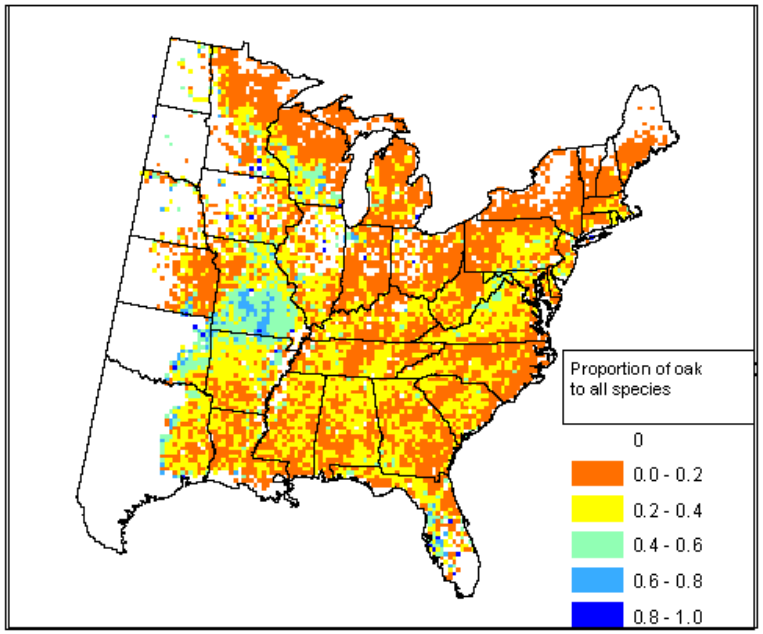


CO_2 has an atmospheric residence time of >100 years

Oak component

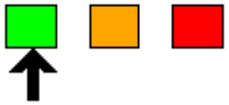
- Of the 134 species we work with 26 are in the genus Quercus
- Represents broad range of conditions



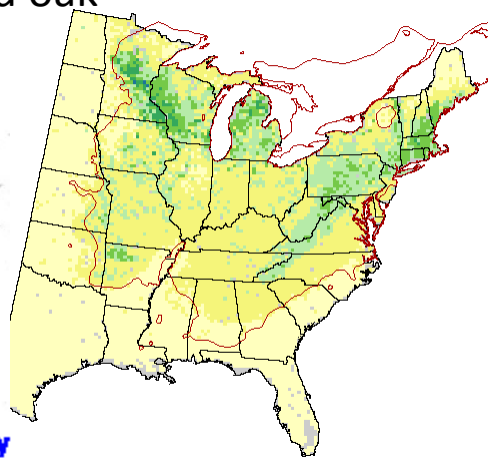


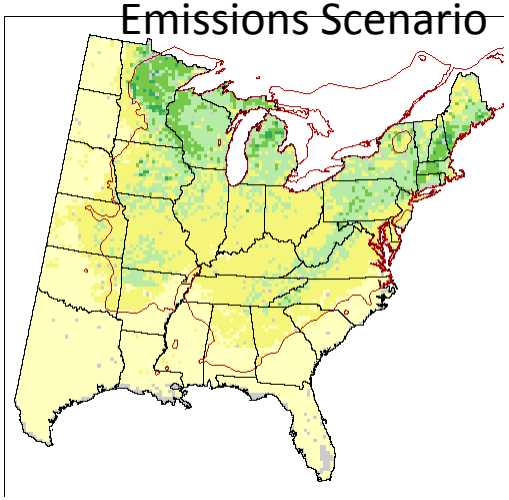
Northern Red oak

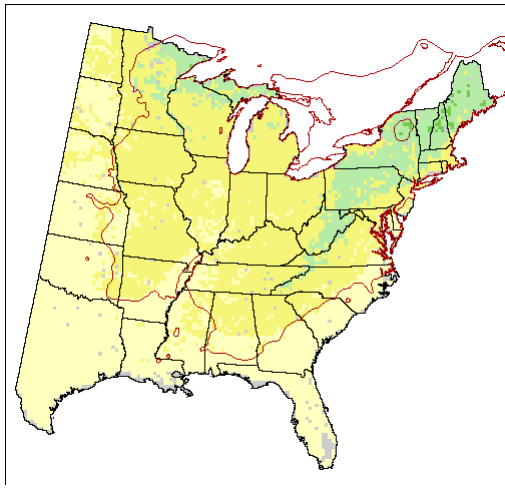
Model Reliability



Emissions Scenario





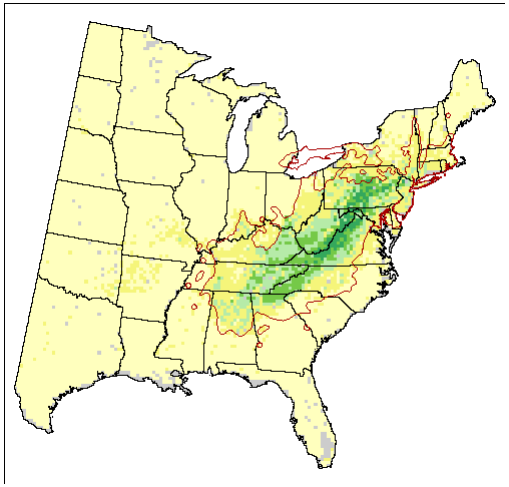


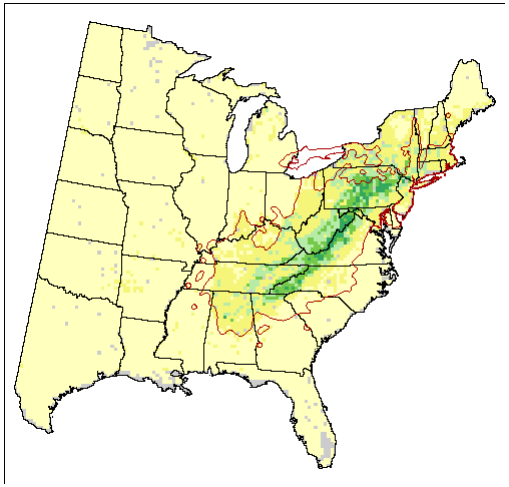
Current Modeled

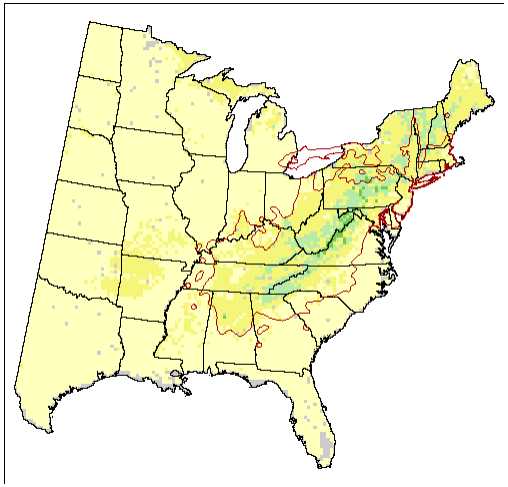
PCM-B1

GFDL-Aifi

Chestnut Oak







Model reliability

Not all species models are equal – need to know about "model confidence" for each species:

