

CLIMATE CHANGE & NORTHEASTERN FORESTS

November 19, 2014



www.forestadaptation.org

Reminder!

Please send us your Step 1 worksheets—we're taking a look at them this week!

Step 1. DEFINE area of interest, conservation/management goals and objectives, and time frames.

Area of Interest:			
Location:			
Ecosystem Type(s)	Conservation Goals	Conservation Objectives	Time Frames

Northern Institute of Applied Climate Science

Climate

Carbon

Bioenergy

**NIACS is a regional
multi-institutional partnership**

Forest Service

- Northern Research Station
- Eastern Region
- Northeastern Area S&PF

Non-FS partners

- Michigan Technological University
- National Council for Air & Stream Improvement
- Trust for Public Land



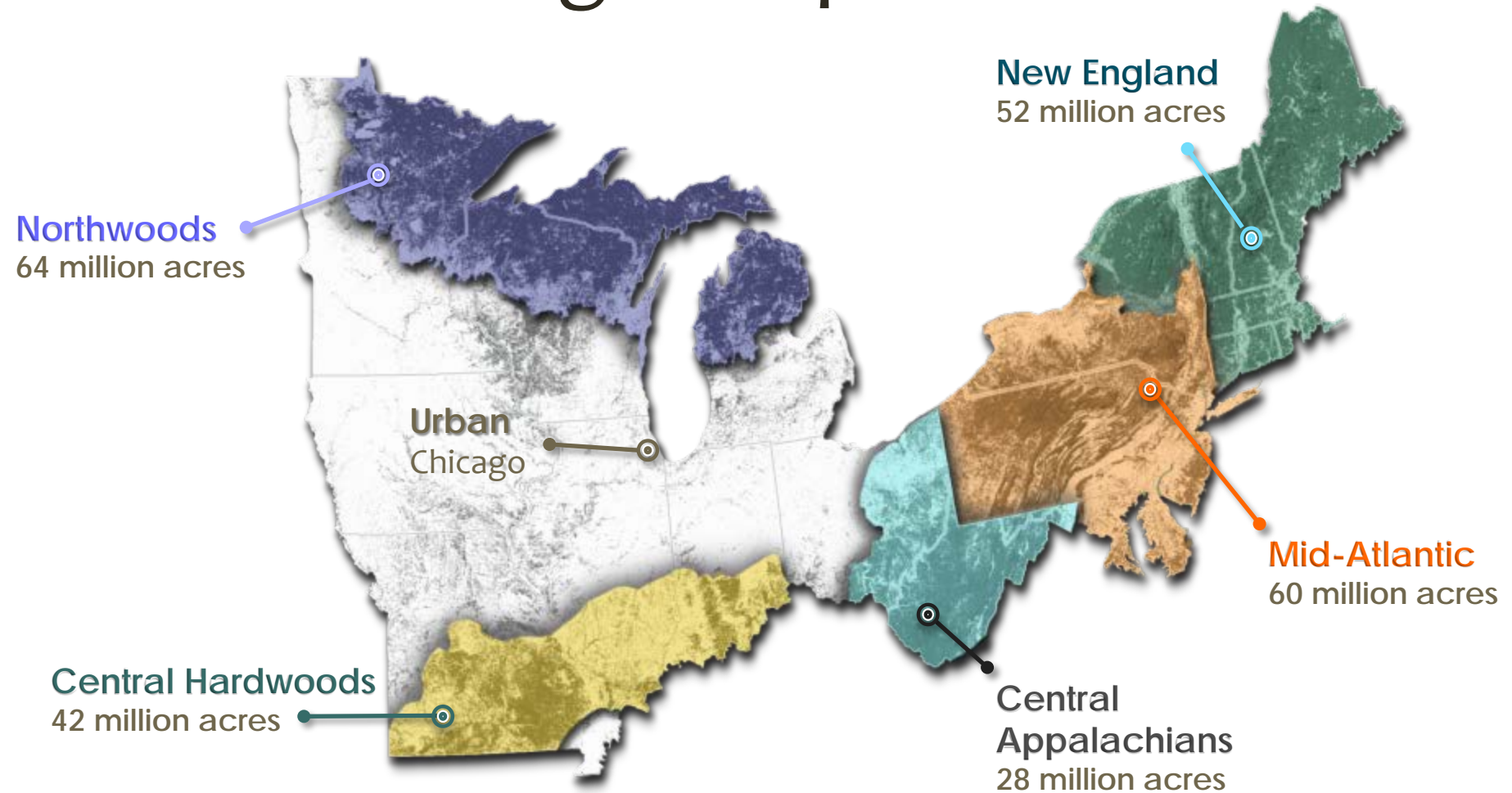
www.nrs.fs.fed.us/niacs/



Michigan Tech
ncasi



Climate Change Response Framework



Midwest USDA Climate Hub

Led by ARS with a **Northern Forests Sub-hub** based in Houghton, MI with NIACS as lead and CCRF integration

Northeast USDA Climate Hub

Led by FS NRS, where CCRFs are integrated into Hub and lead FS outreach and delivery to forest sector

Climate Change Response Framework

Structured, process oriented, works on multiple scales

Components:



Partnerships

Vulnerability Assessment

Forest Adaptation Resources

Adaptation Demonstrations

Progress:

75+ partner organizations
(and counting)

3 published assessments,
3 more in press/revision

Published in 2012, updated
and online versions in prep

50+ demonstrations
underway

NIACS-led Vulnerability Assessments

Audience: Land managers

Scope: Forest ecosystems

Vulnerability of:

- Tree species
- Forest/natural communities

Scientific reports: Do not make recommendations

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

Ecosystem Vulnerability Assessment and Synthesis reports:



NIACS-led Vulnerability Assessments

General Approach:

- Summarize climate change projections (temp./precip)
- Describe expected impacts on forests based on model results and literature
- Use scientist and expert knowledge to assess vulnerability of individual forest types to climate change



NIACS-led Vulnerability Assessments

General Approach:

- Summarize climate change projections (temp./precip)
- Describe expected impacts on forests based on model results and literature
- Use scientist and expert knowledge to assess vulnerability of individual forest types to climate change



New England has (Much) More Info

REVIEW / SYNTHÈSE

Composition and carbon dynamics of forests in northeastern North America in a future, warmer world¹

Jacqueline E. Mohan, Roger M. Cox, and Louis R. Iverson

Abstract: Increasing temperature, precipitation extremes, and other anthropogenic influences (acidic deposition, air chemistry, carbon dioxide) will influence forest structure, composition and productivity in the northeastern United States and eastern Canada. The patterns of projected and modeling studies indicate that the northeastern United States and eastern Canada will see the greatest warming, at least under pessimistic conditions. Data is needed to help us to understand and predict future forest composition and carbon dynamics. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada.

Resumé: L'augmentation des températures, les précipitations extrêmes, et d'autres influences anthropogéniques (déposition acide, chimie de l'air, dioxyde de carbone) influenceront la structure, la composition et la productivité des forêts dans le nord-est des États-Unis et du sud-est du Canada. Ces schémas de changements et de modélisation indiquent que le nord-est des États-Unis et le sud-est du Canada subiront les plus fortes augmentations de température, au moins dans les scénarios les plus pessimistes. Les données sont nécessaires pour nous aider à comprendre et à prédire la composition et la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada.

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at the University of Georgia, College of Forestry, Warnell School of Forestry, 100 Forestry Drive, Athens, GA 30602, USA; National Resources Canada, Canadian Forest Service - Atlantic Forestry Centre, P.O. Box 8000, Fredericton, NB A3B 8P9, NB, Canada

USDA Forest Service, Northern Research Station, 2600 Central Expressway, Corvallis, OR 97331, USA; and the University of New Brunswick, Faculty of Forestry, 100 Brookfield Drive, Saint John, NB A1B 3X9, Canada

Corresponding author: Jacqueline E. Mohan, jmohan@nrc.ca

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Changing Climate, Changing Forests: The Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada

Lindsey Rustad, John Campbell, Jeffrey S. Dukes, Thomas Huntington, Kathy Fallon Lambert, Jacqueline Mohan, and Nicholas Rodenhous



REVIEW / SYNTHÈSE

Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America: What can we predict?

Jeffrey S. Dukes, Jennifer Penttila, David Orwig, Jeffrey R. Dorman, Vikki L. Riddinger, Nicholas Brantley, Barry Cook, Kathleen A. Thoreson, Erik E. Stange, Robb Harrington, Joan Ehrenfeld, Jessica Gurevitch, Manuel Rivera, Kristina Shuman, Robert Cook, and Matthew Ayres

Abstract: Climate models predict that by 2100, the northeastern US and eastern Canada will warm by approximately 1.5°C, with increased winter precipitation. These changes will affect forest diversity and also indirectly through effects on insect pests, pathogens, and invasive plant species. Insect pests, pathogens, and invasive plant species are likely to expand their ranges and increase in abundance. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada.

Resumé: Les modèles climatiques prédisent que d'ici 2100, le nord-est des États-Unis et le sud-est du Canada se réchaufferont d'environ 1,5 °C, avec une augmentation des précipitations hivernales. Ces changements affecteront la diversité des forêts et indirectement à travers les effets sur les insectes nuisibles, les pathogènes et les espèces végétales envahissantes. Les insectes nuisibles, les pathogènes et les espèces végétales envahissantes sont susceptibles d'élargir leur gamme géographique et d'augmenter en abondance. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada.

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Corresponding author: Jeffrey S. Dukes, jdukes@nrc.ca

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REVIEW / SYNTHÈSE

Consequences of climate change for biogeochemical cycling in forests of northeastern North America¹

Charles L. Campbell, Lindsey E. Rustad, Elizabeth W. Boyer, Shadia F. Christopher, John T. Driscoll, Jason J. Fernandez, Peter M. Griffin, Daniel H. Hoyle, Jana Kiebusch, Alison H. Magill, Myron J. Mitchell, and Scott V. Ollinger

Abstract: A critical component of assessing the impacts of climate change on forest ecosystems involves understanding air-soil-atmosphere biogeochemical cycling of elements. Increased temperature, increased precipitation, and increased atmospheric CO₂ will affect forest biogeochemistry. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada.

Resumé: Une composante essentielle de l'évaluation des impacts du changement climatique sur les écosystèmes forestiers est la compréhension des cycles biogéochimiques air-sol-atmosphère des éléments. Une augmentation de la température, une augmentation des précipitations et une augmentation du CO₂ atmosphérique affecteront la biogéochimie des forêts. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada.

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Corresponding author: Charles L. Campbell, ccampbell@nrc.ca

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REVIEW / SYNTHÈSE

Climate change effects on native fauna of northeastern forests¹

Nicholas L. Rodenhous, Lynn M. Christensen, Dylan Parry, and Linda E. Green

Abstract: We review the observed and potential effects of climate change on native fauna of forests of northeastern North America by focusing on mammals, birds, amphibians, and insects. Our assessment is placed in the context of more general climate change projections, forest composition, and forest structure. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada. We use a synthesis of published literature to assess the potential for future forest composition and carbon dynamics in the northeastern United States and eastern Canada.

Resumé: Nous examinons les effets observés et potentiels du changement climatique sur la faune indigène des forêts du nord-est des États-Unis et du sud-est du Canada en nous concentrant sur les mammifères, les oiseaux, les amphibiens et les insectes. Notre évaluation est placée dans le contexte de projections plus générales sur le climat, la composition des forêts et leur structure. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada.

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Corresponding author: Nicholas L. Rodenhous, nrodenhous@nrc.ca

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Resumé: Une composante essentielle de l'évaluation des impacts du changement climatique sur les écosystèmes forestiers est la compréhension des cycles biogéochimiques air-sol-atmosphère des éléments. Une augmentation de la température, une augmentation des précipitations et une augmentation du CO₂ atmosphérique affecteront la biogéochimie des forêts. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada. Nous utilisons une synthèse de la littérature publiée pour évaluer le potentiel de la composition et de la dynamique du carbone des forêts futures dans le nord-est des États-Unis et le sud-est du Canada.

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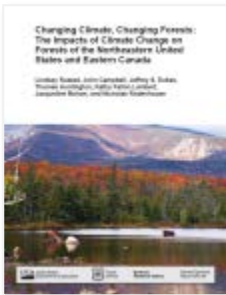
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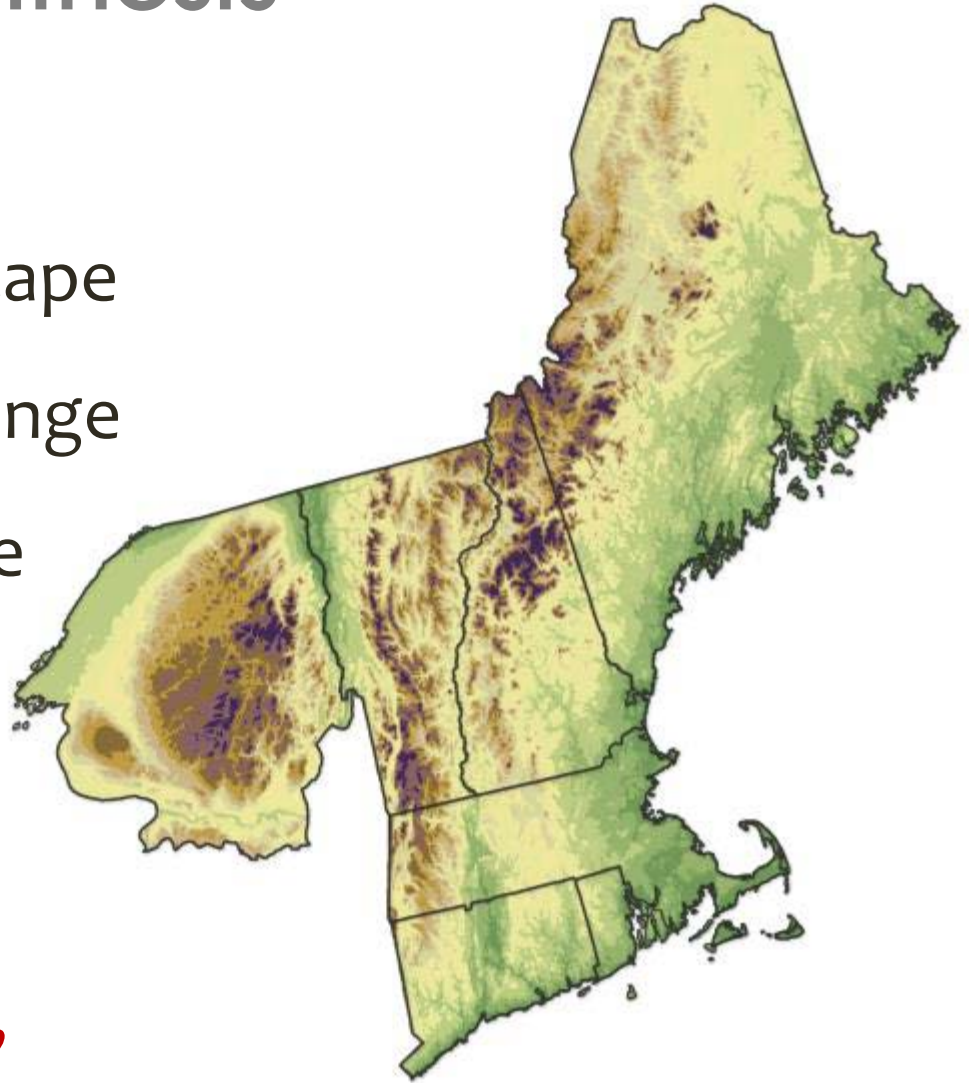
New England has (Much) More Info

- Much larger base of scientific research and climate change assessment.
- Existing information allows for immediate integration of high-quality science into management
- Targeted assessments to fill information gaps and/or improve science delivery
 - Synthesis products: print, video, & web-based
 - Other?



