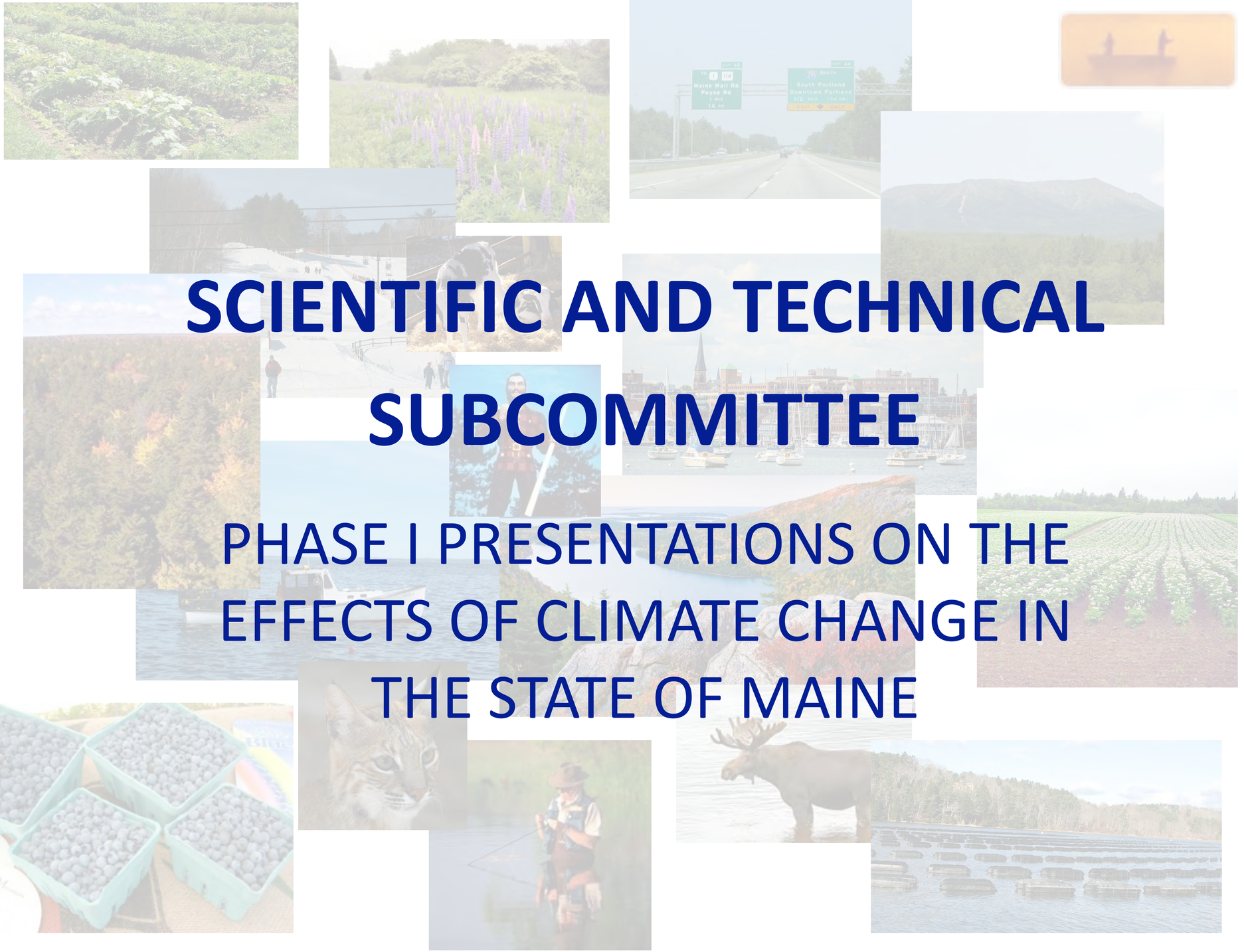
MAINE
CLIMATE COUNCIL

Second Council Meeting
January 29, 2020
9:00 am – 4:00 pm



SCIENTIFIC AND TECHNICAL SUBCOMMITTEE

PHASE I PRESENTATIONS ON THE EFFECTS OF CLIMATE CHANGE IN THE STATE OF MAINE

Climate Impacts Report to the Maine Climate Council

29 January, 2020

Sean Birkel

Bradfield Lyon

Glenn Hodgkins

Pam Lombard

Representative Brian Hubbell

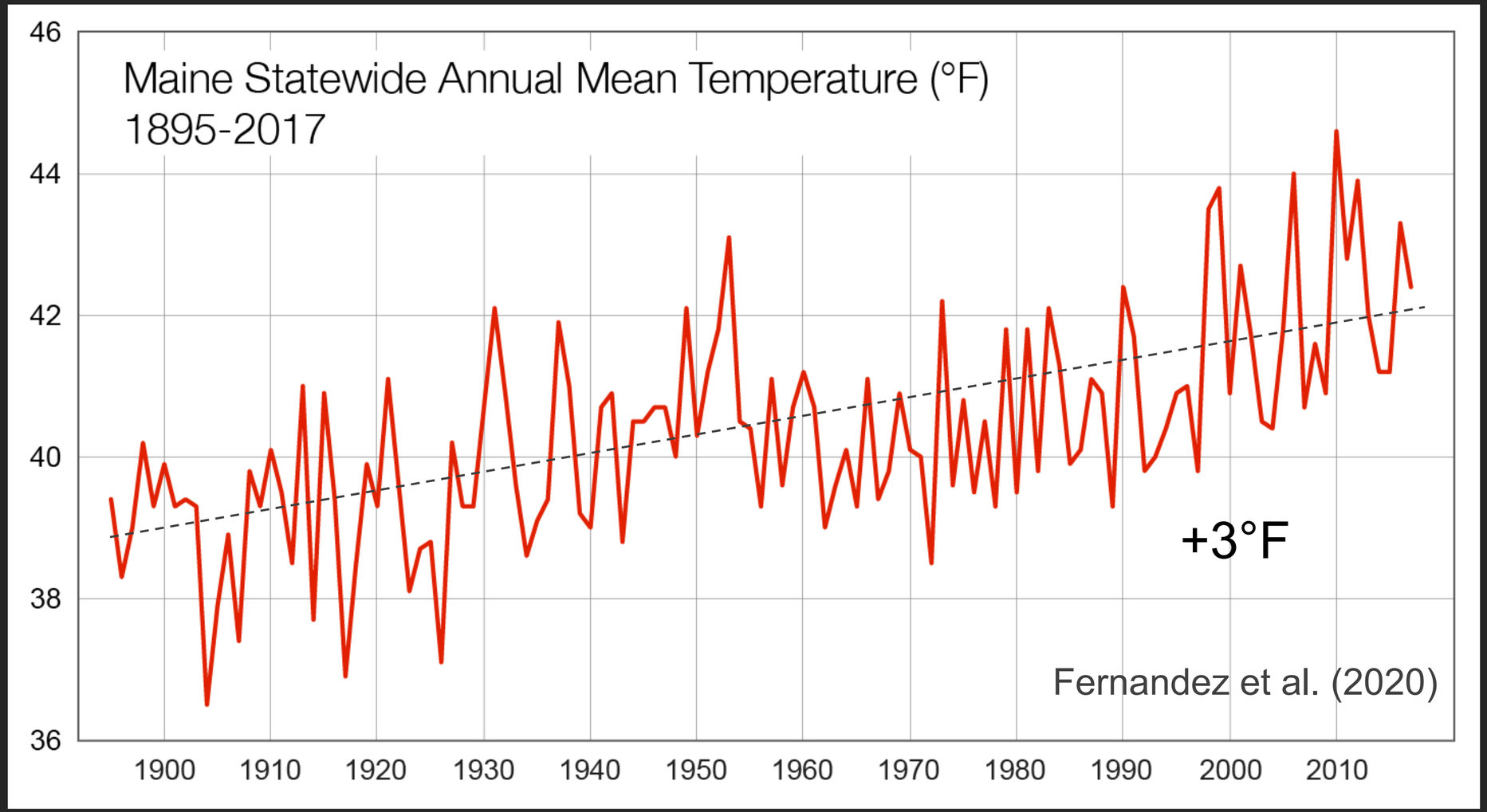
UM School of Earth and Climate Sciences

USGS, New England Water Science Center

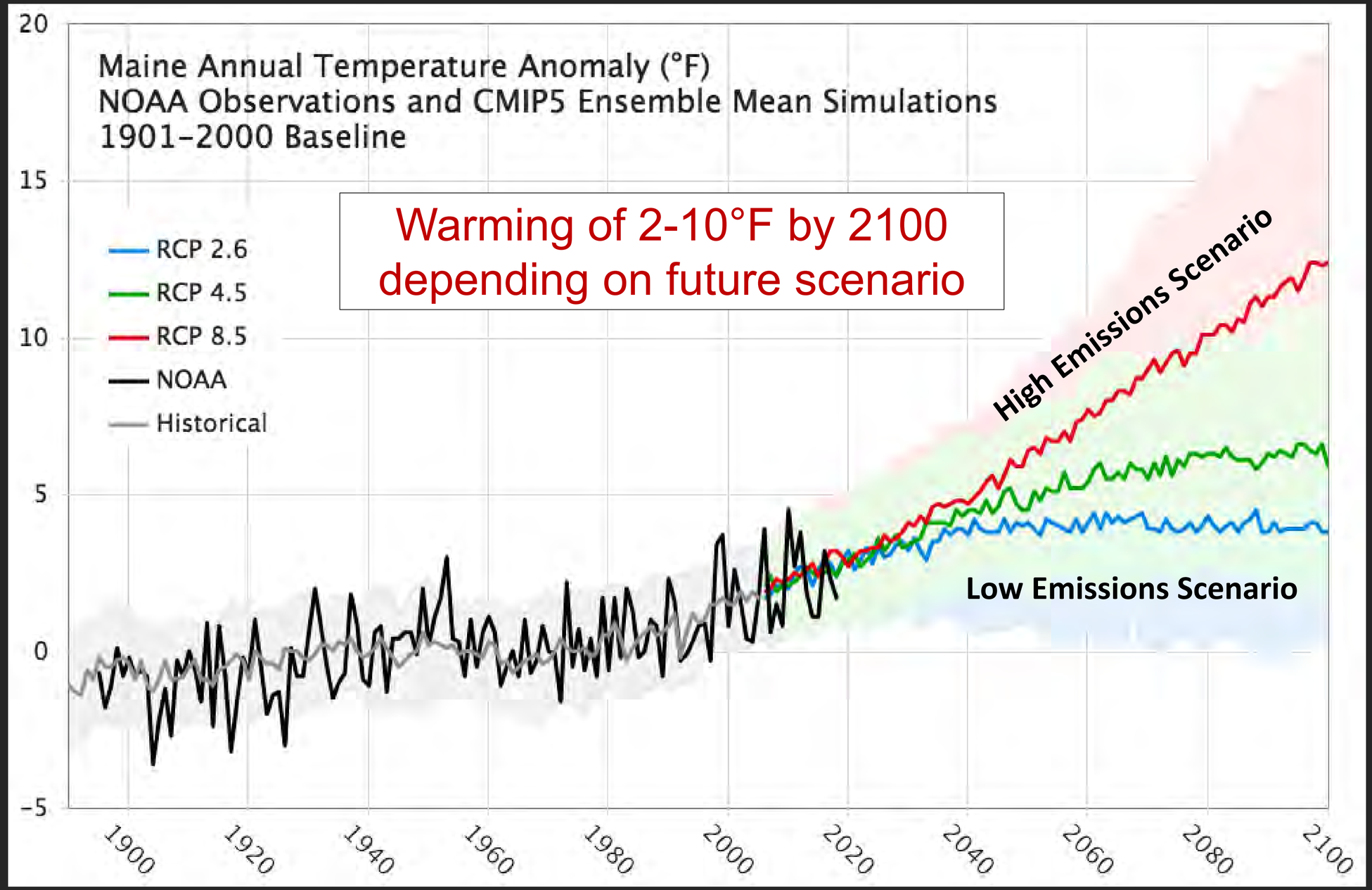
Presentation Outline

- Temperature
- Changing Season Lengths
- Precipitation and Drought
- Extreme Weather
- Snow and Hydrology
- Summary

Temperature

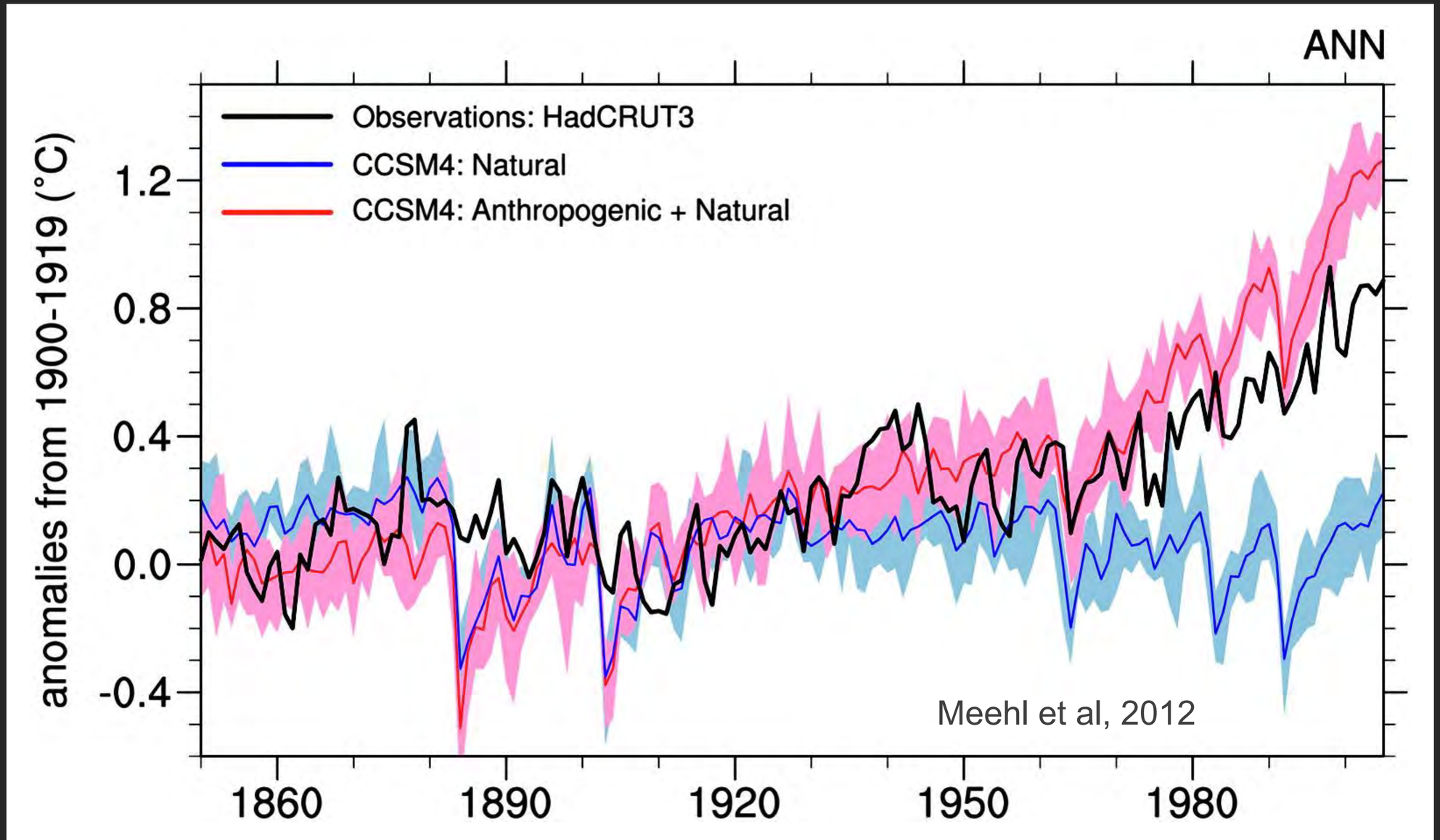


- Annual increase of 3°F since 1895
- Overnight lows have risen more than daytime highs
- The six warmest years occurred since 1998



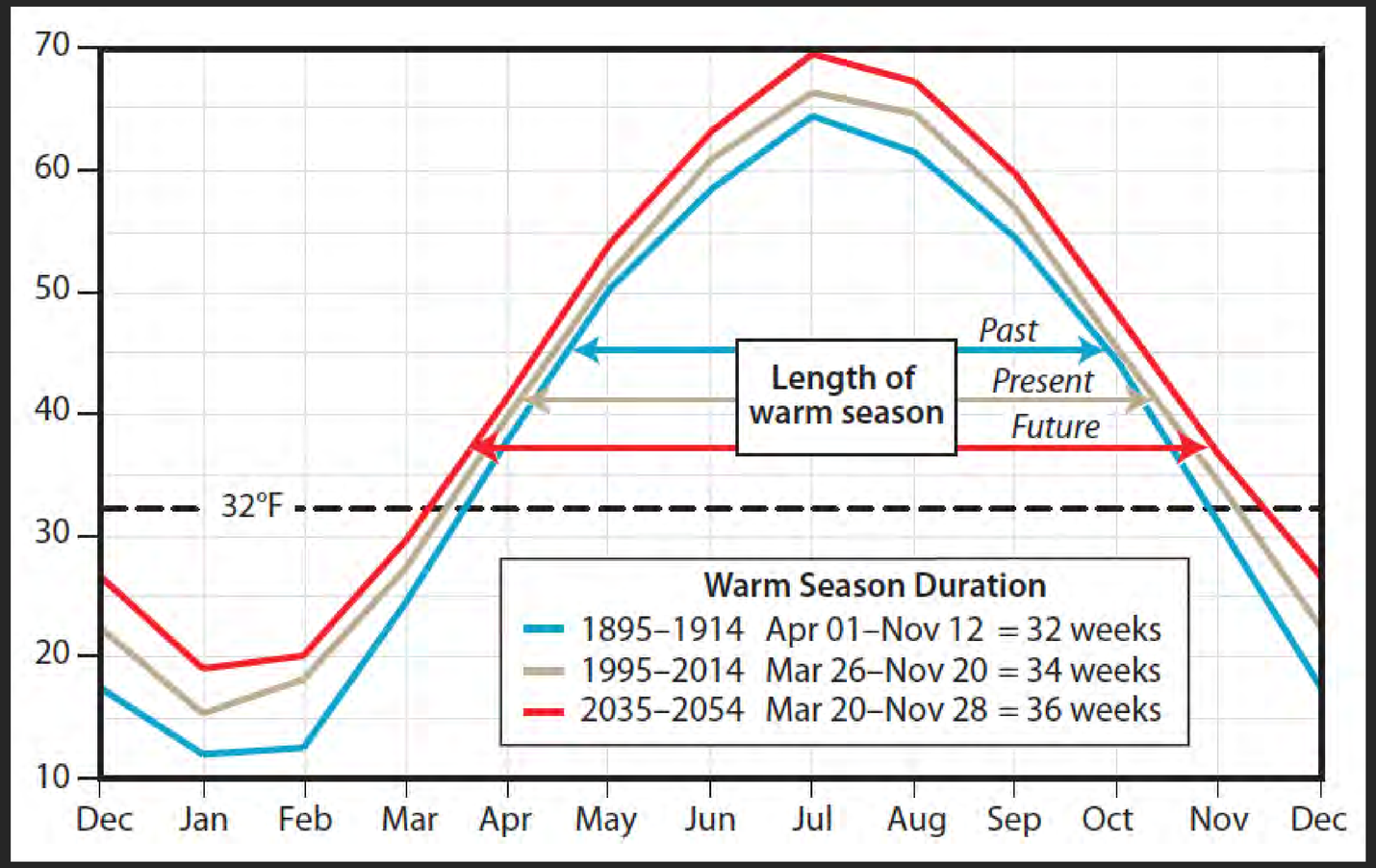
Fernandez et al. (2020)

Natural forcings cannot account for the observed warming since at least 1960



Season Lengths are Changing

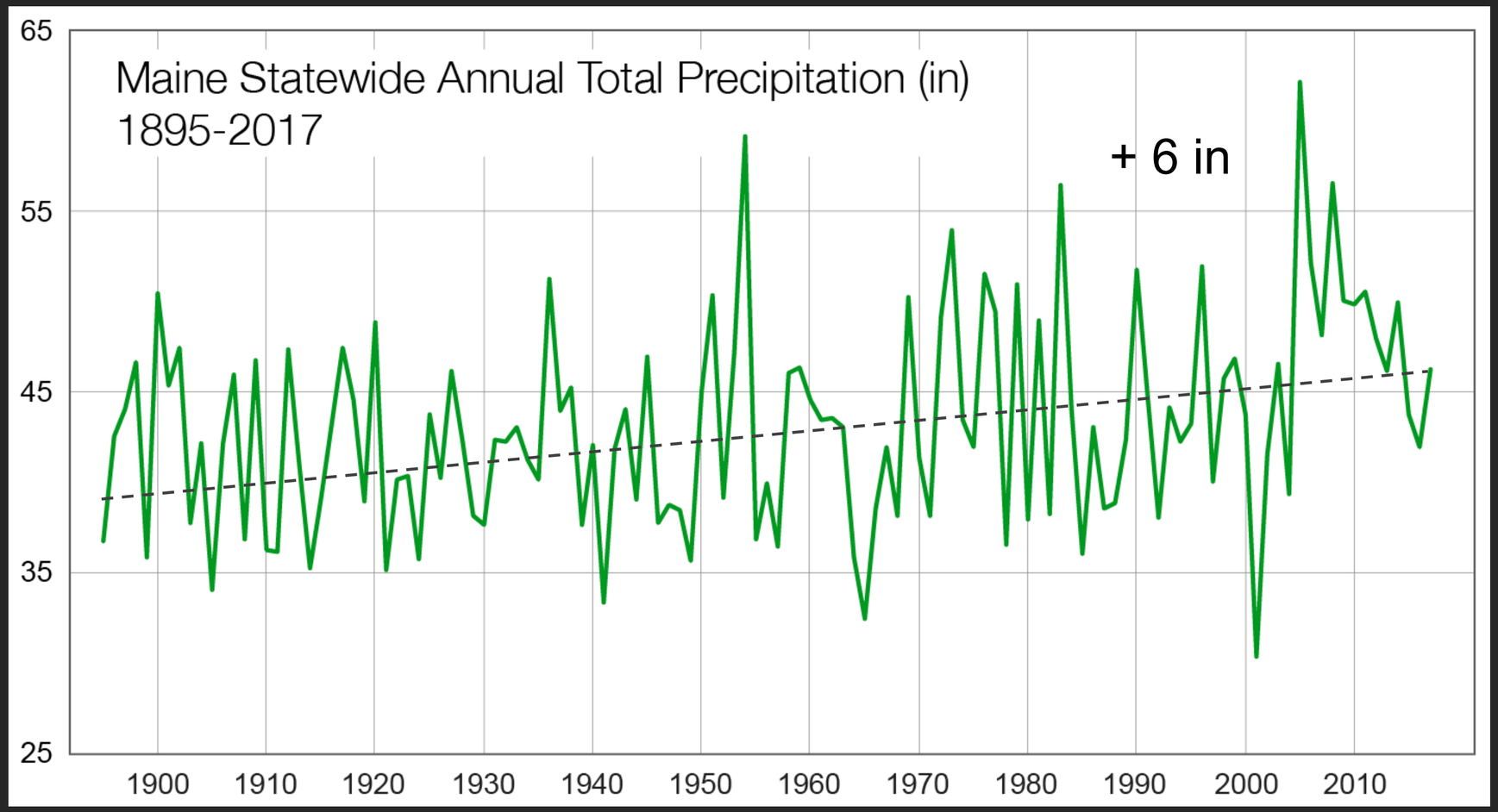
Statewide Mean Monthly Temperature Cycle (°F)



Fernandez et al. (2015)

- Summer is longer and winter is shorter than a century ago.
- Since 1950, the growing season has lengthened by ~16 days (Fernandez, 2020).
- Summer weather & growing season extension mostly into fall.
- Trends projected to continue, but some years will bring unexpected late spring or early fall frosts.

Precipitation & Drought

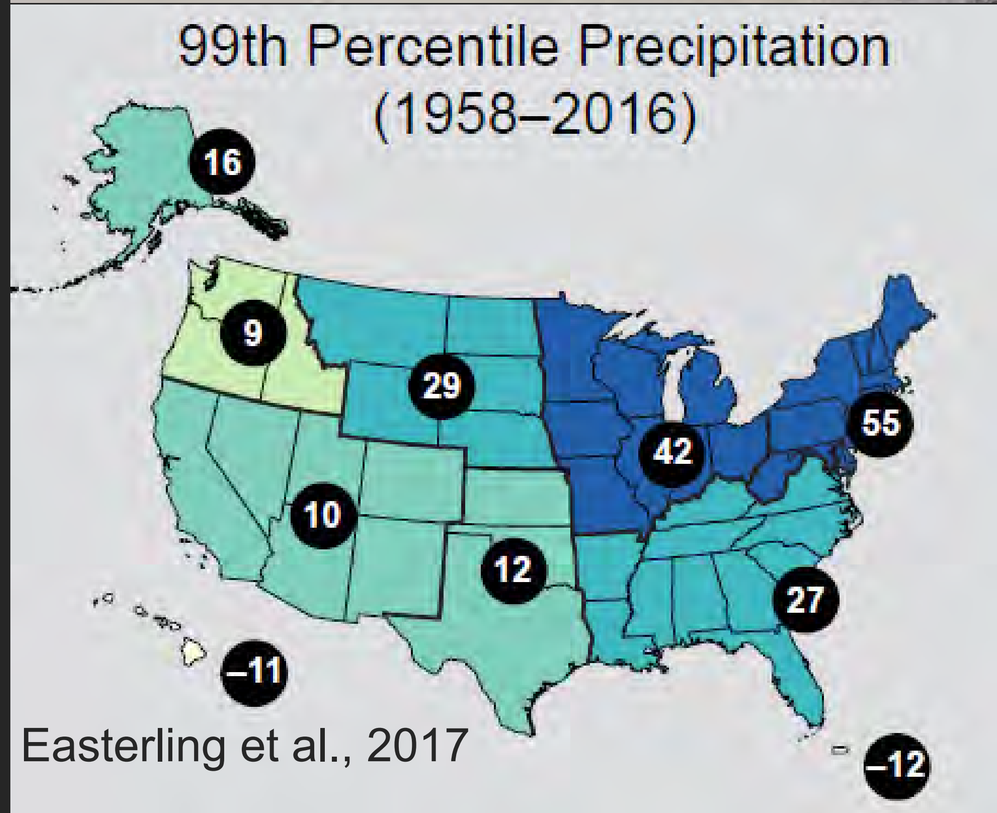


Fernandez et al. (2020)

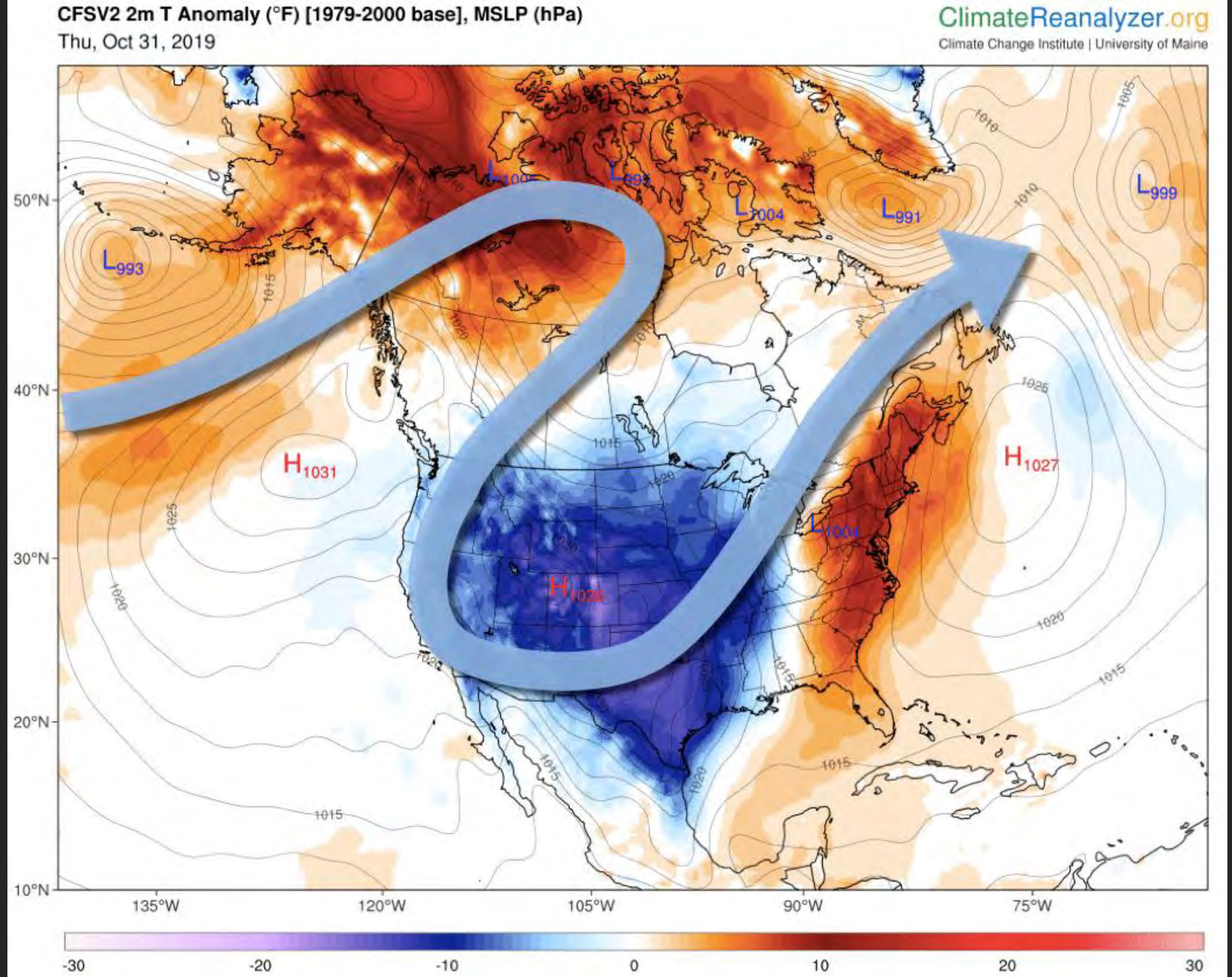
- Maine's annual precipitation increased 6" since 1895. Largest increase last 20 years.
- Trend expected to continue.
- Drought occurrence has not increased, but rising temps can exacerbate droughts that develop.
- Uncertain whether intermittent drought will be or more or less likely in the future.

Extreme Weather

- Extreme weather becoming more common around the Northern Hemisphere due to changes in atmospheric circulation.
- Increased likelihood of heat/cold waves, intense storms.
- Large increases (55%) in annual heavy daily precipitation across the USNE.
- In Maine, the last 10-15 years have seen the highest occurrence of 2”, 3”, and 4” precipitation events (Fernandez et al., 2020).