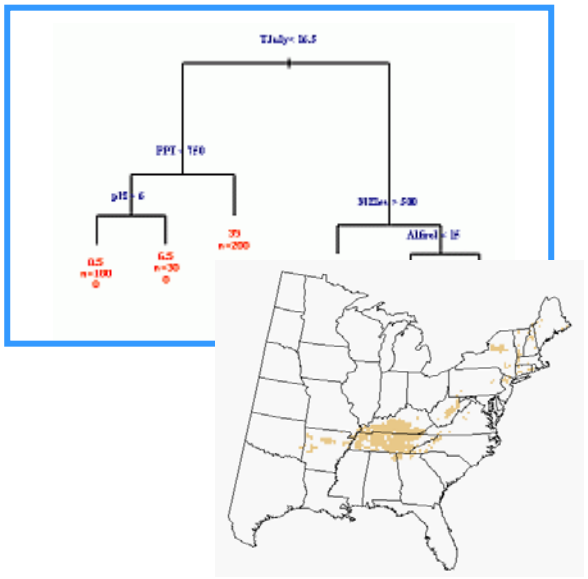
We therefore rate the reliability of the DISTRIB model into three classes - taking into account several model performance factors

Based on: Model fit, Spatial representation , Stability and consistency

Of the 26 Quercus: 10 high, 12 mid, 4 low

Assessing model drivers

- Unlike RTA with direct interpretation of predictor variables RF is more challenging *(Bootstrap sampling + randomized subset of predictors for each split)*



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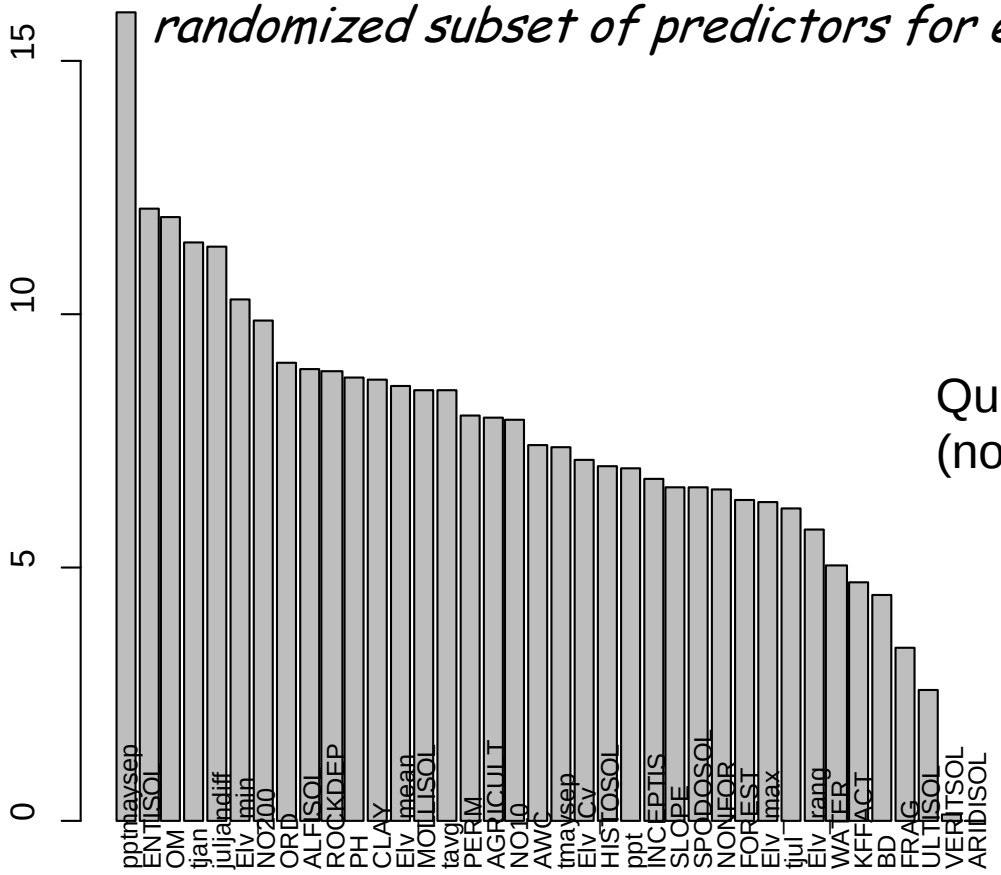
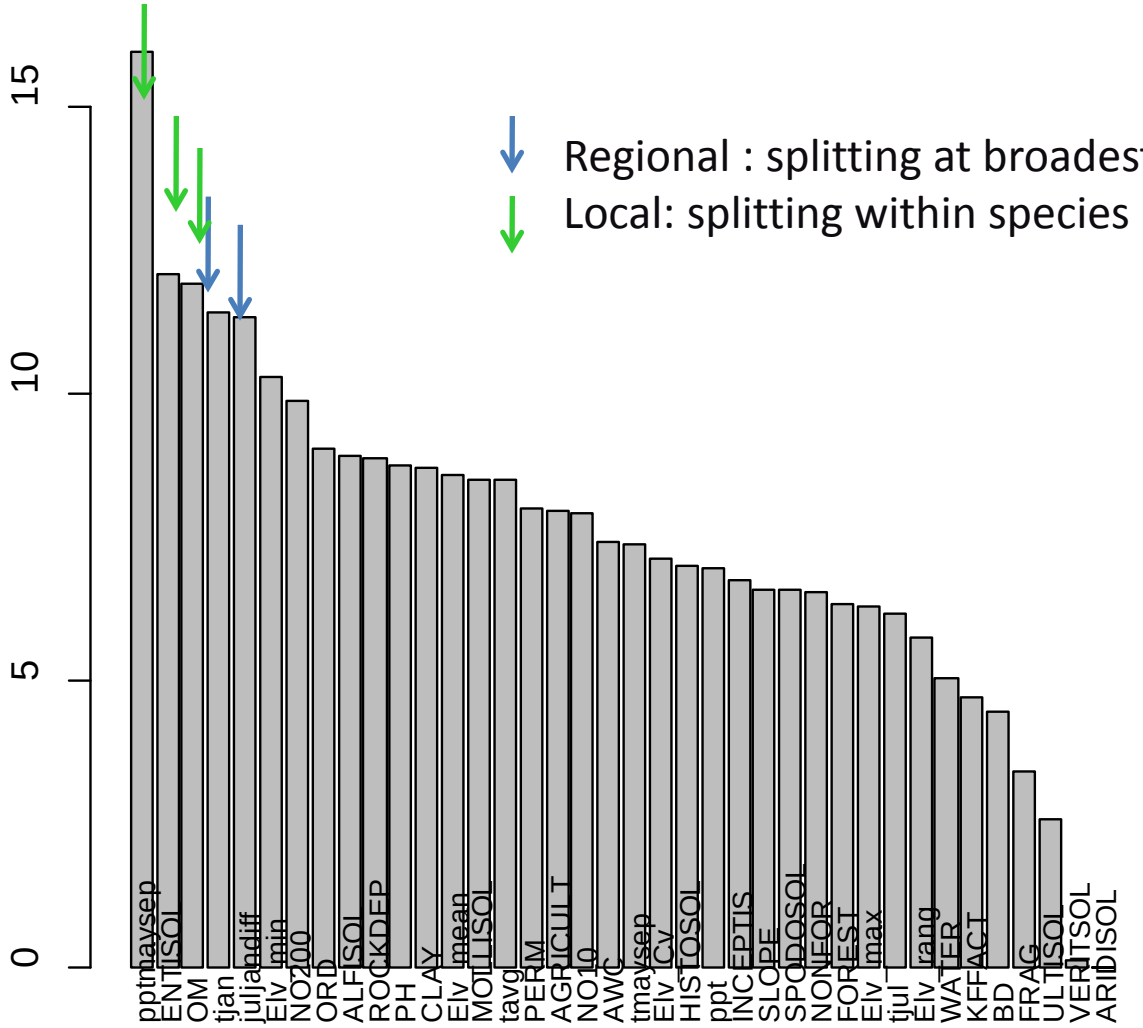