New England Synthesis

- 1) Introduction
- 2) Contemporary Landscape
- 3) Observed Climate Change
- 4) Future Climate Change
- 5) Impacts on Forests
- 6) Conclusions



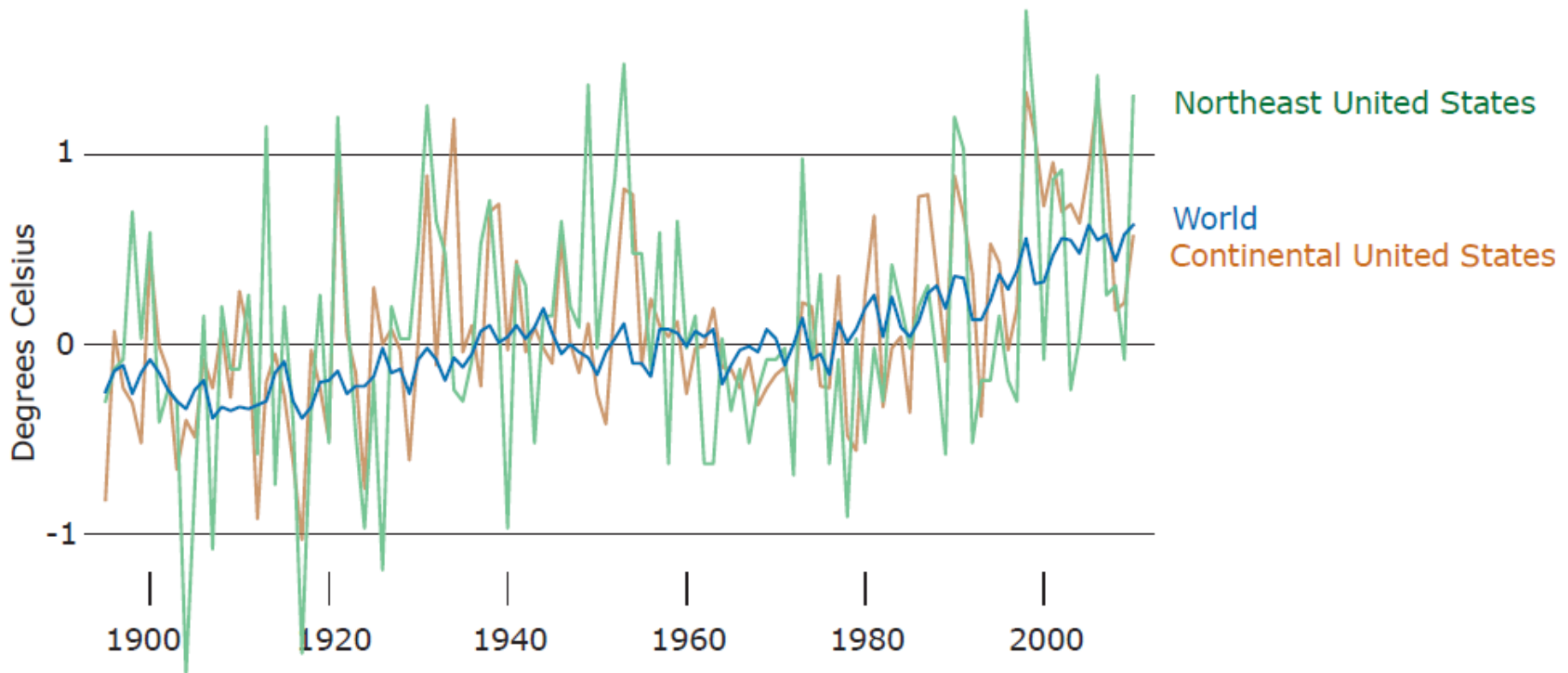
**Timeline = in progress,
draft this winter**

PAST AND FUTURE CLIMATE CHANGE

*How has climate changed
over the past century?*

Observed Climate Trends

Mean temperature change compared to 1951-1980 average
(1 °C = 1.8 °F)

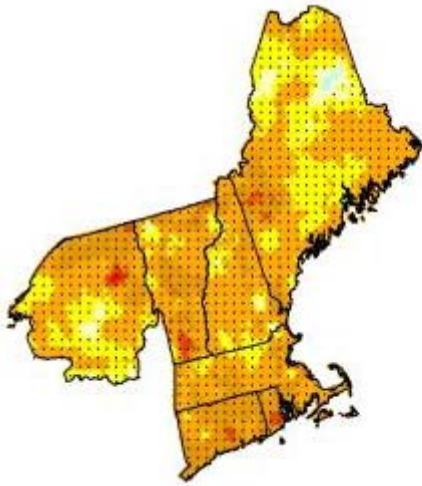


Observed Climate Trends

- ClimateWizardcustom.org
 - PRISM (Parameter-elevation Regressions on Independent Slopes Model)
 - 2.5-mile grid
- 1901 to 2011 departure analysis
 - Mean, Min, Max Temperatures
 - Precipitation
 - Yearly, seasonally

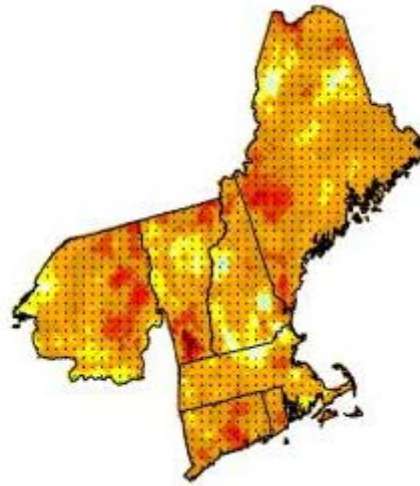
Annual Temperature Change

Mean



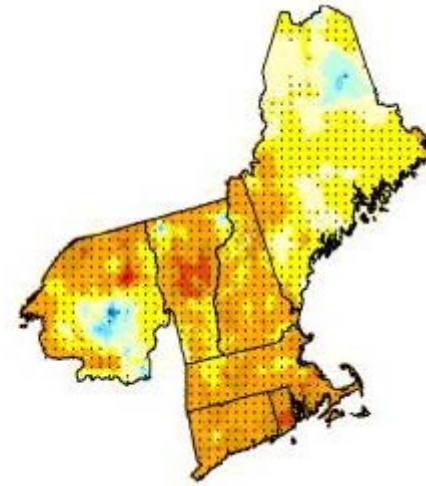
↑ 2.4 °F

Minimum



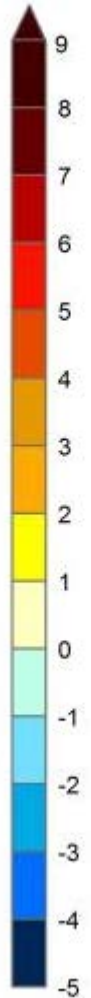
↑ 3.0 °F

Maximum



↑ 1.9 °F

1901-2011
Temperature
change
(°F)



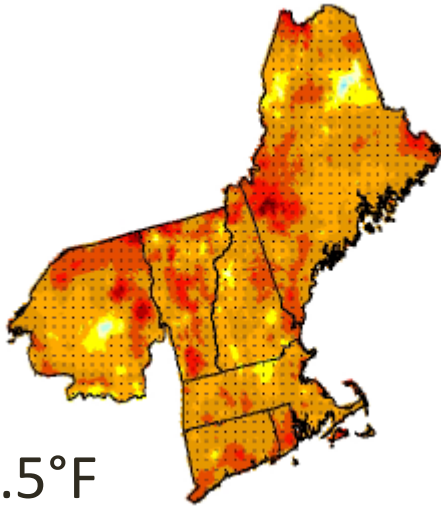
Statistically
significant trend
P-value < 0.1

- $0.022 \text{ deg}^\circ\text{F per year} = 2.4^\circ\text{F over 111 years}$
- Substantial inter-annual fluctuation

Seasonal Mean Temperature Change

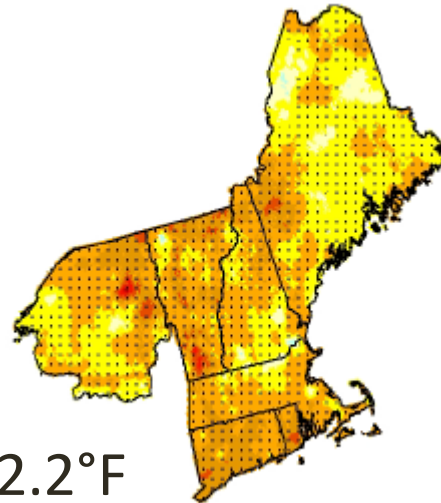
Winter
(Dec-Feb)

↑ 3.5°F



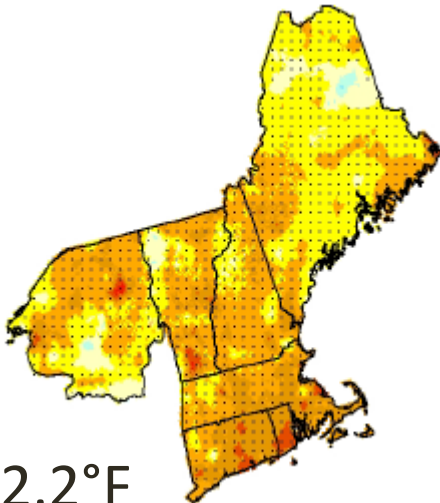
Spring
(Mar-May)

↑ 2.2°F



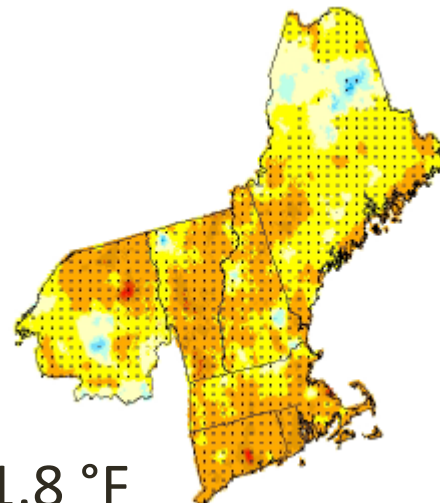
Summer
(Jun-Aug)

↑ 2.2°F

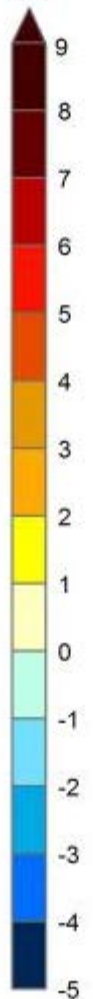


Fall
(Sep-Nov)

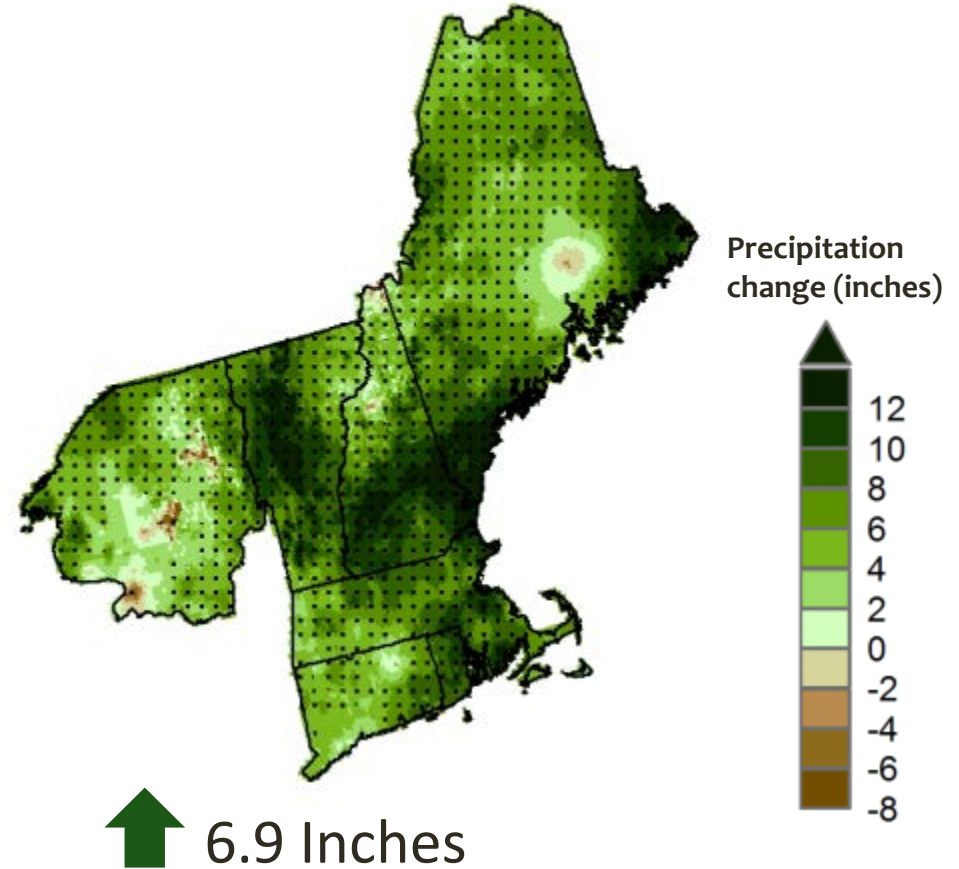
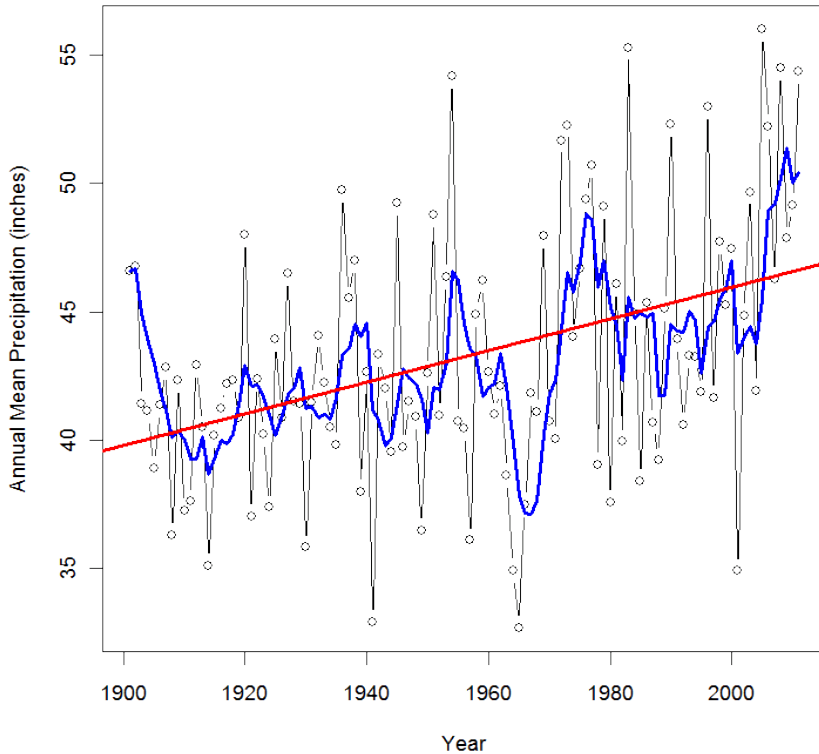
↑ 1.8°F



1901-2011
Temperature
change
(°F)

