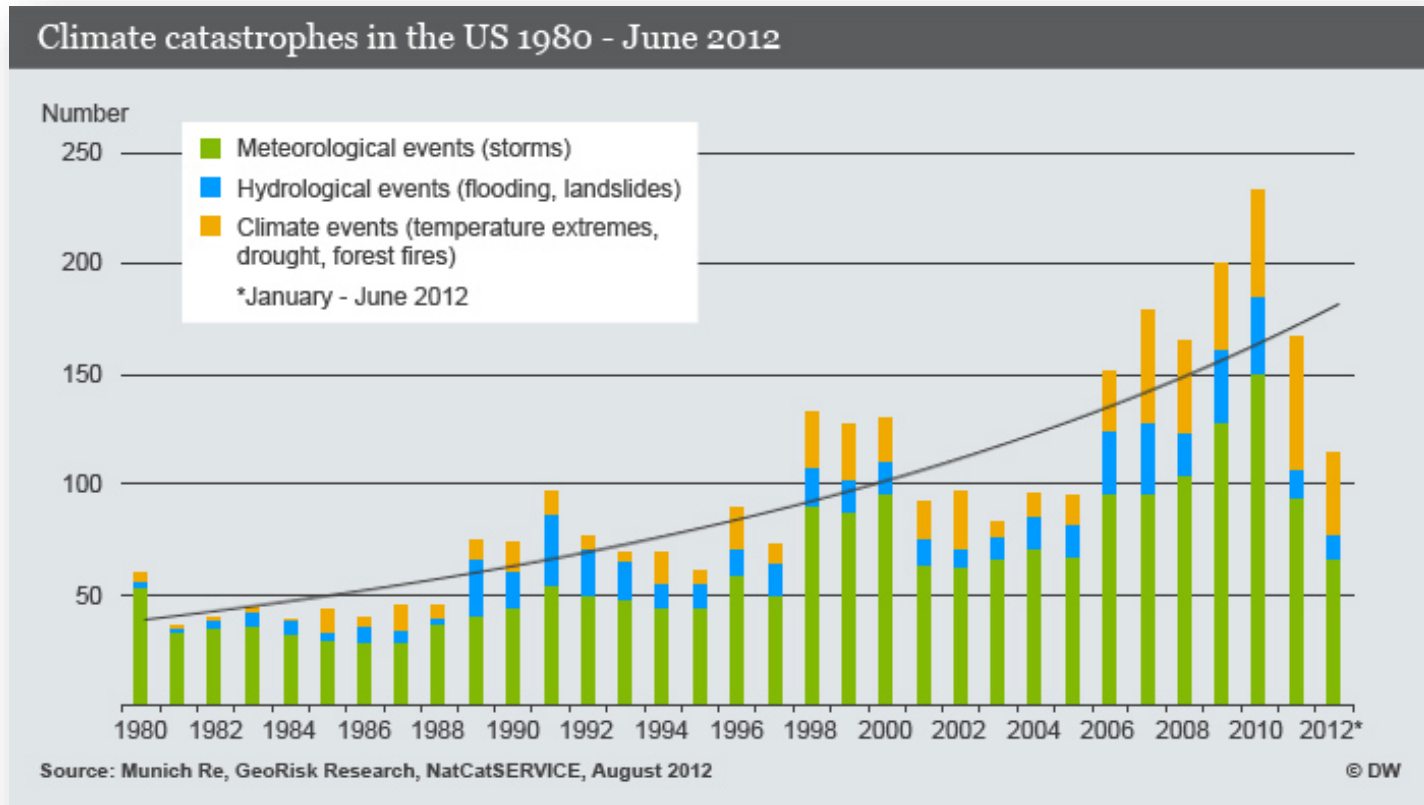


Why temperature matters: Implications for forest watersheds & services



Nicolas Zègre

West Virginia University

Mountain Hydrology Lab



Carson Wright (WV DEP)



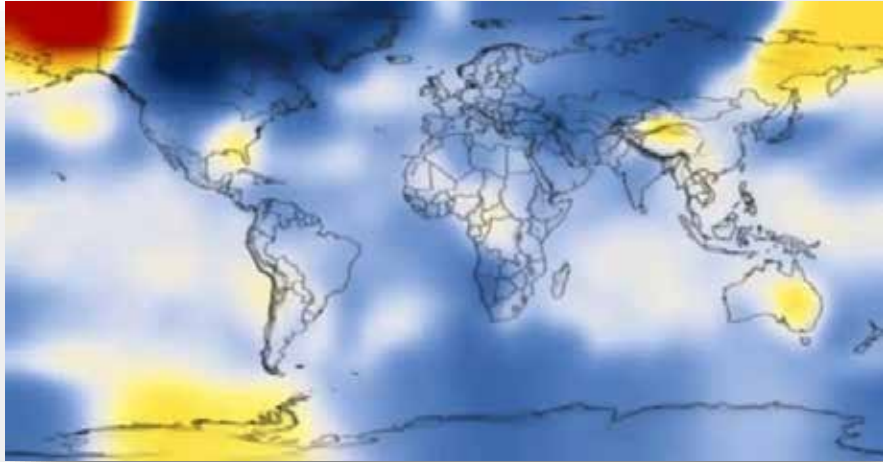
David Young (Green Rivers)



