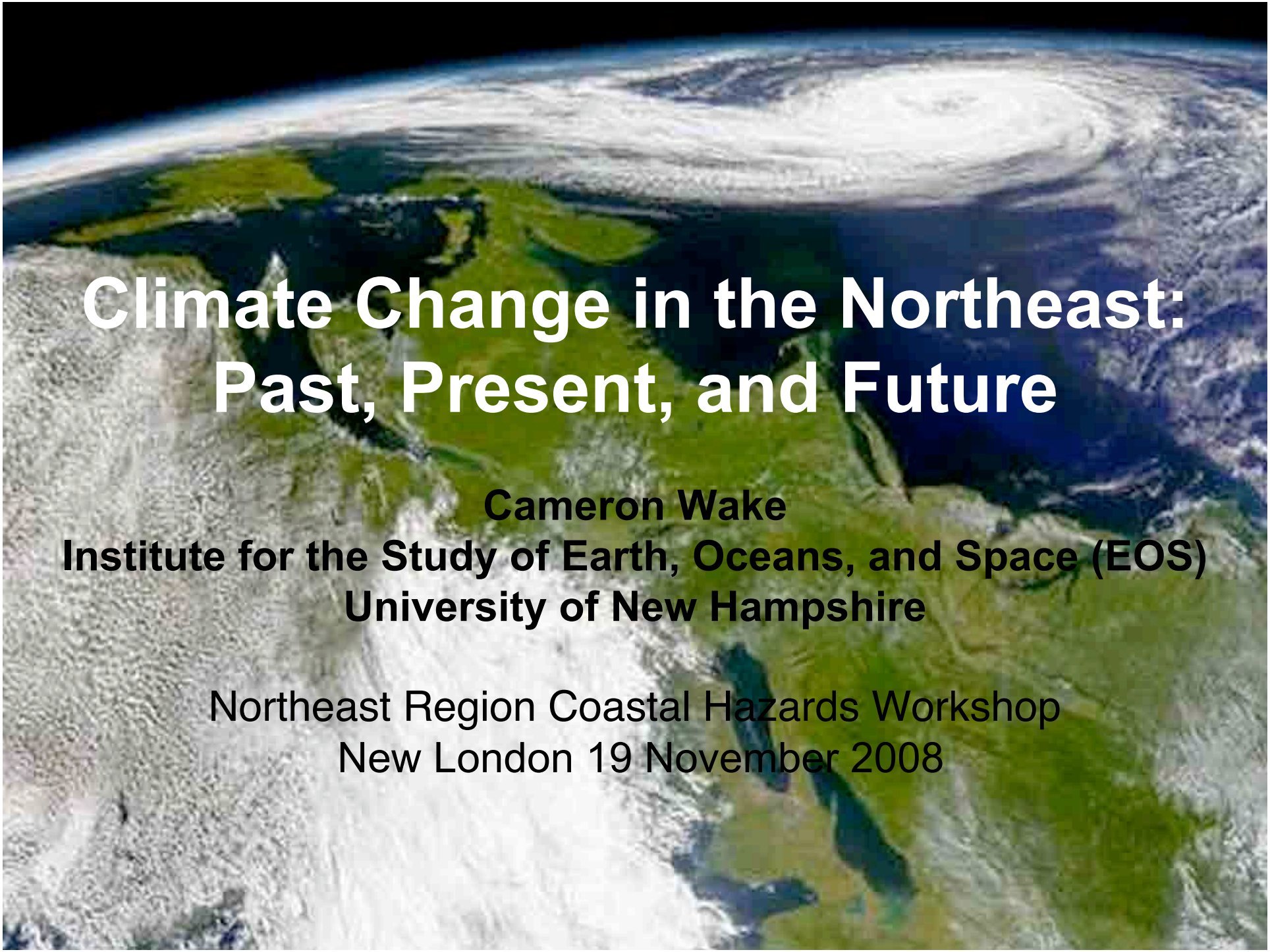


Climate Change in the Northeast: Past, Present, and Future

Cameron Wake
Institute for the Study of Earth, Oceans, and Space (EOS)
University of New Hampshire

Northeast Region Coastal Hazards Workshop
New London 19 November 2008

Atmospheric Carbon Dioxide

Business as Usual

Clean Energy & Efficiency

Current

Vostok Ice Core

carbon dioxide (ppmv)

