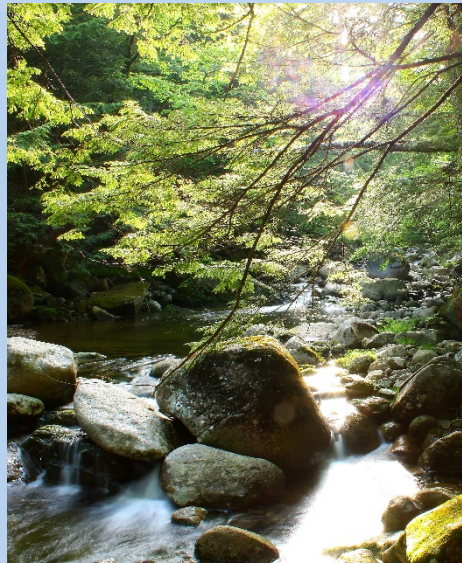


# Changing Hydrology

John Campbell  
Research Ecologist  
USDA Forest Service, Durham, NH



Forest Adaptation Webinar Series  
April 16, 2020



# Hubbard Brook Experimental Forest

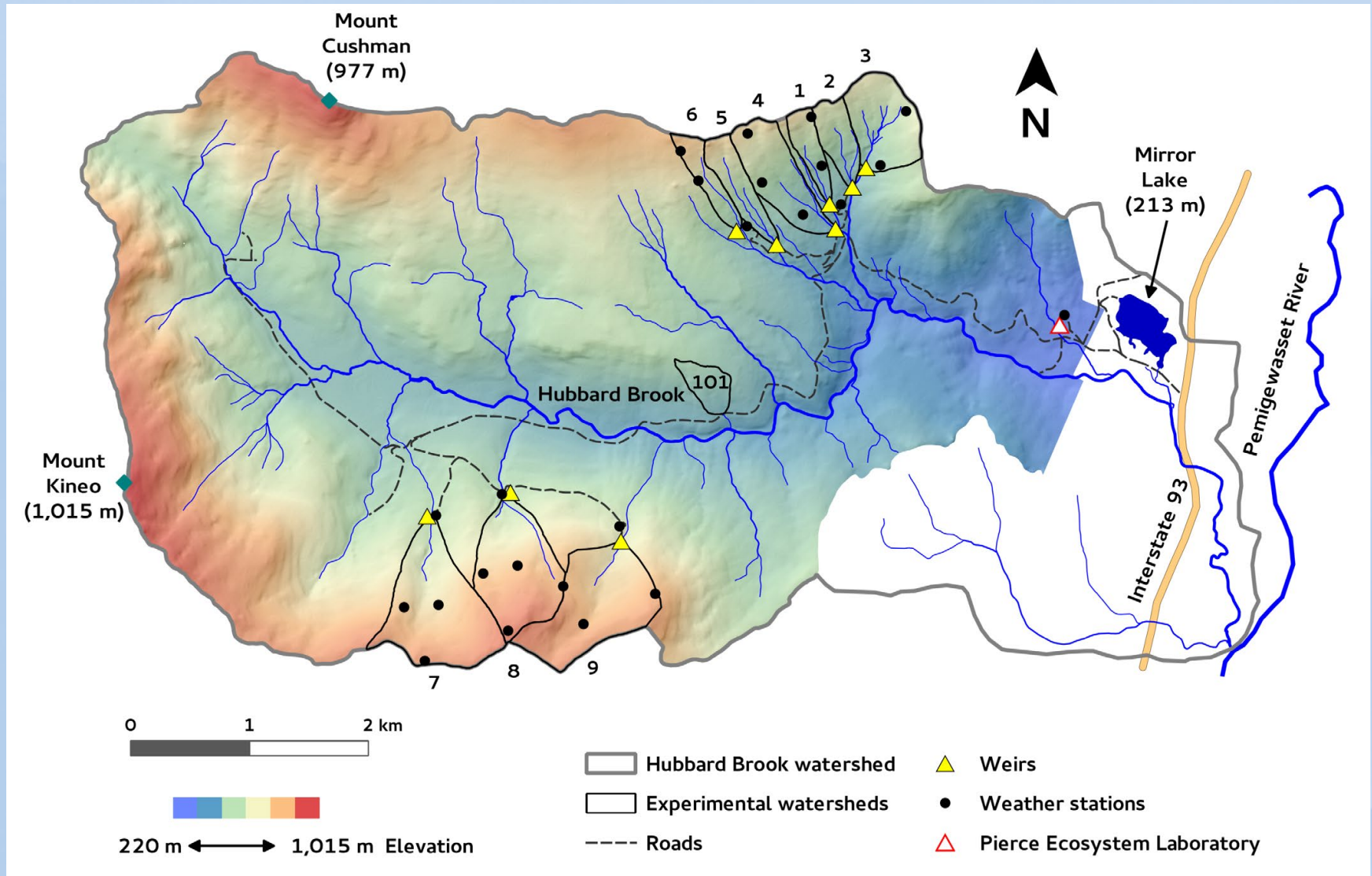
## White Mountain National Forest, NH



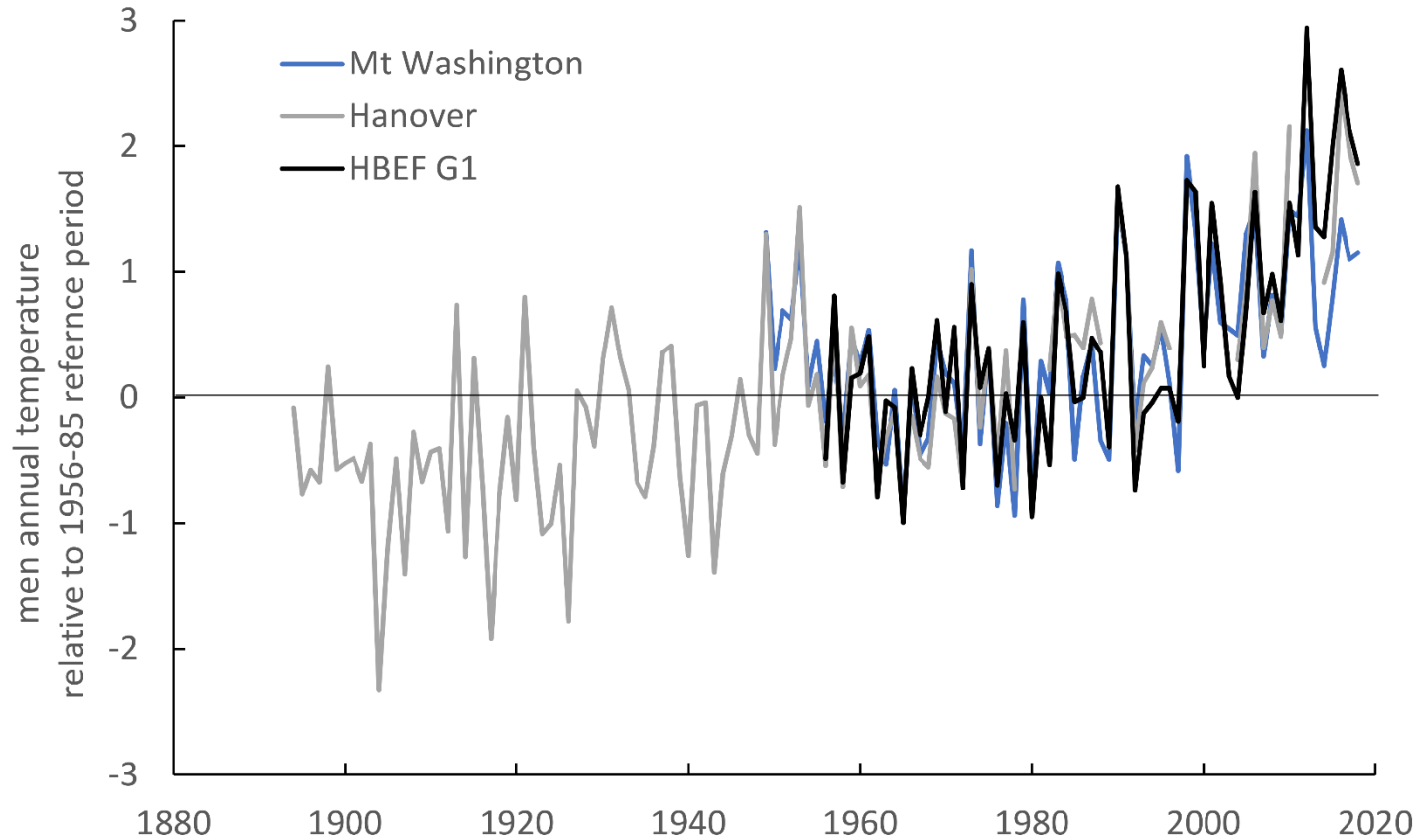
- 8,000 acre research reserve
- Established in 1955
- Study forest harvest effects on flooding, erosion, and water supply
- Started measuring stream and precipitation chemistry in 1963
- First evidence of acid rain in North America



