USDA United States Department of Agriculture
Northern Forests Climate Hub

VIRTUAL WORKSHOP

Climate Change Impacts on Kentucky Forests

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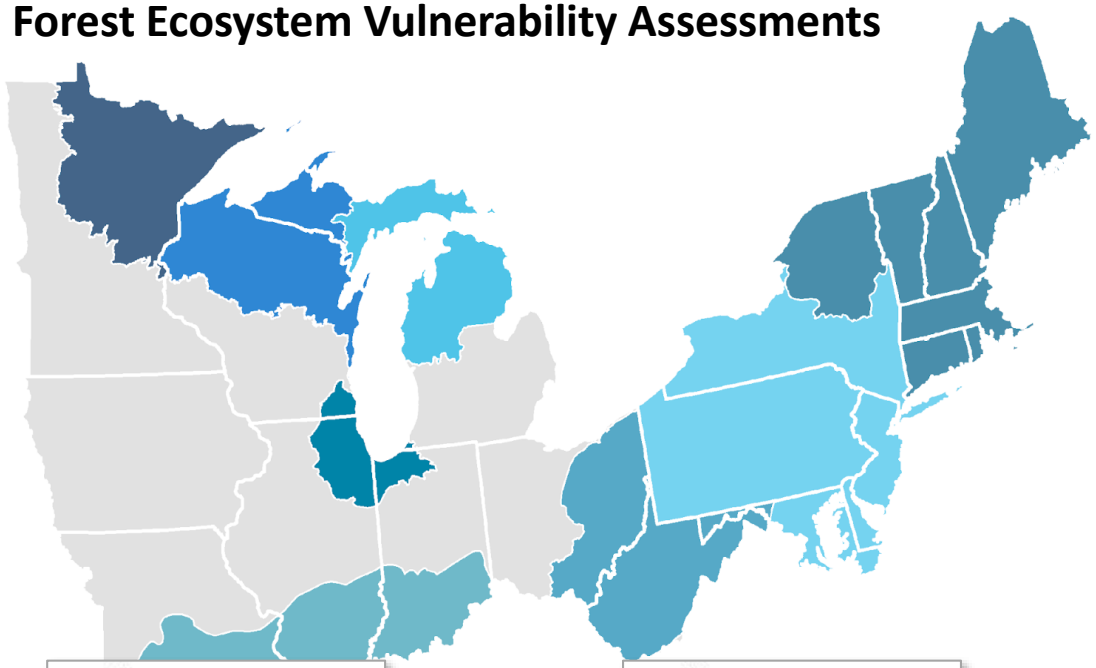
Northern Institute of Applied Climate Science

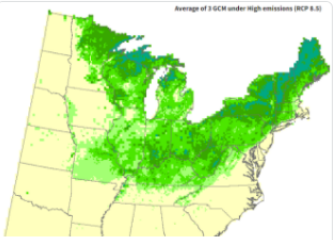
Climate Change Response Framework
www.forestadaptation.org

How is the climate changing?

Forest Ecosystem Vulnerability Assessments



USFS Climate Change Tree Atlas



Tree Atlas Version 4

Modeled potential suitable habitat for 125 tree species in the East, with an additional 23 species with current information only

Latest Tree Atlas

Bird Atlas Version 2

Potential changes in abundance and range for 147 bird species in the East

Latest Bird Atlas

Search or Browse the Atlas

Search for Trees or Birds

Search for Trees or Birds

Browse Previous Tree Atlas

Version 3 | Version 2

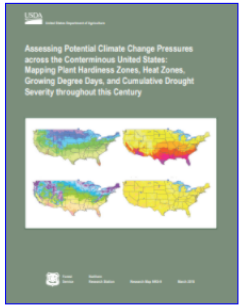
Browse Previous Bird Atlas

Version 1

Publications

Browse Publications

Featured Publication

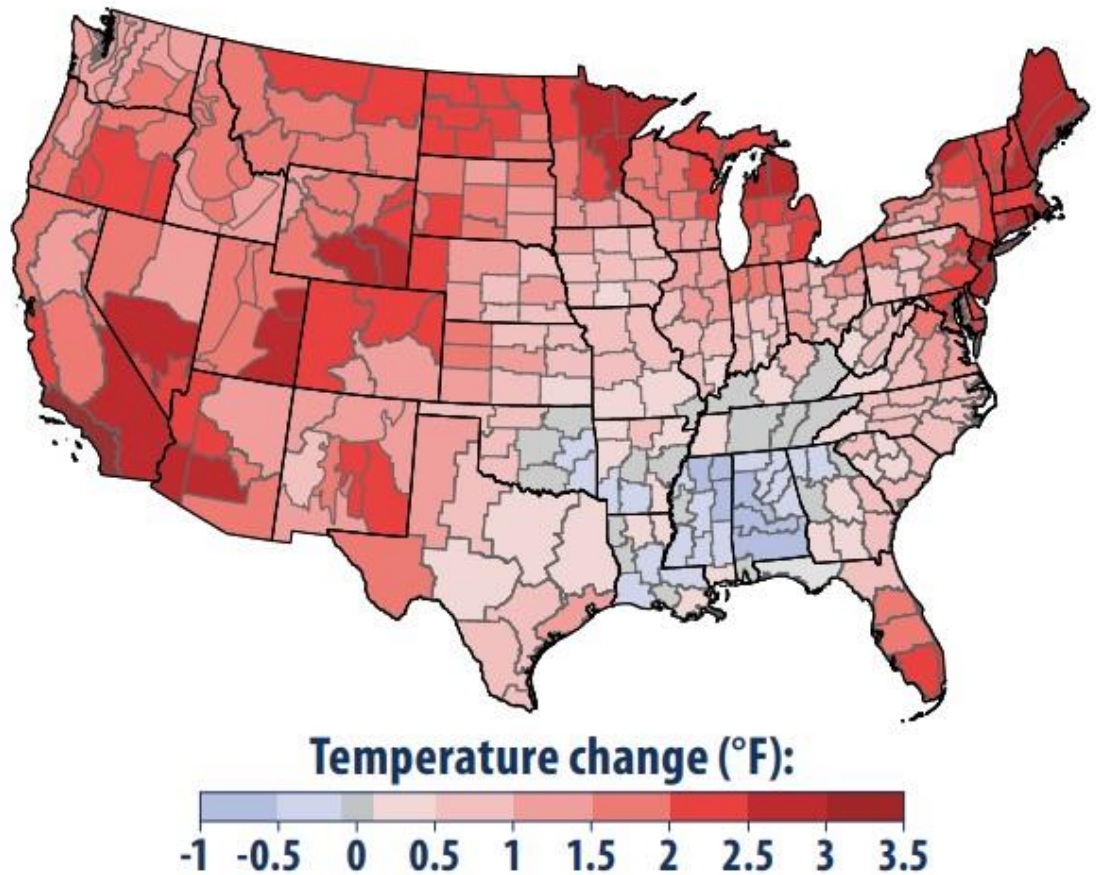


Regional Summary Tree Tables

Current and Potential Future Habitat, Capability, and Migration −

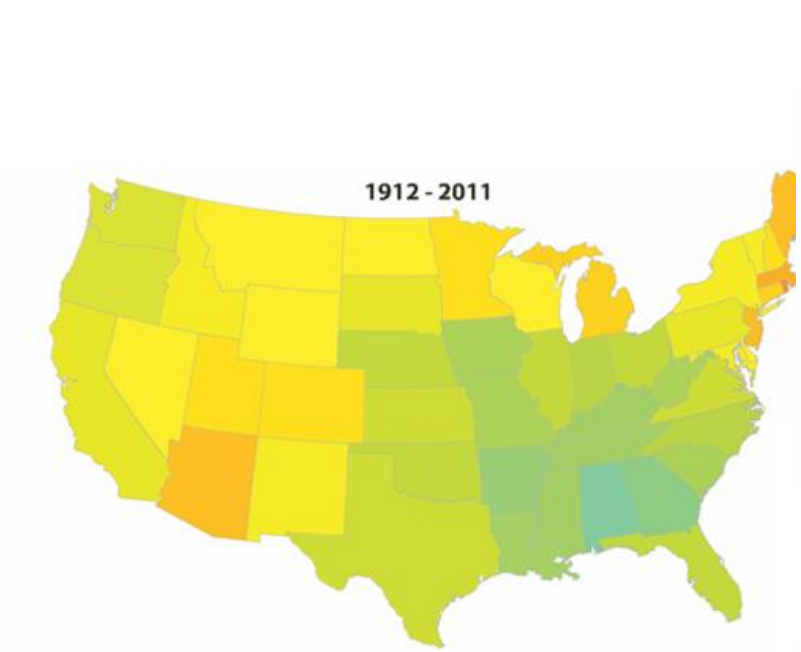
Summaries for tree species are available for a variety of geographies, in both PDF and Excel format. These summaries are based on Version 4 of the Climate Change Tree Atlas

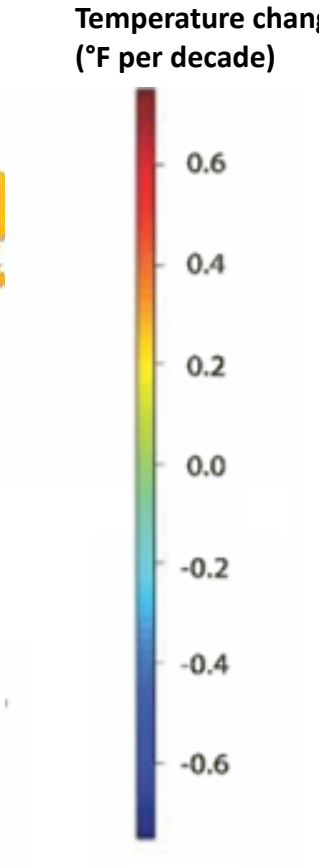
- National Forest Summaries
- National Park Summaries
- HUC6 Watersheds
- Ecoregional Vulnerability Assessments (EVAS)
- USDA Forest Service EcoMap 2007 Sections
- National Climate Assessment (NCA) 2016 Regional Summaries
- 1 x 1 ° Grid Summaries
- Eastern United States
- Urban Areas



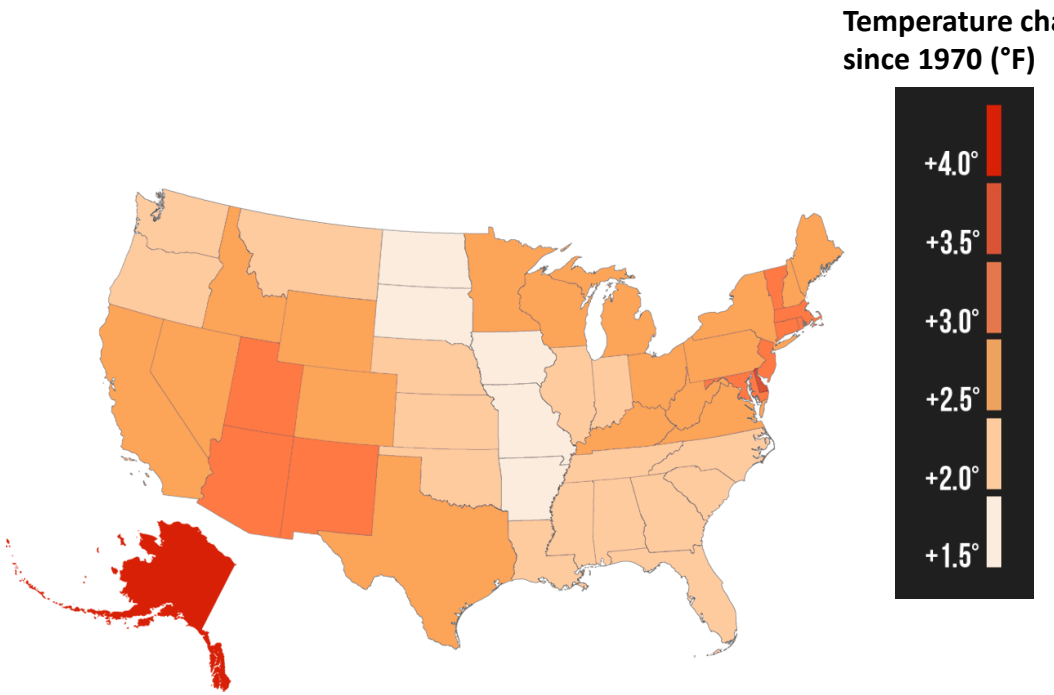
EPA, Climate Change Indicators in the United States

