

What is Meant by Ecologically Significant Flows?

- **Flow** – depth, wetted perimeter, velocity, droughts, floods, scour
- **Temperature** – cold water species
- **Water quality** – nutrients, trophic state, sediment, acidity, organic pollutants, trace metals, color
- Other factors – light, substrate

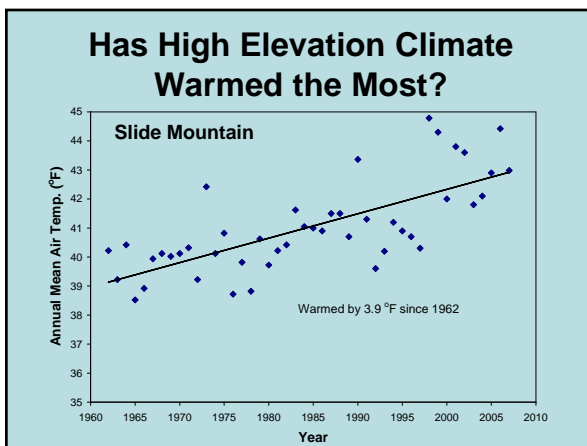
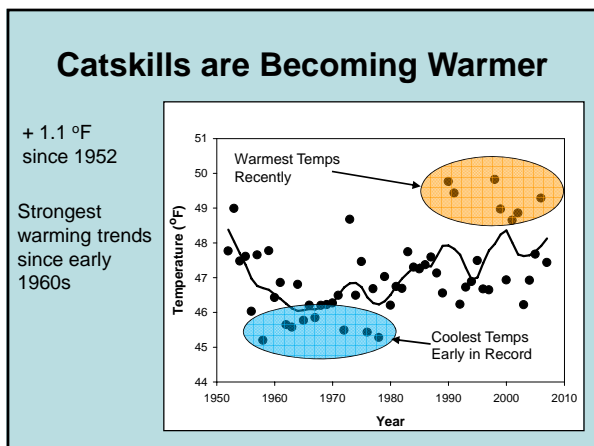
Scope of Presentation

- Catskill Region – lateral headwaters
- Analyses of climate-change-related trends
- Air temperature
- Seasonality of the climate – snowpack, snowmelt, growing season length
- Precipitation trends
- Other work – model-based forecasts of droughts, floods, air temperature
- Key ecosystem indicators – strengths & weaknesses of current measurements

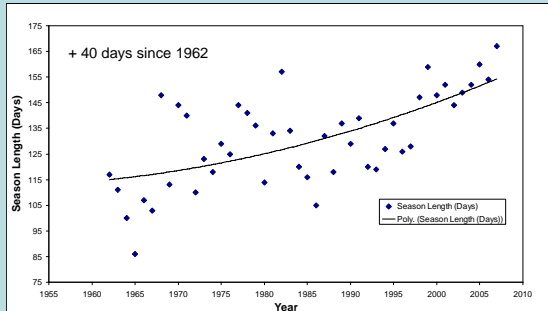
Map of Catskill Region and Climate Stations

EXPLANATION

- USGS Imaging Station
- ▲ USGS Climate Station
- △ USGS Climate Station
- Catskill Region



Slide Mtn. Growing Season Length

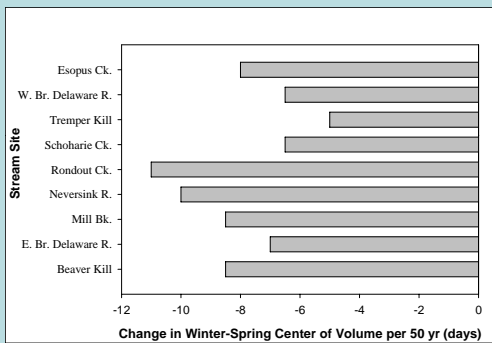


Timing of Snowmelt

- Beginning of warming stream temps.
- Earlier snowmelt might mean lower flows in late spring and summer
- Ephemeral pools
- Water supply
- Difficult to measure peak snowmelt
- Winter-Spring Center-of-Volume – WSCV, half of Jan. 1 to May 31 flow volume



Snowmelt Earlier in Year



Trends in Snow Cover

Variable	Statistical Significance (p value)	Trend (per 50 years)
Maximum seasonal snowpack (in)	0.094	-13.6
Average snowpack depth (in)	0.049	-3.7
Days with snow cover	0.050	-26.5

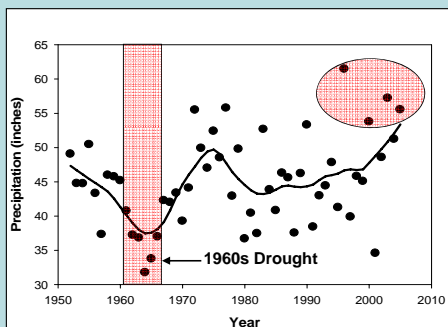


Catskills are Wetter

+5.4 in/yr

Most of the increase in June – Oct. precip.