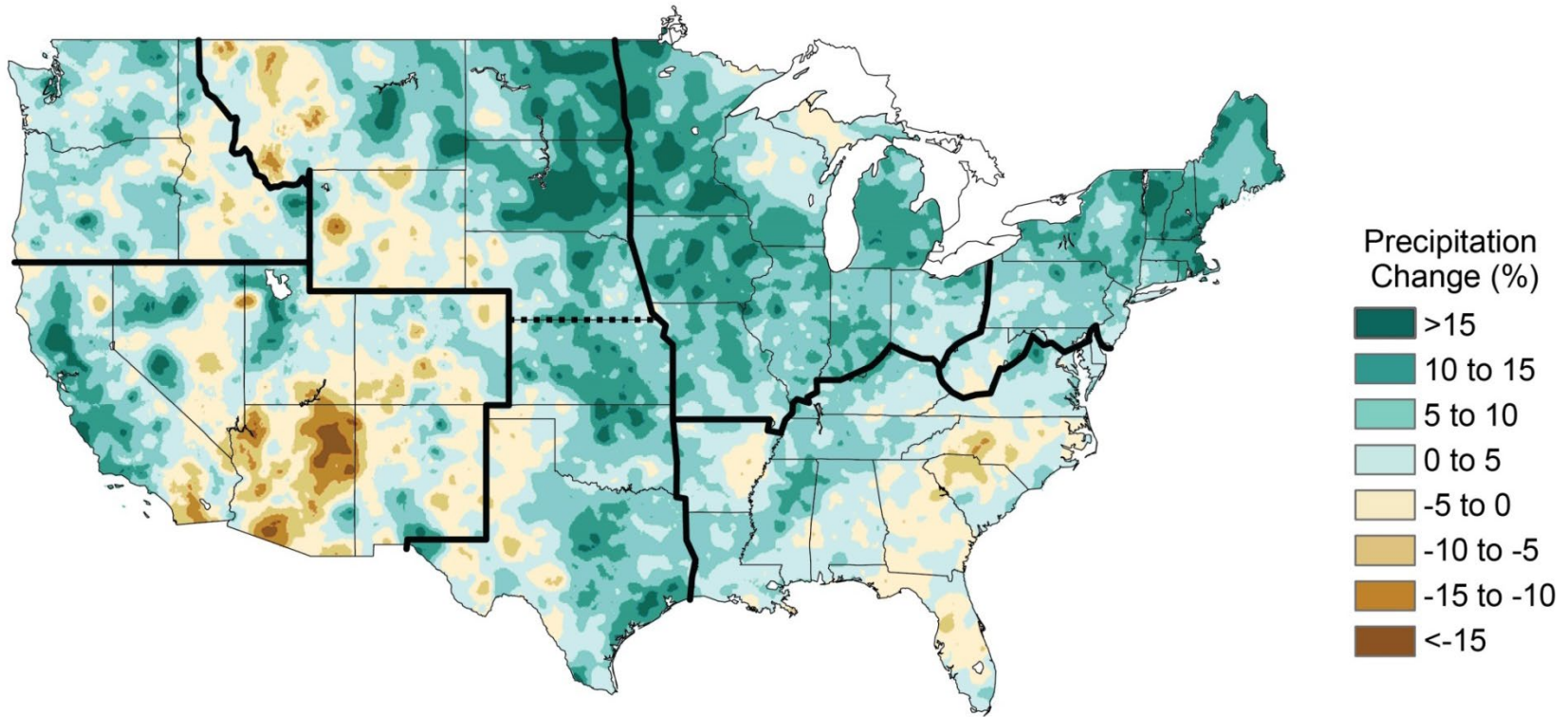
# Hubbard Brook Experimental Forest



# Air temperature changes



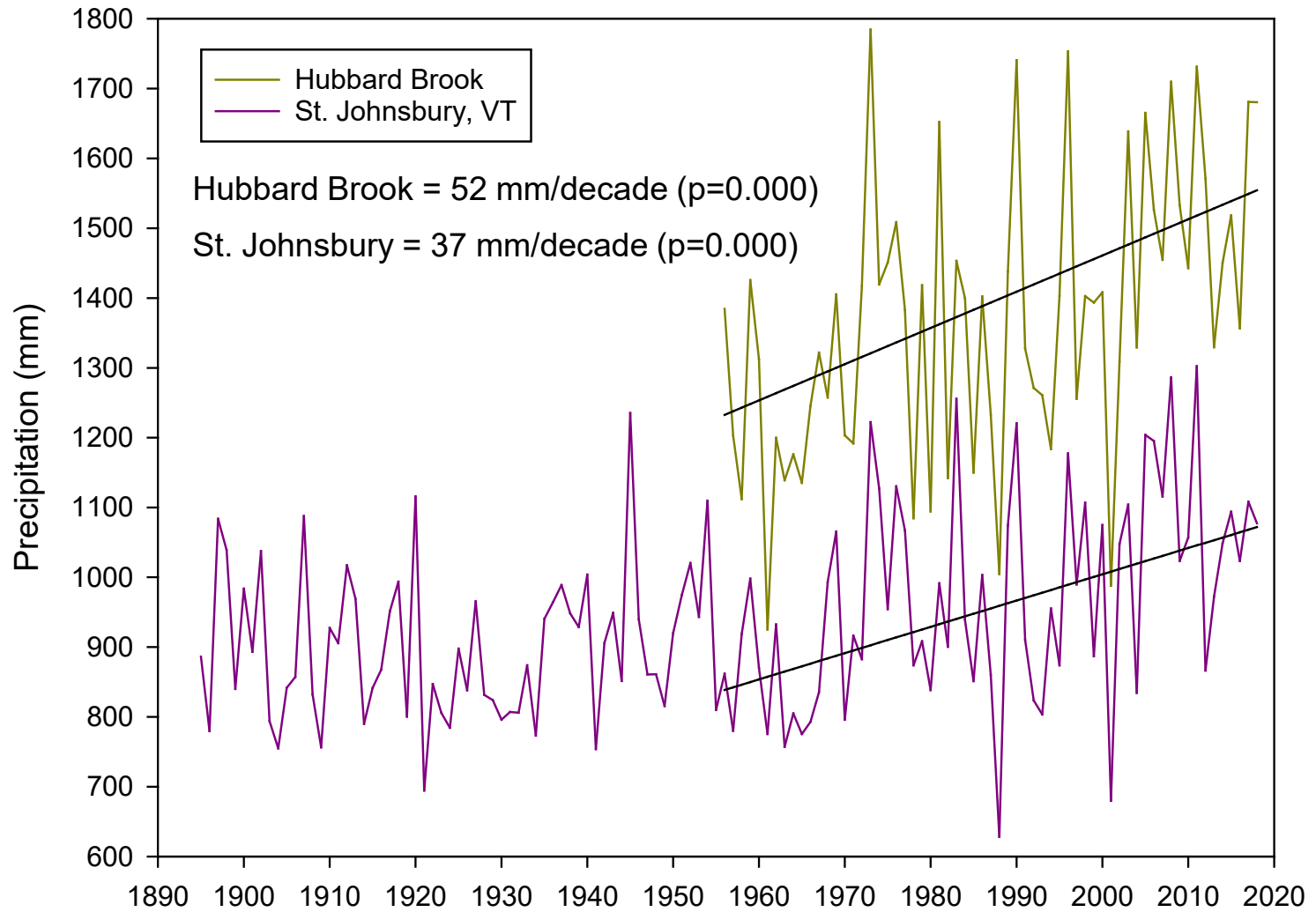
# Observed US precipitation