Climate Change in New Hampshire: Making the Connections

Deerfield, March 2018  
Grafton Co, July 2019  
Deerfield, September 2020

Explore Lakes with NH LAKES  
December 2, 2020

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2019 marks the fifth consecutive year (2015-19) in which 10 or more separate billion-dollar disaster events have impacted the U.S.

https://www.ncdc.noaa.gov/billions/
NH Presidentially-Declared Extreme Weather Events

- 1953-2002 (50 Years)
  - 15 Disaster Declarations
  - 3 Emergency Declarations

- 2003-2018 (16 Years)
  - 21 Disaster Declarations
    - Hurricane
    - Tropical Storm
    - Severe Storms
      - Fall Snow Storm
      - Flooding events
    - Winter Storms
    - Landslide
    - Tornado
  - 10 Emergency Declarations

Source: FEMA.gov
Federal Reimbursement for Extreme Weather in NH
(millions $ 2017)

1998: Ice Storm
2005: Alstead/Keene Floods (Oct)
2006: Mother’s Day Flood (May)
2007: Patriots Day Flood (April)
2008: Tornado; Floods; Ice Storm
2010: Windstorm; Floods
2011: Irene
2012: Sandy; Flooding
2013: Severe Winter Storm; Landslide; Flooding
2015: Severe Winter Storm
2017: Severe Winter Storm; Severe Storm; Flooding
2020 January Weather

Higher than average temperatures
Lower than average snowfall

Sunday, January 12

Portland broke its daily max temp record at 52 (old record 51 in 2014) and Concord did the same at 67 (old record 61 in 1885!)

National Weather Service
January 2020 was the planet's warmest January since record keeping began in 1880.
Feb 9, 2020

20°C (68°F)

120 square miles of ice broke off

January – June

Much above average temperatures
Below average precipitation
Summer Heat

- Increasing days over 90 degrees are happening, but more significantly...
- Nighttime temps are increasing at a faster rate
- From 1940-2017 minimum temperatures have increased by 2.5 degrees F (statistically significant)
- Reducing night time cooling can have serious health effects
- Concord had it 4th hottest summer on record with 25 days above 90°
- Manchester had 32 days above 90° usually less than 10 (since 1980)
- Smothering summer humidity in the Northeast has crushed records
- Not going to change – will continue to move in this warmer than average direction

Acuweather | NOAA
HIGH HUMID HEAT DAYS

% INCREASE

Humid heat days based on wet bulb temp.
Source: U.S.A. National Phenology Network

https://www.climatecentral.org/
The Northern Hemisphere had the warmest summer on record
Verkhoyansk
100.4 degrees June 20, 2020

Highest temperature in the Arctic since record keeping began in 1885

Arctic is warming 3x as fast as the rest of the world

400 miles farther north than Anchorage, AK

Warmer than Dallas or Houston

Washington Post/NASA
Siberia hotter than average in first five months of year

January to May 2020 average temperatures relative to the 1951-to-1980 average

-3°C to +9°C

Source: Berkeley Earth

John Muyskens/The Washington Post
September 15, 2020 was the second lowest in the 42-year satellite record

The 14 lowest extents in the satellite era have all occurred in the last 14 years

By the end of October, 2020 Arctic Sea Ice had Still Not Formed in Siberia — the Latest Date on Record

Climate Central + National Snow and Ice Data Center + Yale.edu
Western Wildfires and Air Quality

“Smoke from Western Wildfires leading to hazy skies, vibrant sunsets over NH”  
WMUR Sept 15, 2020

Acuweather

Scotts Mills, OR  
Sept 15, 2020

AirNow.gov
Wildfires in NH

207 fires, ~ 83 acres

Merrimack River Island Fire Burns Out of Control in Concord (Sept 22)

Wildfires in White Mountains
“The fire had burned two feet down into the ground... no soil moisture”
Fire Chief Steven Sherman

Sept 26 - Governor issued a proclamation that bans both outdoor burning and smoking in and near New Hampshire woodlands statewide due to the extremely high danger of wildfires
Drought

DES Raises Risk Of Multi-Year Drought As NH Heads Toward Winter
Hurricanes

- 30 named storms in 2020, second only to 2005's 28 storms.
- 13 hurricanes, 6 major hurricanes
- 12 named storms, including six hurricanes, have made landfall in the U.S. this season
- Unusually active October and November
- Latest Category 5 storm, Iota, ever (Nov 16)
- Warm ocean and sea surface temperatures
- Warming planet
Scientists now link extreme weather events to carbon dioxide in the air from the burning of fossil fuels.