Shifting rates of change

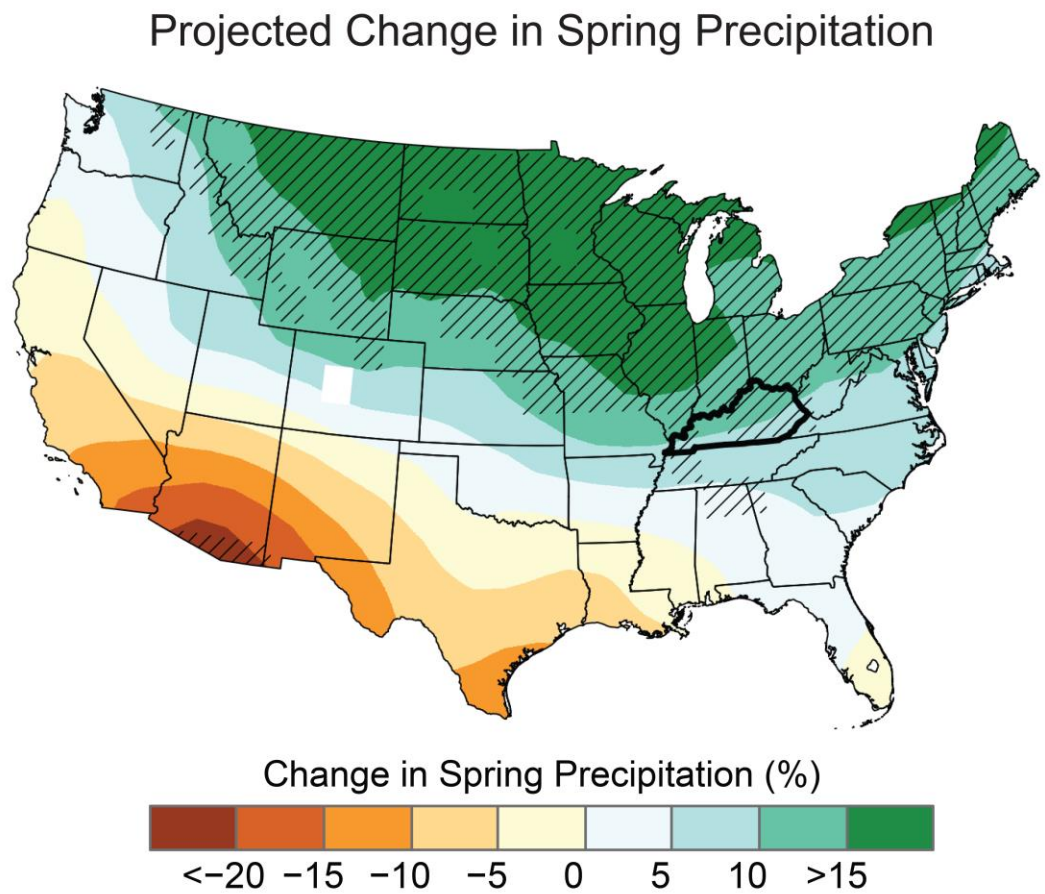




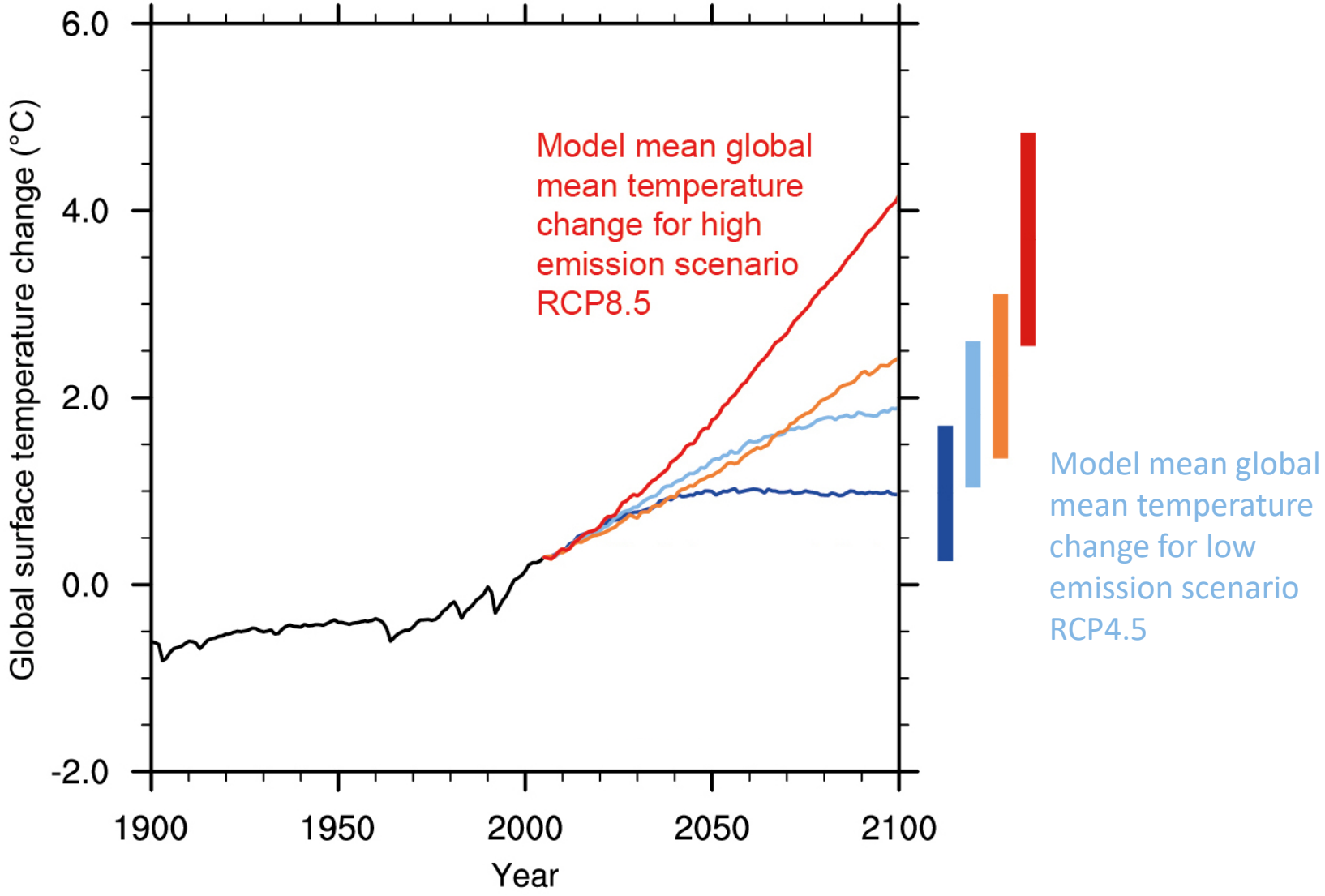
www.climatecentral.org/news/the-heat-is-on/



www.climatecentral.org/climate-matters/earth-day-warming-rankings


Projected Change in Spring Precipitation
Change in Spring Precipitation (%)
<−20
−15
−10
−5
0
5
10
>15

Future changes



https://www.ipcc.ch/report/ar5/wg1/long-term-climate-change-projections-commitments-and-irreversibility/fig-35/

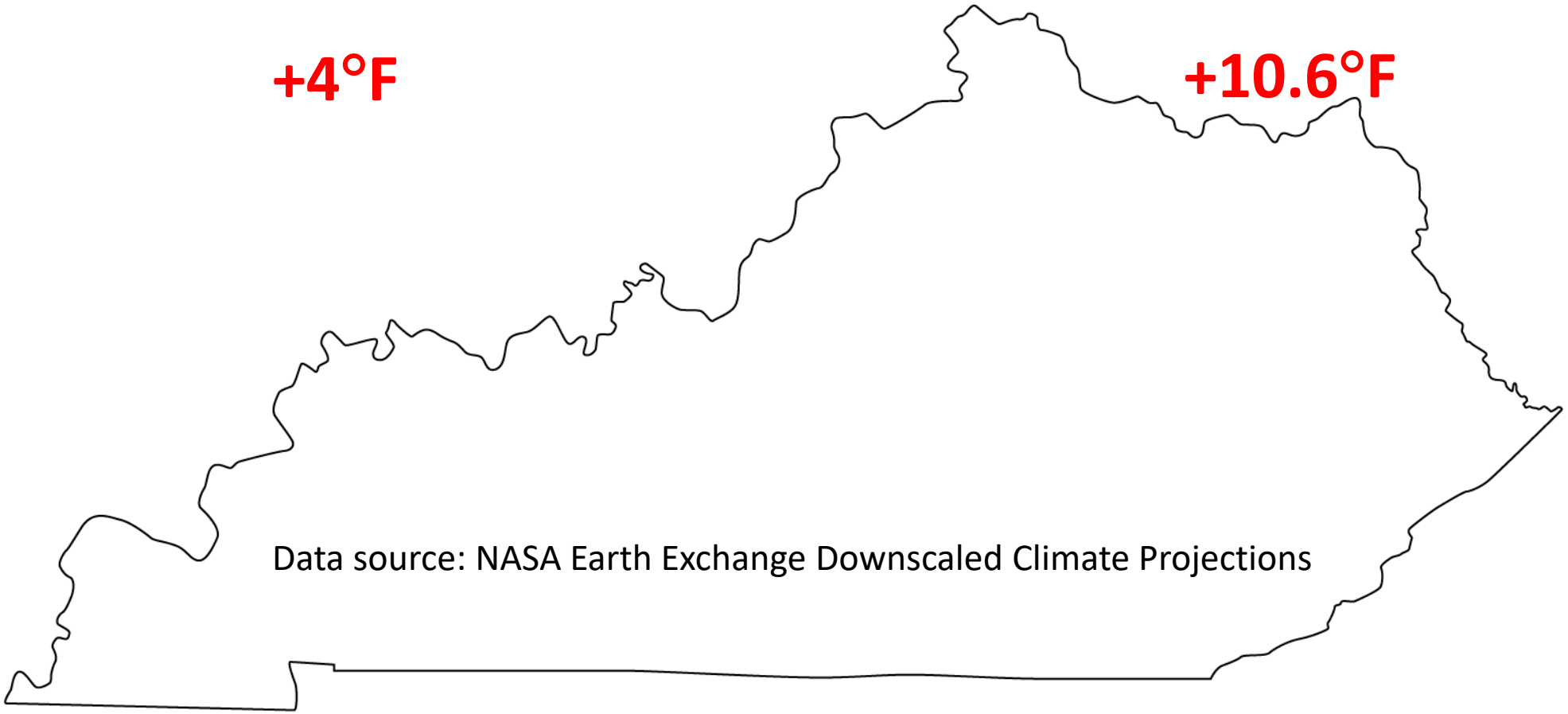
Projected Changes in Annual Temperature

Low emissions
CCSM4 – RCP 4.5

+4°F

High emissions
HadGEM2-ES – RCP 8.5

+10.6°F



Data source: NASA Earth Exchange Downscaled Climate Projections

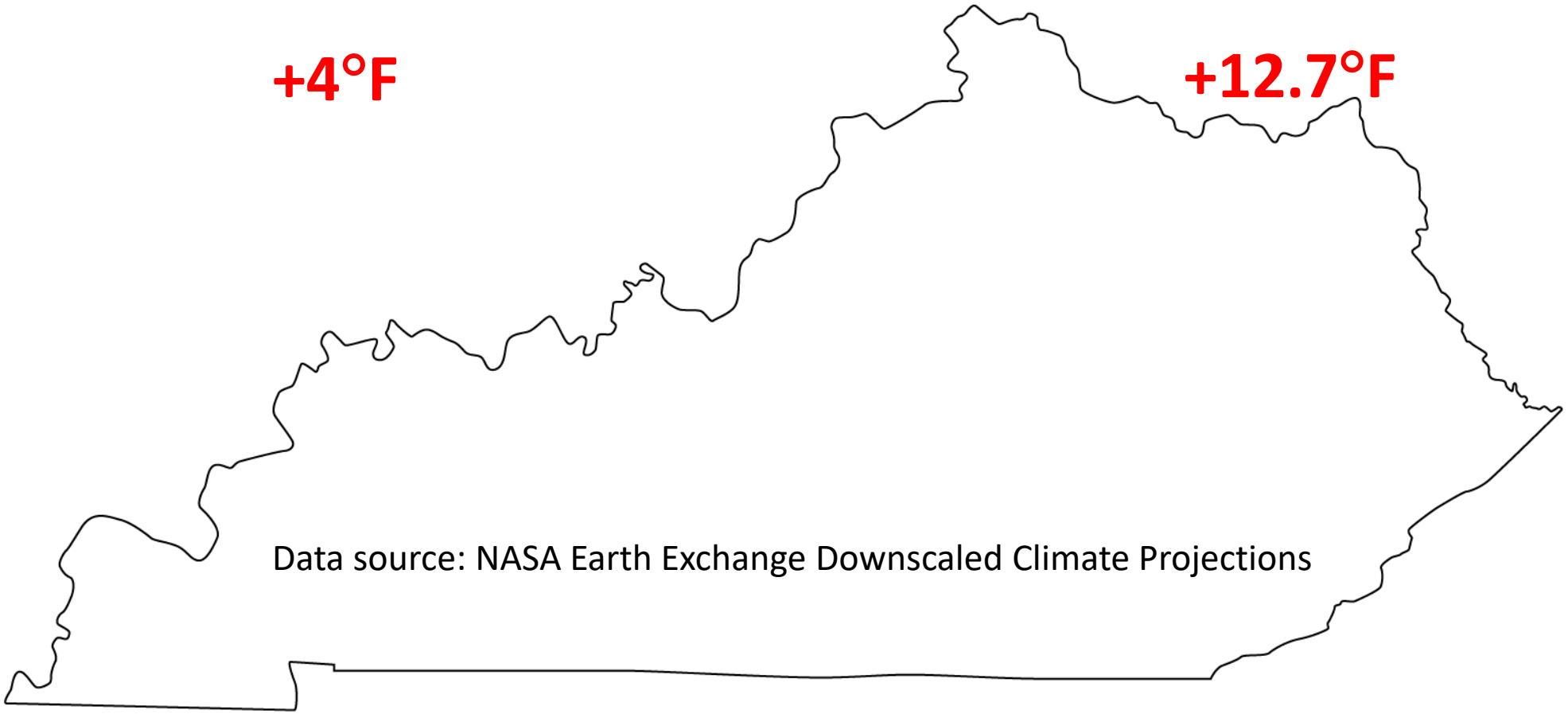
Projected Changes in Growing Season Temperature