change

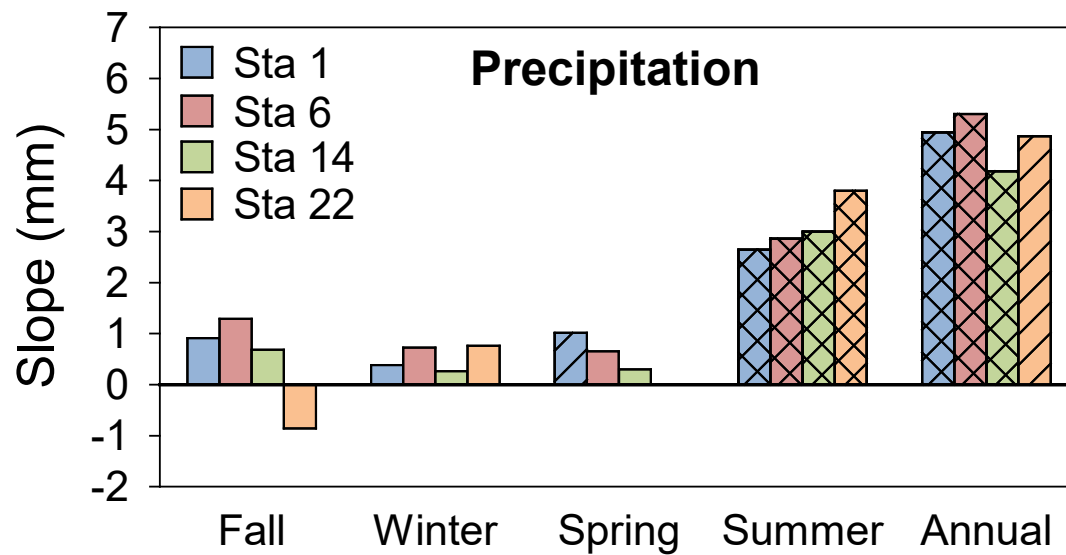
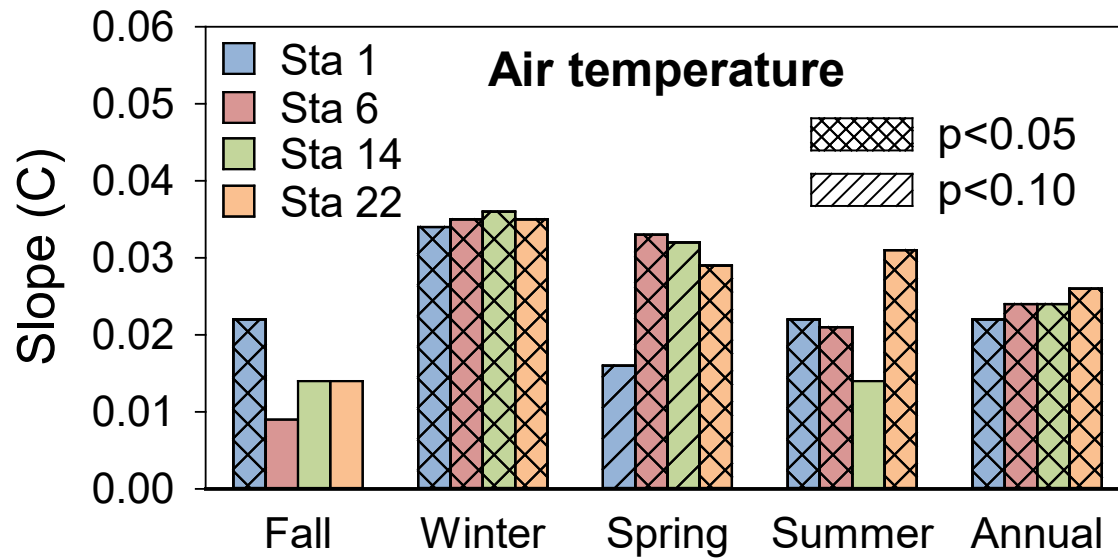


Annual total precipitation change for 1991-2012 compared to the 1901-1960 average.