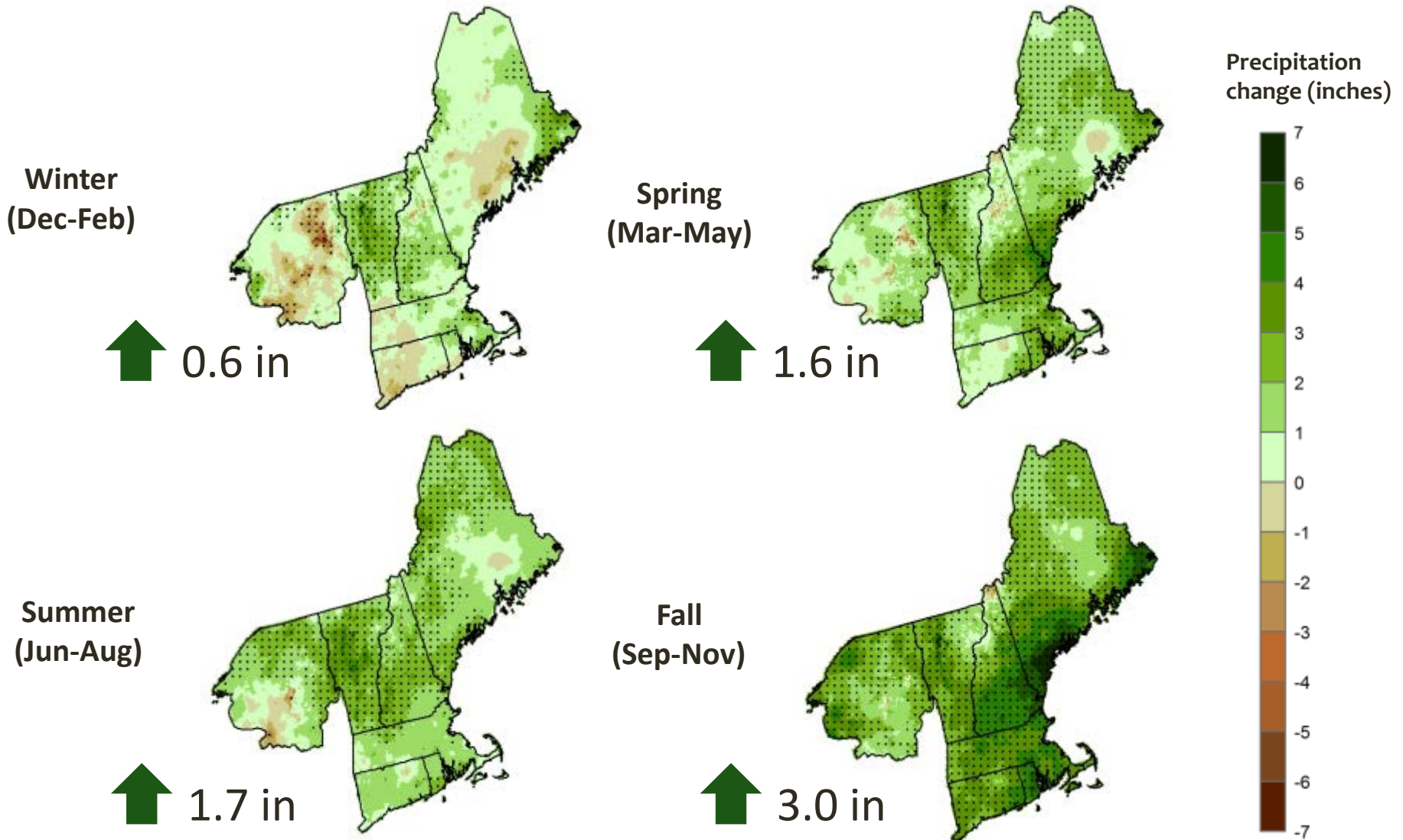


Annual Precipitation Change (1901-2011)



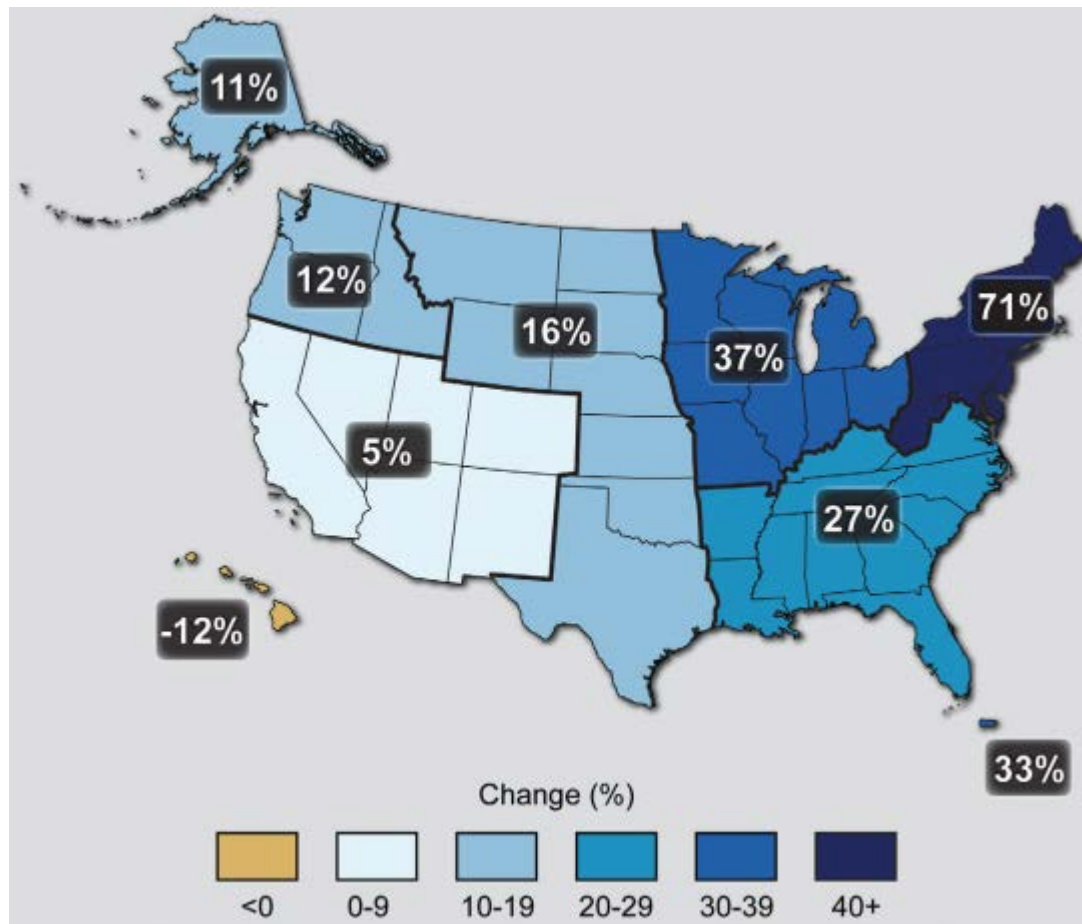
- 0.06 inches per year = 6.9 inches over 110 years
- Substantial inter-annual fluctuation

Seasonal Precipitation Change (1901-2011)



Extreme Precipitation Events

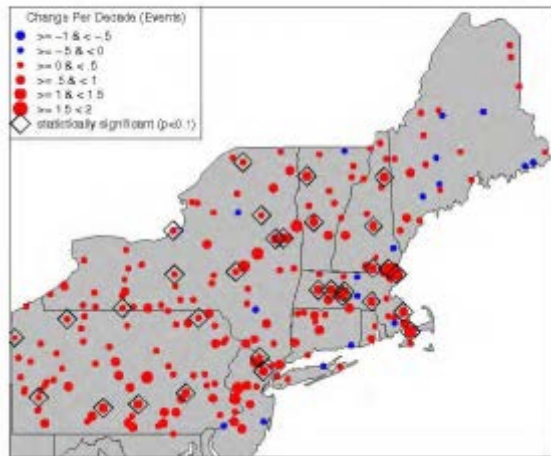
- The amount of precipitation falling in the heaviest 1% of events increased 71% between 1958 to 2012 (NCA 2014)



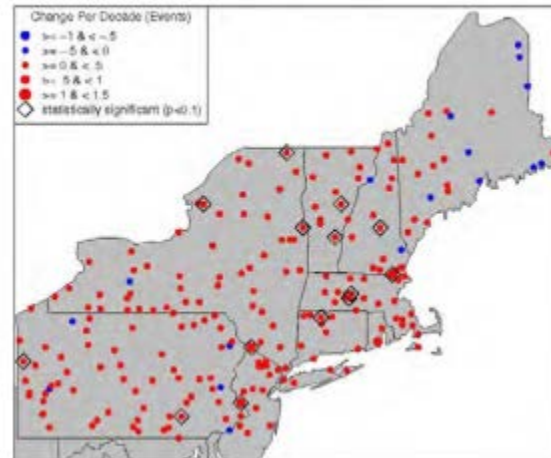
Extreme Precipitation Events

The amount of precipitation falling in single events increased between 1948 and 2007

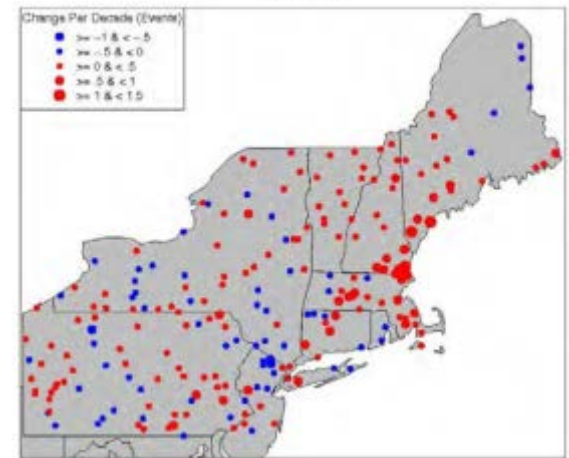
Mean Decadal Change in 1-inch Events
1948-2007



Mean Decadal Change in 2-inch Events
1948-2007



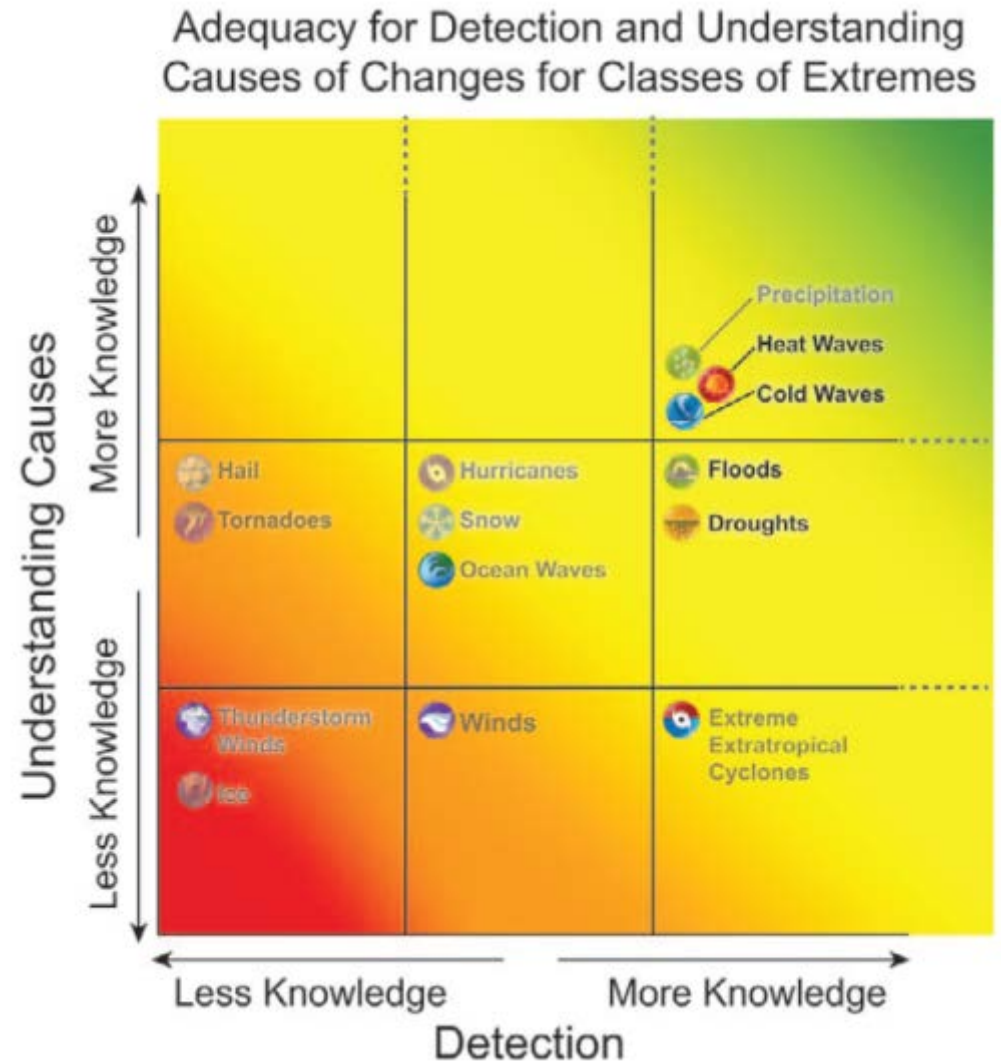
Mean Decadal Change in 4-inch Events
1948-2007



Extreme Events: Detection & Attribution

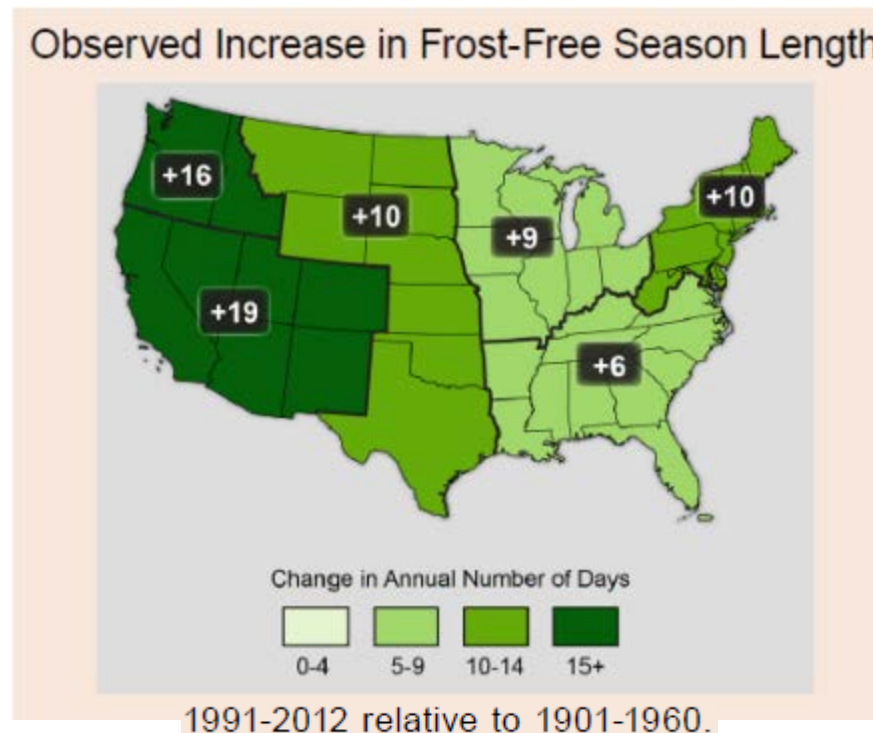
Factors influencing the understanding of extreme events:

- Scientists' understanding of event & what would cause it to change
- Data quality
- Data quantity



Additional Observations & Evidence

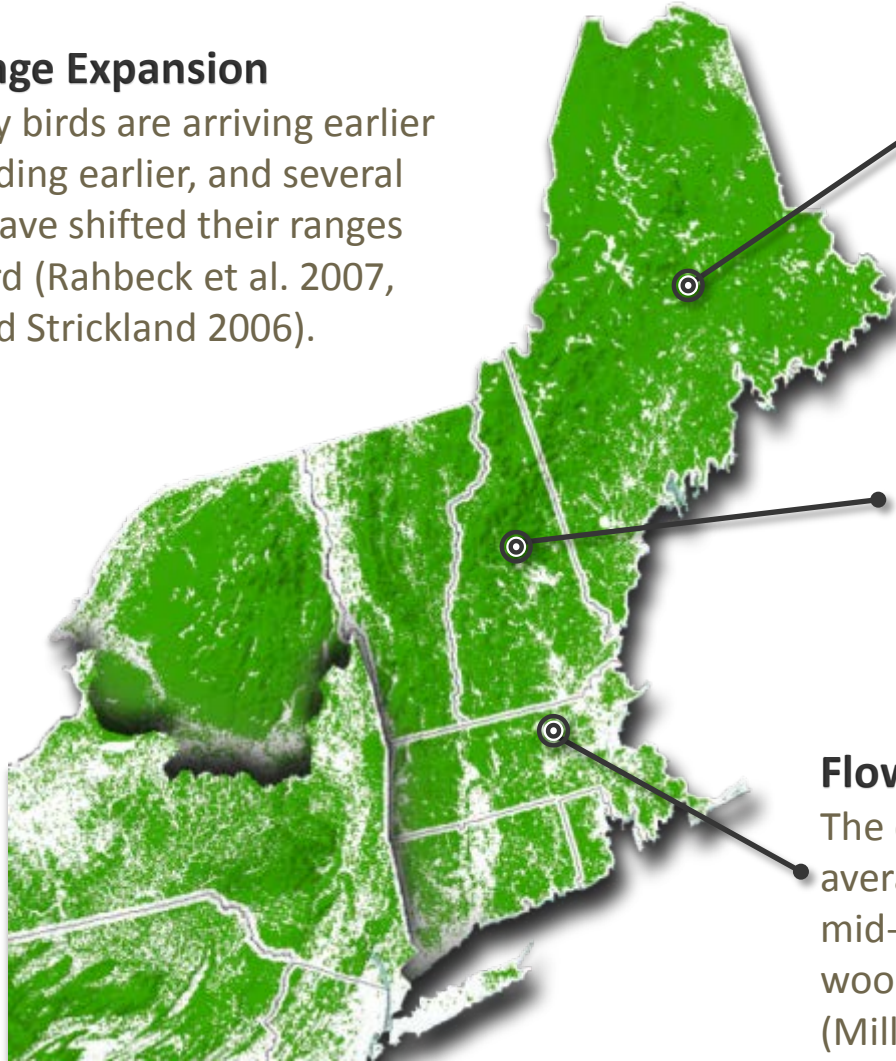
- US has warmed 1.3-1.9°F since 1895 (*Melillo et al. 2014*)
- Lower 48 warmed 1.3 °F per century during 1901-2009 (*EPA 2012*)
- Global sea level has risen about 8 inches since 1880 (*Melillo et al. 2014*)
- Growing seasons have lengthened (*Melillo et al. 2014*)



Phenological Changes

Bird Range Expansion

Migratory birds are arriving earlier and breeding earlier, and several species have shifted their ranges northward (Rahbeck et al. 2007, Waite and Strickland 2006).