Low emissions
CCSM4 – RCP 4.5

+4°F

High emissions
HadGEM2-ES – RCP 8.5

+12.7°F



Data source: NASA Earth Exchange Downscaled Climate Projections

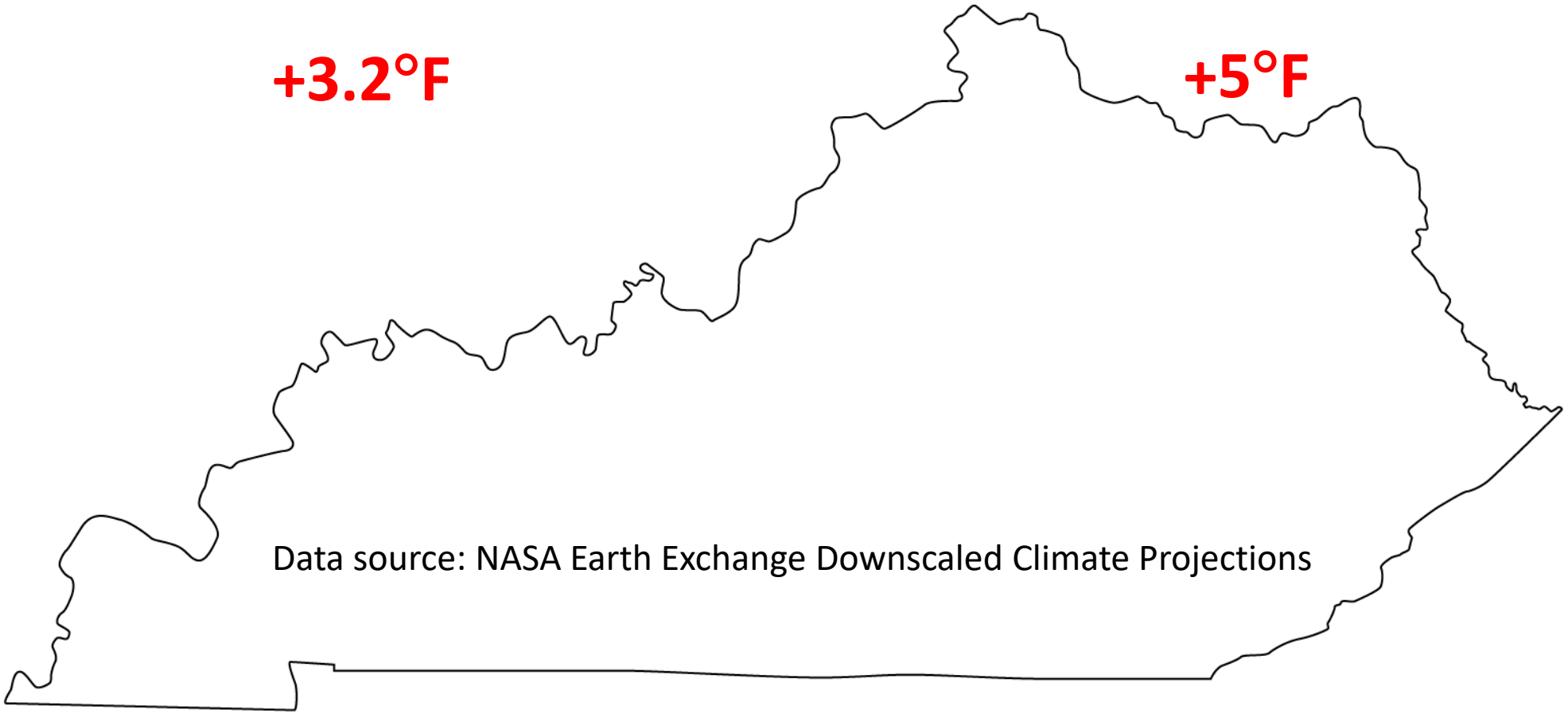
Projected Changes in Coldest Month Temperature

Low emissions
CCSM4 – RCP 4.5

+3.2°F

High emissions
HadGEM2-ES – RCP 8.5

+5°F



Data source: NASA Earth Exchange Downscaled Climate Projections

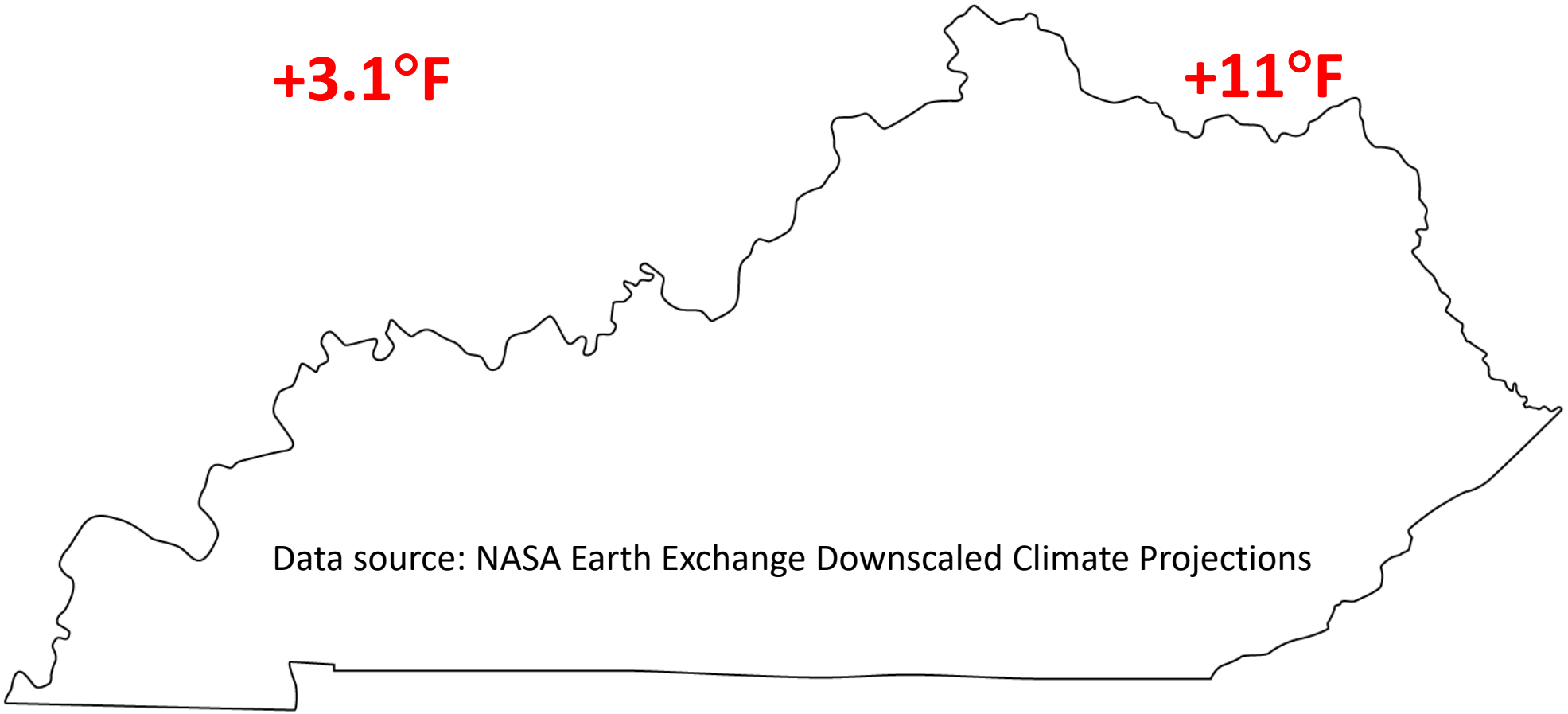
Projected Changes in Warmest Month Temperature

Low emissions
CCSM4 – RCP 4.5

+3.1°F

High emissions
HadGEM2-ES – RCP 8.5

+11°F



Data source: NASA Earth Exchange Downscaled Climate Projections

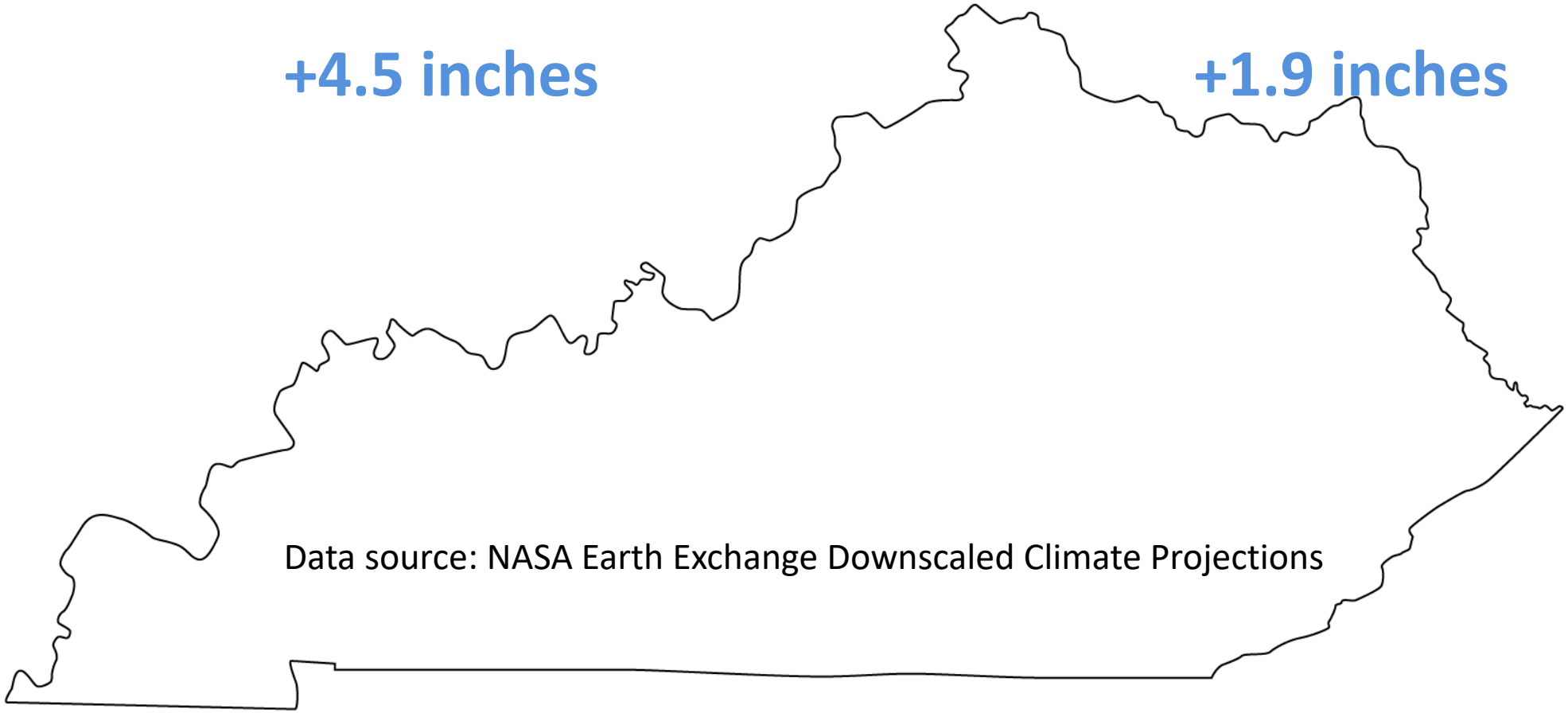
Projected Changes in Annual Total Precipitation