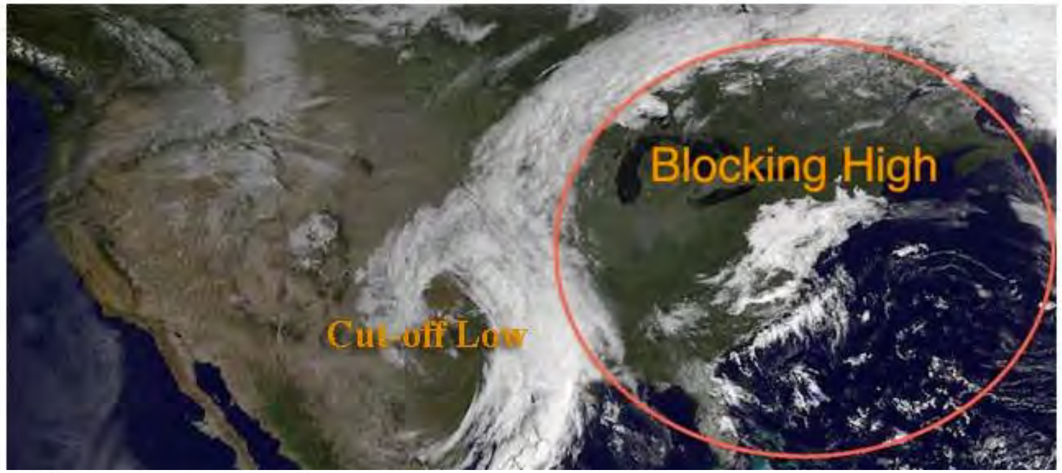


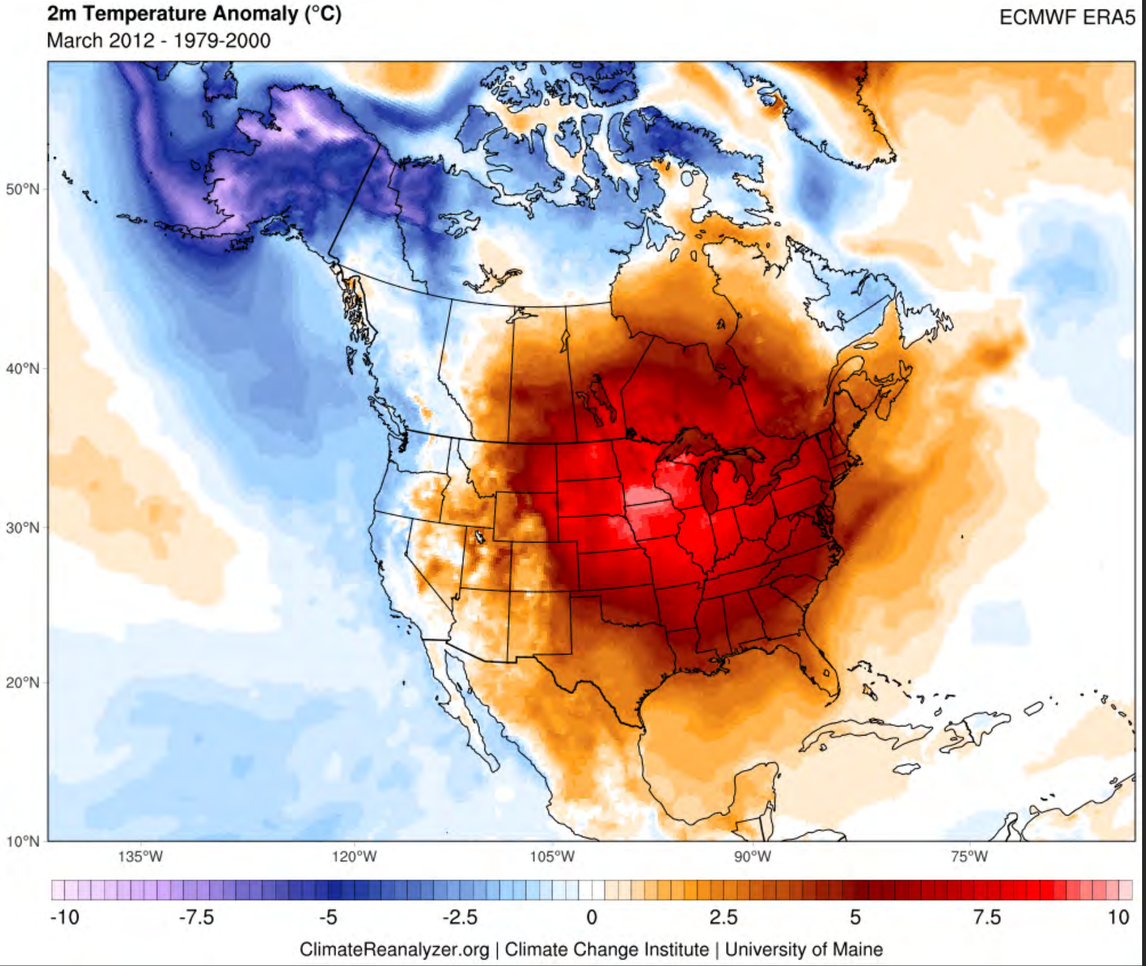
Easterling et al., 2017



Temperature anomaly and Jetstream

Wind Storm
Nov 1, 2019

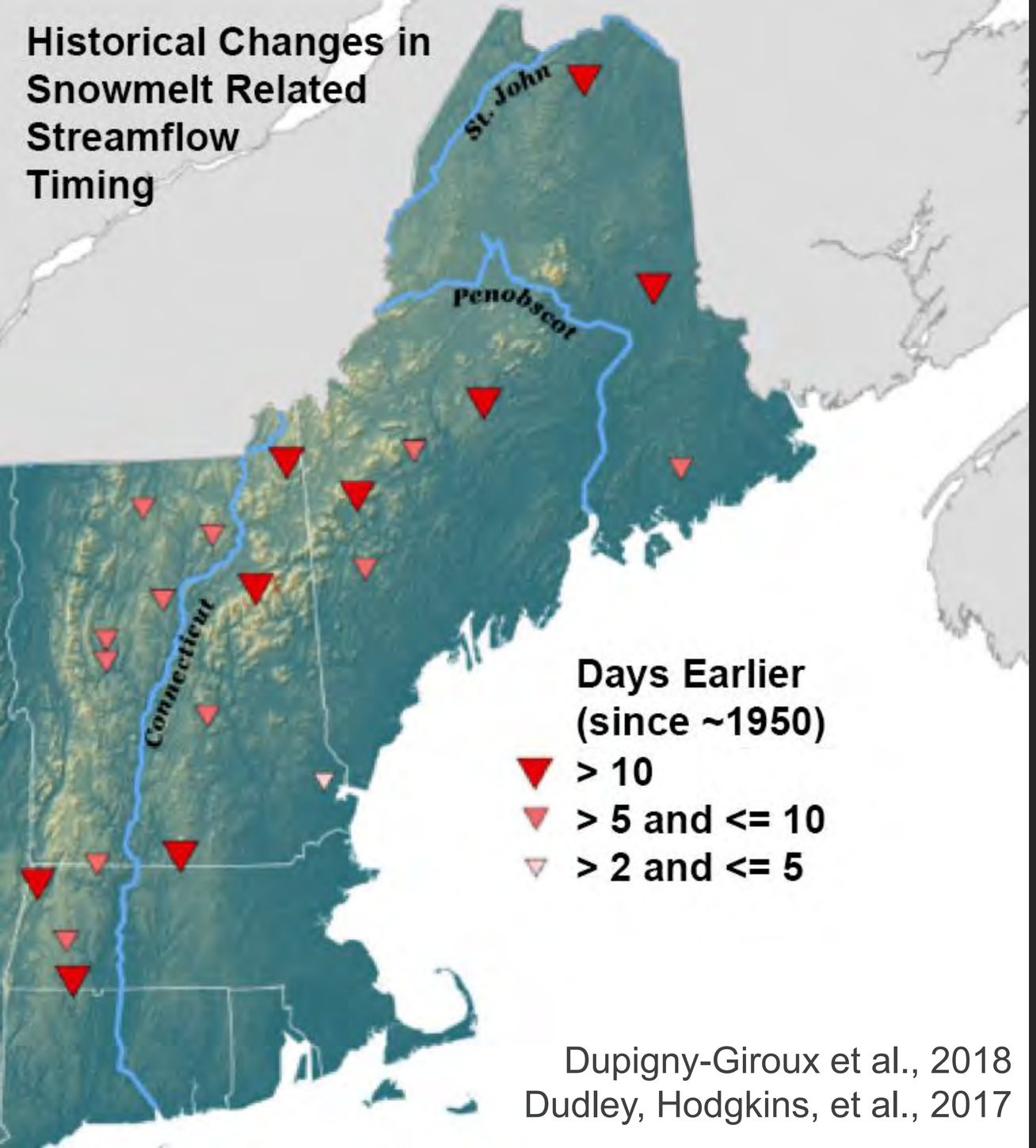




Summer in March, 2012

- Temperatures into the 80s across southern half of Maine 22-23 March with no historical equivalent.
- Farmington 83°F March 23rd – a daily high record set by 17°F!

18 March, 2012

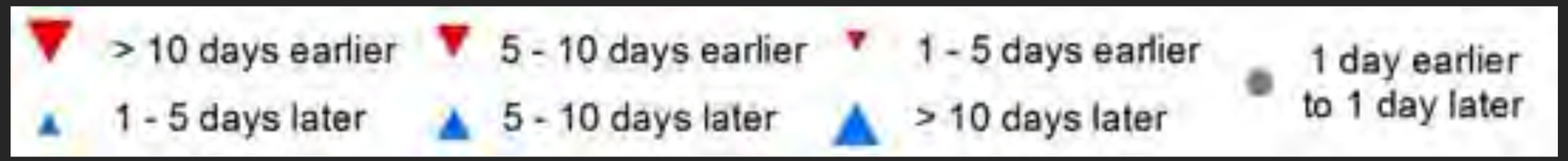


Dupigny-Giroux et al., 2018
Dudley, Hodgkins, et al., 2017

Maine's Snow is Melting Earlier

- Trend toward earlier winter-spring melt runoff
  - 7-14 days earlier than ca. 1950
  - Related to small increases in February–May air temps
- Trends projected to continue
  Hayhoe et al., 2007;
  Demaria et al., 2016b

Ice-Out on Maine Lakes is Occurring Earlier

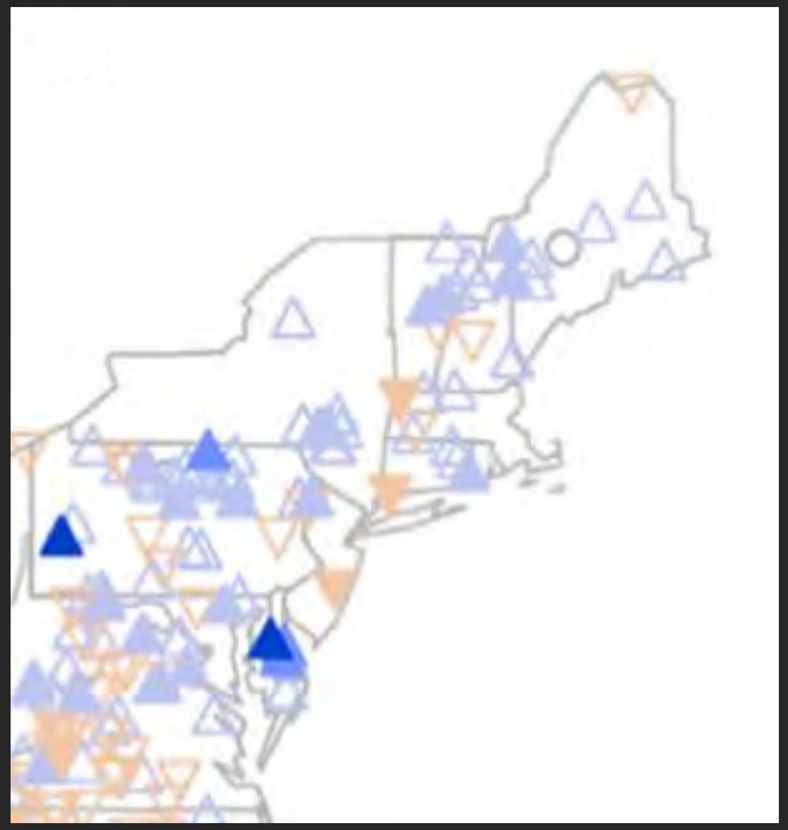


Hodgkins, 2013

Increasing Magnitude & Frequency of Small Floods

- 1941-2015 (75 yrs): average 29% increase
- 1966-2015 (50 yrs): average 19% increase

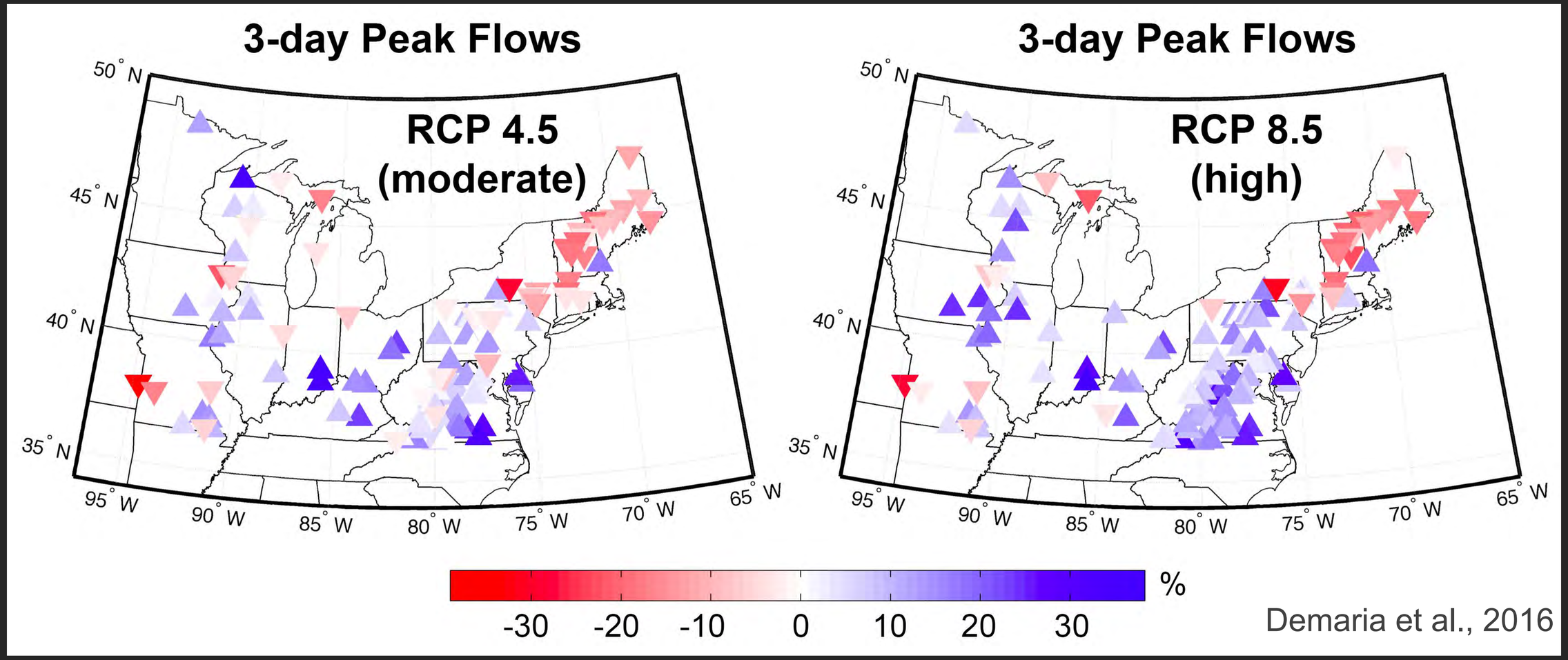
April, 2005, Hallowell, ME
USGS Photo



Blue triangles, increases
Brown triangles, decreases
Open symbols, < 25%
Light solid, 25-50%
Medium solid, 50-75%
Dark solid, > 75%

Hodgkins, Dudley, et al., 2019

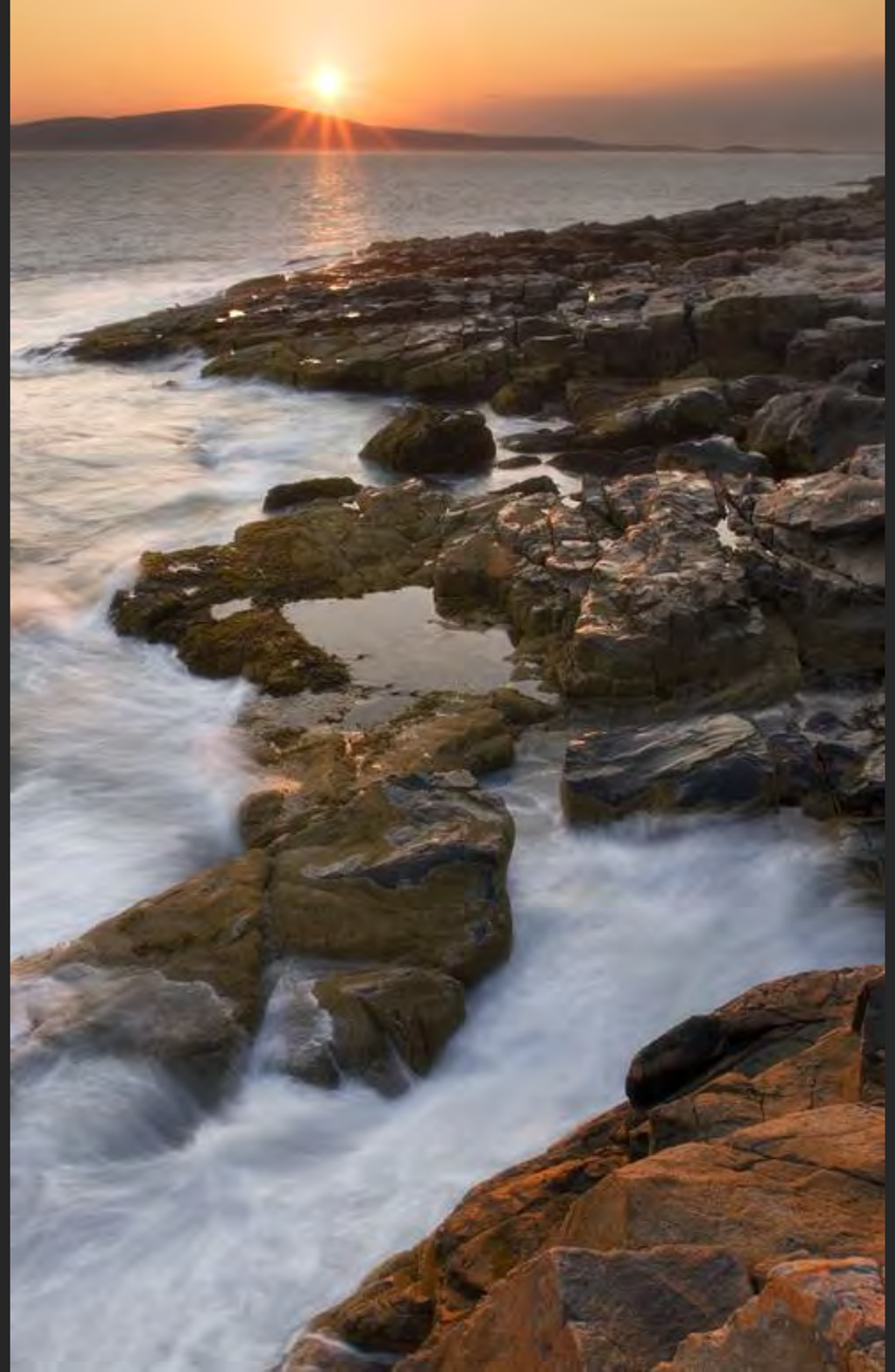
100-year, 3-day Peak Flows are Projected to Decrease



- Likely linked to decreasing late winter snowpack

Summary

- Maine’s statewide annual temperature 3°F warmer since 1895.
- Models project additional warming of 2-10°F by 2100 depending future scenario.
- Warm season lengthened ~2 weeks since 1950, mostly into fall.
- Annual precipitation increased ~6” since 1895. Largest increase over the last 20 years.
- Drought has not increased in frequency, but rising temps could exacerbate droughts that emerge.
- Extreme weather has become more common across the Northern Hemisphere over recent decades.
- More frequent heavy precipitation, more intense storms, and greater tendency for heat/cold waves to develop.
- Trend toward earlier snowmelt and runoff by 1-2 weeks since ca. 1950.
- Magnitude & frequency of small floods increasing.
- 100-yr, 3-day peak streamflows projected to decrease, likely due to late winter snowpack.



Climate Impacts on Maine's Coast and Marine Ecosystems

Team Leads:

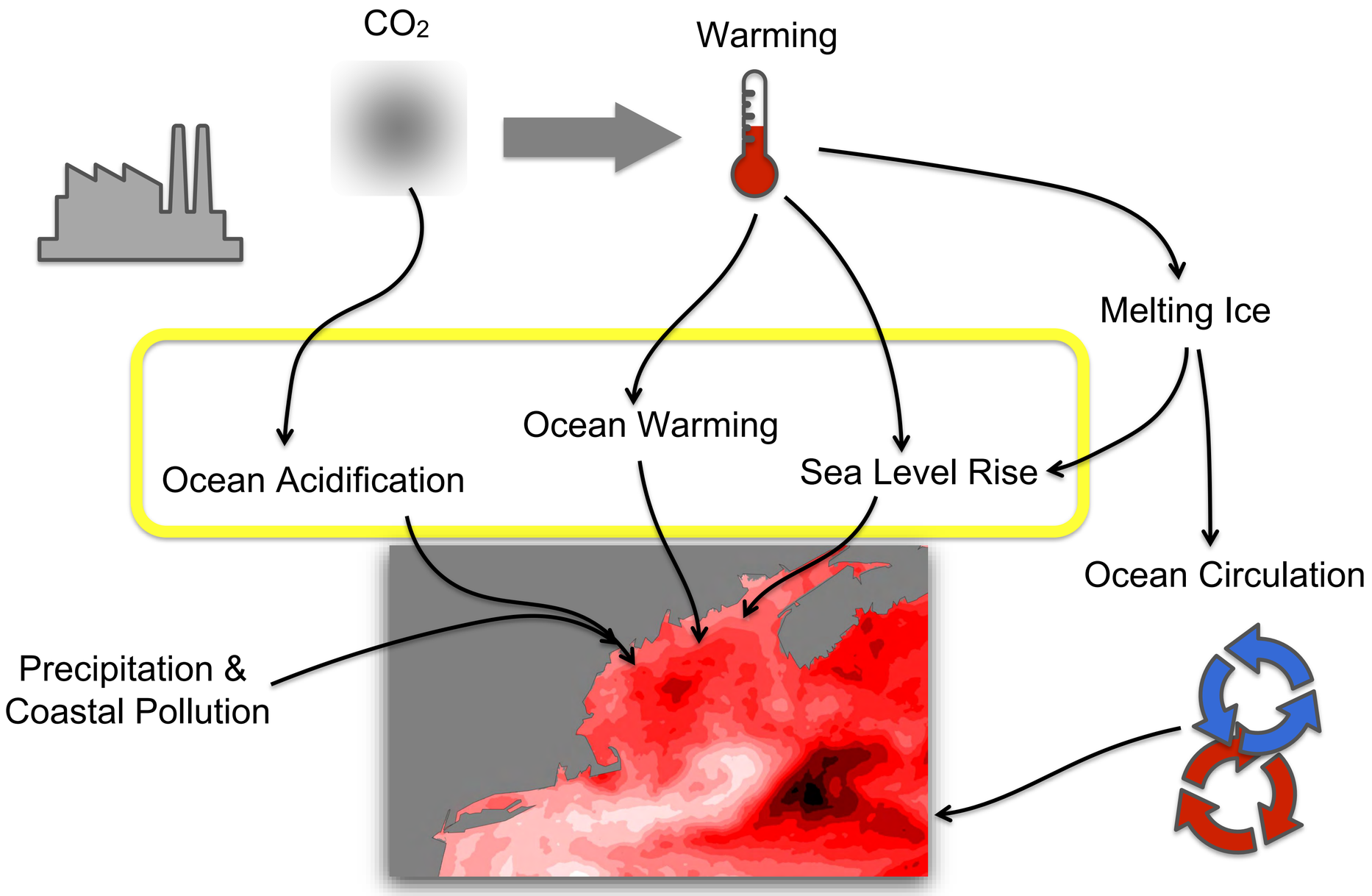
Andrew Pershing

Stephen Dickson

Susie Arnold

Nichole Price

Climate Change & the Ocean



Maine's Sea Level is Rising Now and into the Future

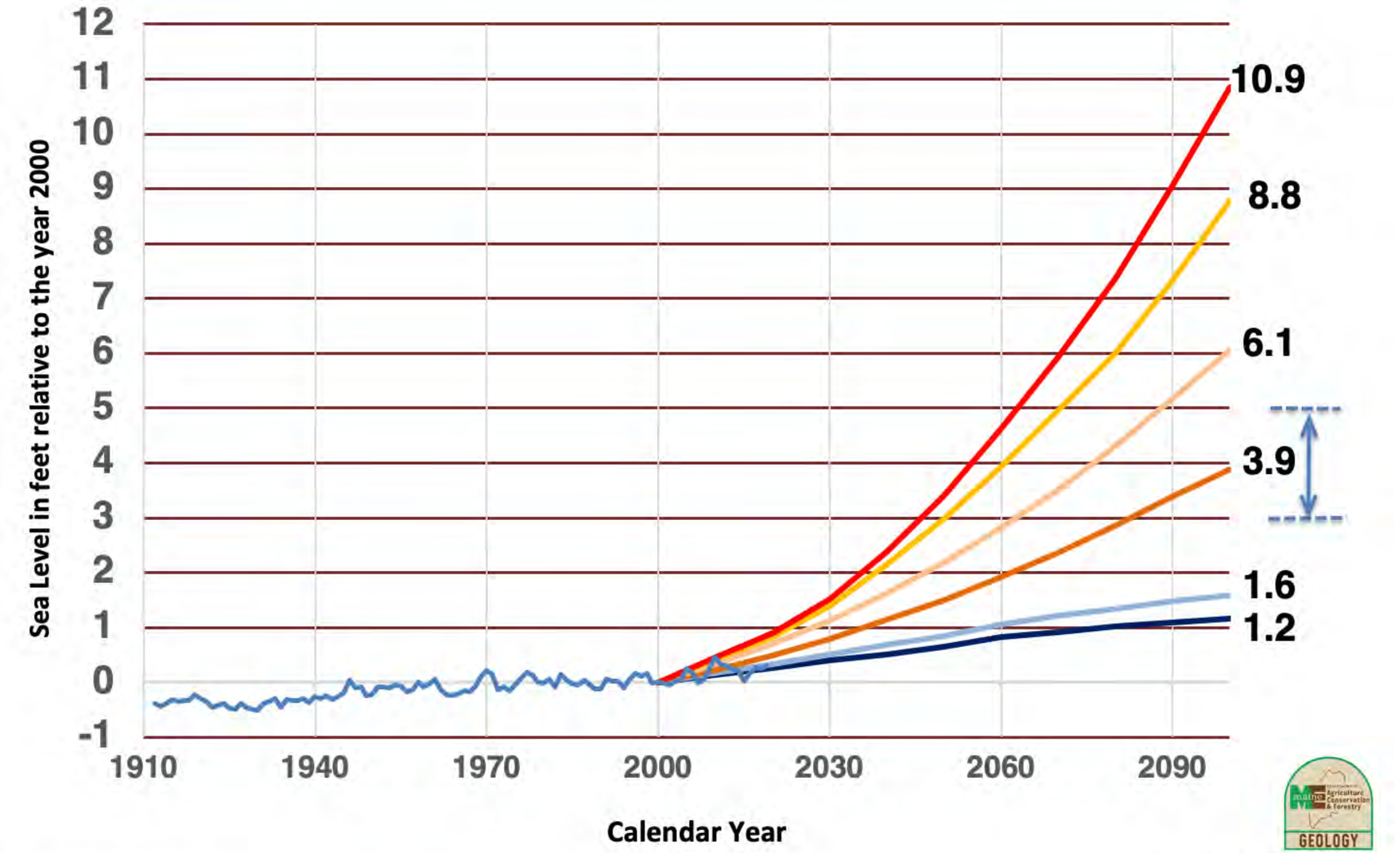


Figure by P.A. Slovinsky, MGS

After Sweet et al. (2017)

Maine's Sea Level is Rising Now and into the Future

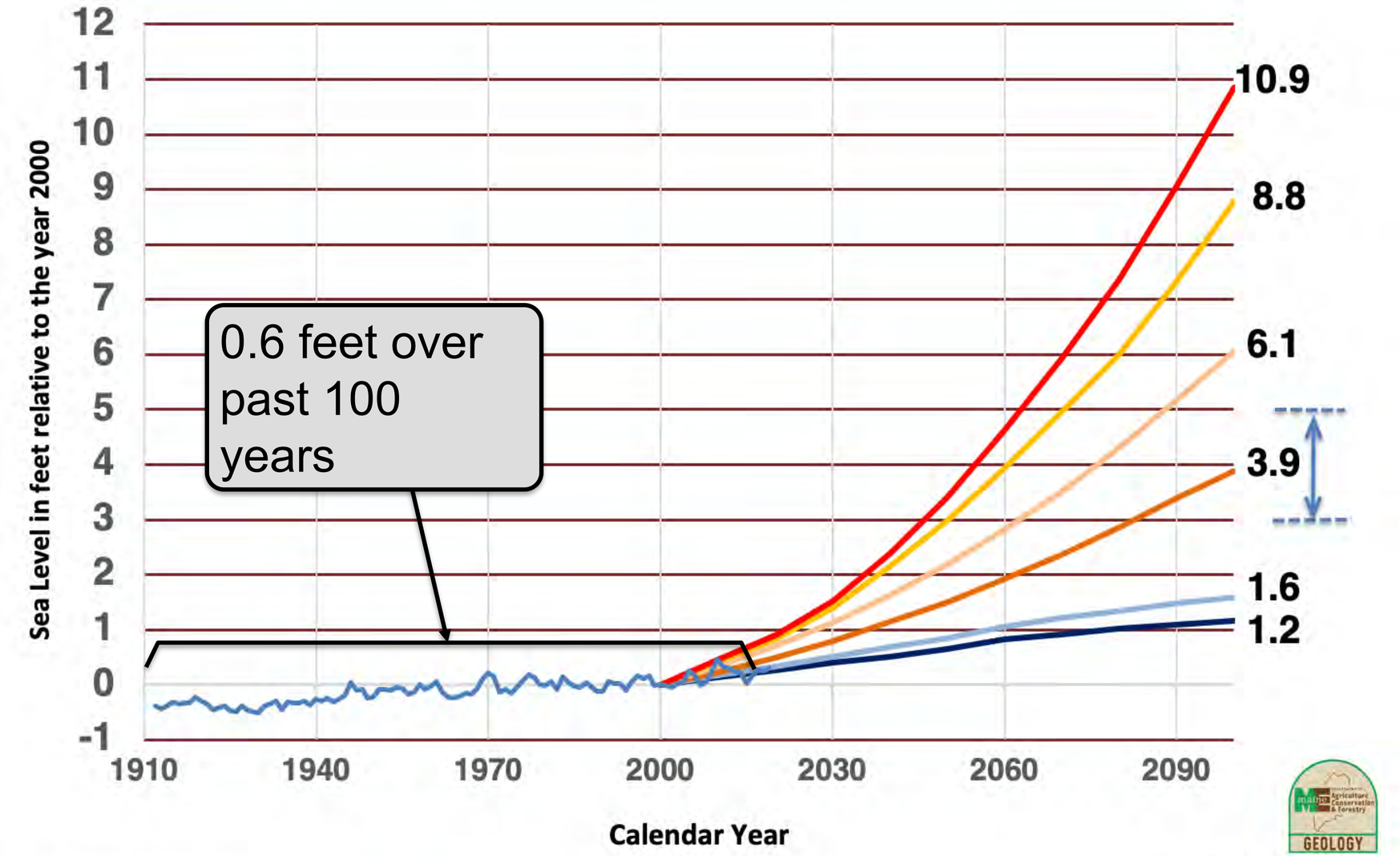
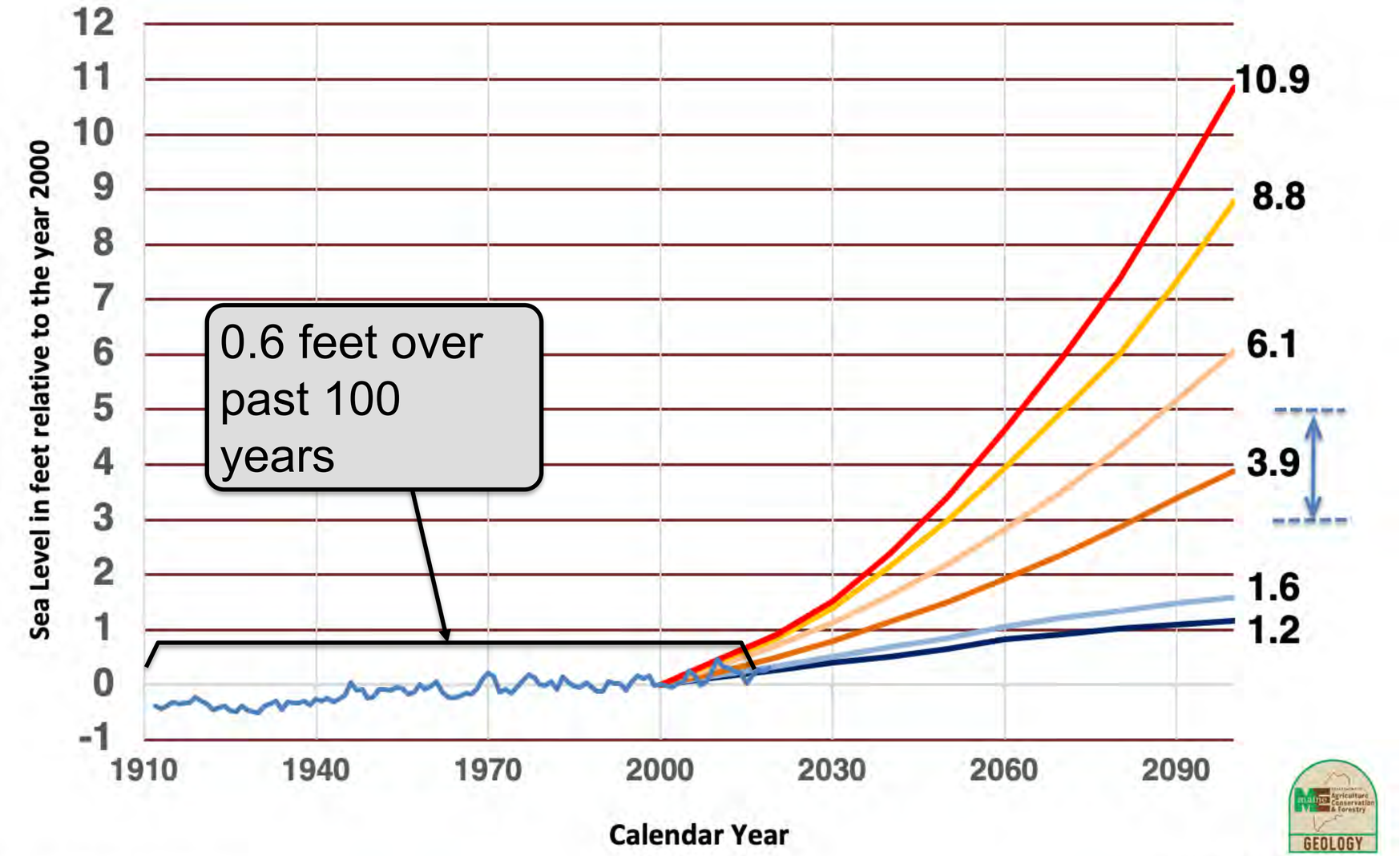