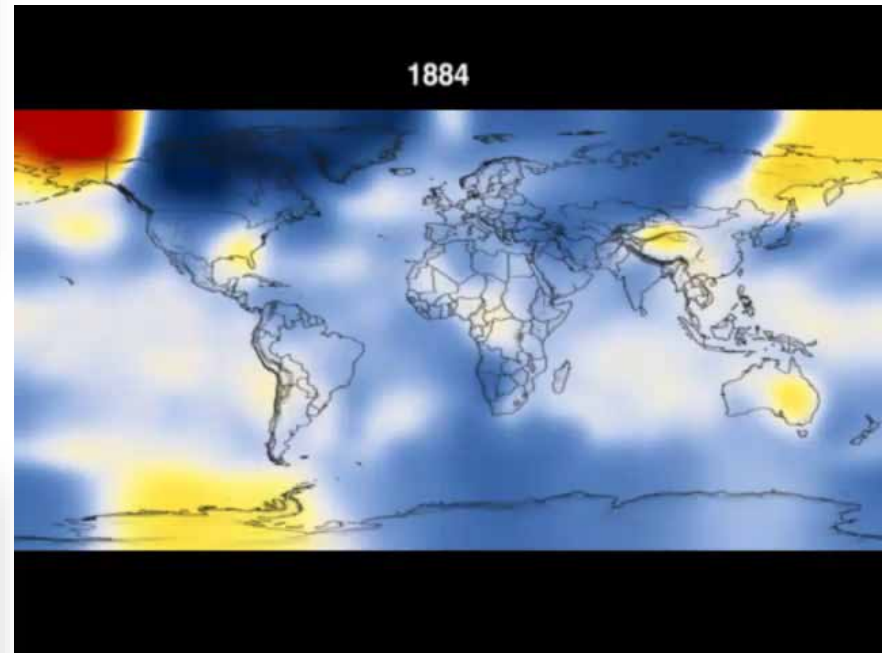
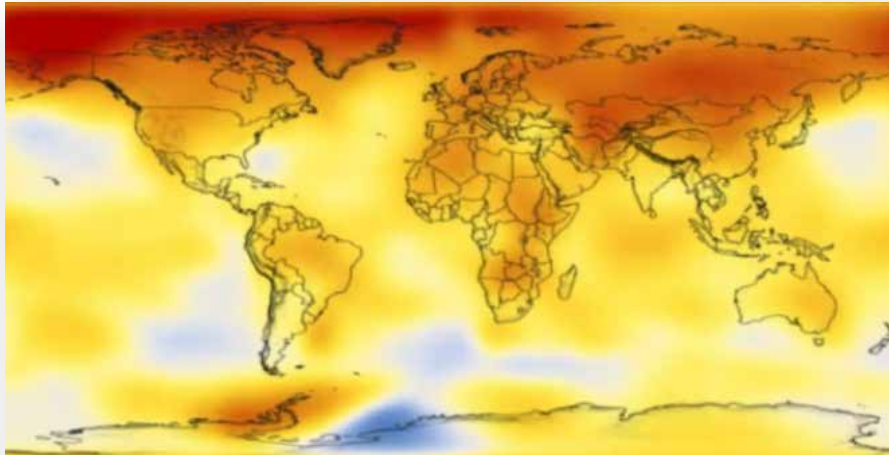
Leighia Eggett (Peace Corps)



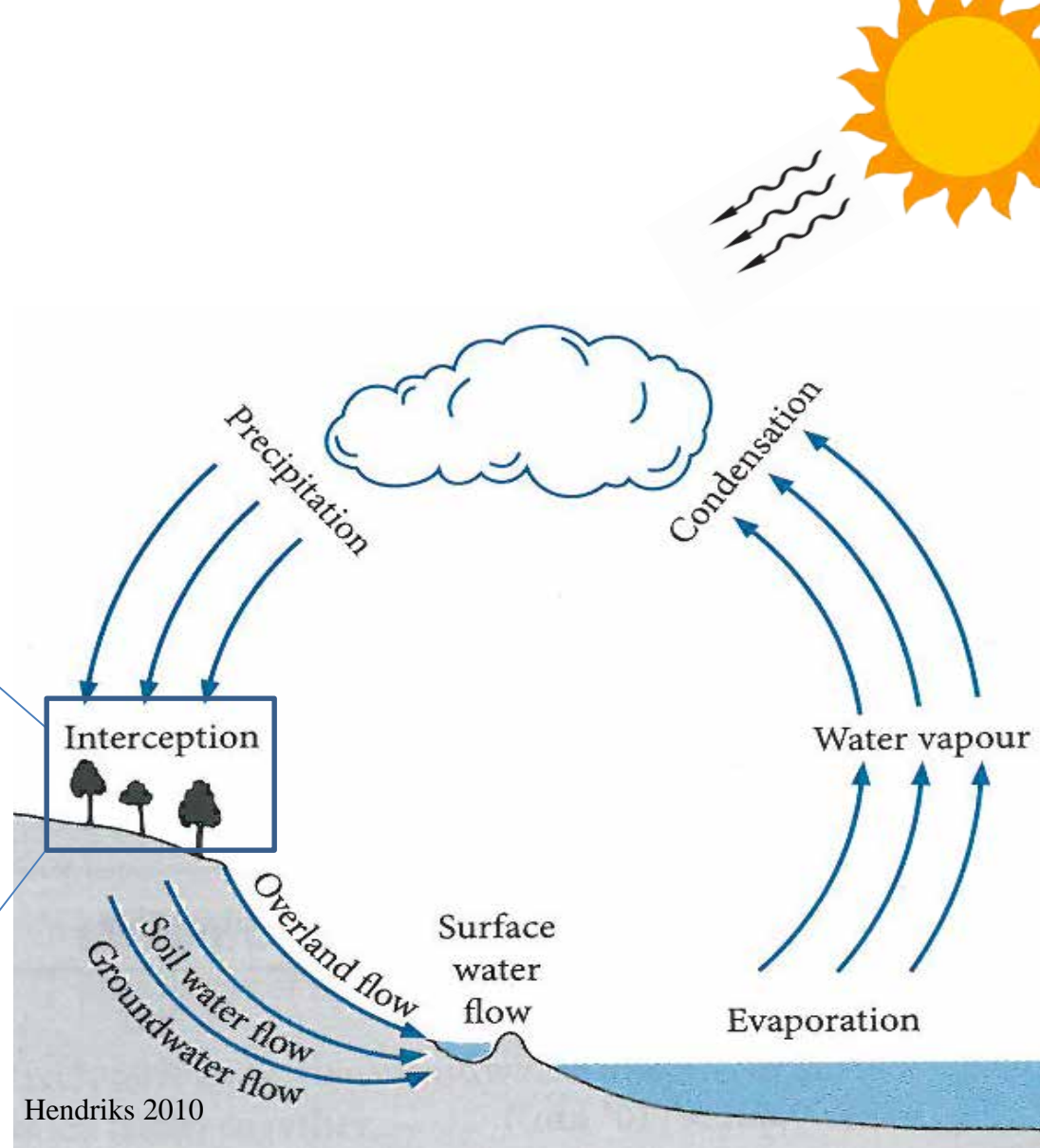
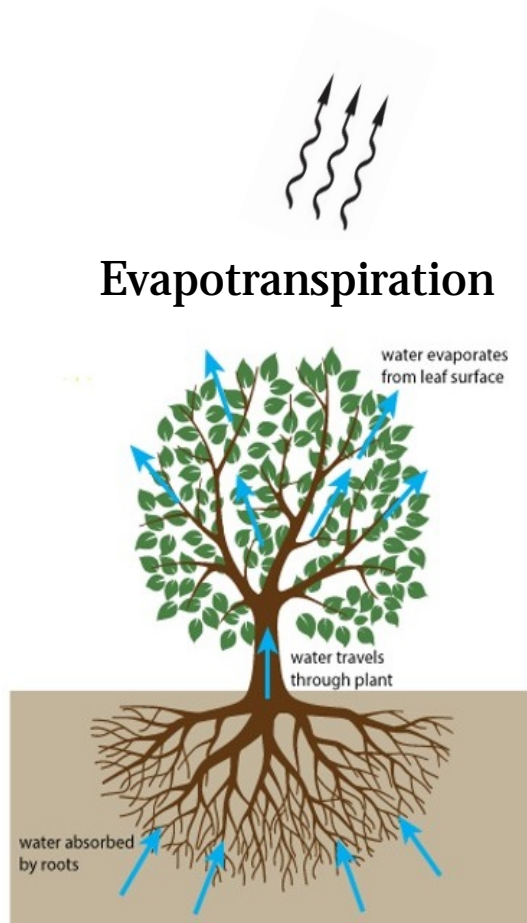
1884