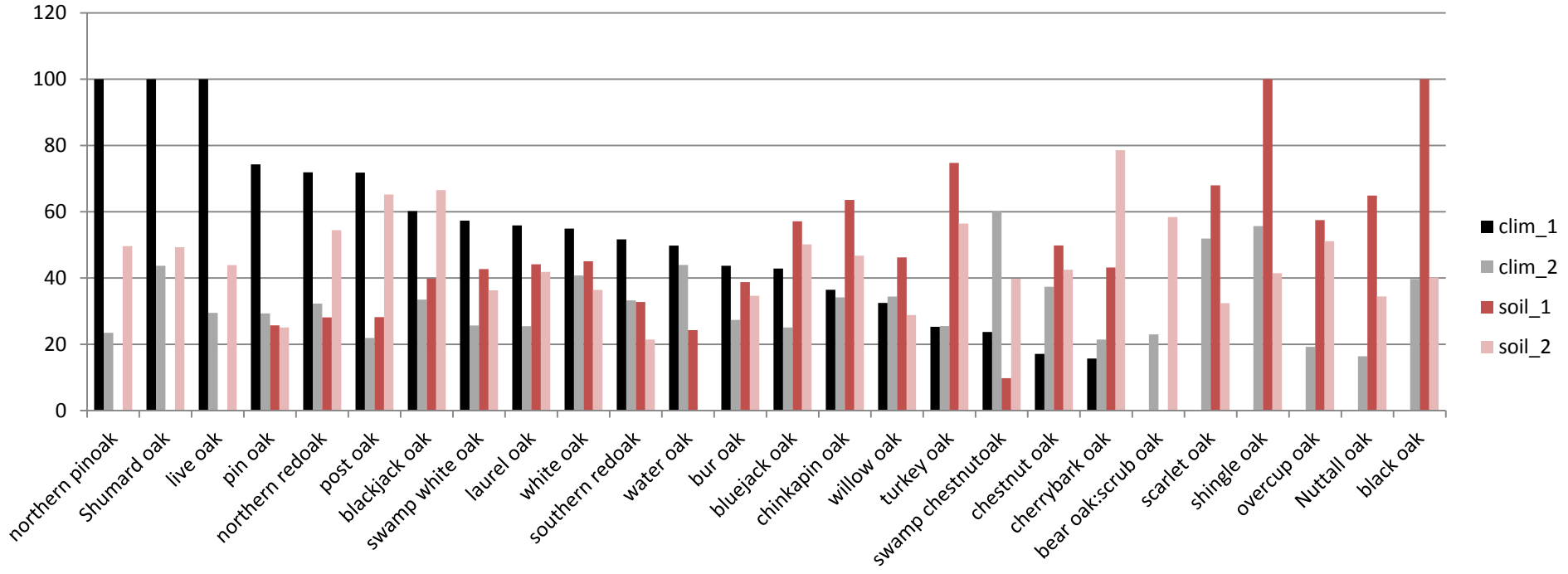
Quercus ellipsoidalis
(northern pine oak)

Assessing Drivers: Quercus ellipsoidalis



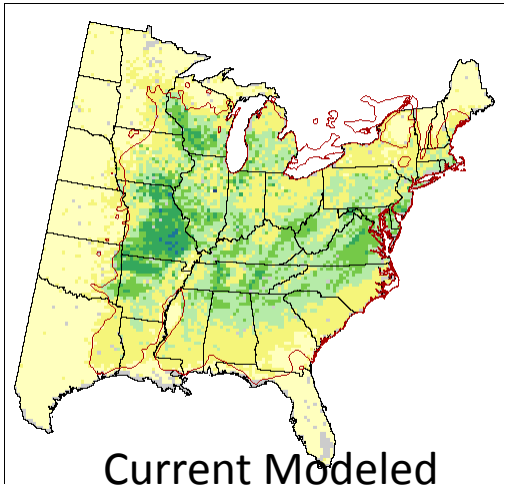
Tends to vary more by species than by group:

Identify how the model is partitioning the species distribution and if variables are more associated with species extent or within range patterns of occurrence

