Extreme Weather and Climate Change: Implications for Forest Health

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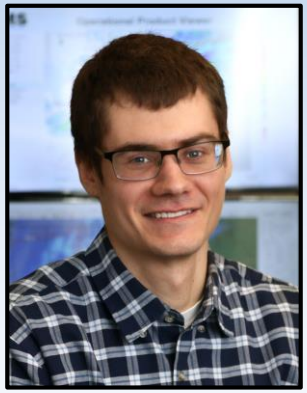


Kevin Cronin

Connor Pasquale

Northview WEATHER

Northern Vermont UNIVERSITY

vermont electric power company VELCO

Conference agenda: https://www.uvm.edu/femc/cooperative/conference/2020/agenda

Our Perspective - The Electric Grid Ecosystem

Majority of power outages caused by weather

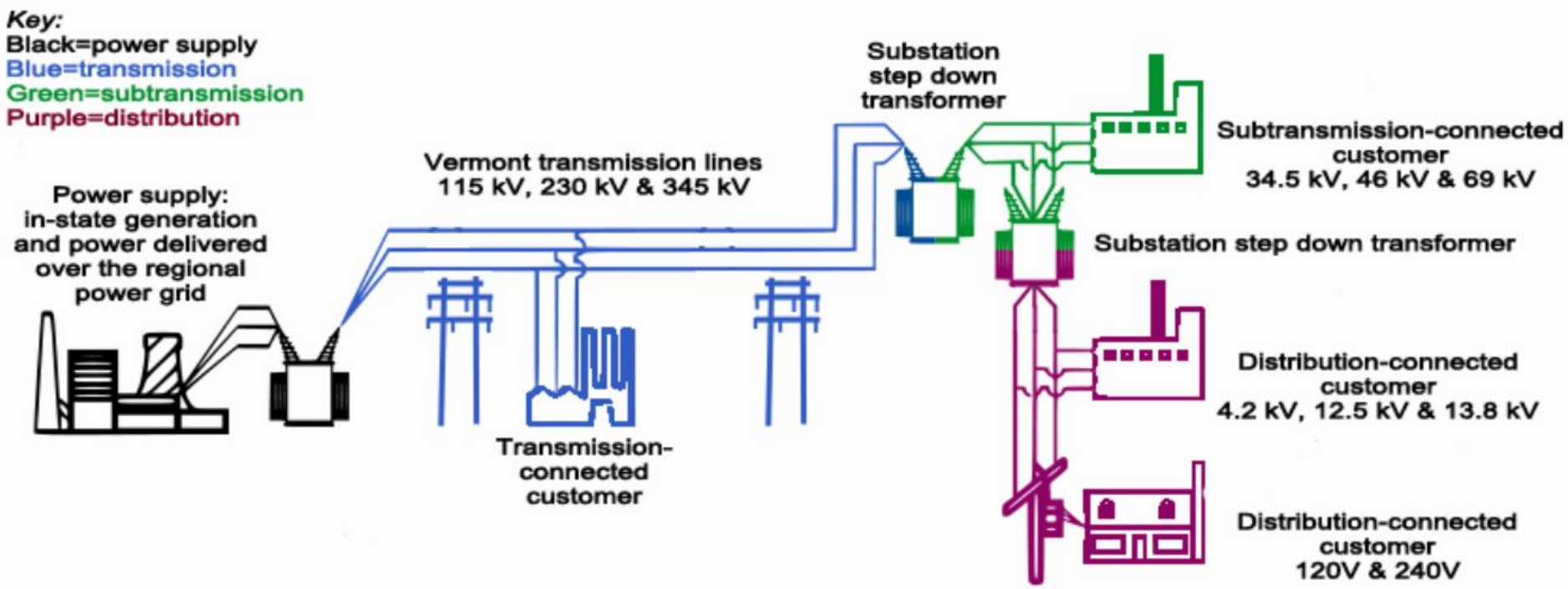
Majority of weather-caused power outages are caused by tree conflicts

This research is focused on understanding how electric power grid may be affected adversely by different types of extreme weather with climate change

Costs to maintain vegetation along right of ways are a top-three cost driver to electricity rates