Low emissions
CCSM4 – RCP 4.5

+4.5 inches

High emissions
HadGEM2-ES – RCP 8.5

+1.9 inches



Data source: NASA Earth Exchange Downscaled Climate Projections

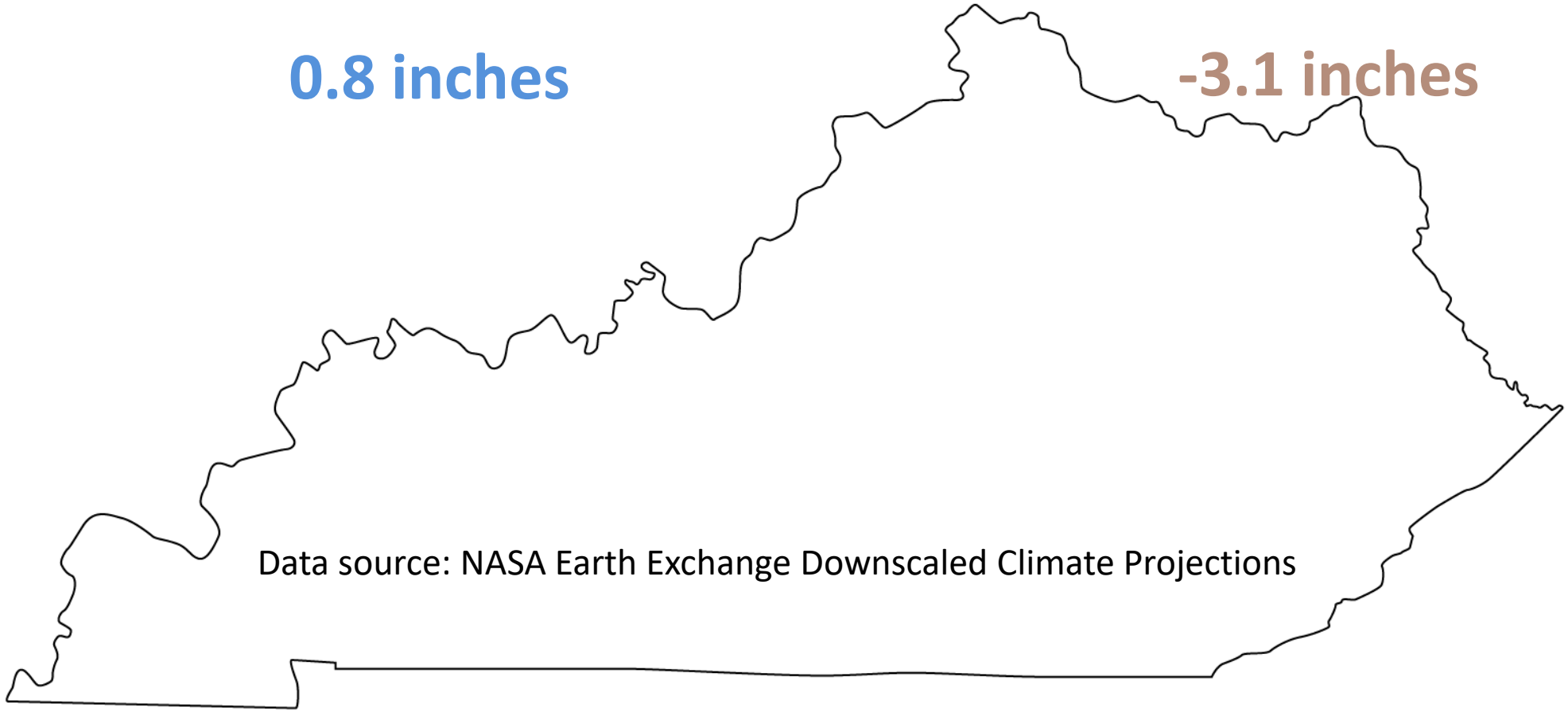
Projected Changes in Growing Season Precipitation

Low emissions
CCSM4 – RCP 4.5

0.8 inches

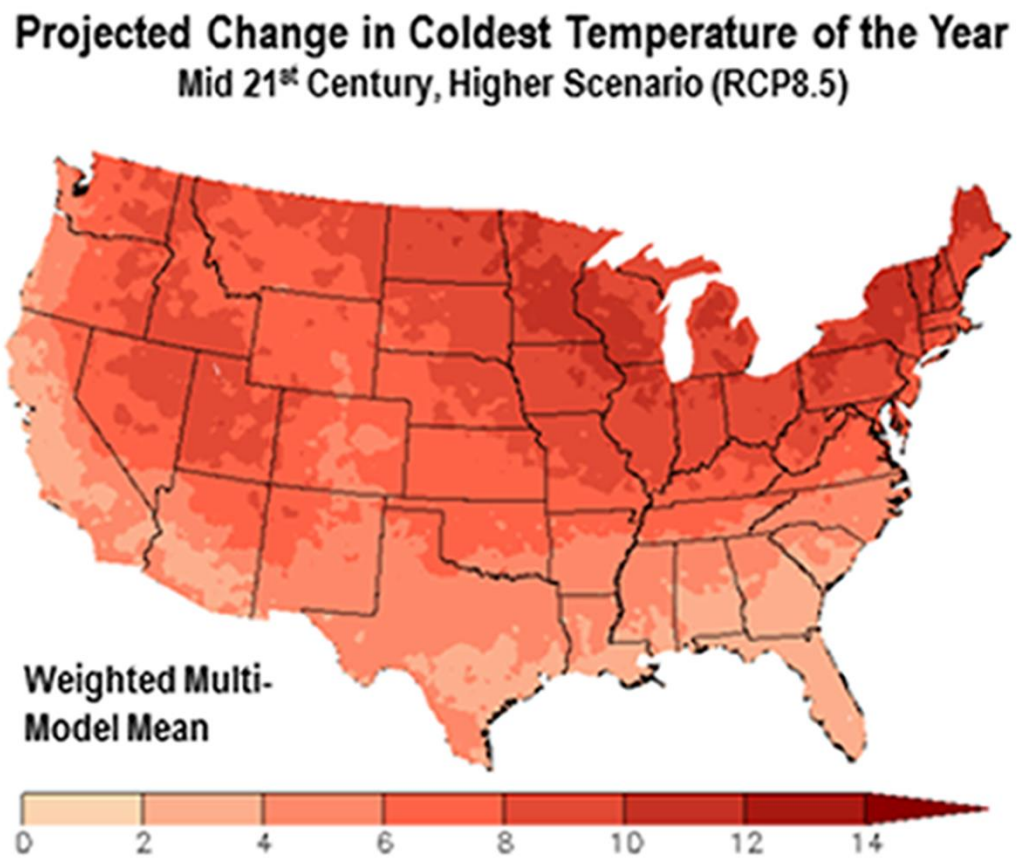
High emissions
HadGEM2-ES – RCP 8.5

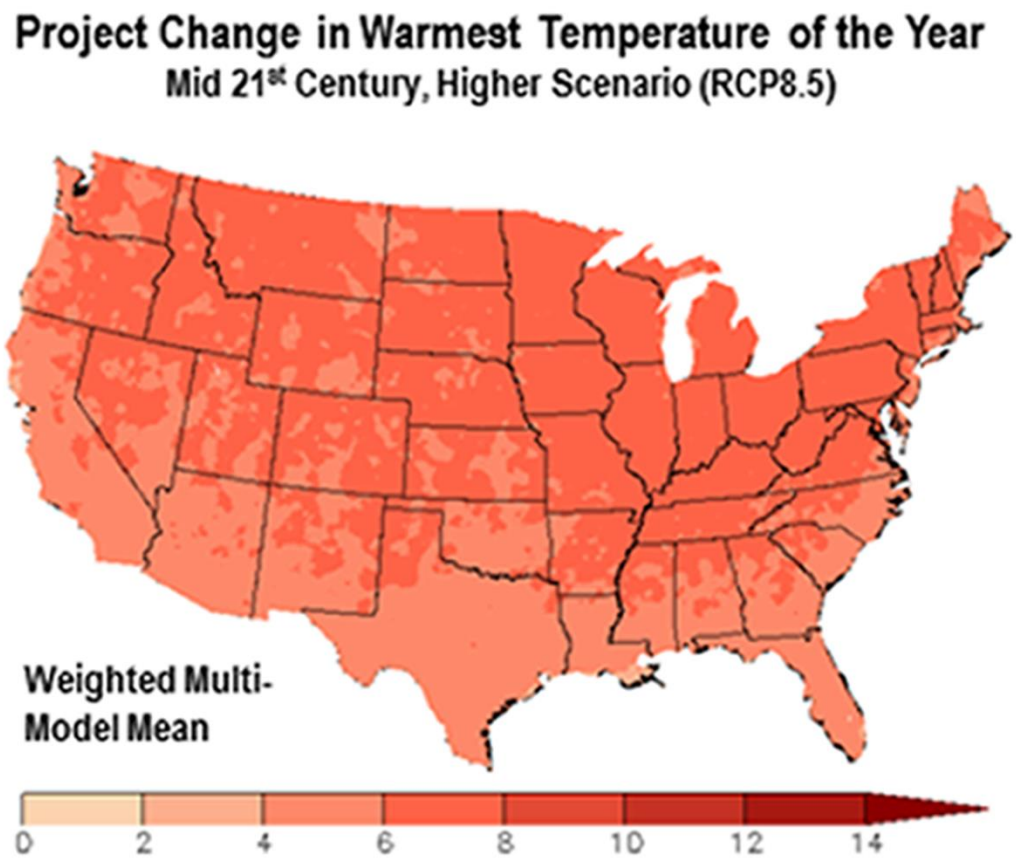
-3.1 inches



Data source: NASA Earth Exchange Downscaled Climate Projections

Extreme Temperatures

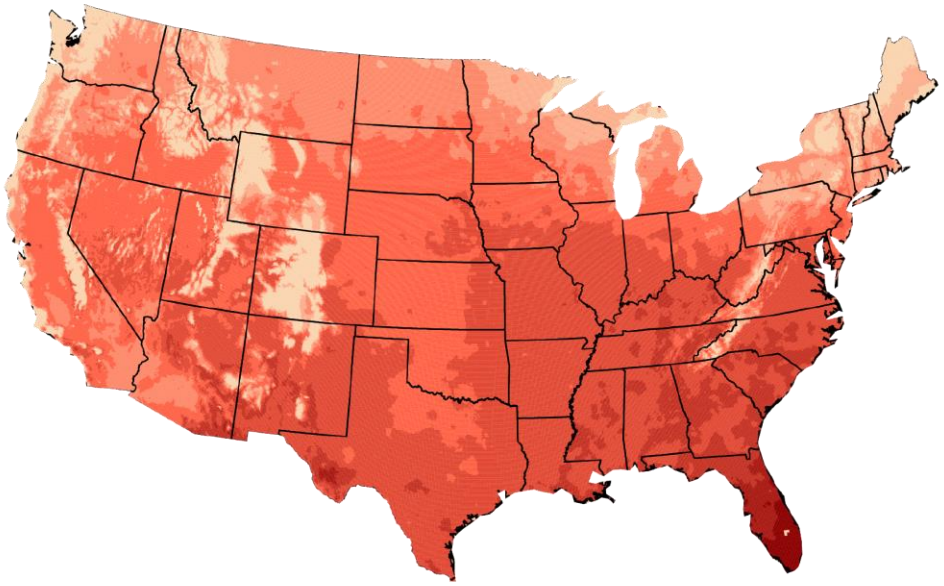




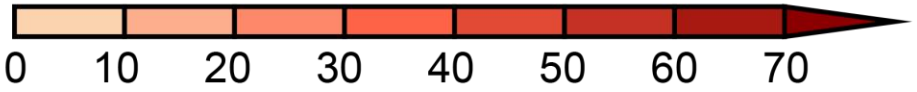
https://science2017.globalchange.gov/chapter/6/