Figure by P.A. Slovinsky, MGS

After Sweet et al. (2017)

Observed Impacts on Natural and Built Environments

Maine's Sea Level is Rising Now and into the Future



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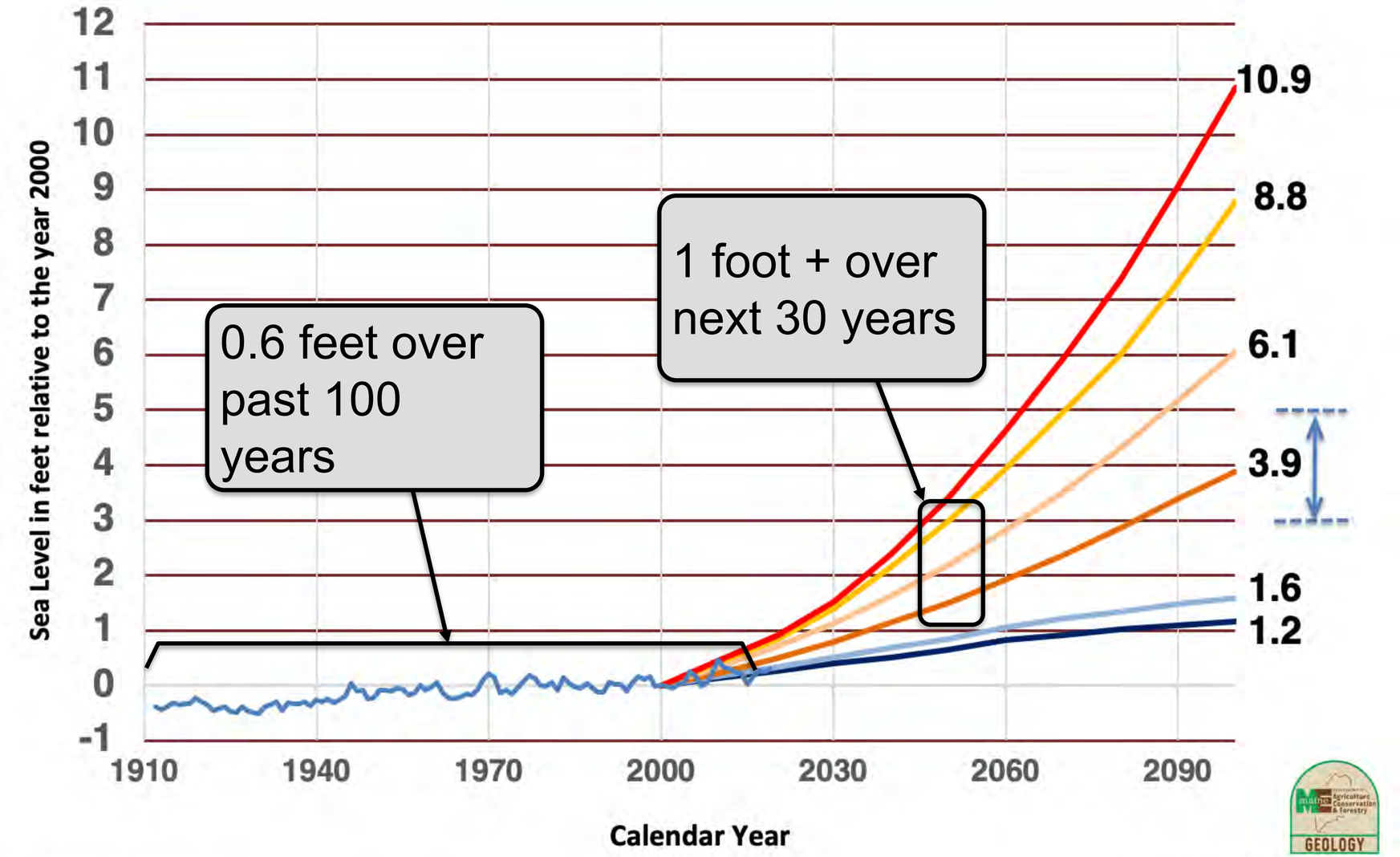
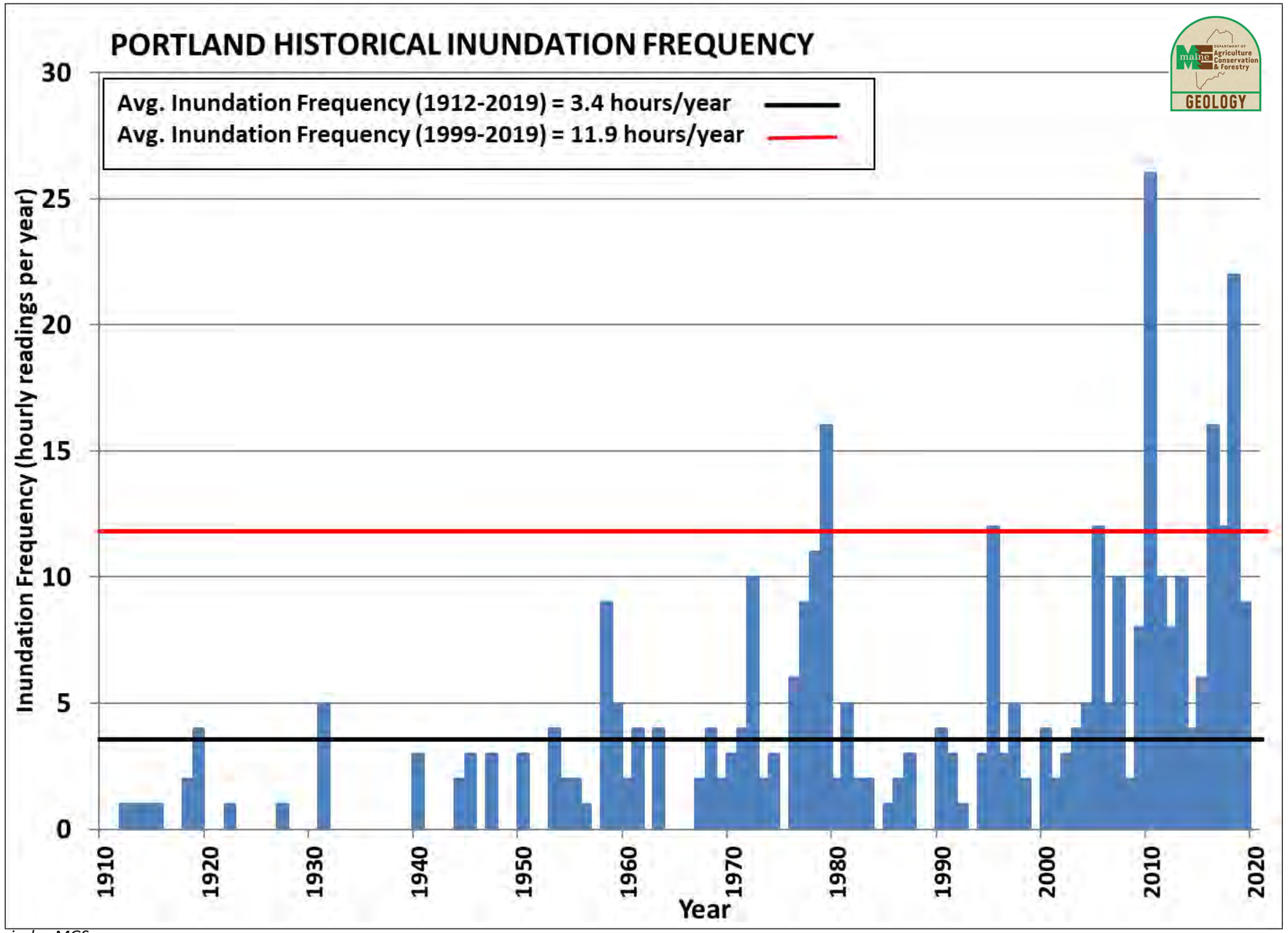


Figure by P.A. Slovinsky, MGS

After Sweet et al. (2017)

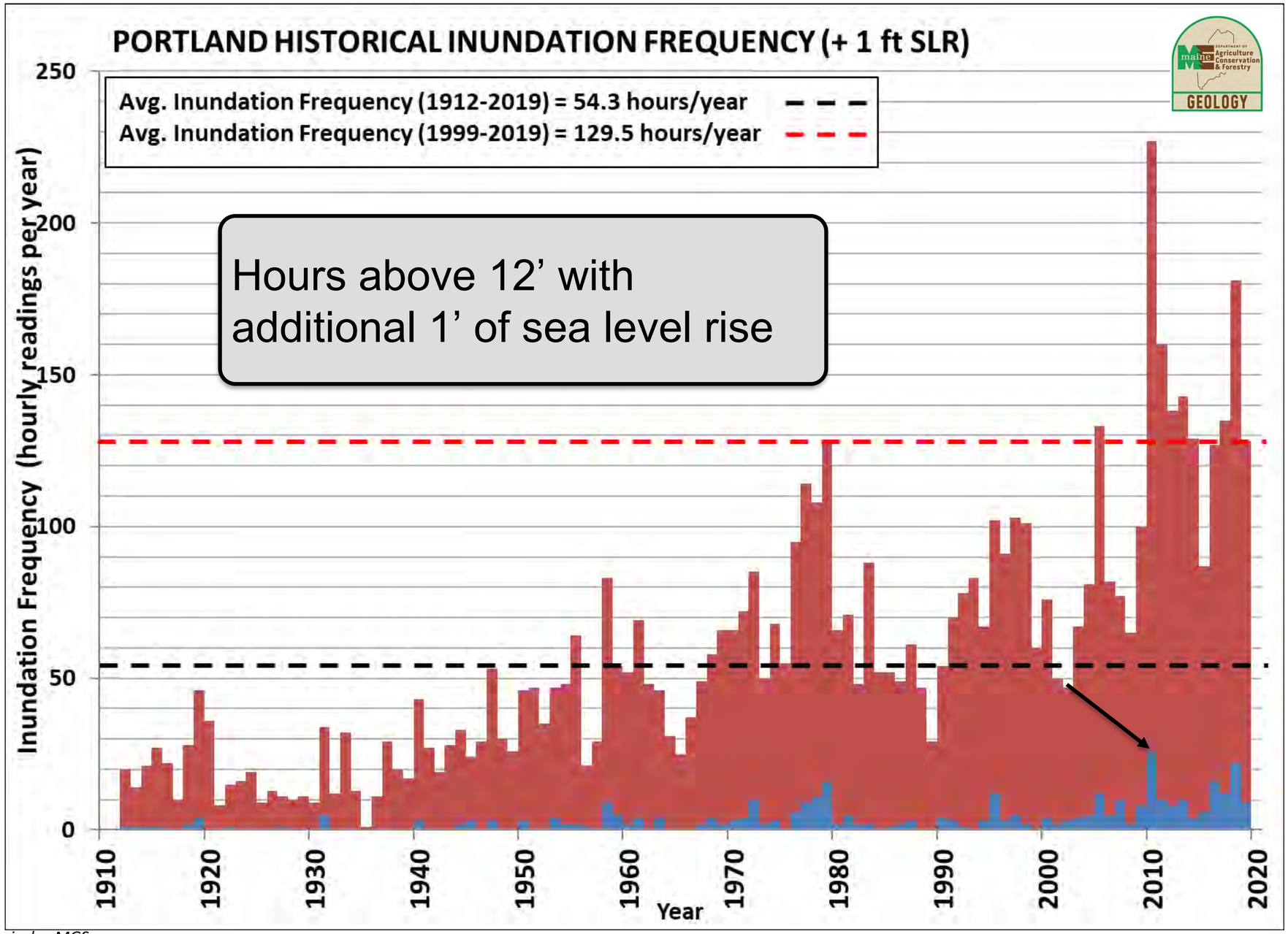
Sea Level Rise Impacts – Nuisance Flooding



King Tide in Portland, Maine 10/25/2016
A. Sherwin, Maine Coastal Program

P.A. Slovinsky, MGS

Sea Level Rise Impacts – Nuisance Flooding



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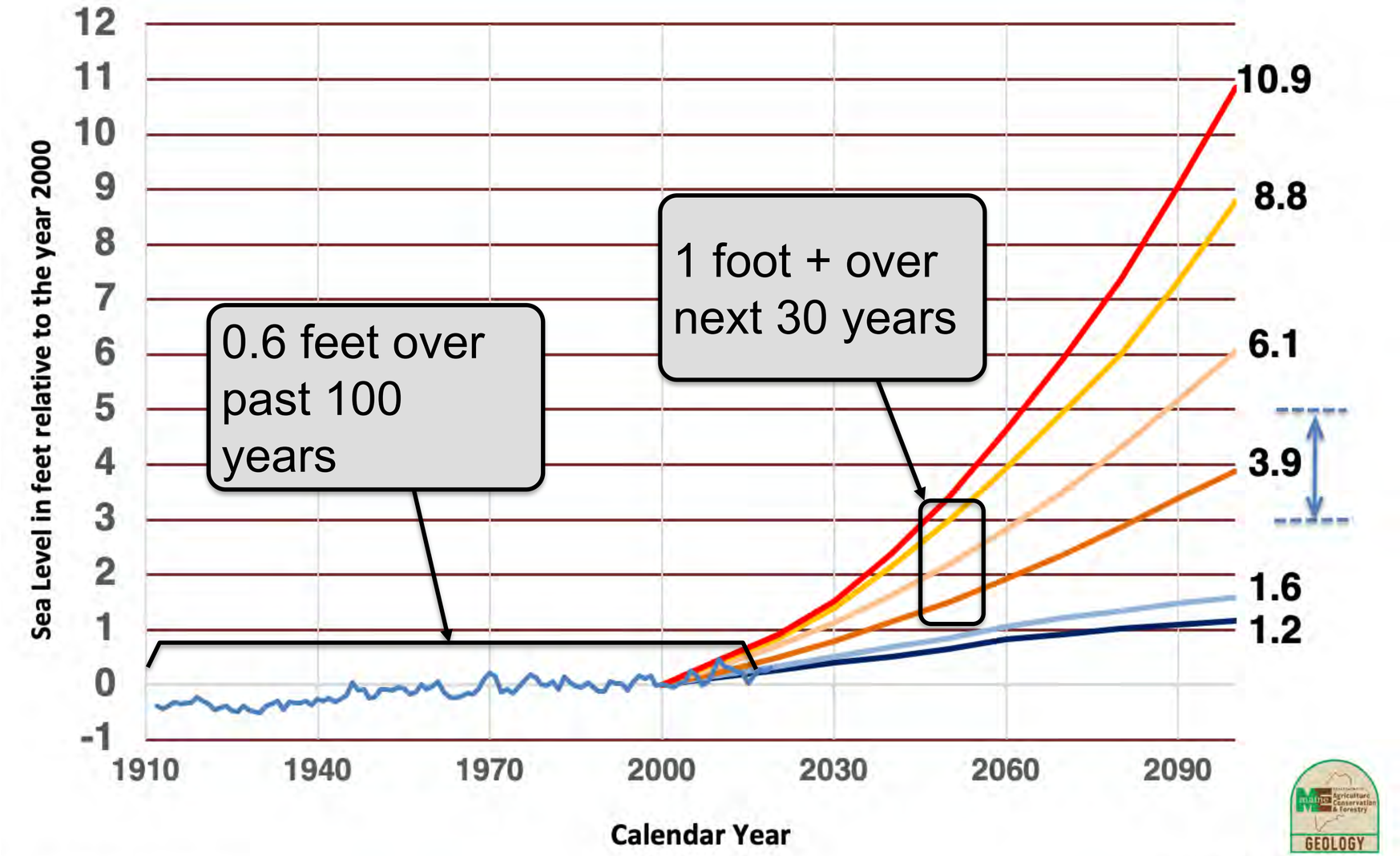
Maine's Sea Level is Rising Now and into the Future

Gulf of Maine Research Institute
Science. Education. Community.



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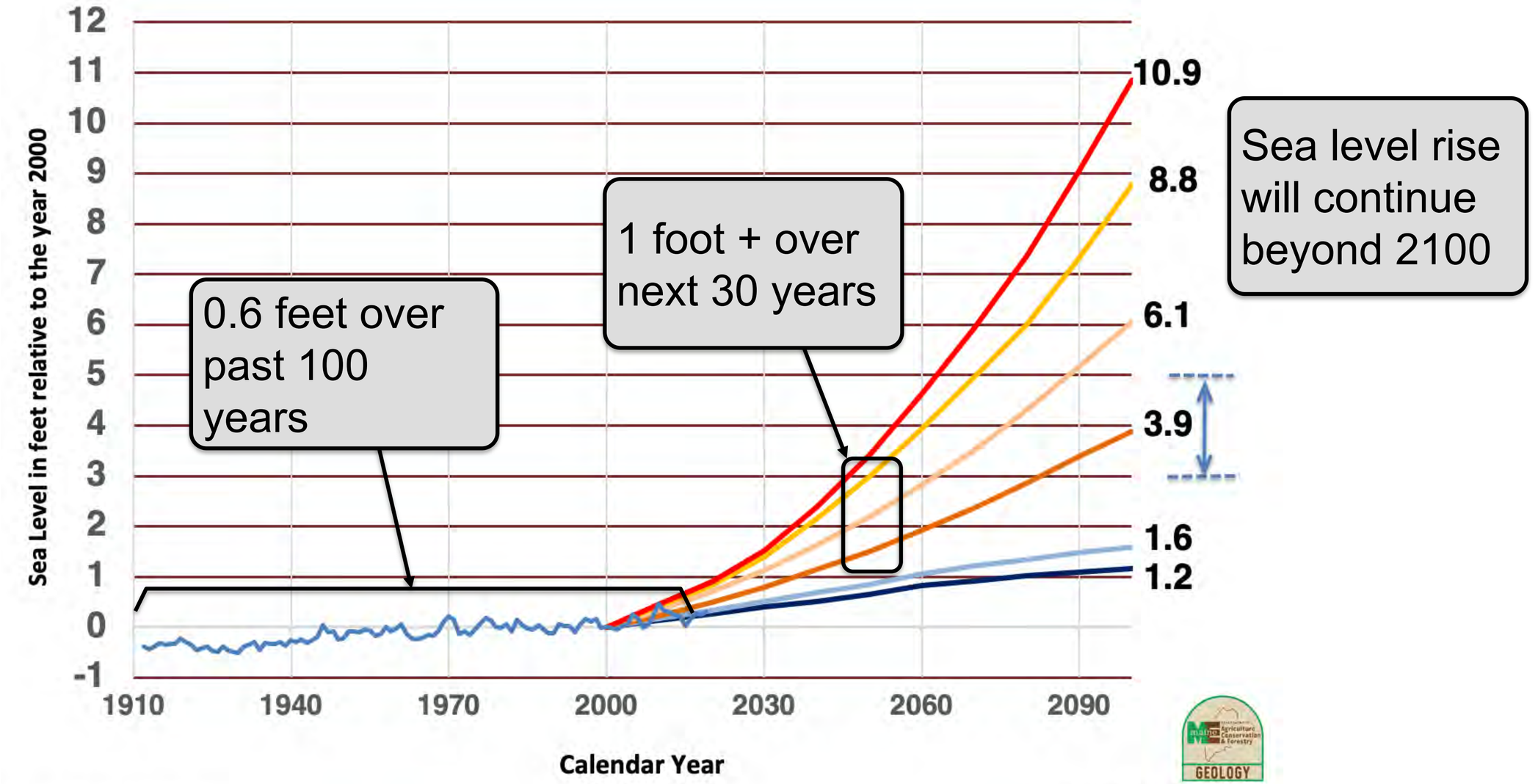
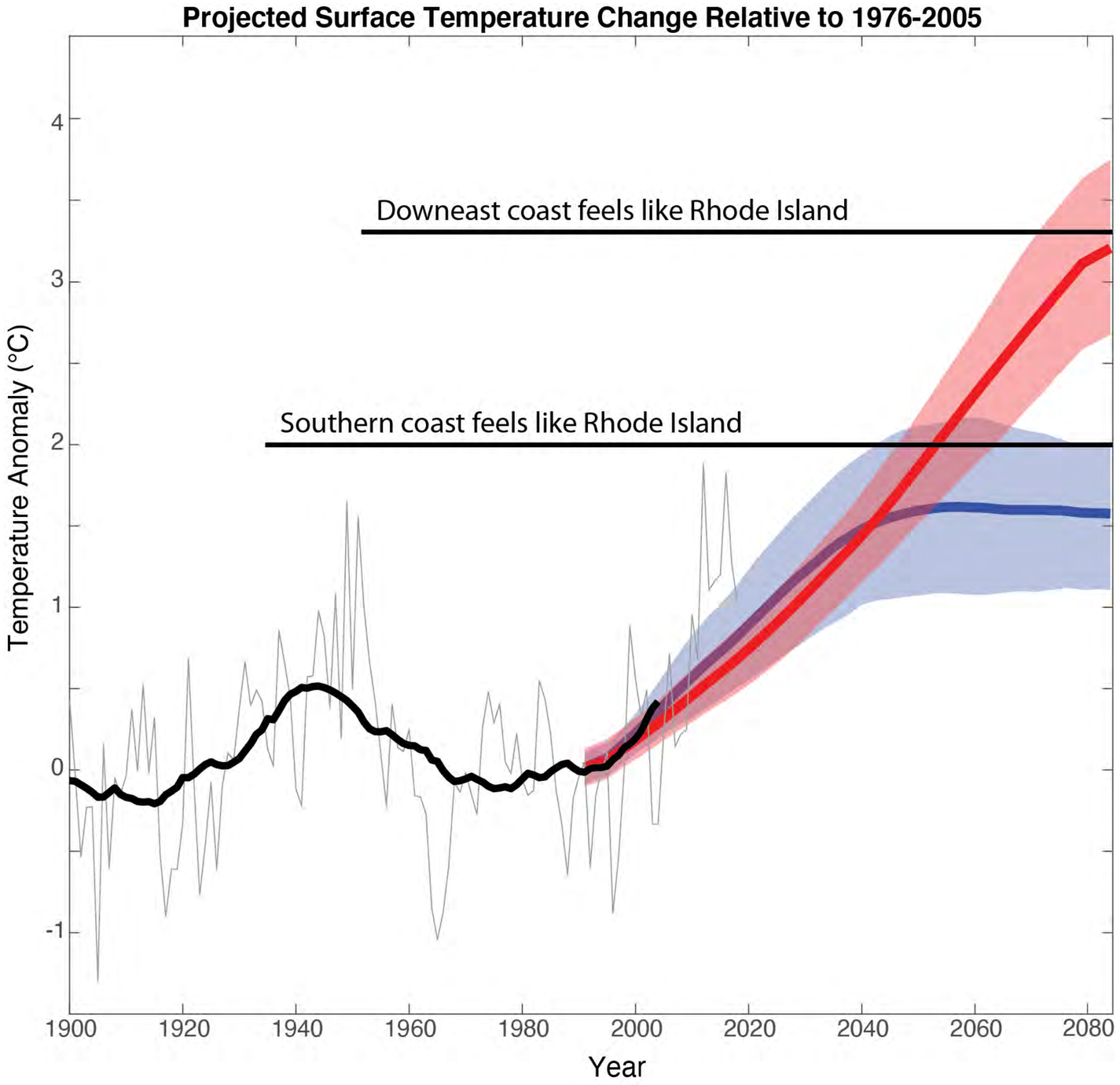


Figure by P.A. Slovinsky, MGS

After Sweet et al. (2017)

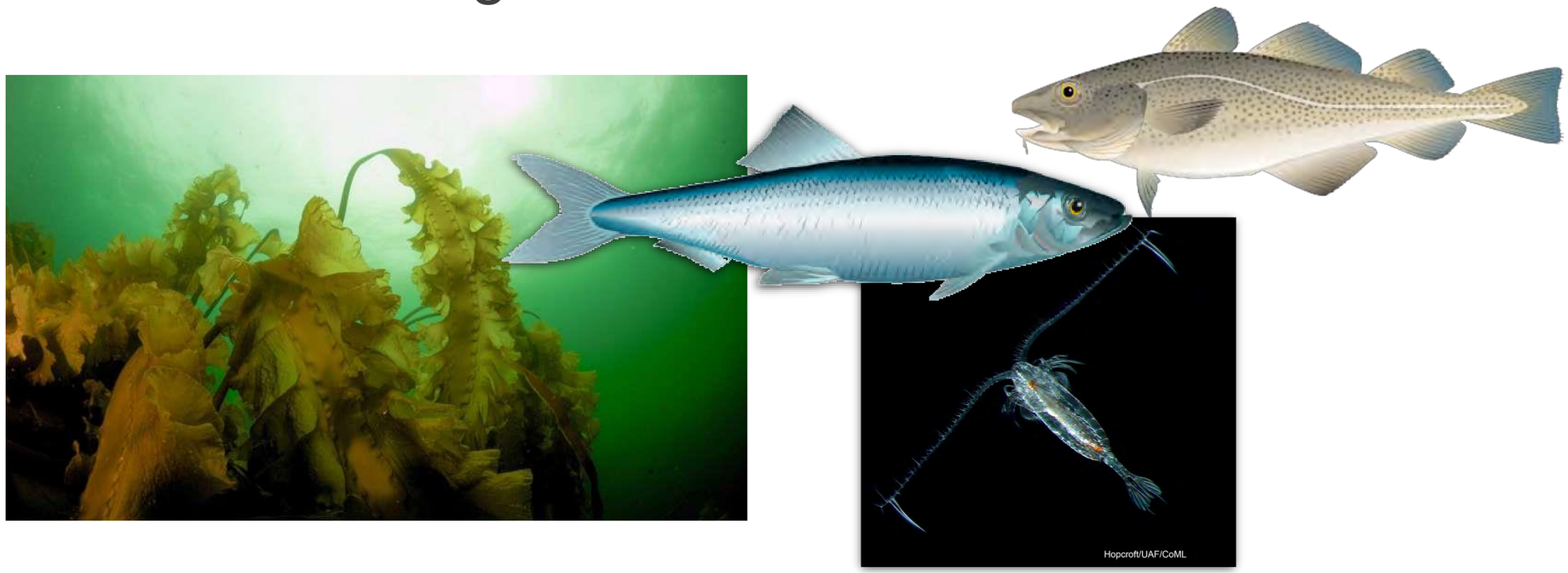
Ocean Temperatures

- Recent marine heatwaves provide a preview of average conditions in 2050
- Southern coast will have a climate similar to today's Rhode Island
- High emissions will threaten temperatures Downeast