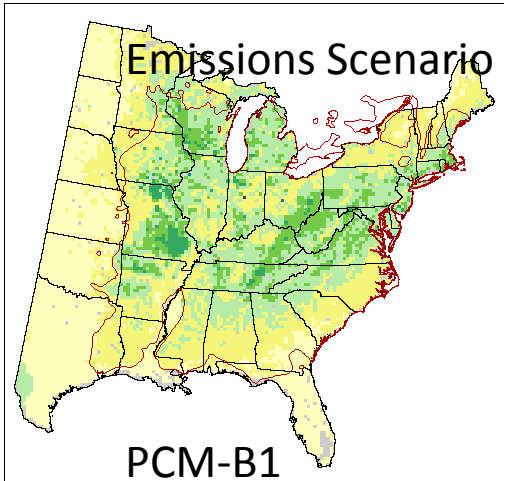


White oak

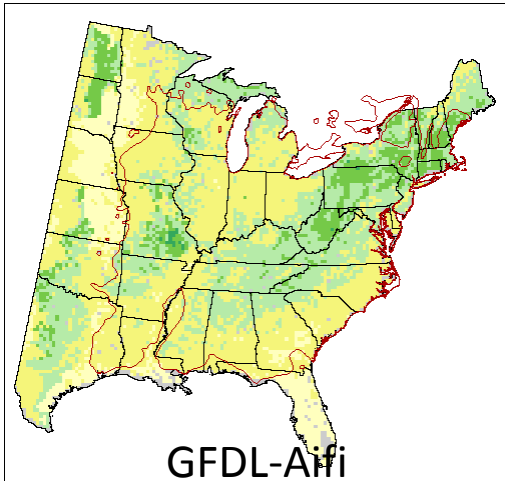
Emissions Scenario



Current Modeled

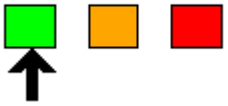


PCM-B1

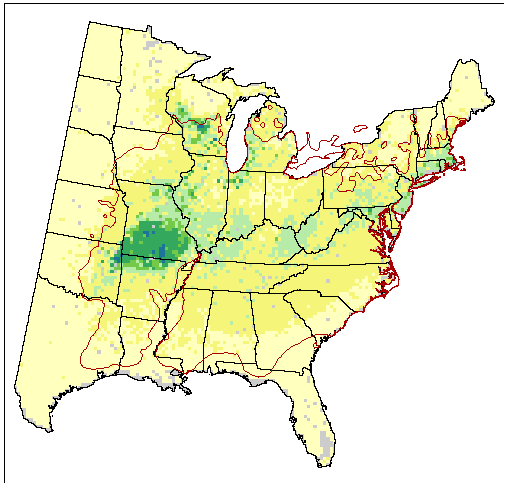


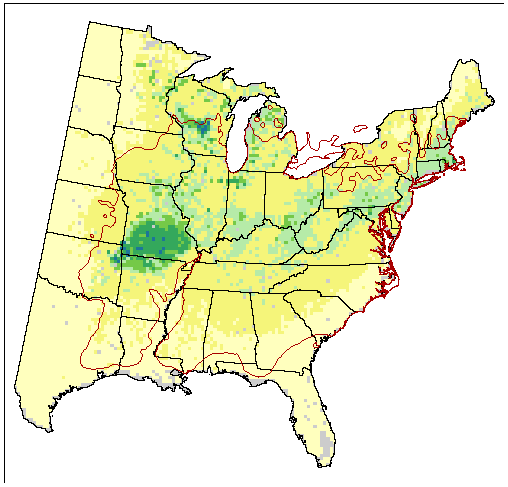
GFDL-Aifi

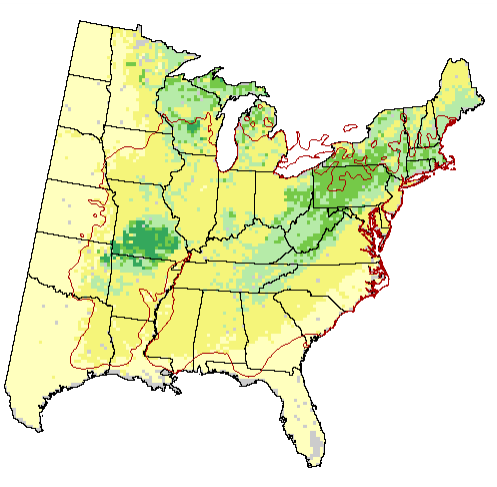
Model Reliability



Black Oak



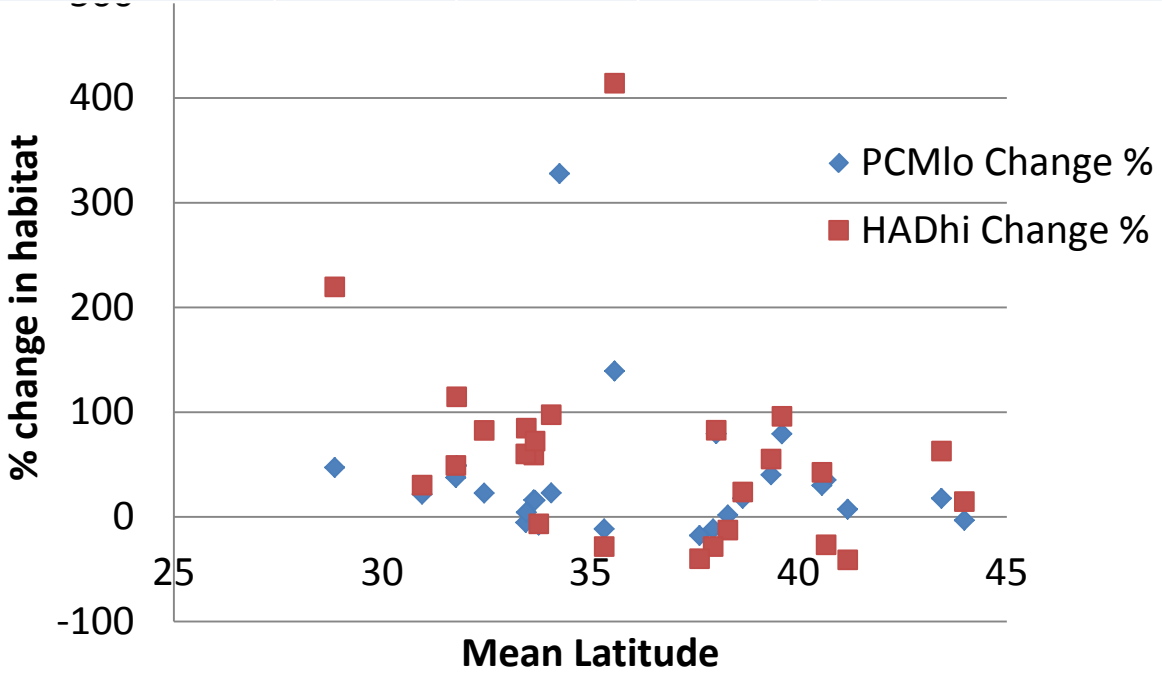




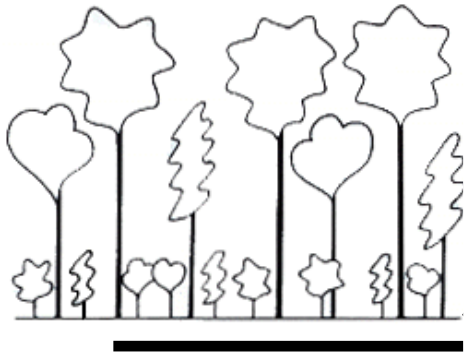
Summary across oaks

- Quercus as a group has projected increases in habitat, with 63 to 74 percent of the species projected to gain at least 10% in suitable habitat
- Between 15 and 26 percent of the species are projected to decline by at least 10% depending on the climate change model and emissions scenario

	Eastern US (%)	Longitude	Latitude	Mod Rel	PCMlo Change %	HADhi Change %	New habitat outside range %
white oak	47.3	-86.86	38.3	High	1.7	-12.6	3
swamp white oak	4.7	-86.66	40.66	Low	35.3	-26.7	56.8
chestnut oak	14.4	-80.97	37.95	High	-11.5	-28.3	14.8
scarlet oak	20	-82.92	37.62	High	-17.8	-39.9	24.6
bur oak	13.2	-94.17	43.43	Medium	17.6	62.9	27.8
northern redoak	43.1	-85.37	41.18	High	7.3	-41	2.2
black oak	36	-87.76	38.66	High	17.6	23.7	4