2006



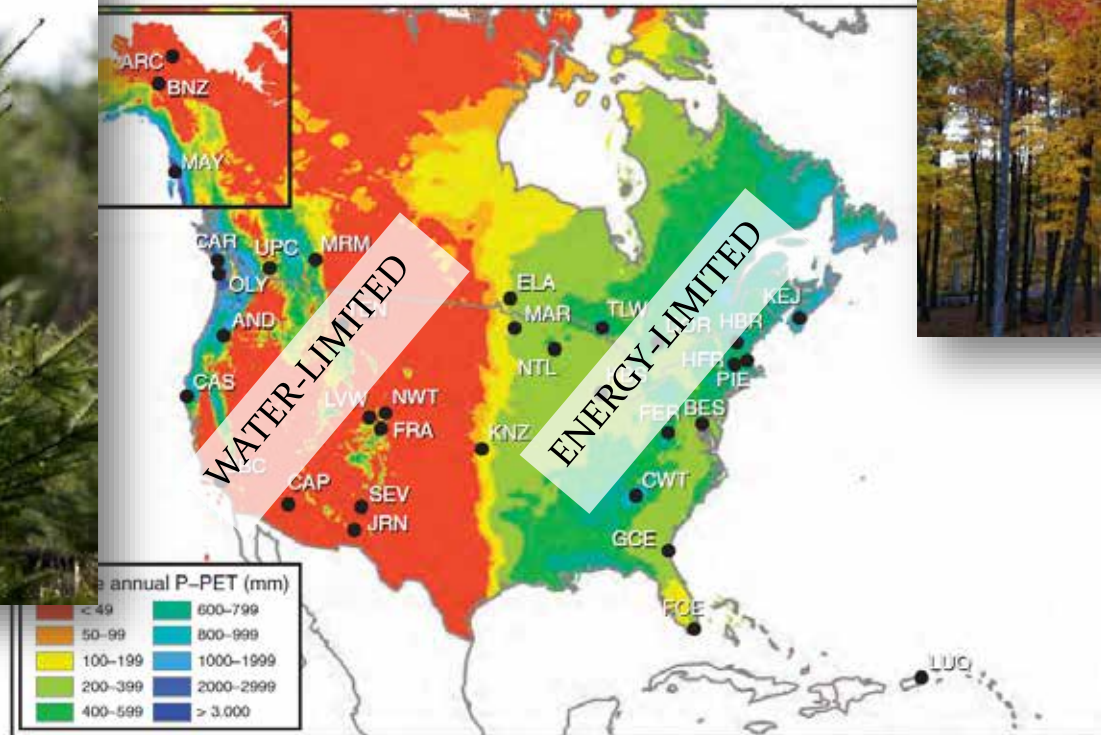
The Water Cycle



Hendriks 2010

Controls on hydrology

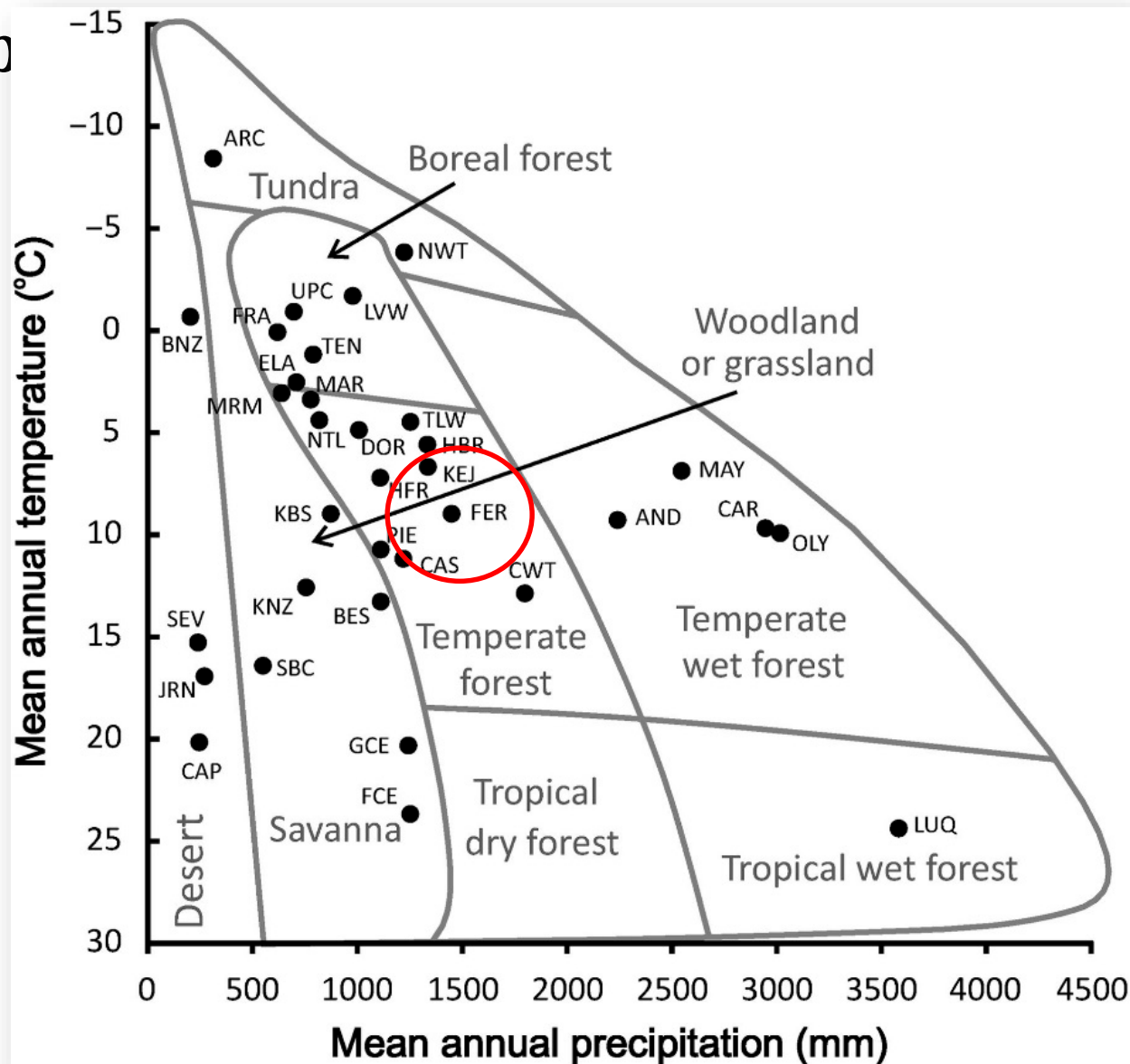
Climate, Landcover, & Morphology



Controls on hydrology