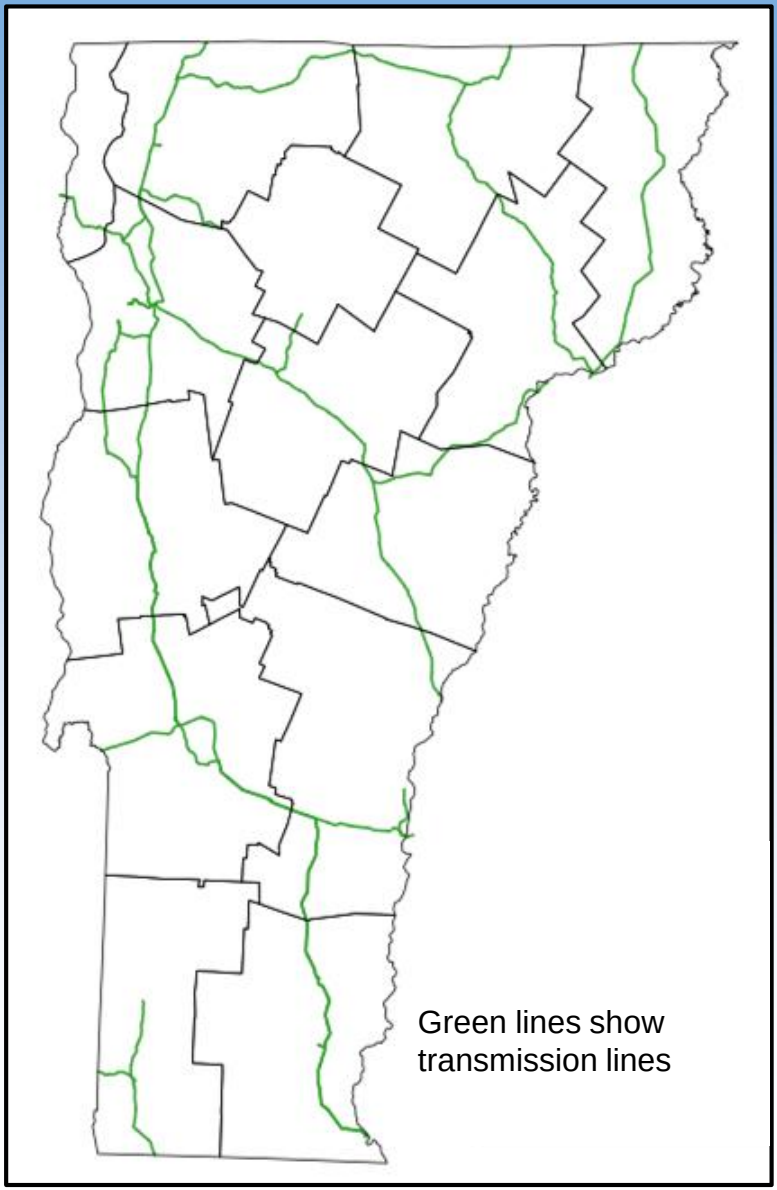
Photo: The Republican Journal

Electric Grid Overview



https://www.velco.com/about/learning-center/what-is-transmission

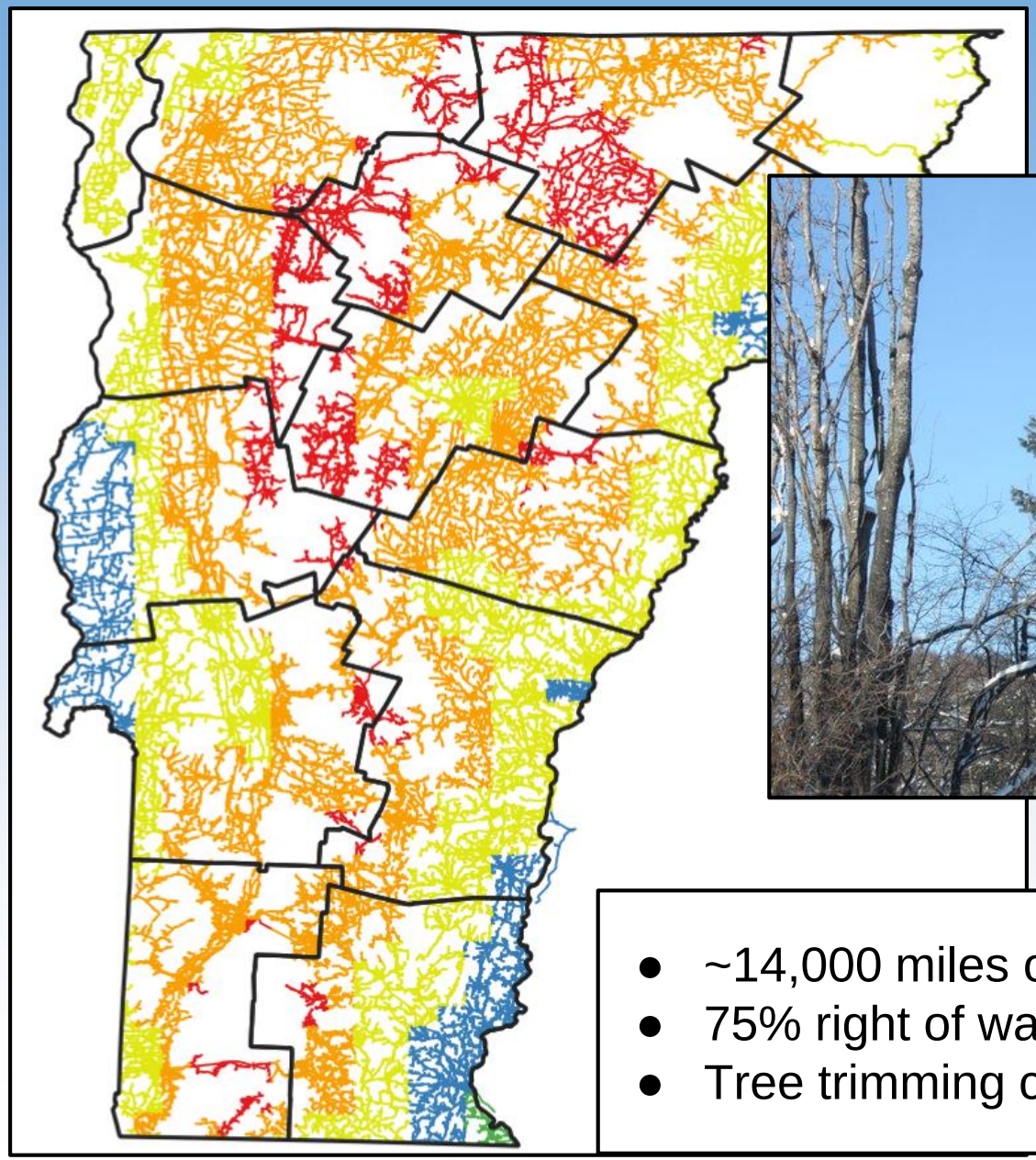
Vermont Transmission Grid



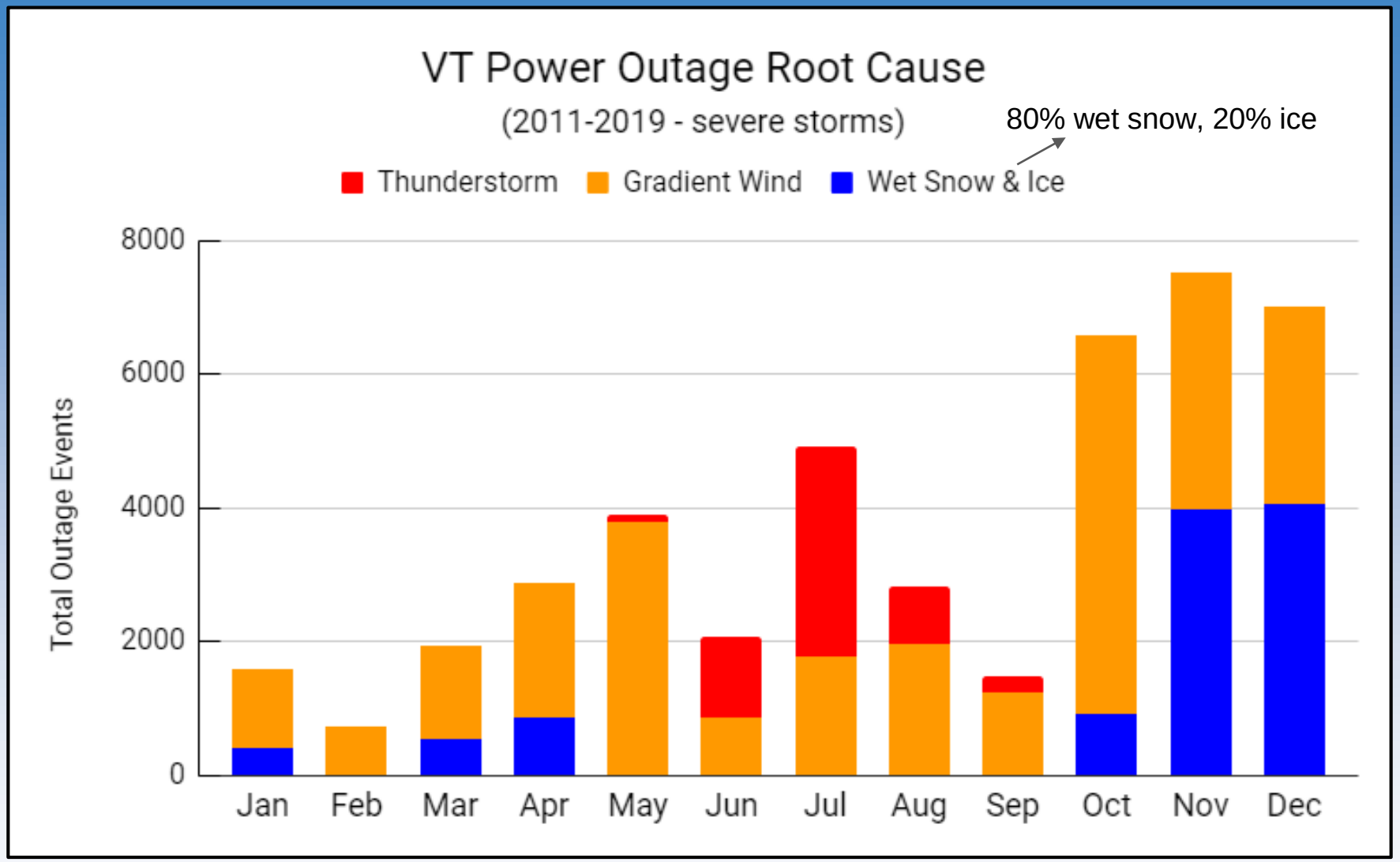
738 miles, 55 substations
13,000 acres of right of ways

Vermont Electric Power Company
VELCO

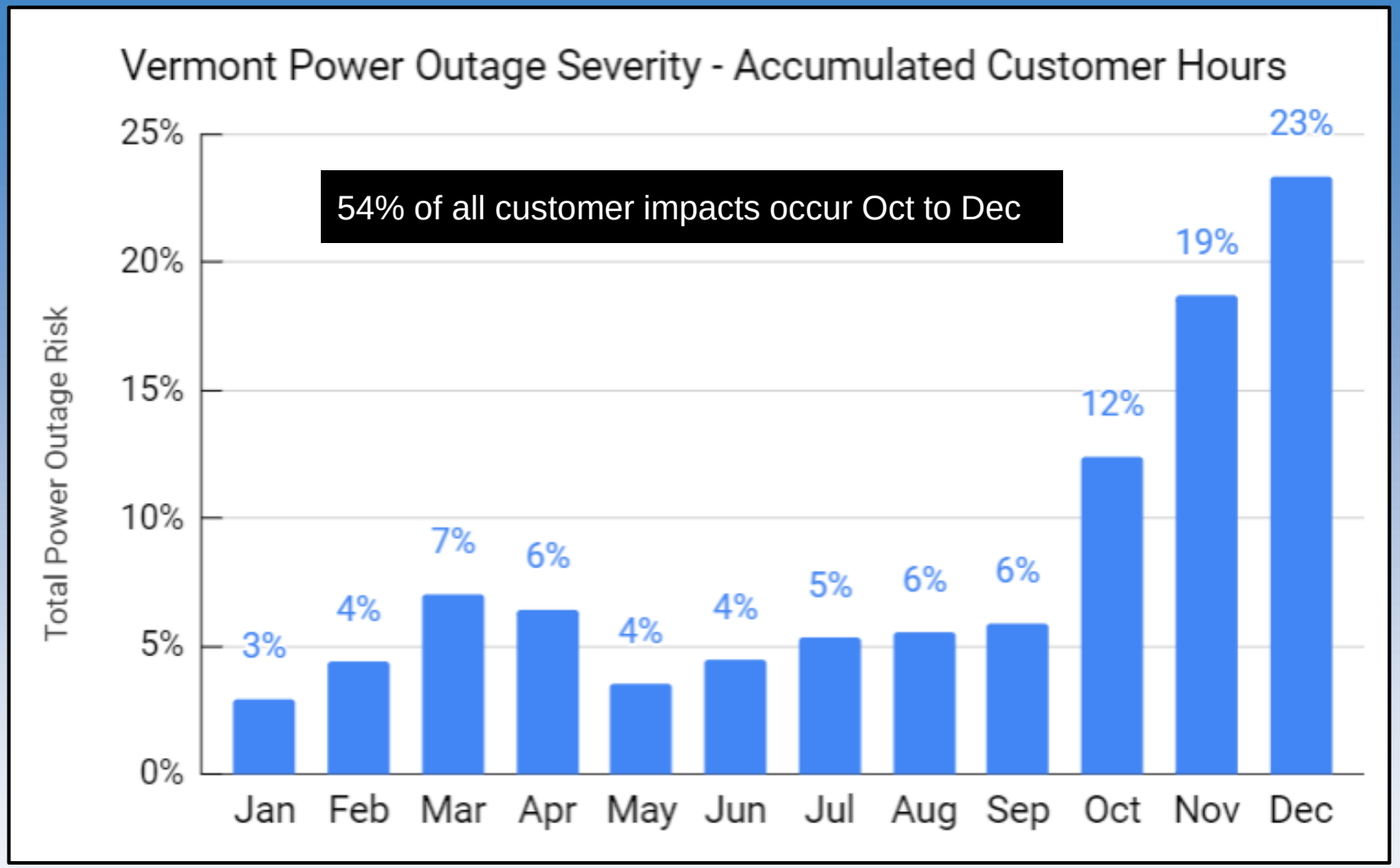
Vermont Distribution Grid



- ~14,000 miles of overhead lines
- 75% right of ways have trees nearby
- Tree trimming cycles can vary 5-10 years