Average streamflow increasing as well

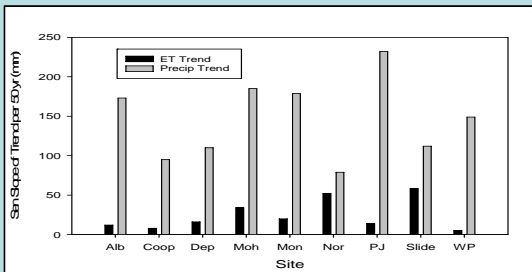


Global Climate Change Expected to Increase Precipitation

- Models - +1 to +3% per deg C of warming
- Observations - +6 to +7.5% per deg. warming since 1980s
- Catskills have been increasing at an even greater rate
- Other factors contributing – global brightening
- We don't have a full explanation for regional trend



Evapotranspiration is Increasing



Burns et al., 2007



Additional Changes Expected in Water Resources

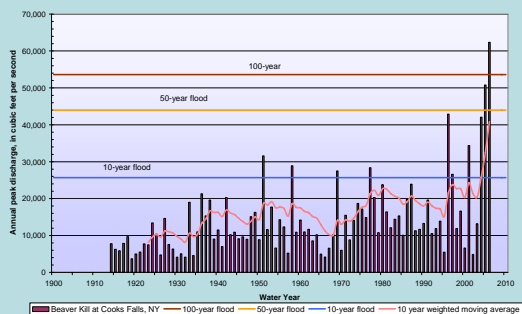
- Increasing intensity and frequency of large rain events – bigger, more frequent floods?
- Increasing intensity and frequency of drought
- More forest fires
- Slide Mtn. not showing trends in drought or frequency of large rain events



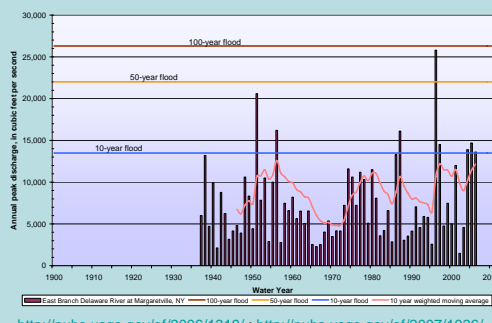
See: Hayhoe et al., 2007 and 2009; Huntington et al., 2009



Some Catskill Rivers Show Increasing Flood Peaks....

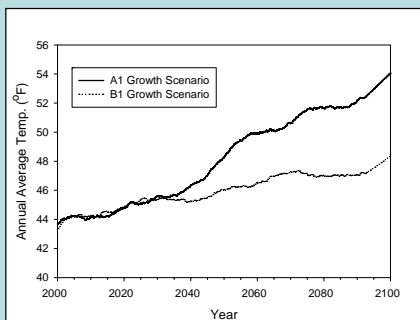


And Some Don't



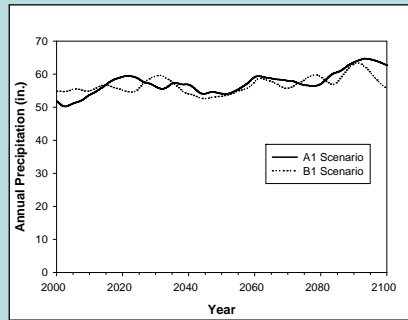
<http://pubs.usgs.gov/of/2006/1319/> ; <http://pubs.usgs.gov/of/2007/1036/>

Temperature Predictions for Catskills – GFDL Model




Poumokhtarian, unpublished data

Precipitation Predictions for Catskills – GFDL Model





Poumokhtarian, unpublished data




Key Ecosystem Indicators for Water Resources

- **Streamflow** – floods, low flows, snowmelt, Adirondacks have few “natural” stream/river gages
- **Stream temperature** – little long-term data available
- **Snowpack** – little data on snow water equivalents
- **Water quality** – USGS UNO/ONO network closing
- **Evapotranspiration** – few sites with sufficient data
- **Light/transparency** – aquatic productivity




Light Available to Aquatic Systems

- **Canopy leaf out affects light in spring early summer – longer growing season could diminish spring radiation**
- **Transparency affects aquatic productivity**
 - Sediment – land disturbance, high flows
 - DOC – has been increasing in recent years, decreased acid rain, influence of climate warming and wet/dry cycles

Closing Thoughts

- Human land use/disturbance effects can completely overwhelm climate effects
- Climate varies from year-to-year
- Other climate change patterns – multi-decadal oscillations, ENSO, NAO
- Steepness of greenhouse gas trends will greatly affect extent of ecological effects of climate warming


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- **I have electronic versions of any citations I referred to here**

