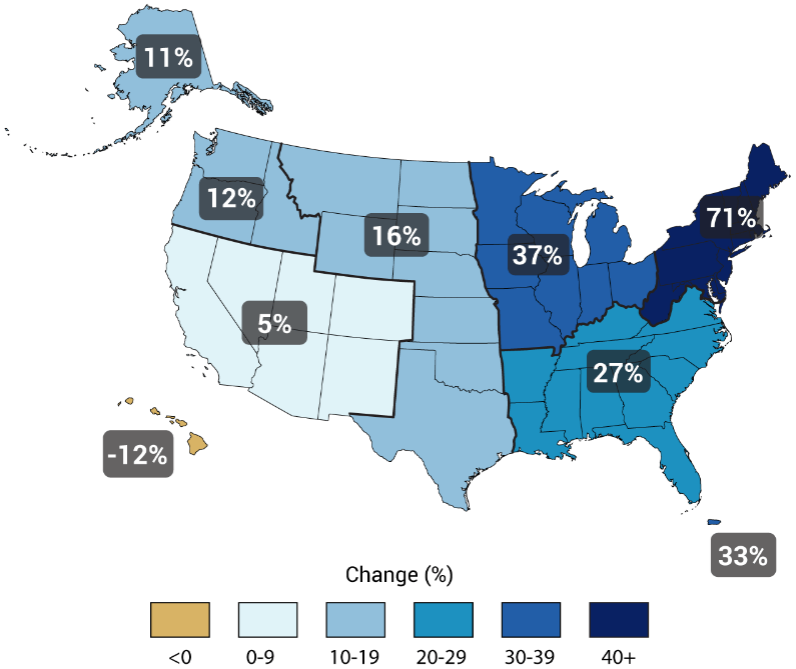
Changing Extreme Precipitation Across the Northeastern United States

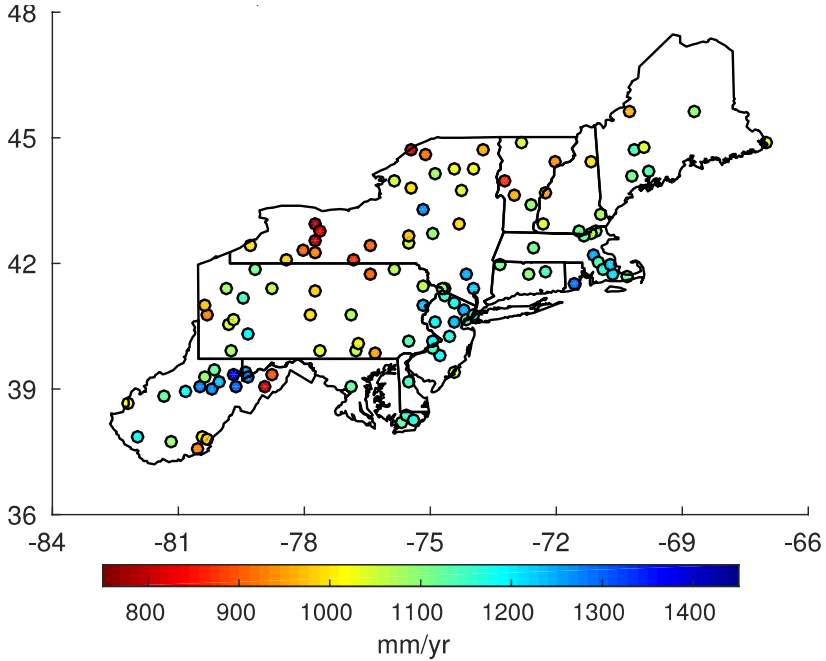
Jonathan Winter, Huanping Huang, Erich Osterberg, Charlotte Cockburn, Natalie Teale, Christopher Picard



USGCRP, 2014; Burlington Free Press, 2023; New York Times, 2024

How is Northeast Extreme Precipitation Changing?

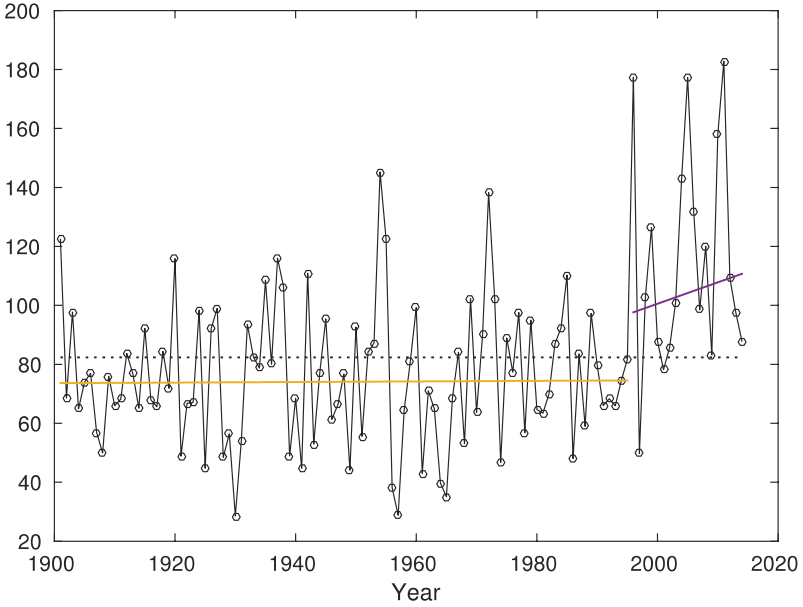
- Global Historical Climatology Network – Daily (GHCN-D): Menne et al. 2012; 116 stations; 1901-2014
- Extreme precipitation defined as 99%-ile precipitation days

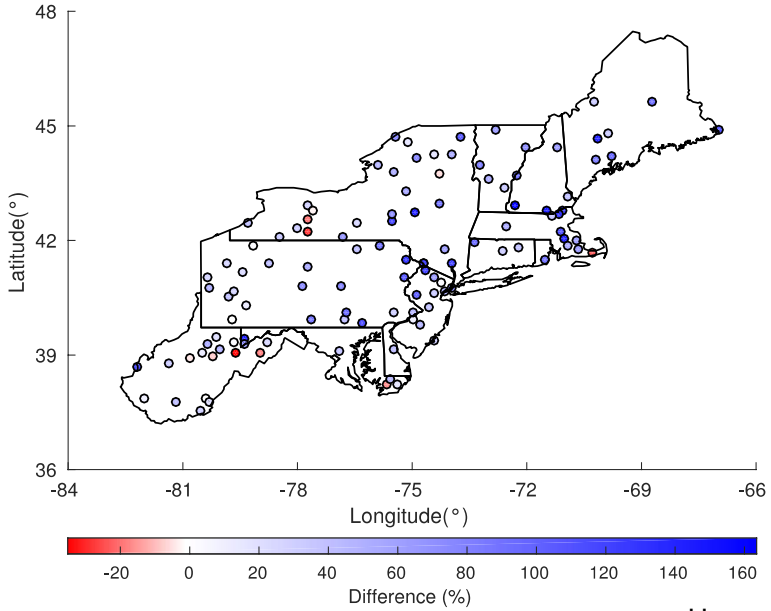


Huang et al., 2017

Northeast Extreme Precipitation Has Increased 50% 1996-Present

- Trends generally increasing with later start year: 2.4 mm decade^{-1} (1901-2014) to 14.7 mm decade^{-1} (1979-2014)
- Change in extreme precipitation best characterized as a shift in 1996: 53%