Ecosystem Impacts of Warming

- Gulf of Maine is becoming less subarctic

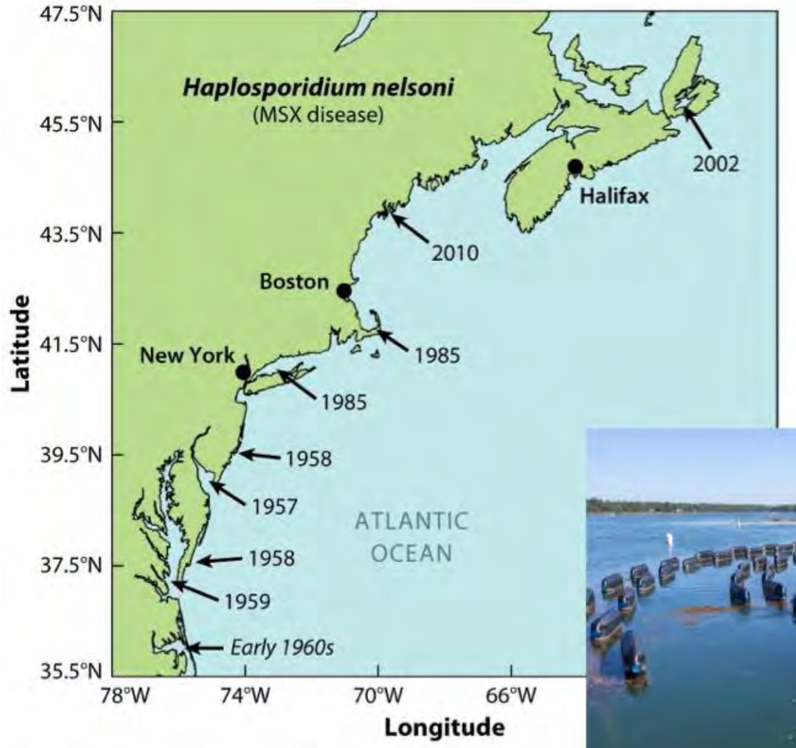


Ecosystem Impacts of Warming

- Gulf of Maine is becoming less subarctic
- Warm water species & diseases are moving in

butterfish

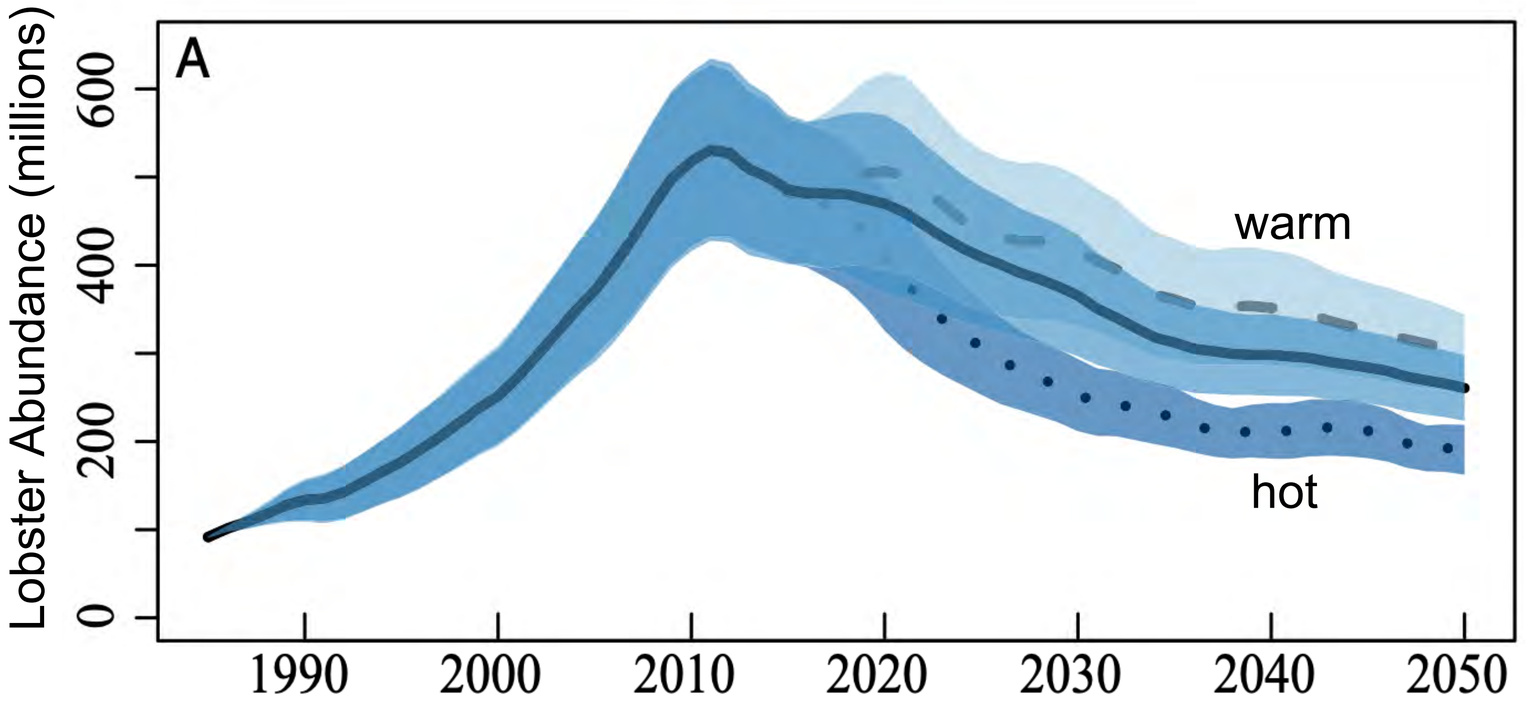
green crab



Burge CA, et al. 2014.
Annu. Rev. Mar. Sci. 6:249–77

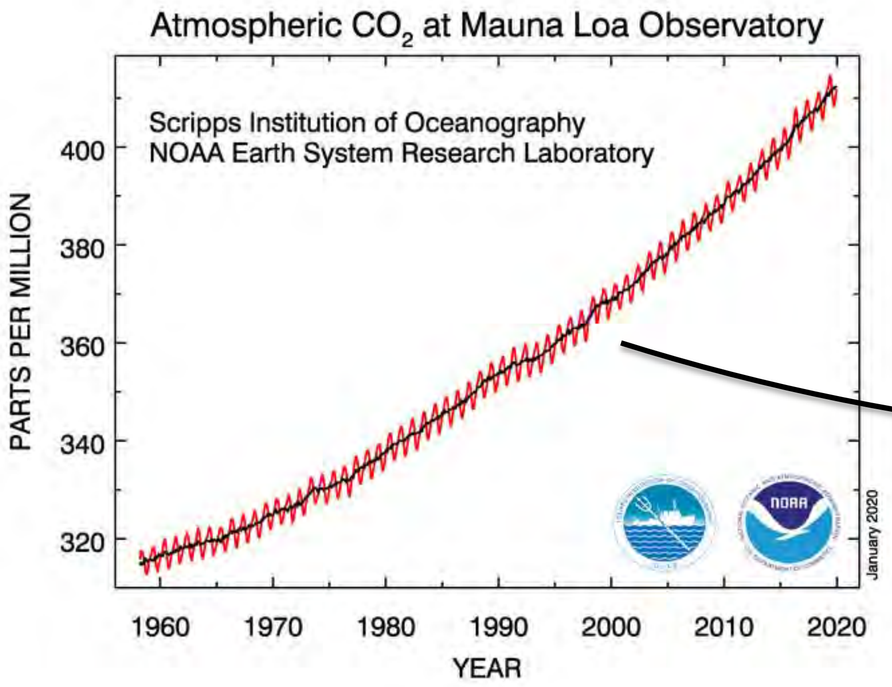
Ecosystem Impacts of Warming

- Gulf of Maine is becoming less subarctic
- Warm water species & diseases are moving in
- Expect declines in lobster productivity

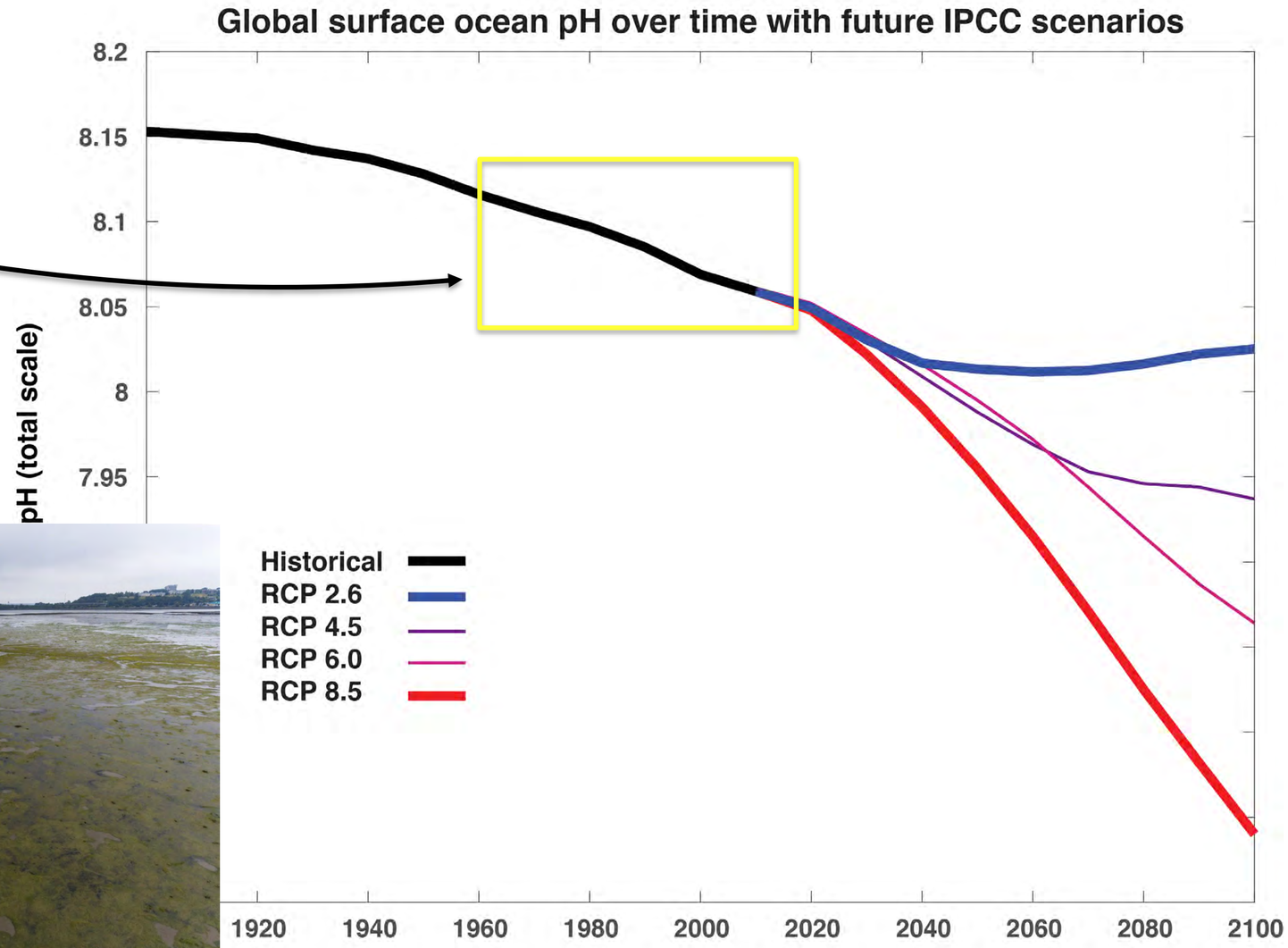


Le Bris et al. 2018

Ocean and Coastal Acidification



Deb Dawson, Friends of Casco Bay



data from Jiang et al. 2019

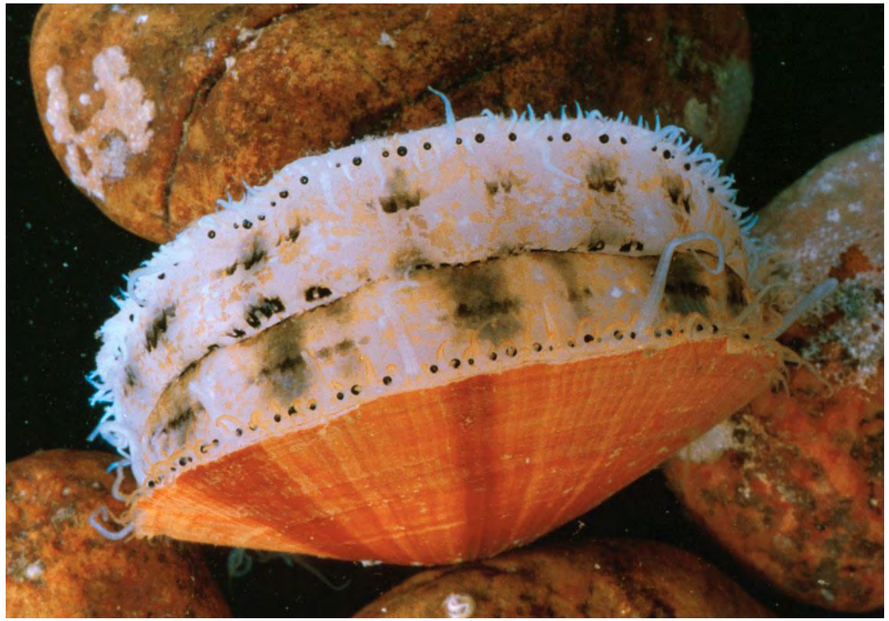
Ecosystem Impacts of Acidification

- Observed impacts on oyster larvae

MOOK SEA FARM
Our world is your oyster!

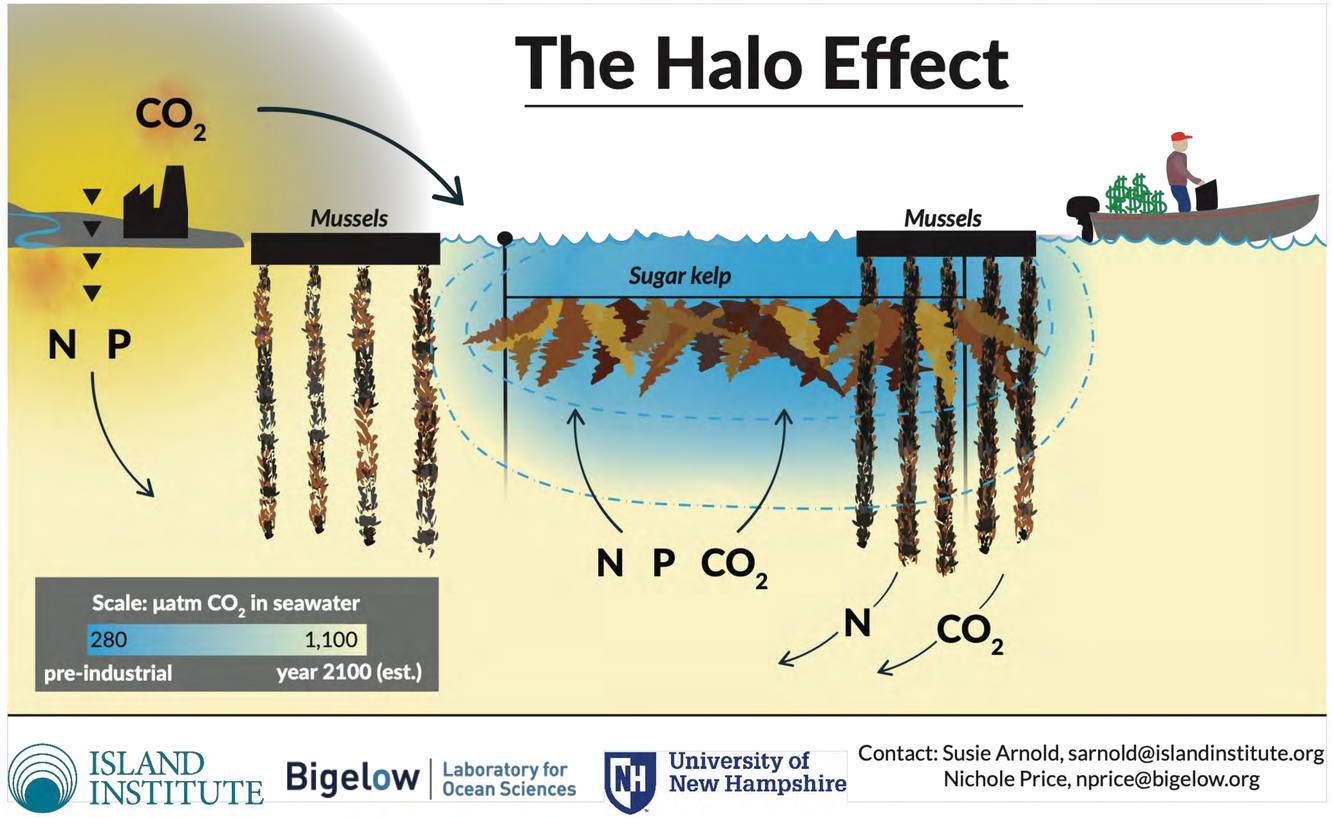
Ecosystem Impacts of Acidification

- Observed impacts on oyster larvae
- Lab studies show impacts on other mollusks and crustaceans

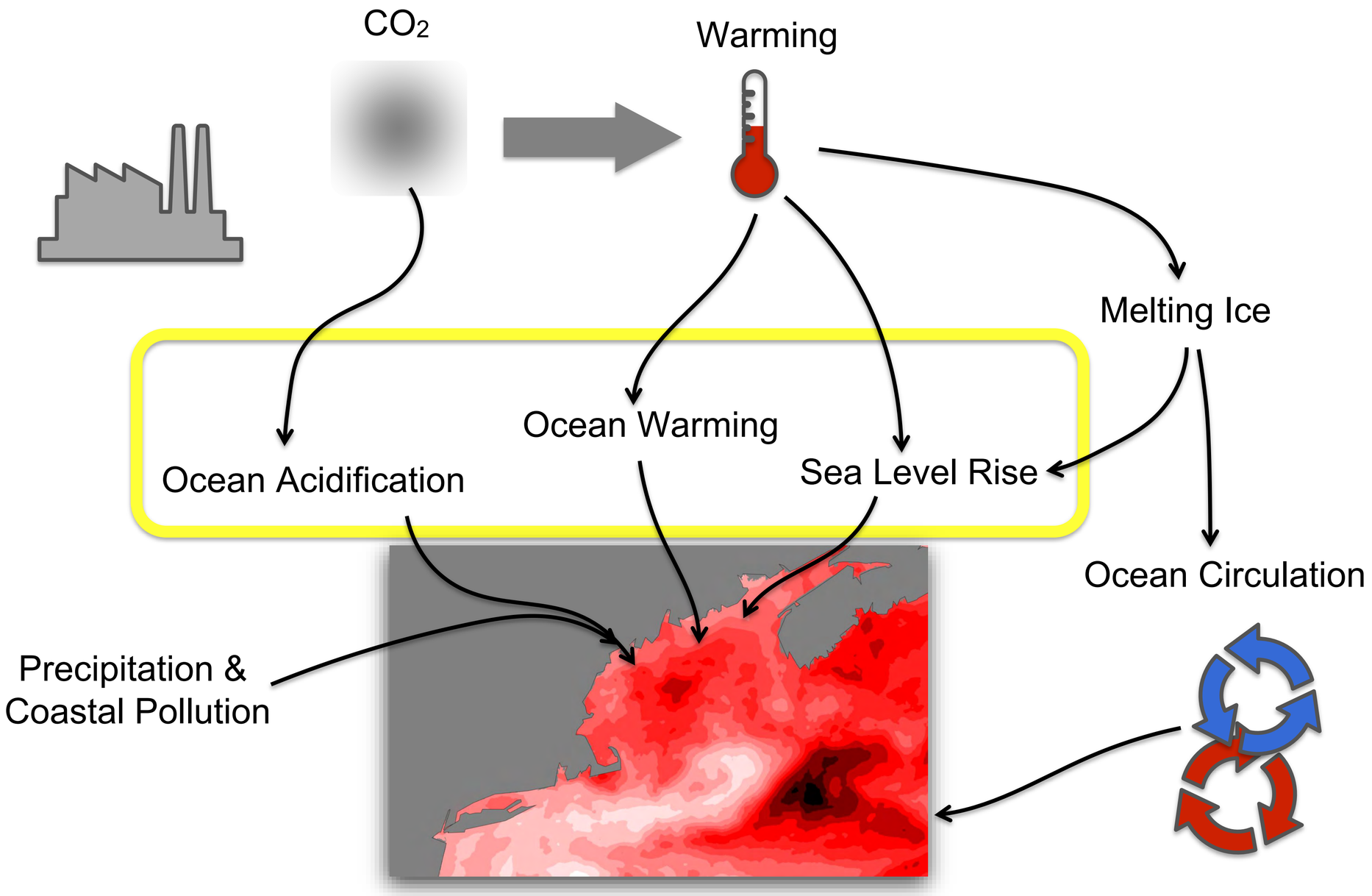


Ecosystem Impacts of Acidification

- Observed impacts on oyster larvae
- Lab studies show impacts on other mollusks and crustaceans
- May be possible to buffer some impacts locally



Climate Change & the Ocean



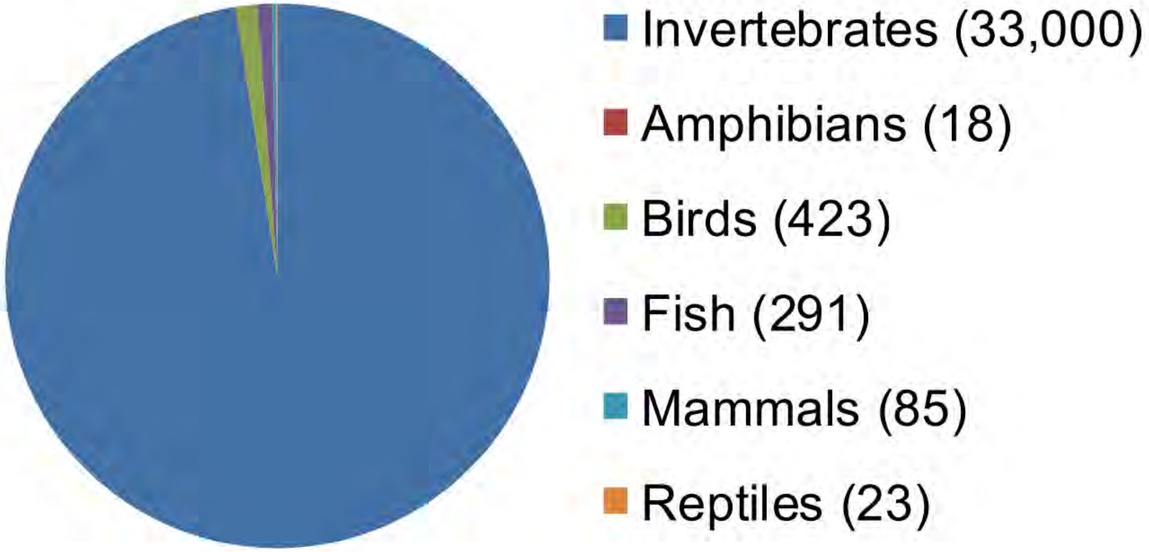
Forest Ecosystems, Forestry, and Biodiversity

Amanda Cross[1], Adam Daigneault[2], Erin Simons-Legaard[2], Sally Stockwell[3], Aaron Weiskittel[2]

[1]Maine Department of Inland Fisheries & Wildlife
[2]University of Maine, Center for Research on Sustainable Forests
[3]Maine Audubon Society

Maine: An Ecological Transition Zone

Fish and Wildlife Species



Other Taxa Groups

Plants (2100), Phytoplankton (310), Macrophytes (271), Fungi (3500)

Maine's 2015 Wildlife Action Plan

Maine's Extraordinary Range in Climate

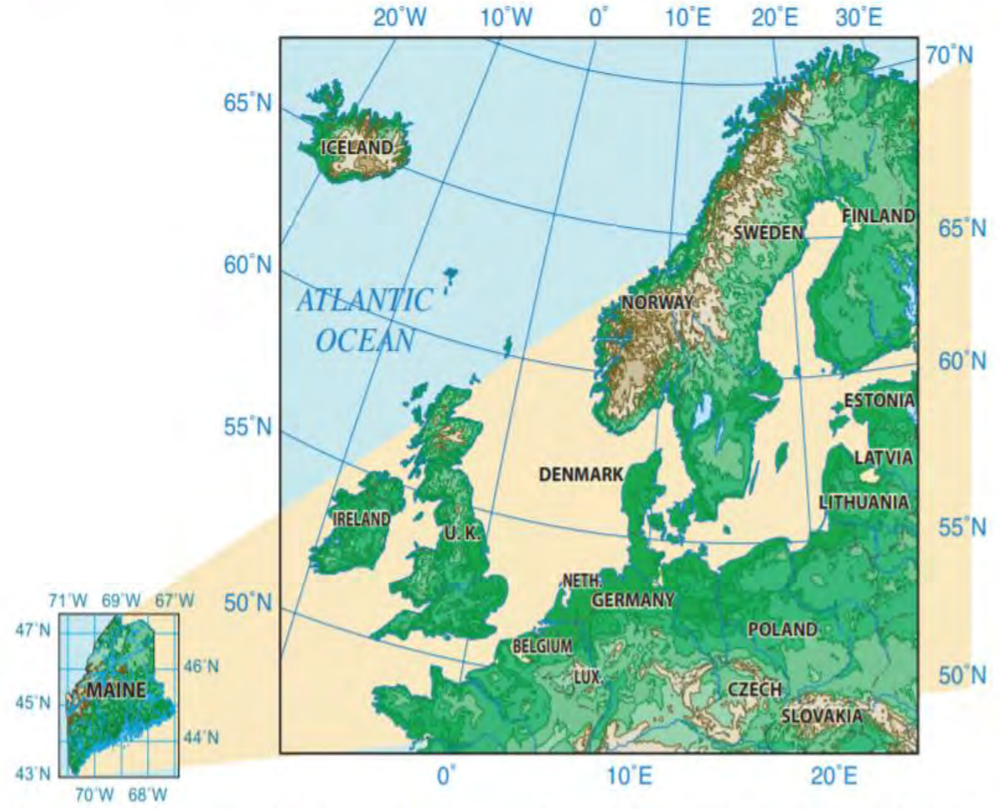


Figure 4 The climate gradient that exists in just three degrees of latitude in Maine occurs over 20 degrees of latitude in Europe, a distance approximately twice the length of California. Figure by K. Maasch.

Maine's Climate Future 2009

What makes a species vulnerable to climate change?

1. Habitat specificity
2. Edge of range
3. Narrow environmental or physiological tolerance
4. Species interactions
5. Limited mobility
6. Sensitivity to pathogens, exotic species

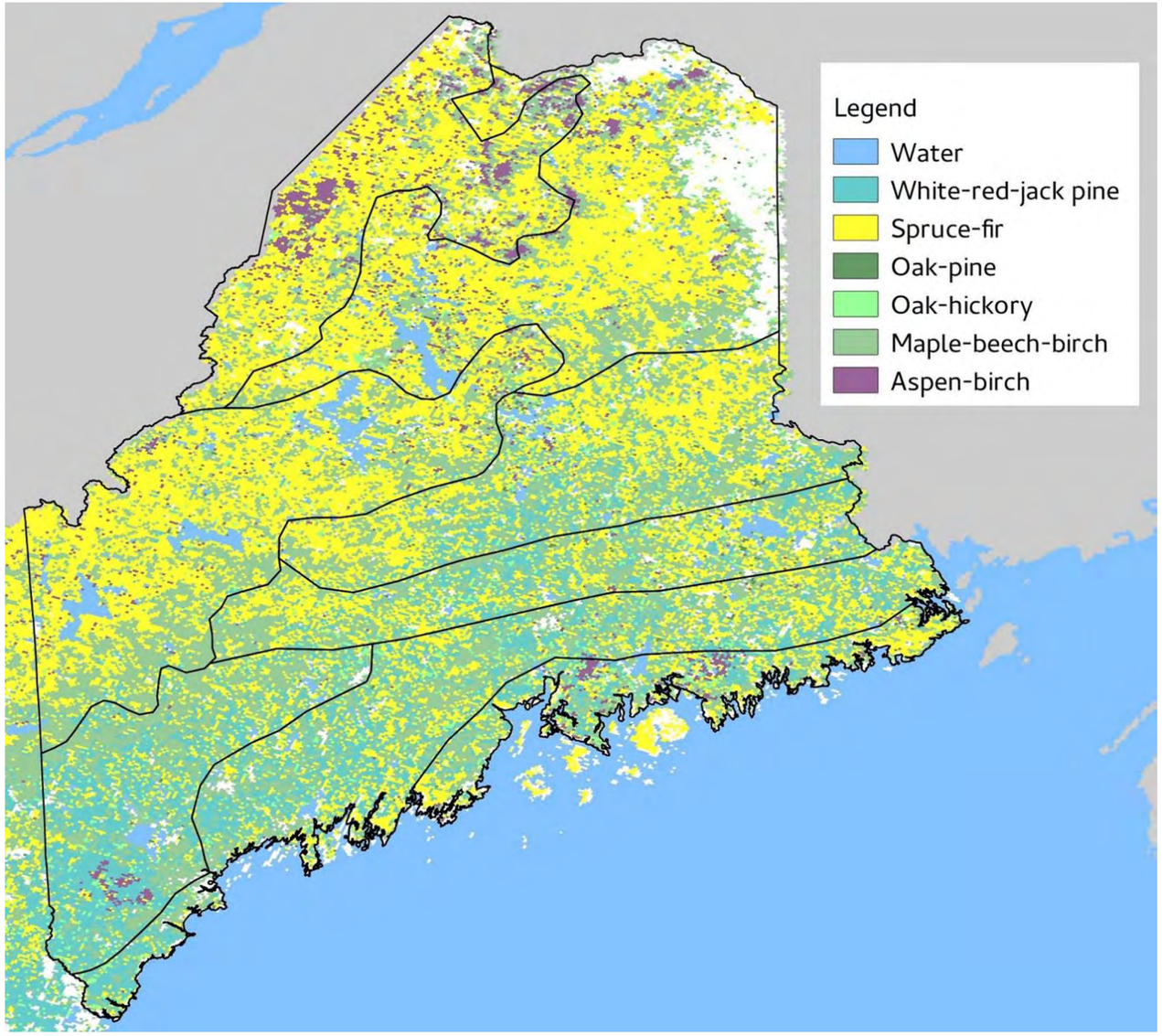
Katahdin Arctic
(High Climate Change Vulnerability), sketch by Mark McCollough

Furbish Lousewort
(High Climate Change Vulnerability Species), Maine Natural Areas Program

Whitman et al. 2014,
adapted from Foden et al. 2008 and Young et al. 2010

Maine's Forest Overview

- 89% of state's land area
  - 16.6 million acres
- Transitional ecosystem
  - South: temperate hardwoods
  - North: boreal softwoods
- Part of the Acadian Forest Ecoregion, which covers ~60 million acres



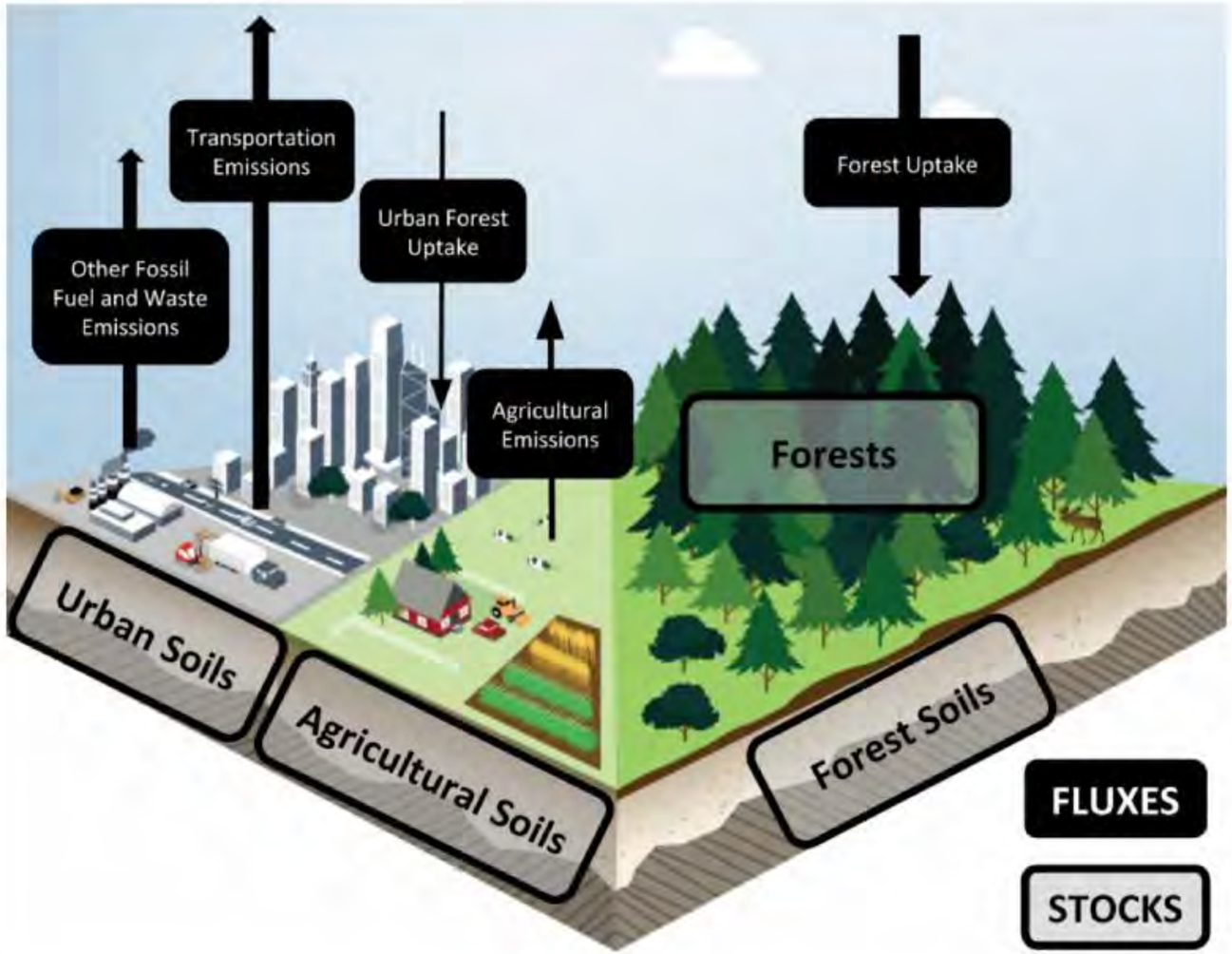
Maine's distinct climate zones and primary forest types