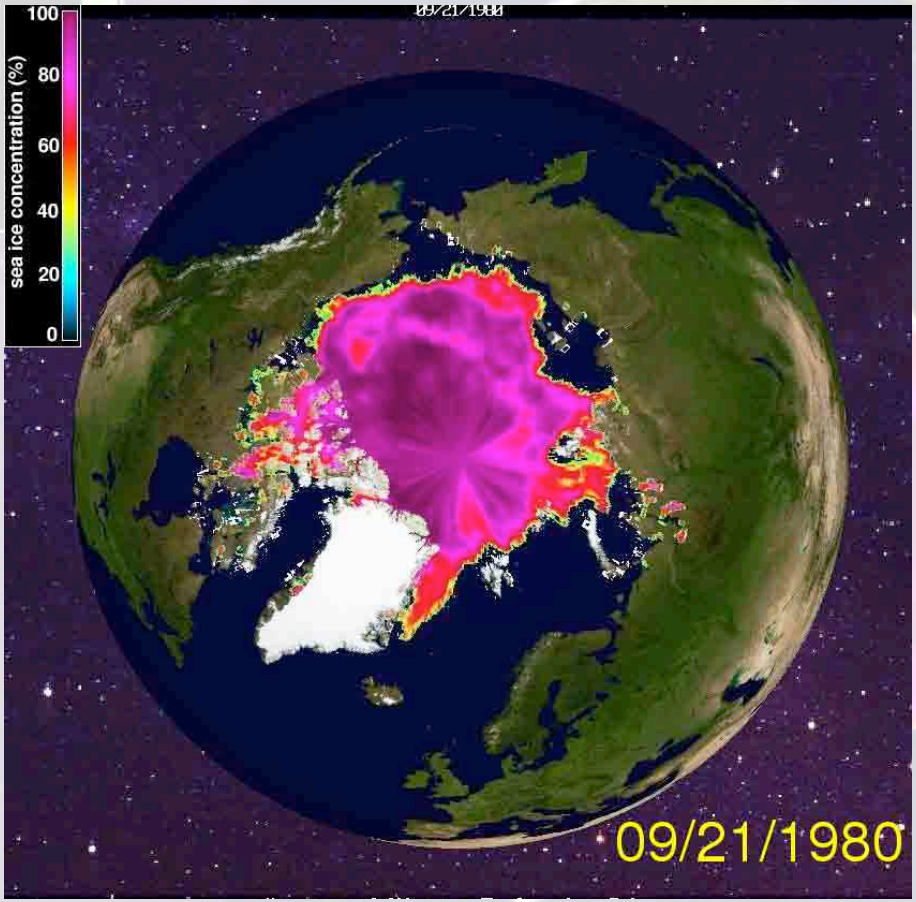
1000
800
600
400
200

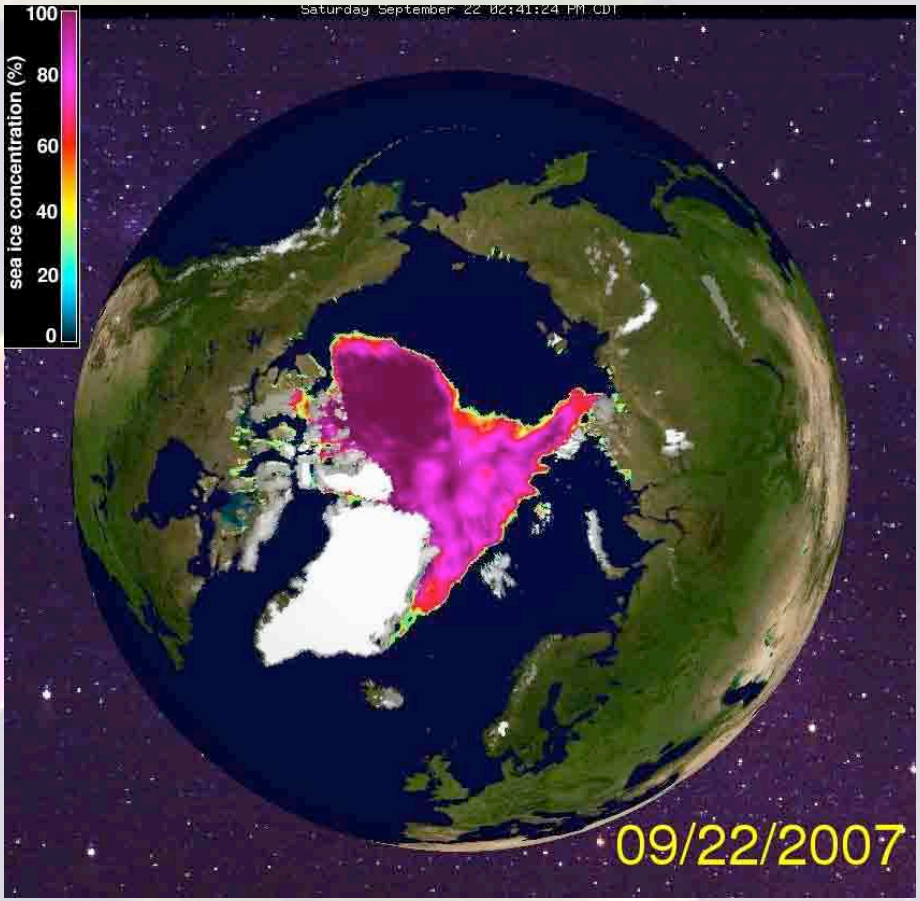
400,000
300,000
200,000
100,000
0

Years Before 2100 AD

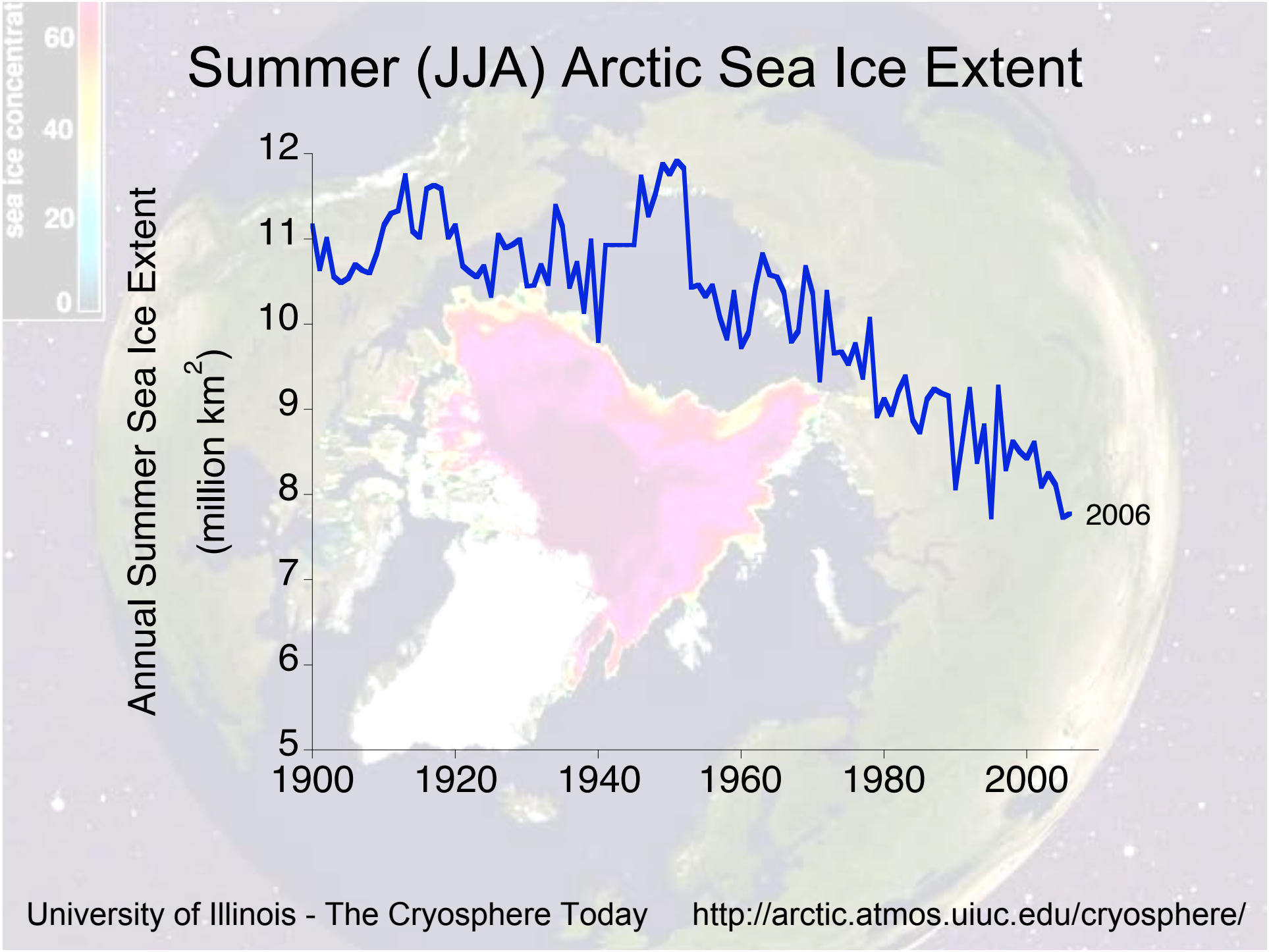
IPCC 2001

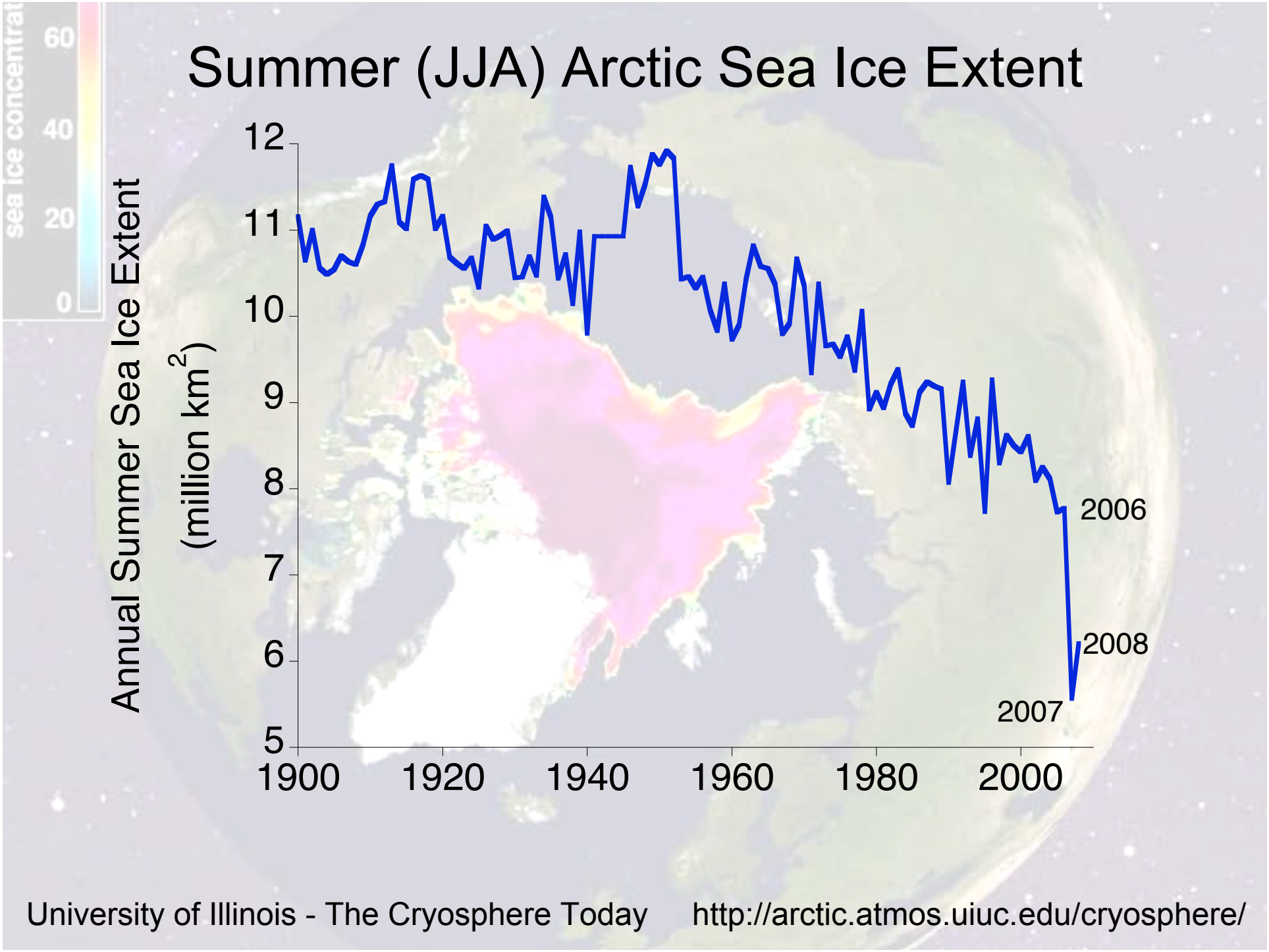
Arctic Sea Ice: Sept 1980 vs Sept 2007

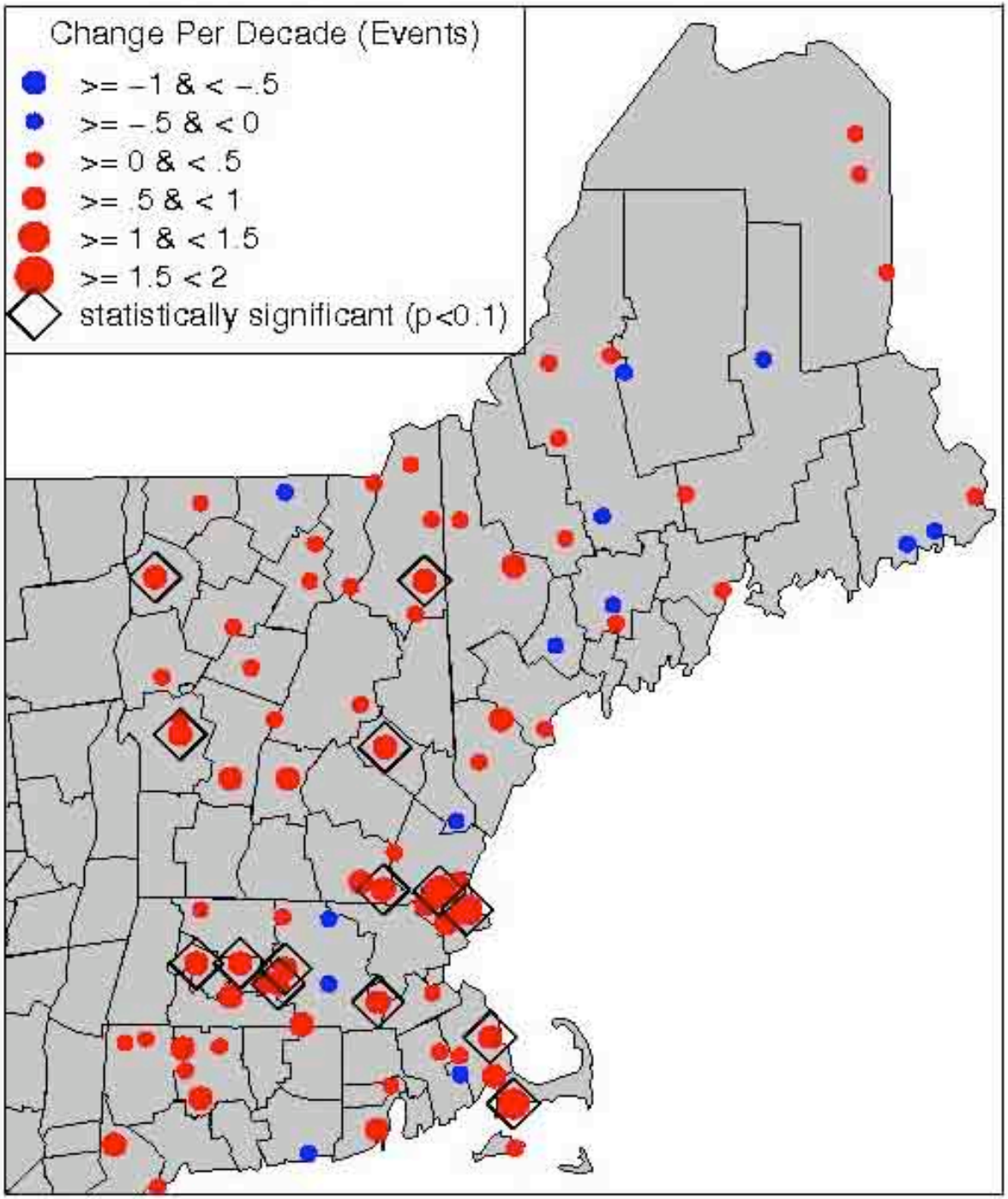




University of Illinois - The Cryosphere Today http://arctic.atmos.uiuc.edu/cryosphere/

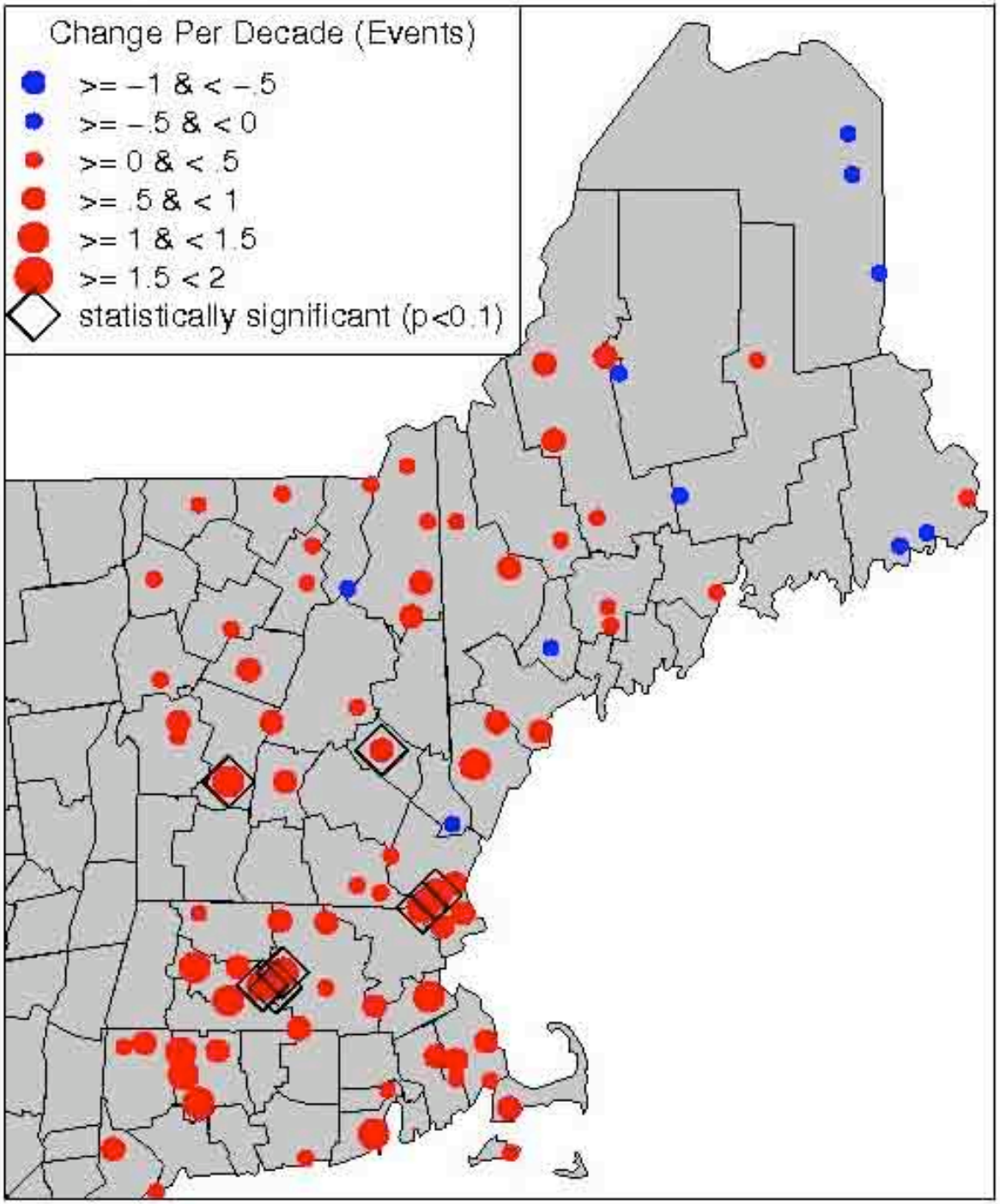

Summer (JJA) Arctic Sea Ice Extent
sea ice concentrat
60
40
20
0
Annual Summer Sea Ice Extent
(million km^2)
12
11
10
9
8
7
6
5
1900
1920
1940
1960
1980
2000
2006
University of Illinois - The Cryosphere Today
http://arctic.atmos.uiuc.edu/cryosphere/


Summer (JJA) Arctic Sea Ice Extent
sea ice concentrat
60
40
20
0
Annual Summer Sea Ice Extent
(million km^2)
12
11
10
9
8
7
6
5
1900
1920
1940
1960
1980
2000
2006
2008
2007
University of Illinois - The Cryosphere Today
http://arctic.atmos.uiuc.edu/cryosphere/



Decadal Trends in 1 inch Precipitation Events 1948-2007

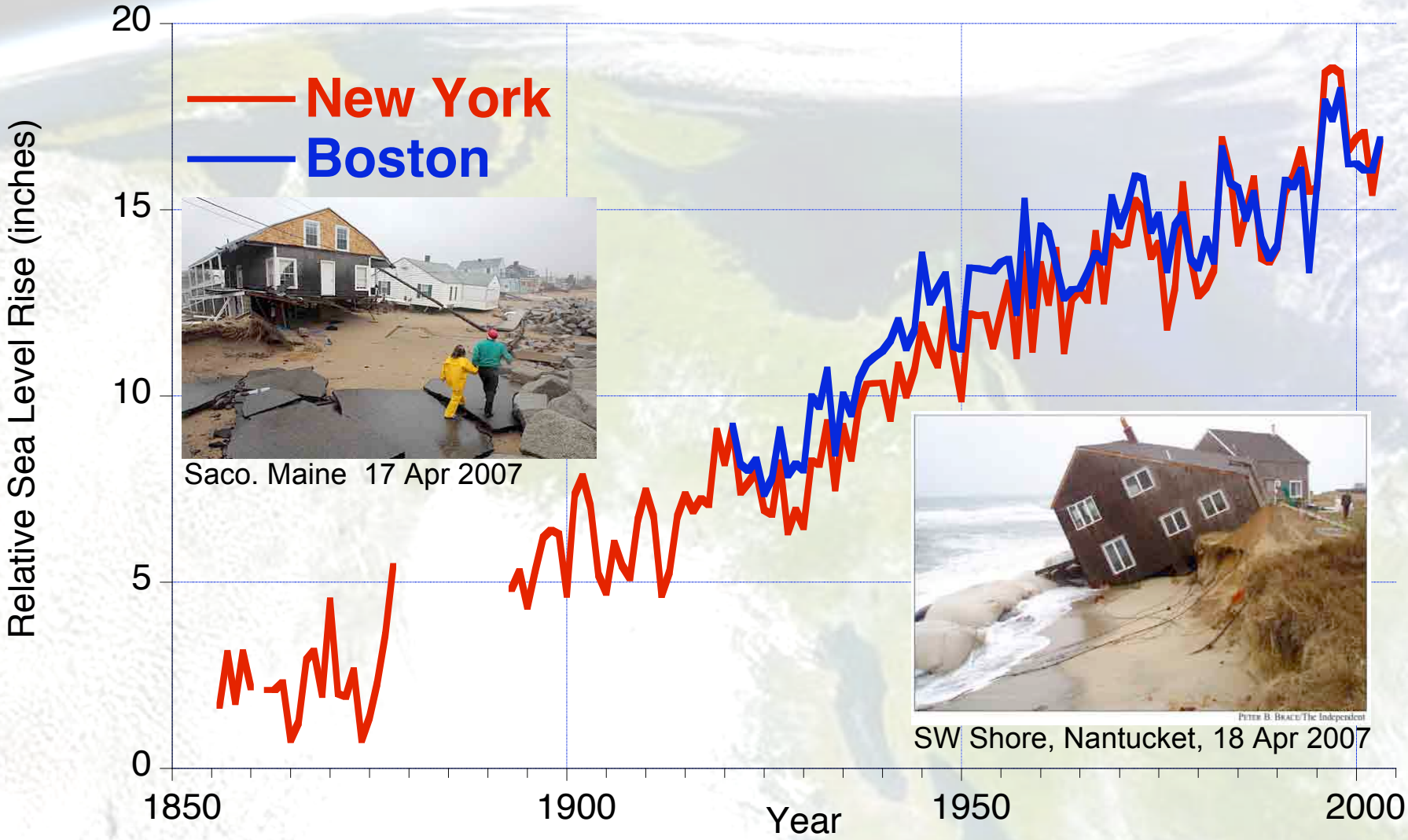
Spierre et al., 2008



Decadal Trends in 2 inch Precipitation Events 1948-2007

Spierre et al., 2008

Relative Sea Level Rise 1856 - 2005



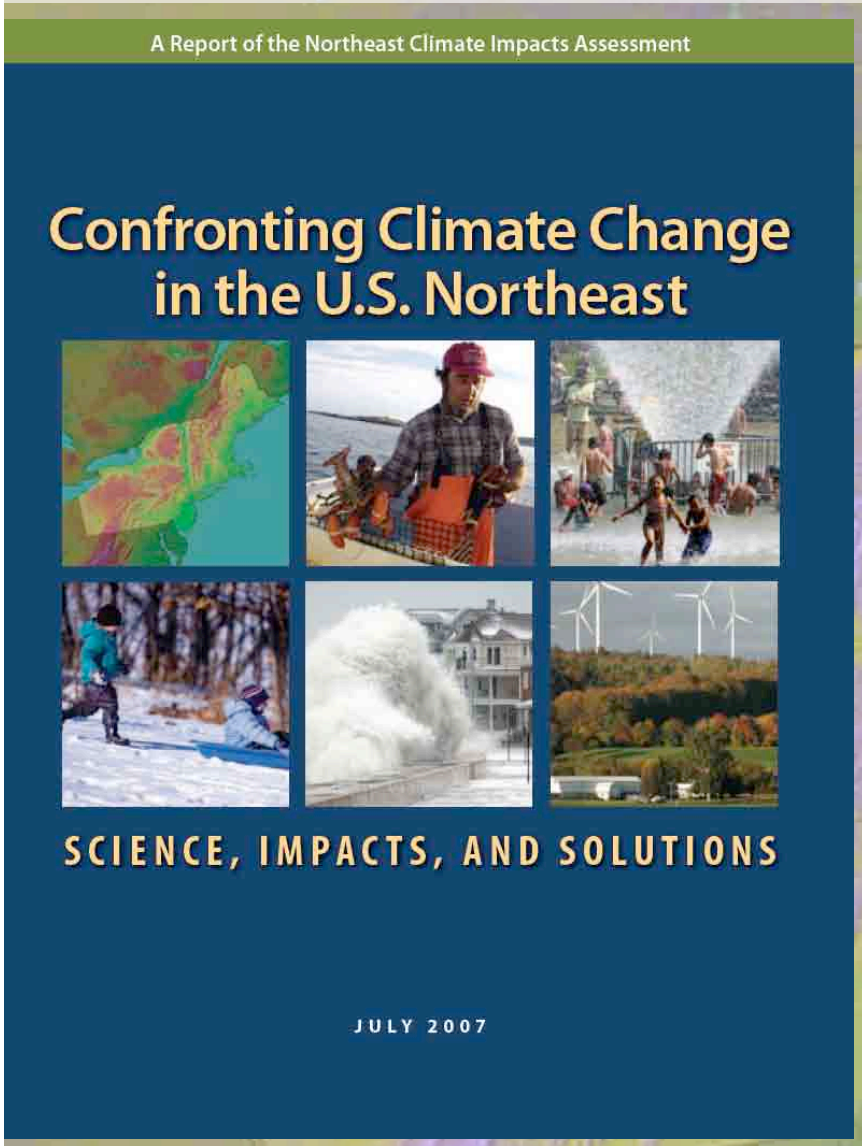
Data from Permanent Service for Mean Sea Level http://www.pol.ac.uk/psmsl/

Indicators of Climate Change in the Northeast US over the last 30-40 yrs

- **Winter warming**
- **Decreased snowfall**
- **Fewer days with snow on ground**
- **Lake ice out dates earlier**
- **Lilac bloom dates earlier**
- **More frequent extreme precipitation**
- **Earlier spring runoff**
- **Sea levels continuing to rise**

Hodgkins et al., 2002; 2003; Wolfe et al., 2005;
Wake and Markham, 2005; Wake et al., 2006