Lake Ice

Lake ice-out dates have advanced across Maine, with many dates now two weeks earlier than in the 1800s (Jacobson et al. 2009)

Green Canopy Duration

Trees at Hubbard Brook Experimental Forest have about 10 more days per year of green canopy (Richardson et al. 2006)

Flowering Dates

The date of first flowering is a week earlier on average compared to Thoreau's records from the mid-1800s. Highbush blueberries and yellow wood sorrel are flowering several weeks earlier (Miller-Rushing and Primack 2009)

Sea Level Rise

Sea level increased by about 1 foot since 1900, which is greater than the global average of about 8 inches and has led to an increase in coastal flooding

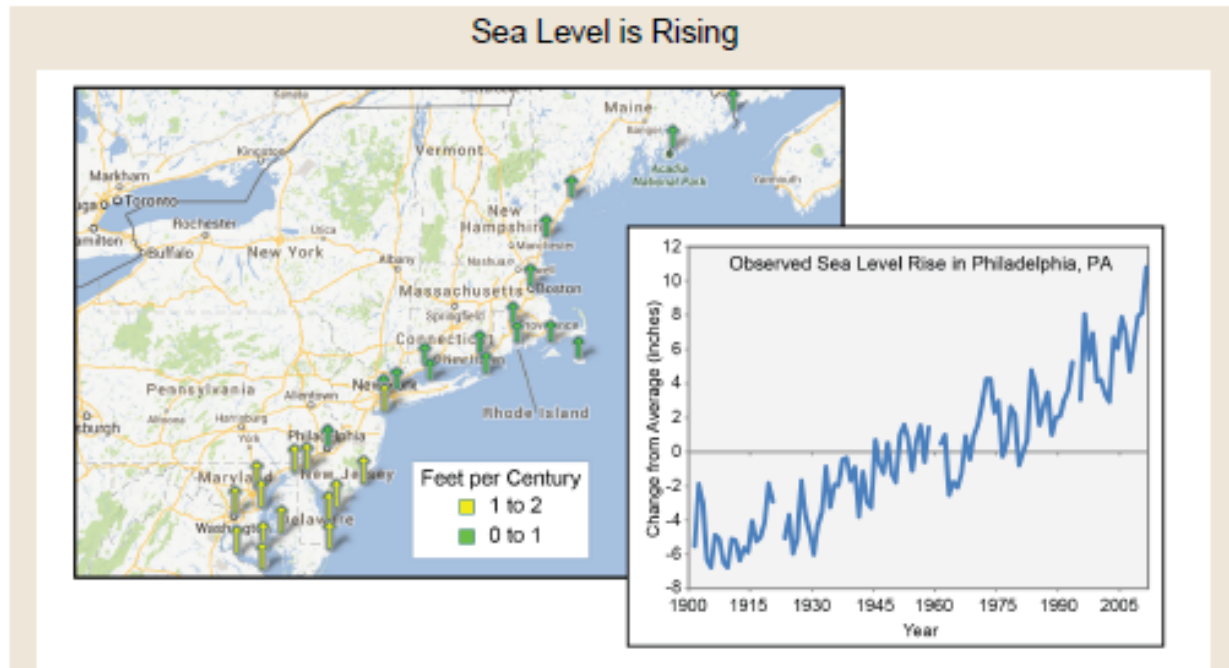


Figure 16.1. (Map) Local sea level trends in the Northeast region. Length of time series for each arrow varies by tide gauge location. (Figure source: NOAA⁶). (Graph) Observed sea level rise in Philadelphia, PA, has significantly exceeded the global average of 8 inches over the past century, increasing the risk of impacts to critical urban infrastructure in low-lying areas. Over 100 years (1901-2012), sea level increased 1.2 feet (Data from Permanent Service for Mean Sea Level).

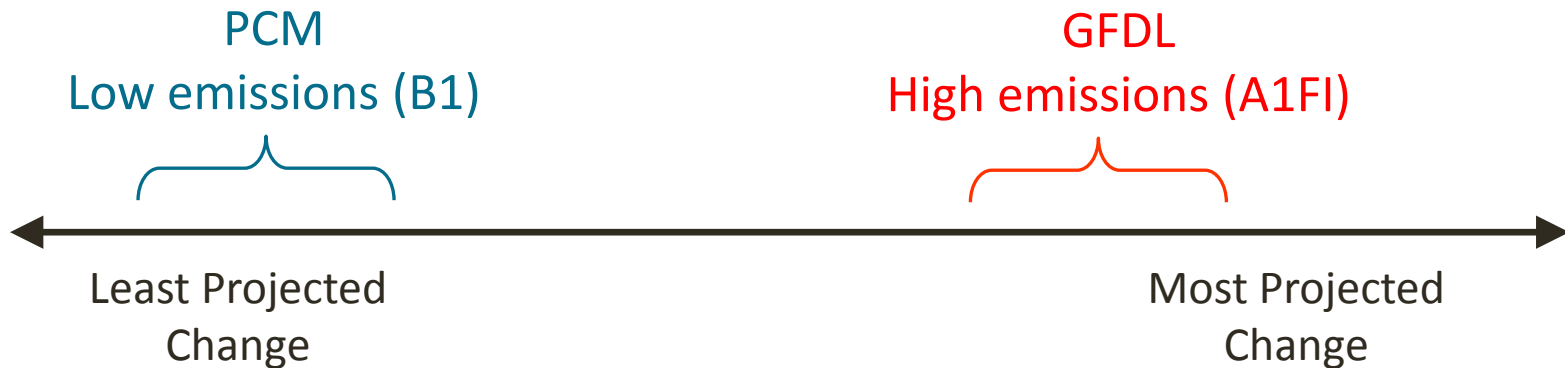
How is the climate expected to change over the next century?

Climate Scenarios Used

- Climate data downscaled by ATMOS/K. Hayhoe
- Three time periods
 - 2010 to 2039
 - 2040 to 2069
 - **2070 to 2099**
- 7.5-mile grid
- Annual and Seasonal changes
- Temperature: Mean, Minimum, Maximum
- Precipitation

Climate Scenarios Used

- Two scenarios show the range of possible change
 - PCM B1: Low emissions scenario + less sensitive GCM
 - GFDL A1FI: High emissions + more sensitive GCM
- Projections are consistent with other data sets
- Think of them like bookends:

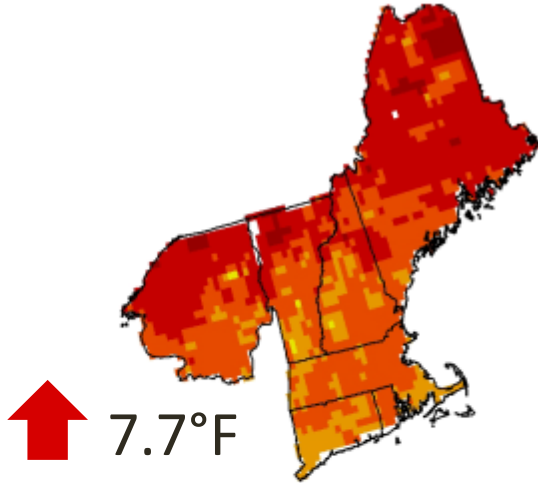
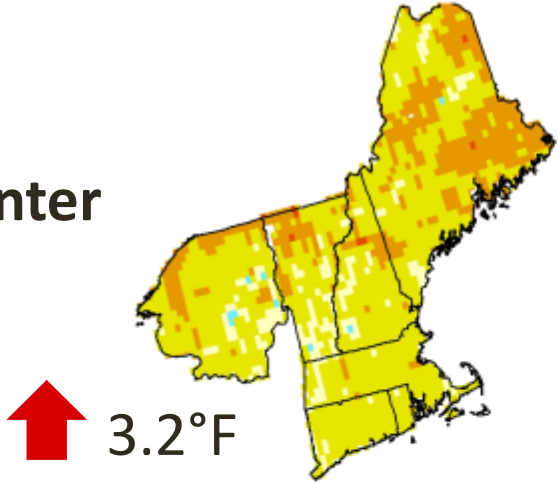


Seasonal Temperature Projections

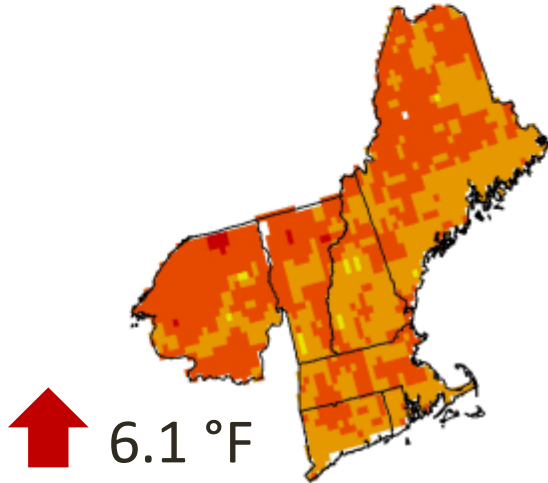
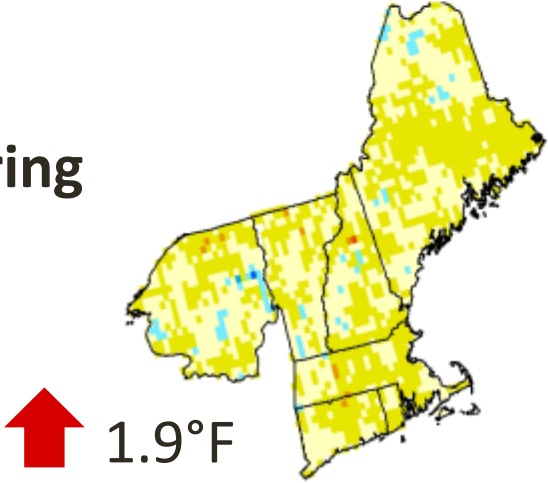
Change in
30-year average (°F)
2070-2099 vs. 1971-2000



Winter



Spring



Low

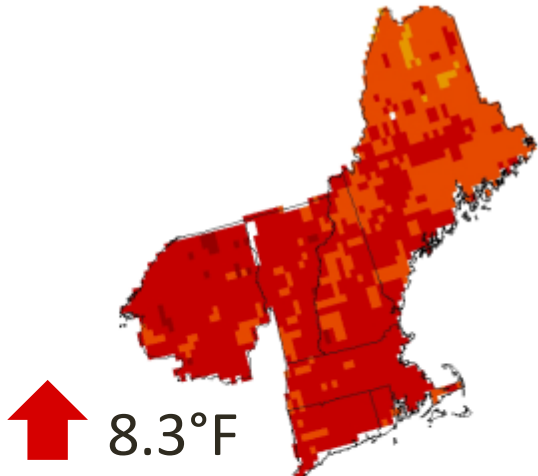
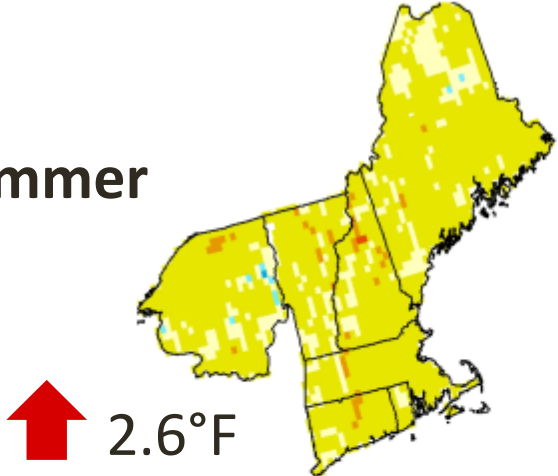
High

Seasonal Temperature Projections

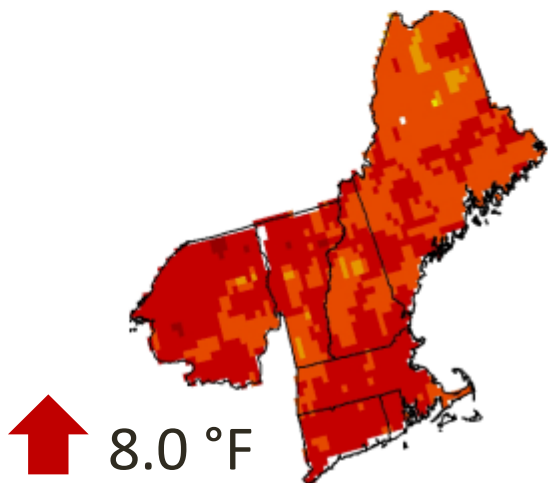
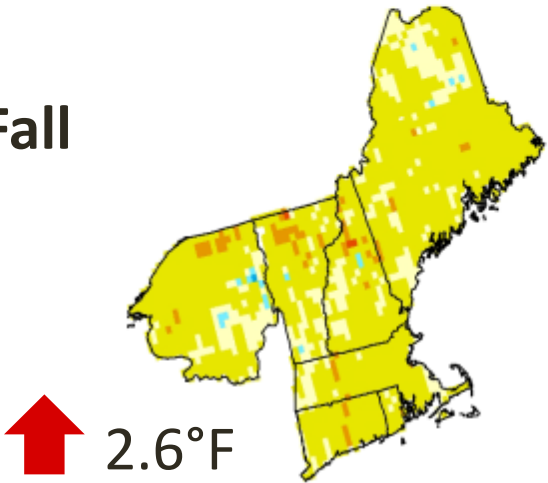
Change in
30-year average (°F)
2070-2099 vs. 1971-2000