Extreme Temperatures

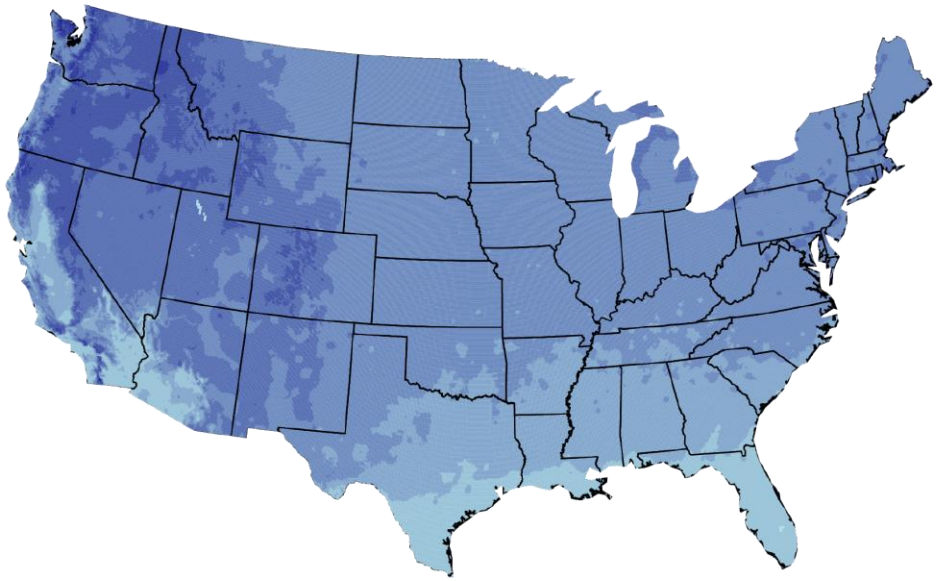
Projected Change in Number of Days Above 90°F
Mid 21st Century, Higher Scenario (RCP8.5)



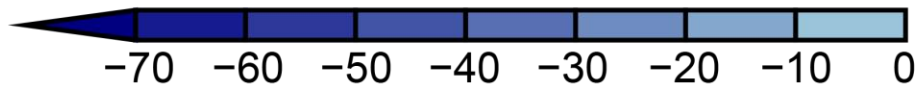
Weighted Multi-Model Mean



Projected Change in Number of Days Below 32°F
Mid 21st Century, Higher Scenario (RCP8.5)



Weighted Multi-Model Mean



https://science2017.globalchange.gov/chapter/6/

7 WAYS THAT CLIMATE CHANGE WILL AFFECT FORESTS

A Synthesis of Anticipated Impacts in Kentucky and the broader Central Hardwoods/Central Appalachians Regions

Climate Change Impacts

1) Longer Growing Season
2) Increased Risk of Moisture Stress
3) Increased Risk of Fire
4) CO_2 Fertilization
5) Changes in Suitable Habitat
6) Extreme Events
7) Invasive Plants

Climate Change Impacts

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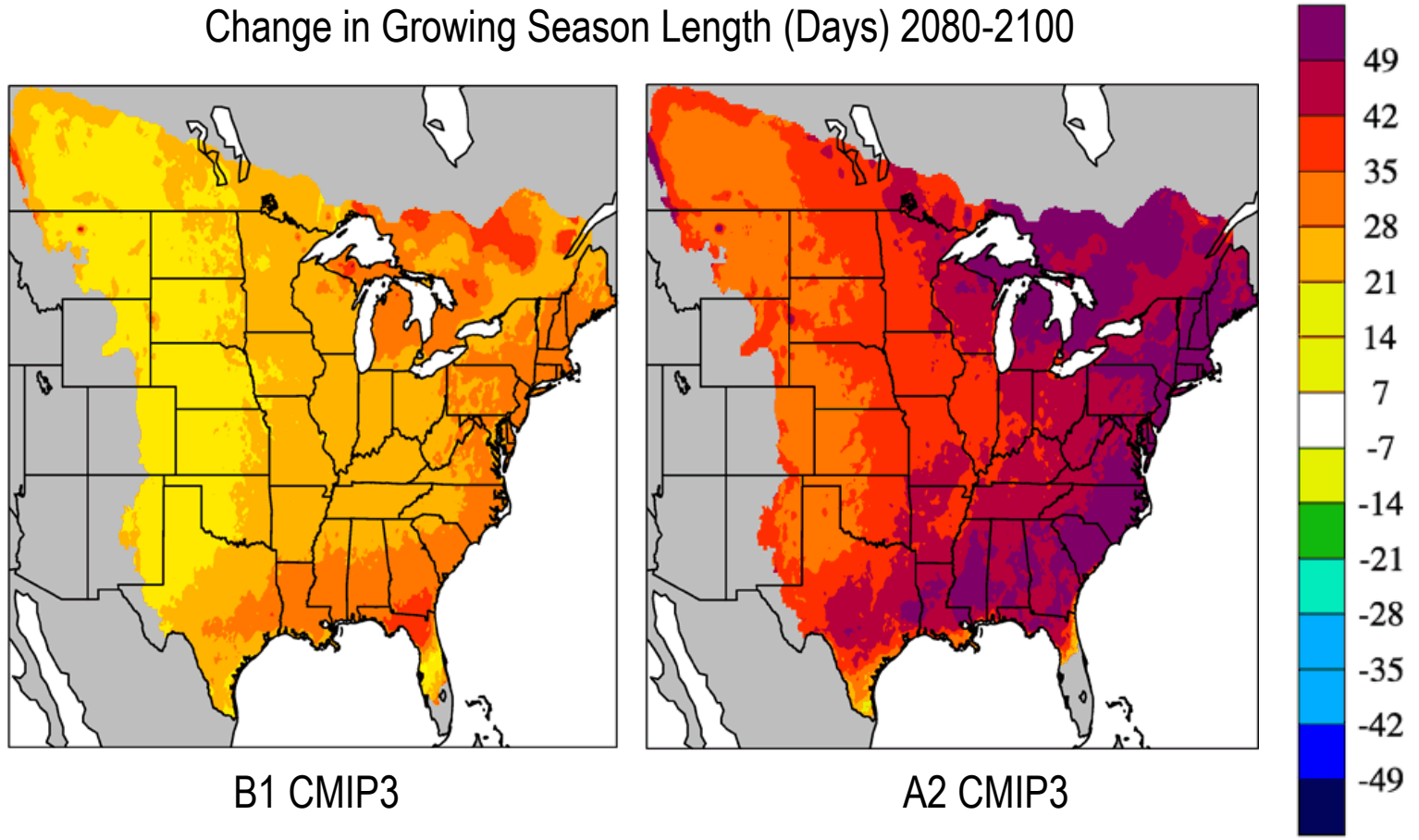
Eric Aldrich/The Nature Conservancy

1) Longer Growing Season

Warmer temps result in longer growing seasons

- Evidence of phenological shifts
- Projected to increase 3 to 7+ more weeks

Longer period for plant growth



1) Longer Growing Season

Warmer temps result in longer growing seasons

- Evidence of phenological shifts
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Longer period for plant growth

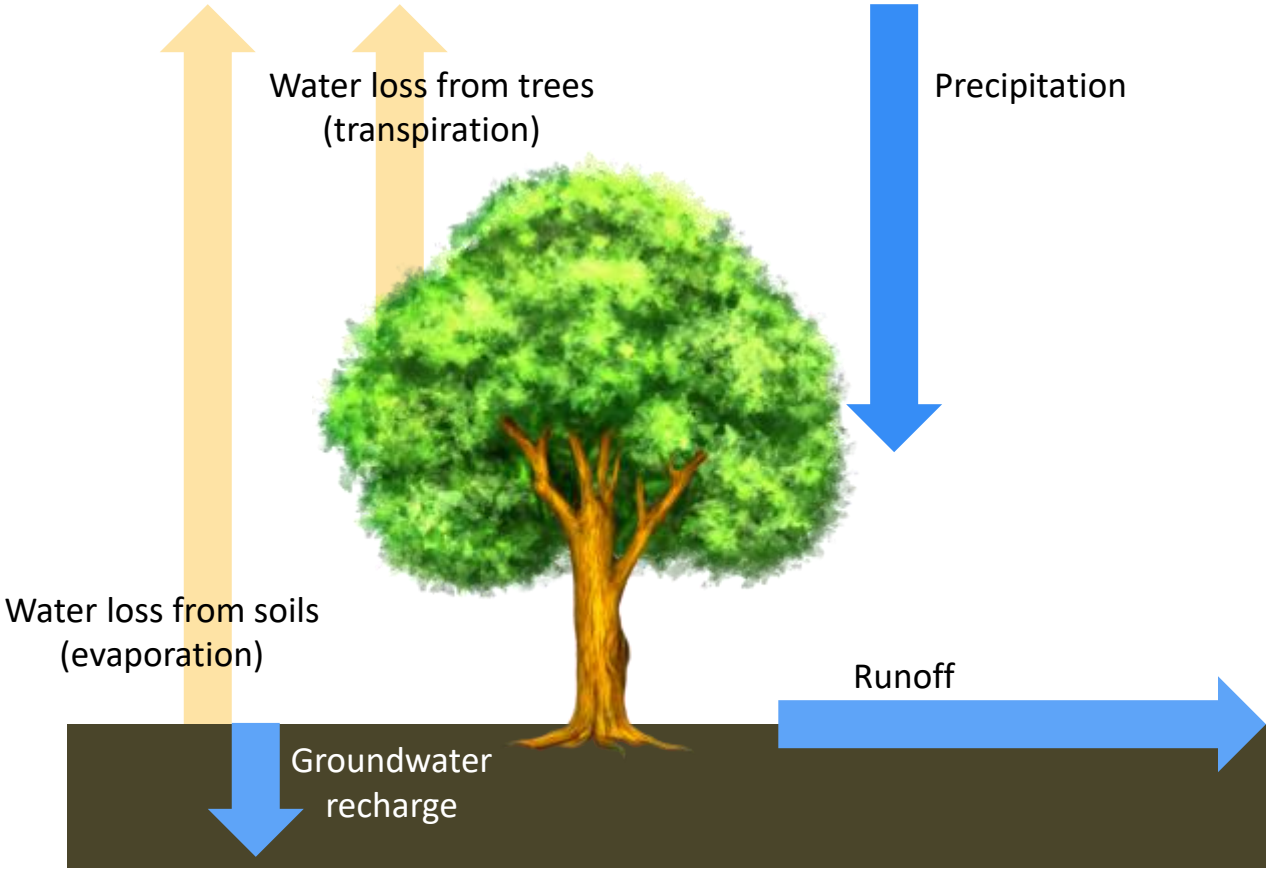
Phenological changes

- Early bud break and frost damage

Melillo et al. 2014, Nelson Center 2014

2) Increased Risk of Moisture Stress

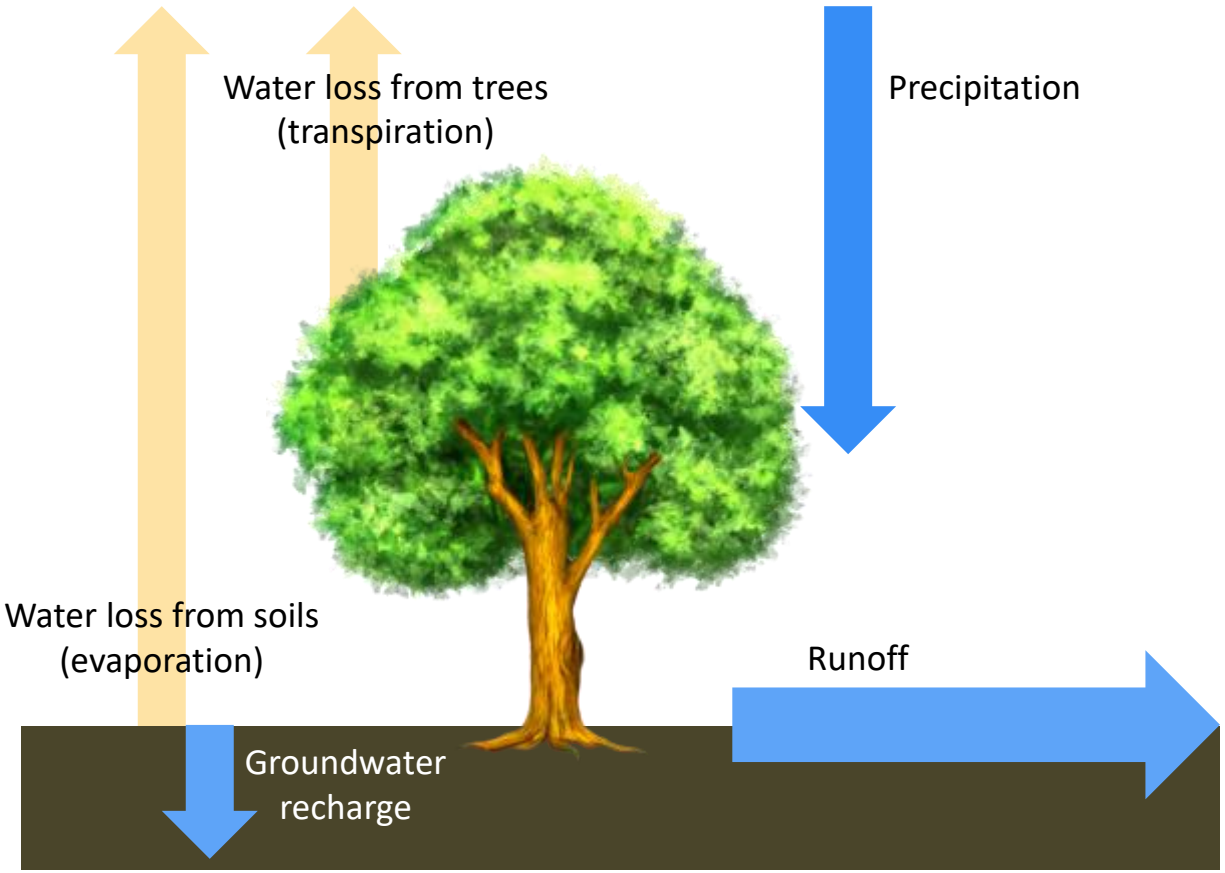
Longer and warmer growing seasons may lead to drier conditions during the growing season.