Maine’s Forest Industry Overview

- $8-10B in annual direct economic contributions
- Diverse yet integrated across sectors
- Additional economic benefits
  - Recreation
  - Wildlife habitat
  - Aesthetics

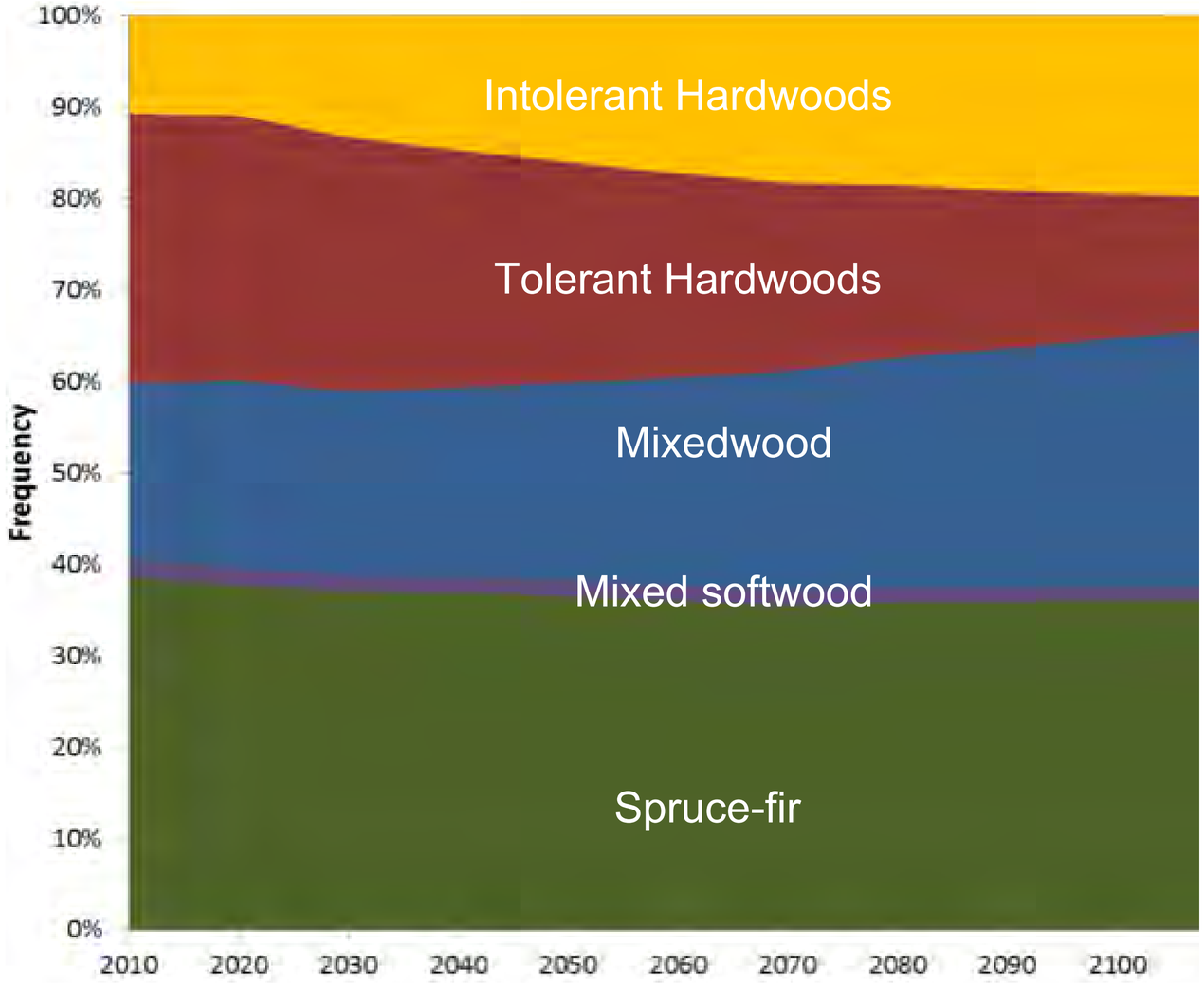
Maine Forest's Importance to State's Annual Carbon Budget

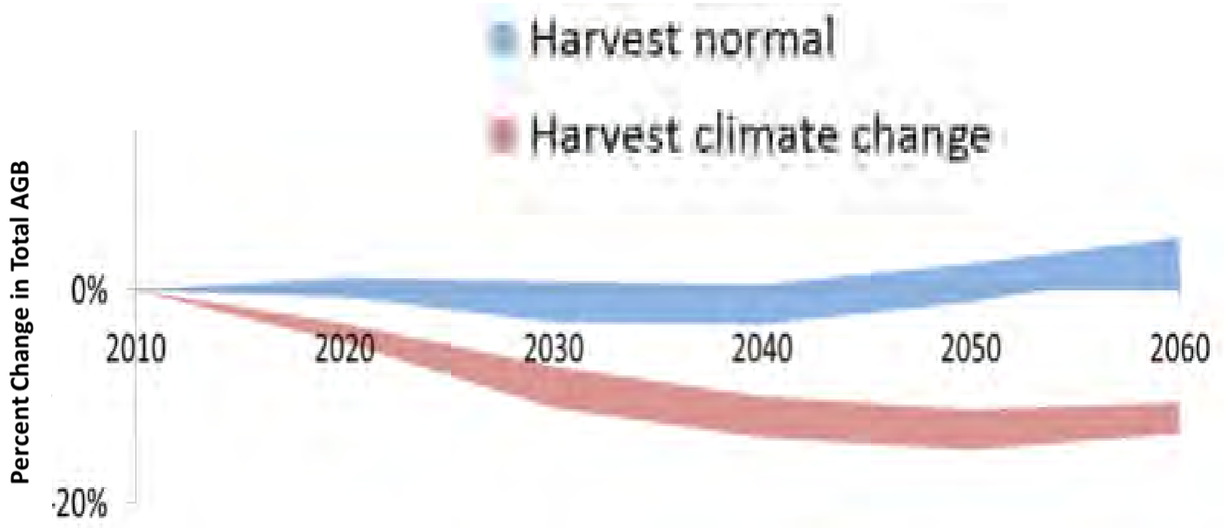
Carbon Pool	% of State's Annual Fossil Fuel Emission
Forest carbon stocks + annual growth	**60%**
Forest products	**15%**
Total forestry sector	**75%**
Net Land Sink	**78%**



crsf.umaine.edu/forest-climate-change-initiative/carbon-budget

Forest Productivity More Variable with Climate Change





Some areas may see higher growth due to ***longer growing seasons***,
Other areas may decline due to greater ***droughts*** and ***pest*** occurrence
Forest management a strong influence of future trends

Impacts of Climate Change on Biodiversity

Global declines

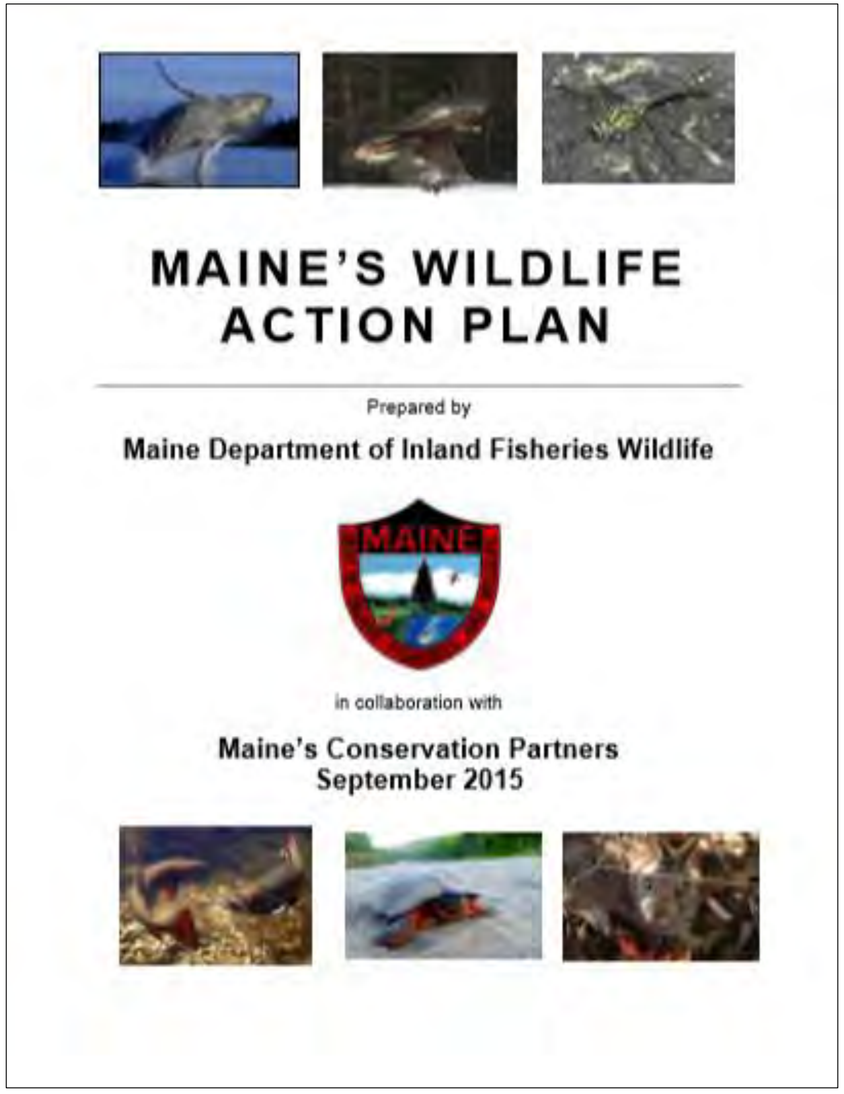
- 3 billion fewer birds in North America since 1970
  - 1 in 4 birds lost
- 75% decline in flying insects in protected areas in Germany over the past 27 years

Future projections

- 34-58% species faced with extinction if unable to shift ranges
- 11-33% lost if able to shift

Cardinale et al. 2019

Climate Change Affects Maine's Most At-Risk Species



Winter Ticks and Moose


Umaine Extension

Up to 70,000 ticks/calf

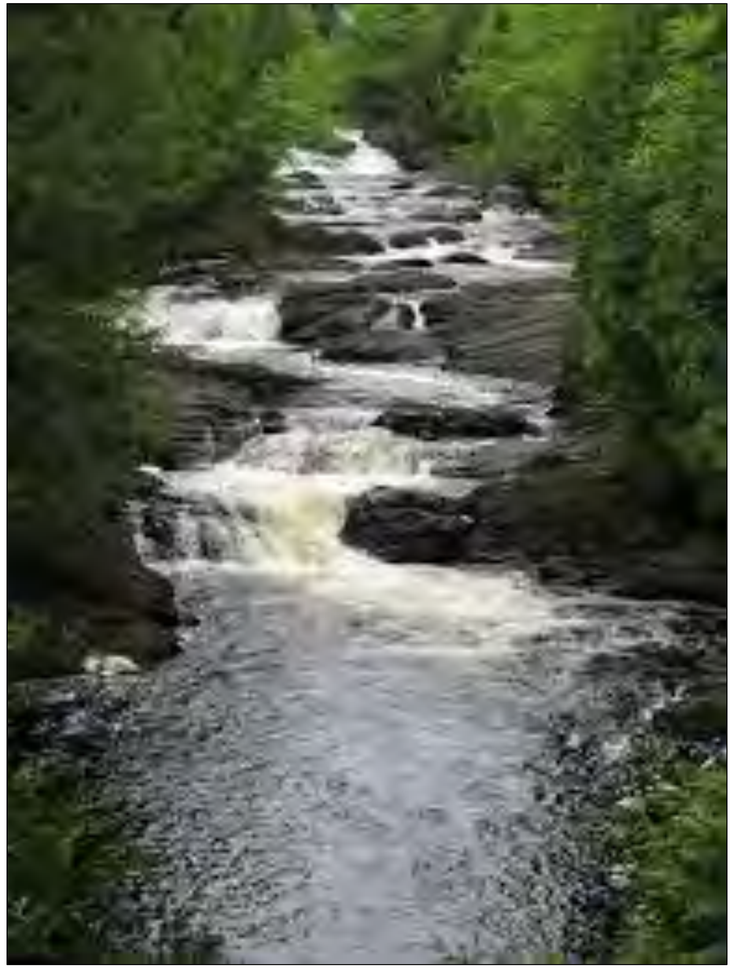

Laura Poppick

70% annual calf mortality 2014-2016
Outbreaks in 5 out of 10 years

Jones et al. 2019, NH Fish and Game, UNH Pete Pekins, MDIFW – Lee Kantar

Piping Plovers and Salt Marsh Sparrows

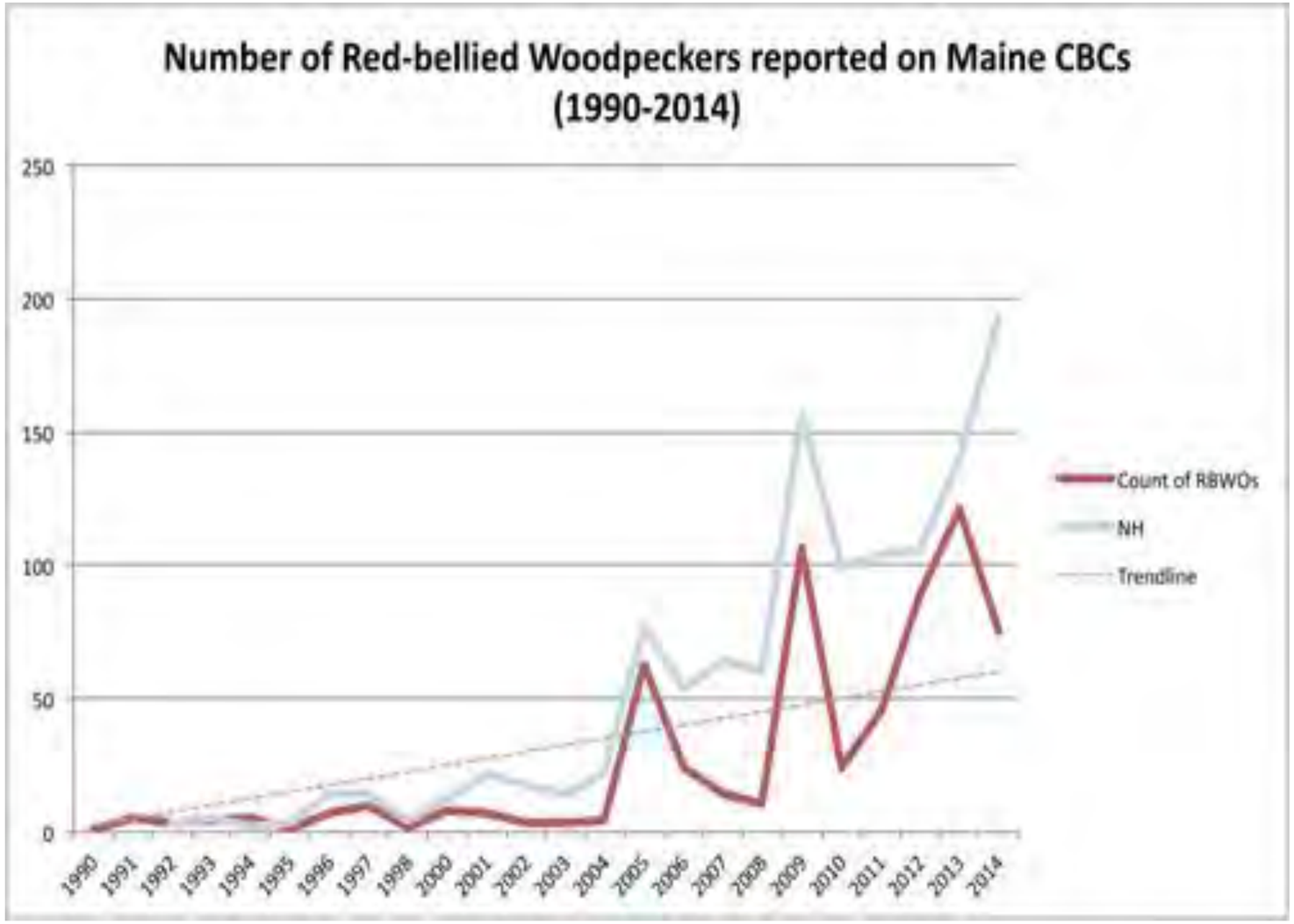
Eastern Brook Trout

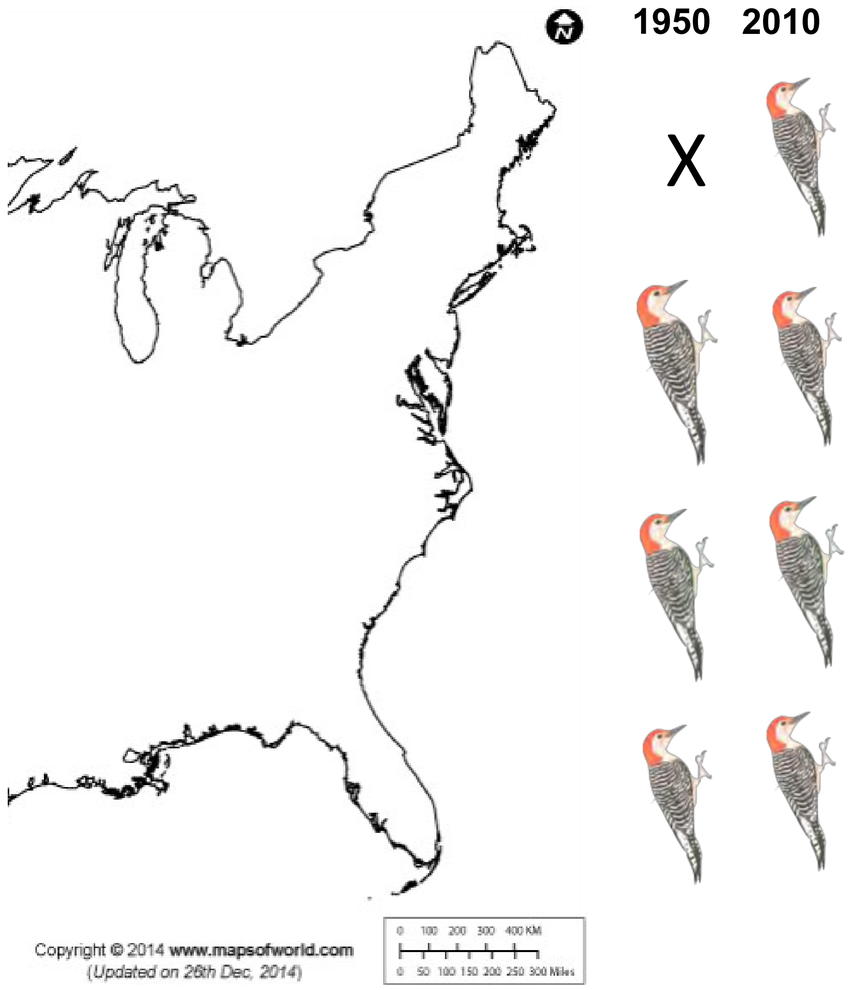


North woods are the last stronghold for wild brook trout in the U.S.

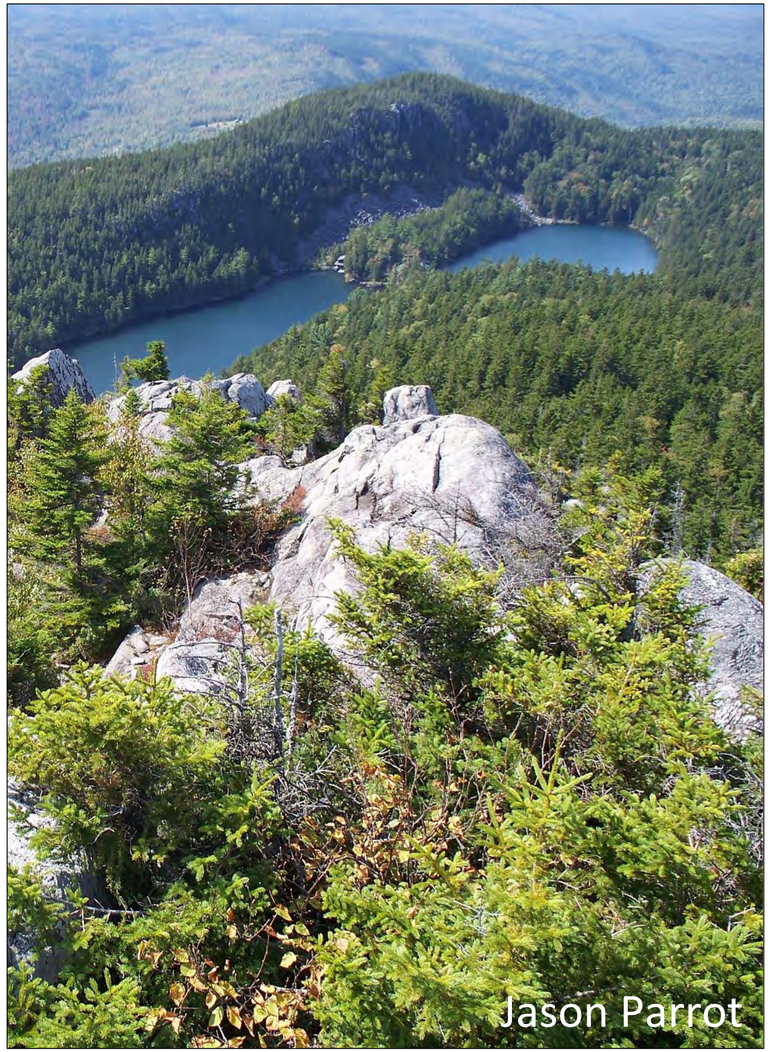
Warmer summer temperatures and more storm events = less suitable habitat, more stress

Red Bellied Woodpeckers are Moving North





Key Recommendation: Conserve and Connect Diverse Landscapes



Anderson and Ferree 2010; Beier, Hunter, Anderson, and many others; Conservation Biology 29(3) 2015

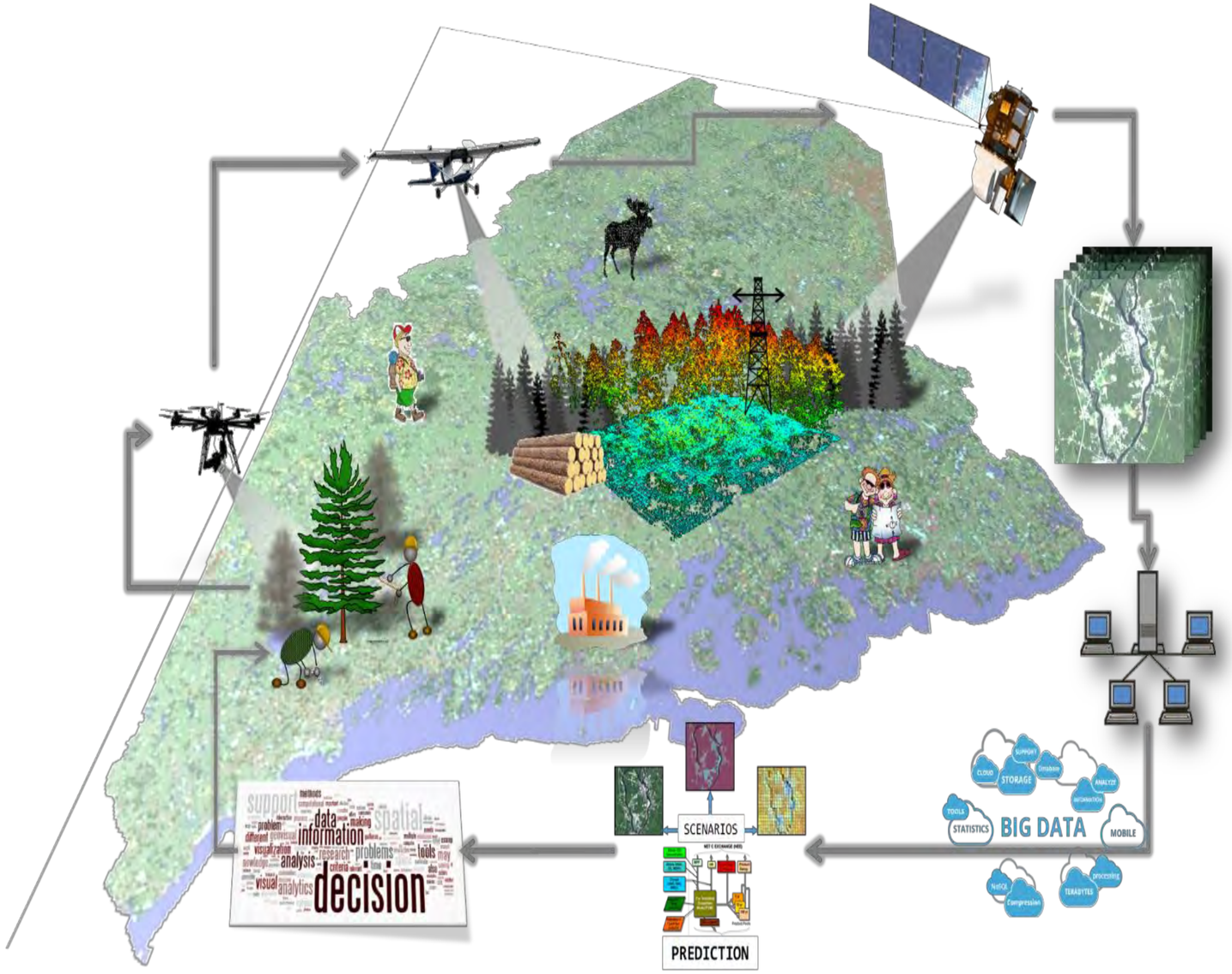
Summary & Conclusions

- Many *species and habitats at risk* of significant decline, degradation, or extinction with climate change
- Forests likely to shift towards *more hardwood* species with *greater variability* in future productivity
- Carbon in growing *forest & wood products* currently *offset about 75% of ME's fossil fuel emissions* → potential for more via management shifts
- *Conserving and connecting* geologically *diverse landscapes* is key to allowing species to shift and respond to climate change

Priority Information Needs for Maine's Forests

- **Forest Impacts**
  - Improved monitoring of key indicators
  - Greater integration of remote sensing technologies
  - More studies on human adaptation component (i.e., management, harvest)

- **Forest Management & Operations**
  - Develop and revise existing Best Management Practices, particularly as it relates to roads, water-crossing, and culverts
  - Complete a full environmental cycle analysis for forest and forestry products
  - Evaluate alternative suite of forest management strategies at a landscape-level



Additional Recommendations for Maine's Biodiversity

- **Research and monitoring**
  - Snowpack and changing winters
  - Water quality and aquatic communities
  - Changing seasons and phenology
  - Invasive species and food webs
- **Adaptation**
  - Reduce impervious surfaces
  - Replace failing structures with StreamSmart designs
  - Manage and plan for diverse future landscapes, including migrating marshes, dynamic coastlines, riparian areas, and maturing forests

- **What is good for biodiversity is often equally good for people**
- **Local and traditional knowledge needs to be incorporated**

Acknowledgements

Special Thanks To:

Ken Kimball, Sarah Nelson, Dave Publicover, Sean Todd, Sarah Haggerty, Tracy Hart, Doug Hitchcox, Laura Zitske, Linda Bacon, Tom Danielson, Jeff Dennis, Jean DiFranco, Pamela Lombard, John McPhedran, Barry Mower, Emily Zimmerman, Danielle D'Auria, Merry Gallagher, Lee Kantar, Erin Summers, Don Cameron, Kristen Puryear, Jeff Reardon, Shawn Rummel, Mark McCollough, Kate O'Brien, Linda Welch, and Alix Contosta

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Agriculture and Food Systems

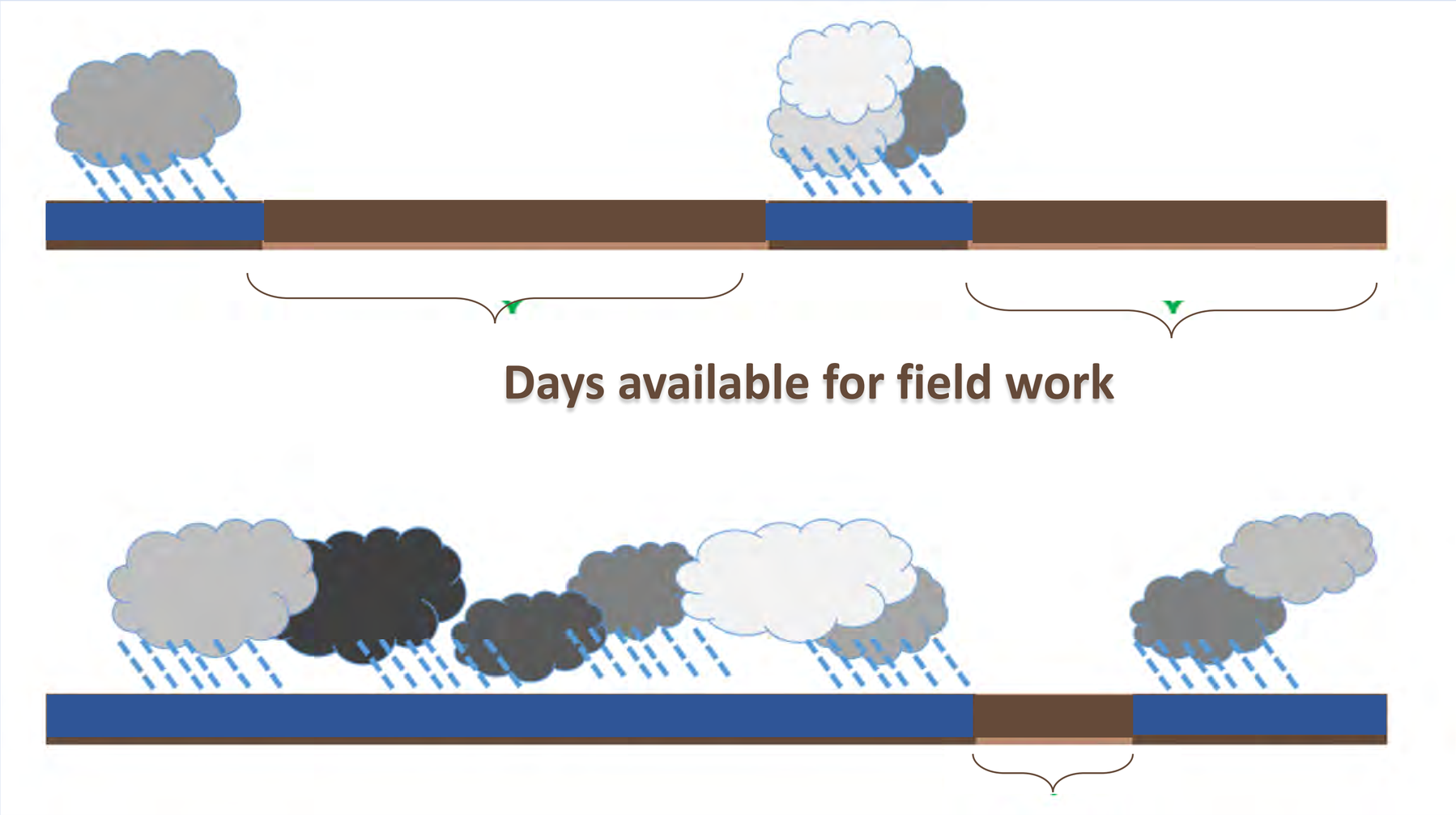
Glen Koehler[1], Richard Kersbergen[1], Senator Russell Black[2]

[1]University of Maine, Maine Food and Agriculture Center, Cooperative Extension

[2] Maine State Legislature

Reduced number of “Field Work Days” constrains farm work

(days with soil dry enough to support tractor, allow tillage etc.)