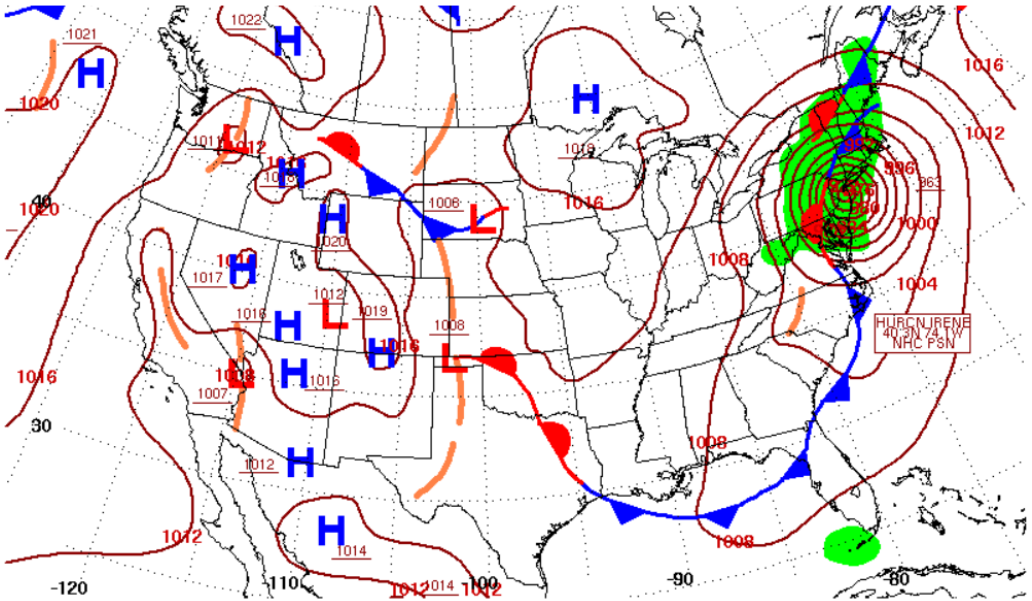




Huang et al., 2017

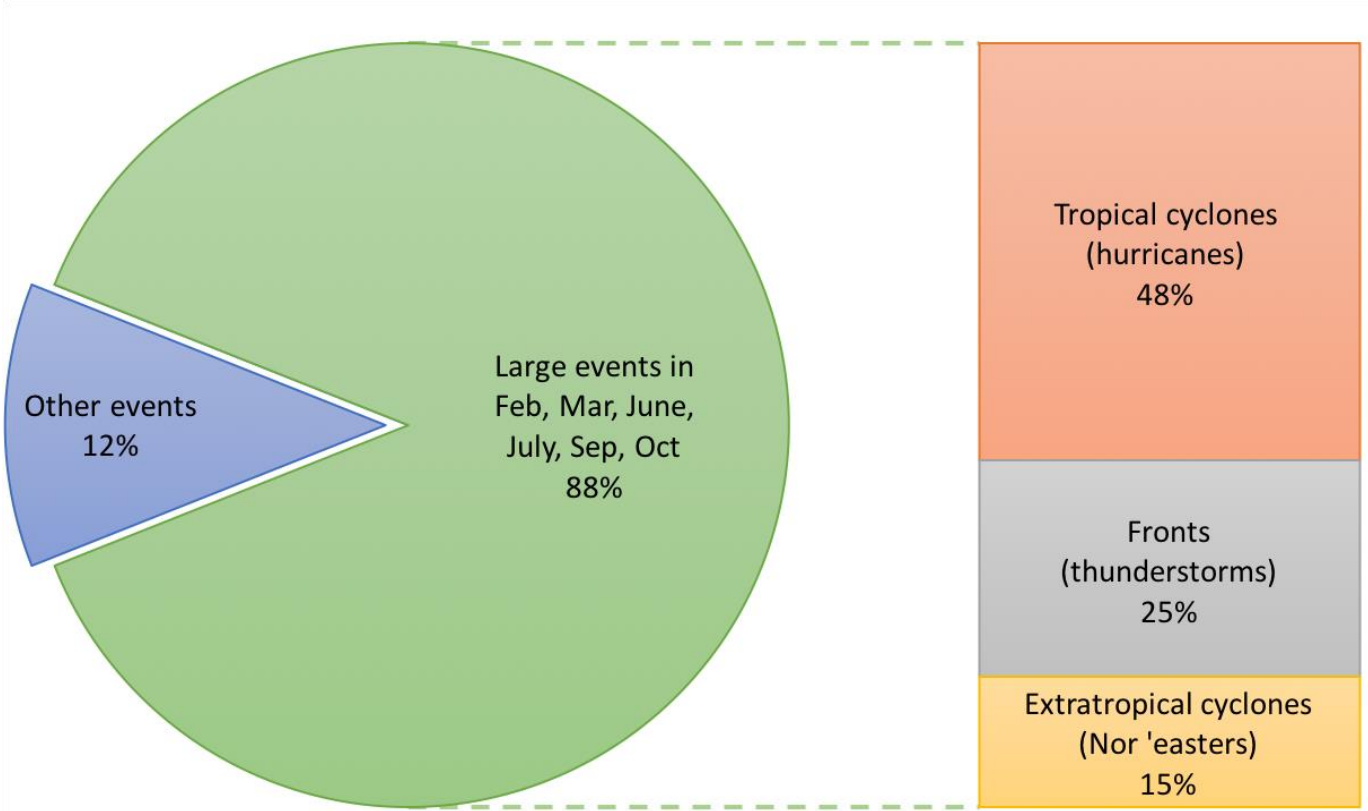
Why Has Extreme Precipitation Increased?

- Global Historical Climatology Network – Daily (GHCN-D): Menne et al. 2012; 210 stations; 1979-2016
- US Daily Weather Maps: NOAA; 1979-2016
- Focus on 5+ station events in early fall (Sep-Oct), early. summer (Jun-Jul), and late winter (Feb-Mar), which explain 88% of the 1996 increase



Huang et al., 2018

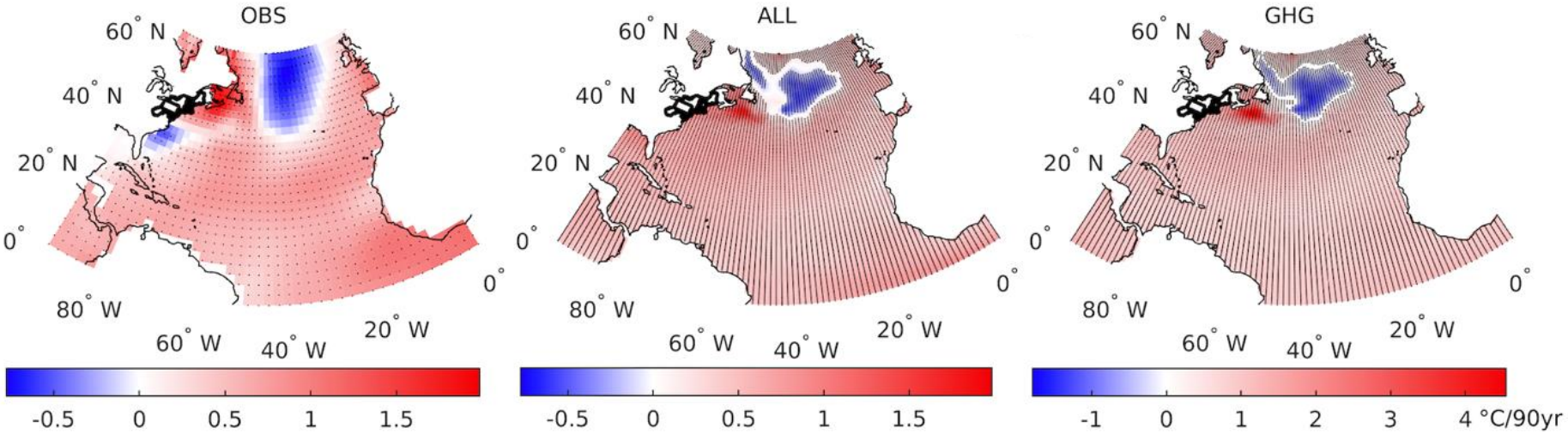
Northeast Extreme Precipitation Increase Driven by Tropical Cyclones and Fronts



Huang et al., 2018

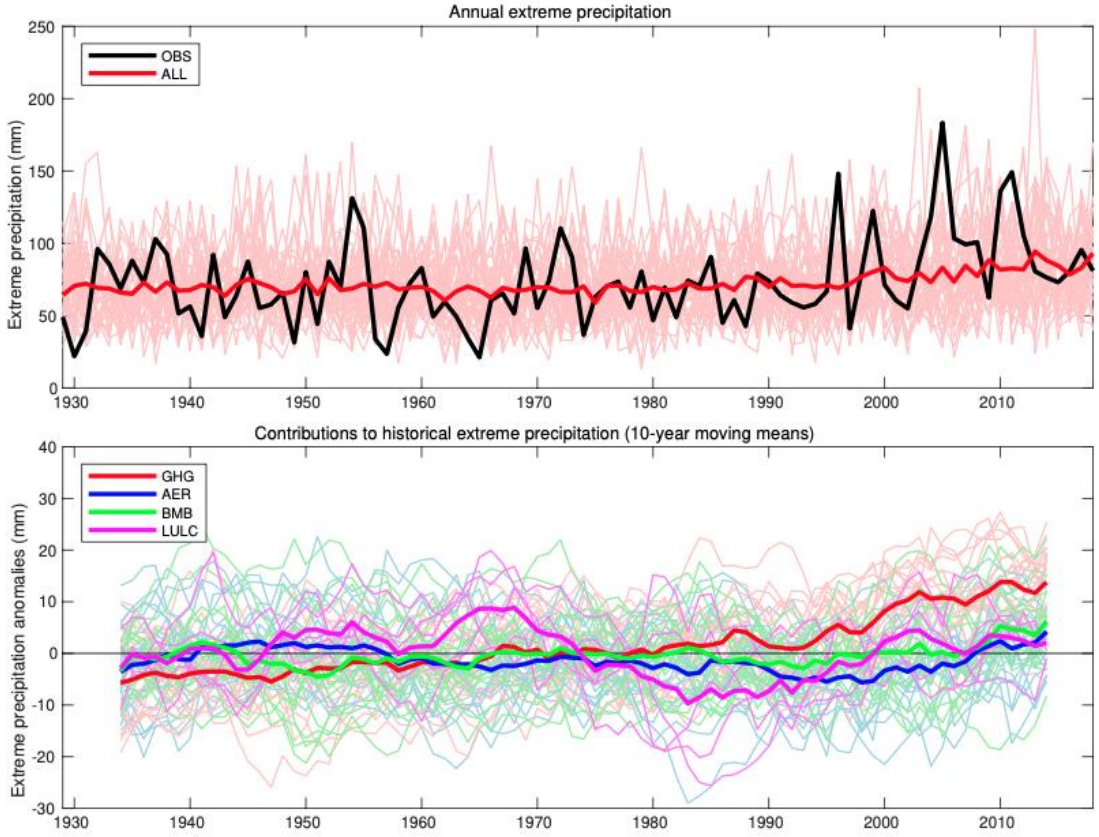
Is the Extreme Precipitation Increase Caused by Climate Change?

- Global Historical Climatology Network – Daily (GHCN-D): Menne et al. 2012; 220 stations; 1929-2018
- CESM1 40-member Large Ensemble (LENS); CESM1 Single Forcing Ensemble: Kay et al., 2015; Deser et al., 2020; 1929 to 2018; RCP 8.5



Huang et al., 2021

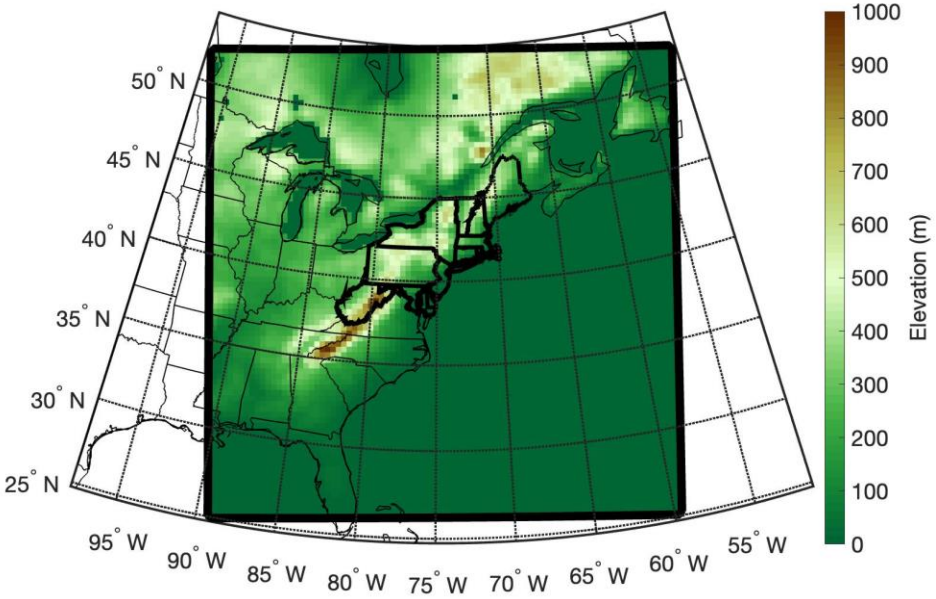
Climate Change Has Contributed to Increasing Northeast Extreme Precipitation