2) Increased Risk of Moisture Stress

Longer and warmer growing seasons may lead to drier conditions during the growing season.

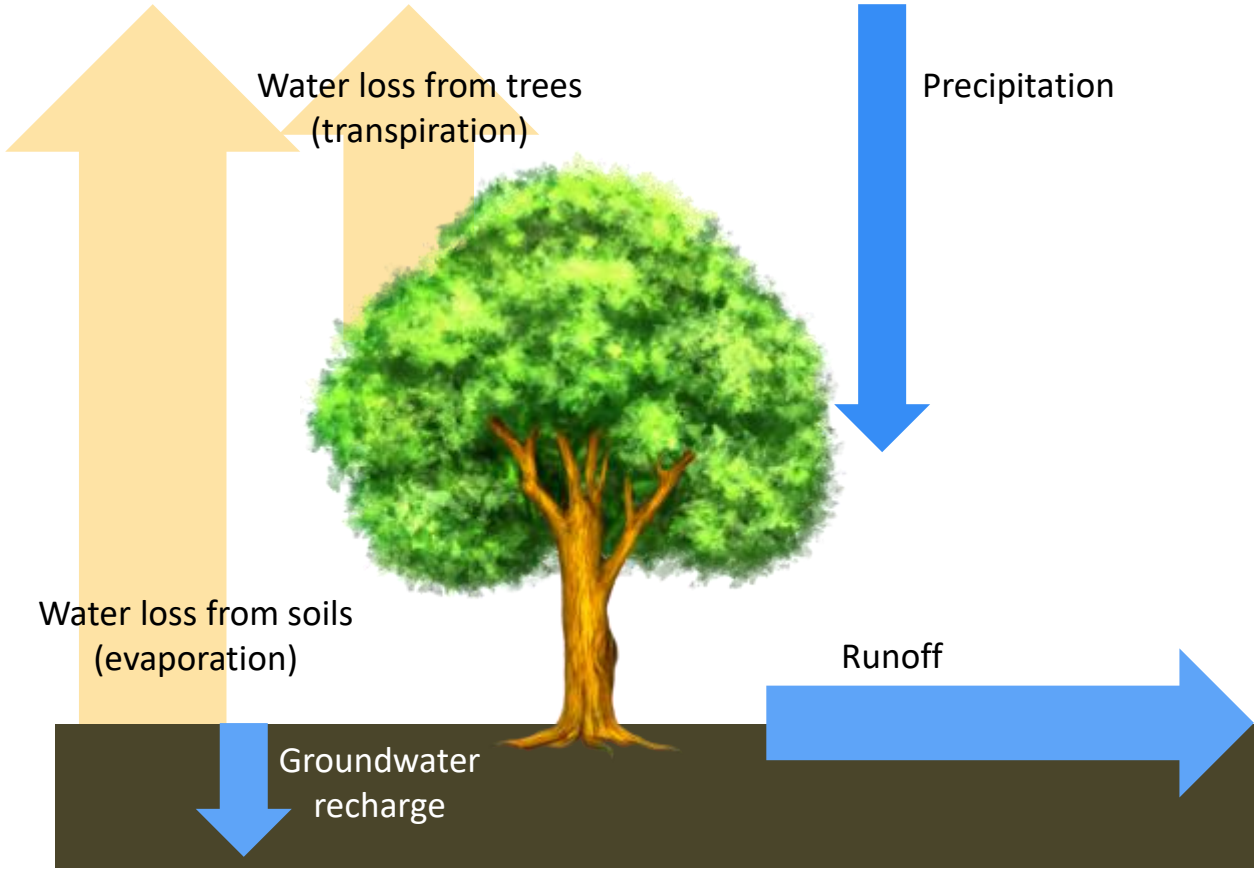
Earlier spring runoff
and
increased runoff during extreme rain events



2) Increased Risk of Moisture Stress

Longer and warmer growing seasons may lead to drier conditions during the growing season.

Warmer temperatures drive greater water loss from soils and plants



Warmer temperatures = ↑ vapor pressure deficit (VPD)

- More evaporation from soils & open water
- More transpiration from plants

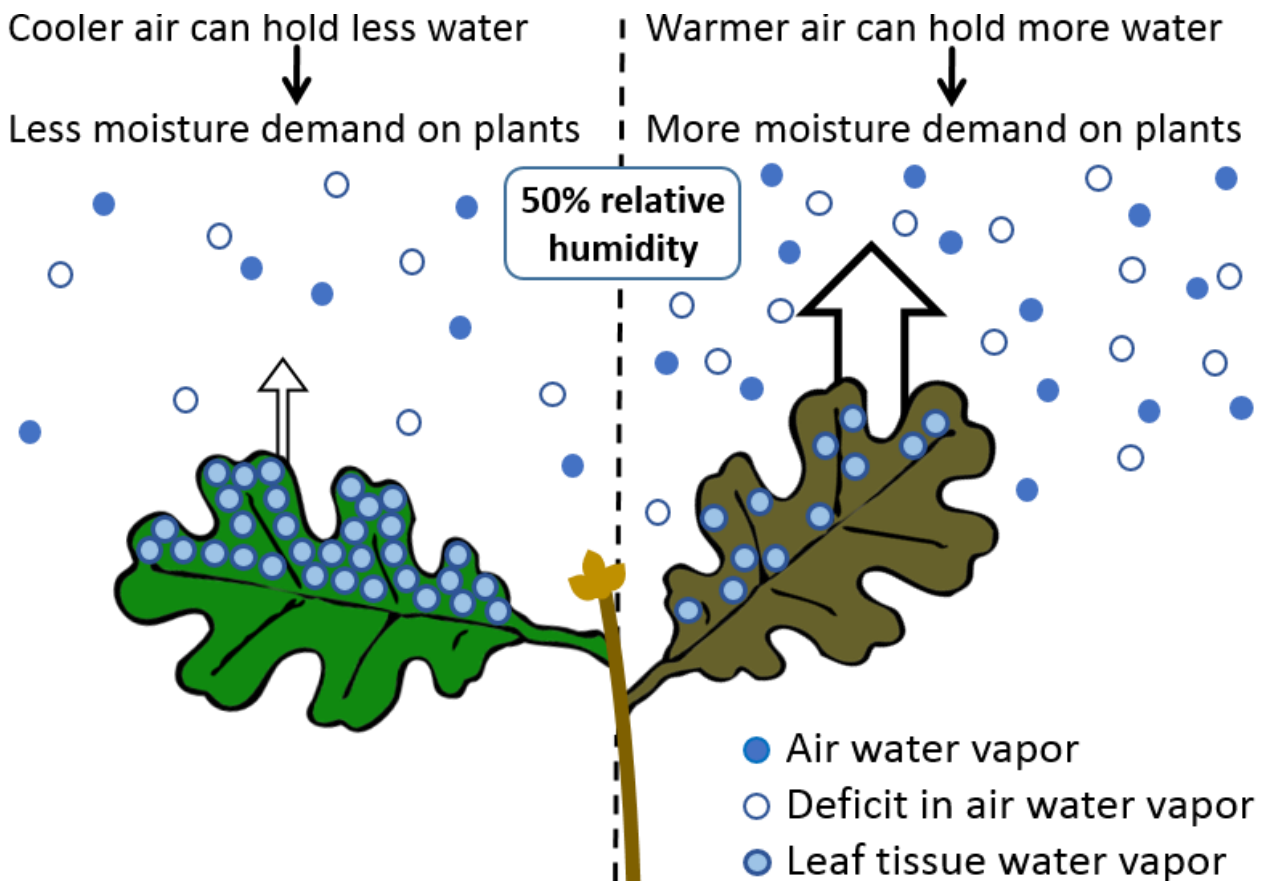


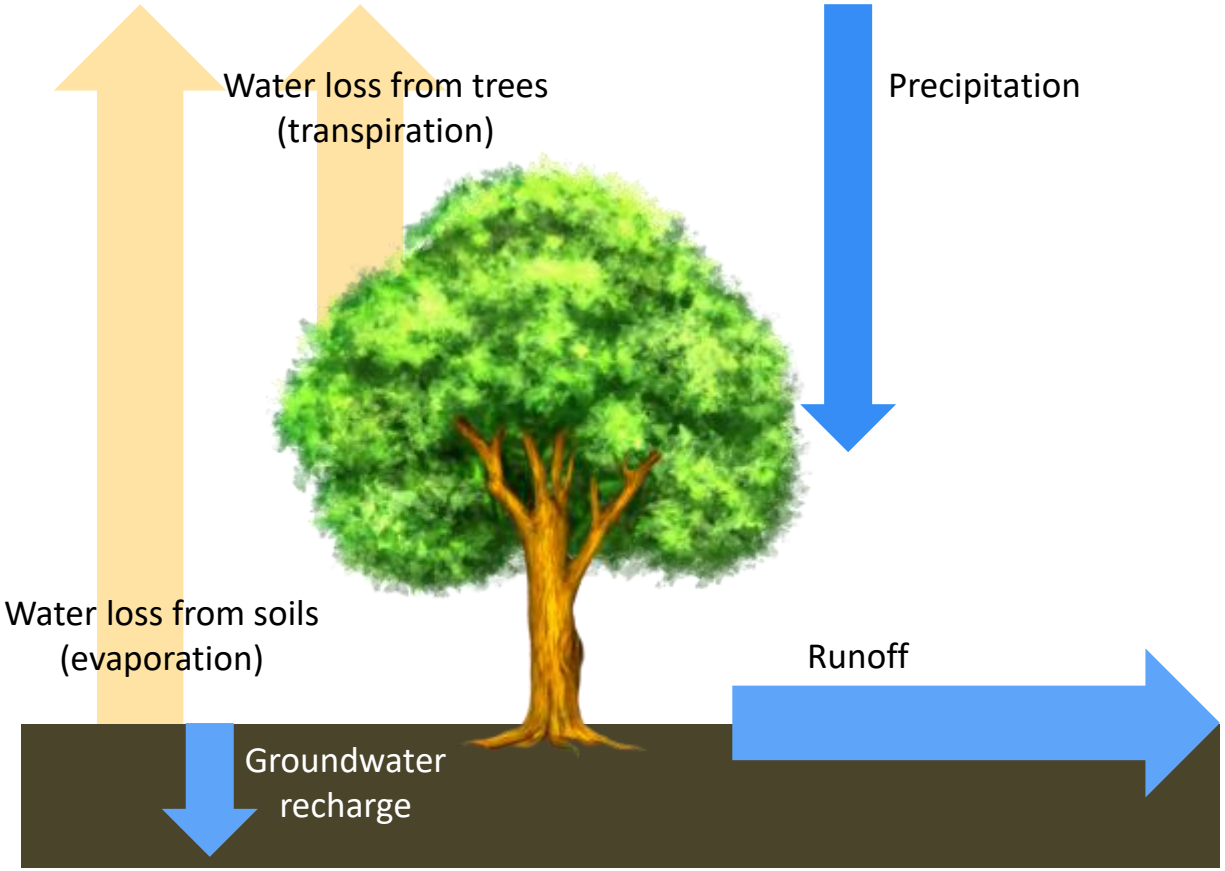
Image: NCA4 – Midwest Regional chapter: https://nca2018.globalchange.gov/chapter/21/