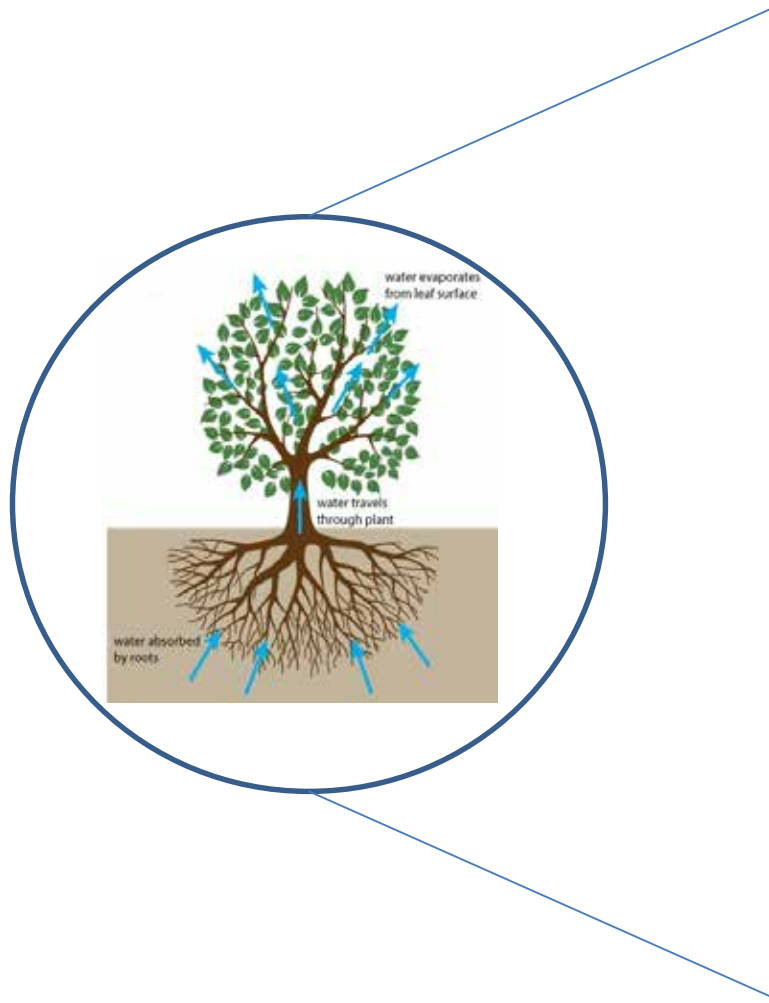
Climate, Landcover, &

Morp



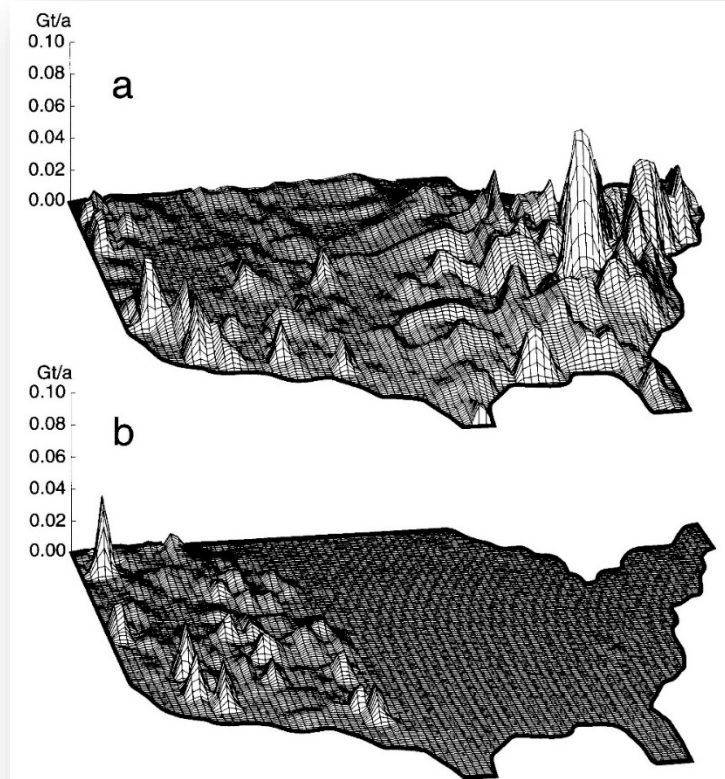
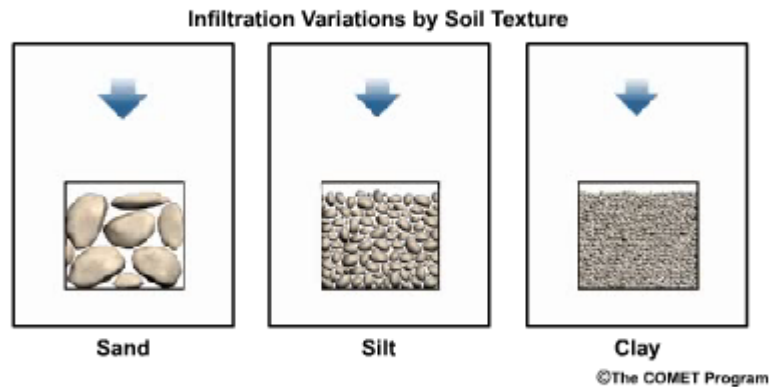
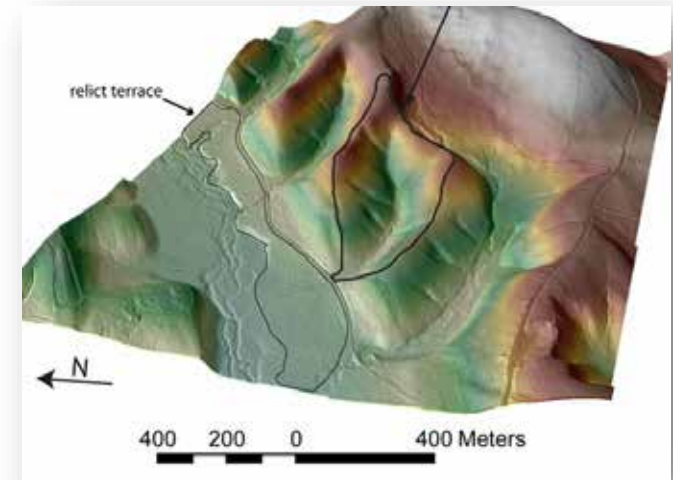
Controls on hydrology