Huang et al., 2021

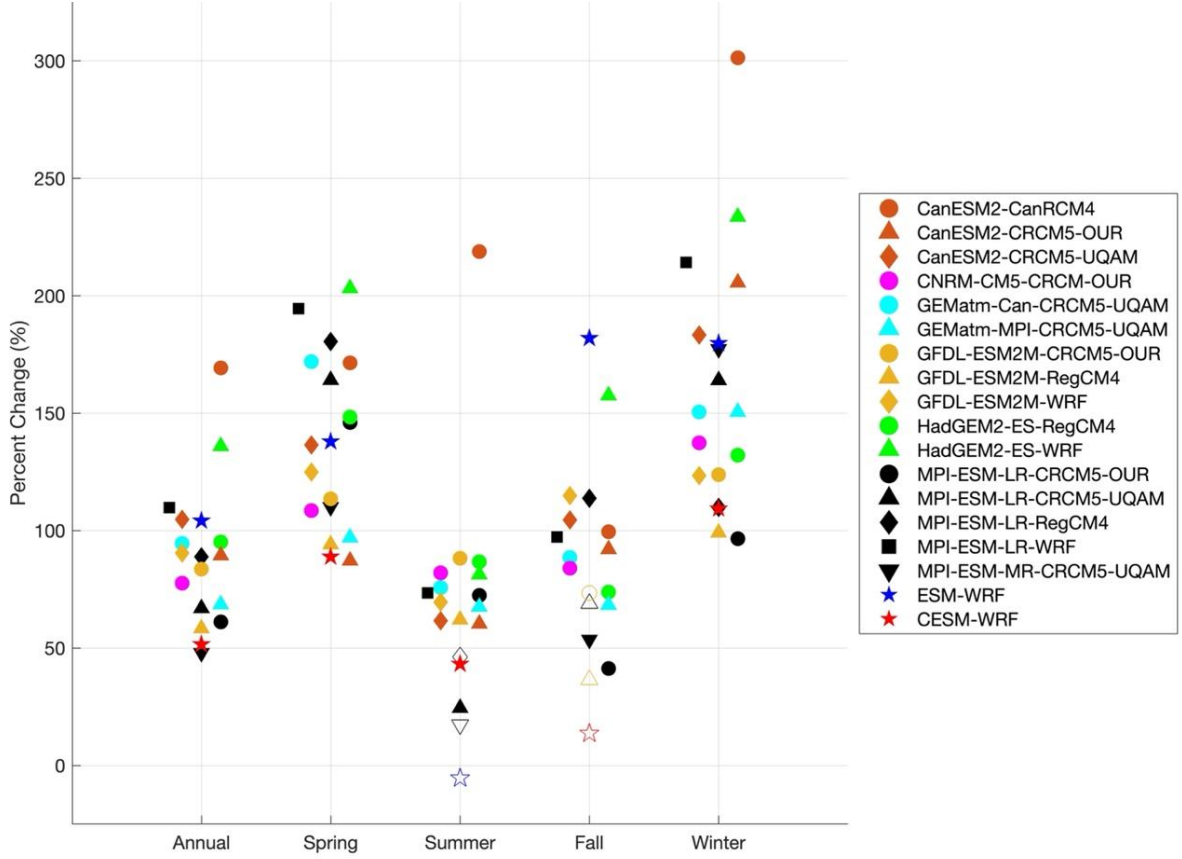
How Will Extreme Precipitation Change in the Future?

- Weather and Research Forecasting Simulations: 36 km resolution, 1976-2099
- Forced with two global climate models (CESM and MPI ESM) and two greenhouse gas emissions scenarios (RCPs 4.5 and 8.5)



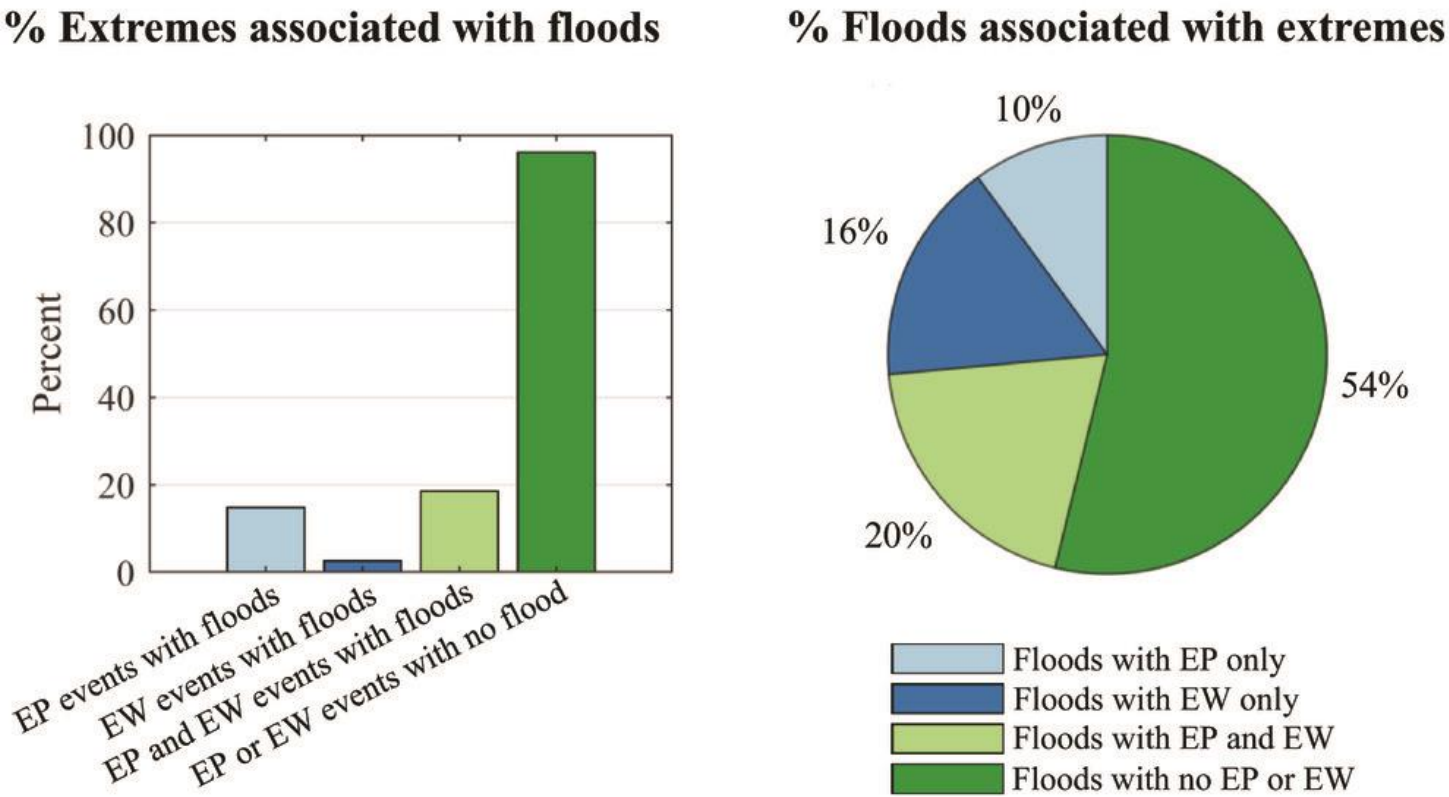
Picard et al., 2023

Extreme Precipitation is Projected to Increase 50%-100% by End-of-Century



Picard et al., 2023

What Kind of Extreme Precipitation Causes Damaging Floods?



Teale et al., 2024

Otter Creek – 15 June 2024. Photo: L-A.L. Dupigny-Giroux

Lesley-Ann L. Dupigny-Giroux, Ph.D.

Distinguished Professor – Geography & Geosciences, UVM
National Academies –Board on Atmospheric Sciences & Climate
Past President – American Association of State Climatologists
Lead author – Northeast chapter – Fourth National Climate Assessment
Fellow – Vermont Academy of Science & Engineering; Vermont Academy of Arts & Sciences
Fellow – American Meteorological Society
Fellow – Gund Institute of Environment
Fellow – African Scientific Institute
Vermont State Climatologist