But many other factors come into play to determine more likely outcomes



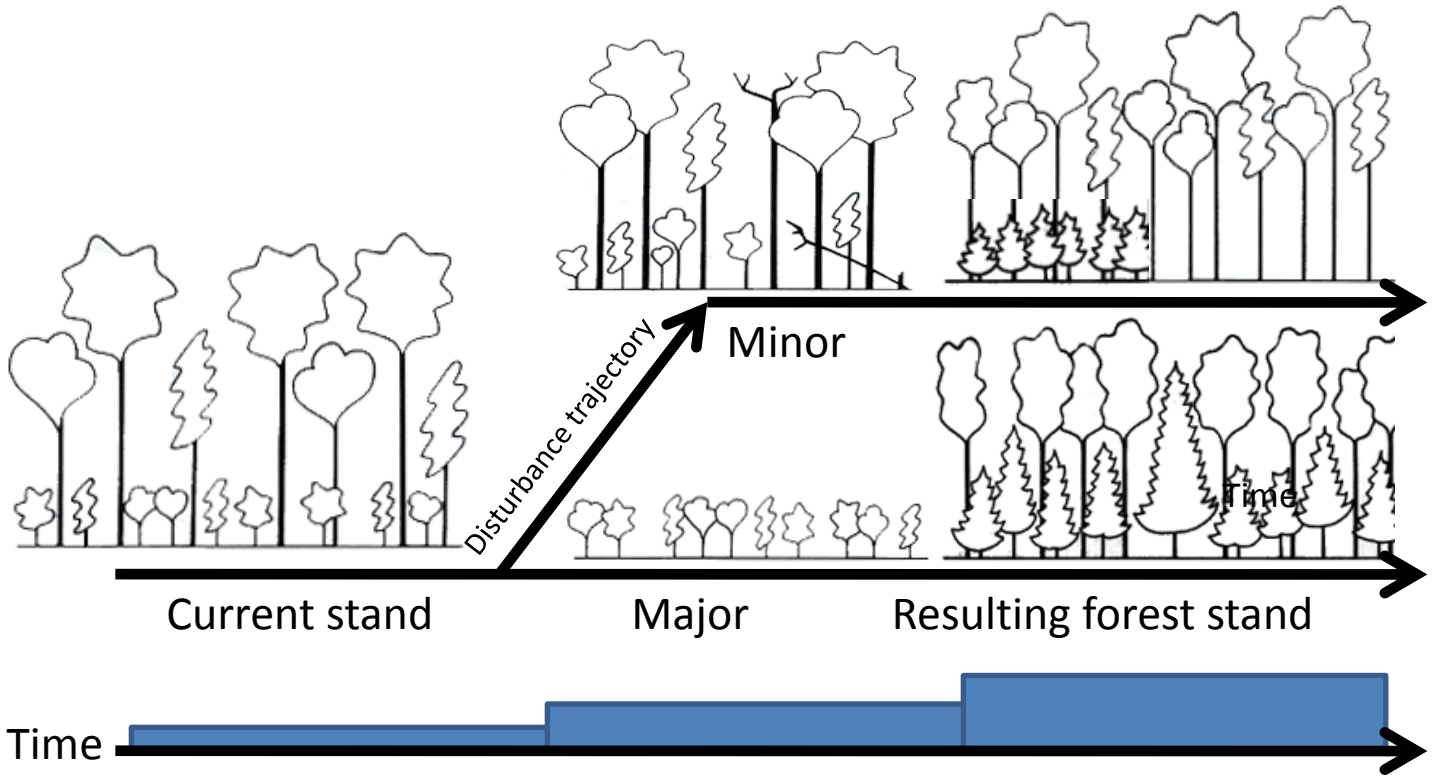
Current stand

Future stand ?

Time

Climate change pressure increases thus altering habitat suitability of species

But many other factors come into play to determine more likely outcomes



Climate change pressure increases thus altering habitat suitability of species

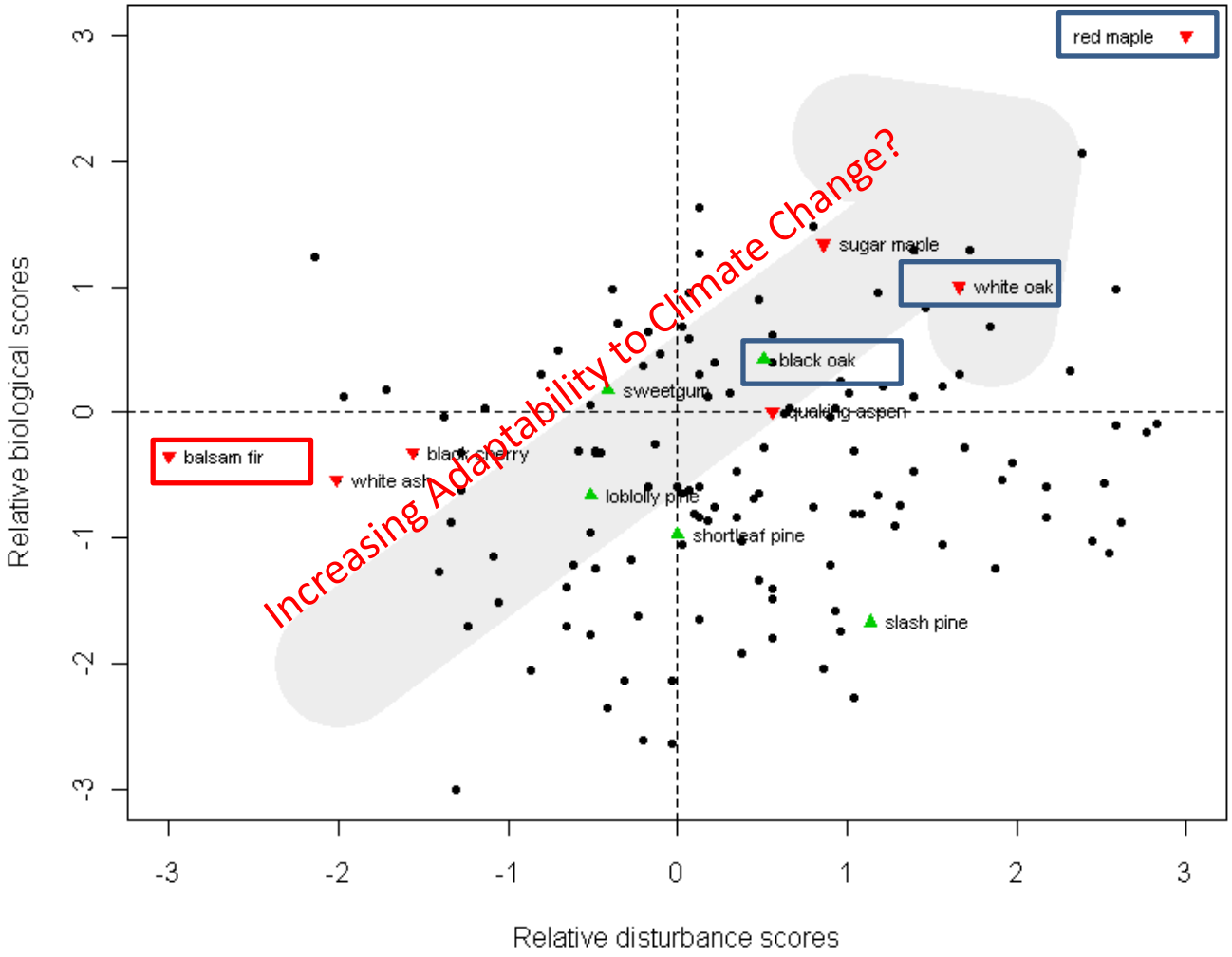
Modifying factors

- We rate biological (n=9) and disturbance (n=12) characteristics for positive or negative impacts
  - Bio: Shade tolerance, Seedling est., Dispersal
  - Dist: Fire topkill, Insect pest, Drought, Flood

- Creating a multi-criteria framework to evaluate more realistic outcomes at regional and local levels

Matthews et al. 2011

Provides an independent means to assess if species traits might be favored or limiting as climate change pressures accelerate

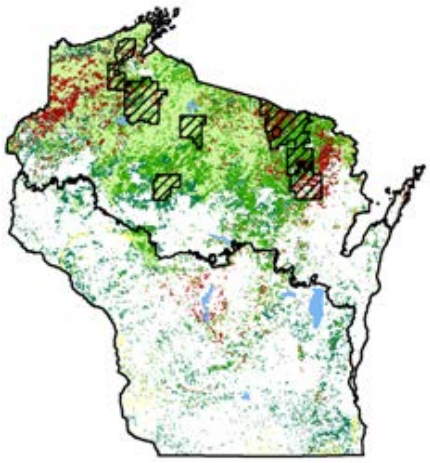


Migration

- So the suitable habitat is changing, but how fast and far might tree species actually move by year 2100?
- If we might want to get involved to help move a species with assisted migration, how might this work?