Melillo et al. 2014. National Climate Assessment.

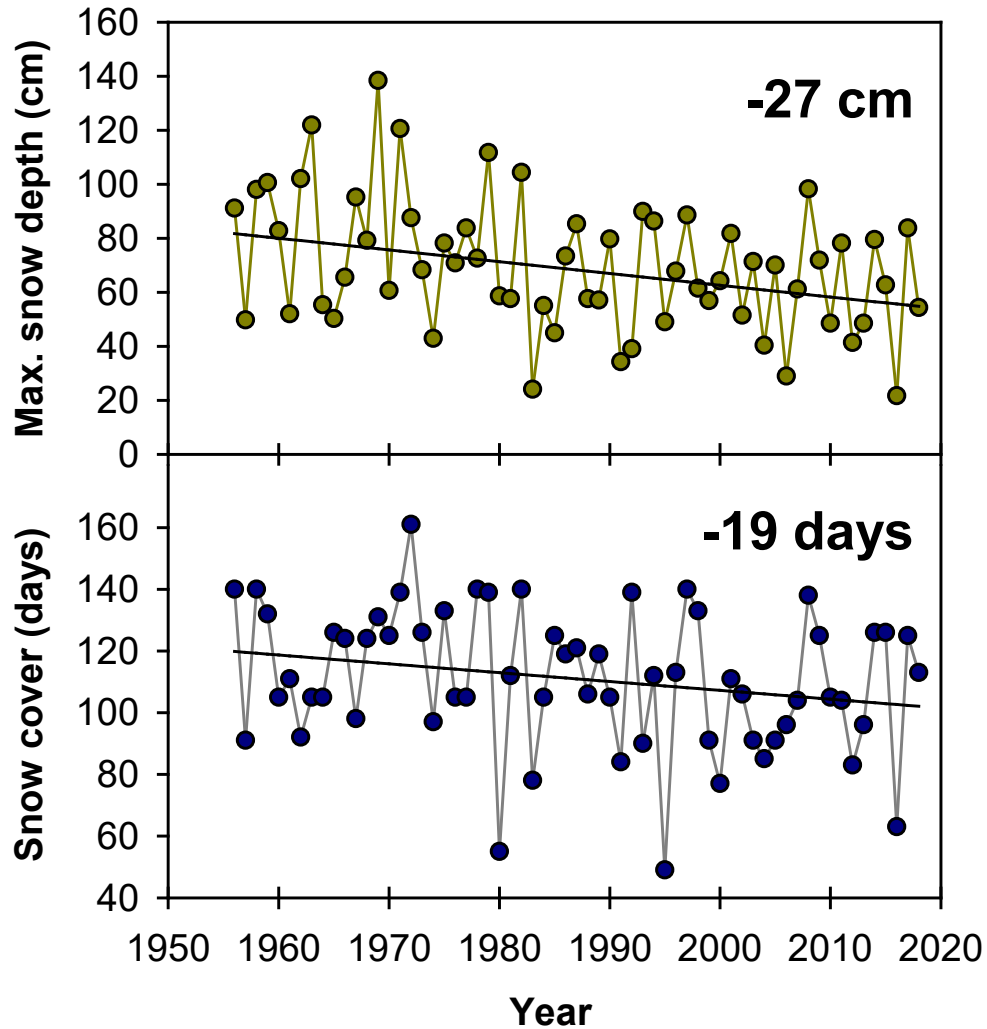
# Trends in precipitation





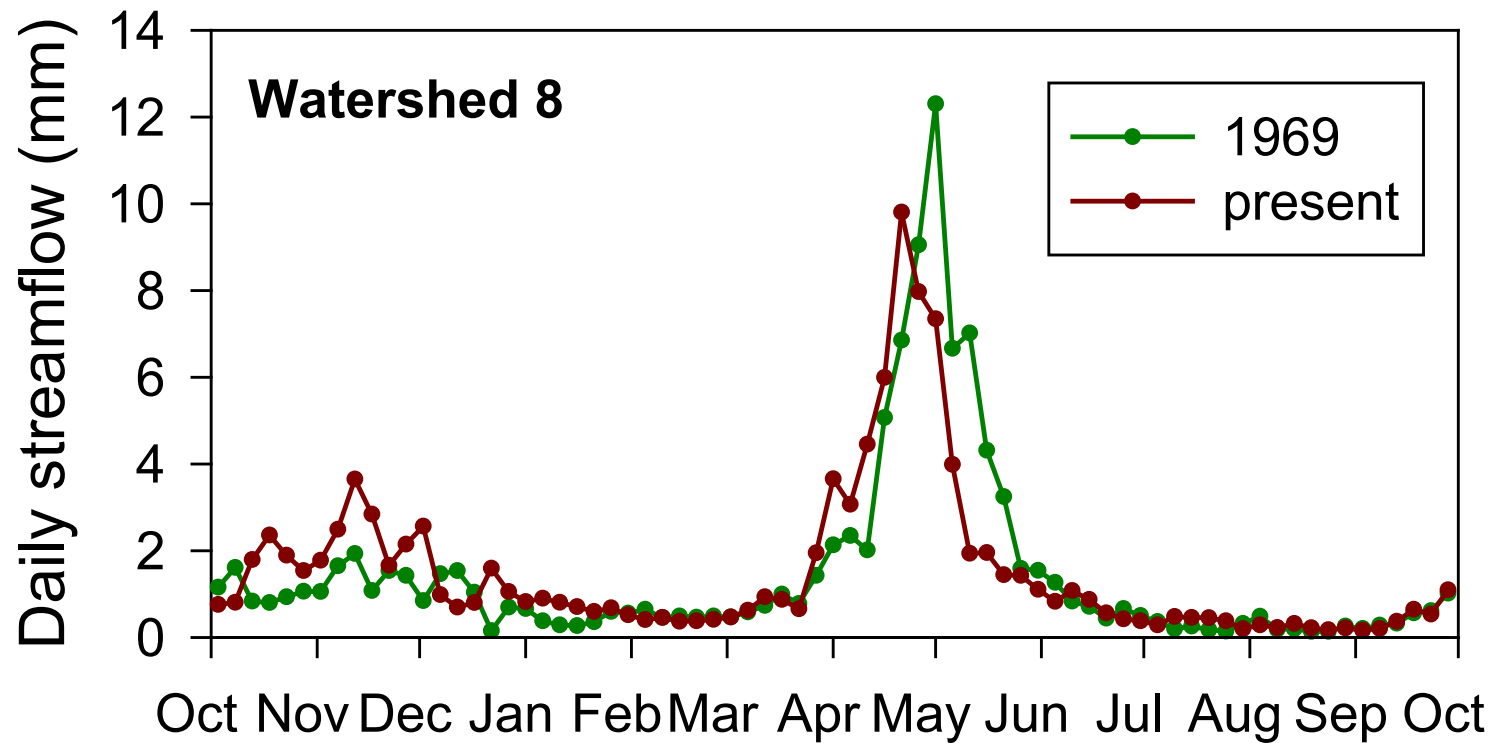


# Changes in snowpack





# Changes in streamflow



# Extreme Weather Events

- Ice storms
- Soil frost
- Rain-on-snow