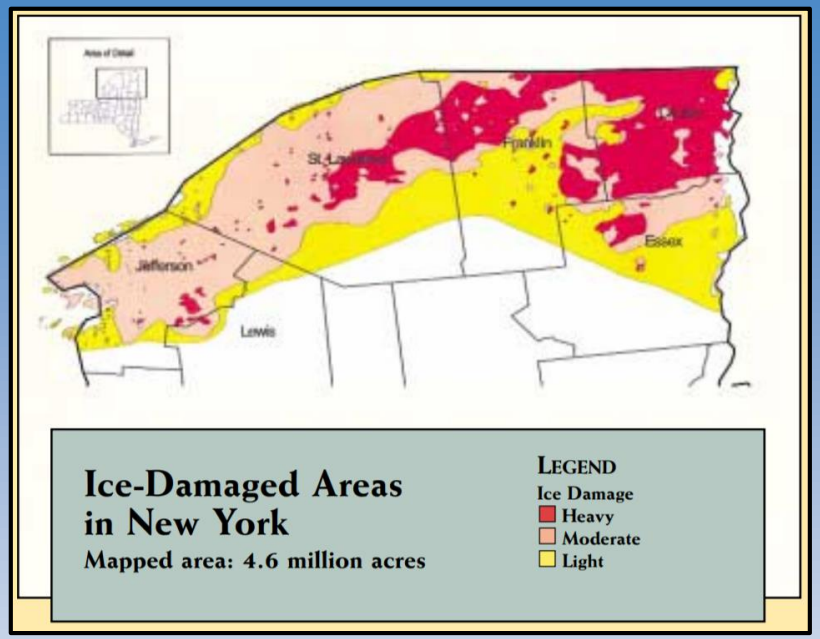
Severe storm days were defined as at least 100 or more outage events statewide (n=169) - about 18 days a calendar year. Most storm events do not produce catastrophic forest damage.

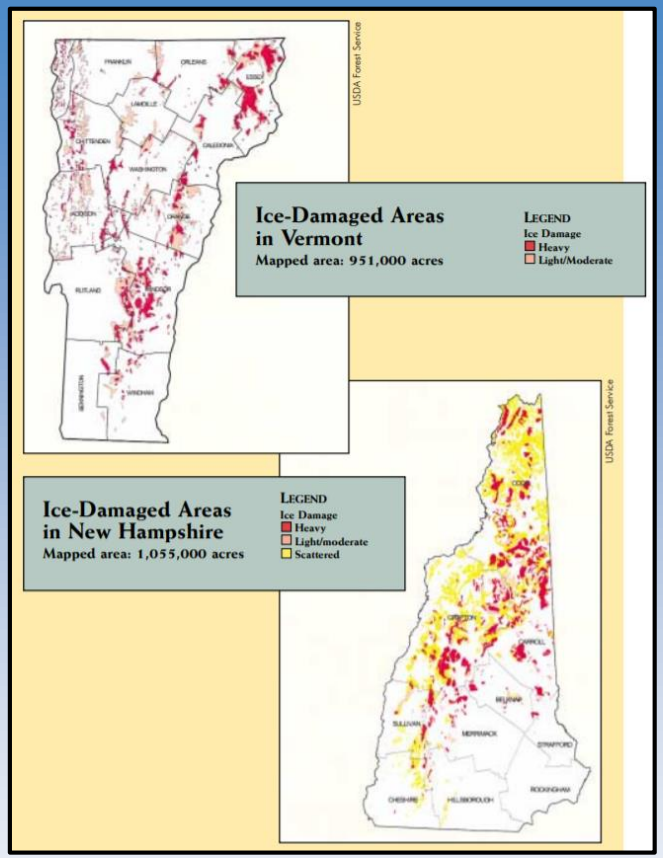


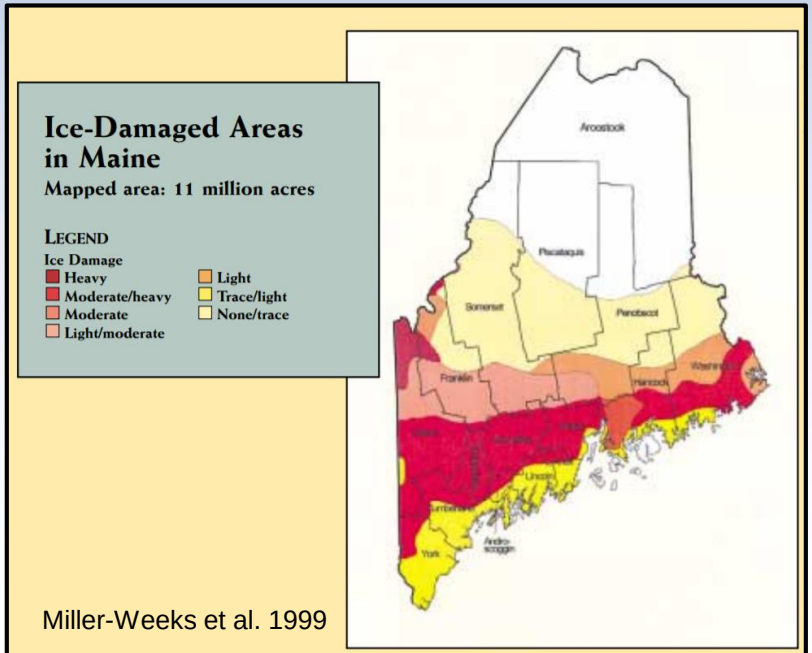
Seasonal risk factors:

- Tree canopy presence (October)
- New seasonal growth lacks weather hardening
- Soil conditions - more likely to be wet (easier to uproot trees)