Modeling Migration and Assisted Migration

- A preliminary example for northern Wisconsin
- Black oak (*Quercus velutina*) – a species modeled to move habitat north

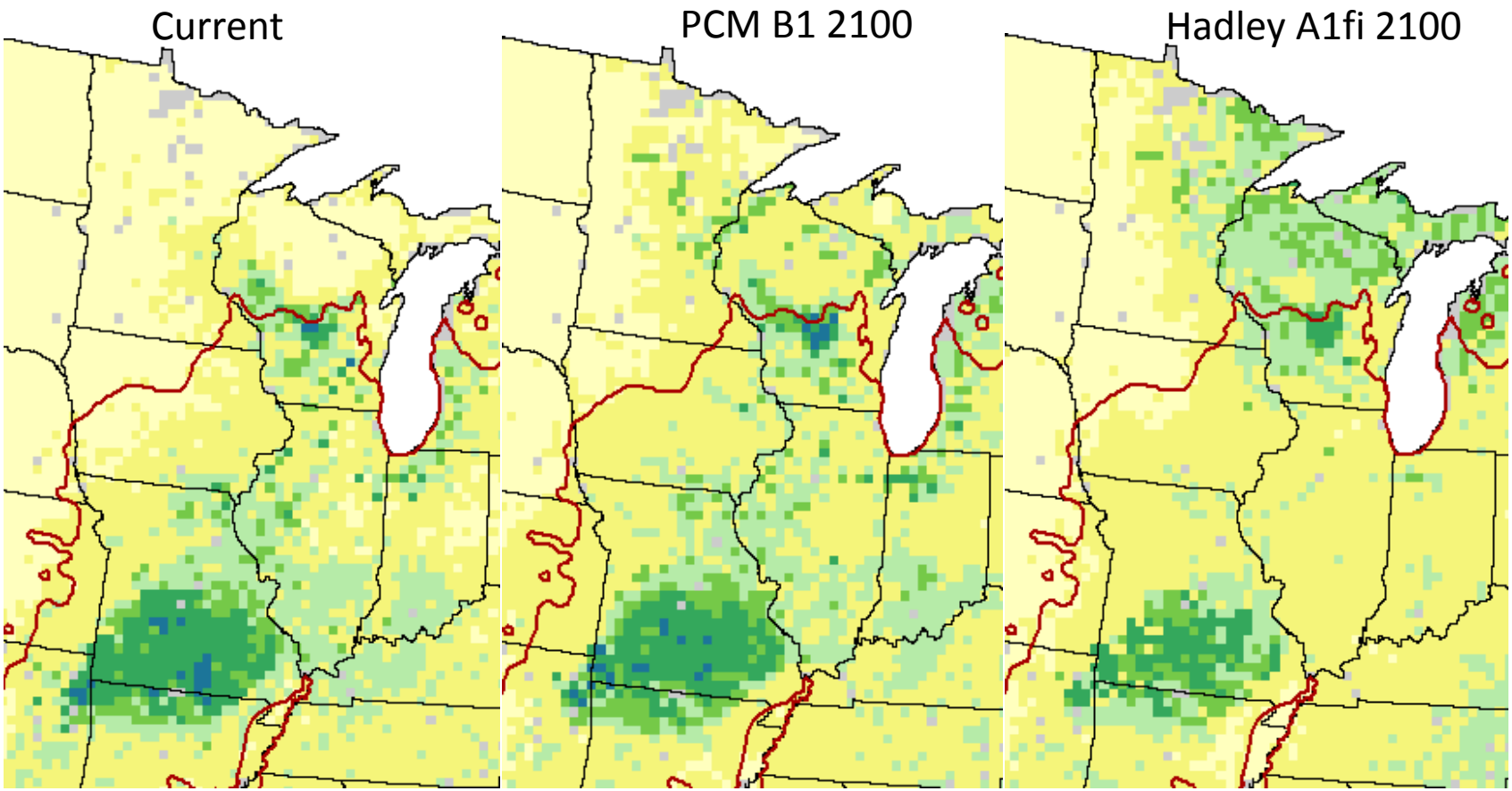


(Gainers)

WhiteAsh
EasternHophornbeam
AmericanHornbeam
AmericanElm

BlackCherry
BurOak
AmericanBeech
WhiteOak
BitternutHickory
BlackOak
Boxelder
SwampWhiteOak
ShagbarkHickory
SilverMaple
BlackWillow
SlipperyElm
EasternCottonwood
OsageOrange
EasternRedCedar
BlackWalnut
Hackberry