Climate & climate change across Vermont & the Northeast

AASC AMERICAN ASSOCIATION OF STATE CLIMATOLOGISTS

Our changing climate

Hydroclimatic hazards in Vermont

severe storms

winter storms

drought

flooding

fires

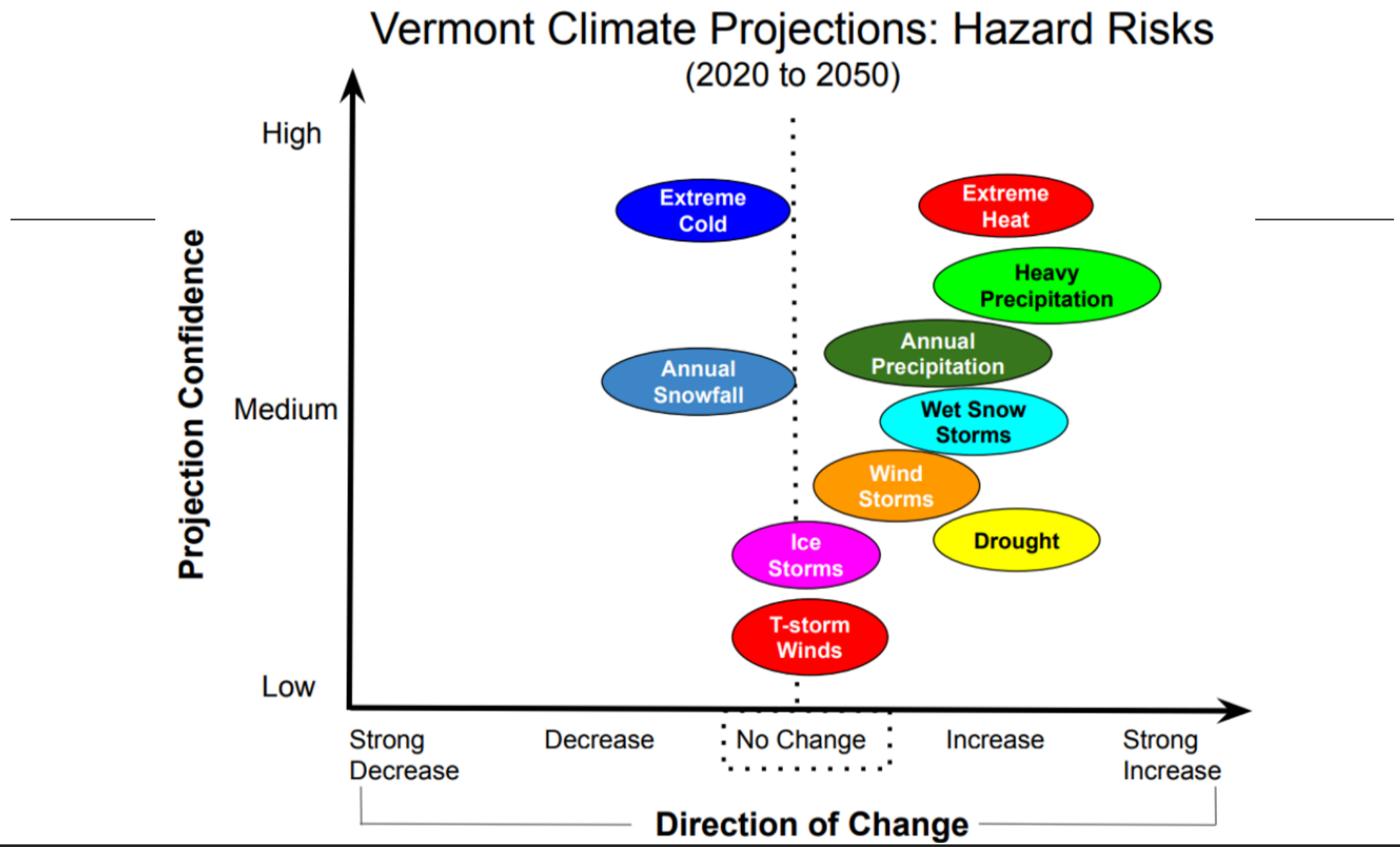
air pollution

temperature extremes

wind
- microbursts
- shirkshires

biotic
- insects
- disease

https://climatechange.vermont.gov/sites/climatecouncilsandbox/files/2021-12/Initial%20Climate%20Action%20Plan%20-%20Final%20-%2012-1-21.pdf



Dr. Jay Shafer, VT Climate Action Plan, 2021

Dr. L-A. Dupigny-Giroux

Forestry and tree crops

invasive species – emerald ash borer

wildfire threat

spring
- frosts and Christmas trees
- over-winter injury to red pine
- length and quality of maple sap productions

summer
- droughts and fall foliage (early)
- outbreaks and defoliation (FTC)

fall
- early frosts
- late freezes – leaf drop; early snowfall
- droughts & fall foliage (late)

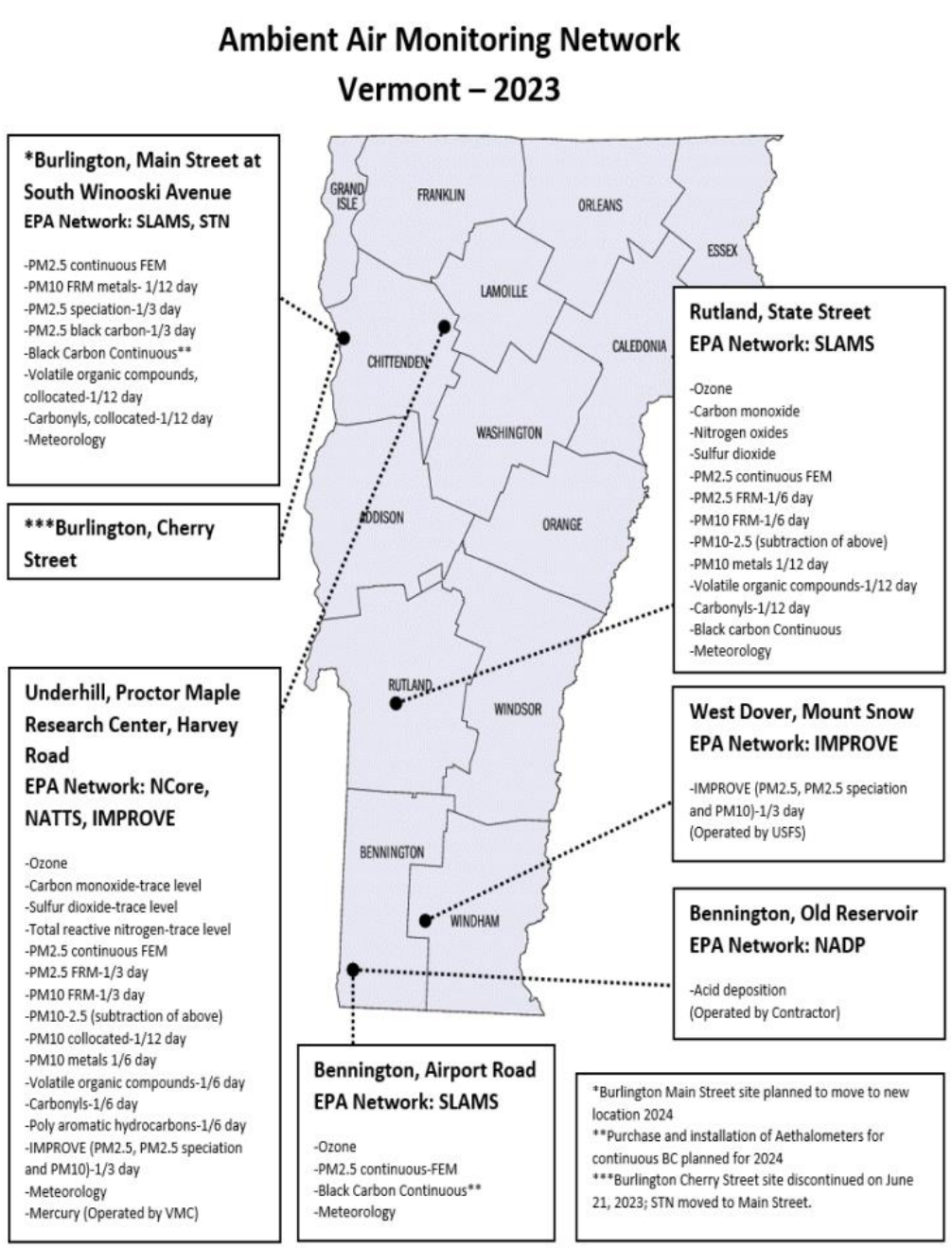
Backward spring

- low temperatures in January – June
- land-locked stations colder
- winter freeze/thaw cycles – predictor
- snow, freezing rain – April to June
- summer killing frosts
- summer drought
- NW flow

Photo credit: L-A. & M. Dupigny-Giroux

Dupigny-Giroux, L.-A. (2009) "Backward seasons, droughts and other bioclimatic indicators of variability," in Historical climate variability and impacts in North America, Lesley-Ann Dupigny-Giroux and Cary Mock (Editors), Springer Publishers, pp.231-250.

Air quality



https://dec.vermont.gov/air-quality/air-monitoring-section/monitoring-network-design