2) Increased Risk of Moisture Stress

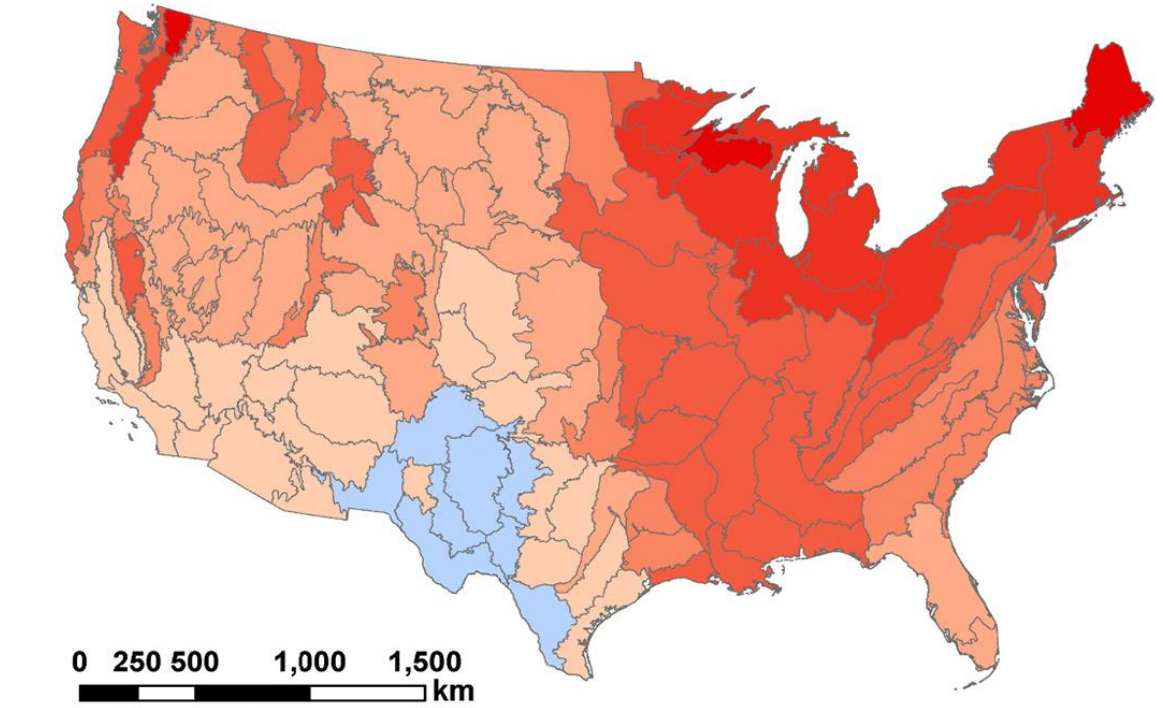
Longer and warmer growing seasons may lead to drier conditions during the growing season.

Risk may be greatest:

- Sites with drought-prone or shallow soils
- South-facing ridges
- Mesic species on drier sites (marginal sites or off-site)
- Crowded stands that compete for water



3) Increased Risk of Wildfire



Projected changes (%) in annual fire probability from baseline (1971-2000) to late century (2070-2099) based on Greenhouse Gas Emissions Scenario RCP 8.5.

Gao et al. 2021

3) Increased Risk of Wildfire

Future climate conditions suggest increased risk of fire.

Wildfire may increase:

- Warmer/drier summers
- Increased stress or mortality from less suitable conditions
- Shift toward fire-associated species like oaks and pines

Wildfire may not change:

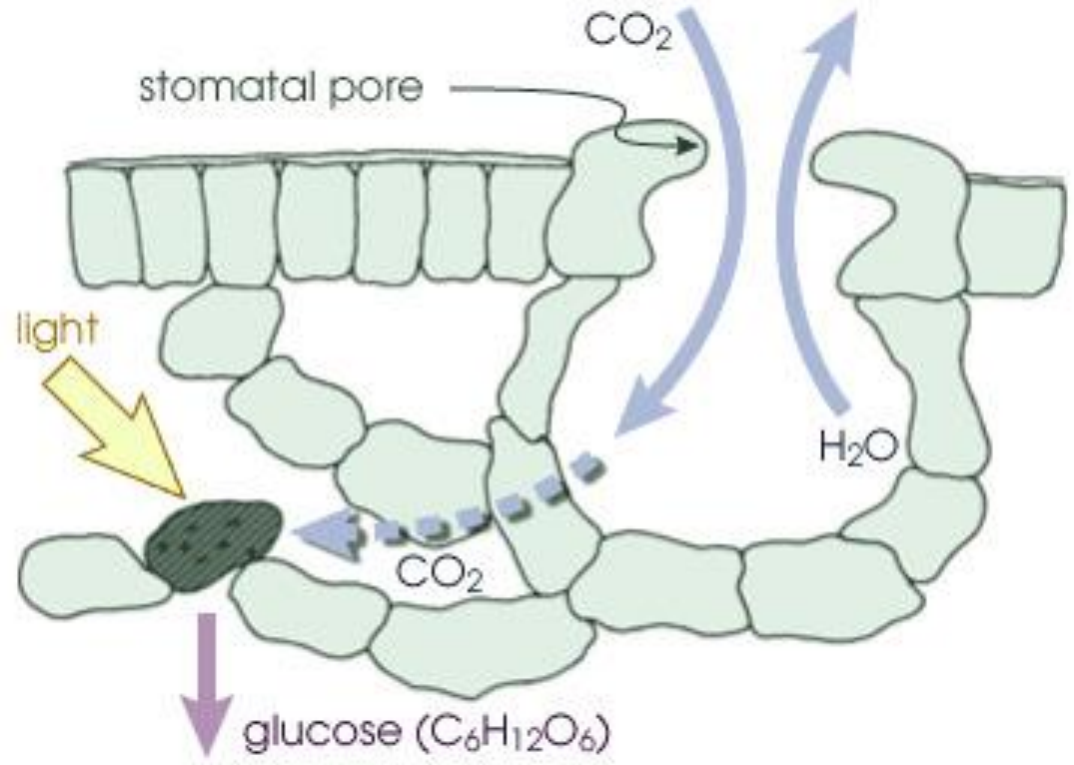
- Spring/early summer moisture
- Current regeneration of more mesic species
- Spatial patterns of land use and fragmentation
- Fire suppression

What may be at risk:
Fire-dependent forests or areas of tree mortality when fire is not suppressed.

4) CO2 Fertilization

Benefits

- Increased photosynthesis
- Increased water use efficiency

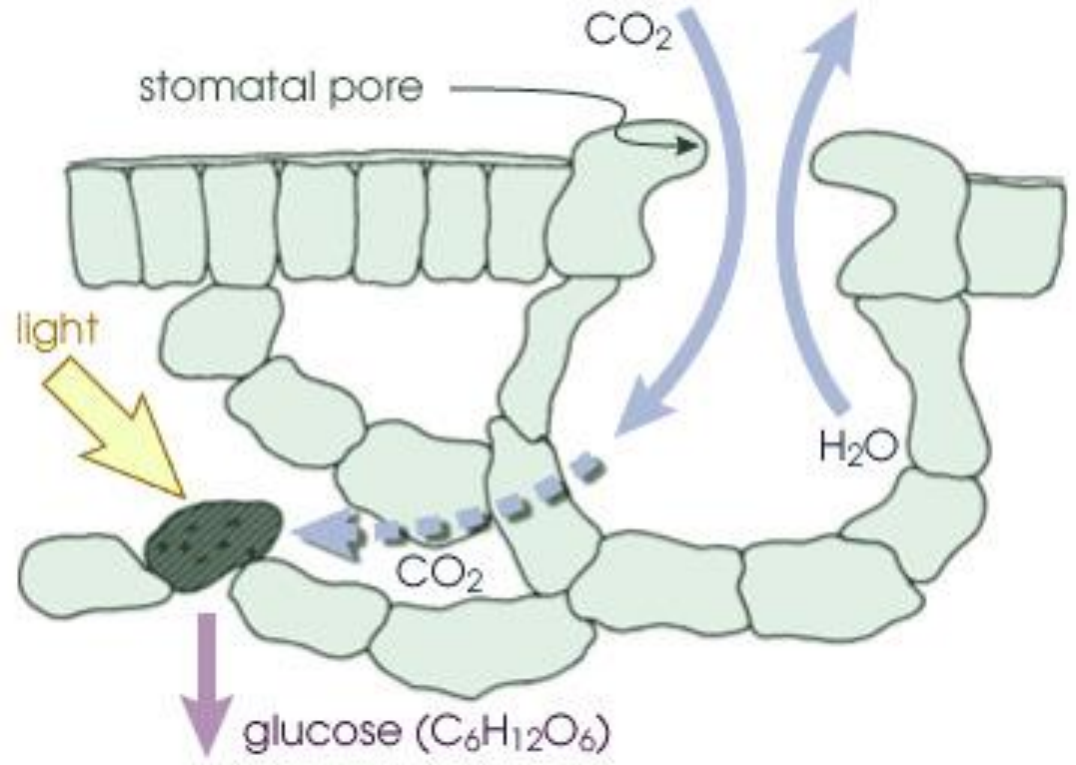


Ainsworth and Long 2005, Ainsworth and Rogers 2007, Norby and Zak 2011

4) CO2 Fertilization

Limits to CO_2 fertilization

- Varies by species and site
- Nutrient deficiencies (especially N)
- Sensitive to ozone pollution
- Limited sink strength
- Limited evidence of long-term sequestration
- Any productivity increases may be offset by reductions from increased drought stress or disturbance



Ainsworth and Long 2005, Ainsworth and Rogers 2007, Norby and Zak 2011

5) Changes in Suitable Habitat

Good Capability

- American elm
- Black oak
- Blackgum
- Blackjack oak
- Eastern redcedar
- Hackberry
- Loblolly pine
- Mockernut hickory
- Northern red oak
- Post oak
- Red maple
- Shortleaf pine
- Southern red oak
- Sugar maple
- Sugarberry
- Sweetgum
- Water oak
- White oak
- Winged elm
- Yellow-poplar
- **….and more!**

Poor Capability

- American basswood
- American beech
- American holly
- Bald cypress
- Black ash
- Bur oak
- Cherrybark oak
- Eastern hemlock
- Eastern white pine
- Pignut hickory
- Pitch pine
- Scarlet oak
- Shingle oak
- Swamp tupelo
- Sweet birch
- Virginia pine
- White ash
- Yellow birch
- **…and more!**

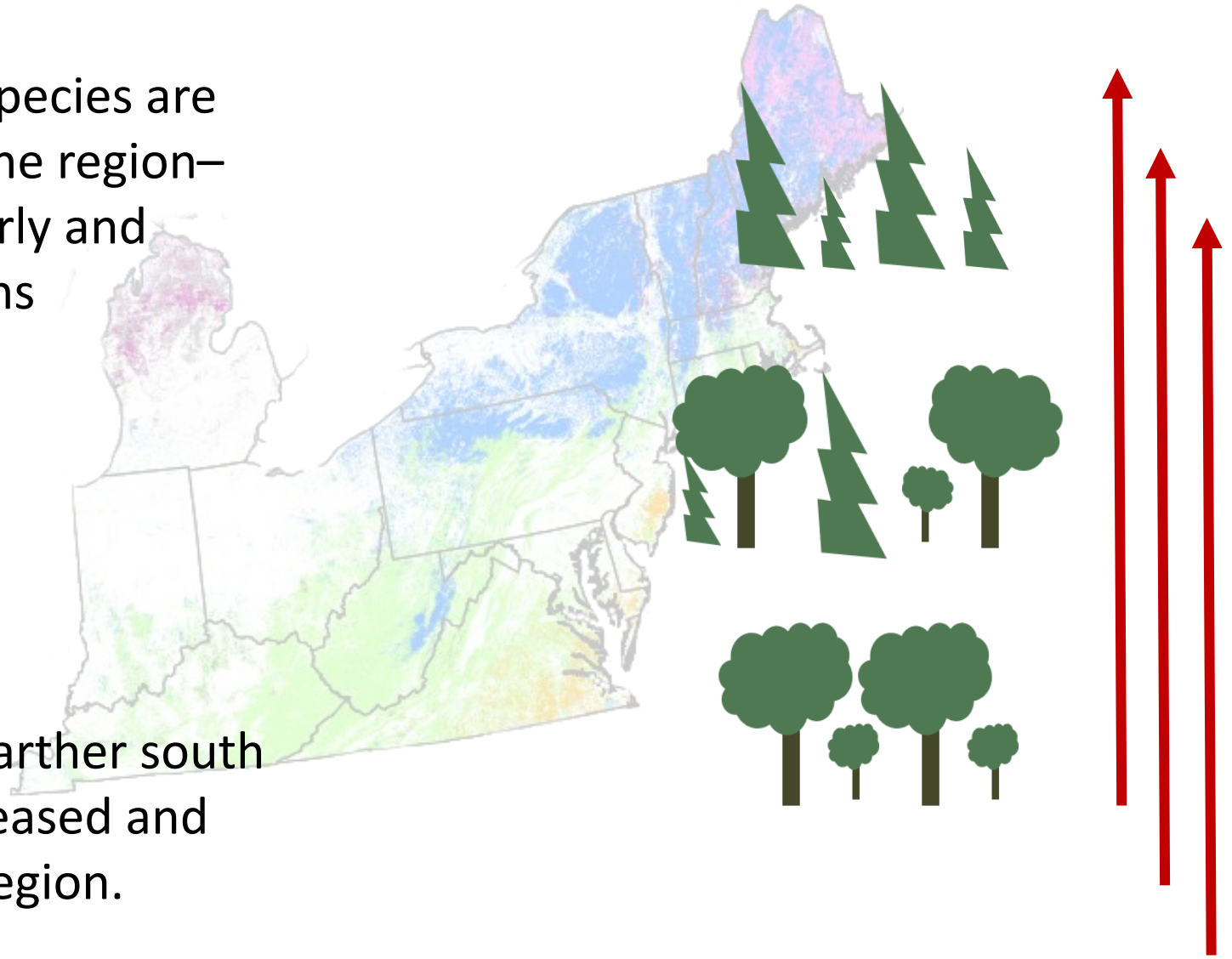
New Habitat with Migration Potential

- Black hickory
- Laurel oak
- Longleaf pine
- Slash pine
- Striped maple

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

5) Changes in Forest Composition

Many northern/boreal species are projected to decline in the region– contract to more northerly and higher-elevation locations



Many species common farther south are expected to see increased and new habitat within the region.