Climate, Landcover, & Morphology



Controls on hydrology

Climate, Landcover, & Morphology



Why temperature matters

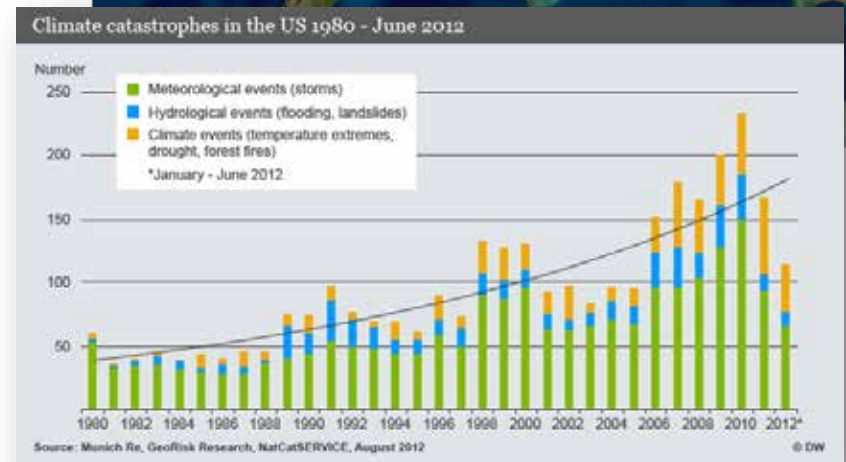
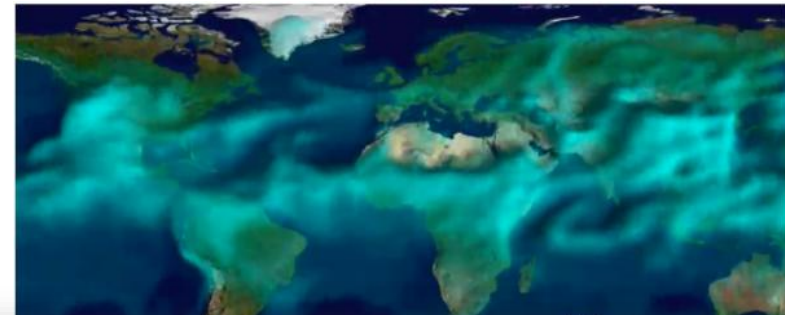
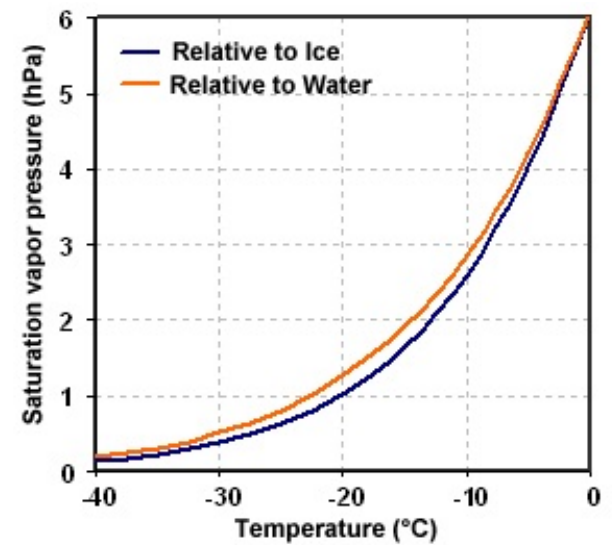
Why temperature matters

Clausius–Clapeyron relation:
warmer air holds more water;

Feedbacks - Water as GHG;

Acceleration in water cycle –
storms, floods, & droughts;

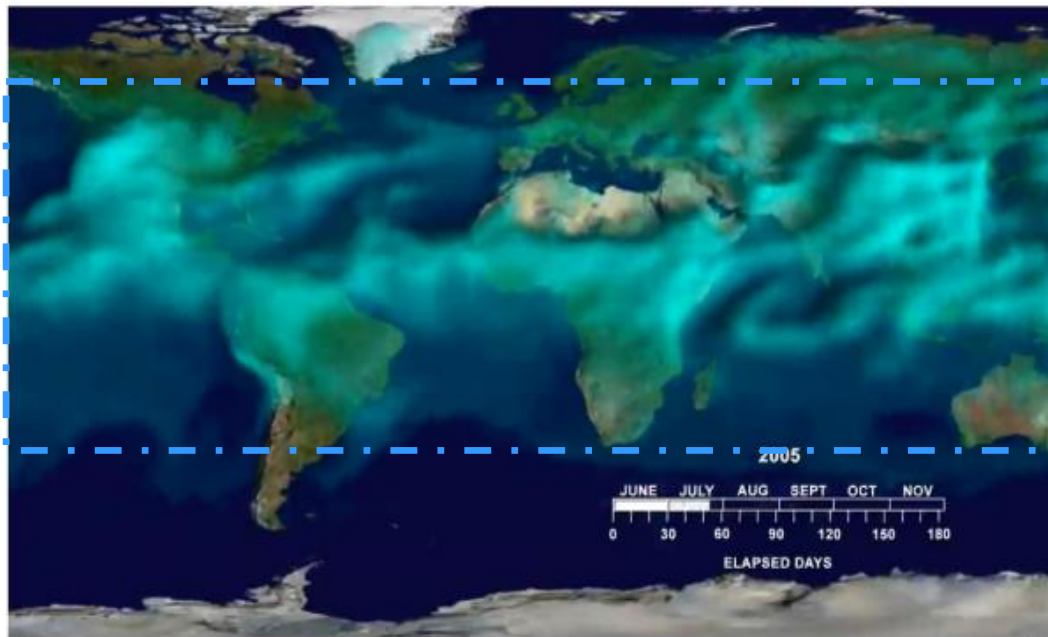
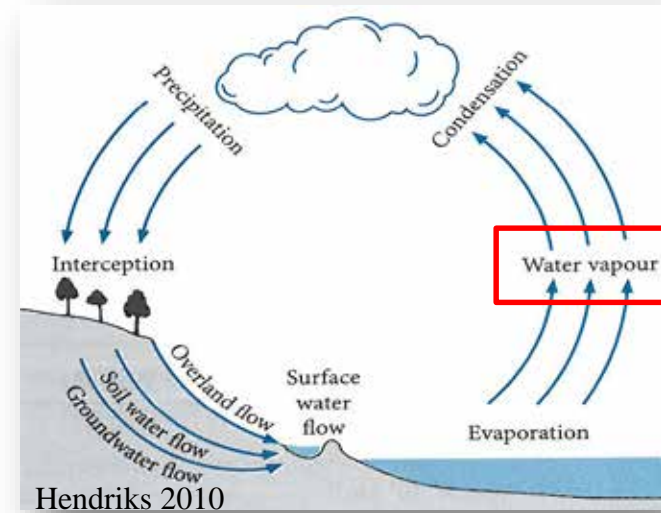
*How sensitive are forest
watersheds (& their
services) to changes in
climate?*