Ground-level ozone

Ozone Injury to White Ash
Photo by Gretchen Smith

reduces plant growth & vigor

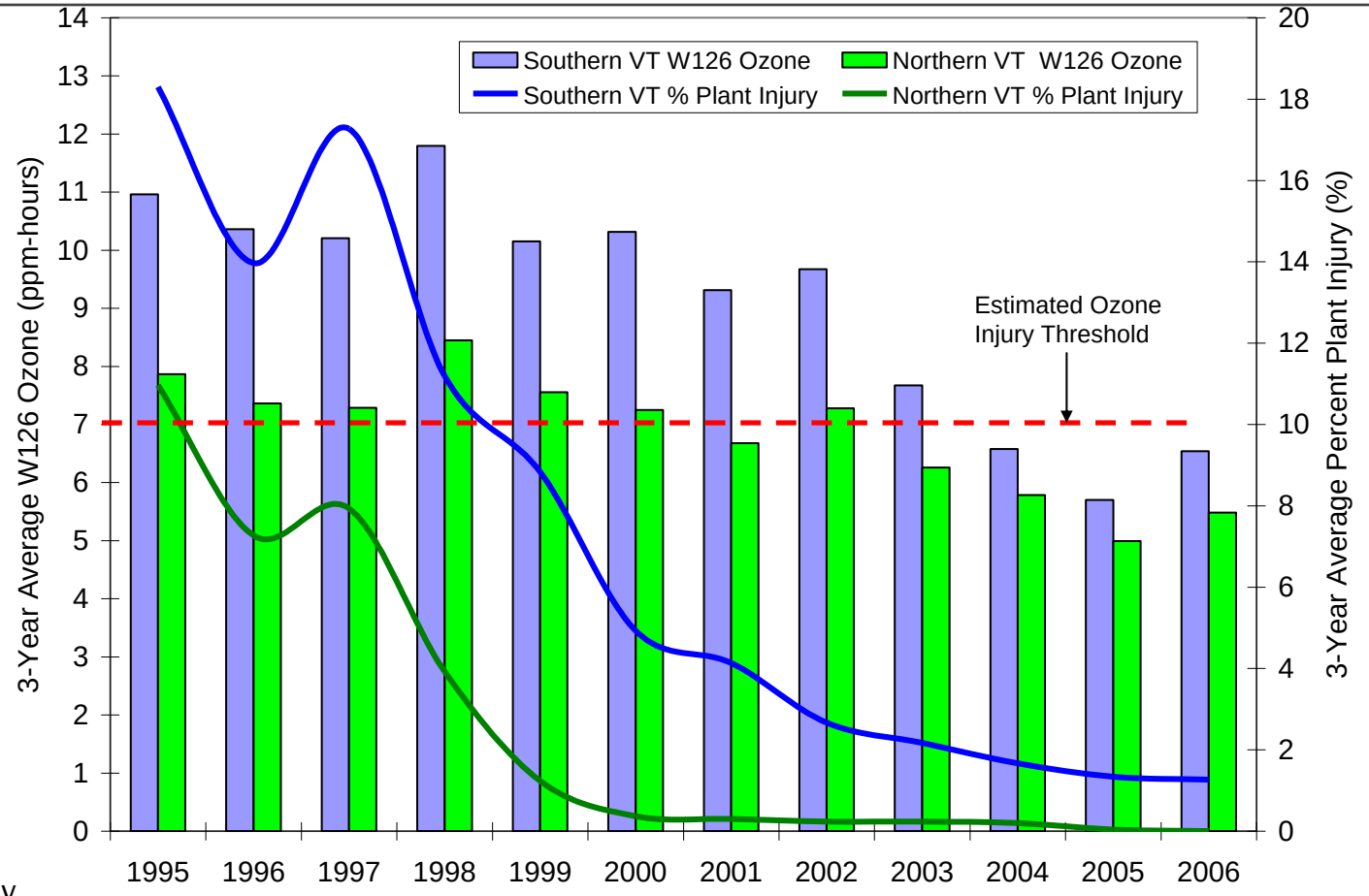
reduces seed production

increases susceptibility to insects & disease

cumulative effect over growing season

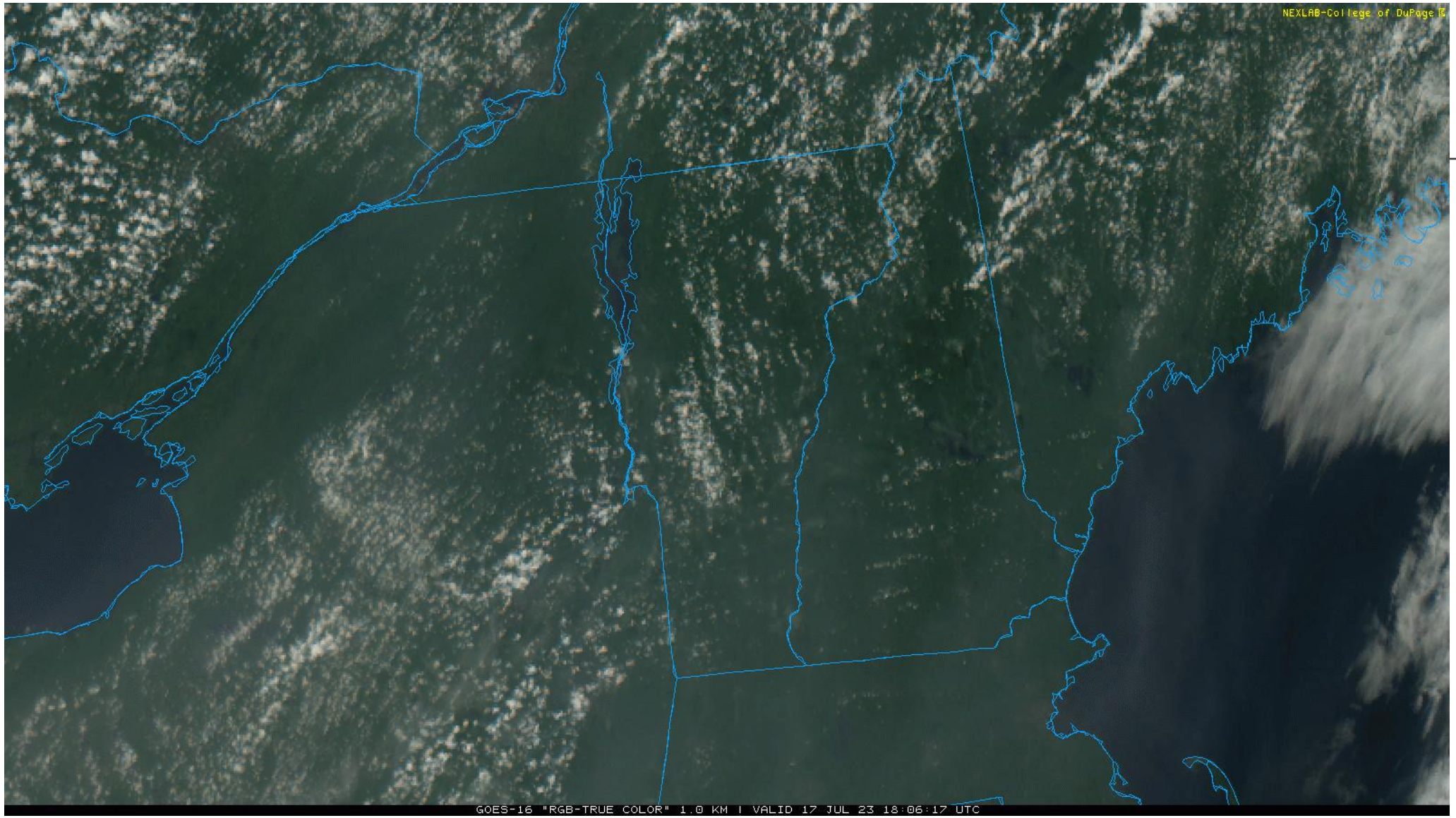
Black cherry, white ash, yellow poplar

Three-Year Average Trends in Ozone Pollution & Plant Injury in Northern & Southern VT



Courtesy R. Poirot – VT ANR/Air Quality

Wildland fire smoke – 17 July 2023



Winds

Microburst

A microburst is a small downburst with an outflow less than 2½ miles (4 kilometers) in horizontal diameter and last for only 2-5 minutes. Despite their small size, microbursts can produce destructive winds in excess of 160 mph. They can also create hazardous conditions for pilots and have been responsible for several disasters

Microburst in the Adirondack Mountains - Photo credit Mark Isselhardt

Downburst damage

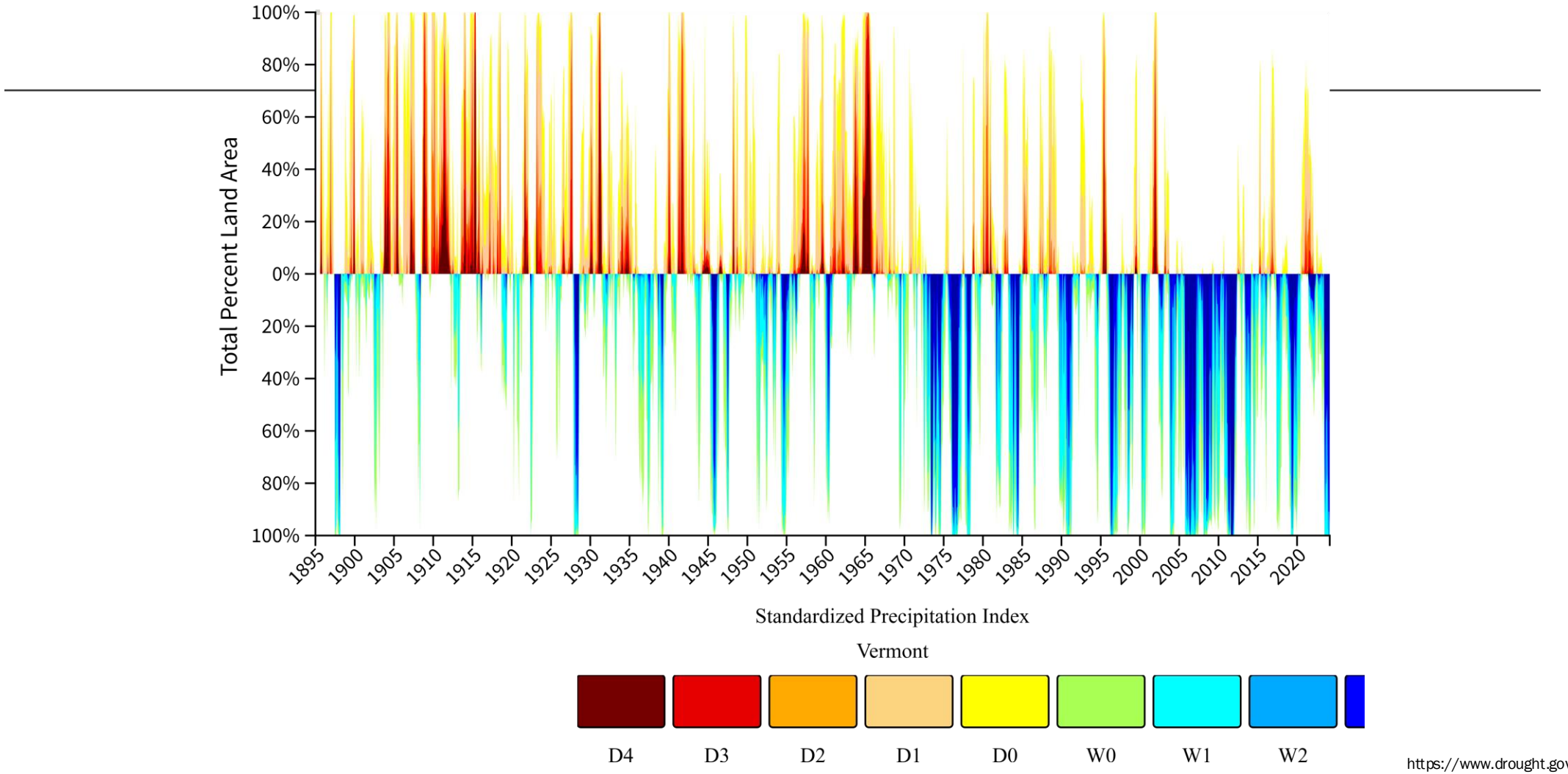
Straightline wind damage in Cavendish, Vermont.
Photo taken by Steve Hogan & Brooke Taber. (July 21, 2003)