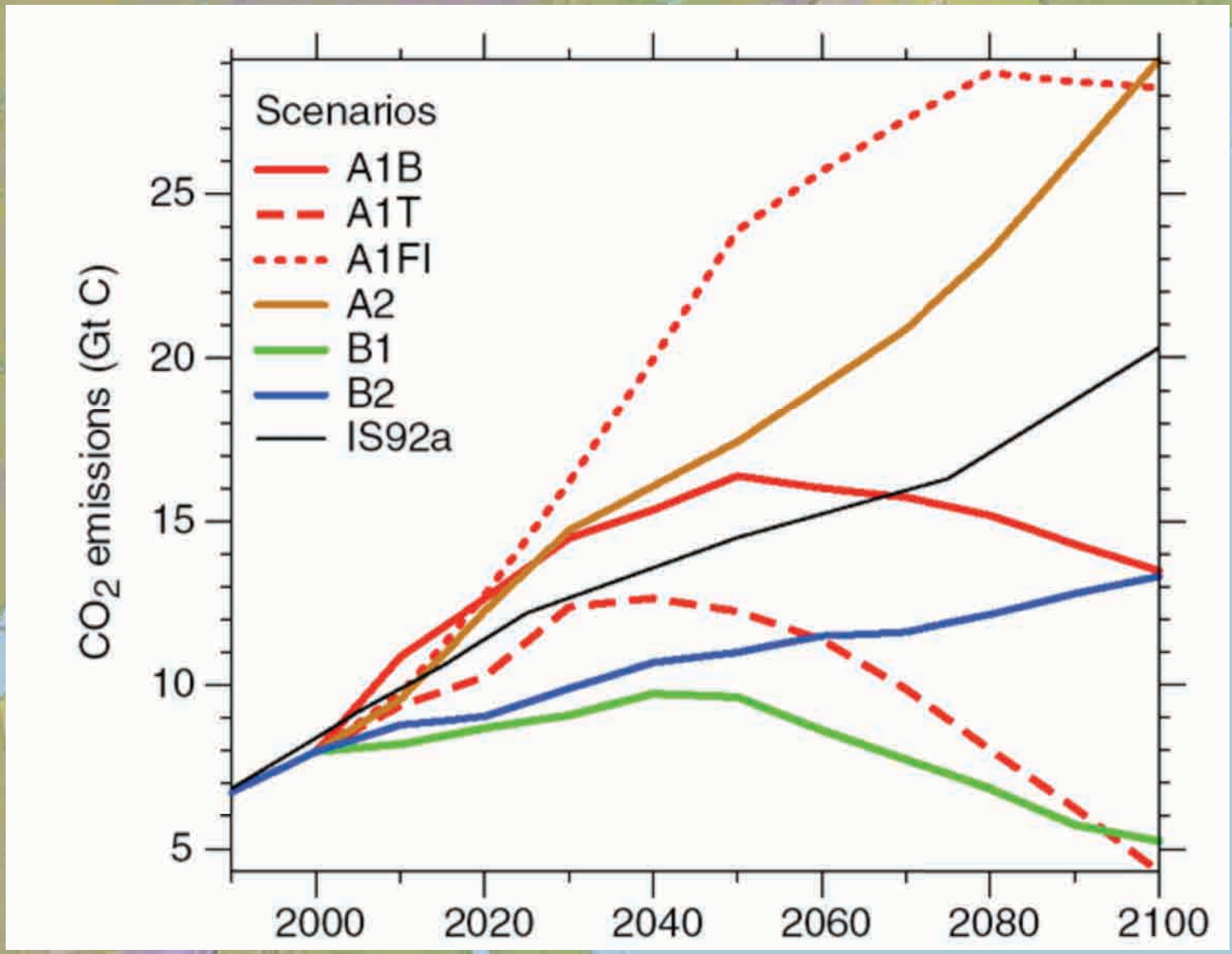
Northeast Climate Impacts Assessment



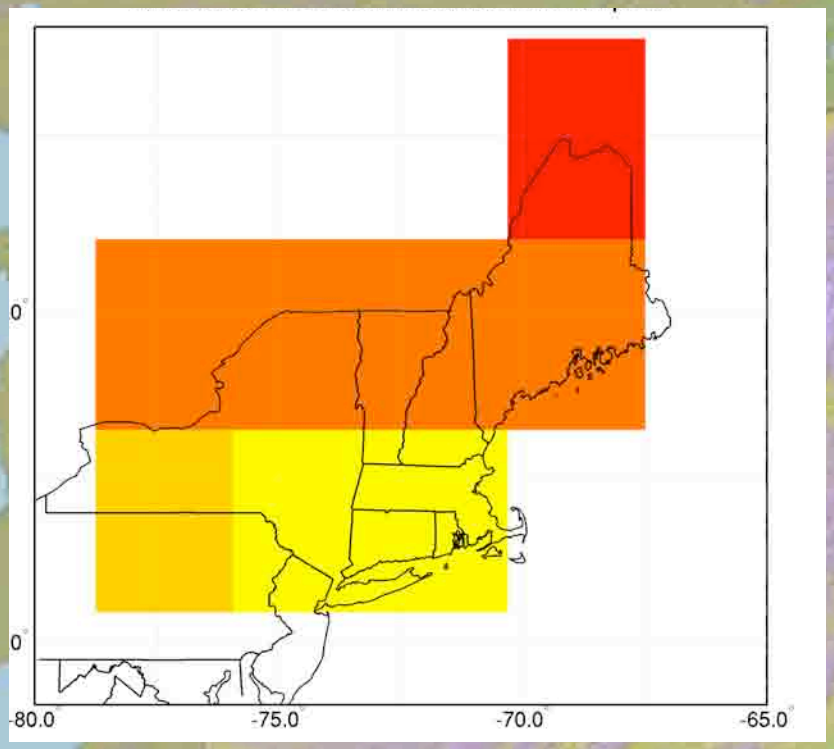
www.climatechoices.org

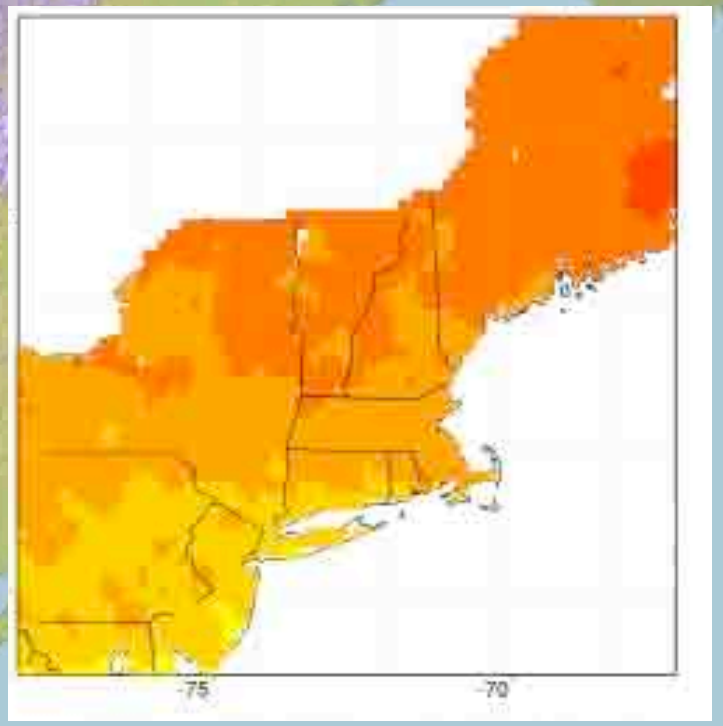
- Collaboration between Union of Concerned Scientists and 50 independent scientists
- **Geographic Scope**
  Nine Northeast states, from Maine to Pennsylvania
- **Peer Review**
  Climate Dynamics, 2007
  14 papers in *Adaptation and Mitigation of Climate Change*, 2008

Projecting Future Climate Change for the Northeast: Greenhouse Gas Emission Scenarios

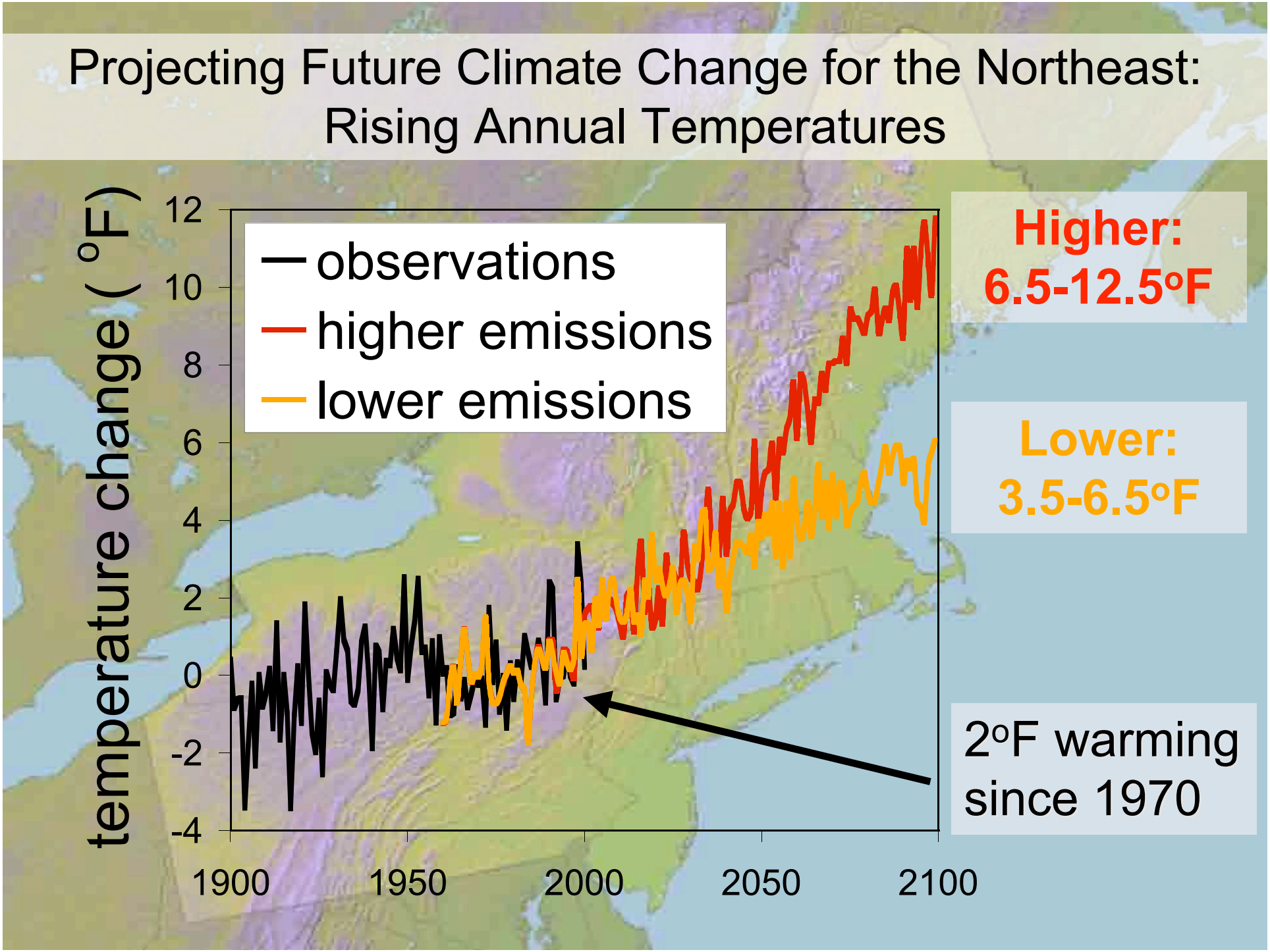


Projecting Future Climate Change for the Northeast: Downscale Global Projections to Regional Level





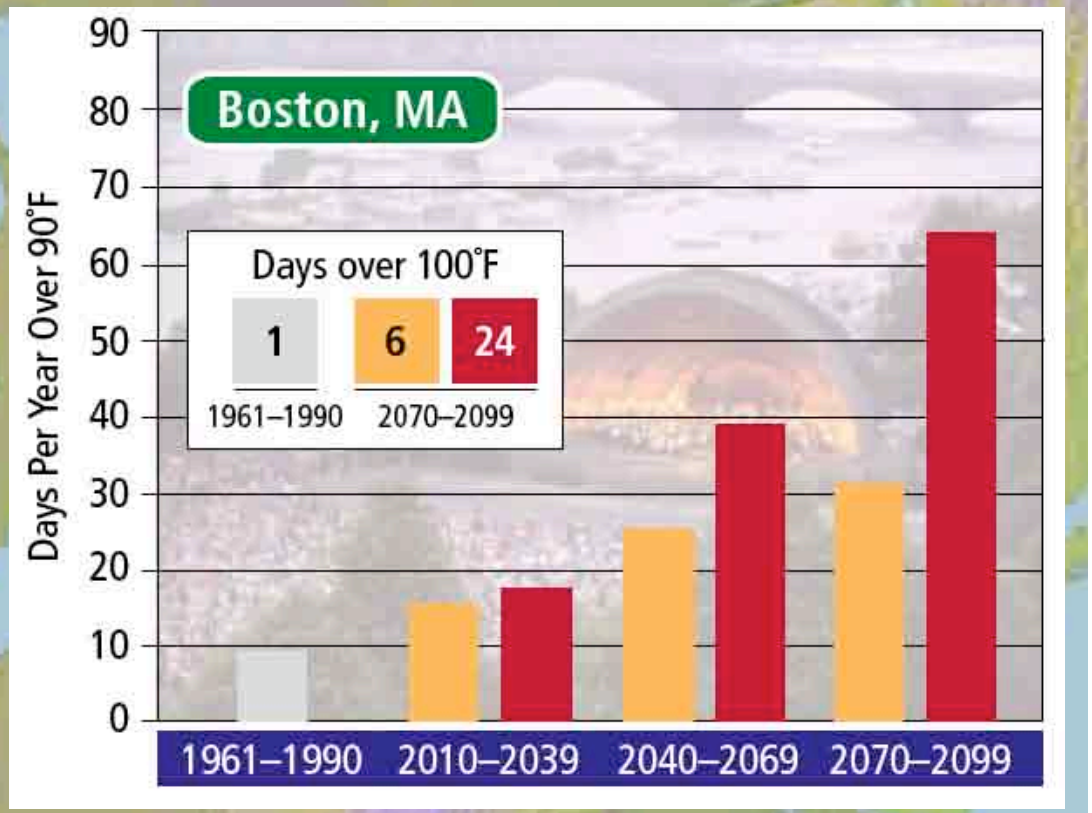
Projecting Future Climate Change for the Northeast: Rising Annual Temperatures

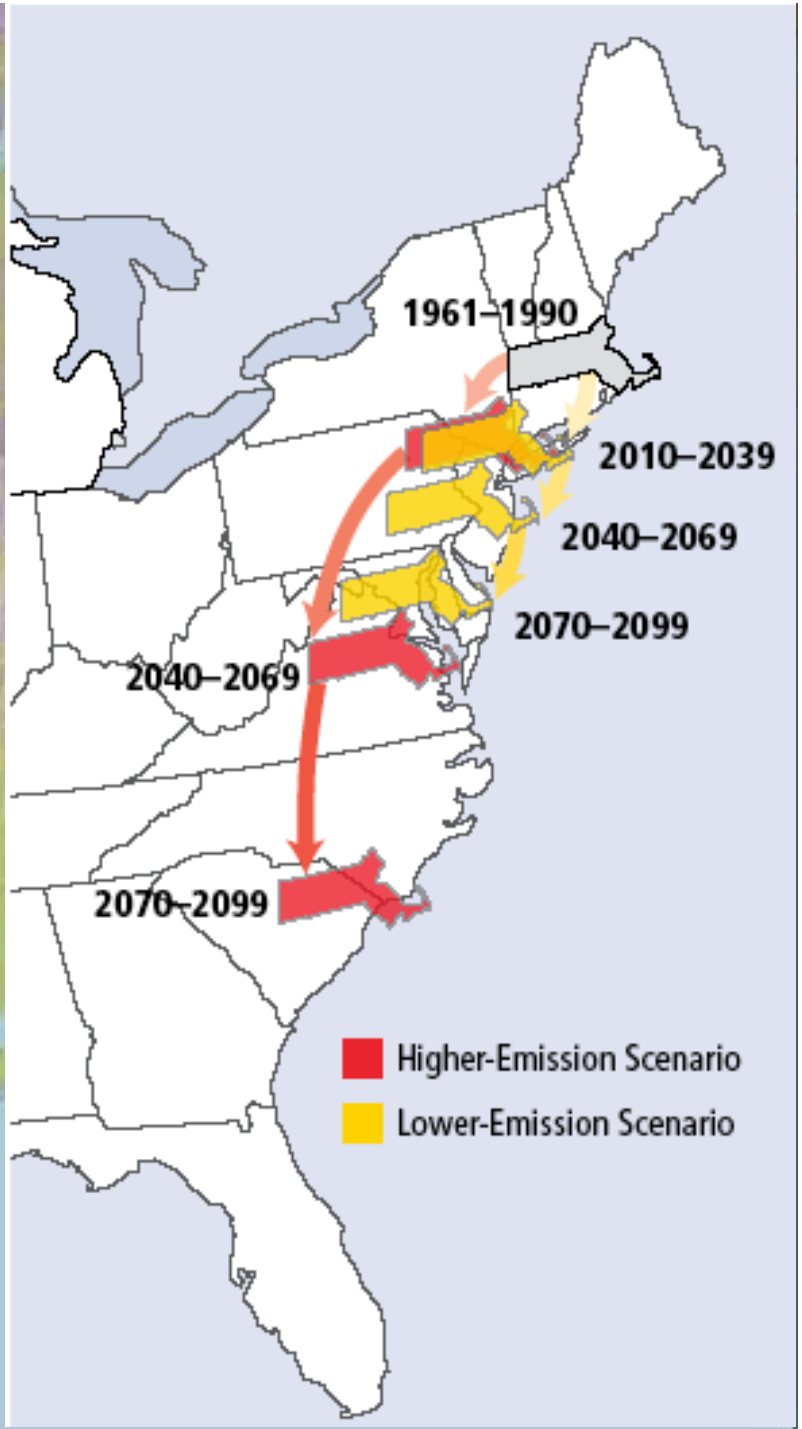


Summer heat index:

How hot summers will "feel" in

Massachuttes

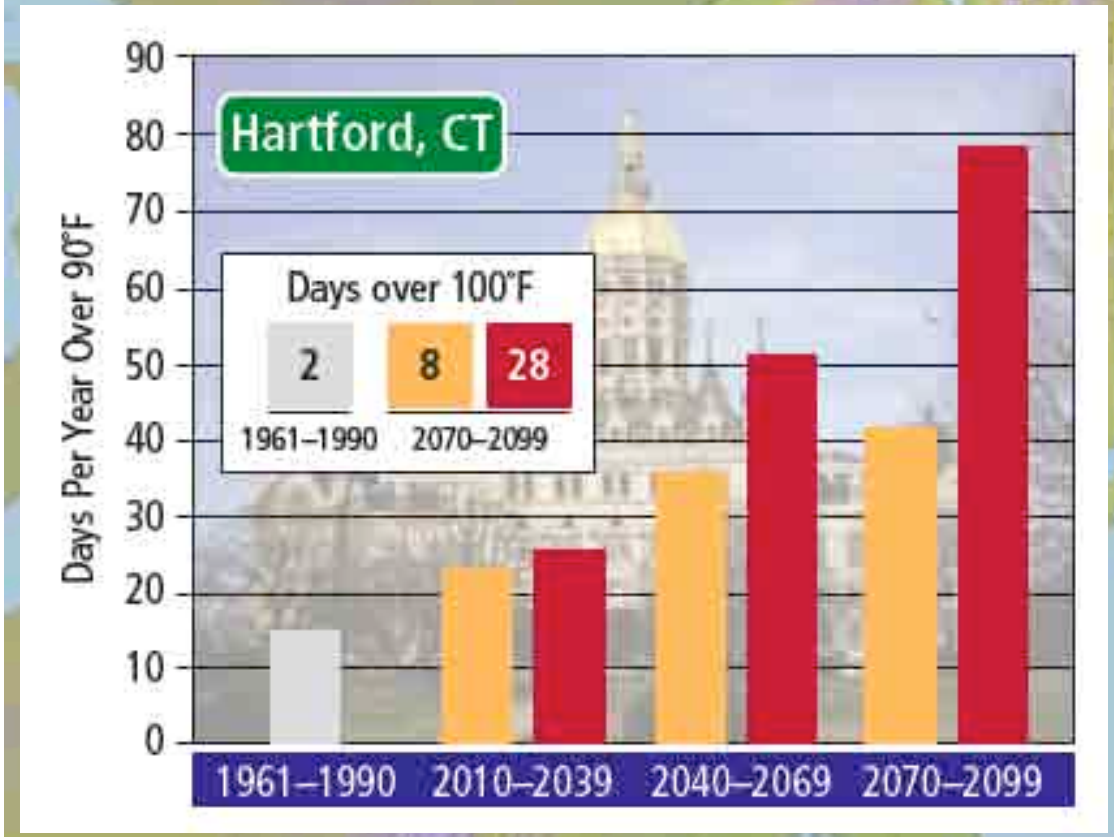


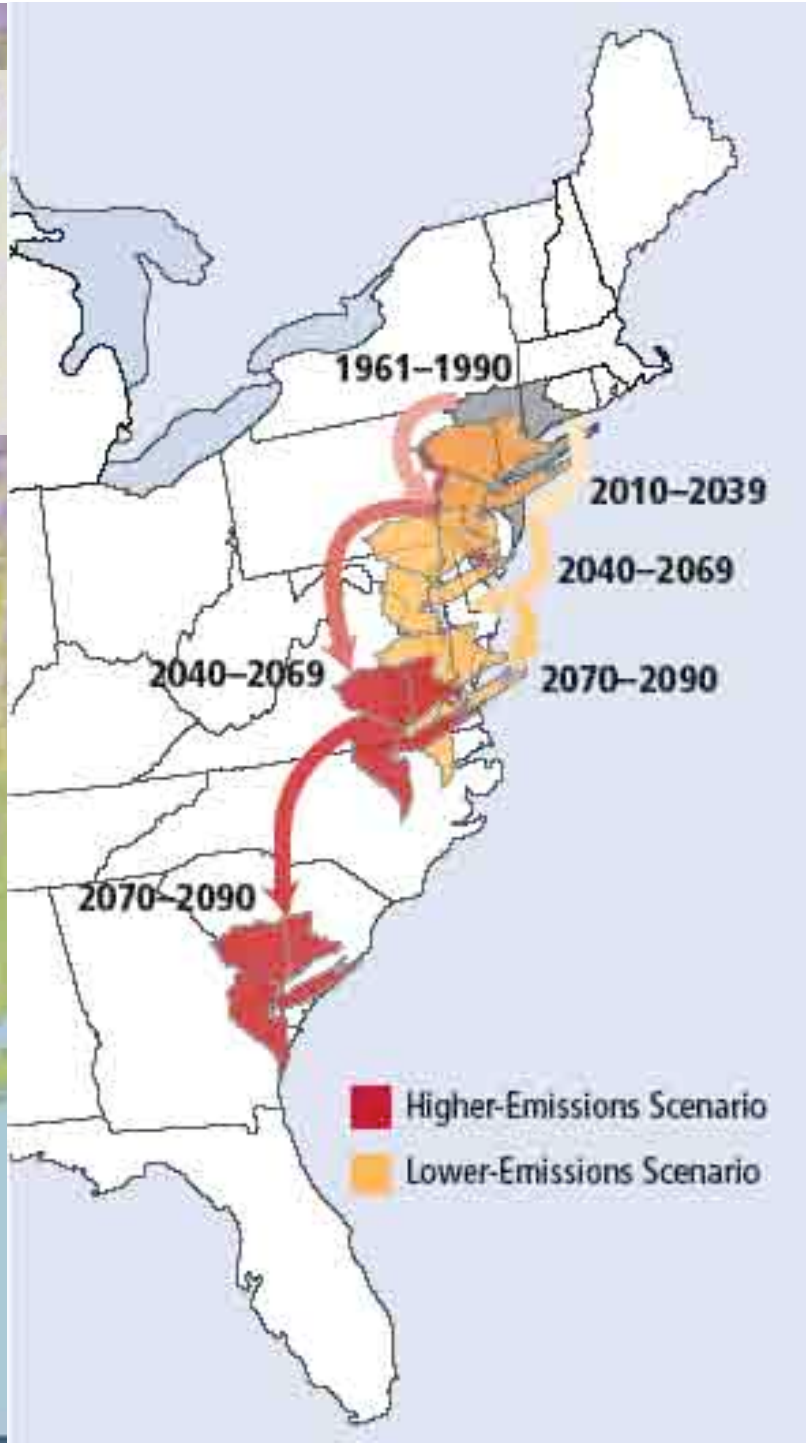


Summer heat index:

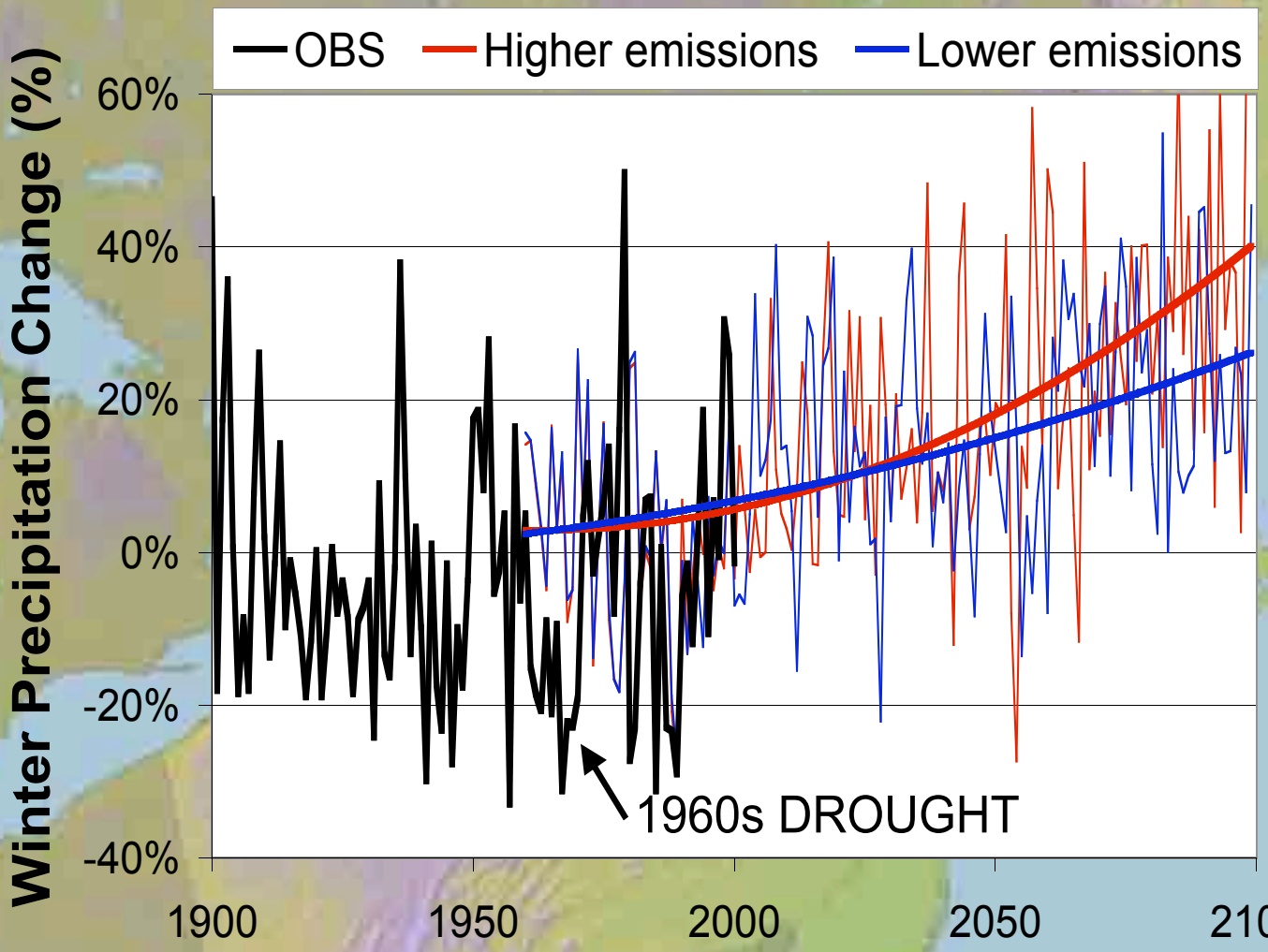
How hot summers will "feel" in

Connecticut





Increasing winter precipitation



As temperatures rise, more falling as rain, less as snow

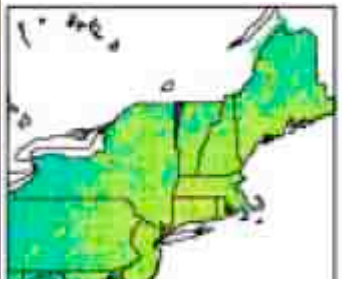
Extreme Precipitation Events Increase

- Heavy rainfall events are becoming more frequent across the Northeast
- Under both emissions scenarios
  - -rainfall is expected to become more intense
  - -periods of heavy rainfall are expected to become more frequent

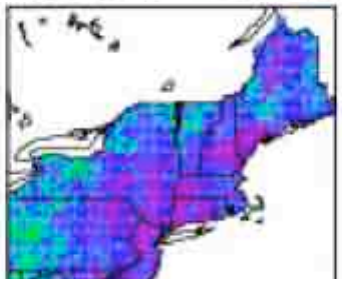
Bridge over Axe Handle Brook, Rochester, NH May 2006.

