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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\$45 Billion



This map denotes the approximate location for each of the 14 separate billion-dollar weather and climate disasters that impacted the United States during 2019.

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



Axe Handle Brook, Rochester, NH, May 2006

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

Current Temps			3
PORTLAND, ME	37°	CONCORD, NH	60°
MANCHESTER, NH	62°	NASHUA, NH	64°
AUGUSTA, ME	33°	ROCKLAND, ME	37 °
LEWISTON, ME	34°	LEBANON, NH	60°
PORTSMOUTH, NH	61°	BERLIN, NH	37°
PLYMOUTH, NHI	39°	JAFFREY, NH	59°
ROCHESTER, NH	58°	LACONIA, NH	43°
KEENE, NHI	59°	MT WASHINGTON, NH	41°
WHITEFIELD, NH	41°	WISCASSET, ME	37°
FRYEBURG, ME	35°	SANFORD, ME	37°
WATERVILLE, ME 34° data valid as of Sen 9.35 am - NWS Gray			

Sunday, January 12

Portland broke it's 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





Land & Ocean Temperature Percentiles Jan 2020

NOAA's National Centers for Environmental Information

Data Source: NOAAGlobalTemp v5.0.0-20200206



January 2020 was the planet's warmest January since record keeping began in 1880



https://www.theguardian.com/world/2020/feb/13/antarctic-temperature-rises-above-20c-first-time-record



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





HIGH HUMID HEAT DAYS % INCREASE



https://www.climatecentral.org/

The Northern Hemisphere had the warmest summer on record



Data Source: 5km Gridded Dataset (nClimGrid)



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



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"



Acuweather



Hazardous AirNow.gov Very Unhealthy Unhealthy **Unhealthy for Sensitive Groups** Moderate Good

WMUR Sept 15, 2020

Scotts Mills, OR Sept 15, 2020

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



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, lota, ever (Nov 16)
- Warm ocean and sea surface temperatures
- Warming planet





weather.com

More CO₂ = More Extreme Weather

Scientists now link extreme weather events to carbon dioxide in the air from the burning of fossil fuels.

More atmospheric CO₂ has boosted the odds of extreme heat, extreme cold, drought, + punishing rain/snow storms....



Extreme Weather: What's climate change got to do with it?

"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

The National Academies Press. 2016 https://doi.org/10.17226/21852



Kevin A. Reed, Stony Brook University Alyssa M. Stansfield, Stony Brook University Michael F. Wehner, Lawrence Berkeley National Laboratory Colin M. Zarzycki, National Center for Atmospheric Research Center for Climate and Energy Solutions November 2018 webinar

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



- 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



Petit et al., 1999

Atmospheric Carbon Dioxide & Temperature Record



10 HOTTEST YEARS ON RECORD GLOBALLY Last 5 = Hottest 5



and adjusted to early industrial baseline (1881-1910). Data as of 1/15/2020.

CLIMATE CO CENTRAL

Wobbly Jet Stream



Source: R. Barry & R. Chorley (2009). <u>Atmosphere, Weather and Climate</u>.

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



Gulf Stream Weakening

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

Potsdam Institute for Climate Impact Research April 11, 2018 Gulf of Maine Research Institute

Local and Regional Climate Assessments



Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future



UNIVERSITY OF NEW HAMPSHIRE Climate Change in Southern New Hampshire PAST, PRESENT, AND FUTURE





Climate Change in Northern New Hampshire PAST, PRESENT, AND FUTURE



Northern NH

Seacoast

Southern NH



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

https://nca2014.globalchange.gov/report/regions/northeast

WINTER WARMING



Drought 2016





Sea-Level Rise



Portsmouth, NH

Hampton, NH

King Tide

Climate Change is Real



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 CO₂ + other greenhouse gases
 - Reduce our use of fossil fuels



- Adaptation
 - Prepare for the current and future impacts





Extreme Heat

Average number of days over 90 degrees per year



Overlap of 0.15° ~17 miles

The growing season is projected to lengthen by about two weeks (lower emission scenario) or five weeks (higher emission scenario)

Future Growing Season

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



Future Precipitation



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...

Snow Covered Days

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



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

Need to do both!

- 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

We Have Met Environmental Challenges in the Past!

45 years ago – Smog

- Solution: Catalytic converters
- Smog reduced by 30% to 50%



We Have Met Environmental Challenges in the Past!

35 years ago – Ozone layer destruction

- Solution: Chlorofluorocarbon (CFC) phase out
- CFCs all but eliminated, ozone layer (slowly) rebounding



We Have Met Environmental Challenges in the Past!

- 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



Making the Connections

 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!







Working Together

- State Agencies
- Regional Workgroups
- Communities
- Conservation Groups
- Businesses
- Non-profits
- Schools
- Neighbors
- Shared voices





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Questions?

Thank You



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