- Hail storms
- Droughts
- Floods
- Hurricanes
- Spring freeze
- Microbursts



Spring freeze (2010), Hubbard Brook, NH

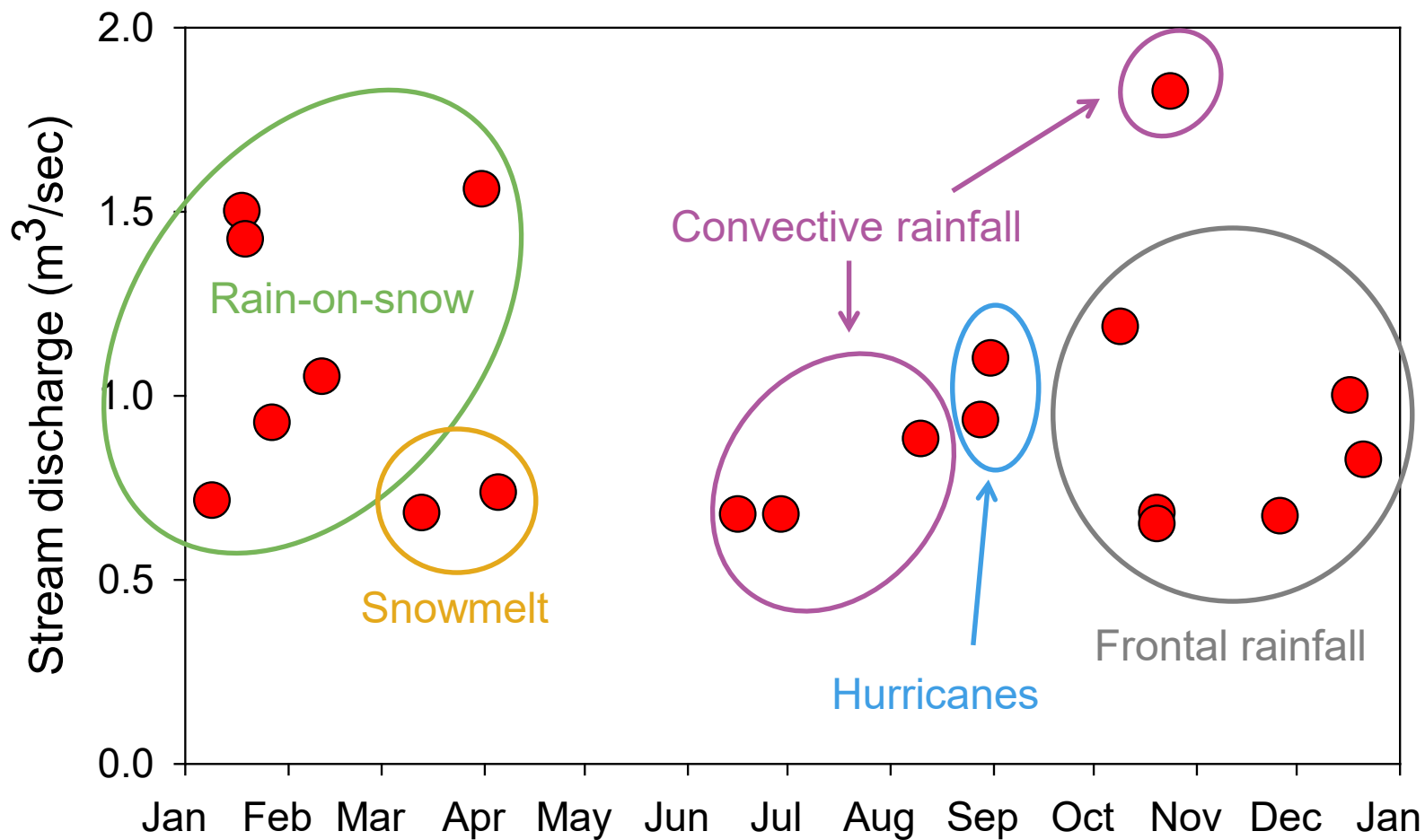
# Tropical Storm Irene



- August 28, 2011
- 15<sup>th</sup> costliest in US history
- Up to 25 cm of rain in NH