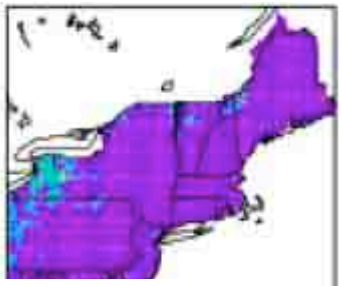
credit: Associated Press

Drought

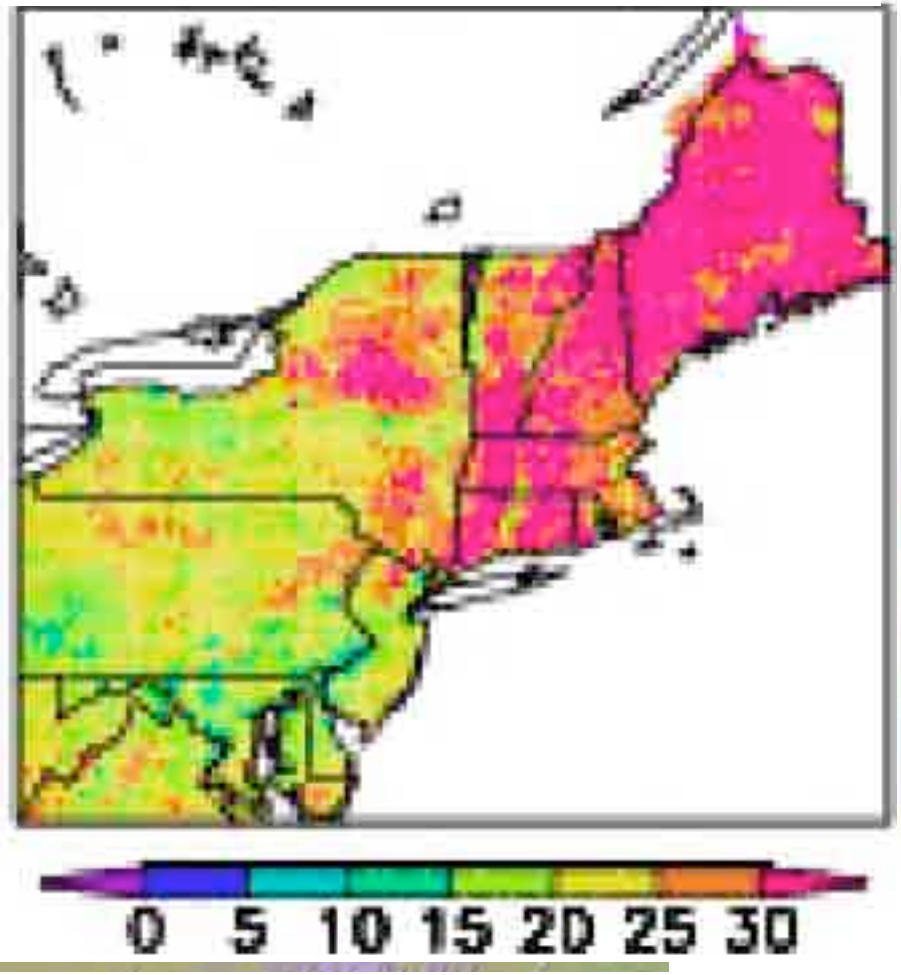


1961-1990

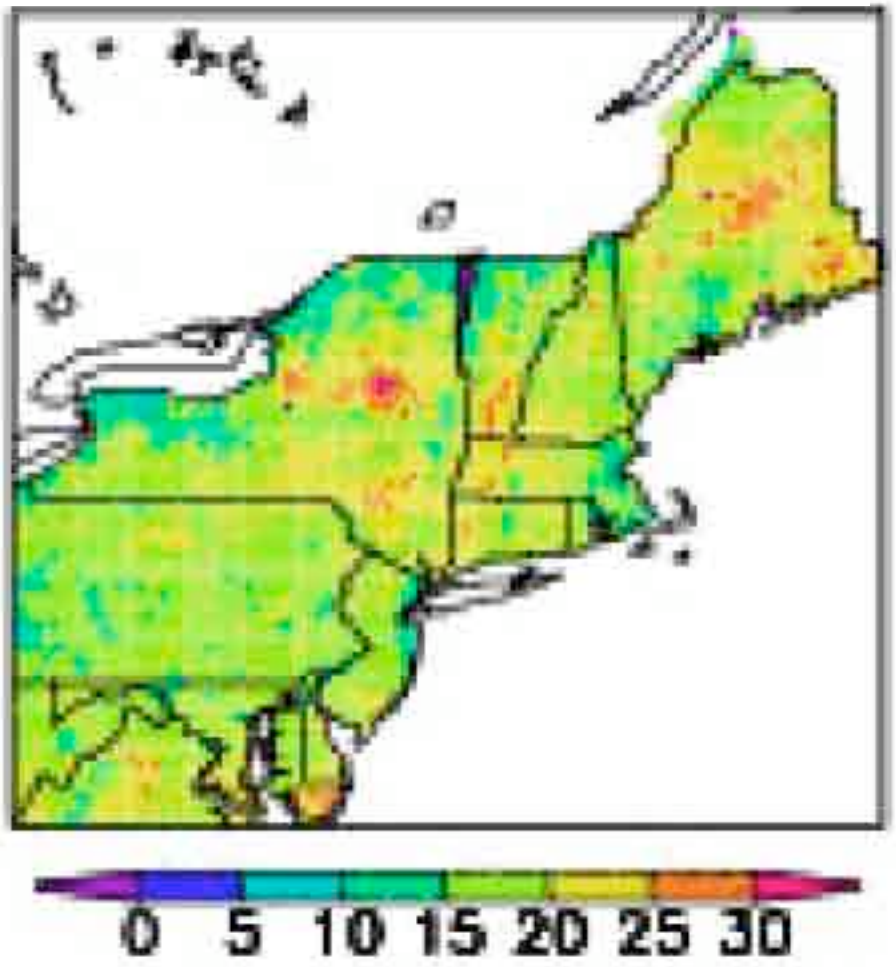




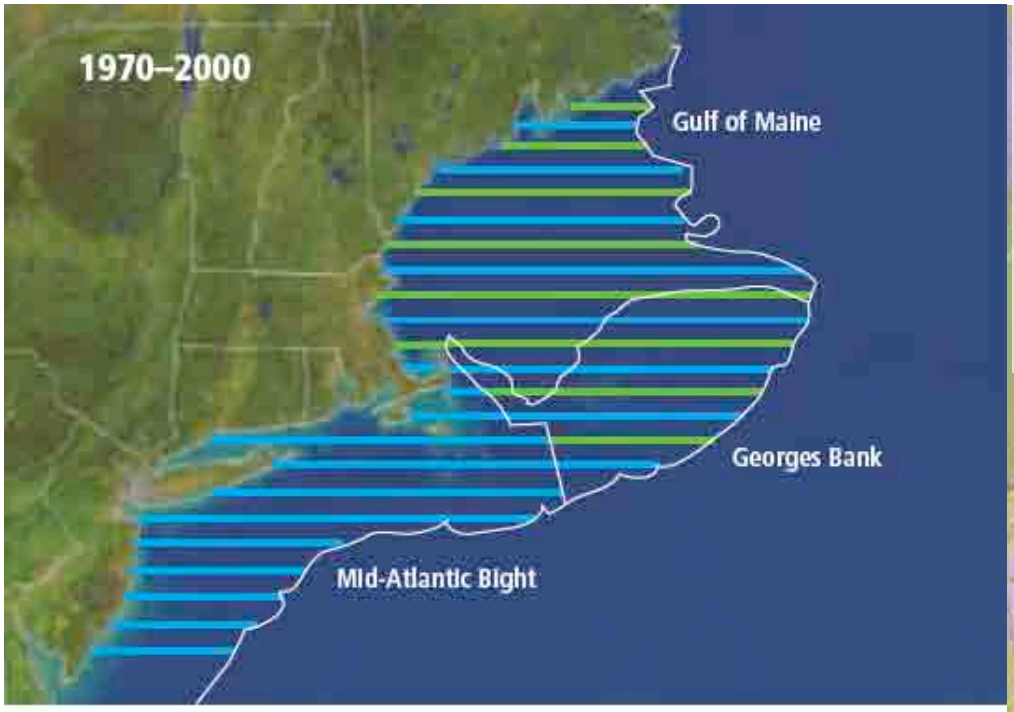
High Emissions

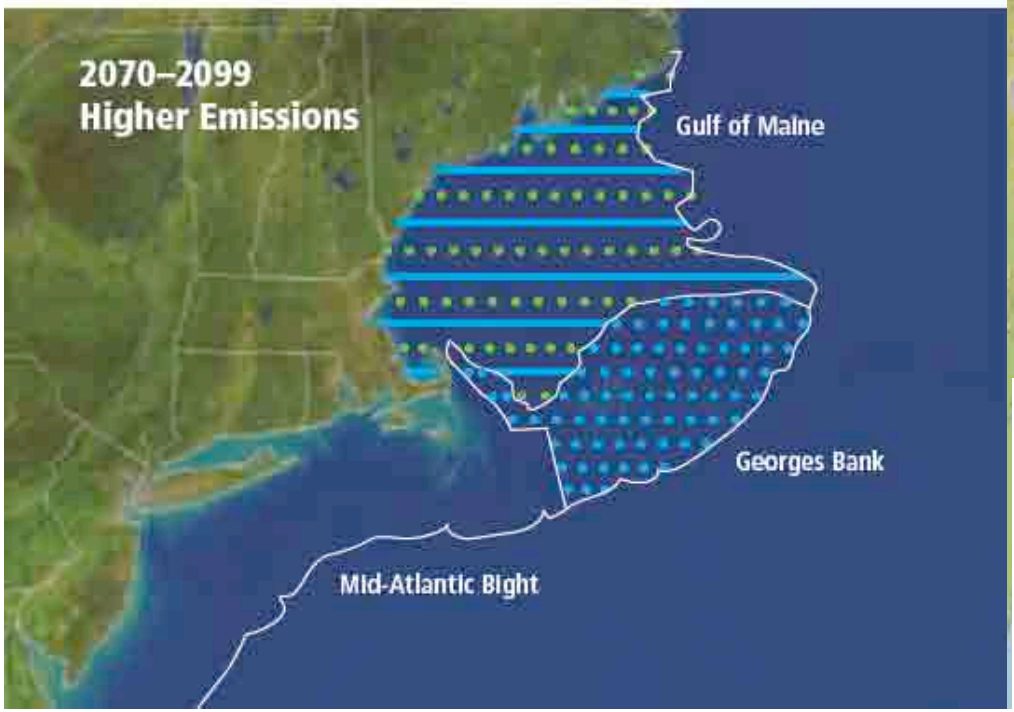


Low Emissions



Potential Loss of Commercial Cod Fishery





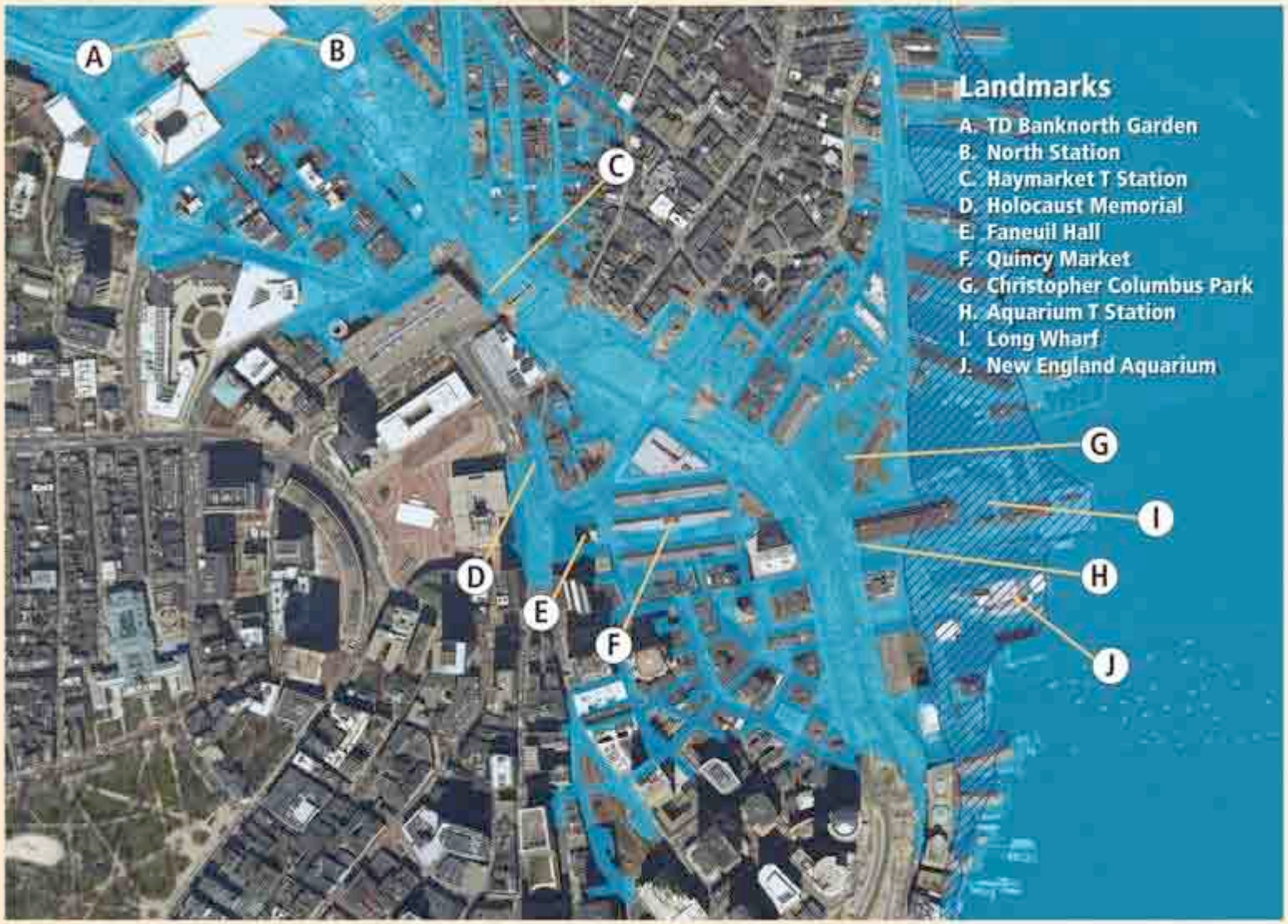
adult cod thermal habitat

young cod thermal habitat

full lines: suitable

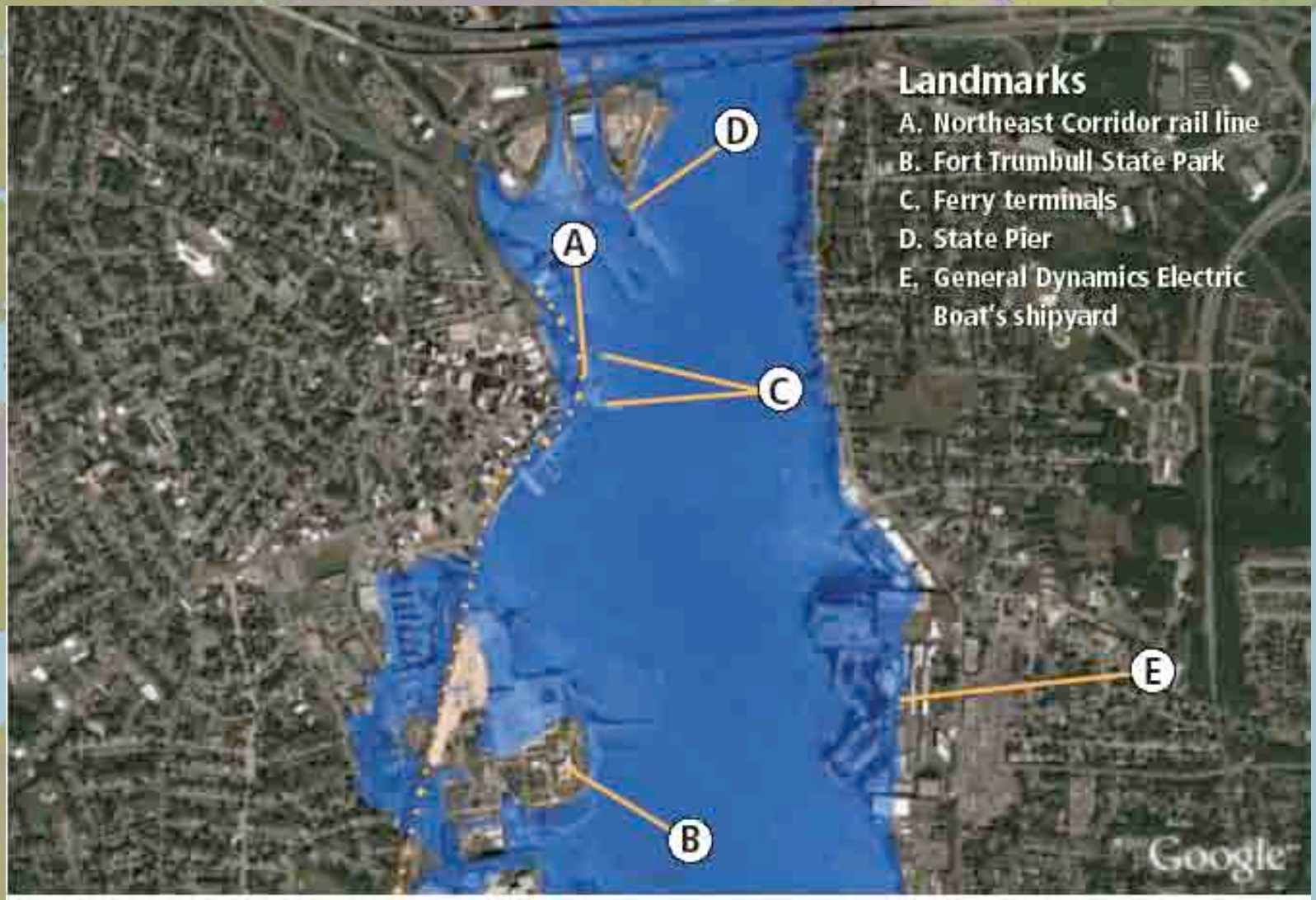
dotted lines: marginal

Boston: The 100-Year Coastal Flood in 2100 (Higher-Emissions Scenario; 16 inches of SLR)



Boston: The Future 100-Year Flood under the Higher-Emissions Scenario (16” of sea level rise)

New London/Groton: 100-Year Flood



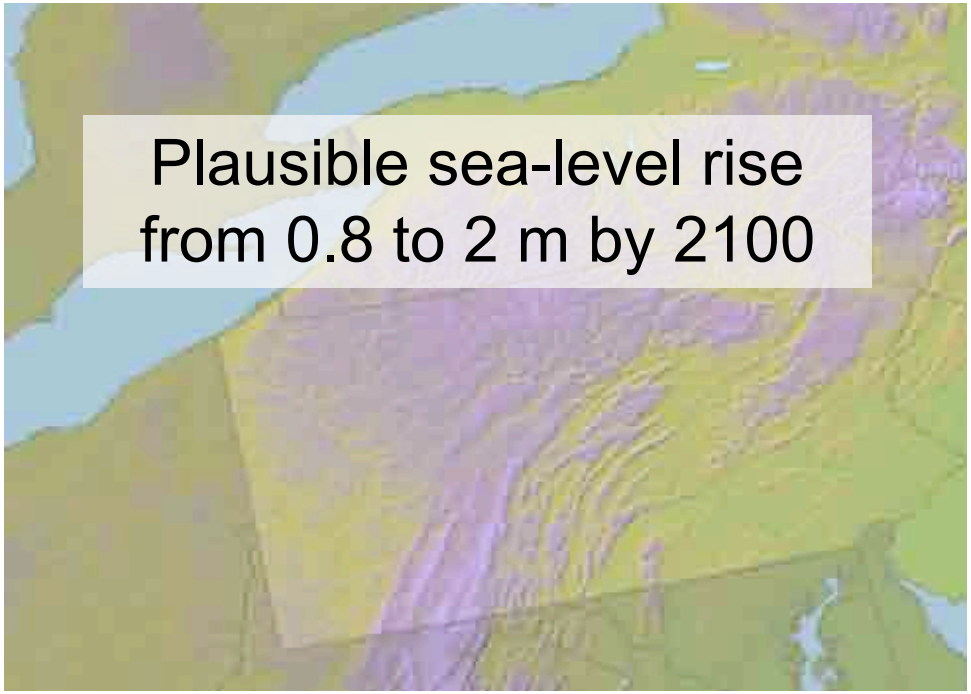
New London/Groton Flooding

Kinematic Constraints on Glacier Contributions to 21st-Century Sea-Level Rise

W. T. Pfeffer,[1]* J. T. Harper,[2] S. O'Neel[3]

On the basis of climate modeling and analogies with past conditions, the potential for multimeter increases in sea level by the end of the 21st century has been proposed. We consider glaciological conditions required for large sea-level rise to occur by 2100 and conclude that increases in excess of 2 meters are physically untenable. We find that a total sea-level rise of about 2 meters by 2100 could occur under physically possible glaciological conditions but only if all variables are quickly accelerated to extremely high limits. More plausible but still accelerated conditions lead to total sea-level rise by 2100 of about 0.8 meter. These roughly constrained scenarios provide a "most likely" starting point for refinements in sea-level forecasts that include ice flow dynamics.

5 SEPTEMBER 2008 VOL 321 **SCIENCE**



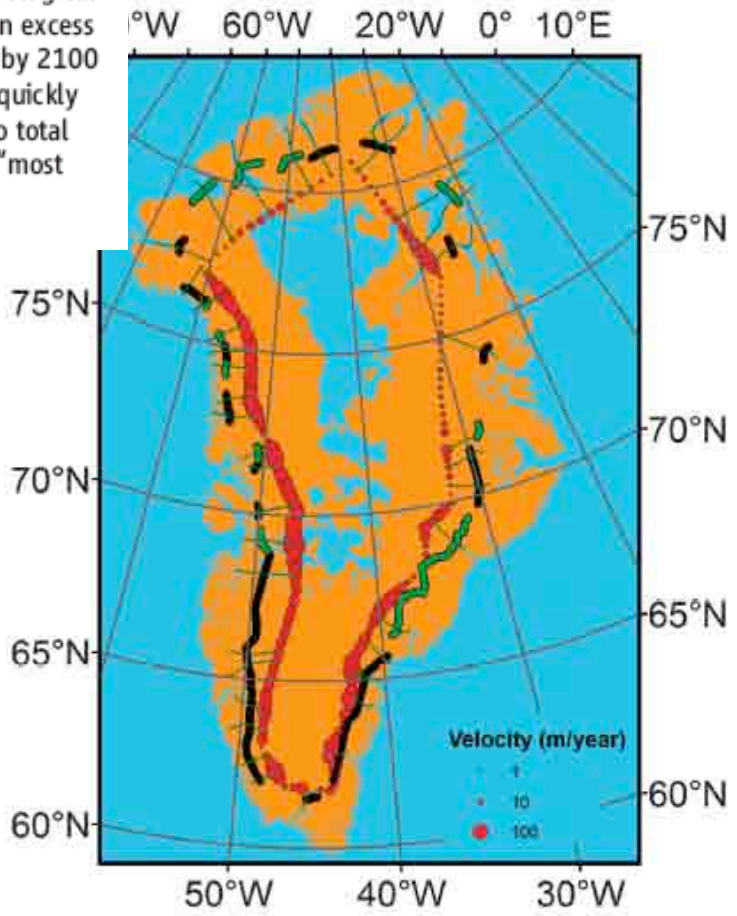
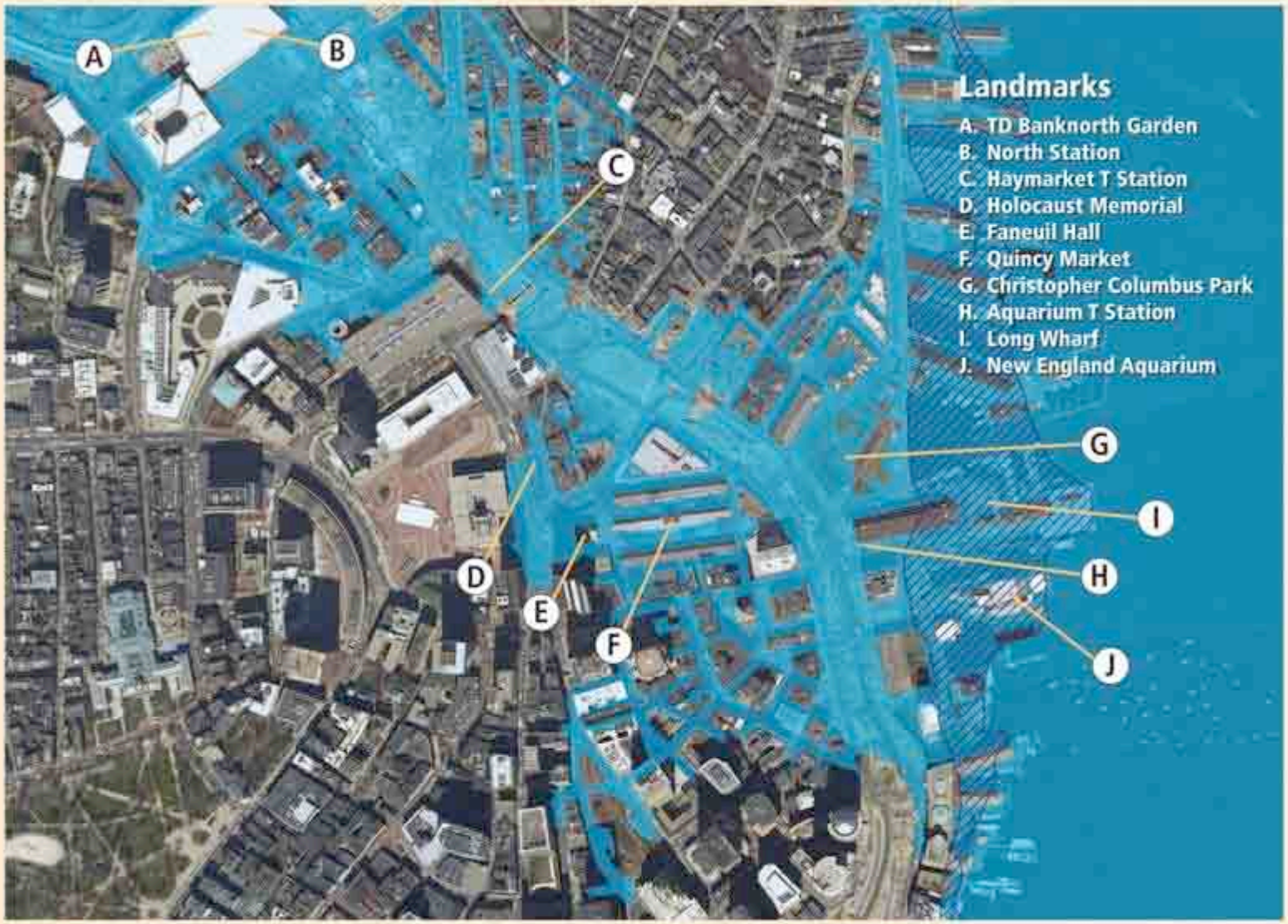


Fig. 1. Map showing Greenland and outlet glacier gates; marine-based gates are shown as dark green and nonmarine as black. Regions below sea level are colored blue. Ice velocities at ~2000 m elevation from (*21*) shown by red dots.