Ice Storm of 1998: Most Catastrophic Ice Storm in Recent History







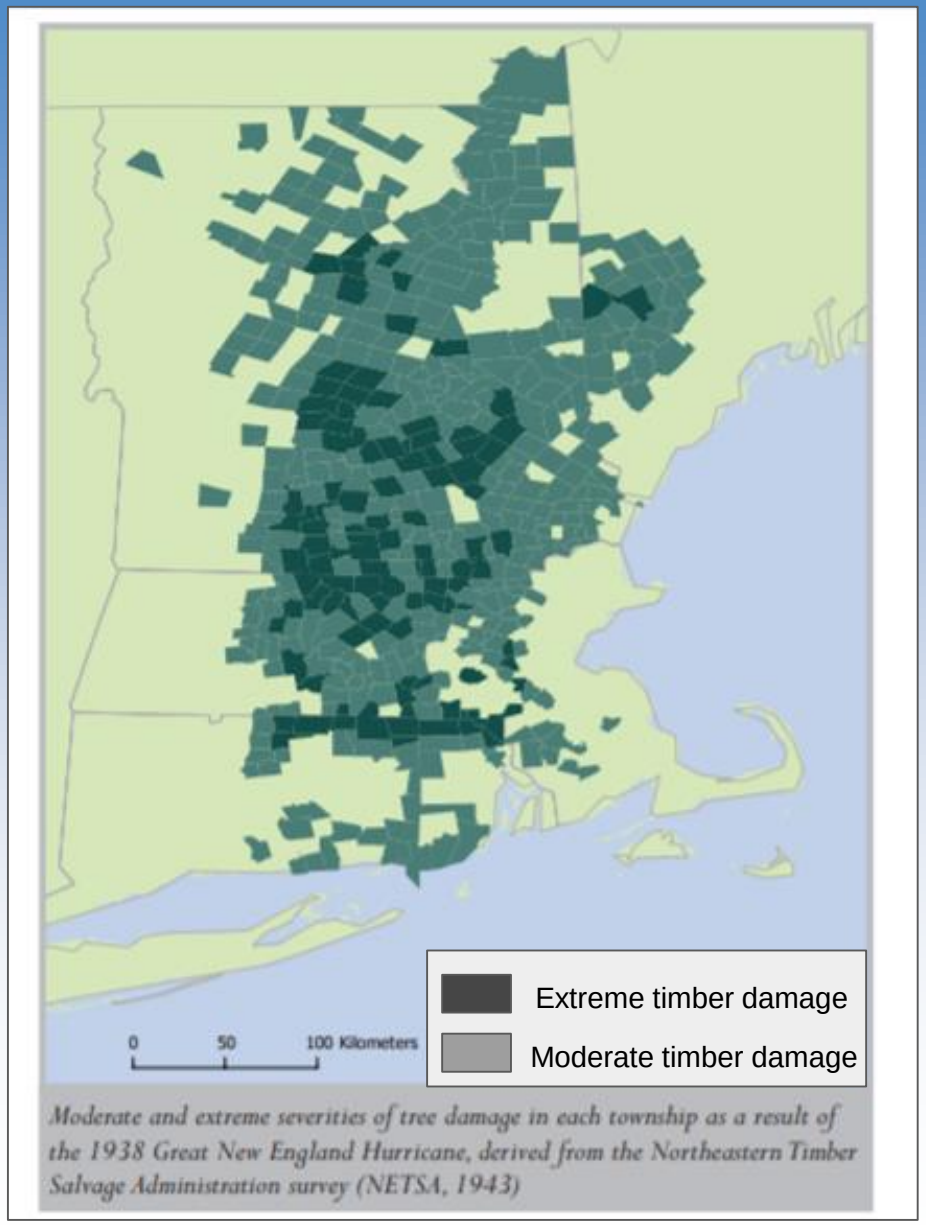
Miller-Weeks et al. 1999

Percent of trees sampled with diameter ≥ 5″ in each crown loss category

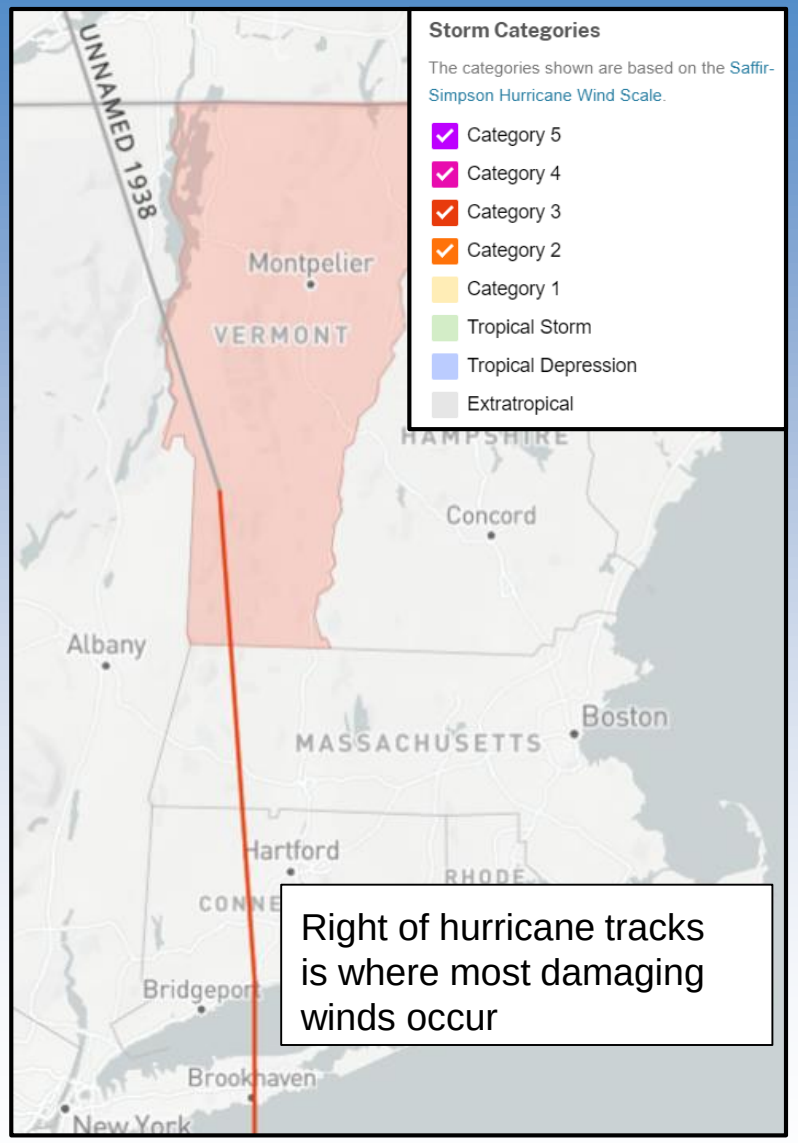
Crown loss	New York	Vermont	New Hampshire	Maine	Region
No damage (0%)	44.7	59.5	49.5	54.2	51.0
Light/moderate (1–49%)	28.4	24.5	27.2	28.8	27.7
Heavy (50–79%)	11.4	7.6	9.3	8.4	9.5
Severe (80–100%)	15.5	8.4	13.5	8.6	11.8

"Even 20 years after the ice storm, mortality rates remained higher than before" (Deschênes et al. 2019)

Hurricane of 1938: A Catastrophic Wind Storm



Moderate and extreme severities of tree damage in each township as a result of the 1938 Great New England Hurricane, derived from the Northeastern Timber Salvage Administration survey (NETSA, 1943)



Hurricane of 1938 Track

Power Grid Weather Risk Changes

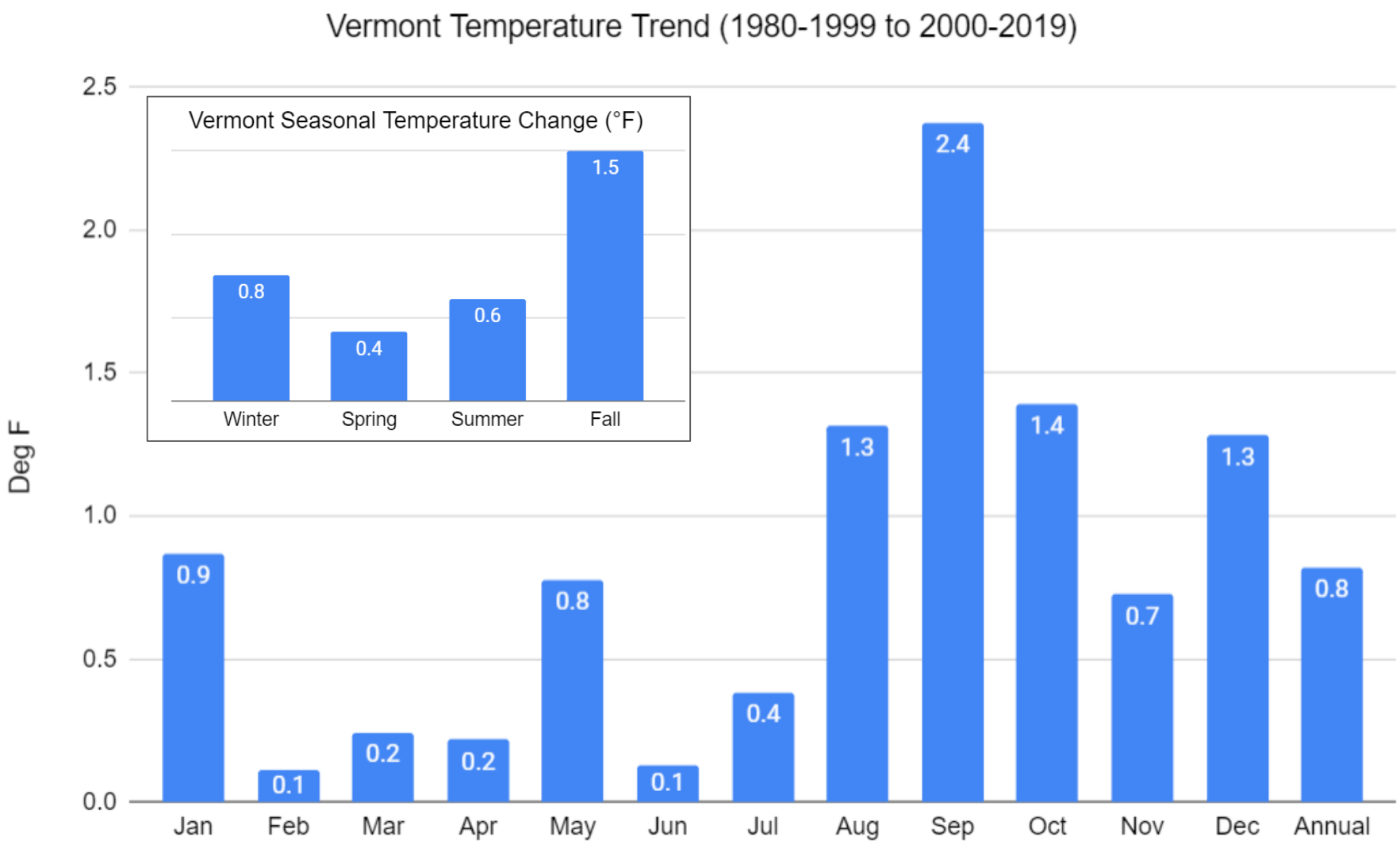
20 Year Trends (1980-2019) Show:

- Overall power outage risks have increased a few percent (wet snow (80%) and wind storms (20%))
- Frequency of high-impact storms is not increasing significantly
- Intensity of high-impact storms is increasing as warmer and wetter climate signals creep into weather behavior (+15% risk for major storms)
- Catastrophic storms that have large-scale effects on forests are not becoming more frequent, but their potential intensity may increase (esp. hurricane/tropical storm risks)