Atmospheric water vapor

Water stored in the atmosphere

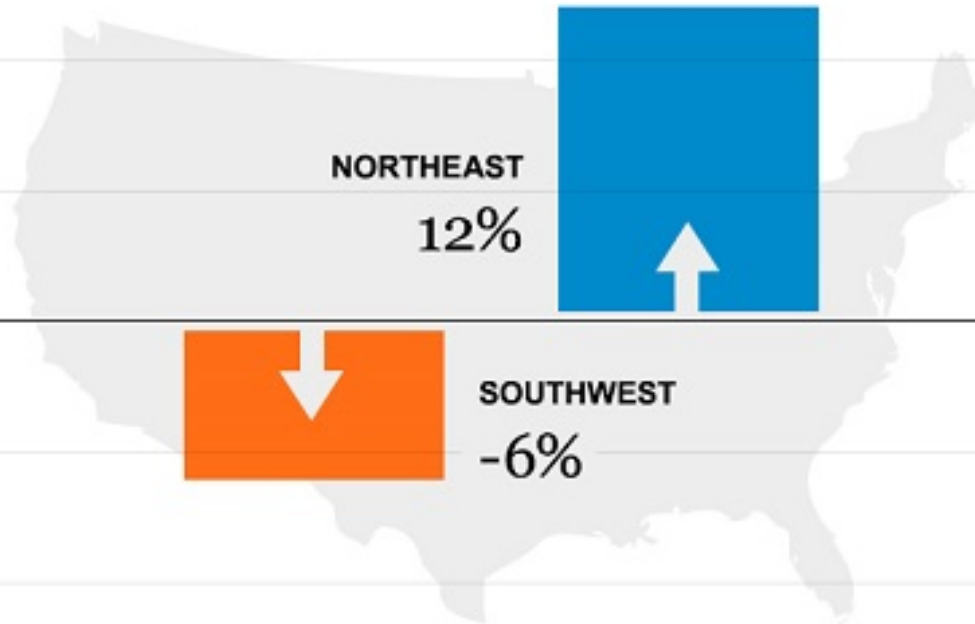
- High spatial variability;
- Increasing between 60°S & 75°N [1]



Precipitation

Global increases by 1-3% [2]

Annual U.S. rainfall



Average rainfall change 2001-2012 relative to 1901-1960 average.
Source: National Climate Assessment 2014

Hemisphere

- incre
- decre
- (southern hemisphere) [4]

Transpiration

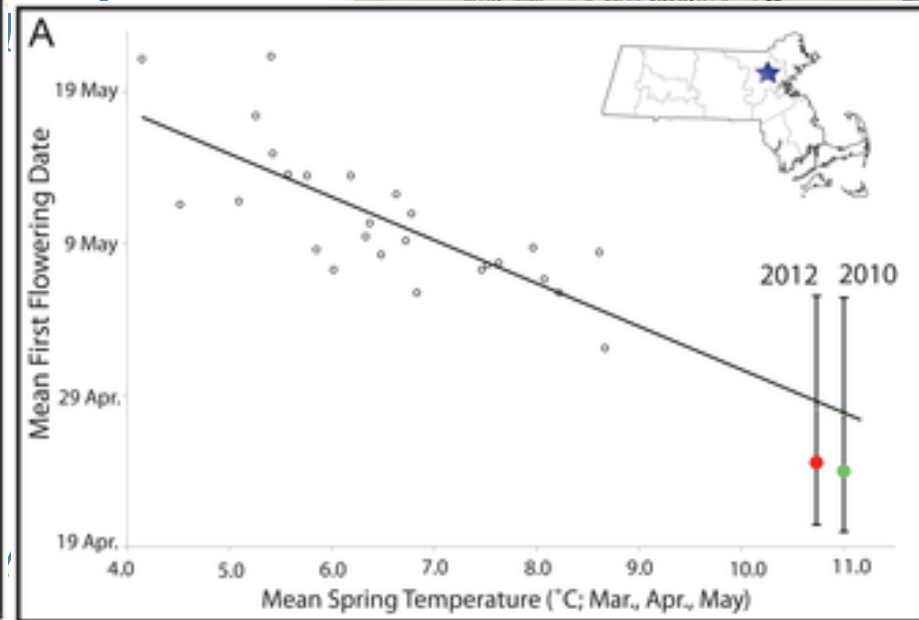
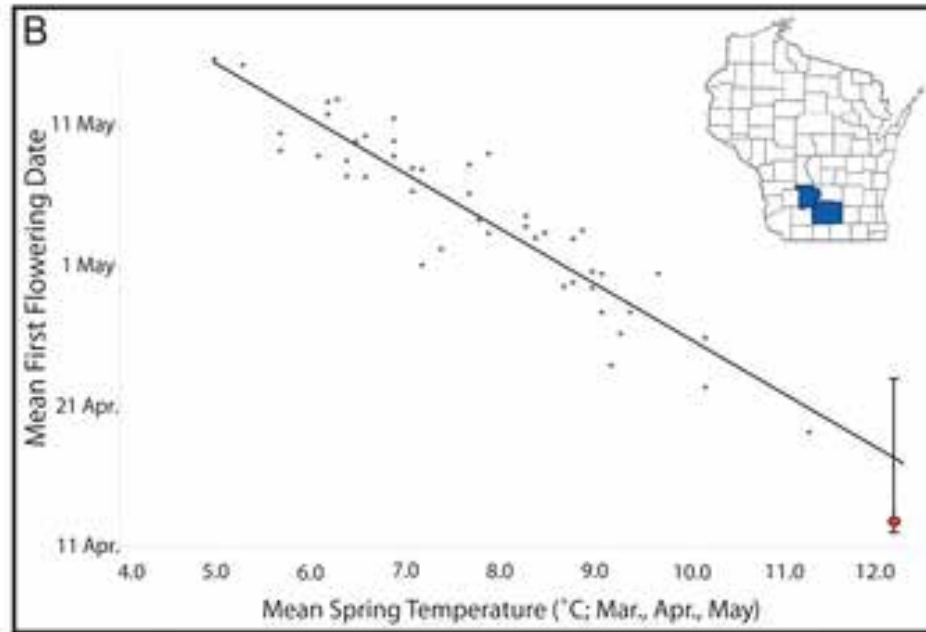
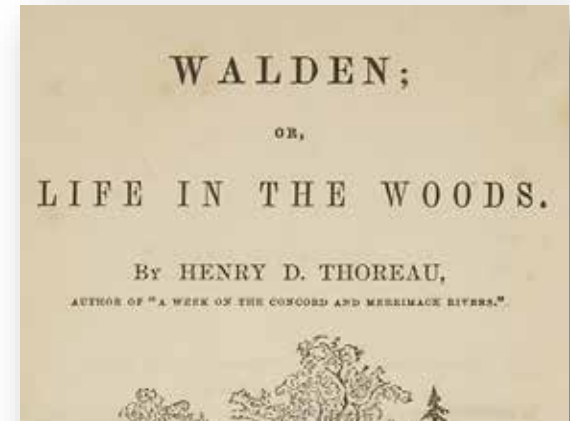
- Plant water uptake;
- Controlled by solar radiation, moisture, vapor gradient, & plant physiology;