Boston: The 100-Year Coastal Flood in 2100 (Higher-Emissions Scenario; 16 inches of SLR)



Resolution of Topographic Data Matters!

Comparison of terrain models for Fresh Creek, Strafford County, NH: NED 30-meter and 10-meter DEMs versus 1-meter LiDAR

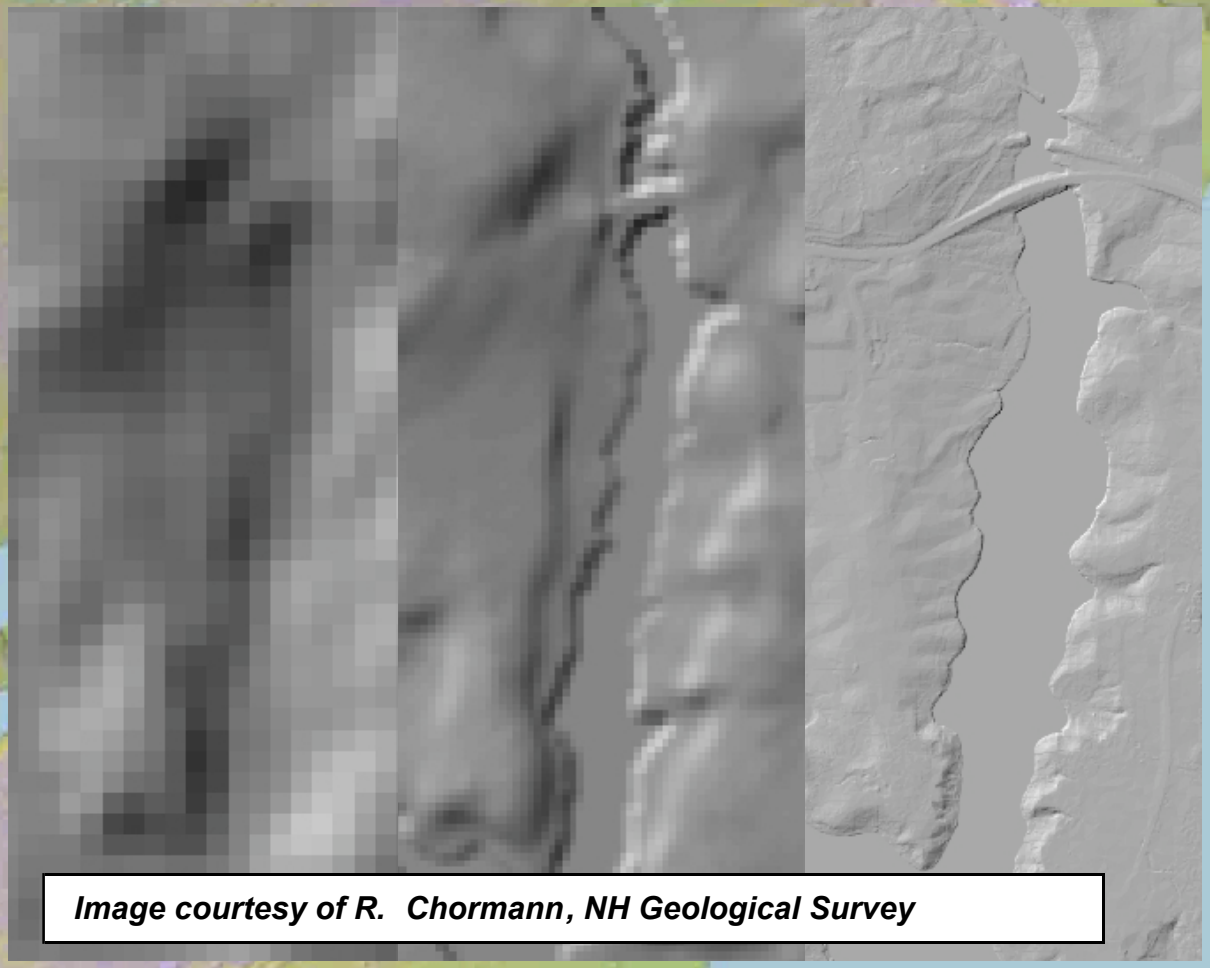


Image courtesy of R. Chormann, NH Geological Survey

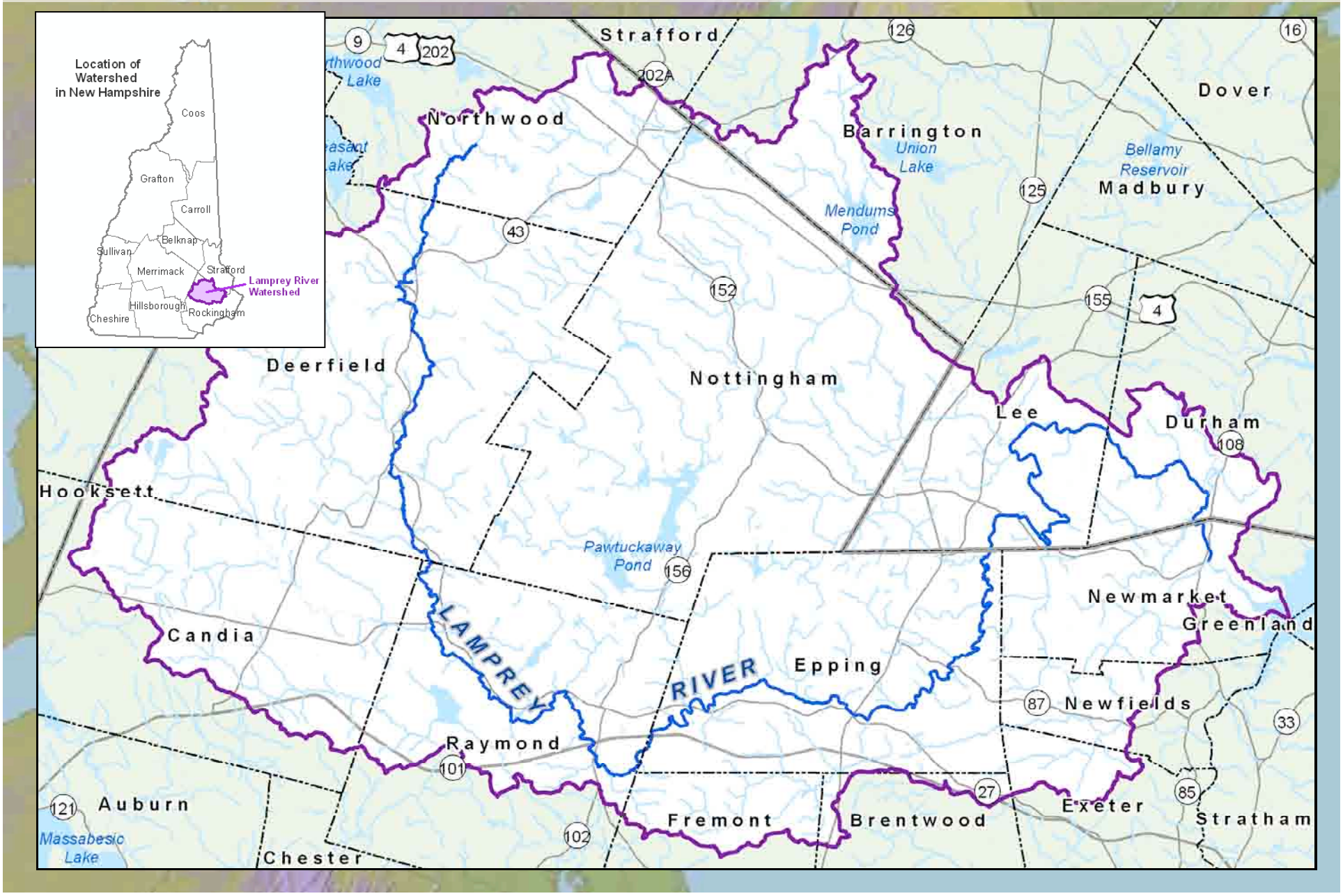
30-meter DEM

10-meter DEM

1-meter DEM

0 0.05 0.1 0.2 0.3 0.4 Miles

Assessing the Risk of 100-year Freshwater Floods in the Lamprey River Watershed from Changes in Climate and Land Use



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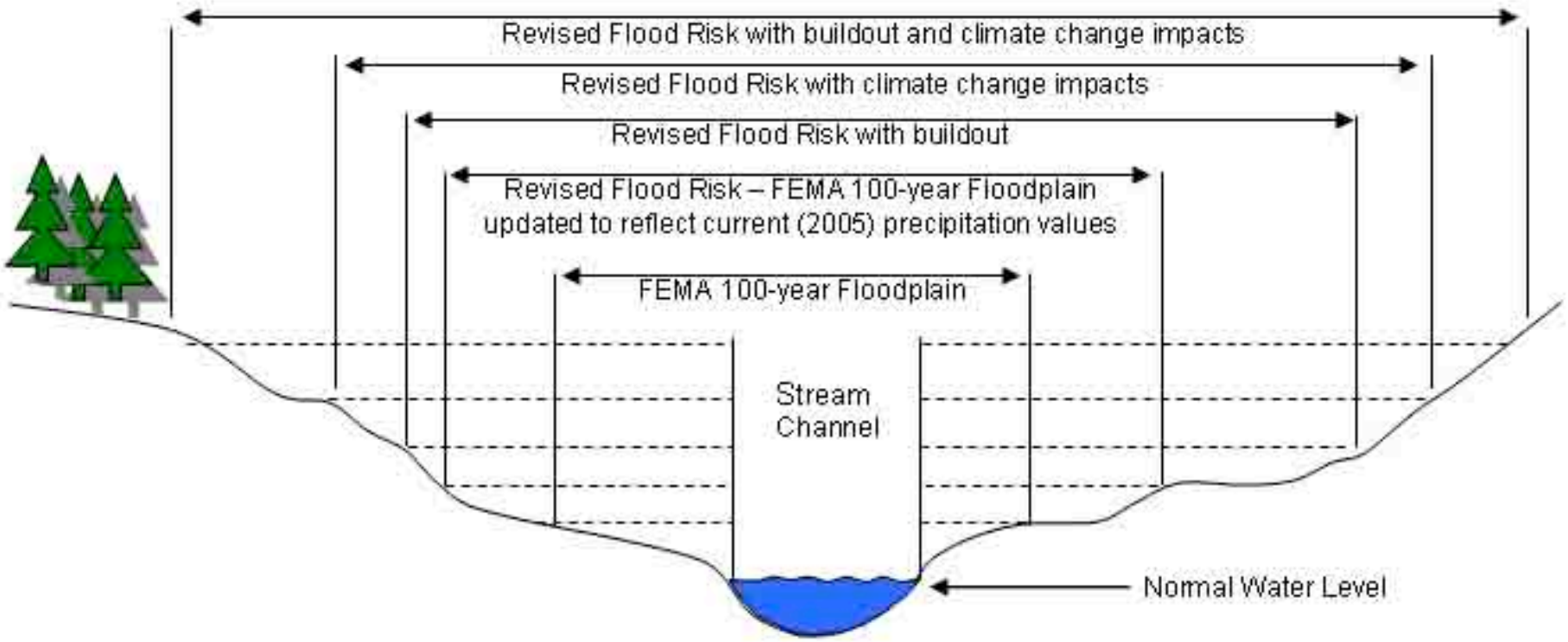
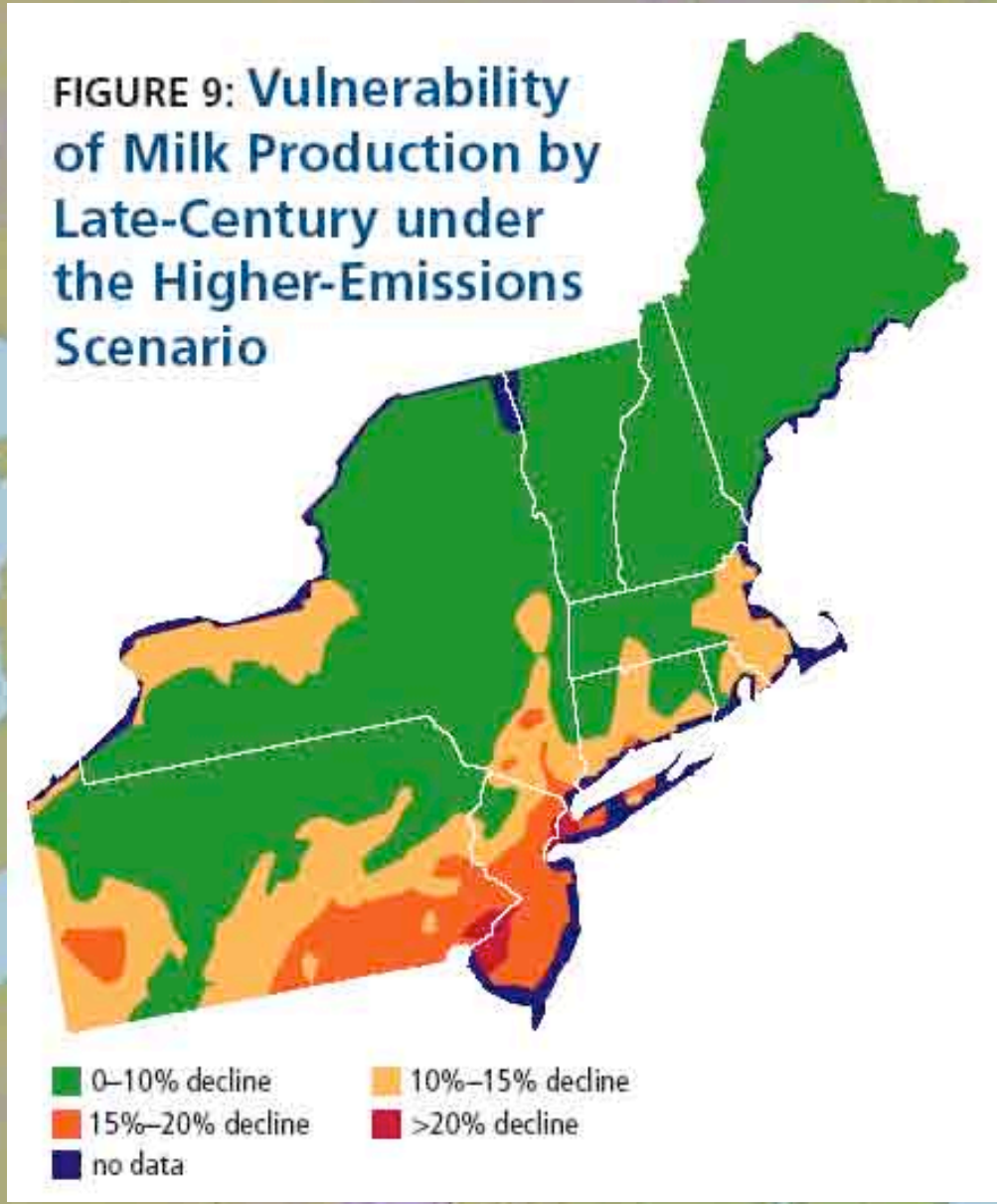


Impacts on Agriculture: Dairy



Higher Temperatures Depress Milk Production

Impacts on Agriculture: Crops

Traditional Fruit Crops May Suffer in a Warmer Climate

What path will we take to the future?

Two roads diverged in a wood, and I -
I took the one less traveled by,
And that has made all the difference.

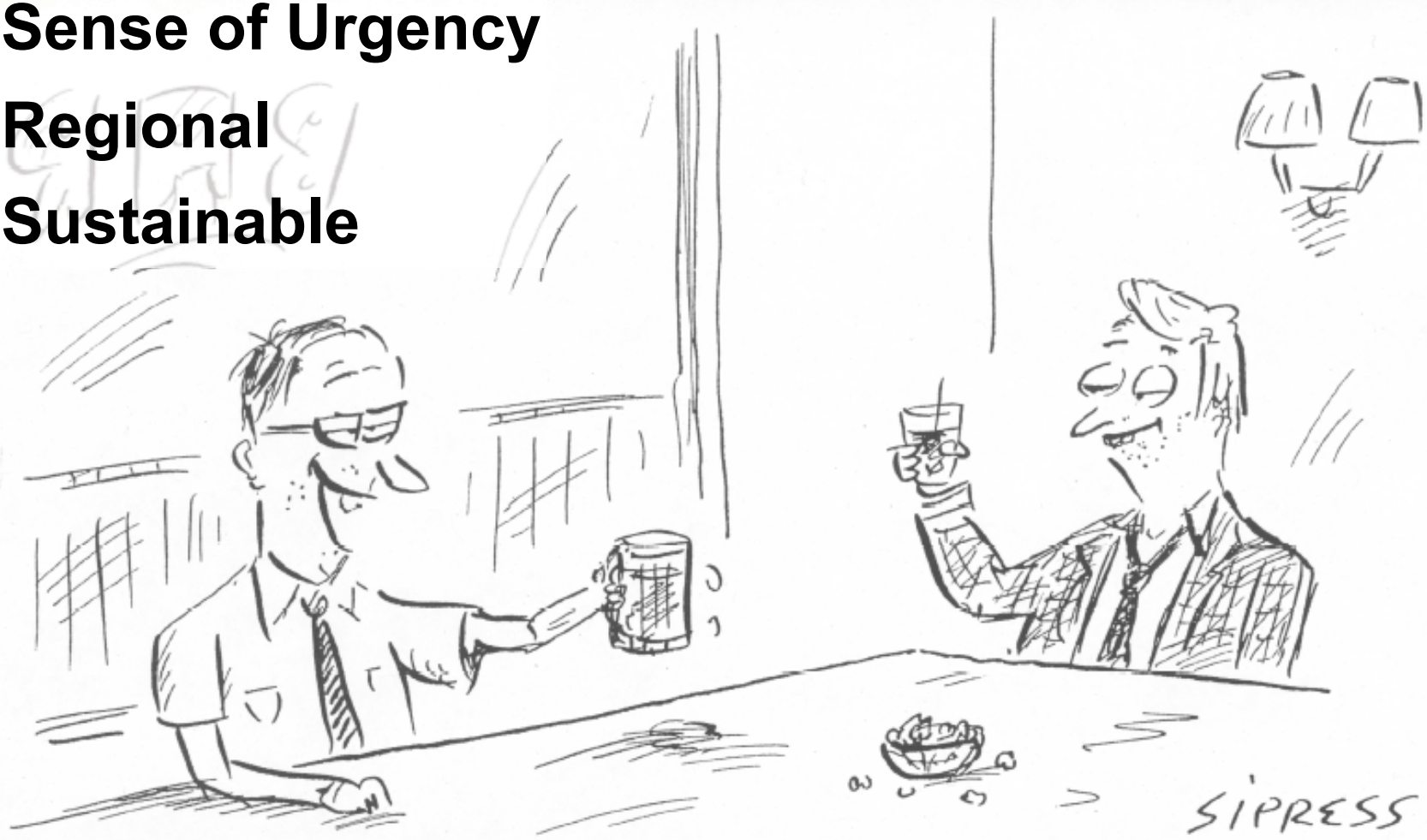
Robert Frost

What is the Big Picture?