5) Changes in Forest Composition

- Many common tree species are projected to have reduced suitability in the future
- Changes will occur slowly—not instant dieback
- Mature and established trees should fare better
- Immense lags to occupy habitats
- Critical factors: competition, management, & disturbance

Risk may be greatest:

- Location is relatively near the southern extent of species range
- Trees are projected to decline and located on a marginal site
- Forest is composed of few species, esp. those projected to decline
- Something is “missing” from the ecosystem
- Other factors cause additional stress

6) Extreme Events

Extreme events may become more frequent or severe

- Heavy precipitation
- Ice storms
- Heat waves/droughts
- Wind storms
- Hurricanes
- “Events” are not well modeled

Photo: Route 72 in Preston County

What may be at risk: Depends greatly on site conditions and susceptibility to different types of disturbance

7) Invasive Plants

Increased habitat for many noxious plants

Indirect:

- Stress or disturbance from other impacts can affect the potential for invasion or success

Direct:

- Expanded ranges under warmer conditions
- Increased competitiveness from ability of some plants to take advantage of elevated CO2

honeysuckle

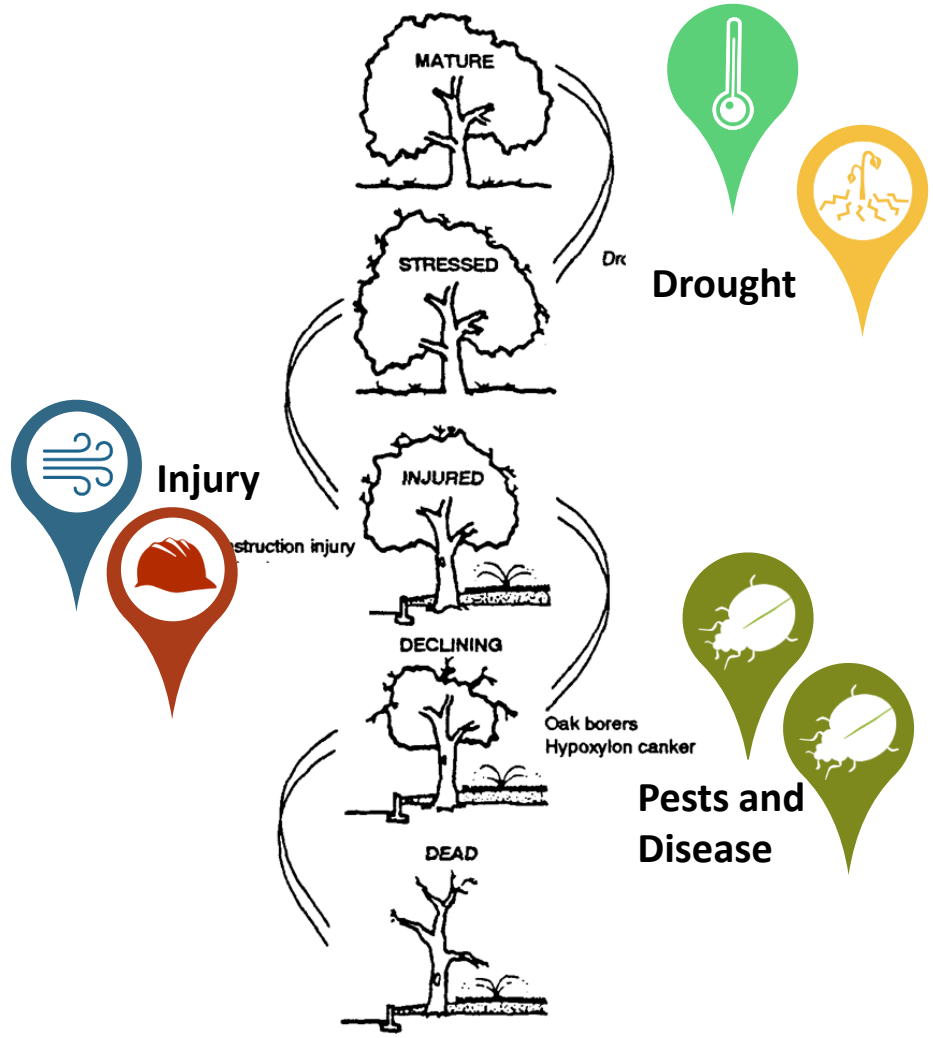
autumn olive

Risk may be greatest: Presence of invasive species nearby; other factors that reduce forest/understory vigor

Climate change is a “threat multiplier”

- Chronic stress
- Disturbances
- Insect pests
- Forest diseases
- Invasive species

Interactions make all the difference.



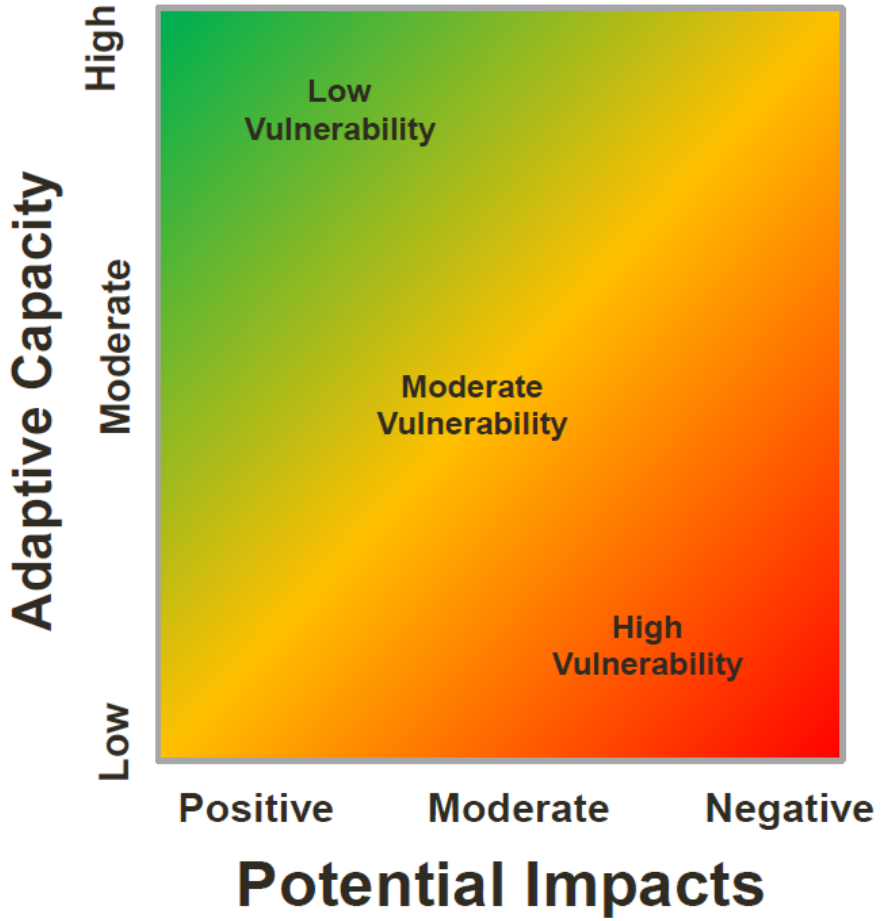
Drawing: Bartlett Tree Experts

Vulnerability Assessment Process

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

Modified from Swanston and Janowiak 2012

Vulnerability



Modified from Swanston and Janowiak 2012

Vulnerability Ratings

Forest Ecosystem	Potential Impacts	Adaptive Capacity	Vulnerability
Appalachian (Hemlock)- Northern Hardwood	Negative	Low-Moderate	High
Dry Calcareous	Neutral-Negative	Low-Moderate	Moderate-High
Dry Oak & Pine-Oak	Positive	Moderate-High	Low
Dry/Mesic Oak	Positive-Neutral	High	Low-Moderate
Large Stream Floodplain and Riparian	Negative	Low	High
Mixed Mesophytic and Cove	Neutral-Negative	Moderate-High	Moderate
North-Central Interior Maple-Beech	Neutral	Moderate	Moderate
Small Stream Riparian	Negative	Moderate	Moderate-High
Spruce-Fir	Negative	Moderate	High

Vulnerability: Dry-Mesic Oak Forest

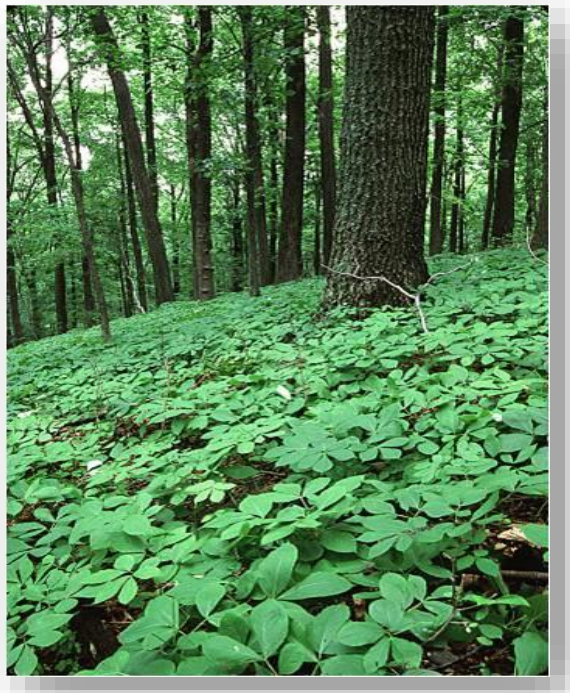
Low-Moderate Vulnerability

Drivers:
Dry to mesic soils, gap-phase dynamics, fire was historically important

Dominant Species:
Pignut hickory, white oak, mockernut hickory, shagbark hickory, chestnut oak, scarlet oak, black oak

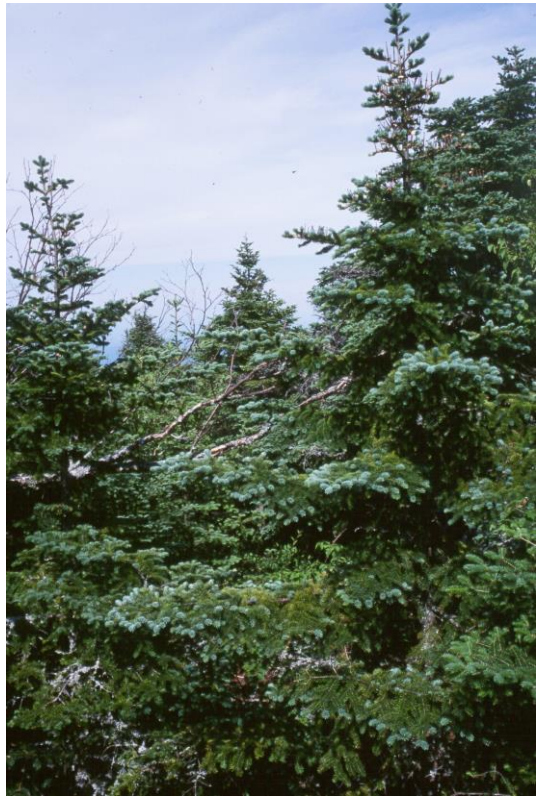
Stressors:
Increased drought, pests and diseases, Ailanthus and other invasive plants

Adaptive Capacity:
Past shift to mesic species (sugar maple, beech, etc. wide distribution, variety of habitat conditions, increased fire could help oak regen.



Location, Location, Location

Research and assessments describe broad trends but local conditions and management make the difference.



Thank you!

More information and resources at:

Forestadaptation.org

Patricia Leopold
pleopold@mtu.edu

NIACS
Northern Institute of Applied Climate Science