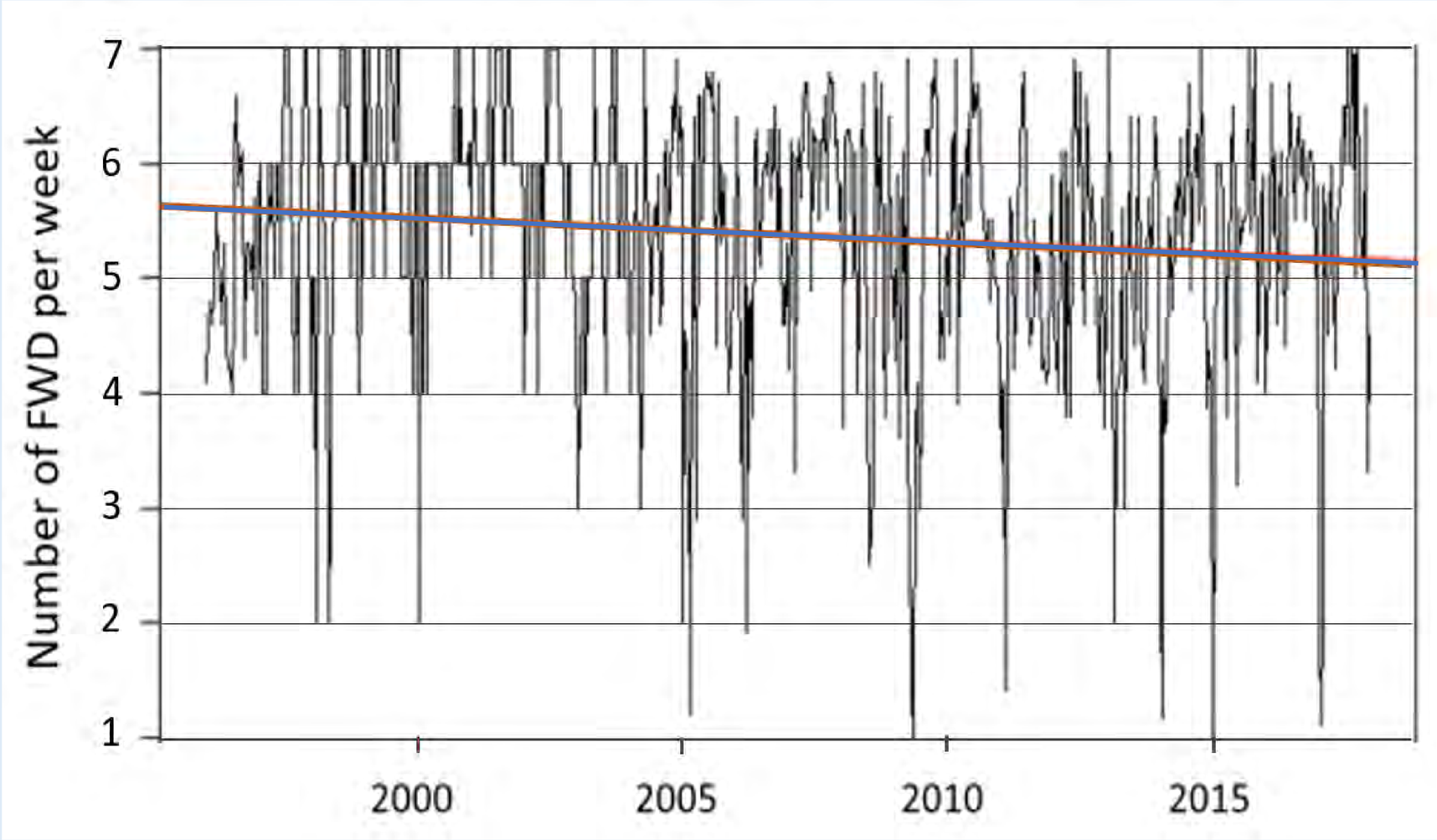


Wet spring with fewer field work days

Adapted from: Birthisel, S. K. 2018. Rain, rain, go away: Effects of changing precipitation on days suitable for agricultural fieldwork. GradCap Webinar. University of Maine School of Food and Agriculture. October 18, 2018.

Fewer Field Work Days in Maine

↓ 0.4 days per week since 1996

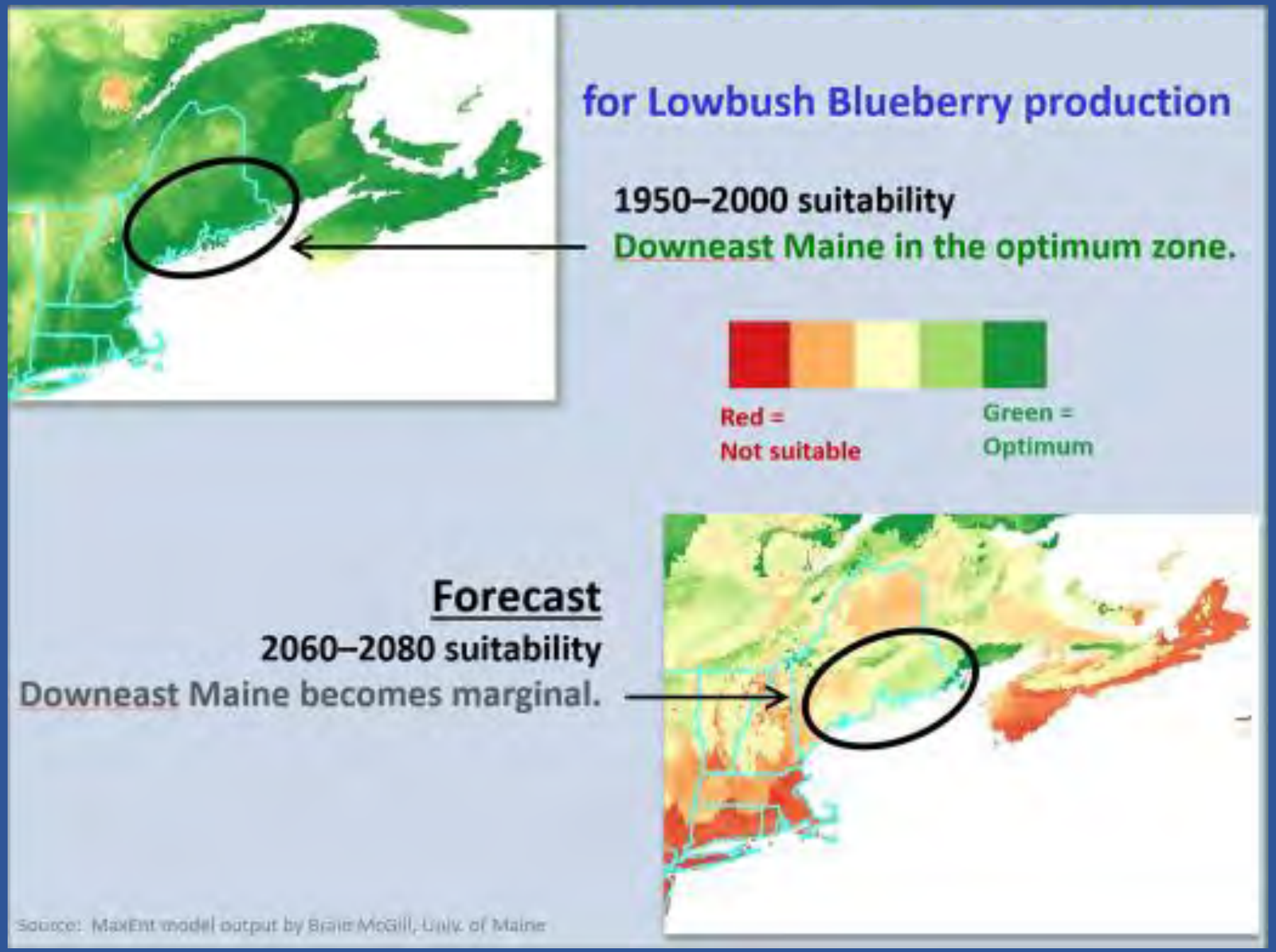


Adapted from: Birthisel, S. K. 2018. Rain, rain, go away: Effects of changing precipitation on days suitable for agricultural fieldwork. GradCap Webinar. University of Maine School of Food and Agriculture. October 18, 2018.

What a lost field work day looks like, and an adaptation response

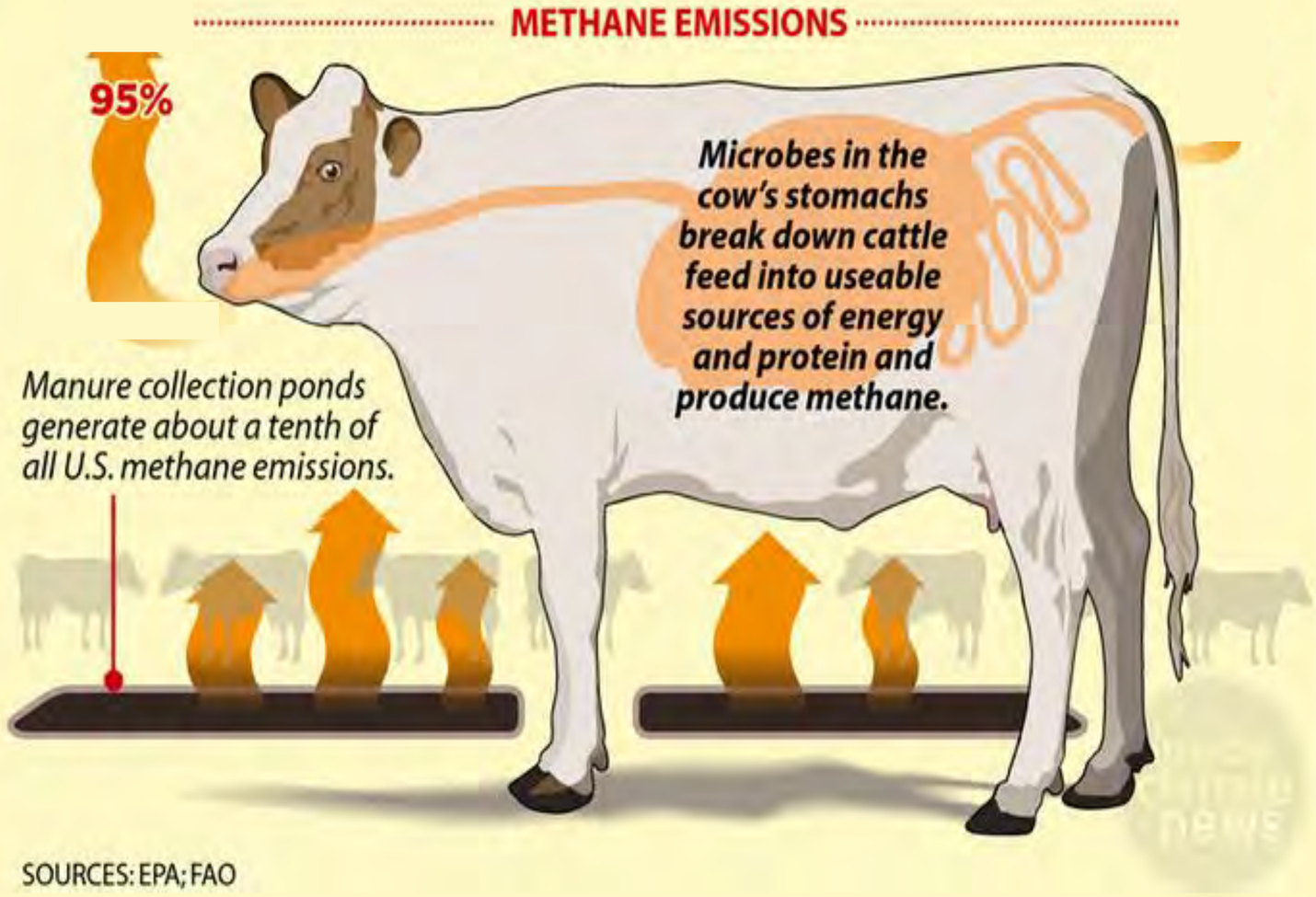
Adapted from: Birthisel, S.K., R. Sexton, A. Daigneault, and E. Gallandt. 2019. Climate Change Perceptions and Adaptation Strategies on Northern New England Farms. USDA AFRI Project: Adaptation Resources.

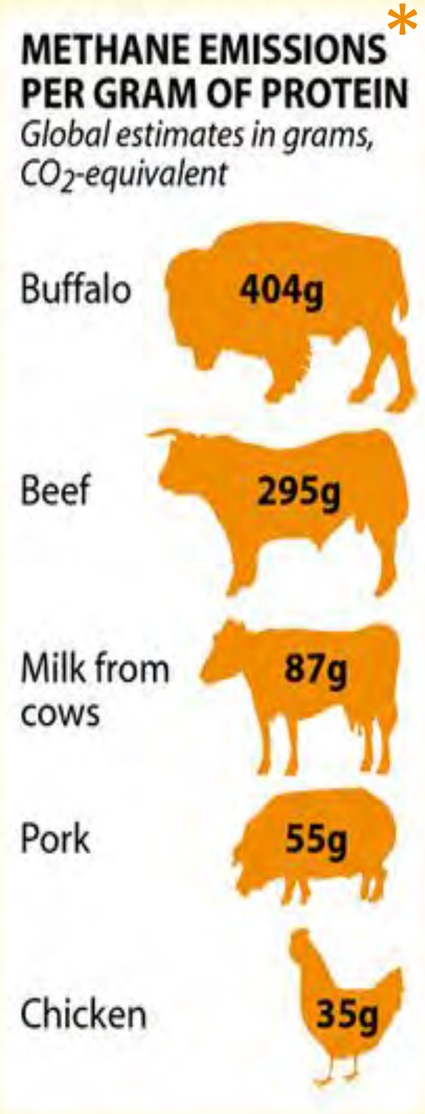
Climatic conditions are likely to become less favorable for Lowbush blueberry



Livestock-Based Methane Emissions *

3.9% of U.S. greenhouse gas emissions come from animal agriculture





*** Methane emissions vary within same species by production method**

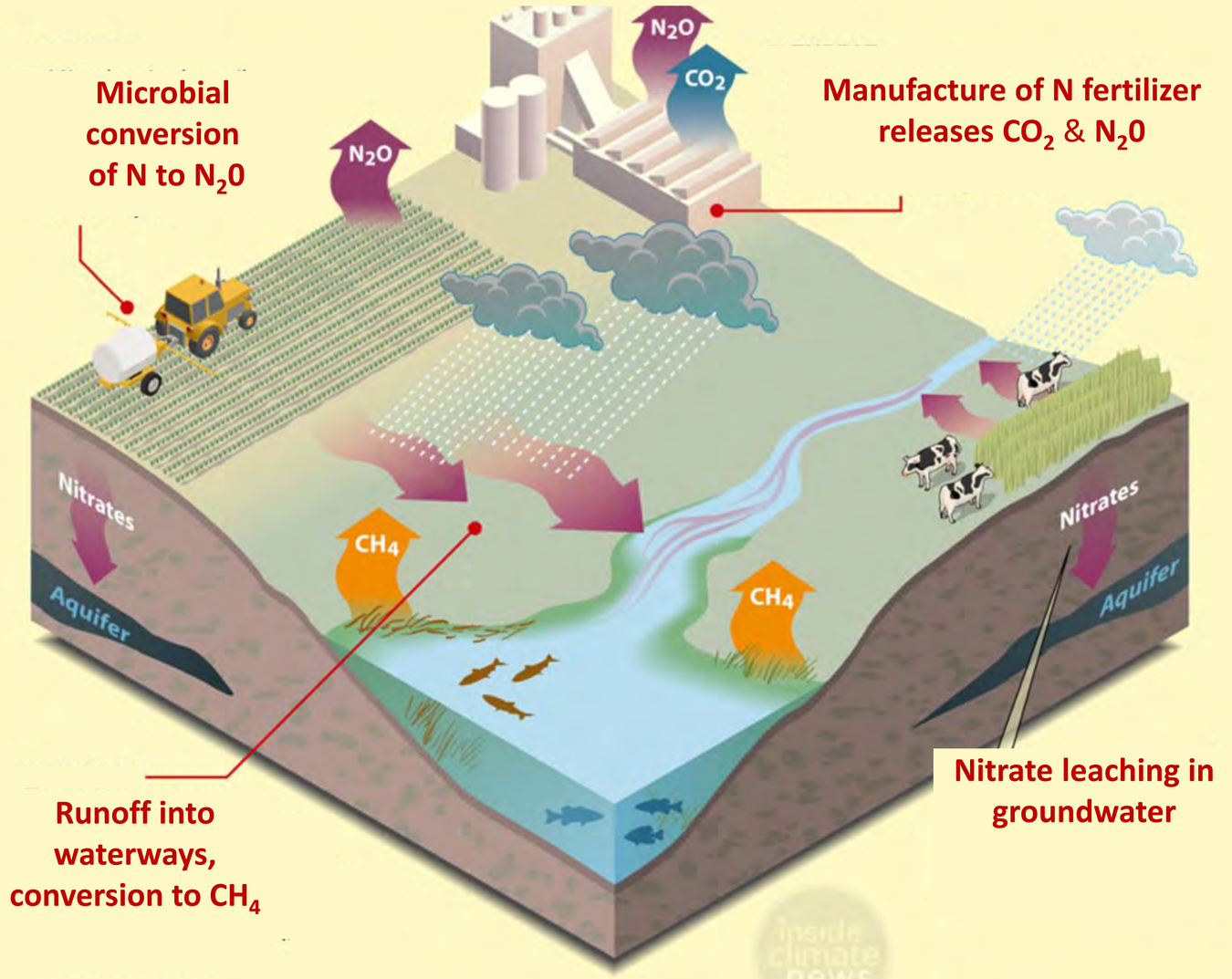
Adapted from: Paul Horn. Infographic: Why Farmers Are Ideally Positioned to Fight Climate Change. Inside Climate News. Oct 24, 2018
https://insideclimatenews.org/news/24092018/infographic-farm-soil-carbon-cycle-climate-change-solution-agriculture

Enhancing soil health and Carbon storage

A 0.5% increase in soil organic matter across all tilled crop acres in Maine would sequester ~ 1 million tons carbon.

Adapted from Paul Horn. Infographic: Why Farmers Are Ideally Positioned to Fight Climate Change. Inside Climate News. Oct 24, 2018
https://insideclimatenews.org/news/24092018/infographic-farm-soil-carbon-cycle-climate-change-solution-agriculture

Nitrogen fertilizer threats



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https://insideclimatenews.org/news/24092018/infographic-farm-soil-carbon-cycle-climate-change-solution-agriculture

Food insecurity in Maine

13.6 percent of households, or nearly 200,000 Mainers, are food insecure. Maine ranks 1st in New England in terms of food insecurity.

Food insecurity refers to "both the dietary quality and also the dietary quantity,"

1 in 5 Maine children are food insecure.

16 percent of Maine seniors (65+) are either food insecure or at risk of become food insecure.

Adapted from: Troutman, C. 2019. Maine Has the Highest Food Insecurity Rate in New England. Here's How 1 Food Bank Is Addressing That. Maine Public. Nov 28, 2019. https://www.mainepublic.org/post/maine-has-highest-food-insecurity-rate-new-england-heres-how-1-food-bank-addressing

Maine Climate Council Scientific and Technical Subcommittee Phase I Update: Human Health

Rebecca Lincoln, ScD, Maine Center for Disease Control
Susan Elias, PhD, Maine Medical Center Research Institute

January 29, 2020

Scientific & Technical Subcommittee Report: Human Health

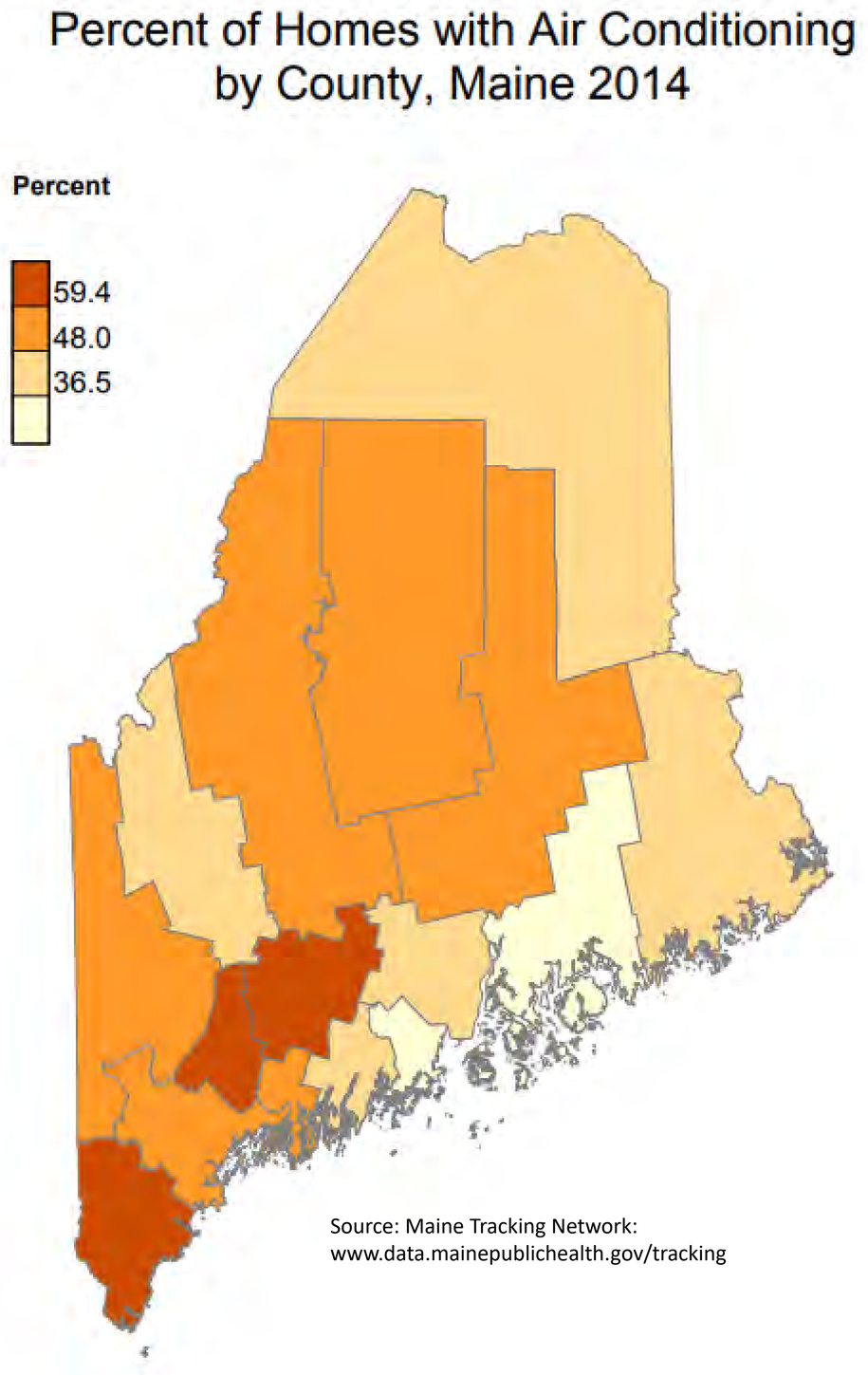
- Direct Impacts of Climate and Weather
  - Extreme Temperatures
  - Extreme Storms
- Ecosystem-Mediated Impacts of Climate Change
  - Vector-borne diseases
  - Food- and water-borne illnesses
  - Air quality (pollen)
- Indirect (Downstream) Impacts of Climate Change
  - Mental health impacts

Extreme Temperatures: Heat

- Heat is the leading weather-related cause of death in the U.S.
- Average of >600 heat-related deaths per year
- Heat waves can cause massive excess mortality
  - Chicago (1995) – 700 excess deaths
  - Europe (2003) – 40,000 excess deaths
  - New England (1911)
    - Temperatures in 90s and 100s for 11 days in July
    - 2,000 excess deaths

Mainers are Vulnerable

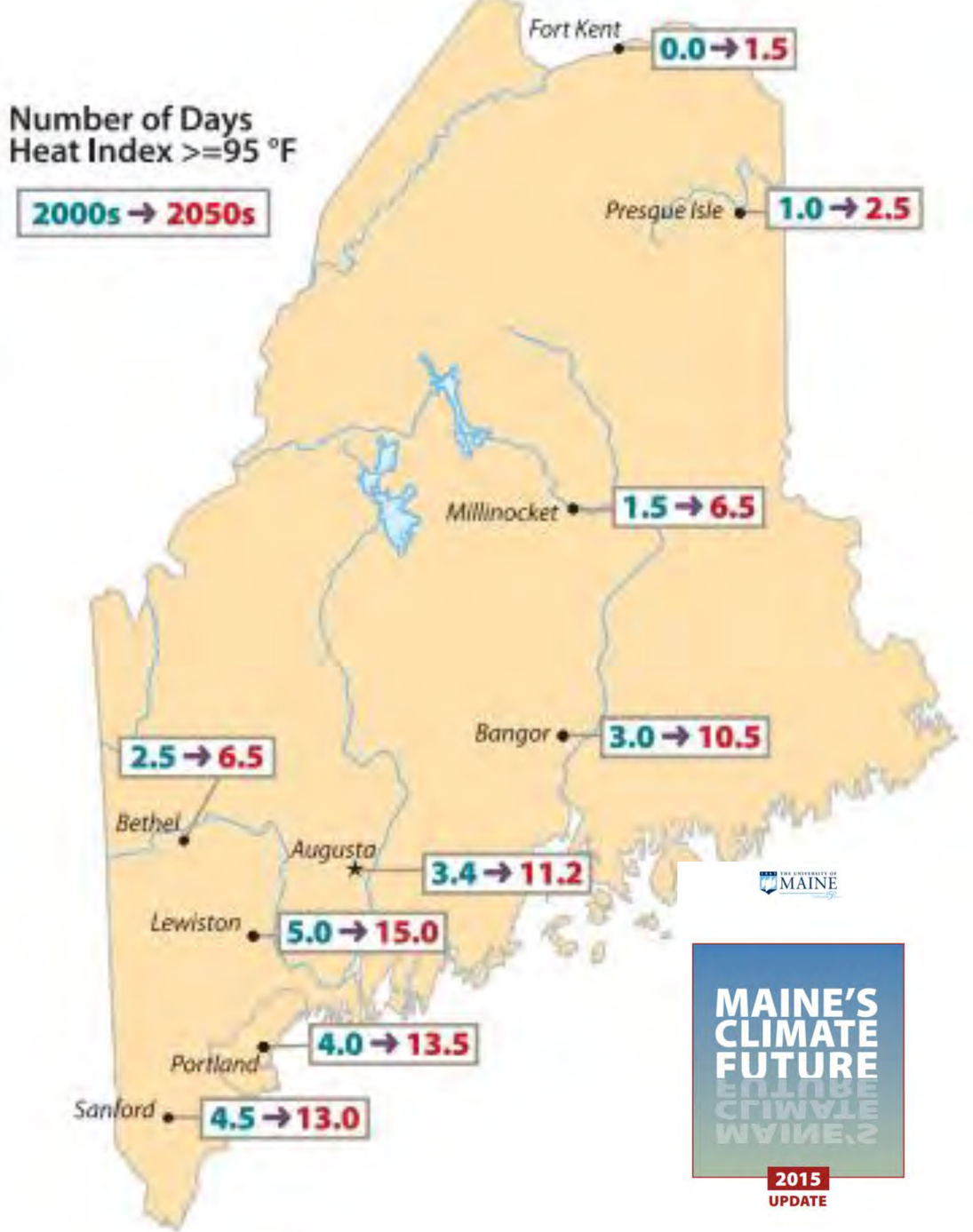
- Physiologically not adapted
- Older population
- Higher rates of chronic diseases
- Rural population, outdoor occupations
- Limited AC in homes, businesses, institutions
  - State average: 50% of homes (25%-70% by county)
  - Rest of Northeast/U.S.: 85%+



Source: Maine Tracking Network: www.data.mainepublichealth.gov/tracking

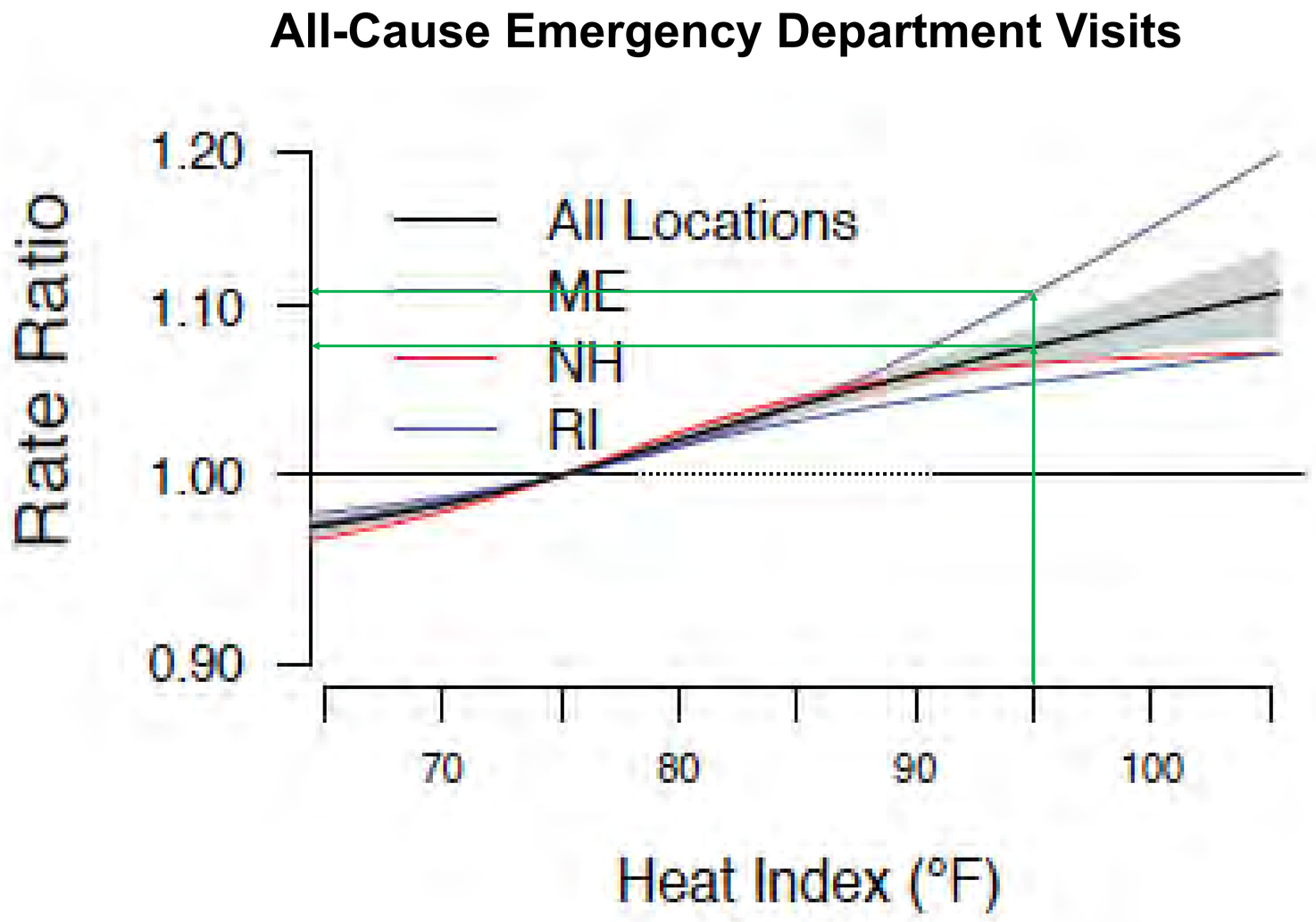
More Heat in Maine's Future

- "Extreme" heat days will increase by two- to four-fold by the 2050s.
- As Maine's climate warms, we will experience more heat-related illnesses and deaths.