Sense of Urgency

Regional

Sustainable



"Here's to missing the big picture."

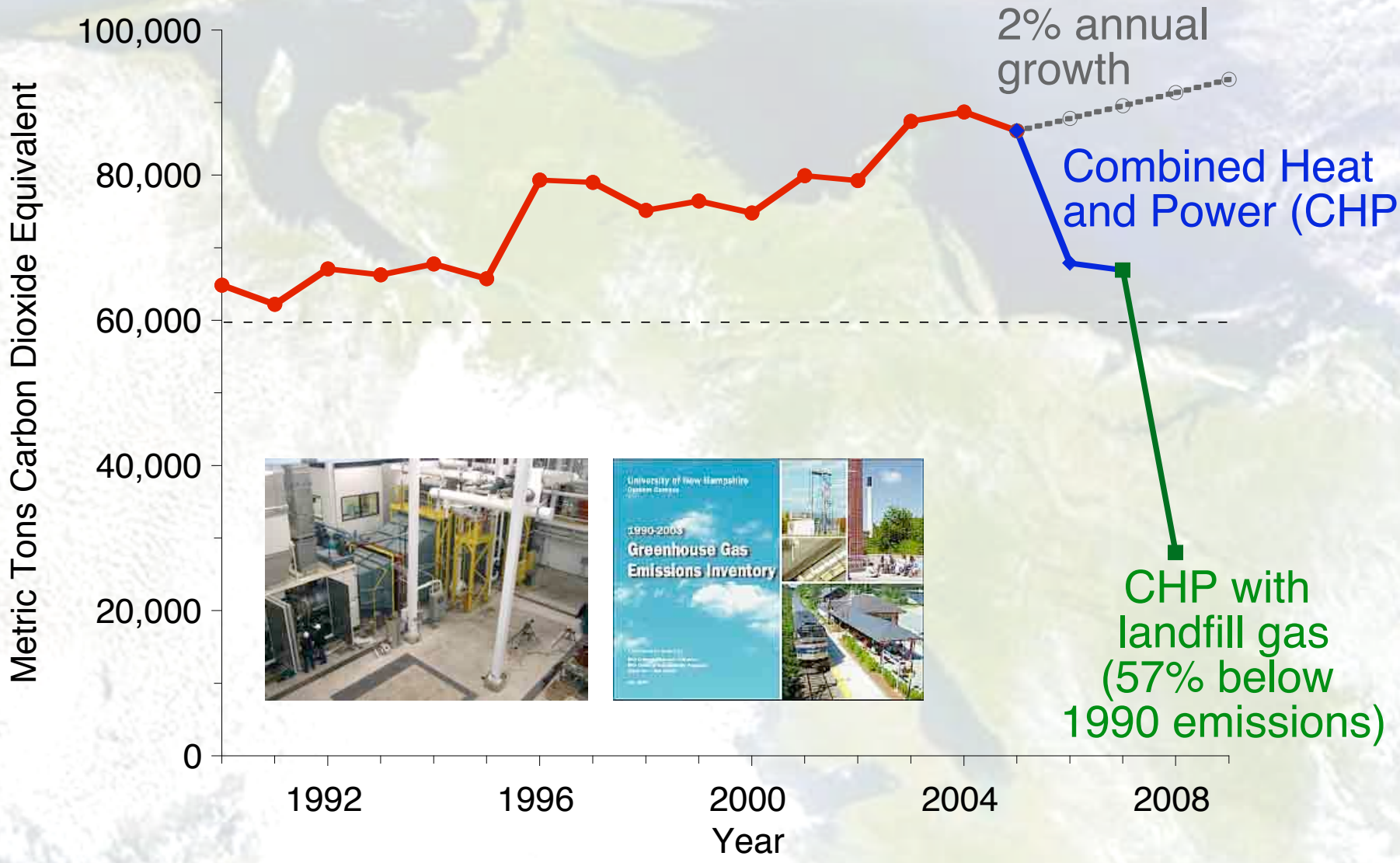
New England: Six Teams - or One?

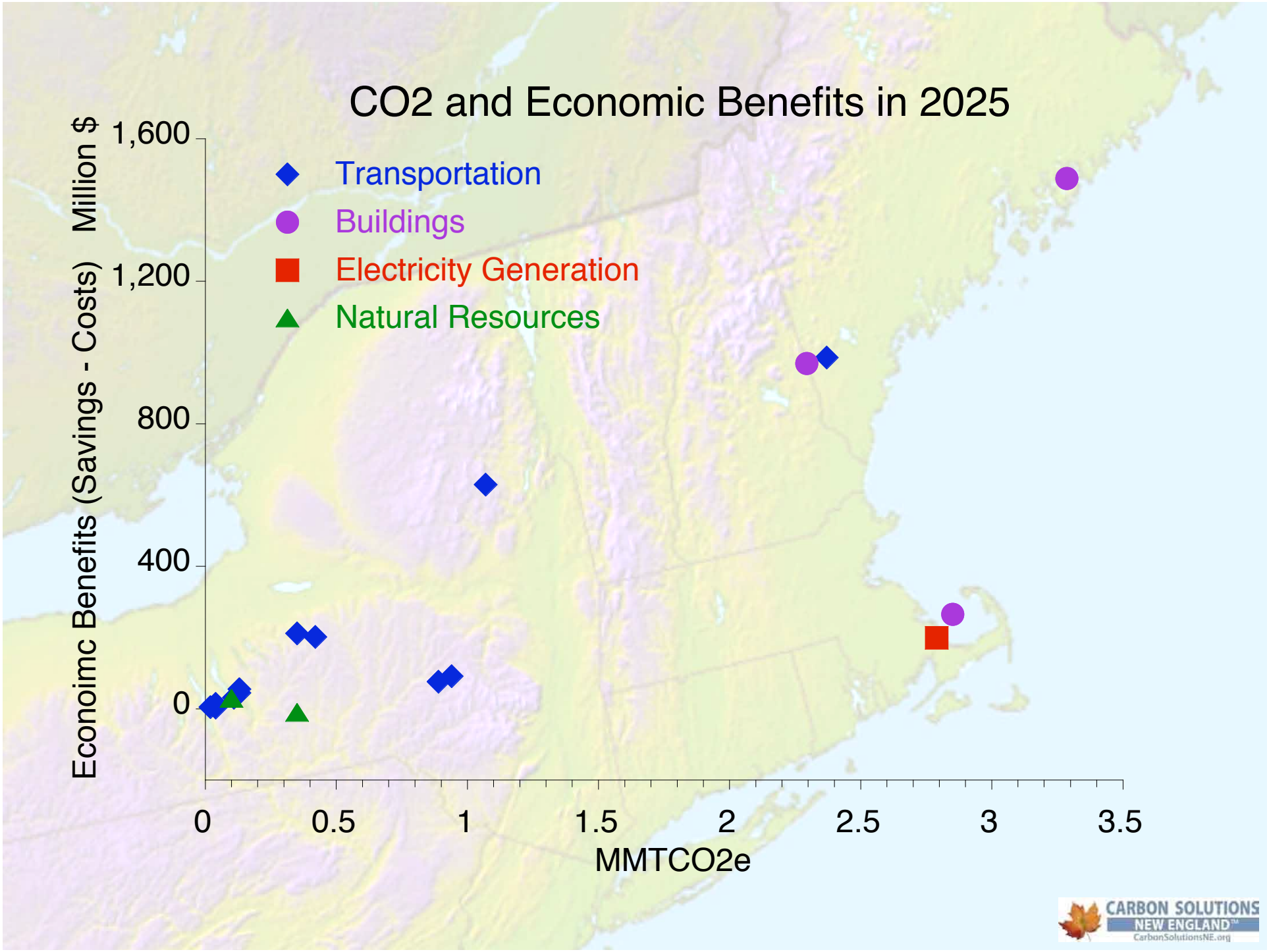
NEW ENGLAND FUTURES
NEW CENTURY, NEW GAME
www.newenglandfutures.org

"We're in peril. We New Englanders must strengthen ourselves, break historic precedent, find new and innovative ways to maximize our joint strengths, work together."

~Former Maine Governor Angus King's message to the region

UNH Greenhouse Gas Emissions




CO2 and Economic Benefits in 2025
Econoimc Benefits (Savings - Costs) Million $
1,600
1,200
800
400
0
Transportation
Buildings
Electricity Generation
Natural Resources
0
0.5
1
1.5
2
2.5
3
3.5
MMTCO2e
CARBON SOLUTIONS
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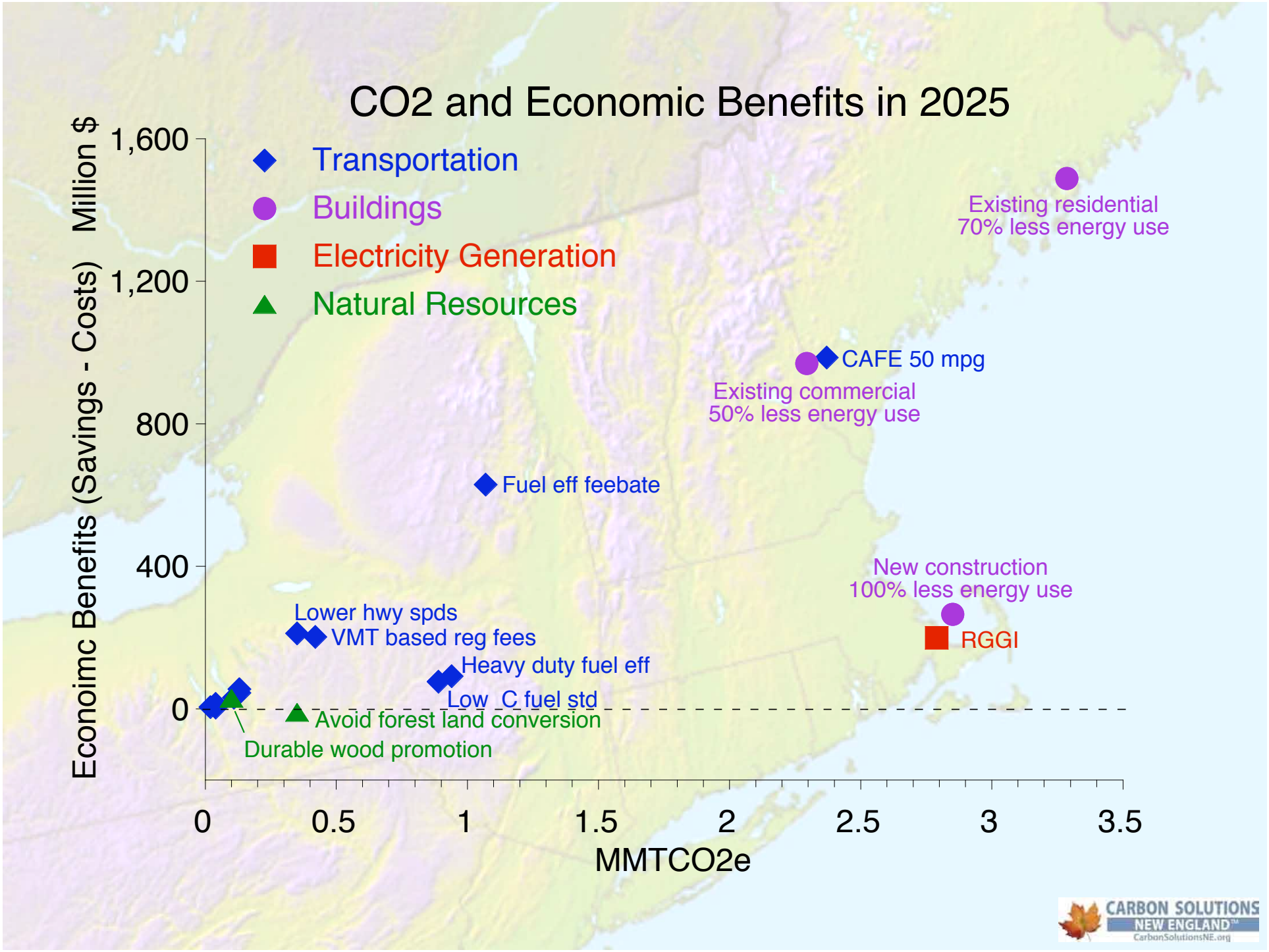
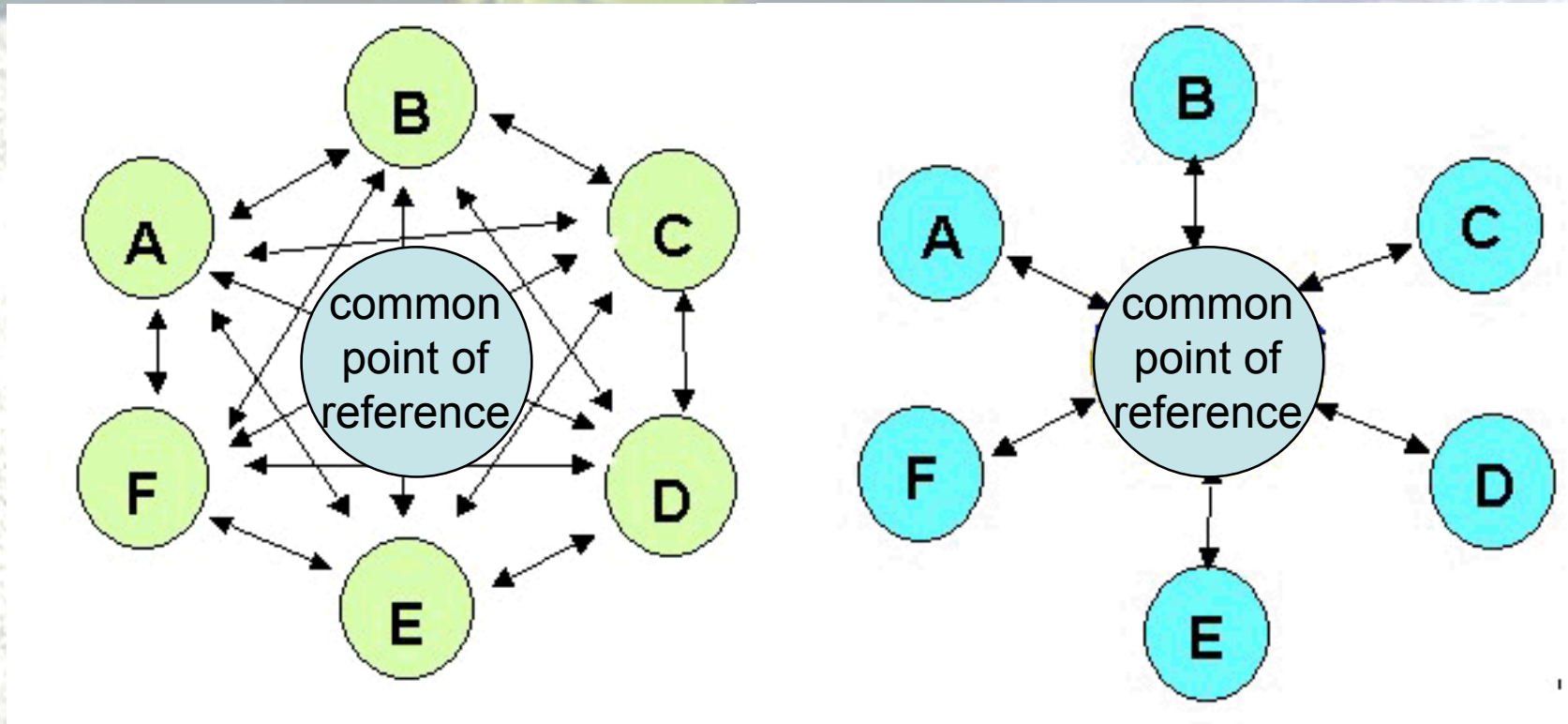
CarbonSolutionsNE.org


CO2 and Economic Benefits in 2025
Econoimc Benefits (Savings - Costs) Million $
1,600
1,200
800
400
0
Transportation
Buildings
Electricity Generation
Natural Resources
Existing residential
70% less energy use
CAFE 50 mpg
Existing commercial
50% less energy use
Fuel eff feebate
New construction
100% less energy use
RGGI
Lower hwy spds
VMT based reg fees
Heavy duty fuel eff
Low C fuel std
Avoid forest land conversion
Durable wood promotion
0
0.5
1
1.5
2
2.5
3
3.5
MMTCO2e
CARBON SOLUTIONS
NEW ENGLAND
CarbonSolutionsNE.org

Integration and Coordination for Sustainability



Building New Institutional Arrangements

Carbon Solutions New England™

- Unite partners from the public, private, and non-profit sectors to build a clean energy future while sustaining our unique natural and cultural resources
- Harness New England's formidable intellectual and entrepreneurial capabilities
- Facilitate the spread of innovation through analysis and dissemination
- Our approach: Build an interdisciplinary and collaborative process across sectors to address a shared problem

Why Collaborate?