Wind speeds 55-72 mph

Courtesy: NWS/BTV

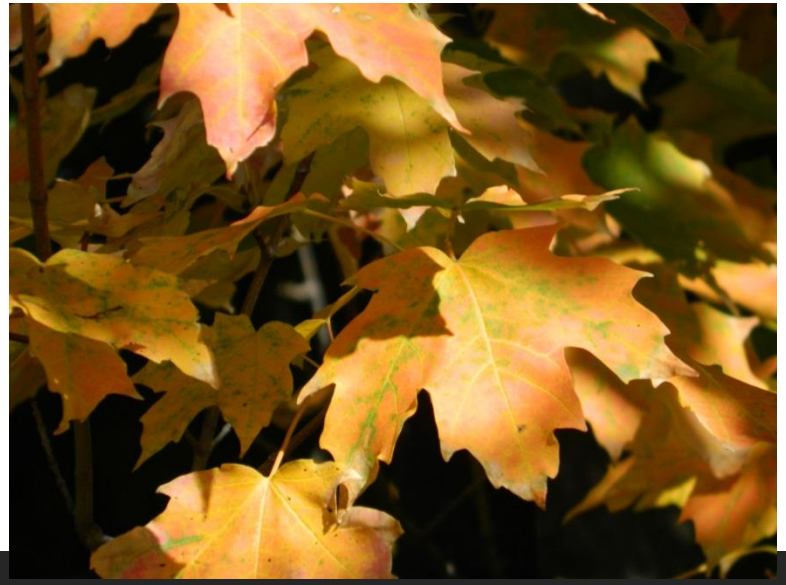
Moisture

Droughts in Vermont - 1895 to present



https://www.drought.gov/states/vermont

Concurrent stressors – Sept. 2016

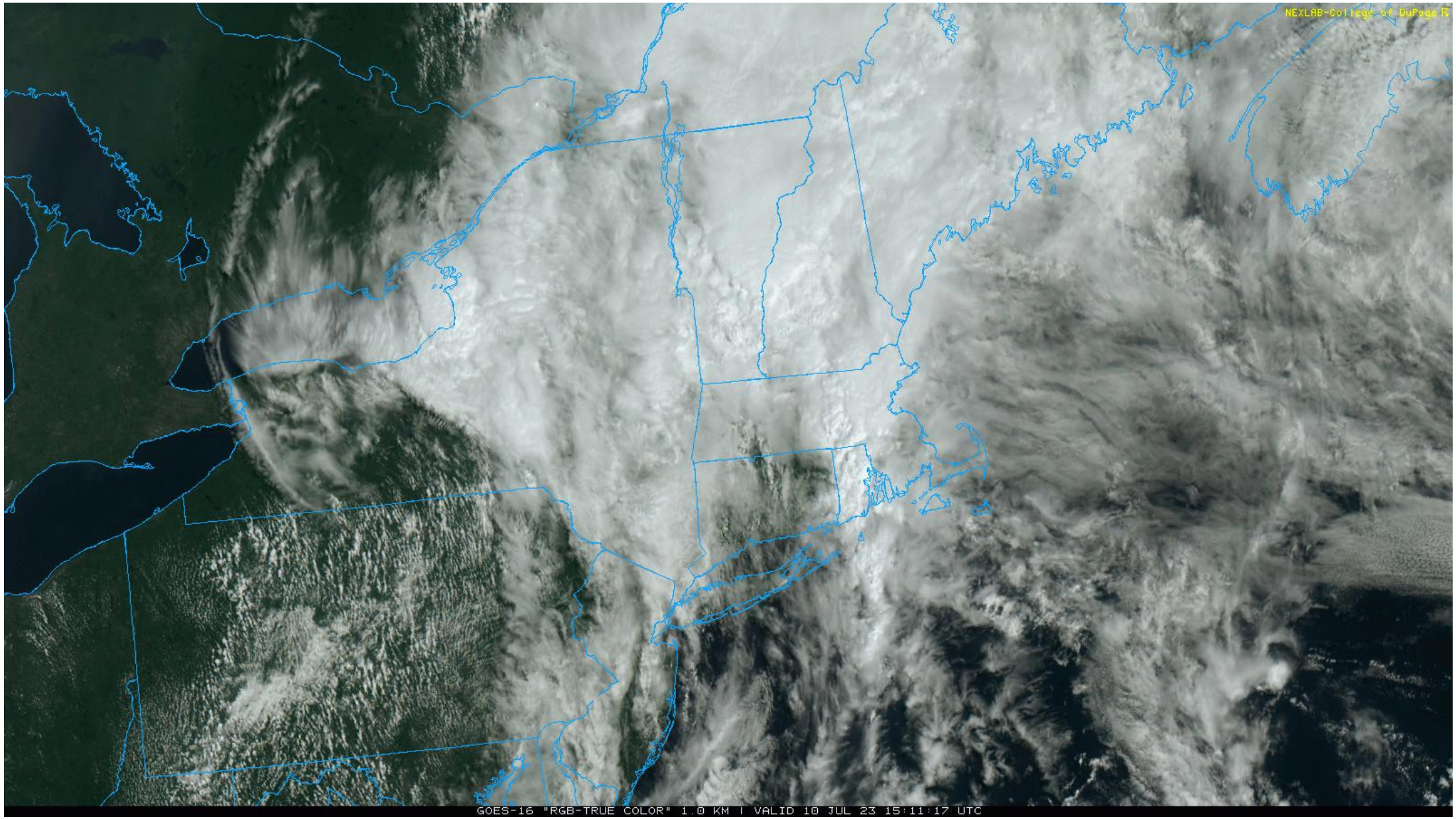


Photos: L-A. Dupigny-Giroux

Concurrent stressors in 2006

Photos: L-A. Dupigny-Giroux

10 July 2023


NEXLAB-College of DuPage
GOES-16 "RGB-TRUE COLOR" 1.0 KM | VALID 10 JUL 23 15:11:17 UTC

TS Irene – moisture disturbance

https://www.youtube.com/watch?v=H71fsL-0r_4

Thank you!

For more information contact:

Dr. Lesley-Ann L. Dupigny-Giroux

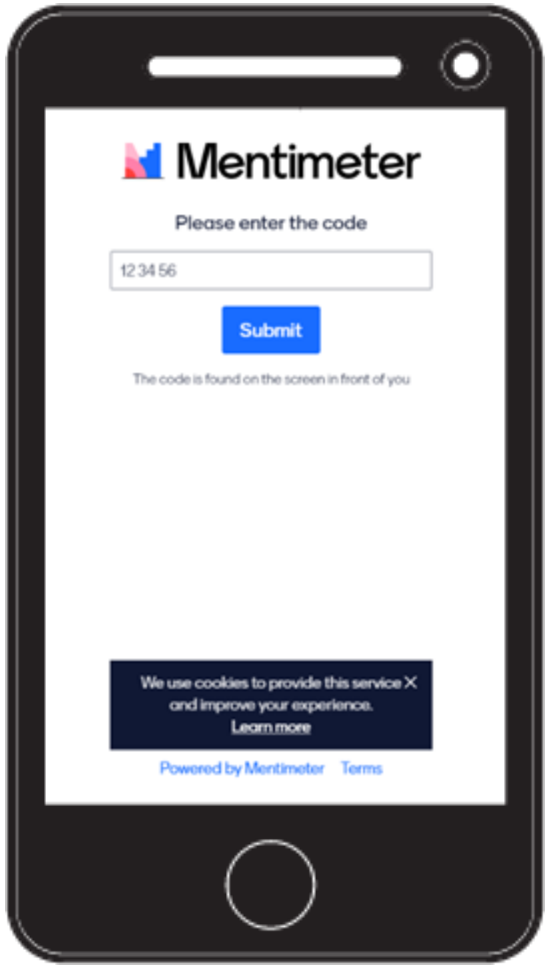
ldupigny@uvm.edu

802-656-2146

Mentimeter Activity

- Find your way to menti.com on your computer or phone!
- Use access code: **9518 3746**
- Or, navigate there using the QR code or link below:

https://www.menti.com/blfhu77jn1tt



Identifying Forest Vulnerability to Climate Change Impacts




USDA

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

NIACS

University of Vermont

FEMC Conference
December 2024

ASSESSING CLIMATE VULNERABILITY

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes.

ASSESSING CLIMATE VULNERABILITY

Regional to Site-Specific: Research and assessments describe **broad trends** but **local conditions** and **management** make the difference.

Site Characteristics: Geophysical

- Slope
- Forest floor depth
- Soils

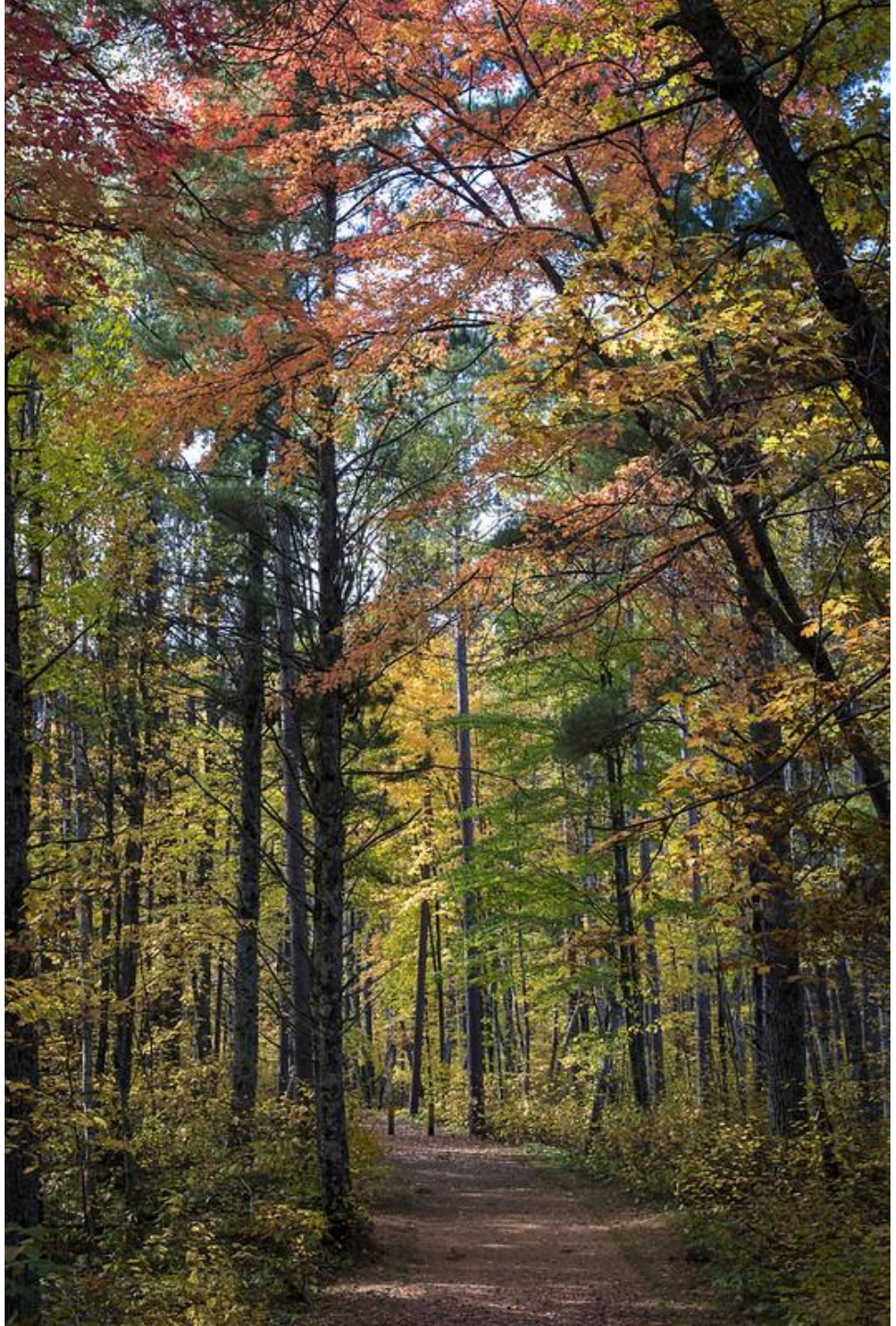
Forest stands with steeper slopes, shallow litter/duff layers, and certain soils may exacerbate impacts of extreme precipitation such as runoff, erosion, or even landslides.