Source: Maine's Climate Future: http://climatechange.umaine.edu/research/publications/climate-future

Mainers are Vulnerable



Source: Wellenius et al. Environmental Research 156 (2017) 845-853

Health Effects of Extreme Storms: Floods

- Floods caused by extreme precipitation events OR storm surge
  - → Injuries, deaths
  - → Waterborne disease outbreaks
  - → Displacement, mental health effects
- Extreme precipitation events have increased, are predicted to continue increasing – especially in winter/spring
- Extreme storms have increased since 1950s – but unclear if this will continue

Flooding: Waterborne Diseases

↑ Precipitation leads to:

- Urban areas: Overwhelmed sewer systems
  - Runoff, mixing of bacteria/ waste/drinking water
- Rural areas: Flooded wells
  - Bacterial/chemical contamination of well water

Health Effects of Extreme Weather: Storms

- Winter / wind storms

  → Injuries

  → Power outages: CO poisonings, foodborne illnesses, effects on healthcare infrastructure

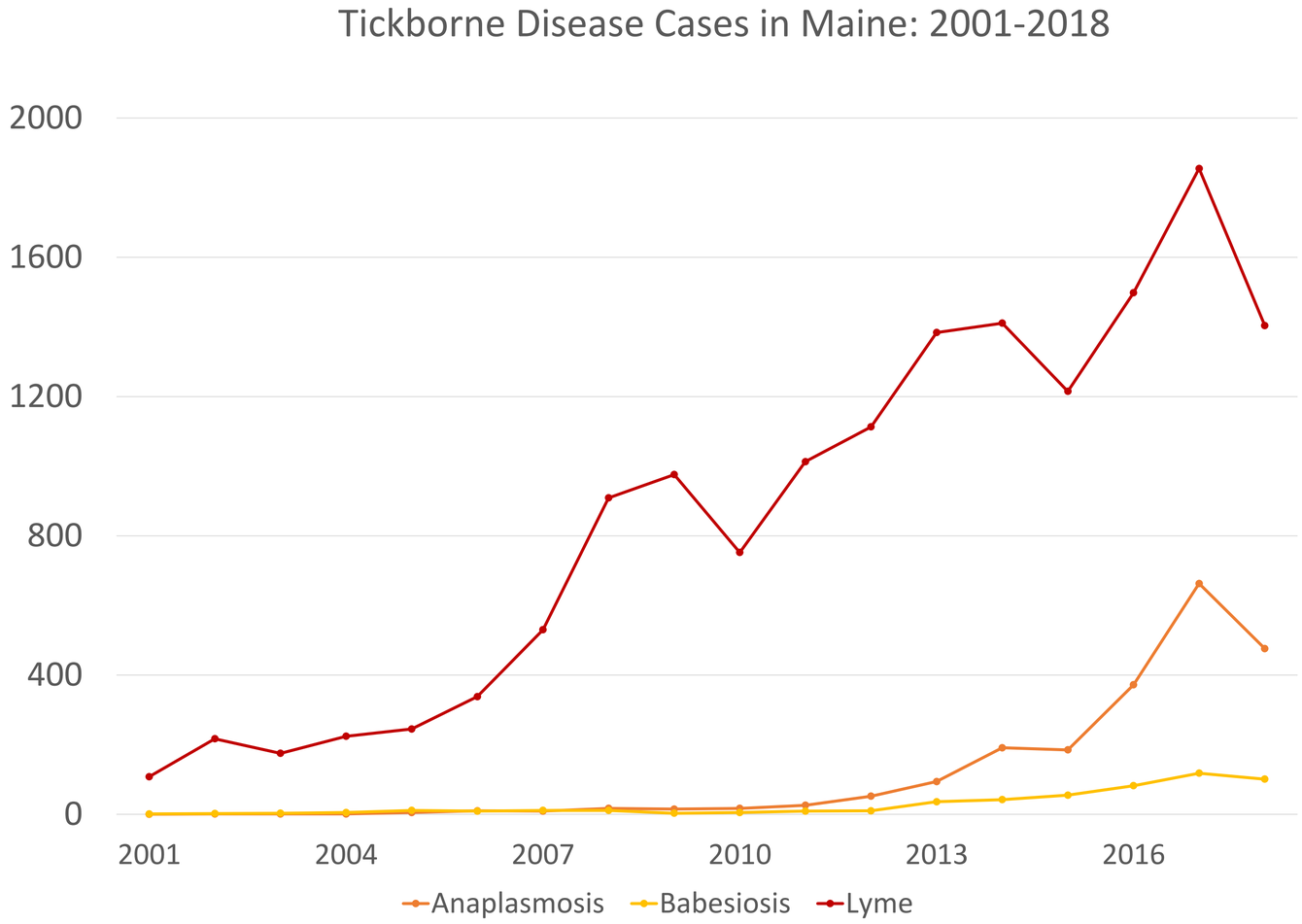
  → Displacement, mental health effects

- Extreme storms have increased since 1950s – but unclear if this will continue

Ecosystem-Mitigated Impacts: Vectorborne Diseases

Tickborne diseases increasing exponentially in Maine

- Lyme, anaplasmosis, babesiosis – transmitted by deer tick
- Powassan virus – less common, also transmitted by deer tick
- Increases expected to continue
- Health impact can be significant

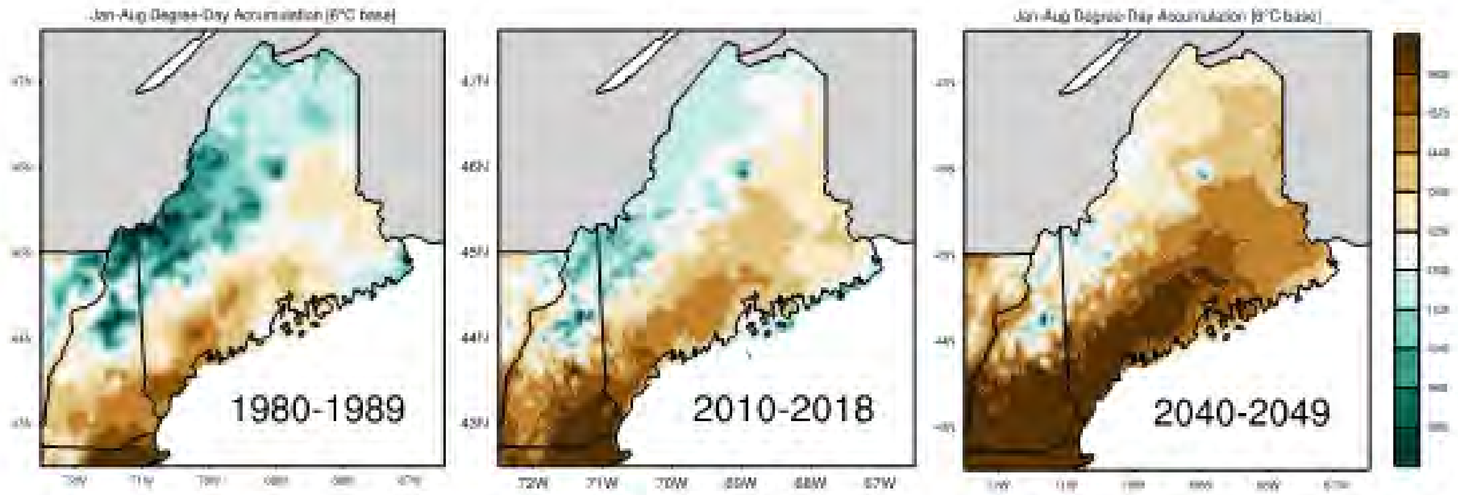


Source: Maine Center for Disease Control, Maine Tracking Network

Ecosystem-Mitigated Impacts: Vectorborne Diseases

- Warmer, shorter winters, more humidity allow tick survival and range expansion
- Climate only <u>part</u> of the problem
- Expect arrival of new vectors as Maine warms

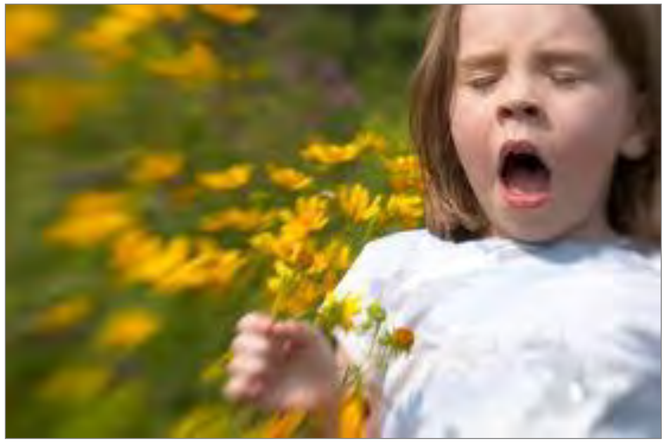
  → Lone Star tick (ehrlichiosis, ‘alpha-gal’ red meat allergy)



Accumulation of 1,240 degree-days >6°C. Orange/white = tick eggs hatch. 2040-49 assumes 1°C warming (Elias 2019). Figure: Sean Birkel, Climate Change Institute.

Medium-Risk Impacts: Pollen

- Earlier springs, warmer temps, higher CO_2
  - ↑ pollen, longer pollen season
  - ↑ hay fever, asthma
- Rates of allergic diseases high
  - — 7.9% of adults report hay fever in northeast
  - — 12% of adults report asthma in Maine
- Currently, no pollen monitoring stations in Maine



Medium-Risk Impacts: Mental Health

- Exposure to extreme weather events, disruption, displacement, and loss can cause <u>significant</u> mental health impacts:
  - Anxiety, depression, PTSD, suicidality
- Exposure to extreme heat associated with significant mental health impacts:
  - Reduced cognitive performance, aggression, violence, suicide
- Those with existing mental illness are vulnerable:
  - Limited resilience, inability to protect from exposures
  - Social isolation, co-occurrence with homelessness
  - Medications that inhibit temperature regulation

Thank You

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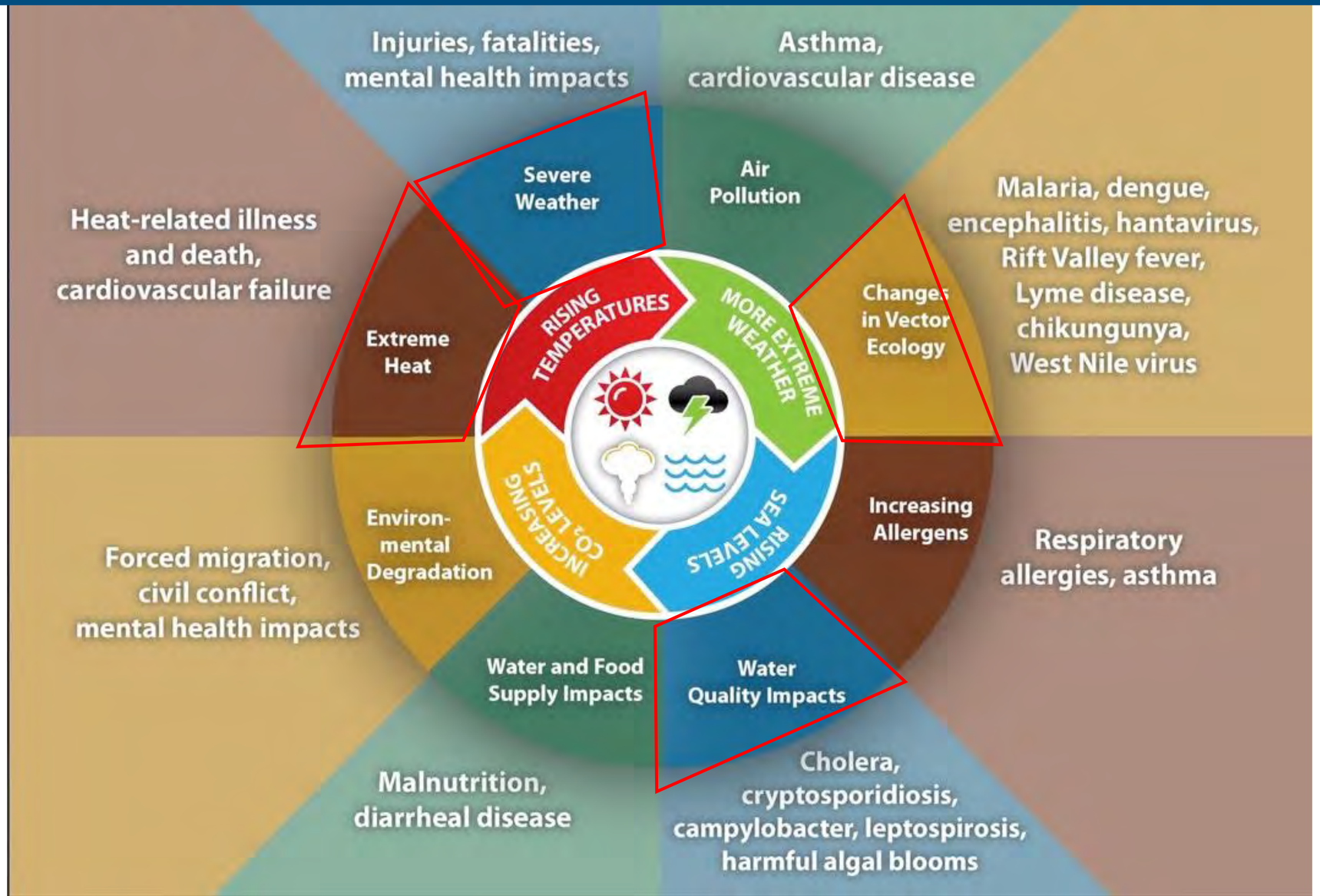
Vulnerability

Varies depending on exposure/outcome

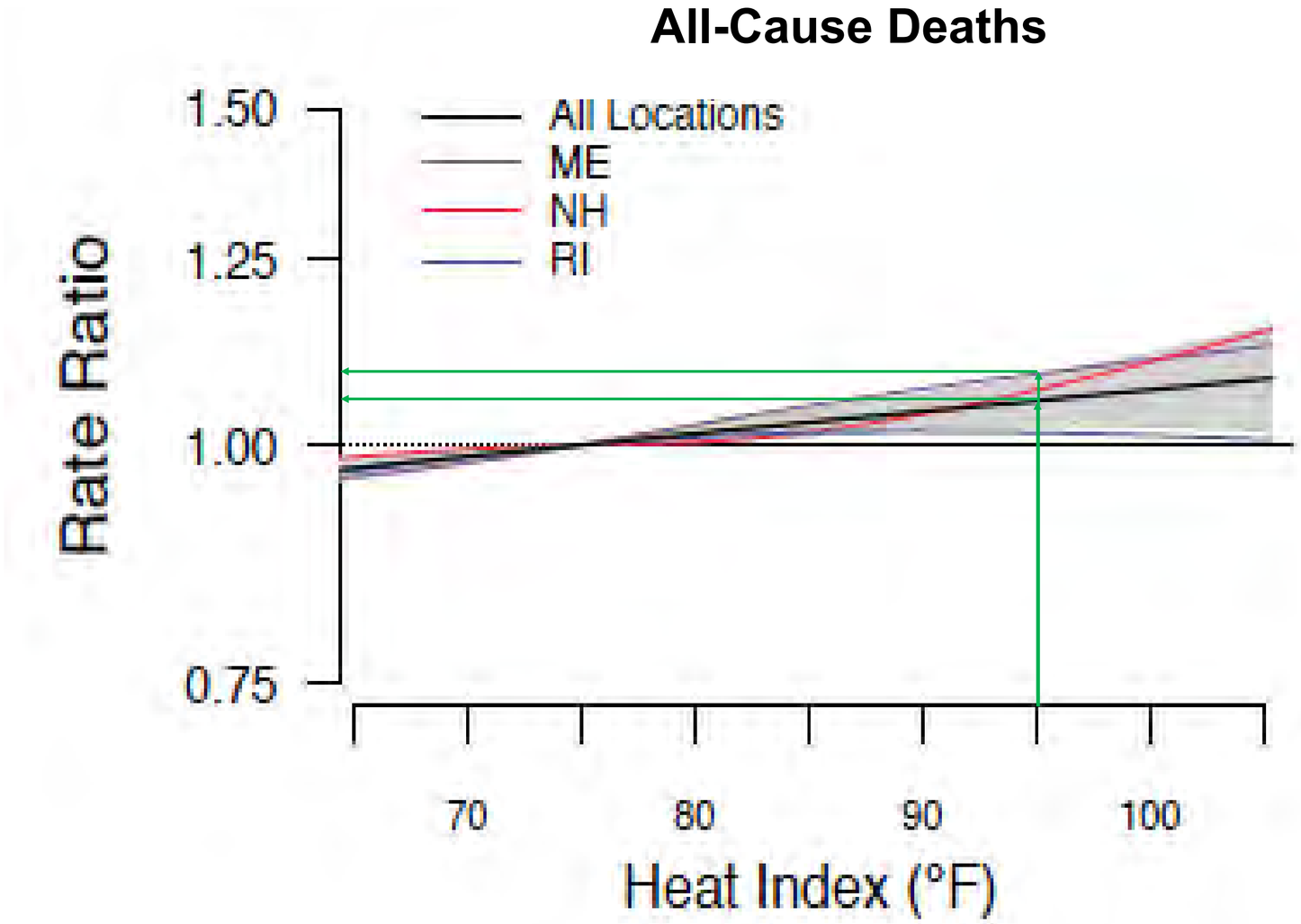
- Kids & older adults
- Those with pre-existing health conditions
- Those in rural areas
- Low-income Mainers
- Those with less social engagement/access to community resources
  - Those experiencing homelessness
  - Socially isolated
  - Refugees
  - Limited/no access to healthcare/insurance

Public Health: Areas of Concern



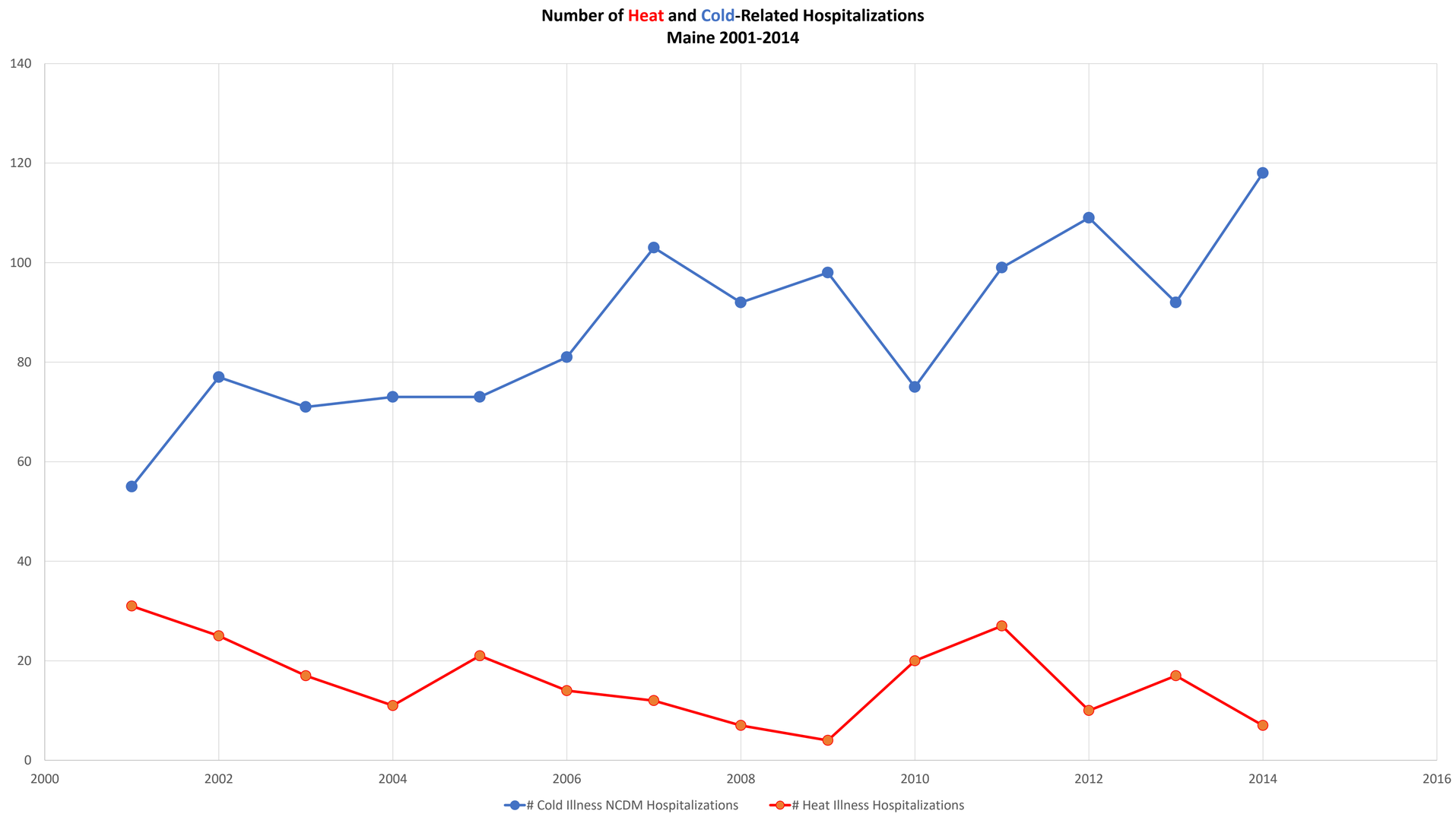
Source: U.S. Centers for Disease Control and Prevention

Mainers are Vulnerable



Source: Wellenius et al. Environmental Research 156 (2017) 845-853

Direct Impacts: Cold-Related Illness



Extreme weather events

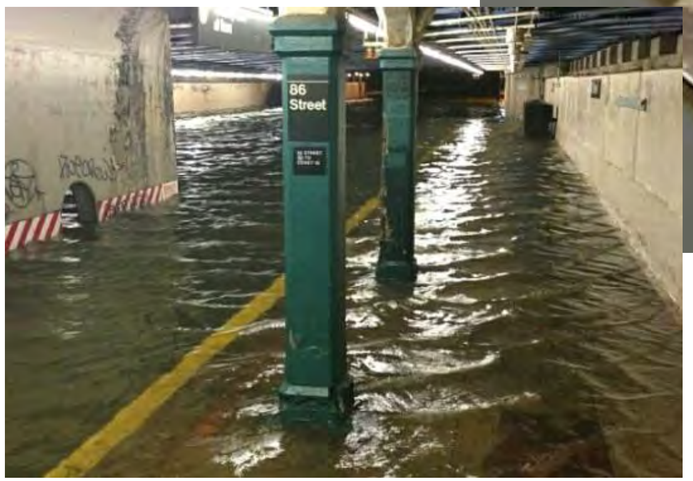
↑ **Air Temps/Water Temps/Atmospheric moisture** →

↑ Hydrologic extremes: droughts, powerful storms, extreme precipitation events

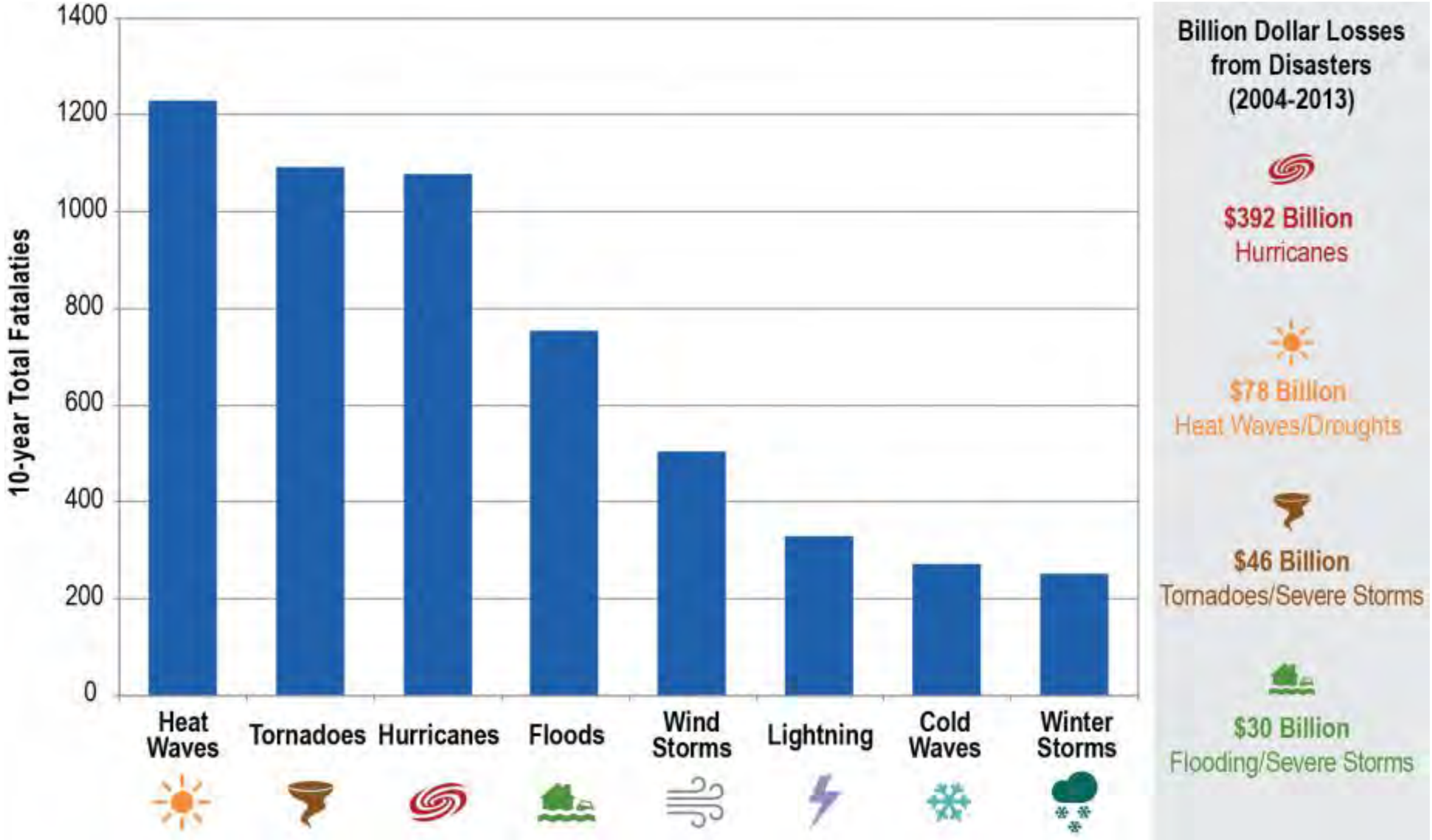
↑ Flooding, mudslides, drought, forest fires…

↑ Wind storms?

↑ Winter storms?