CSNE will build a regional collaborative that rewards and reinforces participation by:

- Pursuing a public good project focused on solutions and a collective legacy
- Facilitating a process focused on learning and innovation that adds value to both individual and collective goals
- Delivering products that are publicly accessible, transparent in purpose, method and reasoning, and valuable for creative problem solving

CSNE Process

Annual State of the Region Assessment

Biannual Summits

Product Working Groups

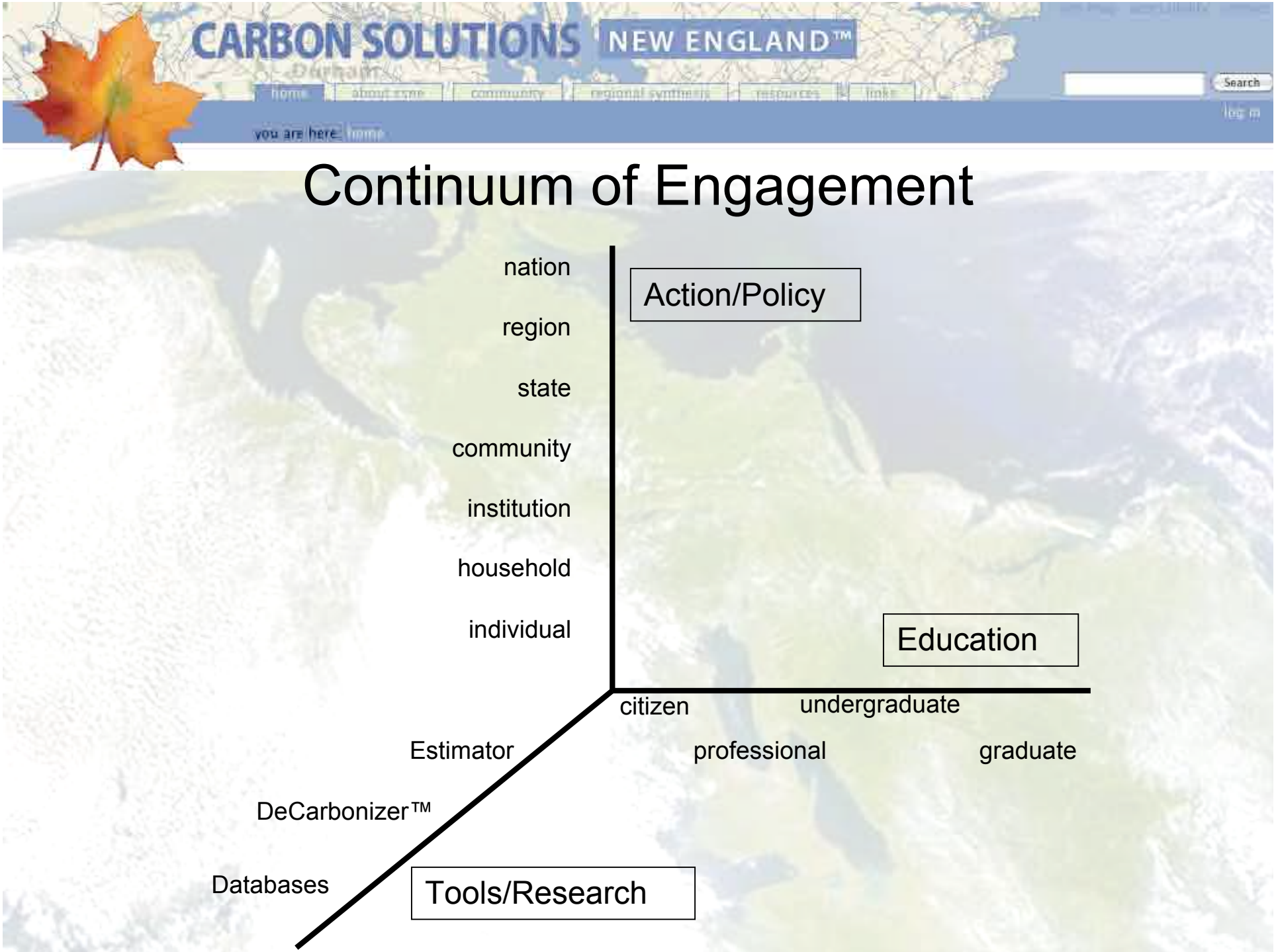
Mutual Learning

Shared Resources

Products

Process

- Regional CO_2 Emission
- Renewable Energy Potential
- Action in all Sectors
- Technologies Assessment
- Indicators & Monitoring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community
regional synthesis
resources
links
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you are here: home
Continuum of Engagement
nation
region
state
community
institution
household
individual
Action/Policy
Education
citizen
undergraduate
graduate
professional
Estimator
DeCarbonizer™
Databases
Tools/Research

Economic Framing: *The "big picture" economic case for New Hampshire Climate Change Policies*

- Reduce dependence on imported energy & electricity
- Energy efficiency & local energy sources keeps $'s in the state
- Fosters business development and creates jobs
- Reduces risk and vulnerability to imported energy prices
- Reduces air pollution and environmental threats to key industries and the economy
  - Protect natural resources
  - Maintain tourism
  - Attract skilled workforce/entrepreneurs
  - Reduce health care costs

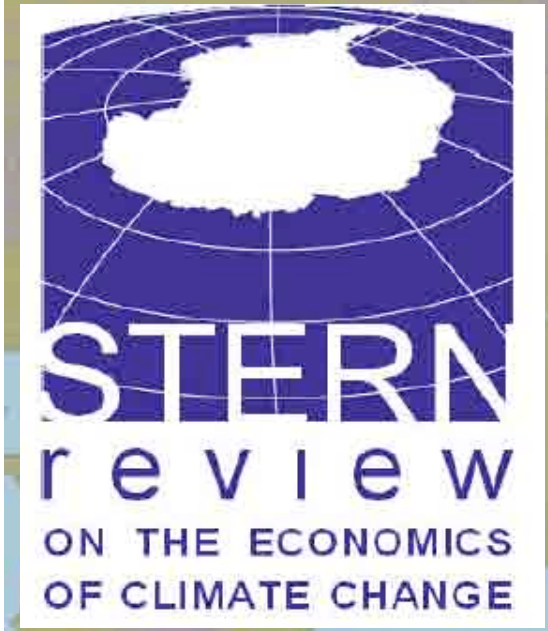
METHODS:

Limited to New Hampshire costs/benefits

Analysis does not consider all the potential benefits such as reduced health costs due to reduced air pollution emissions

Economic benefits include the multiplier benefit of "recycling" of $'s in NH economy. A conservative 1-1 multiplier is used.

What if we do nothing??



October 2006

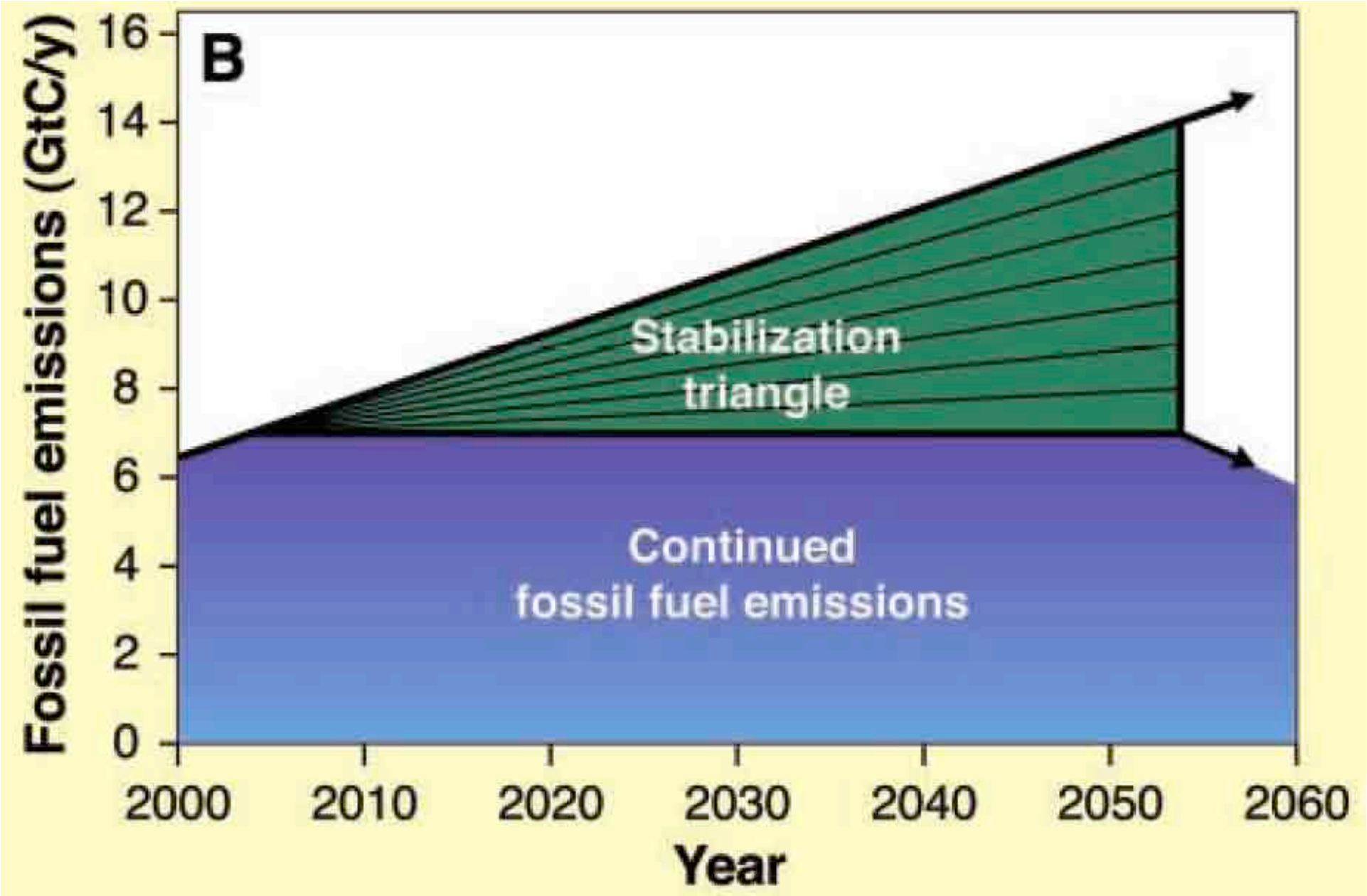
Climate change will affect the basic elements of life for people around the world – access to water, food production, health, and the environment.

If we don't act, the overall costs and risks of climate change will be equivalent to losing **at least 5%** of global GDP each year, now and forever.

If a wider range of risks and impacts is taken into account, the estimates of damage could **rise to 20%** of GDP or more.

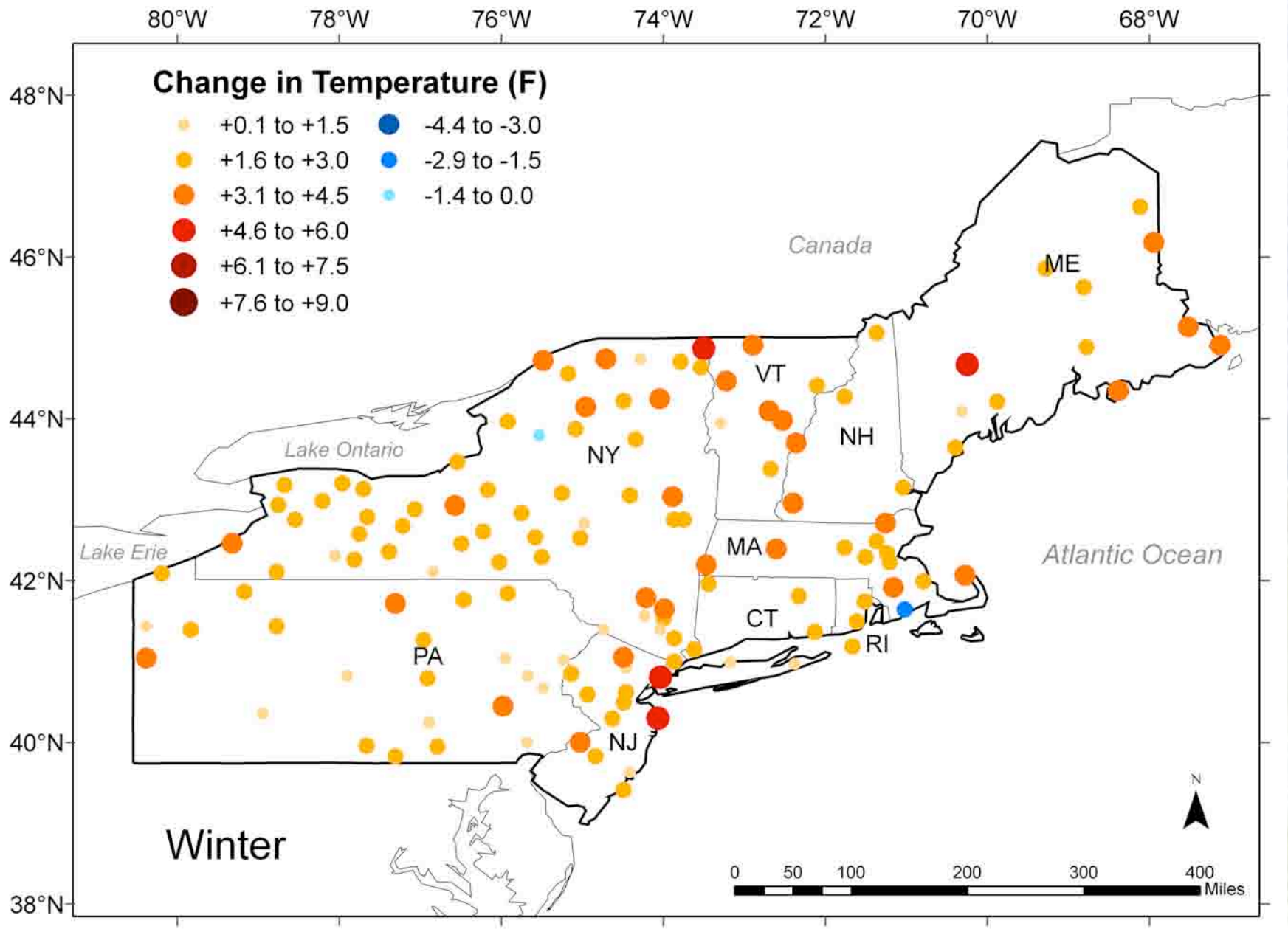
In contrast, the costs of action can be limited to **around 1%** of global GDP each year.

Potential Carbon Emission Reduction Wedges



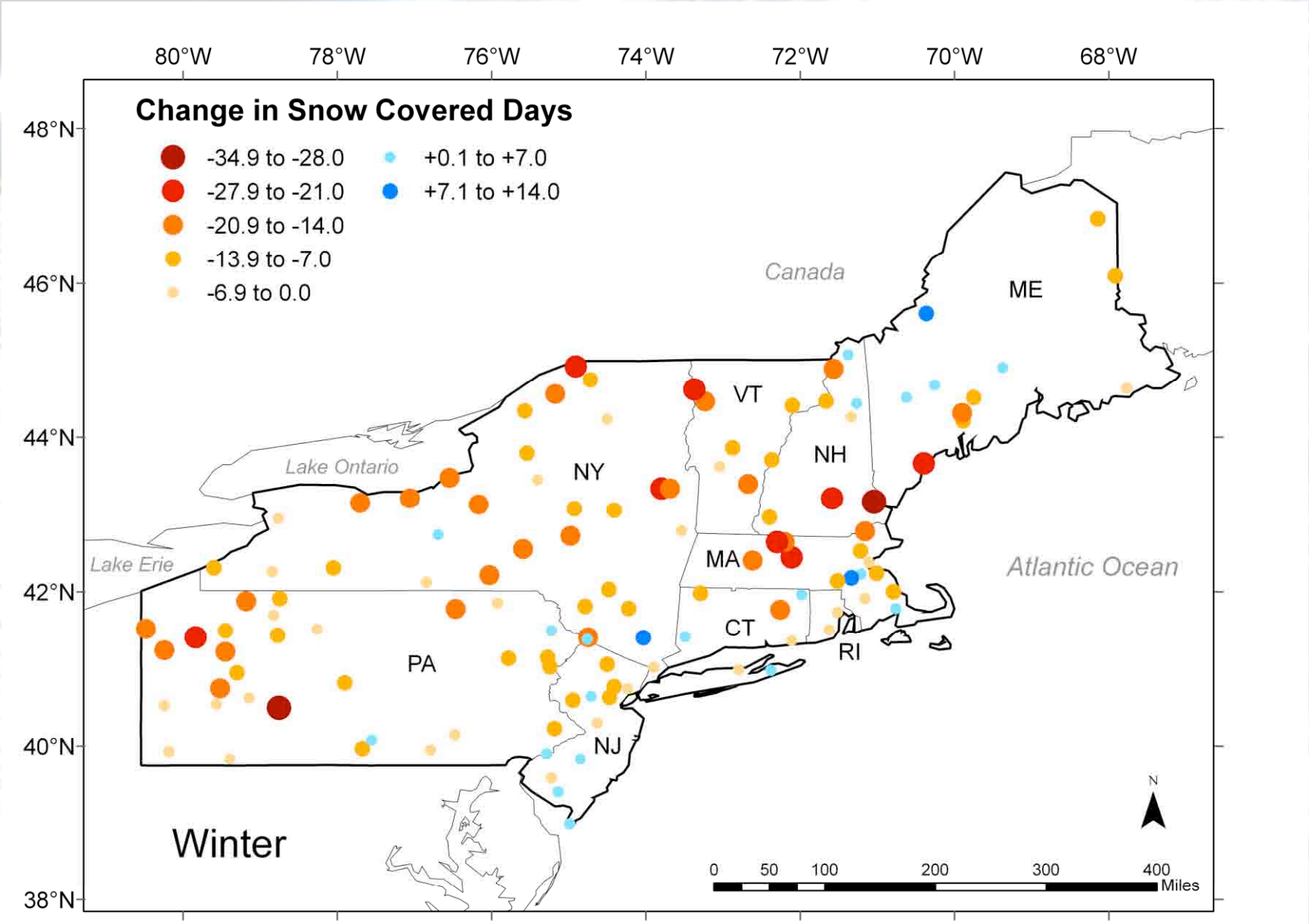
Pacala and Socolow (2004) Science 304, 968-972.

Northeast Winter Temperature Trends 1970-2005



Burakowski et al., 2008, JGR

Northeast Snow Cover Day Trends 1970-2005



Burakowski et al., 2008, JGR