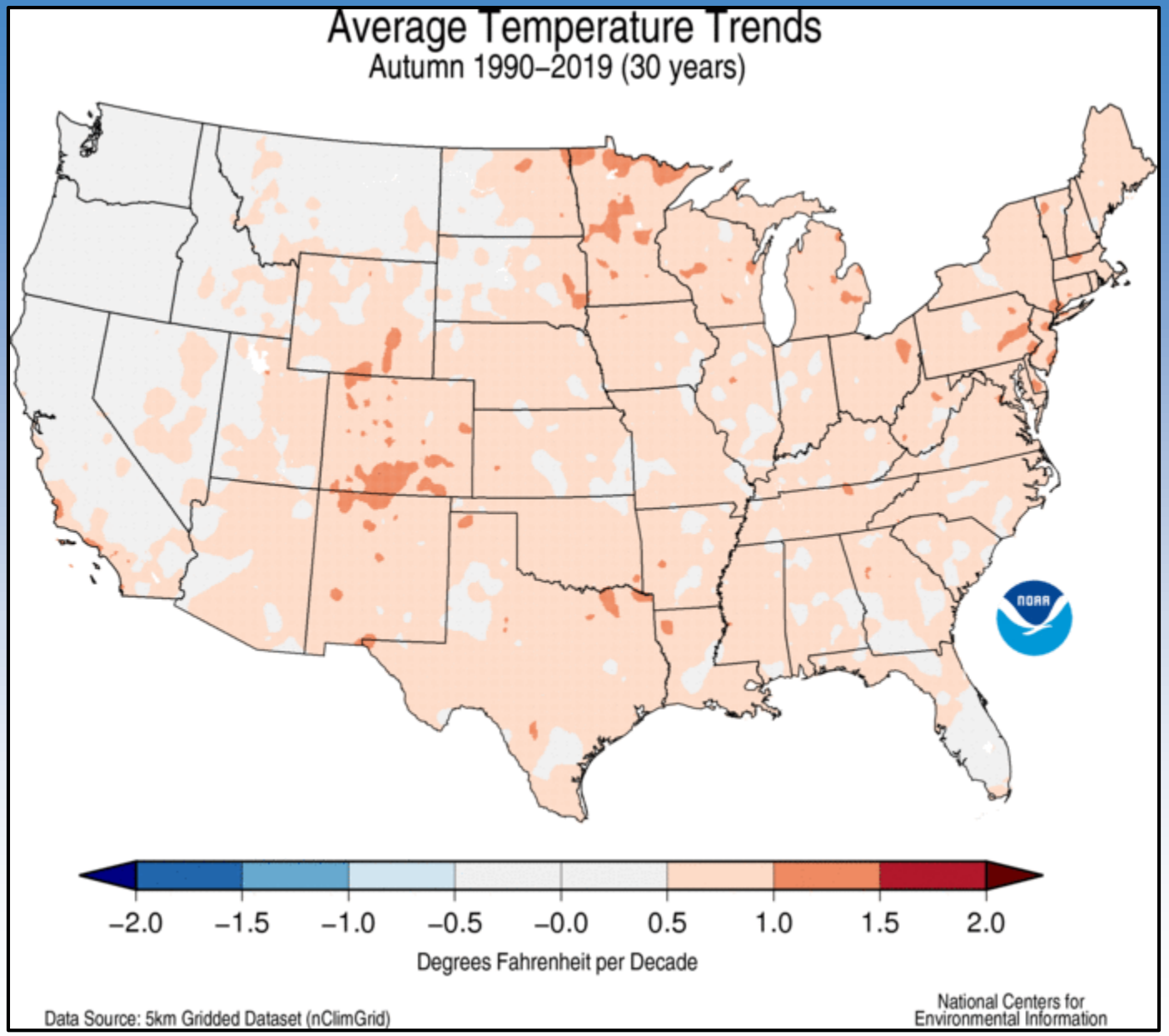
Climate Change Signals

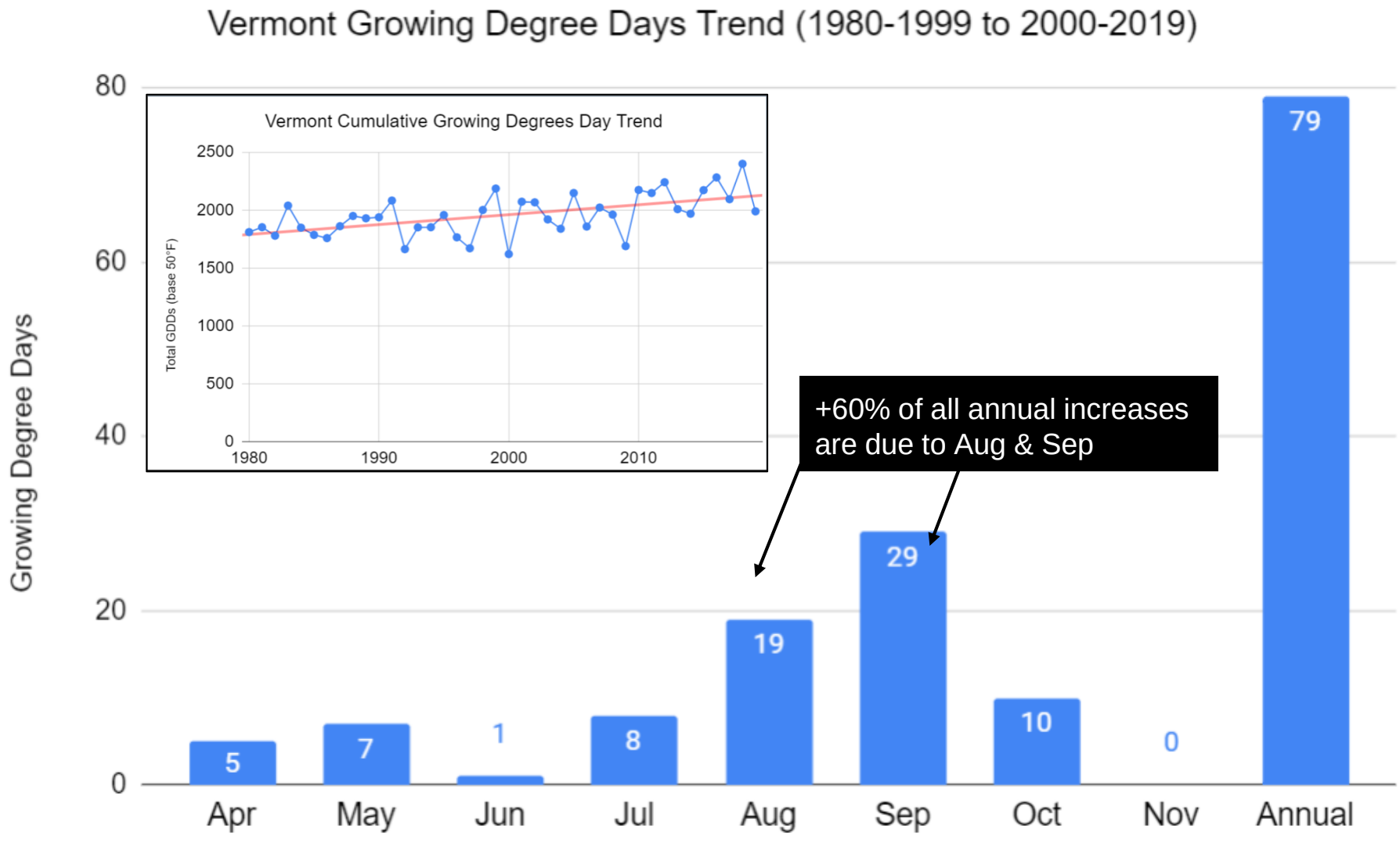
Data and Methods

- The primary weather data source is the ERA5 reanalysis (hourly 1980-2019)
- ERA5 was dynamically downscaled to produce a higher resolution data (5km)
- Higher resolution downscaling was useful for reconstructing wind events, but the native 30 km resolution was found to better for wet snow and ice events
- Wet snow and ice events are accumulated over a 48-hr period
- Results are derived on a county-level basis and aggregated across all of Vermont
- Seasons defined using meteorological standards: winter (DJF), spring (MAM), summer (JJA), fall (SON)
- A 20-year base period is used to determine change (1980-1999 to 2000-2019)