Image: Kailey Marcinkowski (NIACS)

Site Characteristics: Vegetation

- Structural diversity
- Species diversity
- Canopy closure

Stands with more homogenous structure and fewer tree species may be more vulnerable to extreme precipitation depending on species-specific adaptability.



Site Characteristics: Land Use History

- Fragmentation and development
- Old or retired infrastructure
- Altered hydrology

Stands with or near impermeable surfaces, with aging or poor infrastructure, and/or altered hydrology (as along a roadway) may be more vulnerable to impacts from extreme precipitation.

Interactions are Critical

Climate change is a "threat multiplier"

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

Interactions make all the difference.

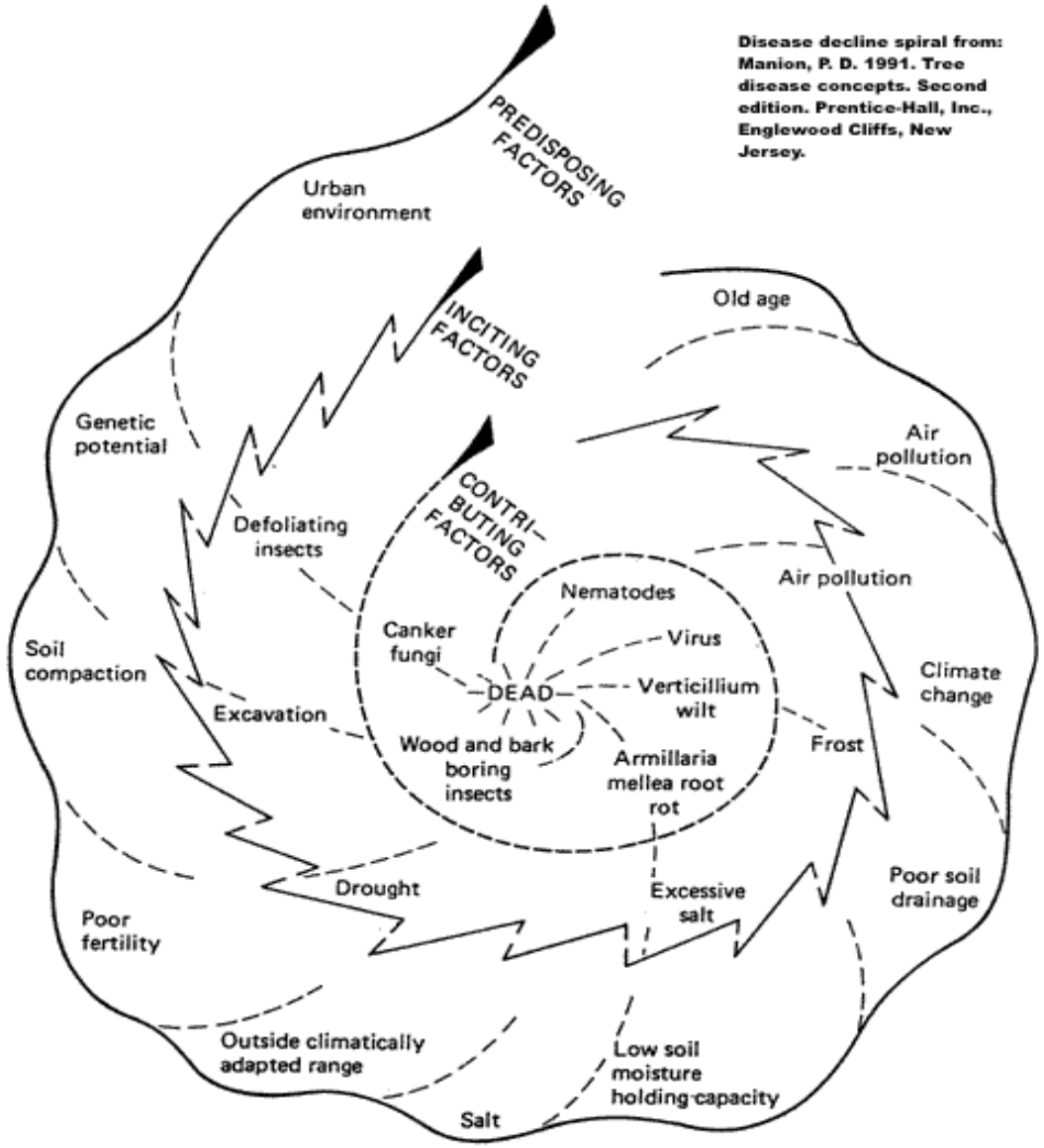


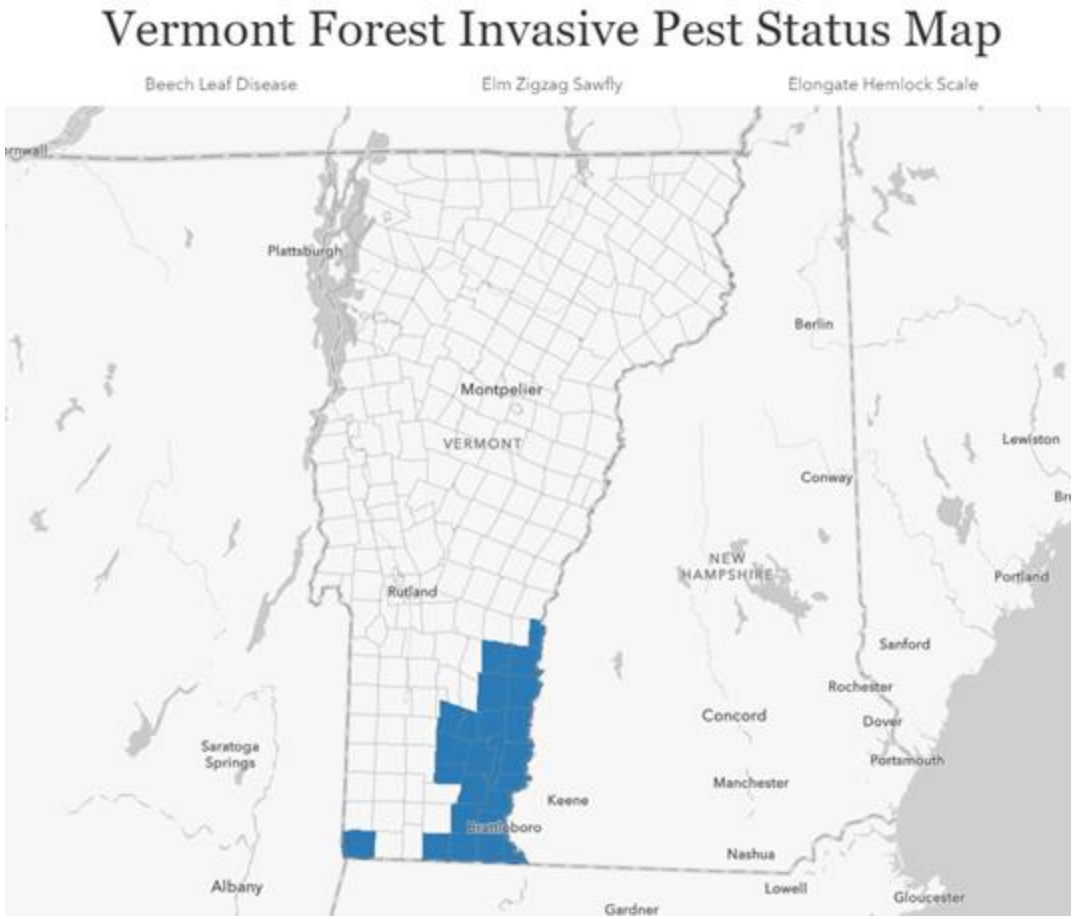
Image: Manion 1991

Insects and Diseases

Increased damage from forest insects & diseases

- Pests migrating northward
- Accelerated life cycles due to less frequent cold lethal temperatures
- Stress from other impacts increases susceptibility (Indirect)

What may be at risk:
Increased tree mortality; reduced canopy complexity; reduced tree health/vigor to withstand flood events; increased susceptibility to fungal diseases



Extent of current hemlock woolly adelgid detections in Vermont as of 2024 - VTFPR Pest Status Map

Ayres and Lombardero 2000, Parmesan 2006, Dukes et al. 2009, Weed et al. 2013, Sturrock et al. 2011, USFS 2019

Invasive Plants

Increased habitat for many noxious plants

- Expanded ranges under warmer conditions
- Increased competitiveness from ability of some plants to take advantage of longer growing season
- Disturbance from other impacts can affect potential for establishment and spread (Indirect)