Extreme weather events



Waterborne diseases

↑ Precipitation →

Urban: Overwhelmed sewer systems

↑ Runoff, mixing of bacteria/waste/ drinking water

Rural: Flooded wells

↑ Bacterial/chemical contamination of well water

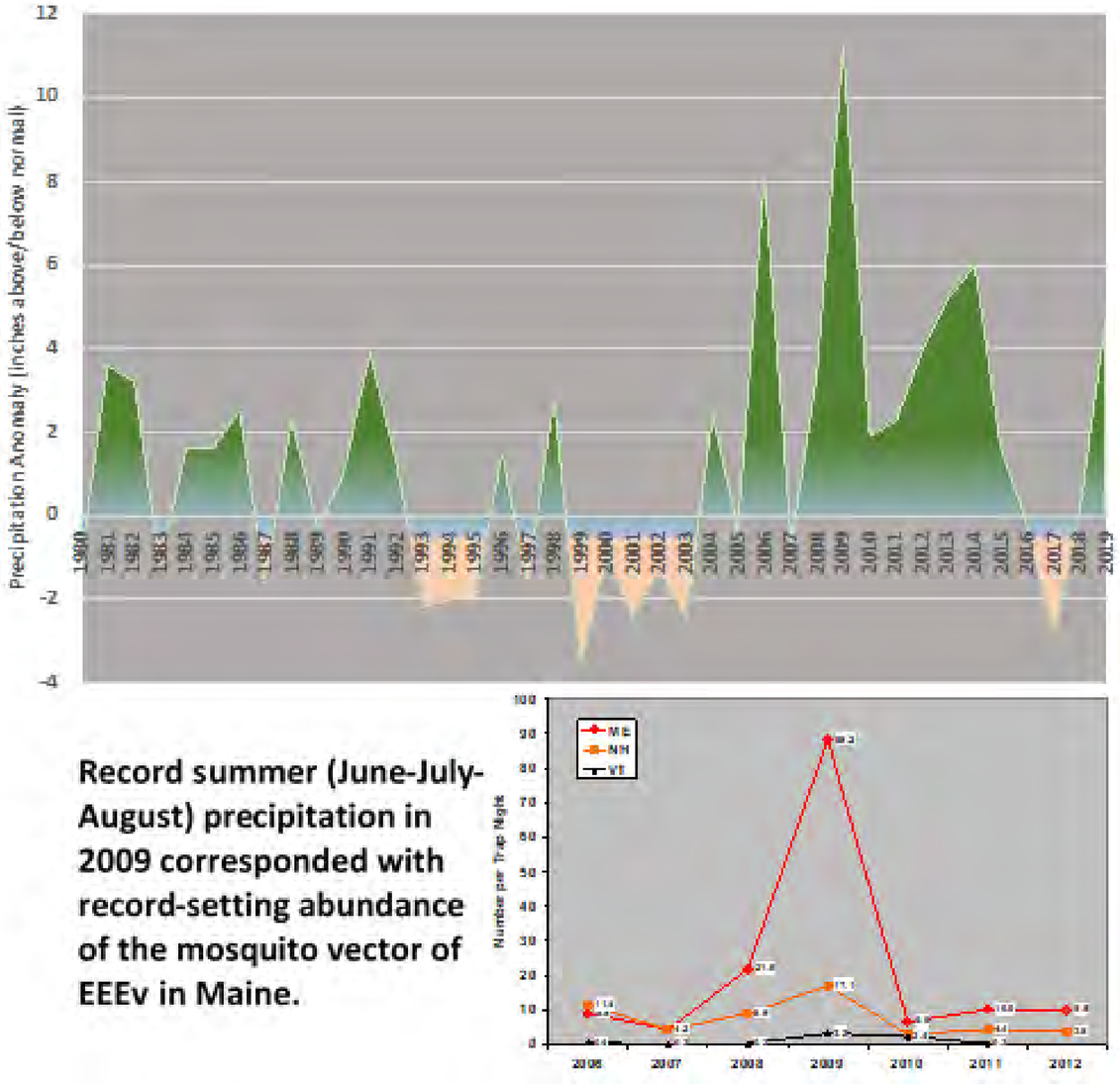
↑ Temperature →

↑ Growth of pathogens (including HABs) in recreational/drinking water sources/fisheries

Cryptosporidium, Giardia, E. coli, Camplyobacter, Salmonella, enteric viruses, noroviruses, rotaviruses, hepatitis A/E, Leptospira, Leptonema

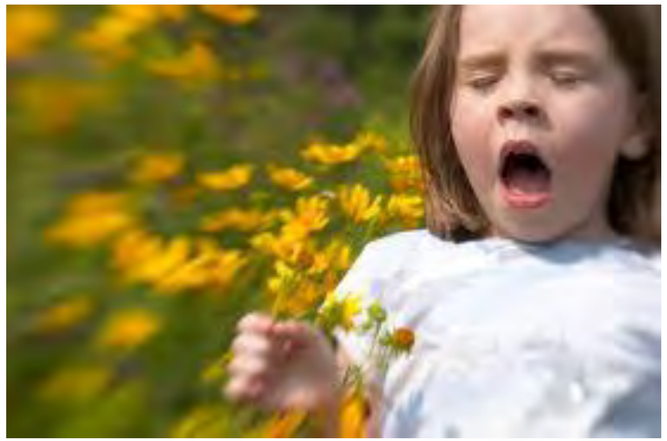
Ecosystem-Mitigated Impacts: Vector-borne Diseases

- Mosquito-borne disease – medium priority
  - → Tree-hole mosquitoes vector of Easter Equine Encephalitis virus, associated with wet summers
  - → Climate change -> more extreme precipitation
  - → Mitigated through management of larvae, emergency response to adults in case of outbreak
  - → Impact of precip/drought on vectors of West Nile virus difficult to predict



Medium-Risk Impacts: Air Quality

- Air quality
  - → Pollen - medium priority; Earlier springs, warmer temps > asthma/hay fever, but 3 former pollen counting programs in Maine discontinued
  - → Ozone, PM – unknown priority; 30-year decline due to national/regional standards, if maintained expect standards to be exceeded locally



AAAAI pollen stations

Resilience, Adaptation

- Resilience
  - Community-driven planning
  - Vulnerable and impacted groups included
  - Developing institutional readiness
- Adaptation
  - Individual, local, and state-level
  - Developing comprehensive response plans
  - “Climate-proofing” healthcare infrastructure
  - Improving surveillance
  - Improving wastewater management

→ Important to ensure that mitigation and adaptation steps recommended by other groups take public health into account – co-benefits vs. added harm

STS: Maine's Economy & Climate Change

Jonathan Rubin

MCS Policy Center & School of Economics, University of Maine

Adam Daigneault

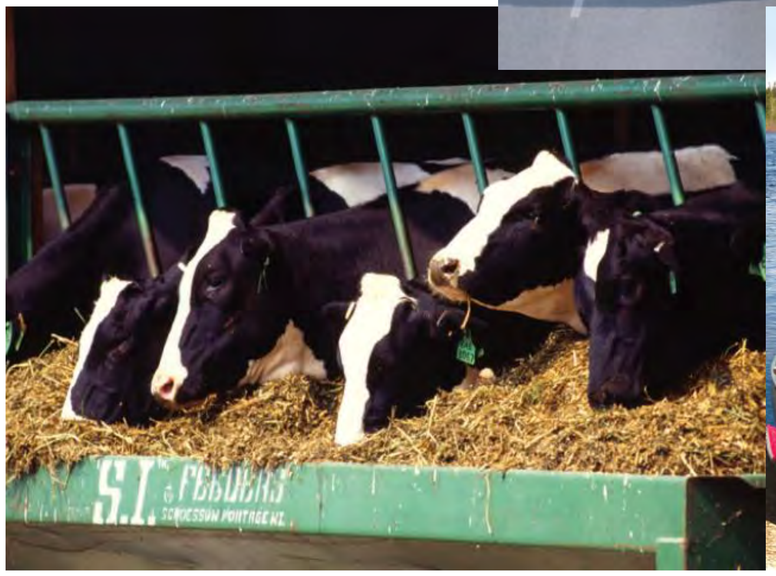
School of Forest Resources, University of Maine

Overview

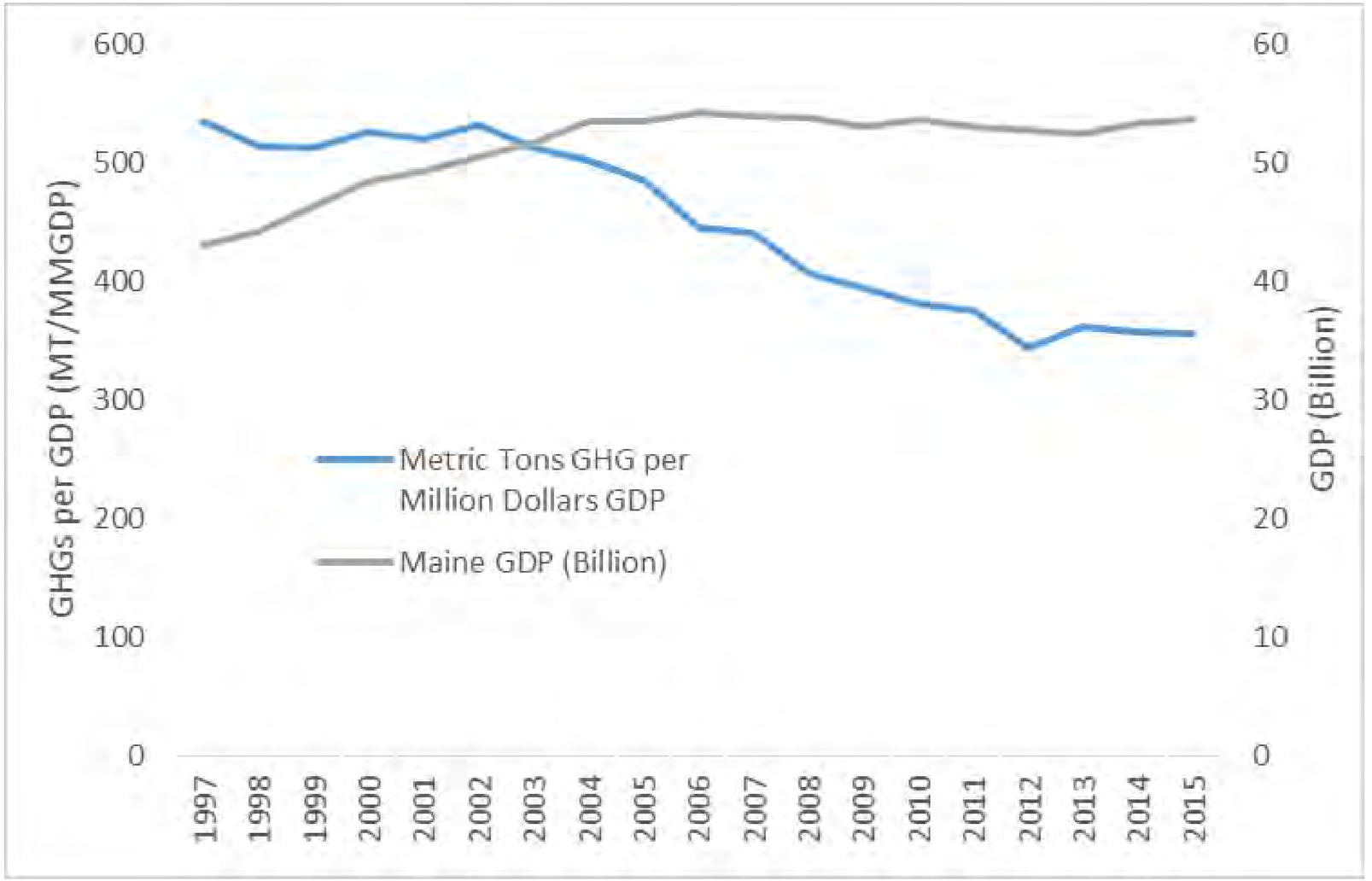
Climate change expected to impact all sectors of Maine's economy

Sectors of particular concern

- Energy
- Transportation
- Tourism & Recreation
- Agriculture
- Forest Products
- Marine Fisheries & Aquaculture



Maine's GDP and GHG Emissions

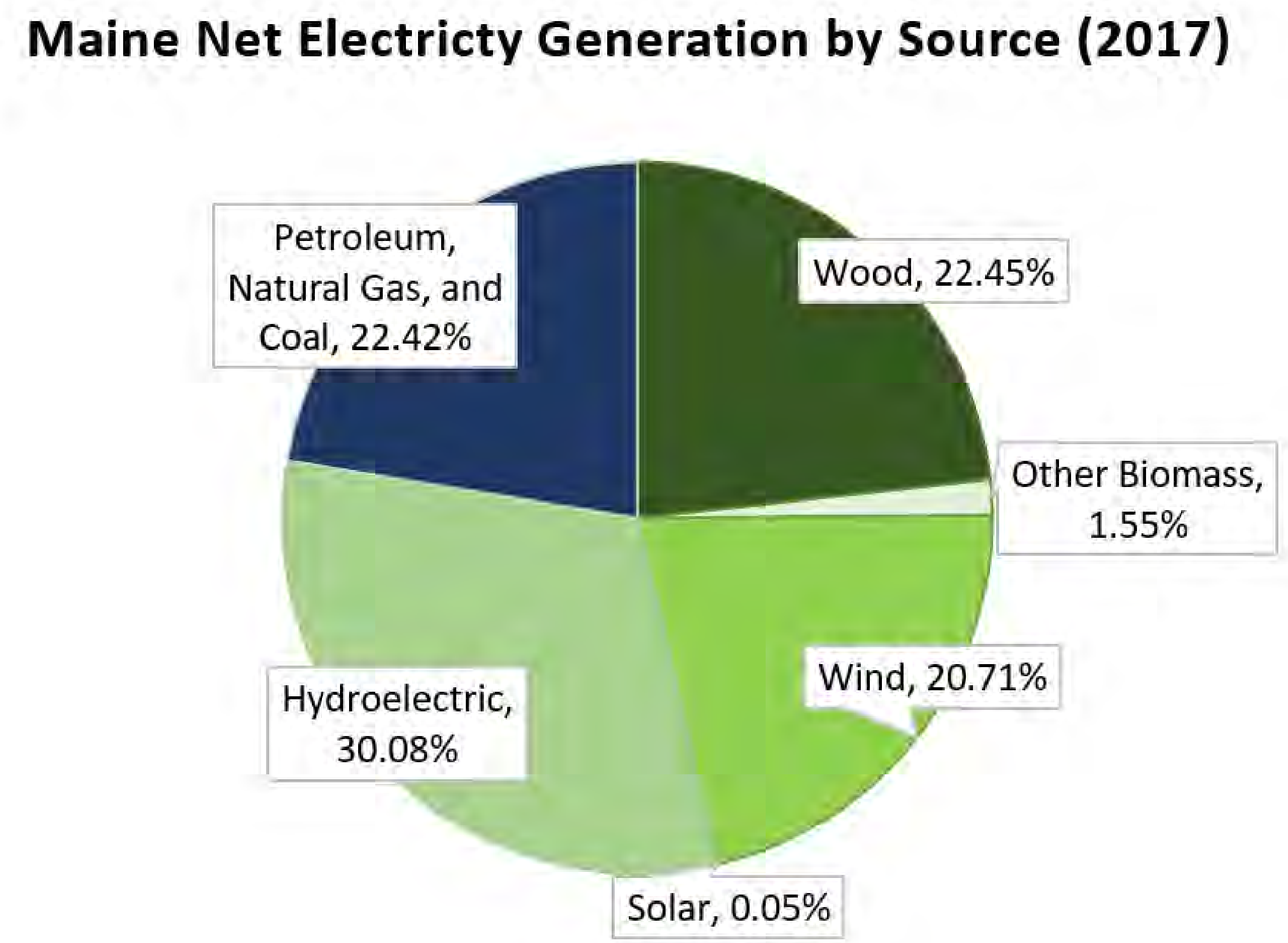


Source: Maine DEP, 7th Biennial Report (2018) and BEA 2019

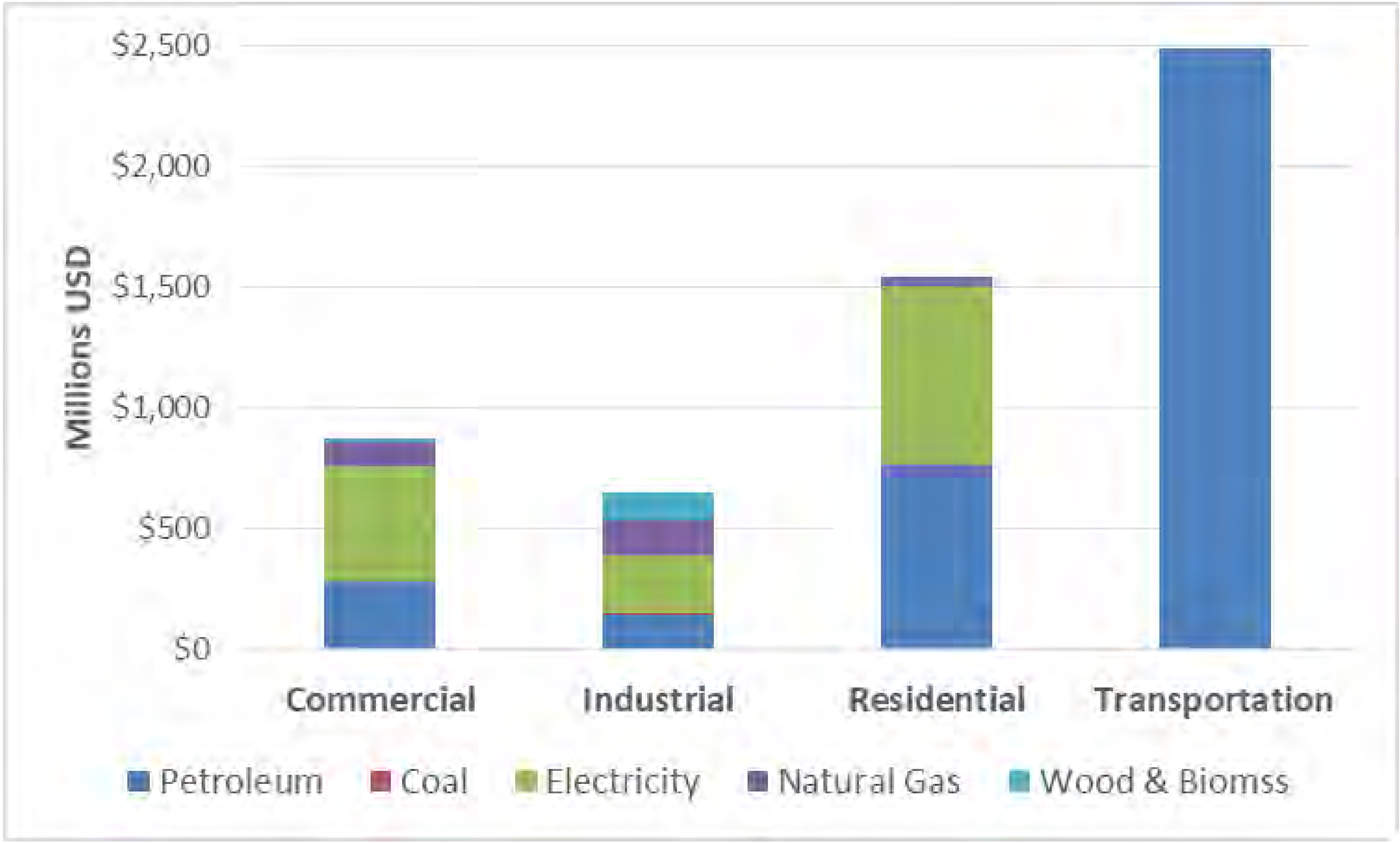
Maine's real **GDP** has been relatively constant since 2004, while **GHGs** have been declining. Maine's economy is transitioning to lower GHGs per dollar of output.

Energy

- Nearly 2/3 of Maine households use fuel oil for home heating
- Petroleum products ~50% all energy used in state
- **Net Electricity ~75% renewable**
  - Hydro, wood & wind
- Opportunities:
  - Fuel switching: heating and transport
  - Renewable energy generation



Maine Energy Expenditures (2017)



Source: EIA SEDS 2017

Transportation Sector

- Maine's GHG emissions, **50+** %
- Maine transport energy, **~ 94%** oil
- ***Per-capita***, Maine's transportation GHGs
  ~ average nationally
- Climate impacts on infrastructure
  - Pavement life
  - Bridge fatigue & culvert washouts
  - Coastal roads & infrastructure – severe weather
- Opportunities
  - Electric Vehicles
  - Locally-produced biofuels
  - Better public health: air quality, mobility, etc.

Source: Maine Climate Future, 2009

Transportation - Opportunities

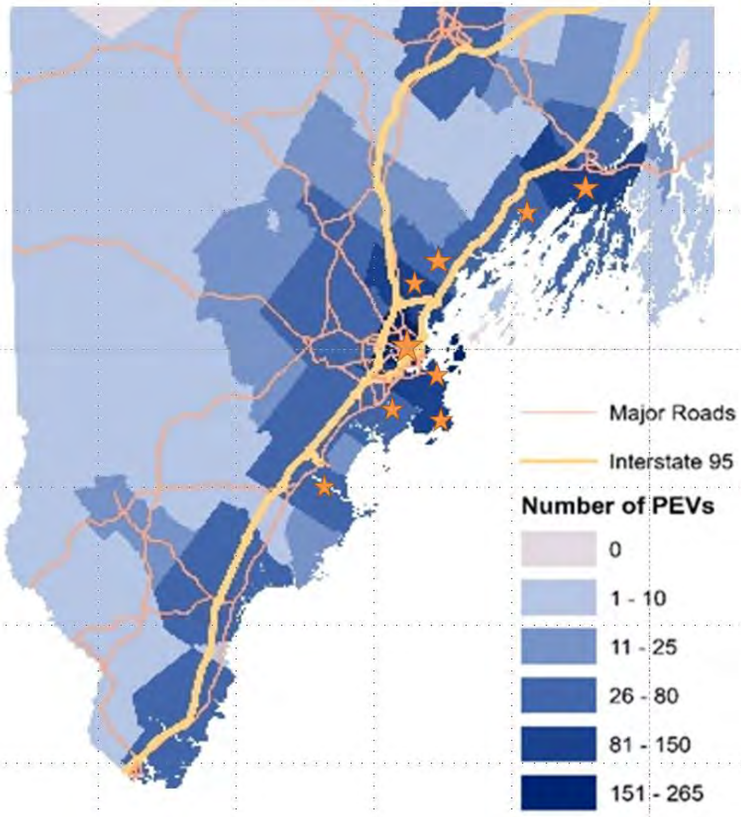
Benefits

- Active transportation
- Better air quality
- Less congestion
- More access & mobility
- Economic development

Solutions

- Electric Vehicles
  - Available/affordable
  - Across Maine
- Biofuels
- Vehicle fuel efficiency
- System efficiency, multimodal
- Reduced carbon intense travel activity
- Reduce GHGs from construction maintenance
- Mobility options: ride hailing & pooling

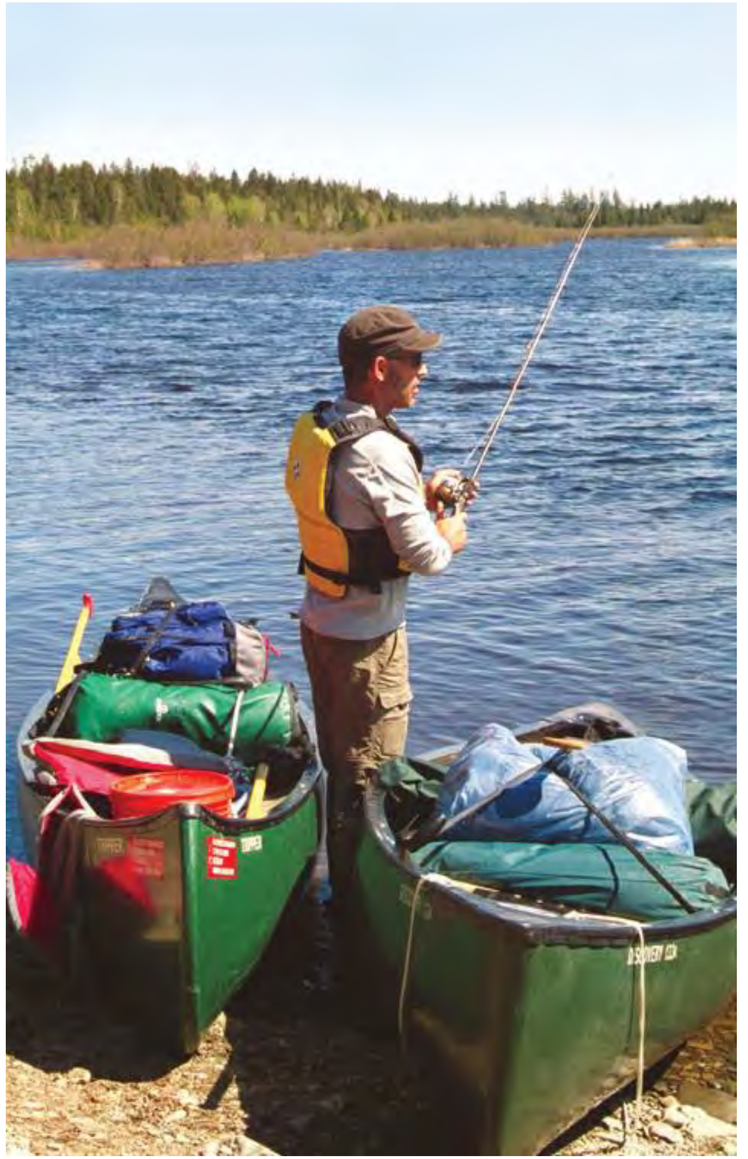
Top 10 EV Towns in Maine



1. Portland
2. Brunswick
3. Falmouth
4. South Portland
5. Bangor
6. Cape Elizabeth
7. Scarborough
8. Cumberland
9. Freeport
10. Saco

Tourism & Recreation

- $6 billion/year direct expenditure
- Primarily outdoor and recreational activities
- Climate change will likely:
  - Increase time for summer activities
  - Decrease availability for winter activities
  - Directly impact spending by activity
- Opportunities:
  - Tourists push/pull northward
  - New recreation ventures



Source: Maine Climate Future, 2009

Forest Products

- $8 billion/year industry
- Diverse species and product mix
- Climate change likely to:
  - Shift species mix towards hardwoods
  - Affect forest productivity
  - Increase risk of pest and disease
  - Have more variable & costly harvests
- Opportunities:
  - Mitigation via improved forest management
  - Emerging wood products and C storage

Source: Maine Climate Future, 2009

Agriculture

- Largest and most diverse agricultural economy in New England ($1+ billion)
- Climate change is likely to:
  - Lengthen growing season
  - Increase need for irrigation and other infrastructure
  - Affect confined livestock due to higher temps
- Opportunities:
  - Mitigation via soil health and manure management
  - New crops and products

Source: Bauer, S., Maine Climate Future, 2009

Marine Fisheries & Aquaculture

- $600+ million in commercial harvests/year
  - 2/3 attributed to lobster fishery
- Climate variability & warming waters likely to have a negative impact on landings and sector-level employment
- Opportunities
  - New aquaculture ventures
  - Capitalize on new markets

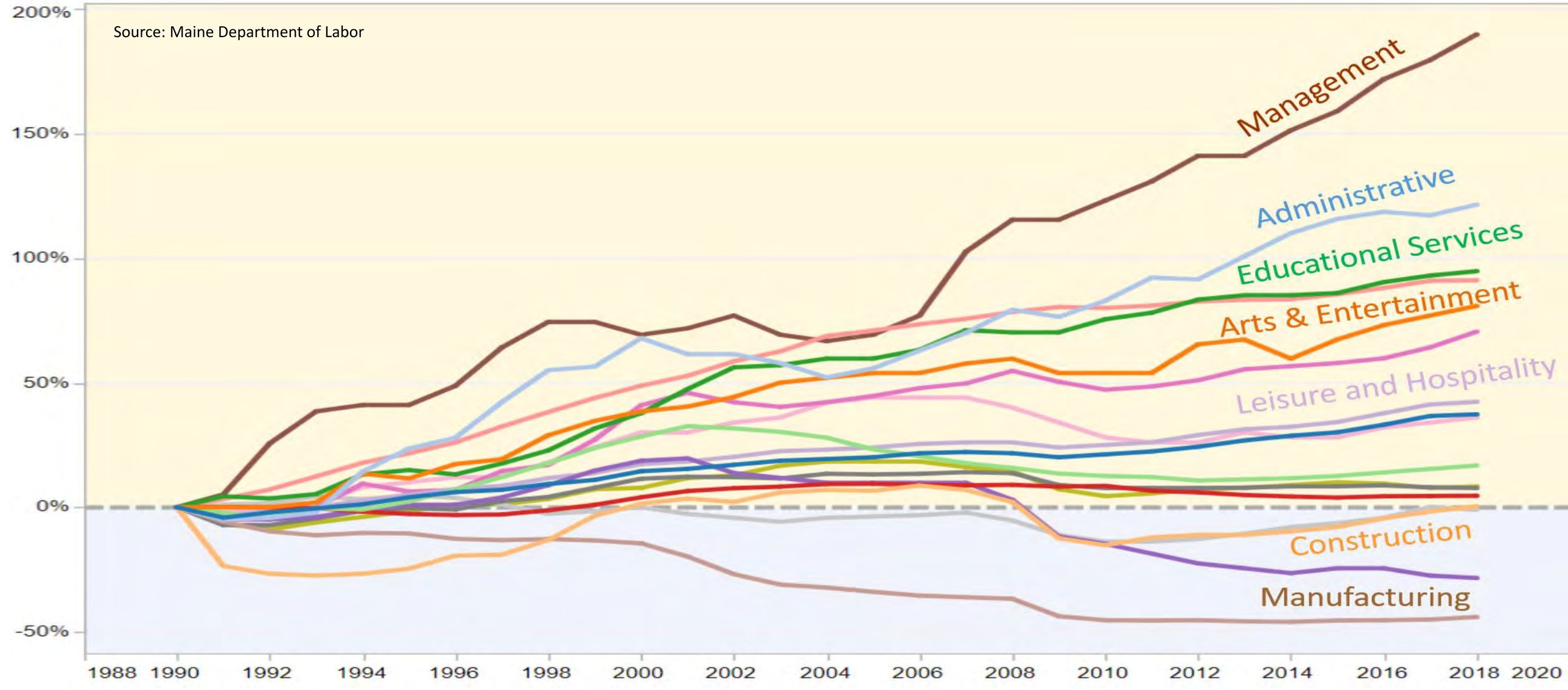
Source: Lilieholm, Maine Climate Future, 2009

Critical Issues

- Maine's economy not just affected by climate change impacts, but climate mitigation policy as well – *our choices matter*.
  - Performance standards v. technology winner
  - Build in flexibility, update as science and data evolves
- Need to *consistently* assess sources of mitigation and potential tradeoffs/impacts for major sectors of the economy across all working groups
- Where can *Maine* have the most impact?
- Who is entering the workforce? What industries are growing? Who will be most affected by policy?

Photo by Joanna Kosinska on Unsplash

Context: Employment Change (%) Since 1990

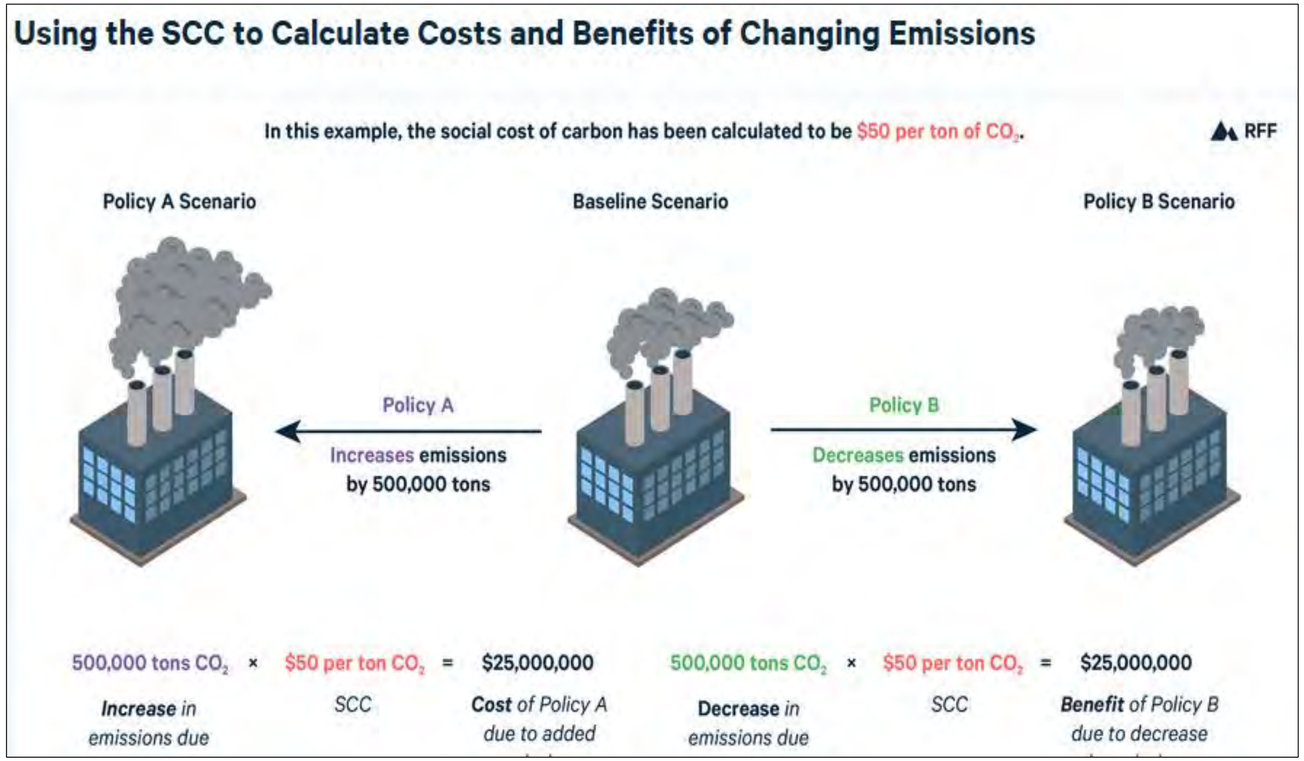


Recommendations for MCC and WGs

- All MCC analyses should use consistent **discount rates** to quantify costs and benefits of climate change impacts and mitigation

- Suggest using the US Government Social Cost of Carbon (SCC) analysis rates of **2.5%**, **3%** and **5%,** but…

Discount Rate	Global SCC ($ per ton CO_2)
2.5%	75
3%	50
5%	14



Source: RfF, Social Cost of Carbon 101

Summary & Conclusions

- Climate change impacts several sectors of Maine's economy, but not all equally
- Maine's GDP and GHG emissions diverging, in the 'right' way
- Mitigation and adaptation efforts can also create economic opportunities
- Economic assumptions for MCC policy analysis needs to be consistent across working groups