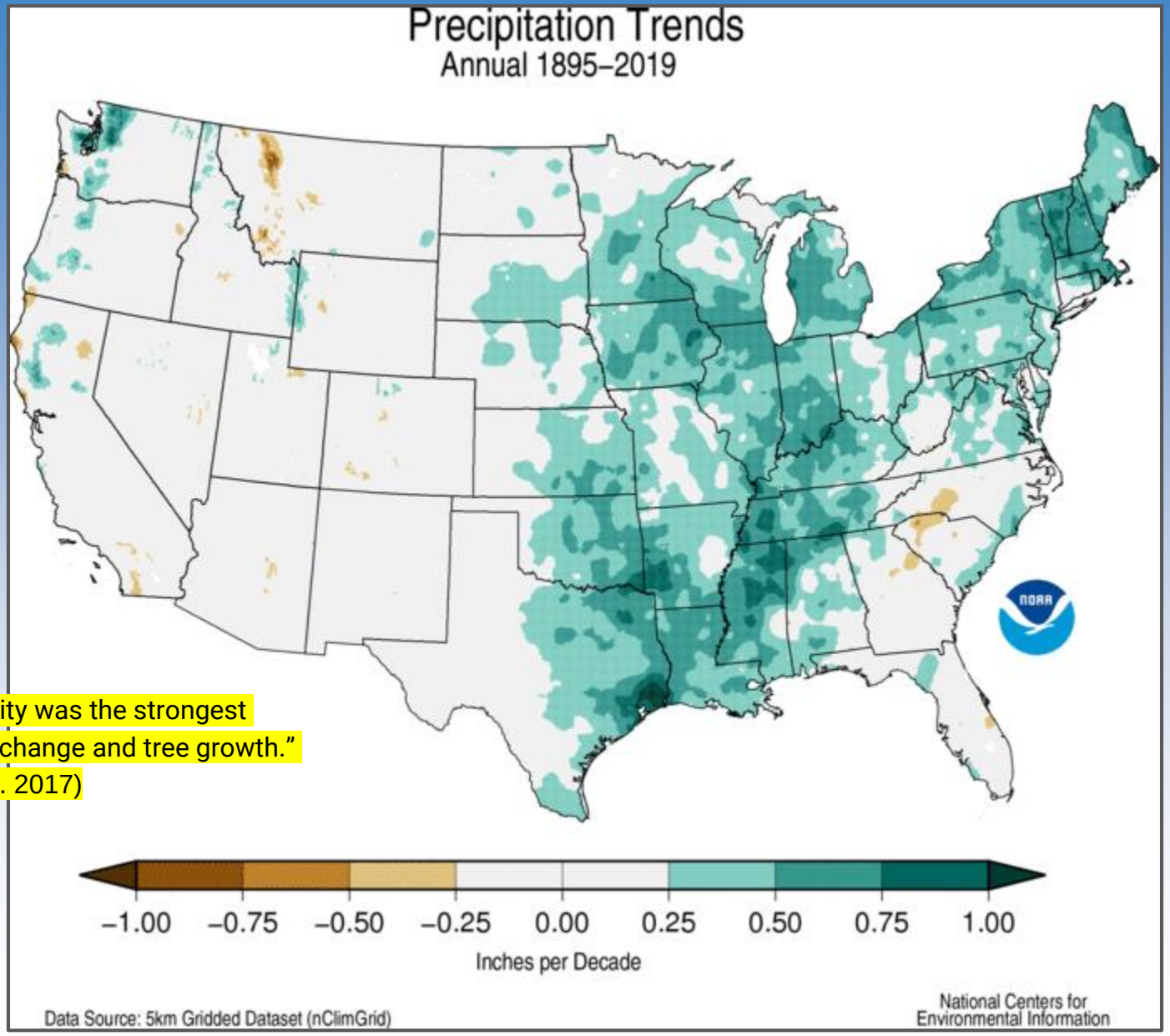


Average annual temperature is warming around 1°F over 50 years. Late summer and fall are warming the fastest, with the warm season being more prolonged.


Average Temperature Trends
Autumn 1990–2019 (30 years)
−2.0
−1.5
−1.0
−0.5
−0.0
0.5
1.0
1.5
2.0
Degrees Fahrenheit per Decade
Data Source: 5km Gridded Dataset (nClimGrid)
National Centers for Environmental Information

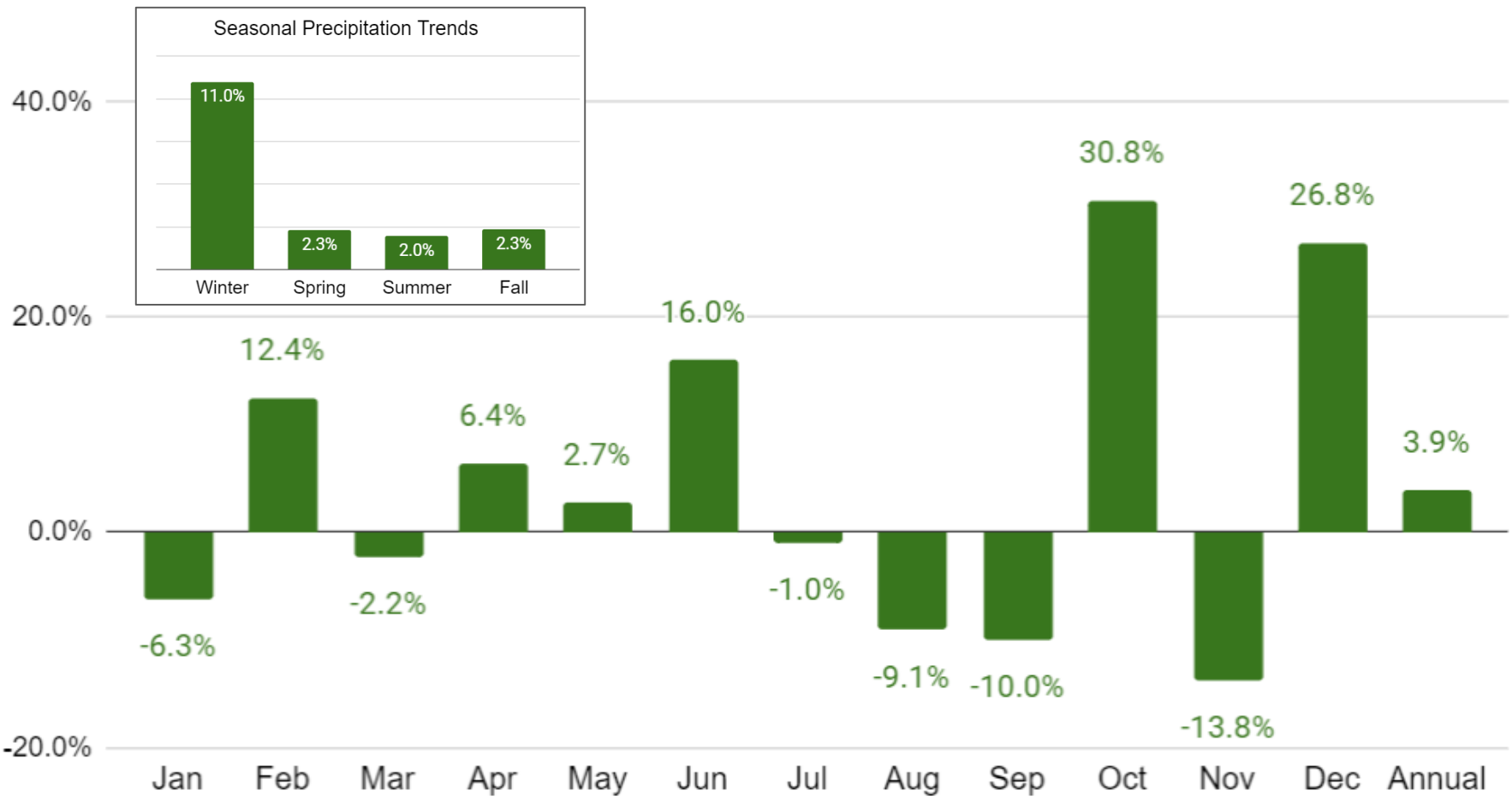


Widening of the growing season is most notable in the late summer to early fall - we're trying to determine how various tree species will respond to these changes. Confers may respond more strongly with greater grow, soil moisture and evapotranspiration capacity may also counteract this warming.