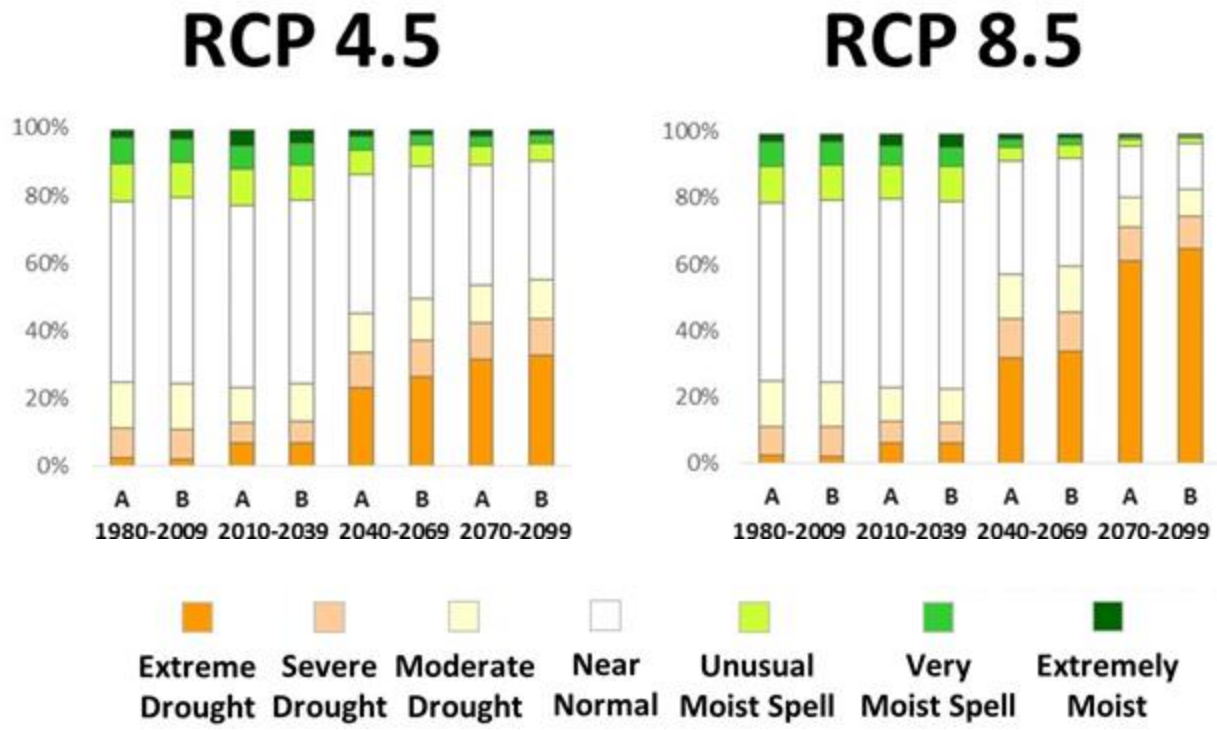
What may be at risk:
Reduced tree regeneration and stand complexity; reduced forest floor and soil nutrient loss from earthworms; flashier floods and increased soil erosion

Dukes et al. 2009, Hellman et al. 2008

Drought?

Palmer Drought Severity Index (PDSI) for the Northeast under two greenhouse gas emissions scenarios

What may be at risk: Increased plant/tree stress, mortality, and conditions vulnerable to runoff and erosion



Asbjornsen et al. 2019; Image: Matt Peters

Warmer Winters (Less Snow, More Rain)

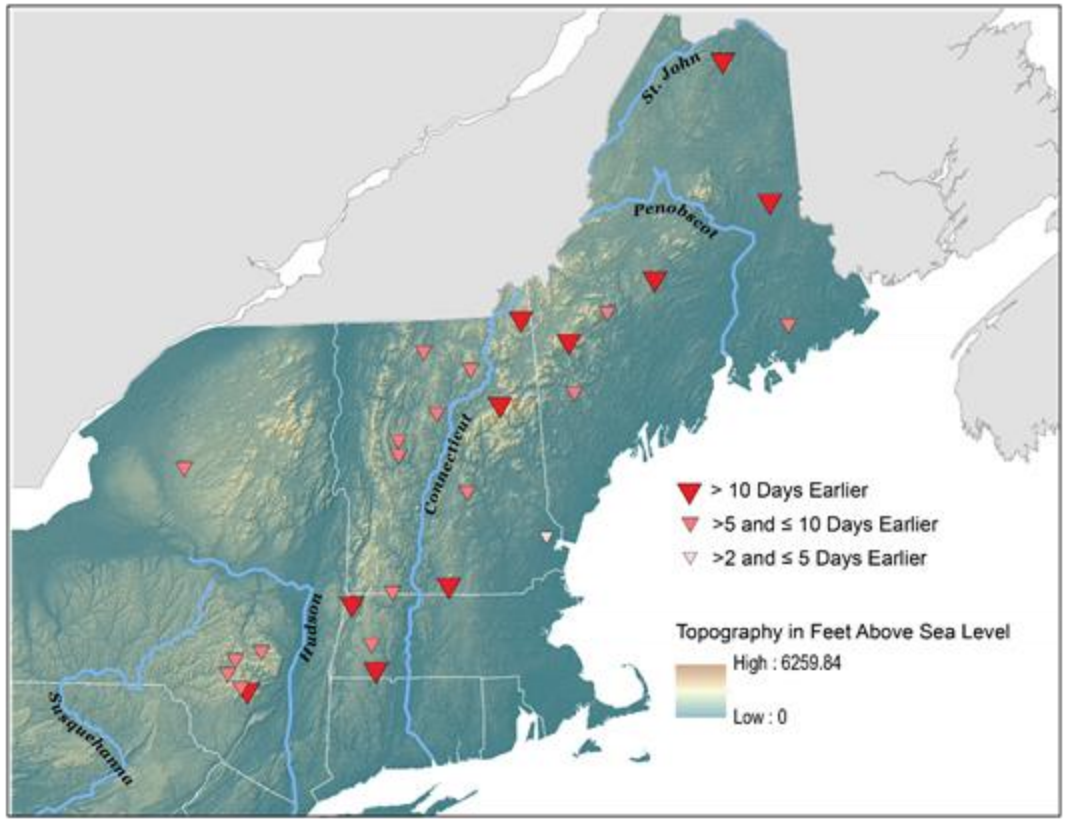
More rain

- Warmer temperatures
- Increased precipitation
- Extreme rain events

Earlier peak stream flows

- Flashiness and episodic high flows may increase

What may be at risk: Increased erosion or sedimentation on susceptible sites; culvert washouts and road damage from extreme events; aquatic habitats and species



Historical changes in the timing of snowmelt-related streamflow (1960-2014)

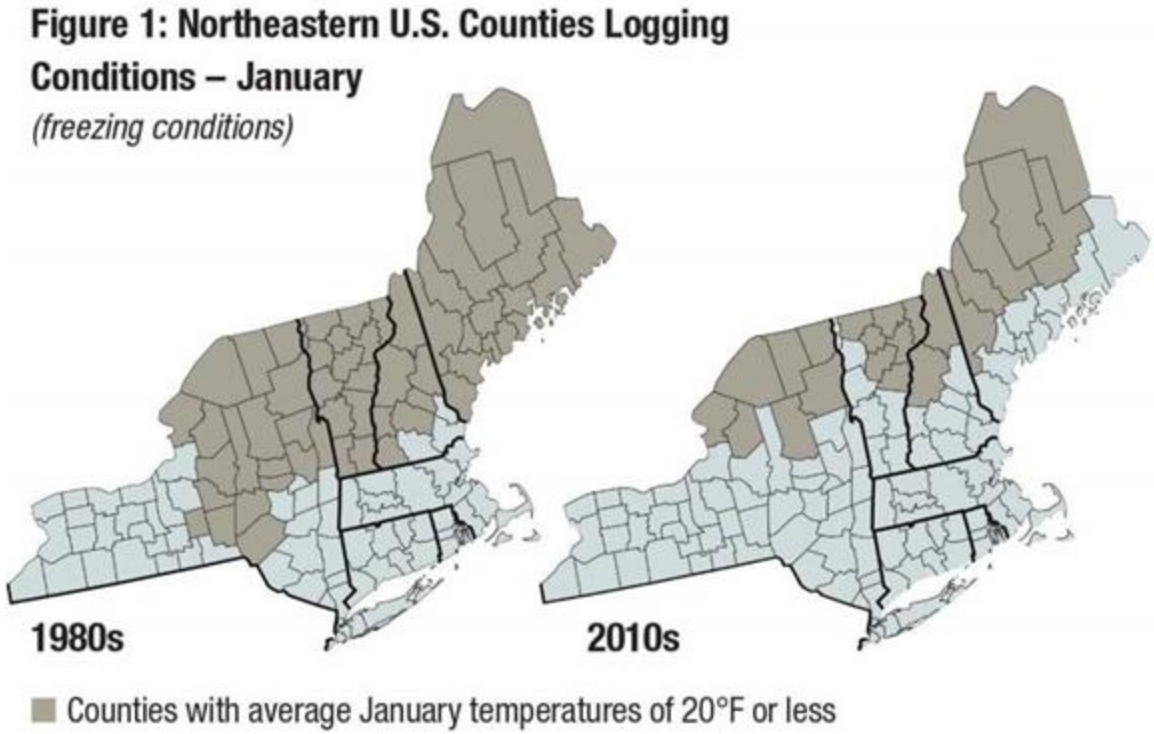
Dale et al 2001, Huntingon 2004, Parmesan 2006, NCA 2018

Warmer Winters (Less frozen ground)

Warmer minimum temps

- Warmer day and nighttime minima
- Earlier and unpredictable freeze thaw cycles
- Freezing later in the season and for less long

What may be at risk: Operability - Increased site disturbance, soil C loss, and difficulty bidding or completing contracted harvest operations; recreation



(Bick et al. 2019)

Putting it in the Landscape Context

- Each site will have different vulnerability to extreme climate change impacts
- Past, present, and future disturbances **including management** can influence current and future forest vulnerability at the site level (e.g., buffer or exacerbate)
- Having a **diversity of forest conditions across the landscape** can provide multiple possible pathways to recover from extreme events (i.e., enhance landscape-scale resilience)

Thank you!

Mattison Brady (mattison.brady@uvm.edu)
Samantha Myers (smyers3@uvm.edu)

Discussion: Information, research, and analysis gaps and needs

- Find your way to menti.com on your computer or phone!
- Use access code: **9518 3746**
- Or, navigate there using the QR code or link below:

https://www.menti.com/blfhu77jn1tt