More atmospheric CO$_2$ has boosted the odds of extreme heat, extreme cold, drought, + punishing rain/snow storms....
“As the climate has warmed over the years, a new pattern of more frequent and more intense weather events is unfolding in the U.S. and across the globe. Because of a rapidly advancing new area of science called ‘event attribution,’ we can now estimate how climate change increases the risk to society of some types of extreme events.”

Marcia McNutt, President, National Academy of Sciences

A new pattern of more frequent and more intense weather events....

new area of science called ‘Event Attribution’

...we can now estimate how climate change increases the risk to society of some types of extreme events.
Hurricane Florence forecasted attribution statement

- "We find that rainfall will be significantly increased by over 50% in the heaviest precipitating parts of the storm."
- "...and that the storm will be approximately 80 km in diameter larger at landfall because of the human interference in the climate system."
- The first attribution statement made in advance of a storm.
- These statements are holding up in the retrospective analysis since the storm.

- Much public interest.

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Alyssa M. Stansfield
Michael Wehner
Colin Zarzycki
Weather and Climate

Weather – the set of conditions at any given point in time
- today, tomorrow, this week

Climate - the average set of conditions over a period of decades
- 30 year averages
• Over the past 50 years, the average global temperature has increased at the fastest rate in recorded history.
• Burning of fossil fuels to for transportation is the largest source of heat-trapping pollution. Second is electricity generation (2016)
Global Warming Causes the Climate to Change

• Greenhouse gases trap heat
  – Warming of our atmosphere causes warmer overall temperatures
  – Changes to water cycle (some more rain, some less rain)
  – Warms oceans, Melts glaciers, Sea-level Rise
  – Effects plant growth

• Industrial Revolution
  – Raised atmospheric carbon dioxide levels from 280 parts per million to 411 parts per million in the last 150 years
Measuring Carbon Dioxide

- Ice cores
- Ambient Monitoring
  - Mauna Loa
collecting data since 1956
**Atmospheric Carbon Dioxide Record**

- **Carbon Dioxide (ppmv)**
- **Years before 2000 AD**

- **CO**$_2$ concentration over time, showing a significant increase post-Industrial Revolution.

- The graph indicates a steady rise in CO$_2$ levels, peaking at 411 ppm in the current era.

Petit et al., 1999
Atmospheric Carbon Dioxide & Temperature Record

Carbon Dioxide (ppmv)

Temperature (°C)

Years before 2000 AD

Atmospheric CO₂ and temperature record showing peaks and troughs over millions of years before 2000 AD, with a notable increase to 411 ppm in recent times.

Petit et al., 1999
10 HOTTEST YEARS ON RECORD GLOBALLY

Last 5 = Hottest 5

Source: NASA GISS & NOAA NCEI global temperature anomalies (°C) averaged and adjusted to early industrial baseline (1881-1910). Data as of 1/15/2020.
Wobbly Jet Stream

January 20-29, 2019 Polar Vortex
The Changing Jet Stream

- The jet stream exhibits extreme behavior
- During the summer, warm air holds more moisture + when stirred by a hurricane, the moisture manifests as intense rainfall
- Same phenomena as the polar vortex in winter
- Predicted to increase by 50% this century if emissions of carbon dioxide + other GHG continue unchecked

Michael Mann, climate scientist at Pennsylvania State University
The oceans’ circulation hasn’t been this sluggish in 1,000 years.

The ocean circulation has declined in strength by 15% since the mid-20th century.

This is a new record low.

Over the past 15 years the Gulf of Maine has warmed 7 times faster than the rest of the ocean.
Local and Regional Climate Assessments

Seacoast

Southern NH

Northern NH

Local Data!

http://sustainableunh.unh.edu/csne-climate-assessments-new-england#map
Observed Climate Patterns and How This Impacts Us

- Increase in precipitation – rain + snow
  - Amount + intensity
- Increase in average temperature
- Increase in extreme weather
- Changing seasonality
- Drought
- Sea-level rise
  - Portsmouth’s sea level has risen 6” since 1926
  - Weekly high tide flooding in Hampton
  - Increases in ground water levels
Observed Change in Very Heavy Precipitation

from 1958 to 2012

WINTER WARMING
SINCE 1970 (°F)

Average winter temperature (Dec-Feb).
Source: NOAA/NCEI Climate at a Glance
Drought 2016

Known Water Use Restrictions and Bans
Last Update: October 13, 2016

Legend
- County Boundary
- Town Boundary

Municipality or Water System Status
- Outdoor Use Ban
- Restriction
- Voluntary Restriction or Ban

Drought Condition
- Abnormally Dry
- Moderate Drought
- Severe Drought
- Extreme Drought


Disclaimer: The status of water use restrictions and bans is based on information submitted to the New Hampshire Department of Environmental Services and may not be comprehensive.
Sea-Level Rise

Portsmouth, NH

Hampton, NH

King Tide
99% of climate scientists agree that climate-warming trends are likely due to human activity.
Climate Change is Already Occurring

The impacts of climate change are already being felt by communities across the country.