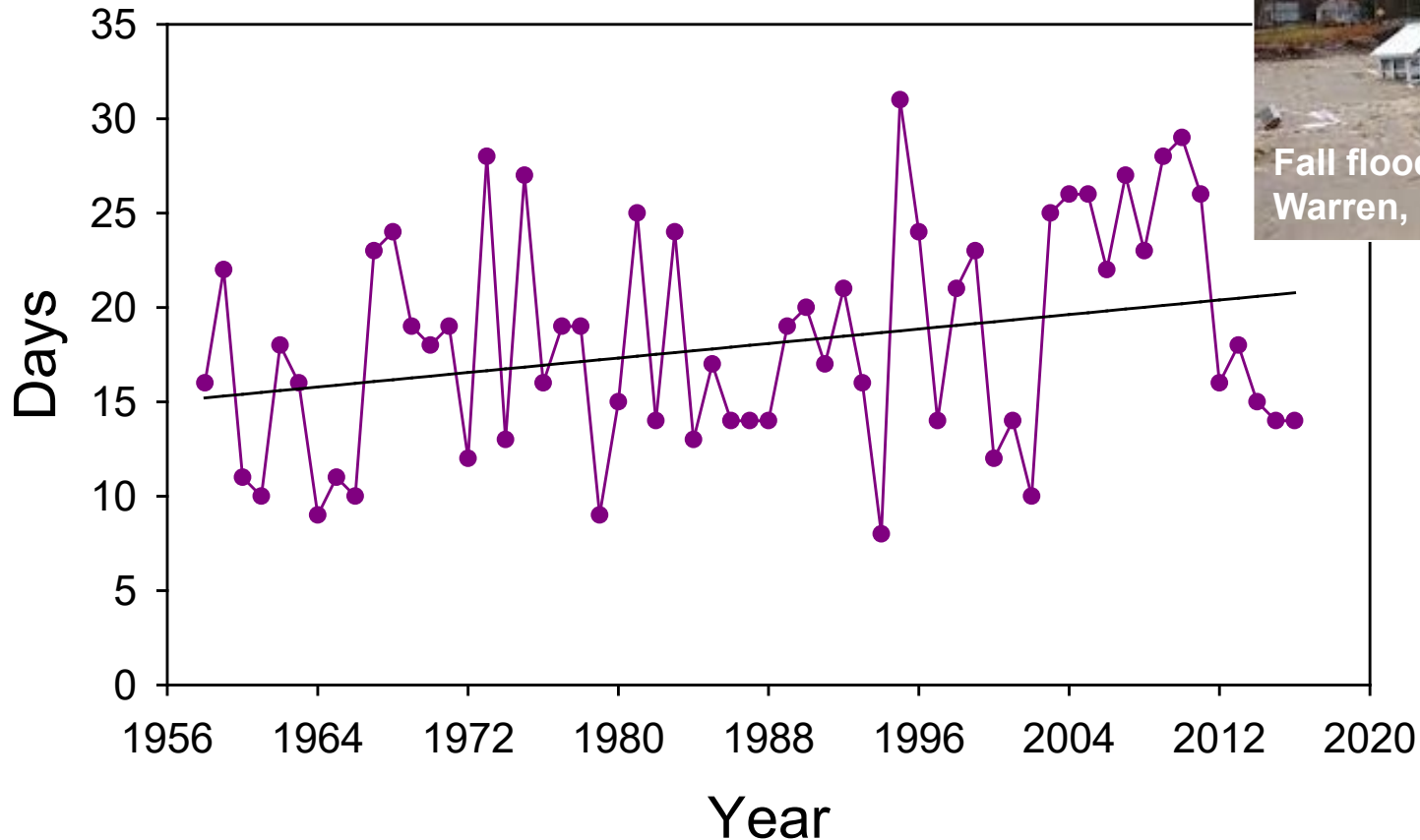
*Photographs courtesy of S. Bailey*

# Top 20 streamflow events



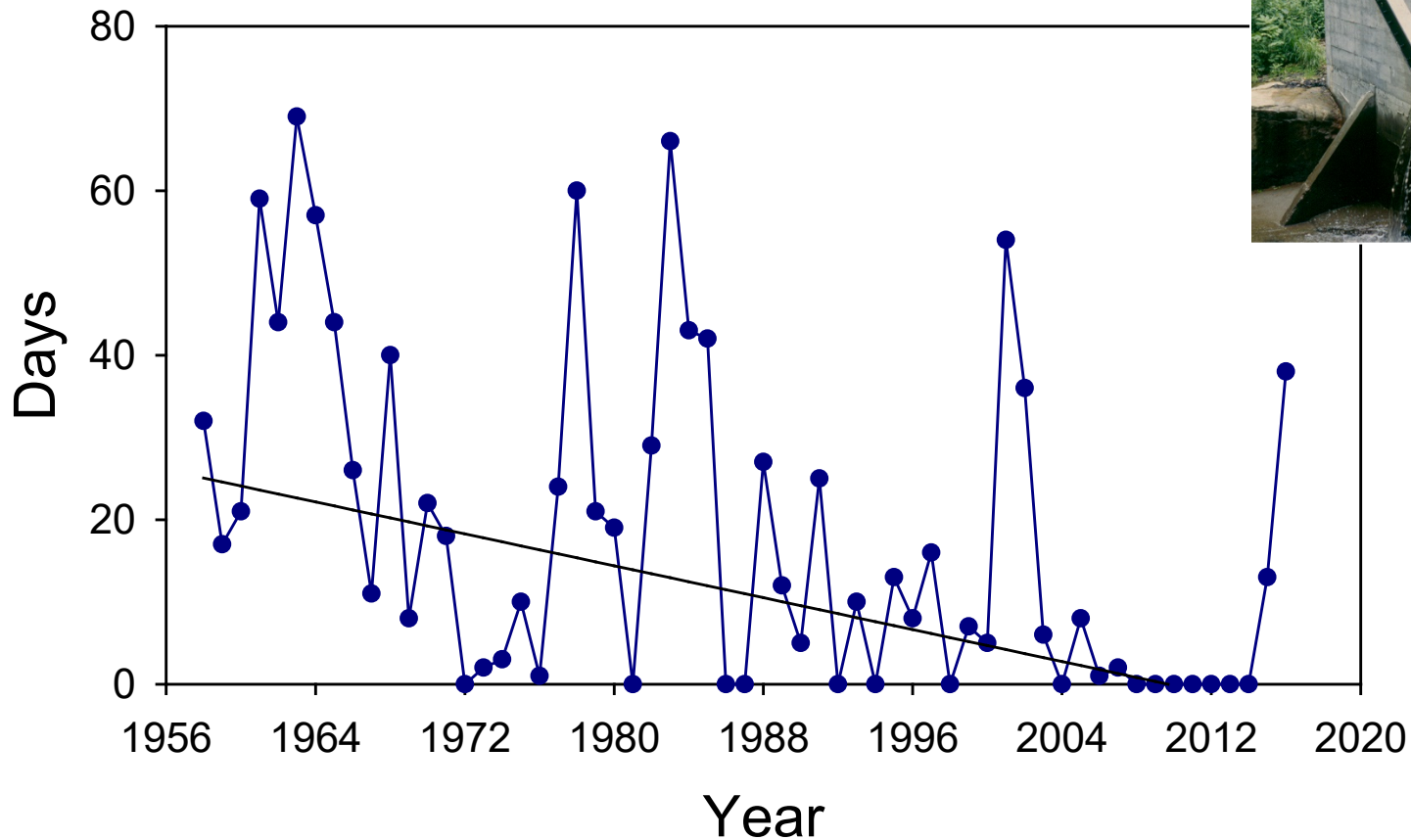


# High flow days are increasing



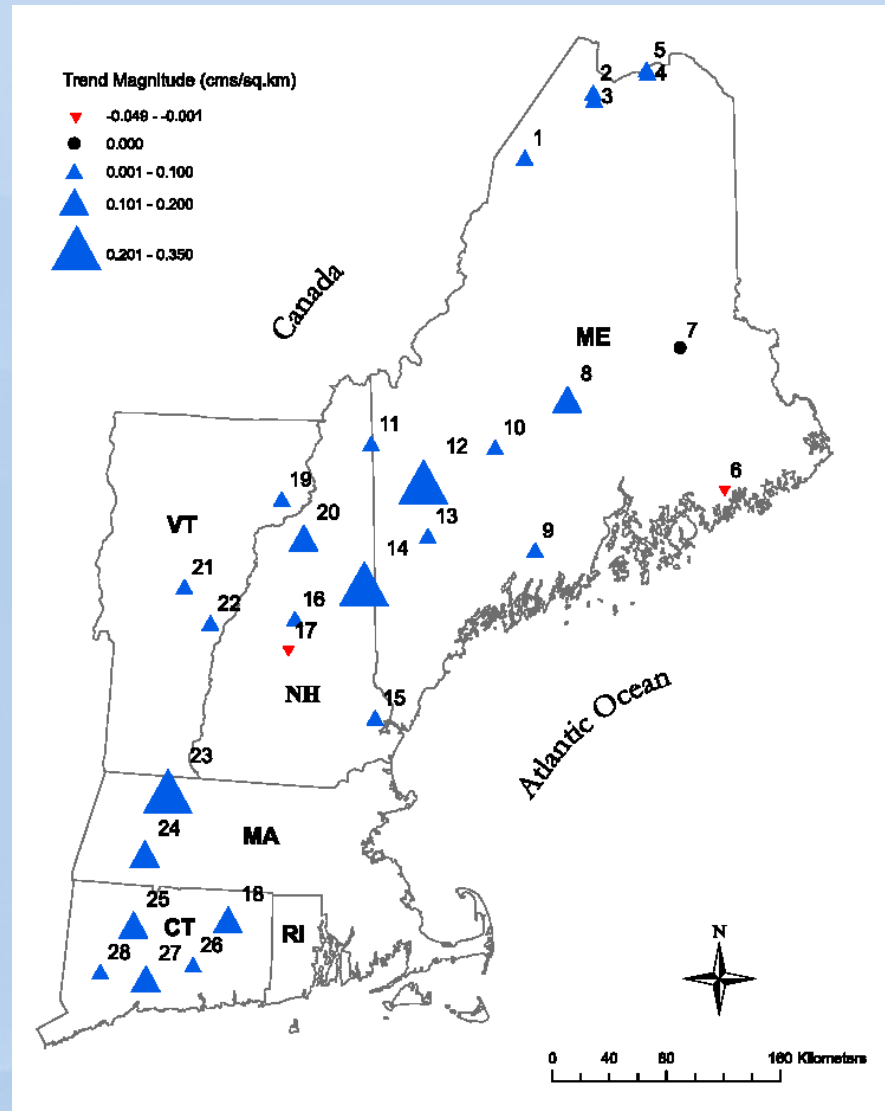
Number of days per year with streamflow > 95th percentile

# Low flow days are decreasing

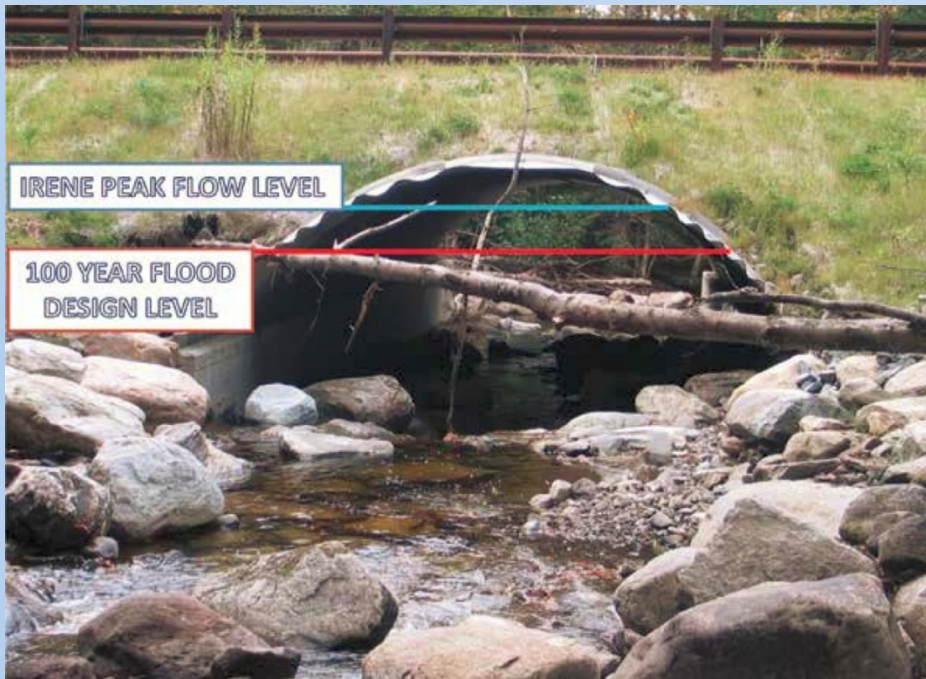


Number of days per year with streamflow < 5th percentile

# Regional Trends in Flood Frequency



# Impacts on infrastructure



*Photograph courtesy of Brian Austin, USFS, Green Mountain National Forest*

- **Damage to roads, bridges, culverts, and dams**
- **Data from the past are not reliable for making predictions of the future**
- **Design with climate change in mind**