Black Oak Suitable Habitat
A large increaser for northern Wisconsin

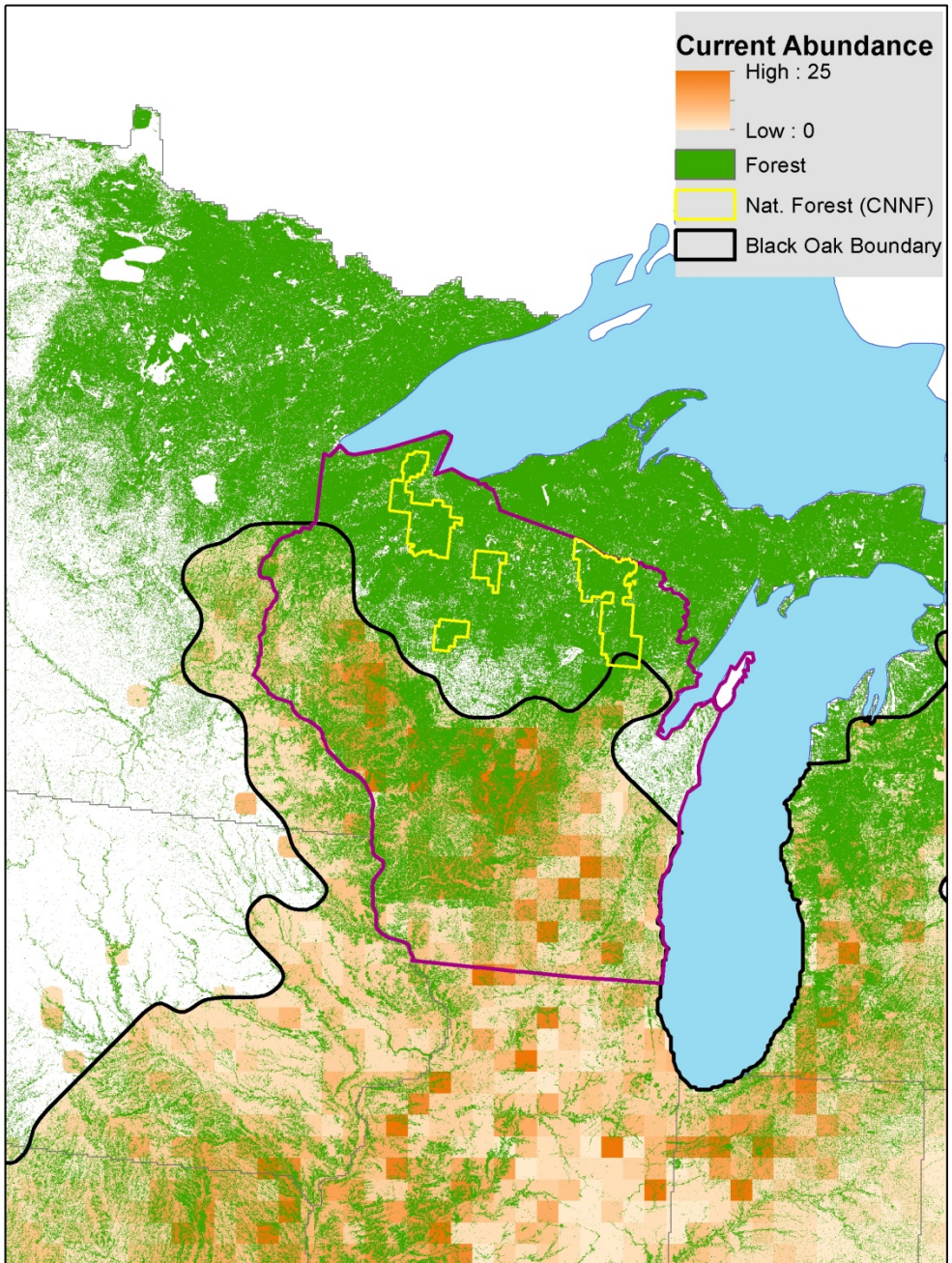


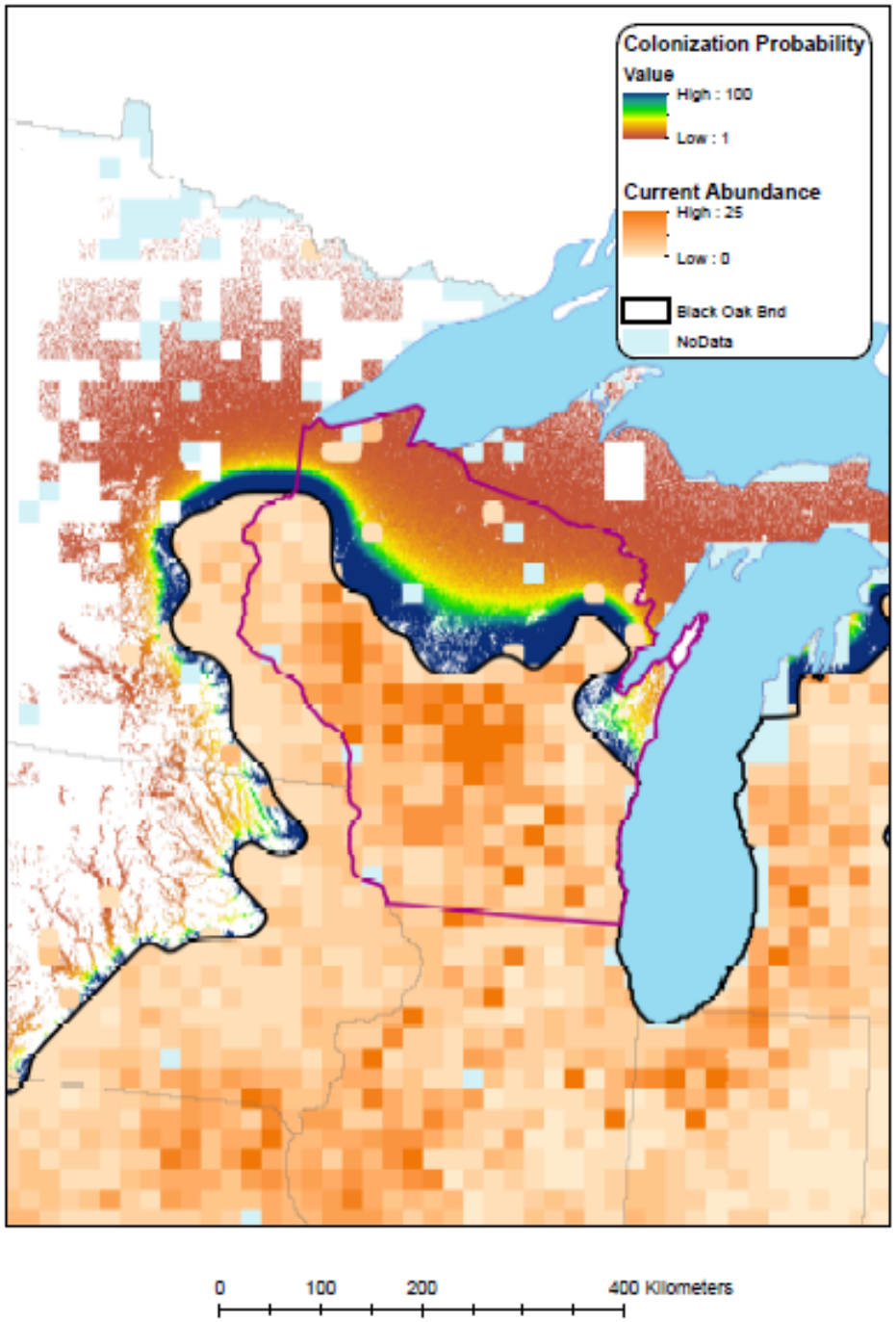
www.nrs.fs.fed.us/atlas

SHIFT: Model 100-year migration

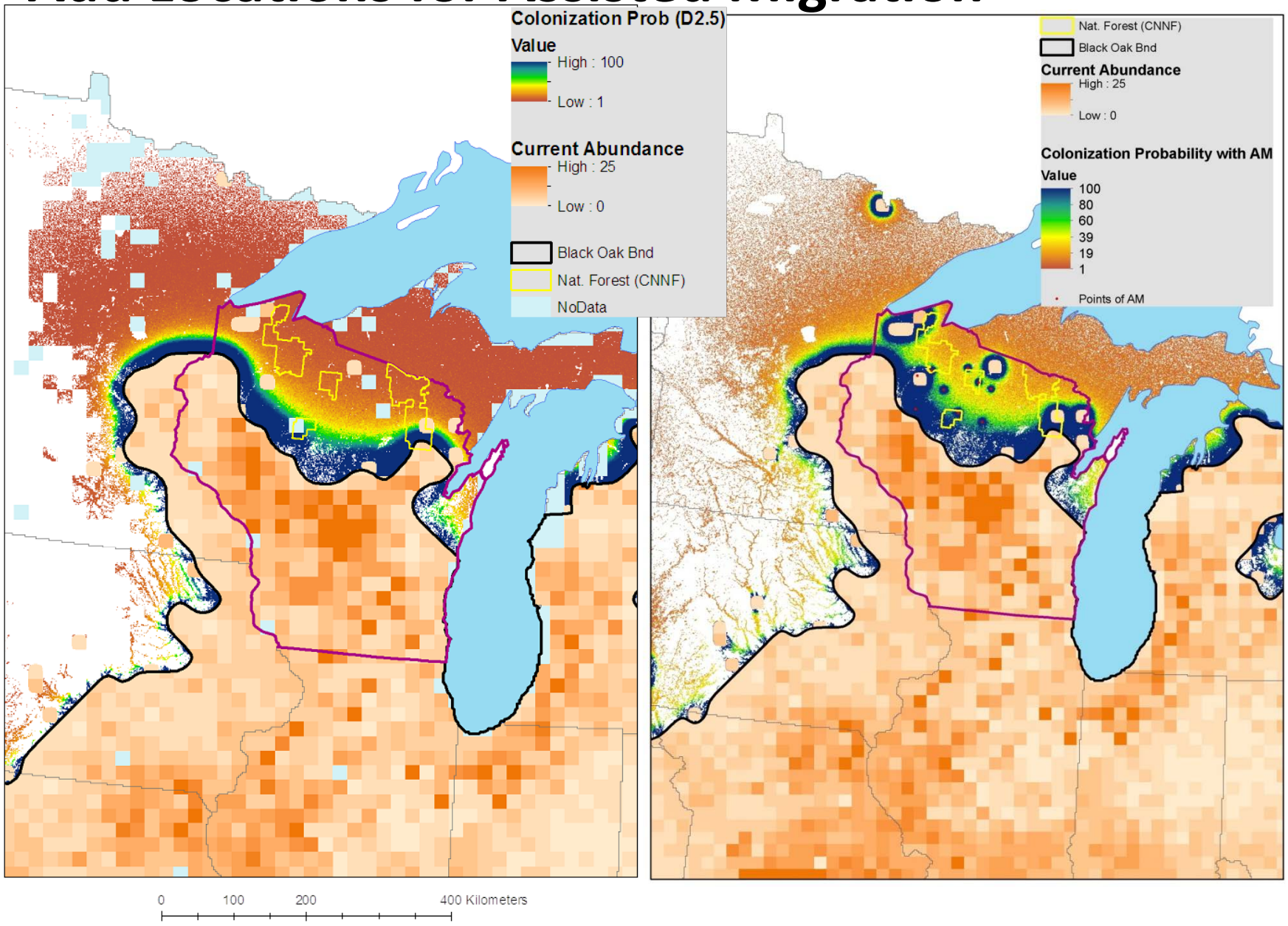
- Based on ~50 km/century (same as Holocene rate of migration)
- Output is probability of a 1 km cell getting colonized in 100 years
- Overlay with where habitat will be suitable in 100 years under 2 scenarios of climate change

