Changing Hydrology

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Forest Adaptation Webinar Series
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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
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

Hubbard Brook = 52 mm/decade (p=0.000)
St. Johnsbury = 37 mm/decade (p=0.000)
The graphs depict the temperature and precipitation data for different seasons and stations. The upper graph shows the temperature (in °C) slopes for Fall, Winter, Spring, Summer, and Annual periods, with indications of p<0.05 and p<0.10 significances. The lower graph illustrates the precipitation (in mm) slopes for the same periods.
Changes in snowpack

-27 cm

-19 days
Changes in streamflow

Watershed 8

Daily streamflow (mm)

Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct

1969

present
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
- 15th costliest in US history
- Up to 25 cm of rain in NH

Photographs courtesy of S. Bailey
Top 20 streamflow events

Rain-on-snow
Snowmelt
Convective rainfall
Frontal rainfall
Hurricanes
High flow days are increasing

Number of days per year with streamflow > 95th percentile

Fall flood (2017)
Warren, NH
Low flow days are decreasing

Number of days per year with streamflow < 5th percentile
Regional Trends in Flood Frequency

Collins. 2009. *Journal of the American Water Resources Association*
Impacts on infrastructure

- 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

Photograph courtesy of Brian Austin, USFS, Green Mountain National Forest
Water quality impacts (erosion/sedimentation)

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

Photograph courtesy of Scott Bailey, USFS
Nitrate in streamwater

Water Year (June 1)

NO$_3$ flux (kg N ha$^{-1}$)

Drought?
Soil frost?
Ice storm

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!