# Water quality impacts (erosion/sedimentation)

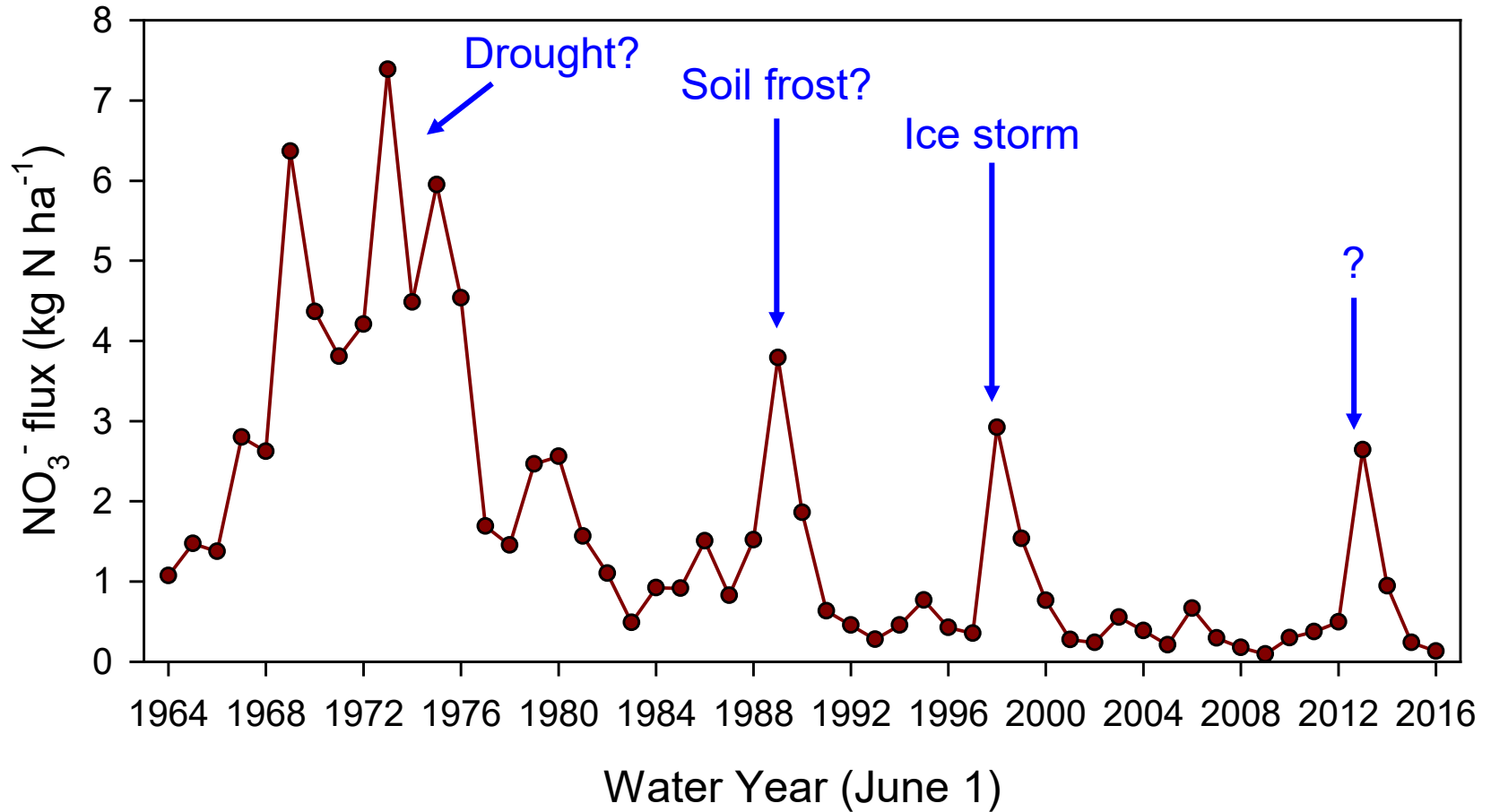


*Photograph courtesy of Scott Bailey, USFS*



- Sediment can adversely affect stream biota
- Sediment can also affect stream morphology
- High flow events produce the most sediment

# Nitrate in streamwater





## Soil Freezing



## Soil Warming (freeze-thaw)



## Drought



## Ice storm





# Managing forests for water supply and quality



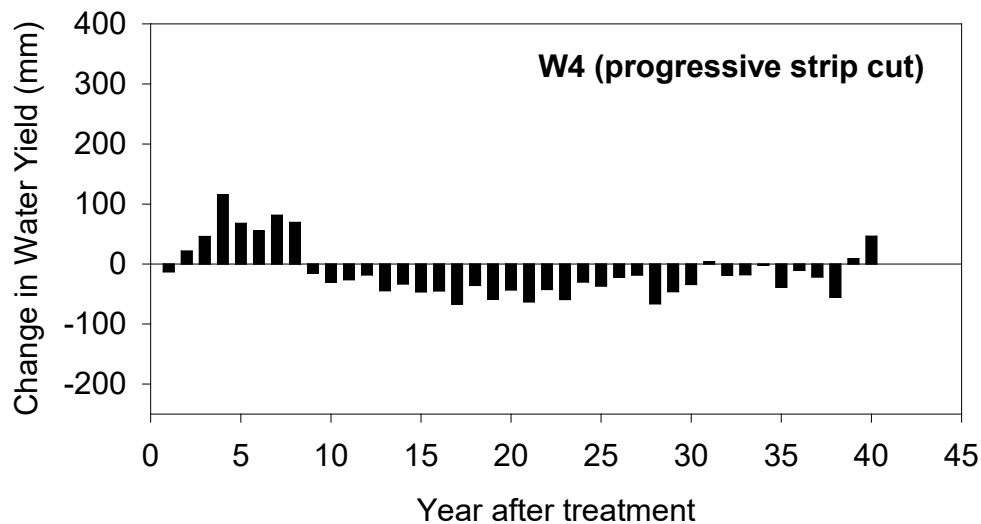
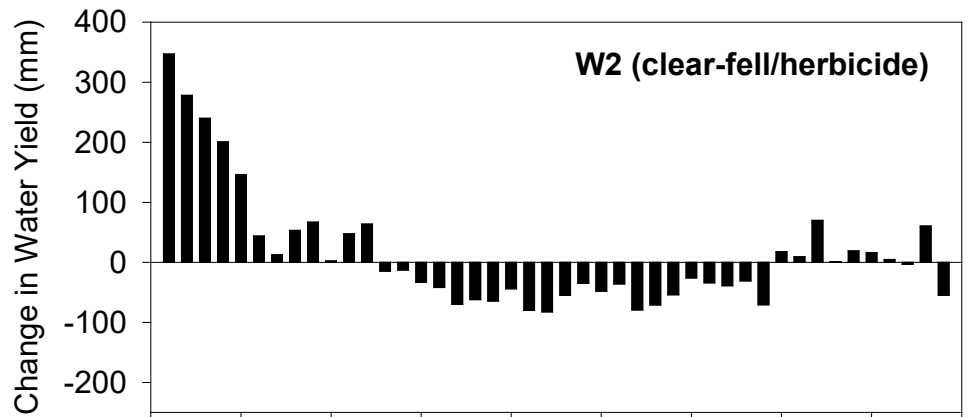
Quabbin Reservoir



1966 drought



# Can forest management mitigate/exacerbate climate change effects on water?



# How do you create the “invincible forest?”



**Maintain a diversity of species**  
**Maintain a diversity of age classes**



**Thank you!**