Summer



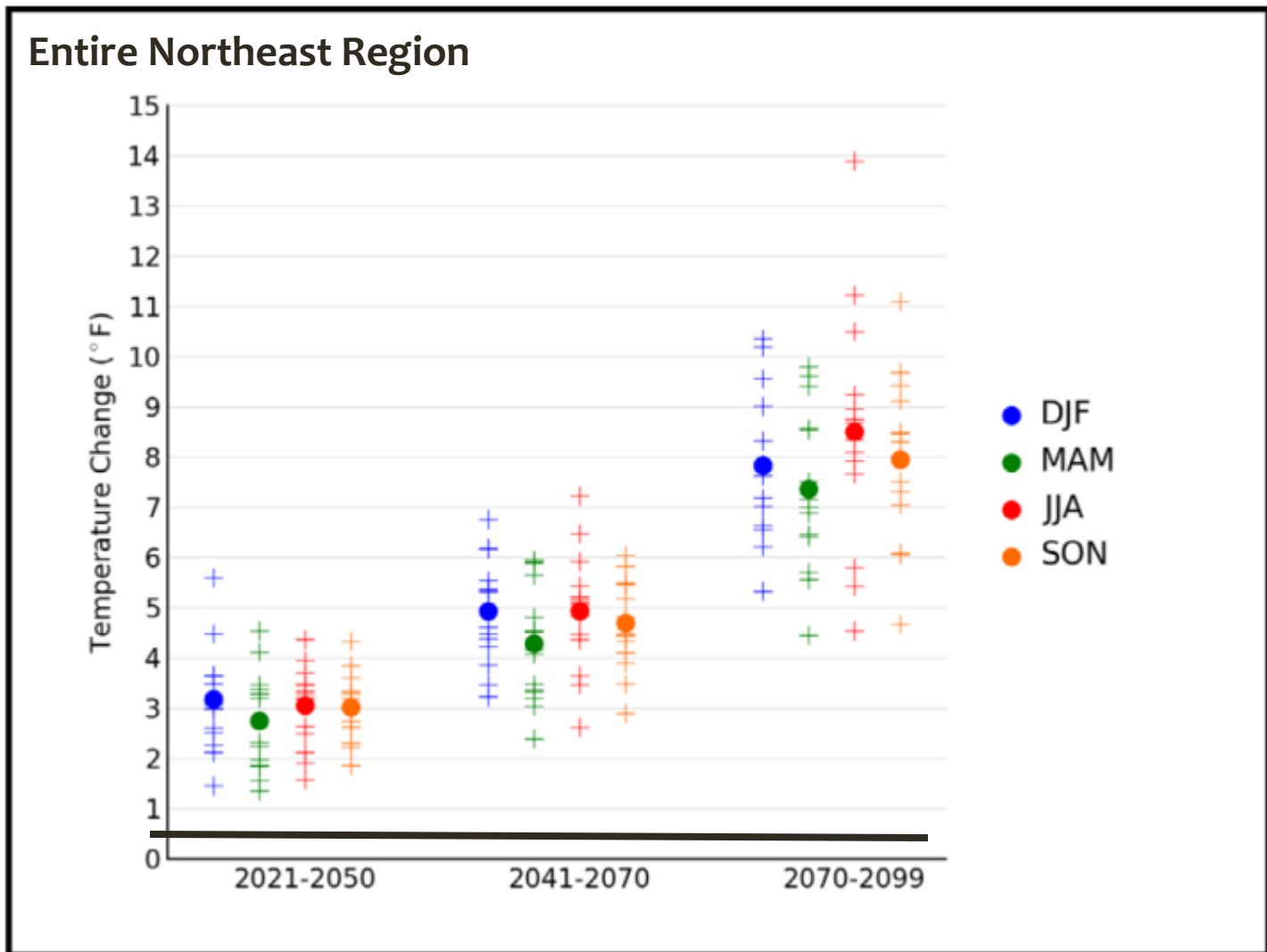
Fall



Low

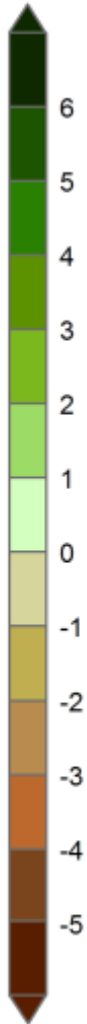
High

Temperature Change Projections



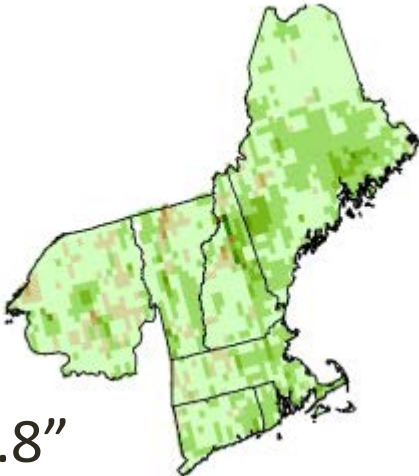
Seasonal Precipitation Projections

Change in
30-year average
2070-2099 vs. 1971-2000

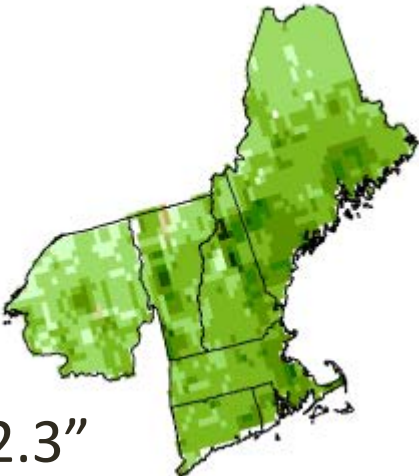


Winter

↑ 0.8"



↑ 2.3"

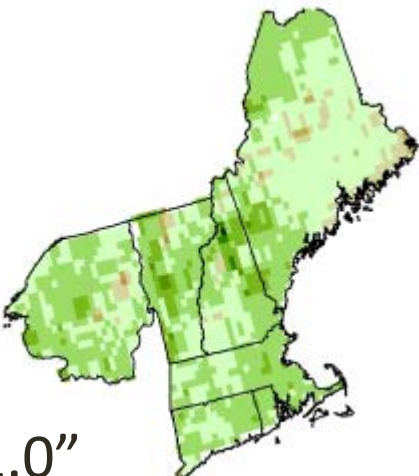


Spring

↓ -0.1"



↑ 1.0"



Low

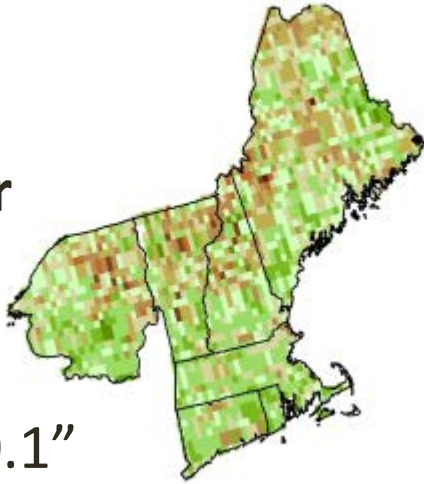
High

Seasonal Precipitation Projections

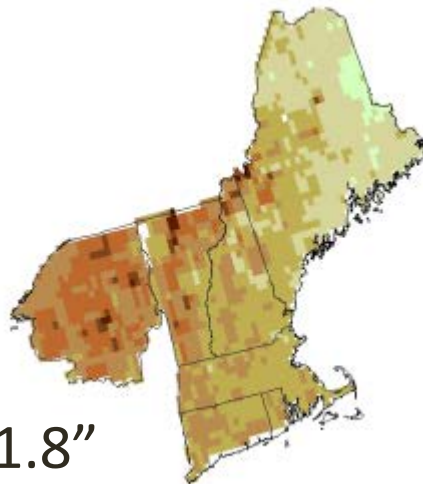
Change in
30-year average
2070-2099 vs. 1971-2000

Summer

↑ 0.1"

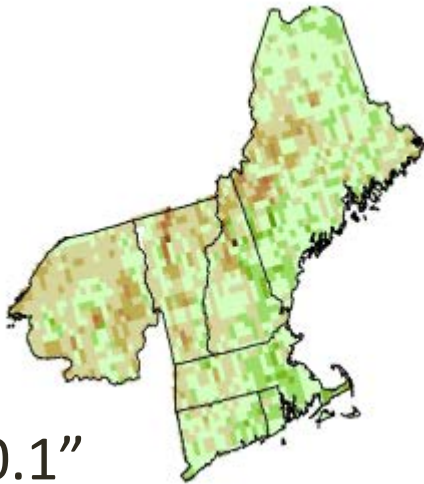


↓ 1.8"

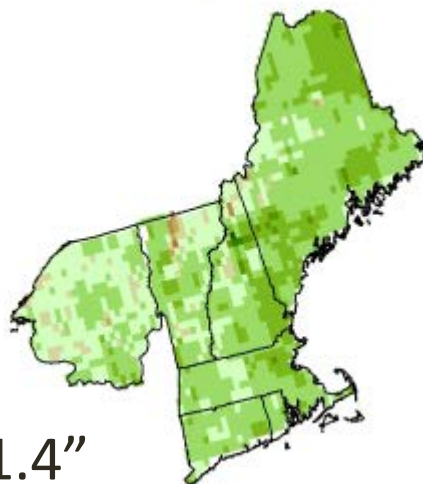


Fall

↑ 0.1"



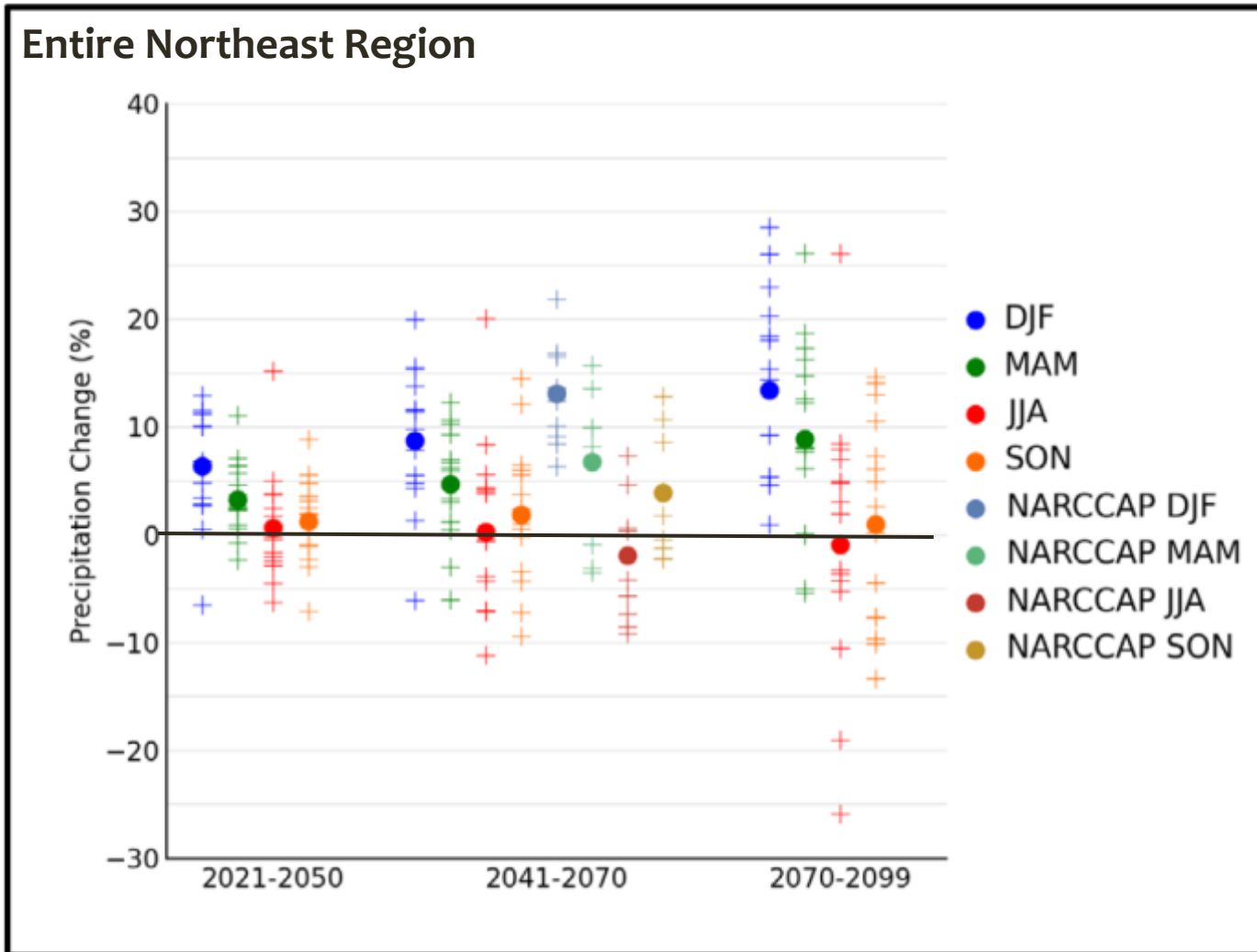
↑ 1.4"



Low

High

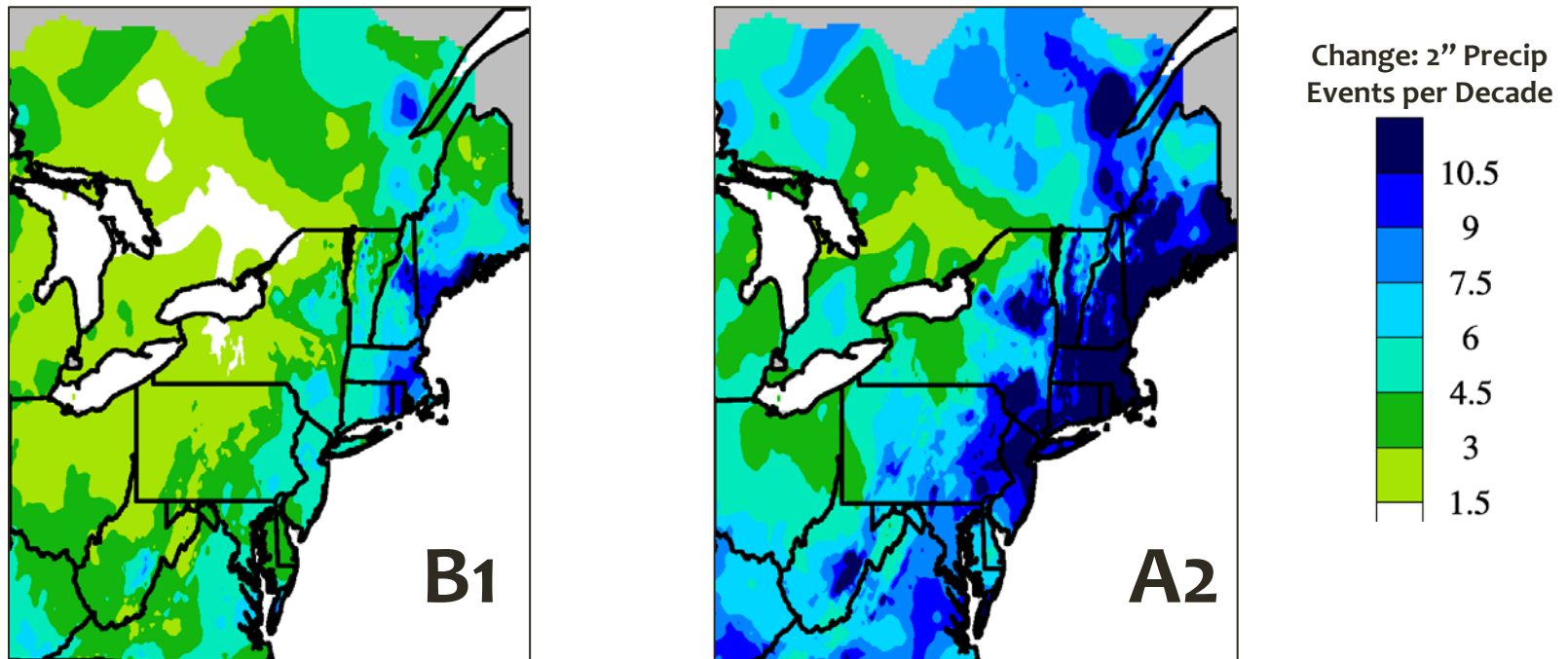
Precipitation Change Projections



Extreme Precipitation Events

- Extreme precipitation has increased dramatically
 - Precip in heaviest 1% of events increased 71% between 1958 to 2012
- Trend expected to continue/increase

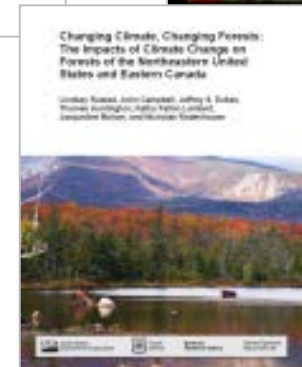
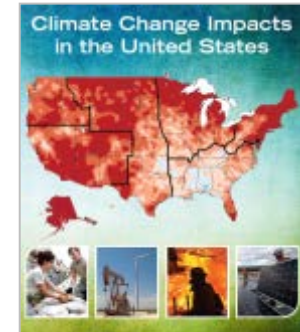
Change in 2-inch Precipitation Events (late 21st century)



How could forests be affected?