These extreme events (heat, cold, storms, drought) are disrupting and damaging critical infrastructure, labor/economies, natural resources, and the vitality of our communities.
We Have a Choice

Do nothing – Continue with business as usual
We Have a Choice

- **Mitigation**
  - Reduce emissions of CO$_2$ + other greenhouse gases
    - Reduce our use of fossil fuels

- **Adaptation**
  - Prepare for the current and future impacts
WELCOME TO THE FUTURE
Extreme Heat

Average number of days over 90 degrees per year

- south of 43.9°N
- north of 43.75°N

Overlap of 0.15° ~17 miles

Climate Change in Southern/Northern NH – CSNE
https://sustainableunh.unh.edu/csne-climate-assessments-new-england
The growing season is projected to lengthen by about two weeks (lower emission scenario) or five weeks (higher emission scenario).

Hotter temperatures, reduced chilling hours, enhanced evapotranspiration, and more extreme precipitation will likely result in a decrease in crop yields.

Climate Change in Southern/Northern NH – CSNE
https://sustainableunh.unh.edu/csne-climate-assessments-new-england
Annual precipitation is projected to increase 17 to 20% (both emission scenarios, both regions) by the end of the century.

Increase in extreme precipitation events, results in excessive runoff, flooding, damage to critical infrastructure (buildings, roads, dams, bridges, culverts), increased erosion & degradation of water quality...

Climate Change in Southern/Northern NH – CSNE
https://sustainableunh.unh.edu/csne-climate-assessments-new-england
Historically we had 105 [S]/140 [N] days per year with snow cover (>1” of snow).

By the end of the century (high emissions scenario), we could have only 52 [S]/~100 [N] days.

Snow Covered Days

From 105 to 52 days
From 140 to ~100 days

Climate Change in Southern/Northern NH – CSNE
https://sustainableunh.unh.edu/csne-climate-assessments-new-england
Exacerbating Issues

• Population increase
  – Displaced people
• Development increases – more pavement
• More homes built in risky areas
• Old infrastructure - undersized
• Federal funding decreases
• Politics
• Other?
Mitigation – reducing our fossil fuel use

- Saves money – now and into the future
- Reduces the amount we will have to adapt to

Adaptation

- Proactive adaptation—including changes to policies, business operations, capital investments + other steps—yields benefits in excess of their costs now + into the future. $1.00 invested now saves $7.00 to recover

Need to do both!
We Have Met Environmental Challenges in the Past!

45 years ago – Smog
   – Solution: Catalytic converters
   – Smog reduced by 30% to 50%
35 years ago – Ozone layer destruction
   – Solution: Chlorofluorocarbon (CFC) phase out
   – CFCs all but eliminated, ozone layer (slowly) rebounding
30 years ago – Acid Rain
- Solution: market-based program for regulating utility sulfur dioxide emissions
- Acid rain emissions cut by 50%; forests rebounding, lakes (slowly) recovering
• Climate change will cost taxpayers more than a half a trillion dollars this decade + trillions more in the future unless we mitigate the impacts. (Government Accountability Office)

• We cannot ignore the impact of climate change on our public health, our environment + our economy.

• The lessons will continue to be taught until they are learned.

• We’ve got to connect the dots!
• State Agencies
• Regional Workgroups
• Communities
• Conservation Groups
• Businesses
• Non-profits
• Schools
• Neighbors

• Shared voices
Questions?

Thank You

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Concerns for our Lakes

- Flooding
  - Infrastructure impacts
  - Runoff + erosion
  - Pollutants/bacteria/cyanobacteria
- Drought
  - Lower surface water + groundwater levels
  - Later “ice-in” and earlier “ice out”
    - Longer growing season for invasives + cyanobacteria
  - Less recharge
- Warmer temperatures
  - Changes to surface water stratification oxygen and nutrients
  - Decreased water quality