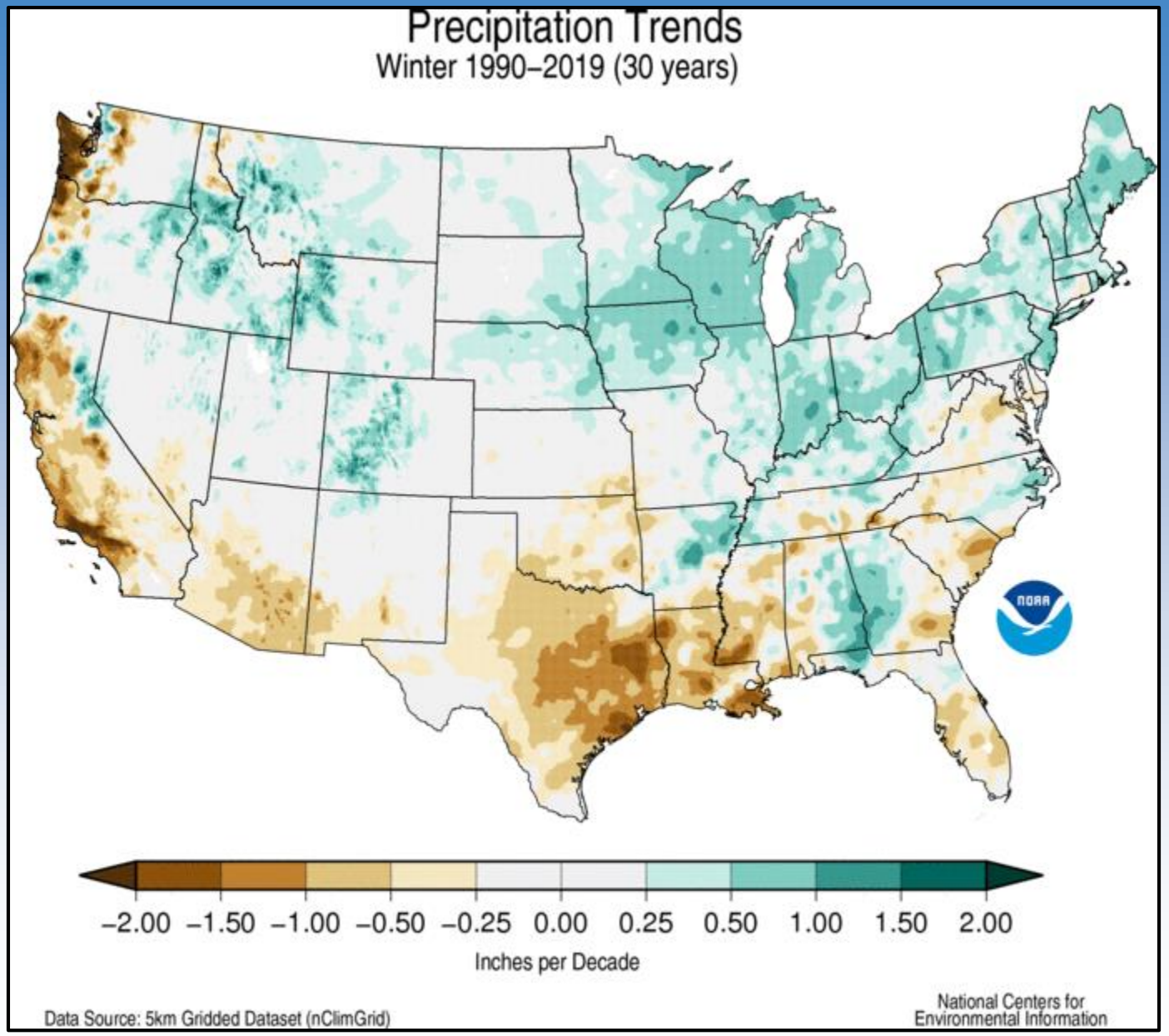


"Water availability was the strongest driver of gas exchange and tree growth." (Levesque et al. 2017)

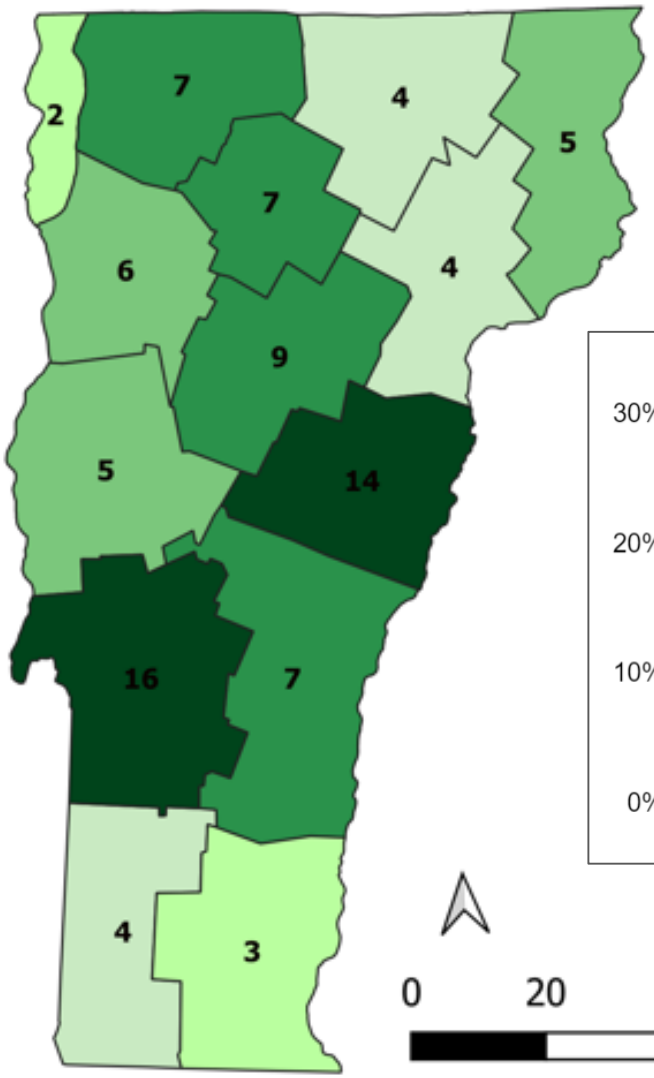
Vermont Precipitation Trend (1980-1999 to 2000-2019)

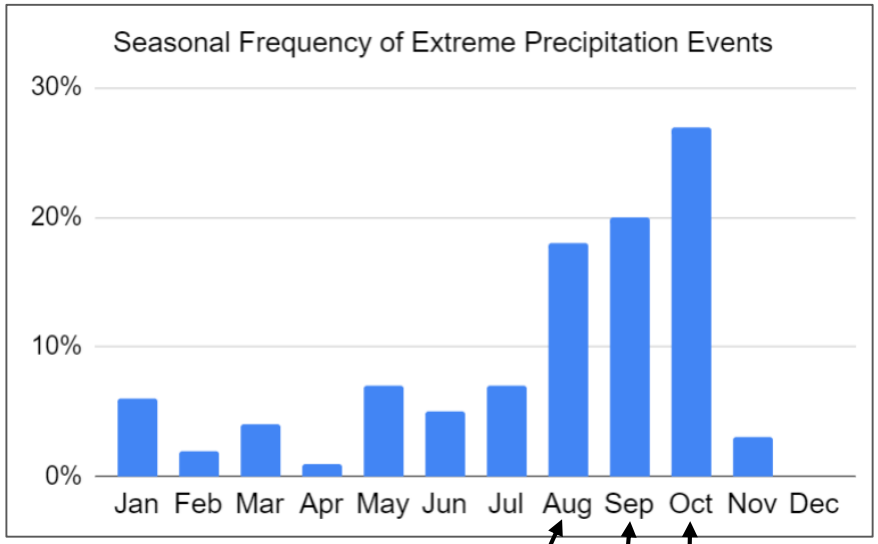


Average annual precipitation has increased about 2” over 40 years, with winter precipitation increasing the fastest. Mid summer to early fall has seen an overall decline. This general pattern is expected to continue.


Precipitation Trends
Winter 1990–2019 (30 years)
NOAA
−2.00 −1.50 −1.00 −0.50 −0.25 0.00 0.25 0.50 1.00 1.50 2.00
Inches per Decade
Data Source: 5km Gridded Dataset (nClimGrid)
National Centers for Environmental Information

Percent increase in heavy precipitation days (1980-1999 to 2000-2019)

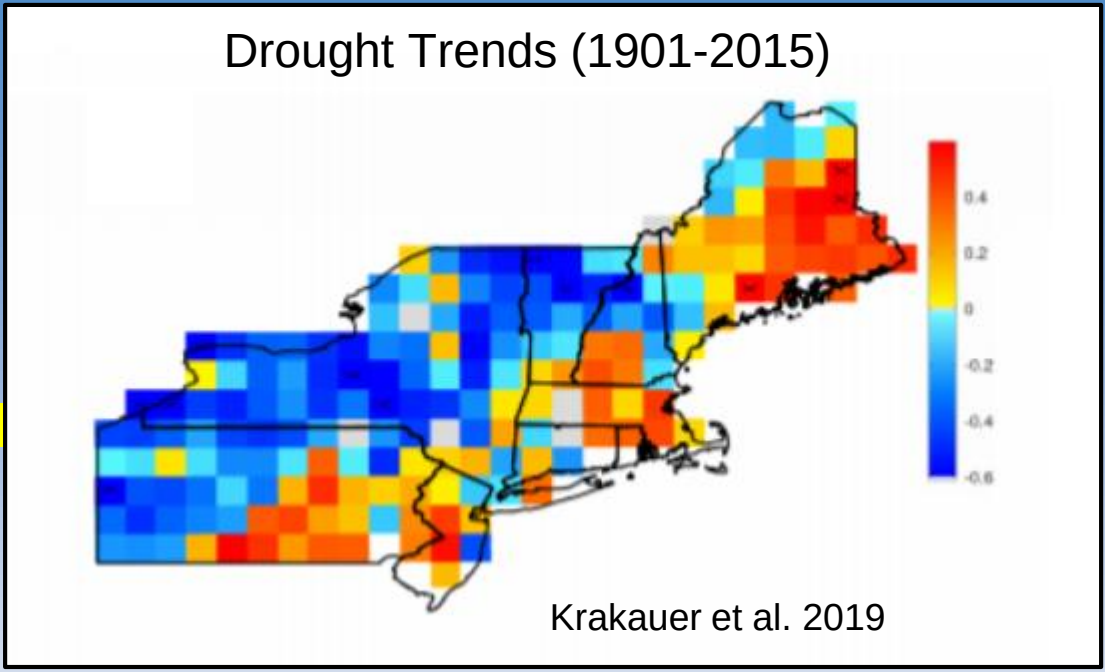




This maximum is related to interactions between tropical and midlatitude storm systems.

A heavy precipitation day is defined as 1” or greater in 24 hr at the county-level.

Drought-induced reductions in tree growth were greatest when the droughts occurred during early-season peaks in radial growth (D'Orangeville et al. 2018)



Red areas: increasing trend
Blue areas: decreasing trend

Coastal areas being drier is likely a result of more westerly flow from the continent and progressive storm systems that fall apart and weaken as they move from the west.