Nine Impacts on New England Forests

- 1) Longer Growing Season
- 2) Shorter Winters
- 3) Potential for Summer Drought
- 4) CO₂ Fertilization
- 5) Changes in Suitable Habitat
- 6) Extreme Events
- 7) Wildfire Risk
- 8) Forest Pests and Diseases
- 9) Invasive Plants

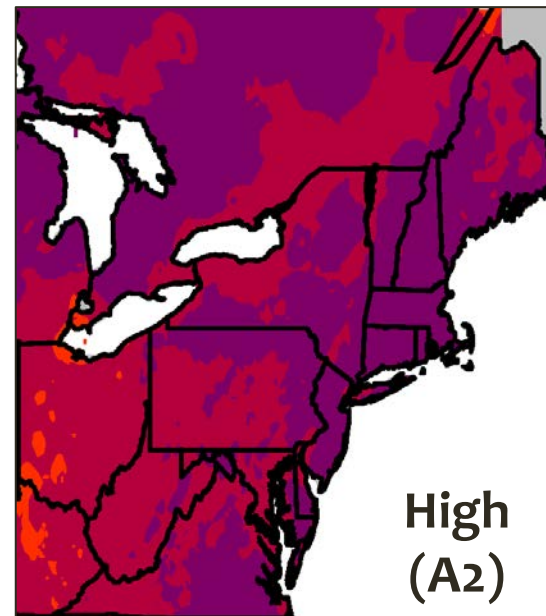
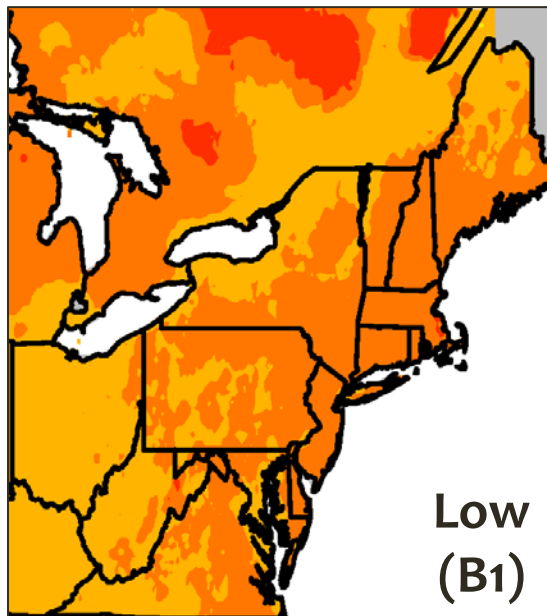


1: Longer Growing Seasons

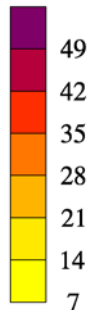
Warmer temps result in longer growing seasons

- Projected to increase 3-7+ weeks by 2100

Growing Season– End of Century Change



Change in Growing Season (days)



1: *Longer Growing Season*

Warmer temps result in longer growing seasons

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

Longer period for plant growth



1: *Longer Growing Season*

Warmer temps result in longer growing seasons

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

Longer period for plant growth

Potential risks:

- Early bud break/loss of cold hardening
- Frost damage during spring freezing

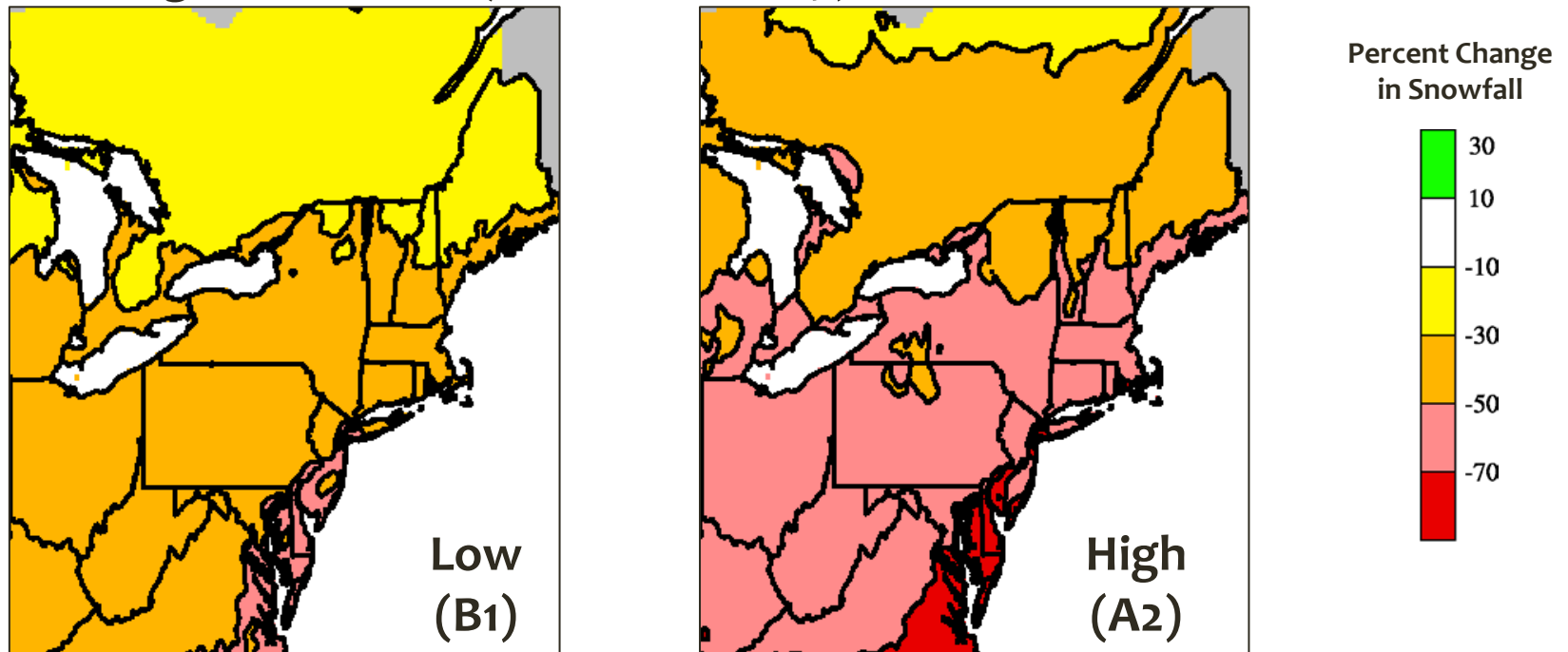


2: Shorter Winter (Less Snow)

Projected decreases in snow fall, cover, and depth

- 30-70% decreases in snowfall
- Greatest snowfall decreases in December or January

Percent change in snowfall (late 21st century)



2: Shorter Winter (Less Snow)

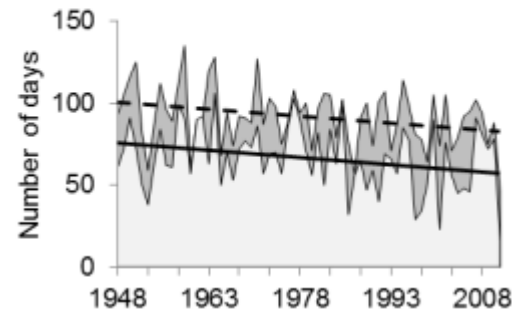
Decreased snowpack

- Increased soil frost and root damage in cold temps
- Warmer soil temperatures and altered processes

Wisconsin Frozen Ground



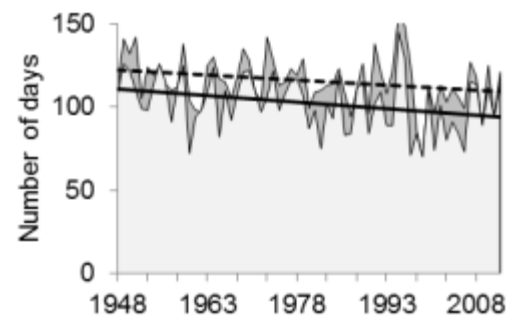
Dane County



Frozen Ground Season

Annual data
Trend

Onieda County

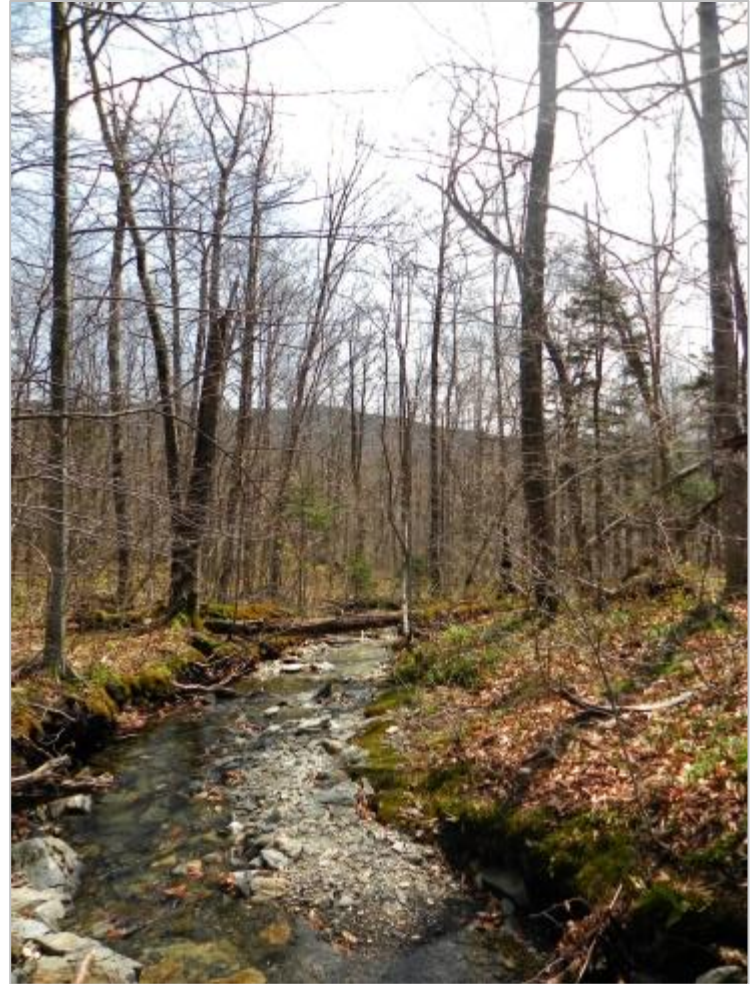


Frozen Ground Days

Annual data
Trend

2: *Shorter Winter (Less Snow, More Rain)*

Precipitation is projected to increase = more rain



2: *Shorter Winter (Less Snow, More Rain)*

Precipitation is projected to increase = more rain

Altered streamflow timing and amount

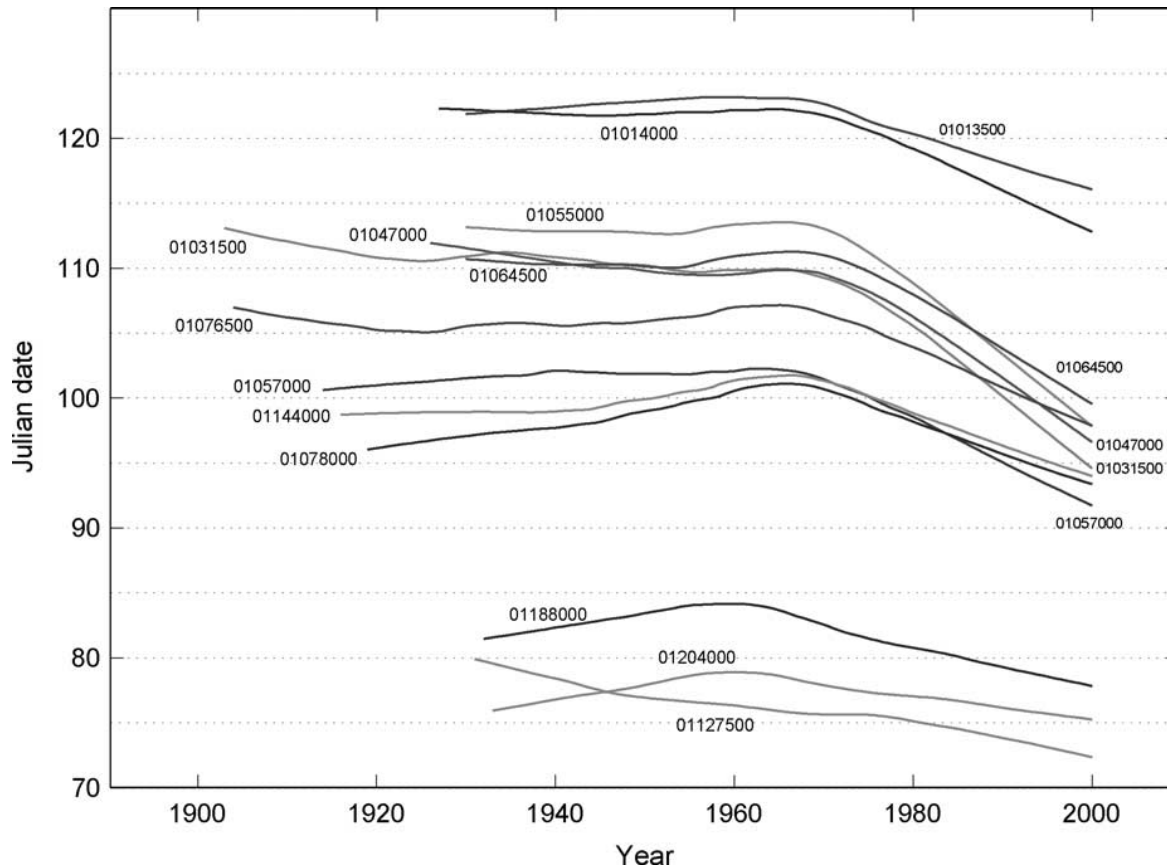
- Earlier spring peak flows
- Potential increases in flashiness and episodic high flows
- Potential declines in summer seasonal stream flow



2: Shorter Winter (Less Snow, More Rain)

Altered streamflow timing and amount

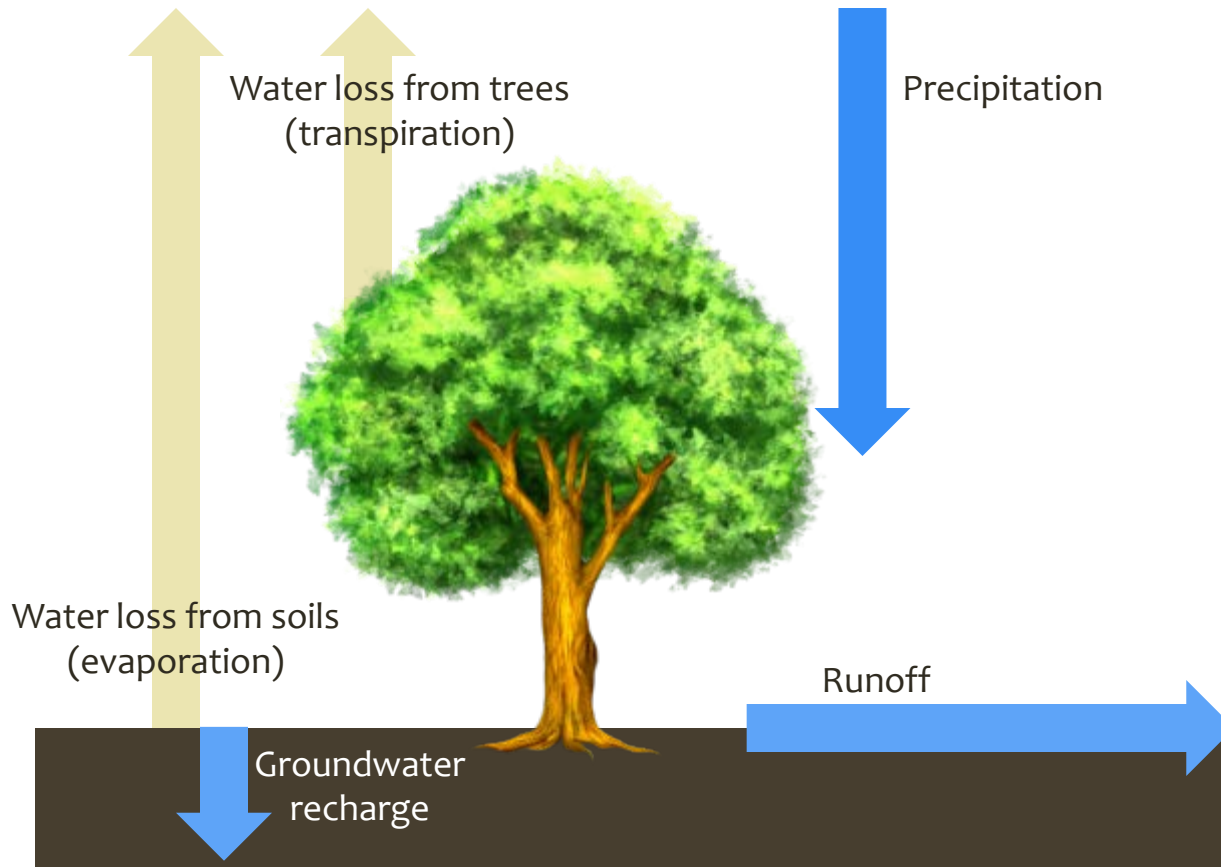
Winter/spring center of volume dates for 13 New England rivers