Source and Sink Strength



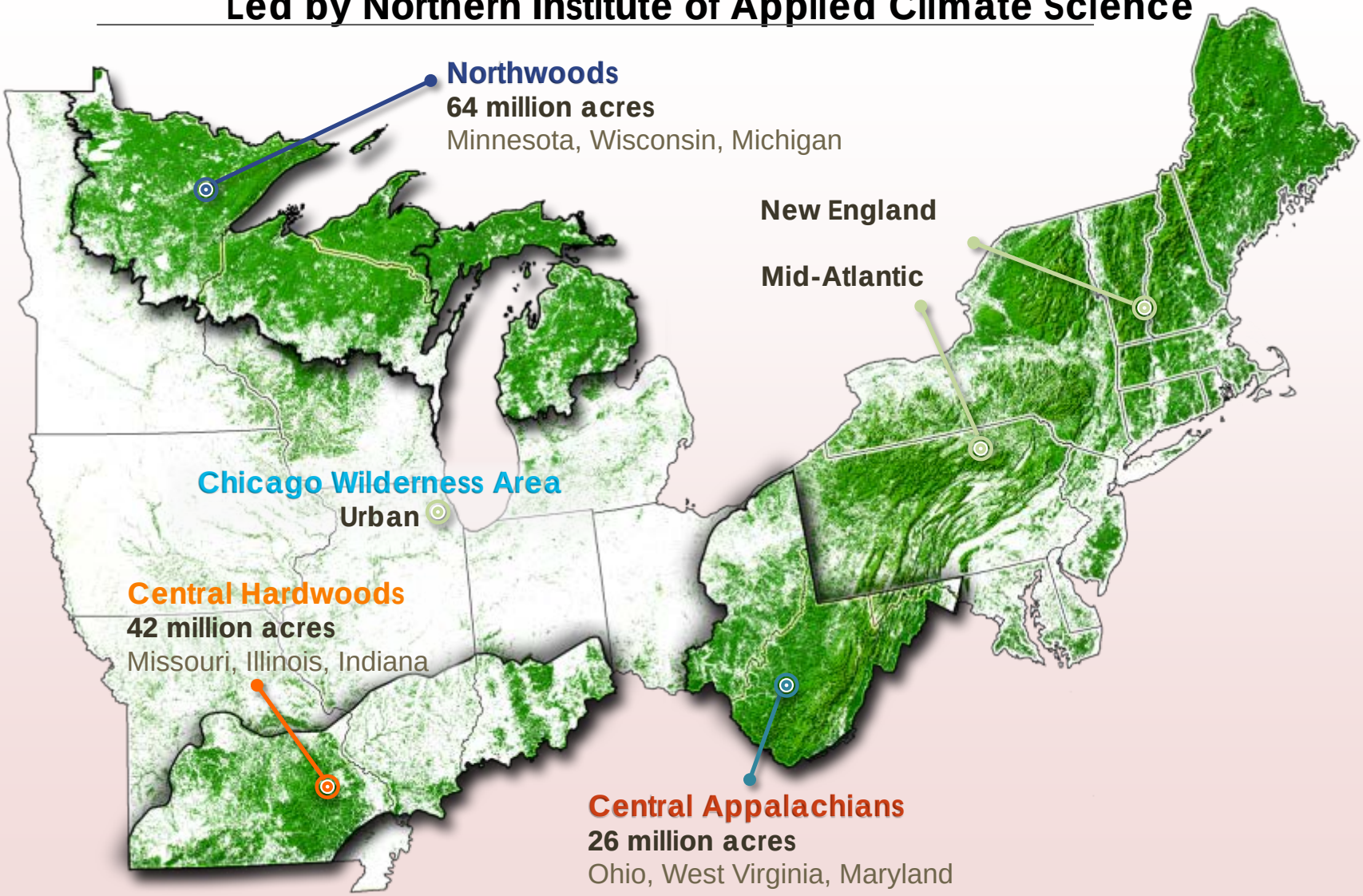

Colonization Probability
Value
High : 100
Low : 1
Current Abundance
High : 25
Low : 0
Black Oak Bnd
NoData
0
100
200
400 Kilometers

Add Locations for Assisted Migration



CLIMATE CHANGE **RESPONSE** FRAMEWORK

Led by Northern Institute of Applied Climate Science



Climate-Informed
Conservation and Forest Management

forestadaptation.org

Climate Change Response Framework

Structured, process-oriented, works on multiple scales

Components:	**Progress:**
Partnerships	75+ partner organizations (and counting)
Vulnerability Assessment	6 published assessments
Forest Adaptation Resources	Published in 2012, updated and online versions in prep
Adaptation Demonstrations	60+ demonstrations underway

Vulnerability Assessment

Ecoregional Vulnerability Assessments

Audience: Land managers

Scope: Forest ecosystems

Vulnerability of:

- Tree species
- Forest/natural communities
- Does not make recommendations

Vulnerability Assessment

Local Info → Potential Forest Change →  → Vulnerability *(& Confidence)*

Place-based, model-informed, expert-driven, transparent

Forest Ecosystem Vulnerability Assessment and Synthesis for Northern Wisconsin and Western Upper Michigan: A Report from the Northwoods Climate Change Response Framework Project

Table 13.—Climate change vulnerability determinations for the forest systems considered in this assessment

Forest system	Potential impacts	Adaptive capacity	Vulnerability	Evidence	Agreement
Aspen-birch	Moderate-Negative	Moderate	Moderate-High	Medium-High	Medium-High
Jack pine	Moderate-Negative	Moderate-High	Moderate	Medium	Medium-High
Lowland conifers	Negative	Moderate-Low	High	Medium	Medium-High
Lowland-riparian hardwoods	Moderate-Negative	Moderate	Moderate-High	Limited-Medium	Medium
Northern hardwoods	Moderate-Negative	Moderate-High	Moderate	Medium-High	Medium
Oak	Moderate	Moderate-High	Moderate-Low	Medium	Medium-High
Red pine	Moderate-Negative	Moderate-Low	Moderate-High	Medium-High	Medium-High
Upland spruce-fir	Negative	Moderate-Low	High	Medium-High	Medium-High
White pine	Moderate-Positive	High	Moderate-Low	Medium-High	Medium

Oak

Moderate-Low Vulnerability (medium evidence, medium-high agreement)

Oaks are relatively tolerant of drought and warmer temperatures and many species are projected to have increased habitat suitability in the future, although some stressors are also expected to increase. This forest system may expand in the future, but the extent may be influenced by interactions between oak and more mesic species.

Implication of climate change for oaks

- Considerable variability as to the projected changes in oak species habitat in responses to climate change
- But the genus seems well positioned in terms of habitat suitability and in many cases adaptive capacity
- On going challenges to sustain oak are key determinants of how the niches for oak may be filled and realized

Implication of climate change for oaks

- Longer term processes
  - Not mortality or specific to regeneration
  - Competition is still key driver to realized change
- Bottom line: silviculture matters especially as we consider climate change
- But given the many global change pressures the broader ecological setting and integration of macroscale influences are important

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Thank you!

- Web site for most data presented today ***www.nrs.fs.fed.us/atlas***:
  - Species-environment data for 147 birds and 134 trees, and relevant papers
  - Its been updated and new launch coming soon! Improved flow, Enhanced search, ModFacs incorporated

Acknowledgements

- Thanks to USDA FS Northern Global Change Program for support
- US Forest Service Northern Research Station