Intersecting research areas - we need to learn more...

Windthrow biomass and carbon cycle and nitrogen cycles

Species dependency to climate change

Age of forests influencing resiliency

Seasonality of climate change influences on growth and general health

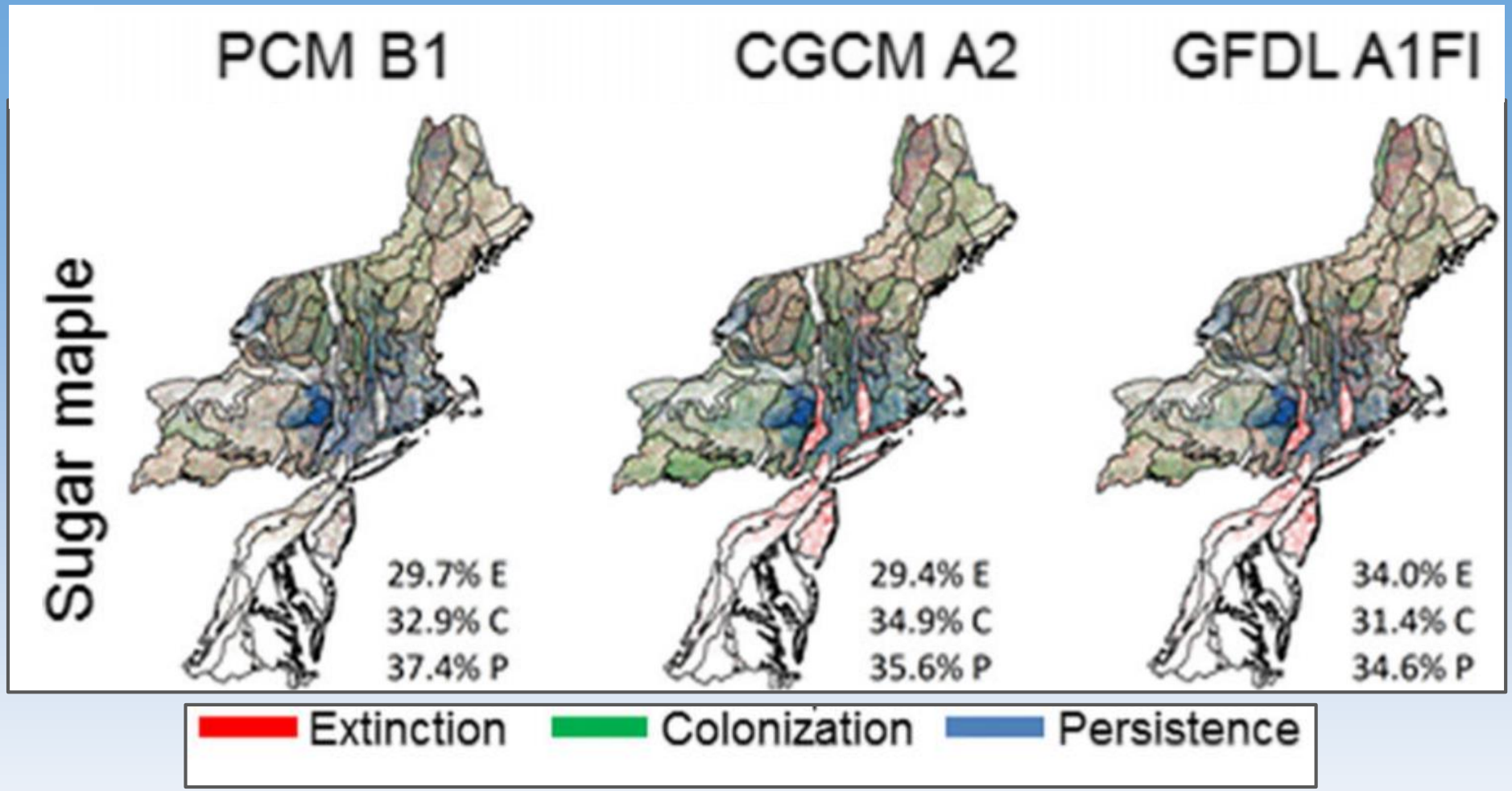


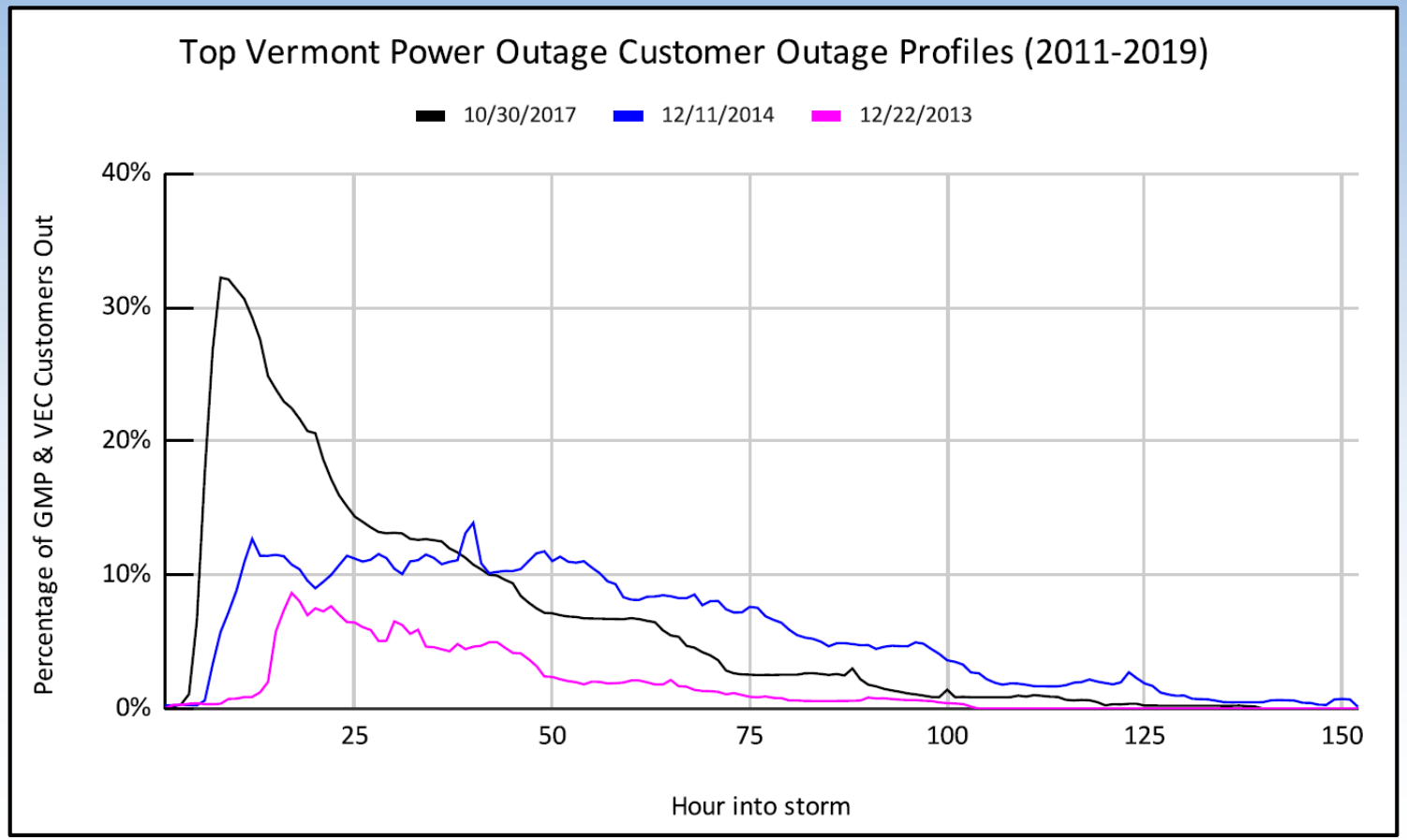
Fig. 5 Predicted extinction (*in red*), colonization (*in green*), and persistence (*in blue*) rates for 24 tree species under PCM B1, CGCM A2, and GFDL A1FI modeling scenarios at 2300 in the northeastern United States. (Color figure online)

Climate change could result in substantial shifts in some tree species distributions. Wang et al. 2016

Feedback Wanted

Are you aware of any work that quantified forest damage from the following major Vermont storms?

- Dec 9-11, 2014 (Largest wet snow power outage storm)
- Dec 22, 2013 (Ice storm across northern Vermont)
- Oct 30, 2017 (Largest gradient wind storm of the decade)



Summary - Northeast US

1. Wind storms top cause of power outages and forest damage
2. Catastrophic wind storms
   a. Do not appear to be getting more frequent
   b. Intensity changes appear modest for midlatitude storms
3. Catastrophic ice storms
   a. No detectable frequency or intensity changes
   b. Climate could still support major ice storms like ‘98, but we are tending to see more low- to moderate-end icing events with mixed-phase winter storms
4. Overall power outage storm severity (wind & wet snow) has increased primarily from warmer and wetter storms in concert with widening of seasonal risk factors
5. Catastrophic wind storms are more likely to be from hurricanes interacting with midlatitude storms (e.g., Superstorm Sandy)

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