Most change in past 30 years, dates advancing 1-2 weeks

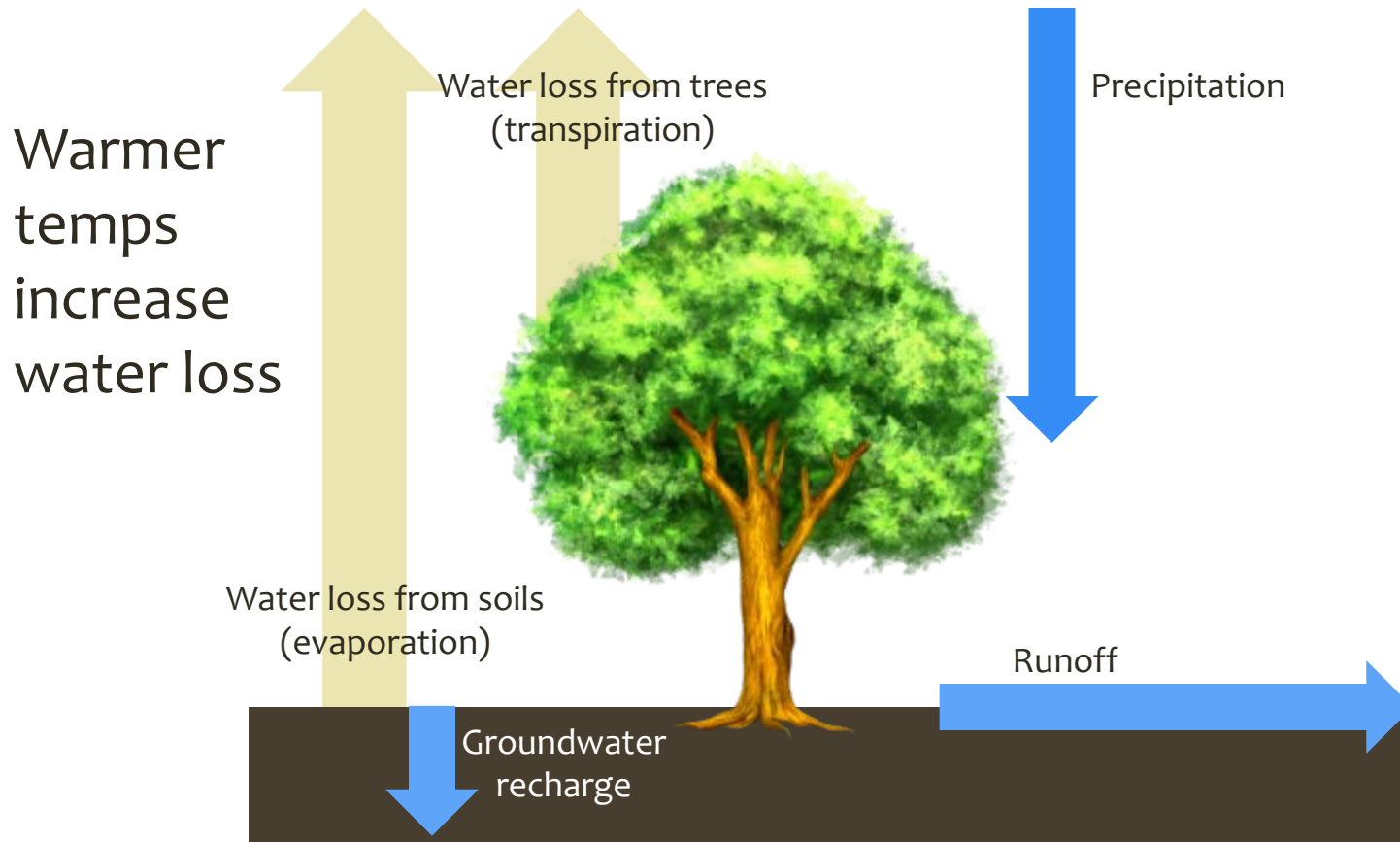
3: *Potential for Summer Drought*

Greater uncertainty about future precipitation, but increased risk of summer moisture stress



3: *Potential for Summer Drought*

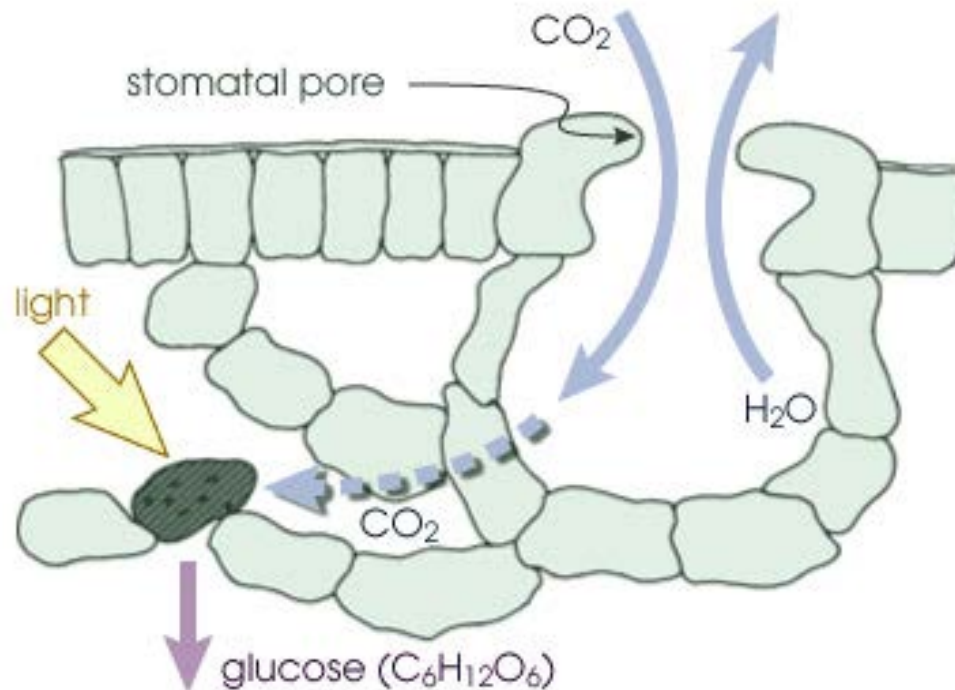
Greater uncertainty about future precipitation, but increased risk of summer moisture stress



4: CO₂ Fertilization

Benefits

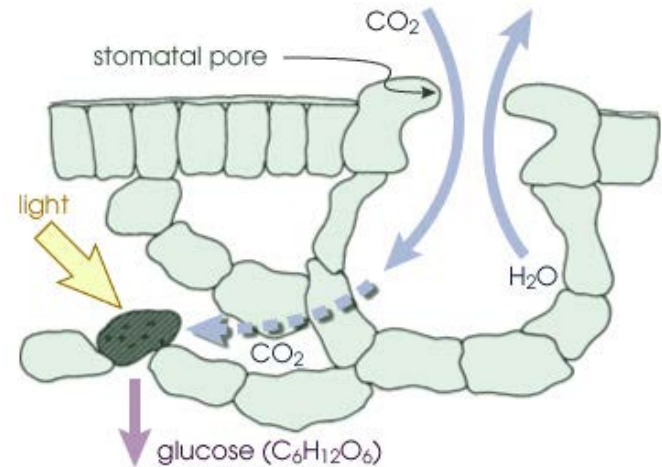
- Increased photosynthesis
- Increased water use efficiency



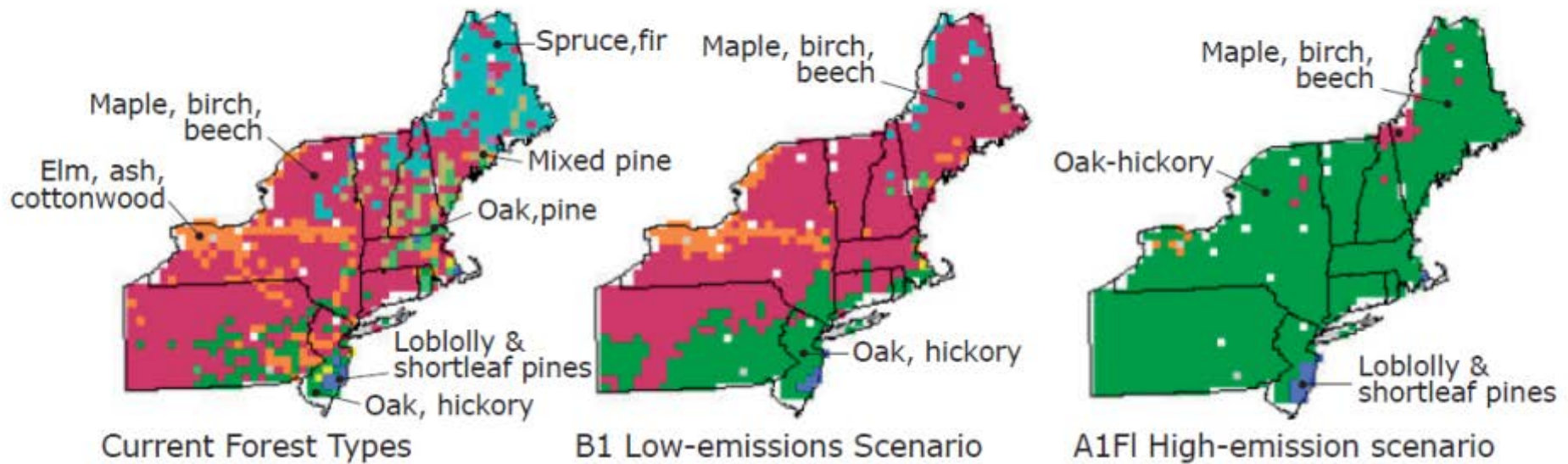
4: CO₂ Fertilization

Limits to CO₂ 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



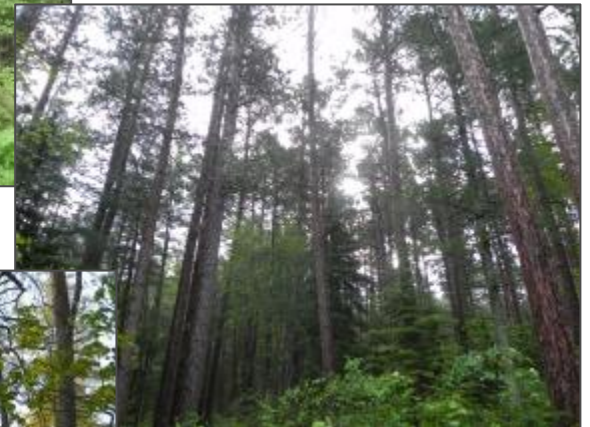
5: Changes in Suitable Habitat



5: *Changes in Suitable Habitat*

Habitat based on:

- Temperature
- Precipitation
- Elevation
- Latitude
- Soils
- Slope & Aspect
- Land use
- Competition
- Past management



5: *Changes in Suitable Habitat*

Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect
- Land use
- Competition
- Past management

Climate Change Atlas:

What happens to tree and bird habitat when climate changes?

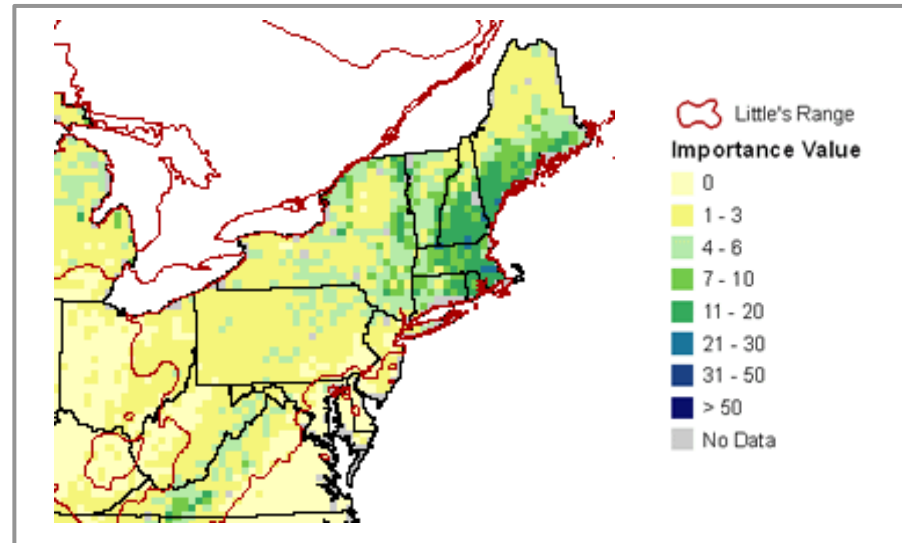
- 134 Trees
- 147 Birds

5: *Changes in Suitable Habitat*

Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect

White Pine: Current Habitat (modeled)

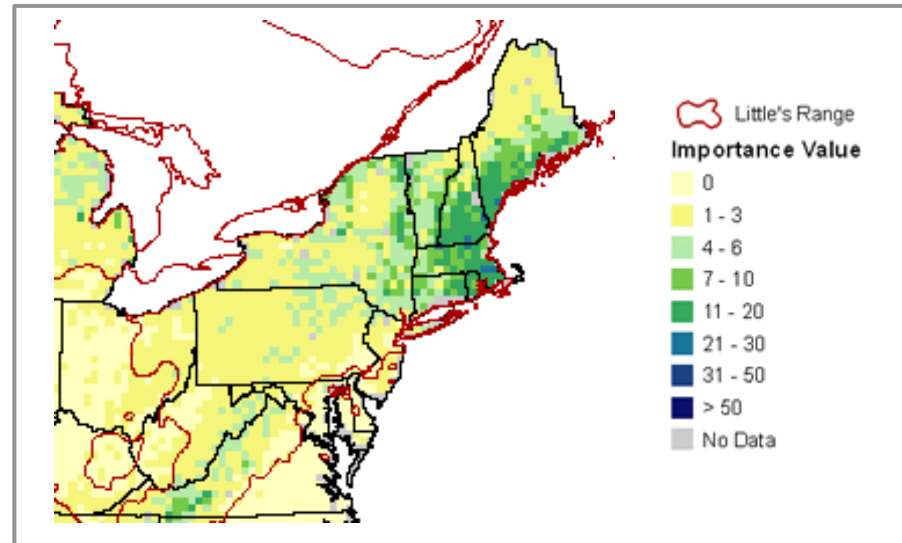


5: Changes in Suitable Habitat

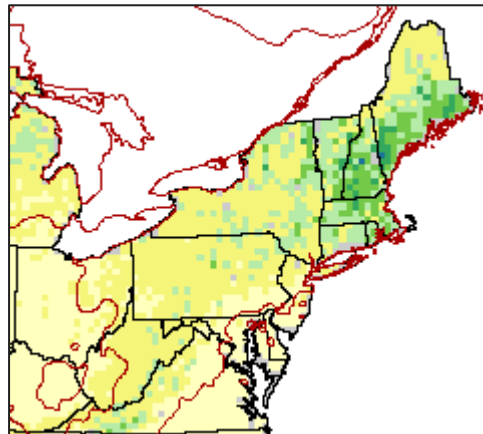
Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect

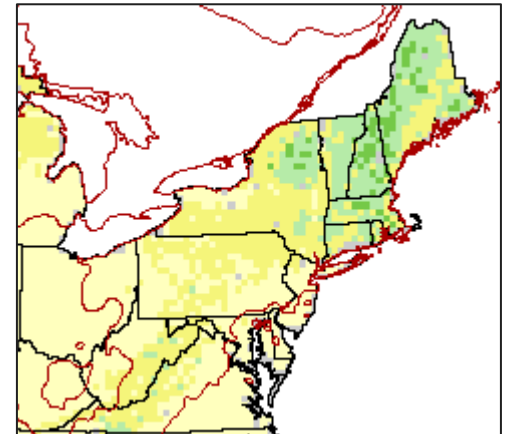
White Pine: Current Habitat (modeled)



PCM B1 (Less Change)



GFDL A1FI (More Change)

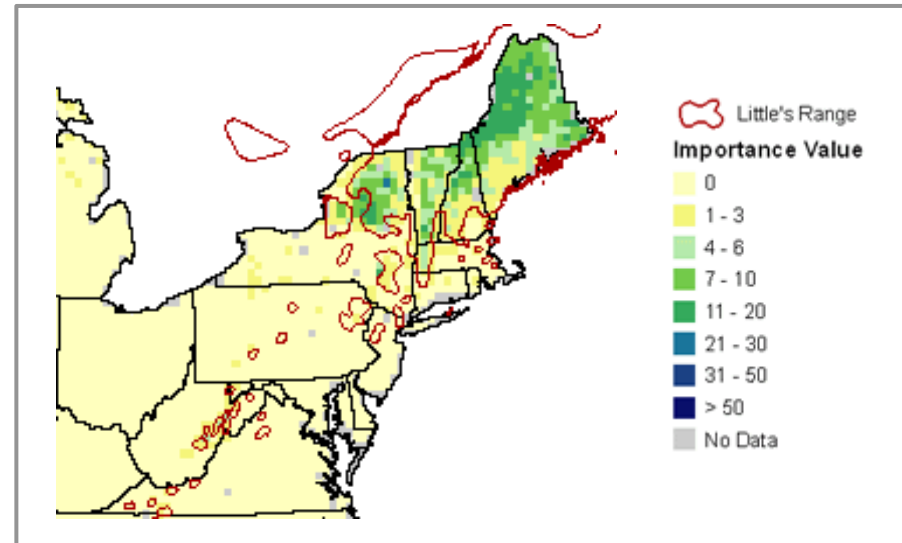


5: Changes in Suitable Habitat

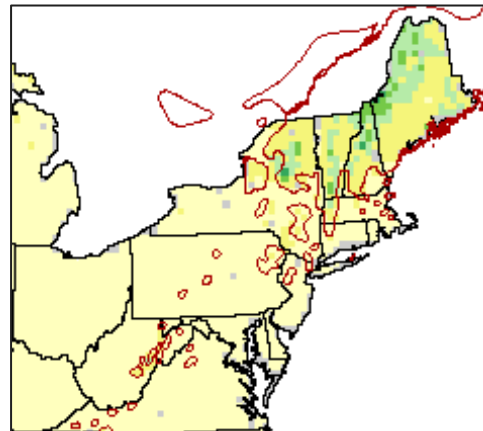
Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect

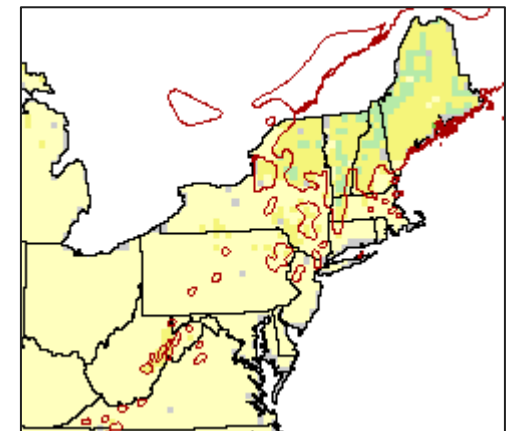
Red Spruce: Current Habitat (modeled)



PCM B1 (Less Change)



GFDL A1FI (More Change)

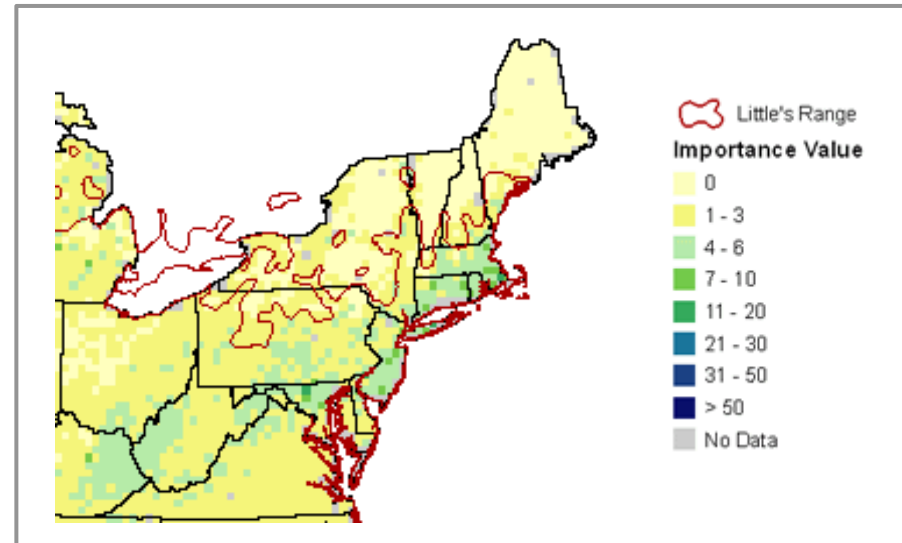


5: Changes in Suitable Habitat

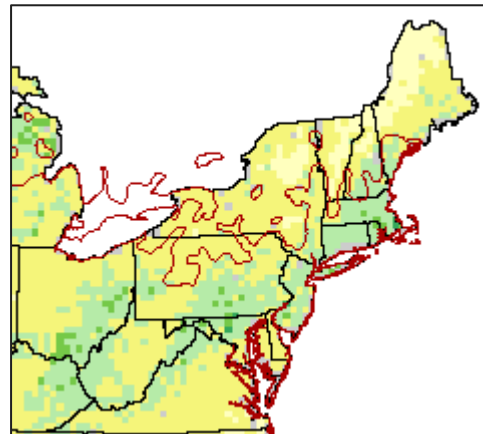
Habitat based on:

- *Temperature*
- *Precipitation*
- Elevation
- Latitude
- Soils
- Slope & Aspect

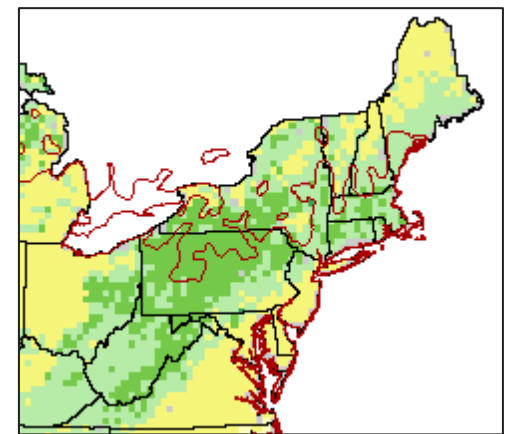
Black Oak: Current Habitat (modeled)



PCM B1 (Less Change)



GFDL A1FI (More Change)



5: *Changes in Suitable Habitat*

- Immense lag times
 - Range shifts \neq instant catastrophic dieback
 - Changes over time: temperature, moisture, competition
- Mature and established trees should fare better
 - Developed root system, Greater carbohydrate reserves
- Game changers: Disturbance, Land use, ...

5: *Changes in Suitable Habitat*

Use the Climate Change Atlas to:

- Evaluate how suitable habitat may change for species
 - Species more likely to decline or increase
 - Consider multiple scenarios
 - Consider local conditions and anticipated impacts
- Identify factors driving the modeled changes
- Generate ideas for potential future-adapted species

5: Changes in Suitable Habitat

www.fs.fed.us/nrs/atlas/combined/

USDA United States Department of Agriculture
Forest Service

Landscape Change Research Group
LCRG

Northern Research Station

Forest Service Home | About the Agency | Contact the National Office

You are here: [Northern Research Station Home](#) / [Tools & Applications](#) / [Climate Change Atlas](#) / All Species Output

Climate Change Atlas

All Species Output

Current Distribution

- [Current Forest Types](#)
- [Current Species Abundance by State](#)
- [Current Species Abundance by Region](#)
- [Current Mean center of Distribution \(lat/long\)](#)

Modelled-Future Habitats

- [Potential Changes by Forest Types](#)
- [Potential Changes by Region](#)
- [Potential Species Winners and Losers by State](#)
- [Potential Species Winners and Losers in National Forests/Grasslands](#)
- [Potential Species Winners and Losers in National Parks](#)
- [Potential Species Winners and Losers in Ecoregions](#)
- [Future Mean Center of Distribution \(lat/long\)](#)
- [Potential Changes of Mean Center Distribution \(polar graphs\)](#)

Search for Trees & Birds:

Enter a common or scientific name

[List of Trees](#) | [List of Birds](#)

Climate Change Atlas Videos

- [Quick Start Guide](#)
- [An Introduction to the Climate Change Atlas: How does it work?](#)
- [An Overview of the Climate Change Atlas Components](#)
- [Exploring Current Species Information](#)
- [Modeled Future Habitats](#)
- [Combined Species Outputs](#)

Climate Change Atlases	Learn About the Models	Products	Get Help
Tree Atlas	DISTRIB	Publications	Quick Start Guide
Bird Atlas	SHIFT	Regional Assessments	Tutorial Videos
Combined Species Outputs	ModFacs	National Climate Assessment	How to Cite the Atlas
Summary of Predictors			Contact Us

6: *Extreme Events*

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



Dan Turner, Cambridge Fire Dept.



NY DEC



VTRANS/VT ANR

7: *Wildfire Risk*

Fire may increase:

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



Prescribed fire – MASS DCR

Fire may not change:

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

8: *Forest Pests and Diseases*

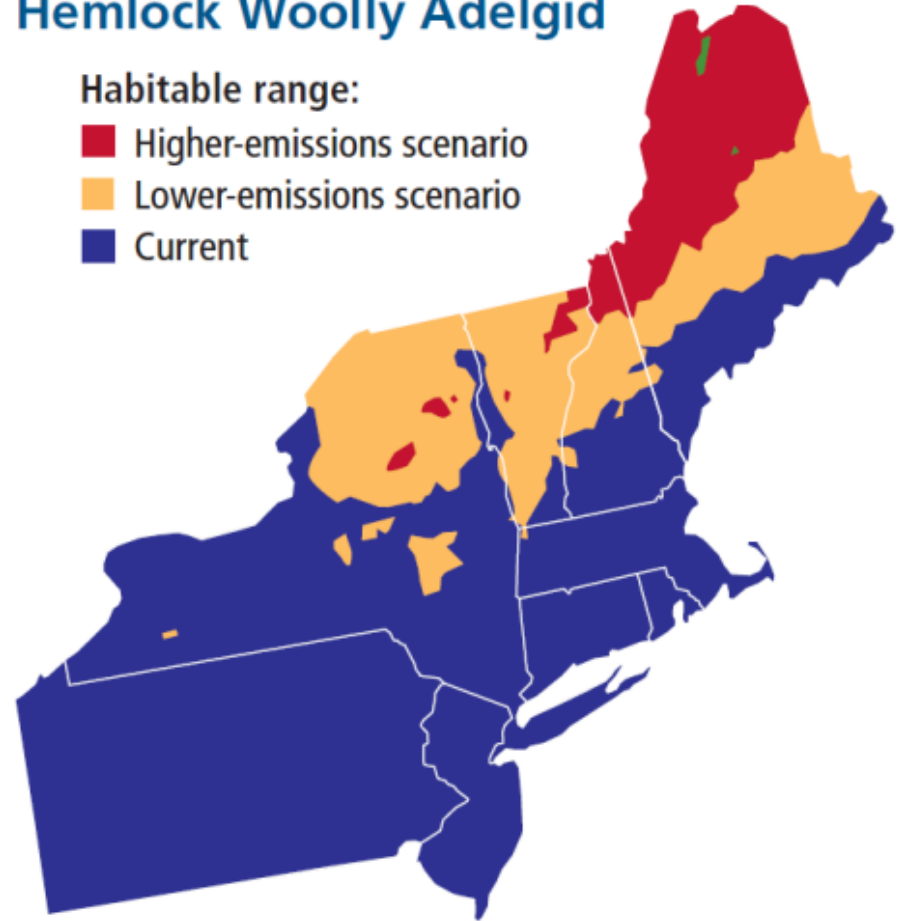
Indirect: Stress from other impacts increases susceptibility

Direct:

- Pests migrating northward
- Decreased probability of cold lethal temperatures
- Accelerated lifecycles

Hemlock Woolly Adelgid

Habitable range:
■ Higher-emissions scenario
■ Lower-emissions scenario
■ Current



HWA lethal temp: -20 to -30°F

9: *Invasive Plants*

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

Direct:

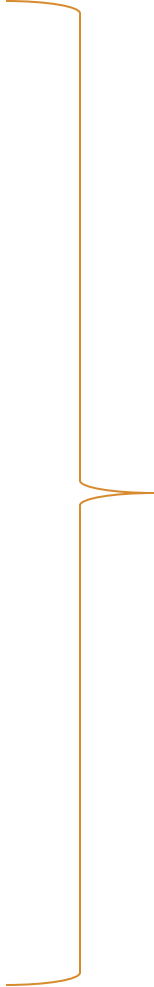
- Expanded ranges under warmer conditions
- Increased competitiveness from ability of some plants to take advantage of elevated CO₂



Invasives Plants Atlas of New England (www.eddmaps.org)

Climate Change Impacts

- 1) Longer Growing Season
- 2) Shorter Winters
- 3) Potential for Summer Drought
- 4) CO₂ Fertilization
- 5) Changes in Suitable Habitat
- 6) Extreme Events
- 7) Wildfire Risk
- 8) Forest Pests and Diseases
- 9) Invasive Plants



*What
conclusions
can we draw
from all this?*

Vulnerability: *Forest Communities*

Forest communities will be affected differently

May have greater risk:

- Low diversity
- Static
- Threatened, rare, or endangered
- Already in decline
- Fragmented

May have less risk:

- More diversity (species, genetics, ...)
- Adapted to disturbance
- Wider ecological range of tolerances
- Currently increasing
- Larger, contiguous blocks

Vulnerability: *Spruce-fir*

Impacts:

- Warm temperatures
- Declines in boreal tree species
- Extreme storms

Adaptive Capacity:

- Generally slow to adjust to change
- Constrained by elevation/latitude
- Isolated mountaintops



Generally rated as **most vulnerable forest community**, especially at southern extent of range.

Vulnerability: *Hardwood Forests*

Impacts:

- Extreme storms
- Several diseases, pests, invasives
- Several northern species projected to decline

Adaptive Capacity:

- Mixed species forests
- Several southern species projected to increase
- Extensive type, exists farther south



Vulnerability rated as low (central hardwoods) or moderate (northern hardwoods) based on species and location.

Vulnerability: *Local Considerations*

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



So... before the training

Start to think about how your particular project area could be affected by climate change

Focus on the place (we'll get to management a tad later):

- **Location**: elevation, latitude, inland/coastal, ...
- **Landform**: topographic position, geology, complexity, ...
- **Soil characteristics**: moisture, productivity, ...
- **Management**: Past, current, ...
- **Diversity**: species composition, structural complexity, ...
- **Presence of or susceptibility to stressors**: pests, diseases, nonnative species, herbivores, ...

Given these considerations, how vulnerable is your site to the anticipated effects of climate change?