Generally increasing

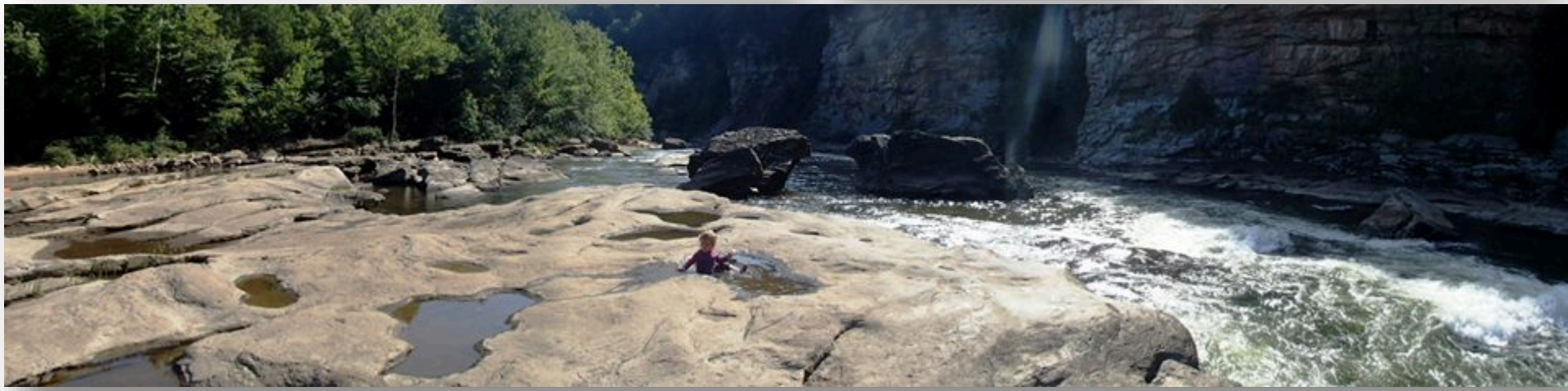
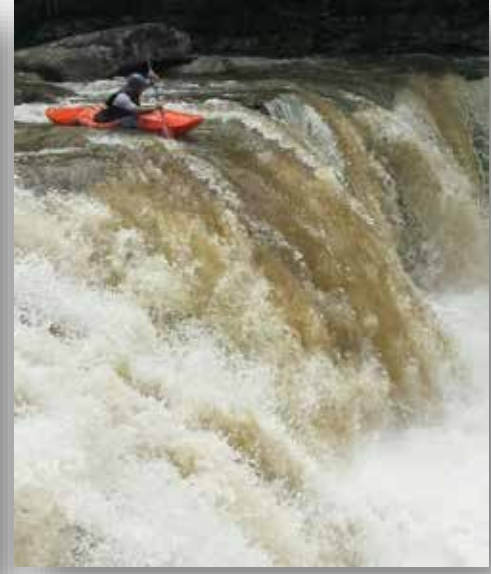


Growing Season Length

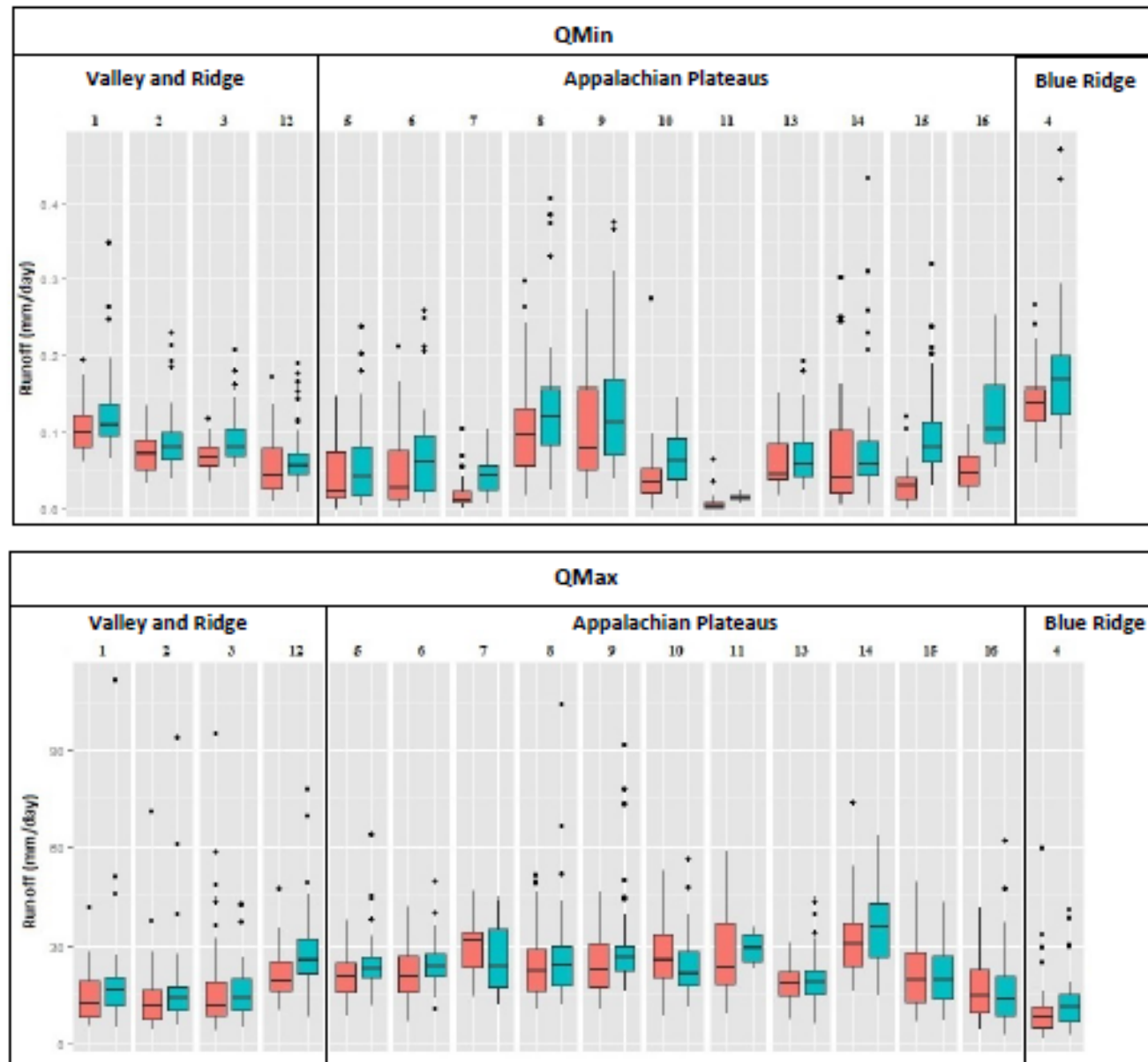
Look back to the founders of environmental lit & philosophy:



Water World – West Virginia



Historical variability



Intensification Study

Cheat River [3,700 km²/1,428 mi²]

Max elevation: 1,482 m / 4,863 ft

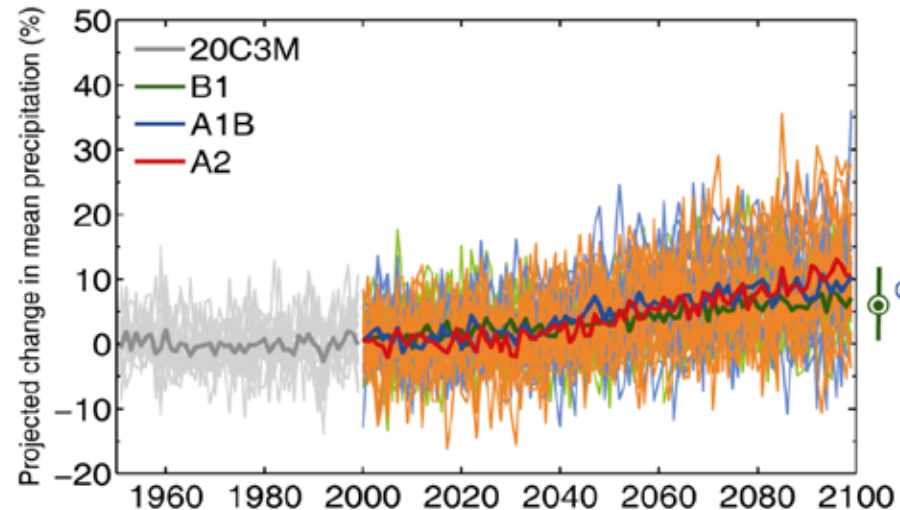
Temperate forest - mixed hardwood

Precipitation: 1,480 mm / 58 in.

Air Temp: 9.3°C / 49°F



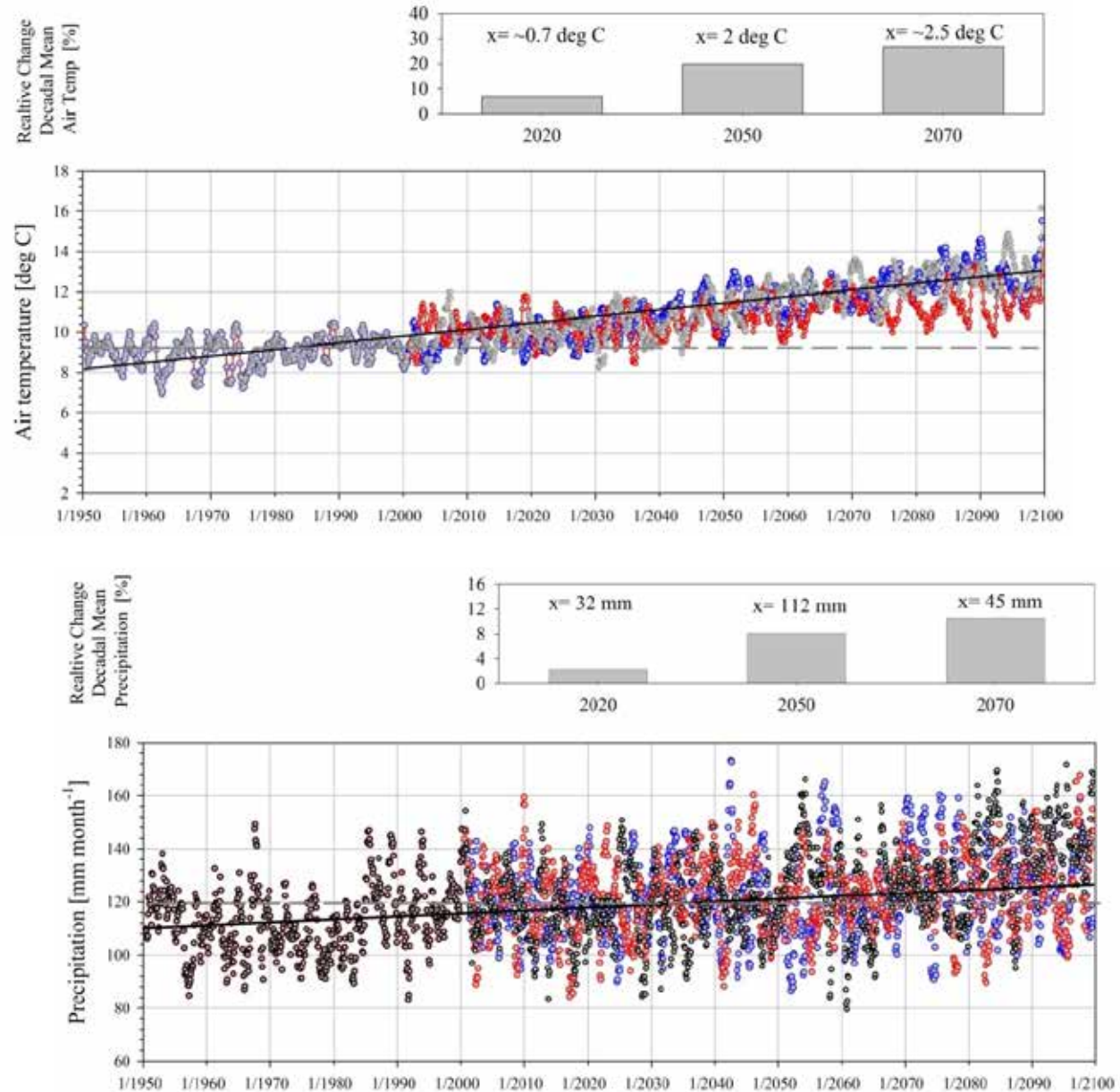
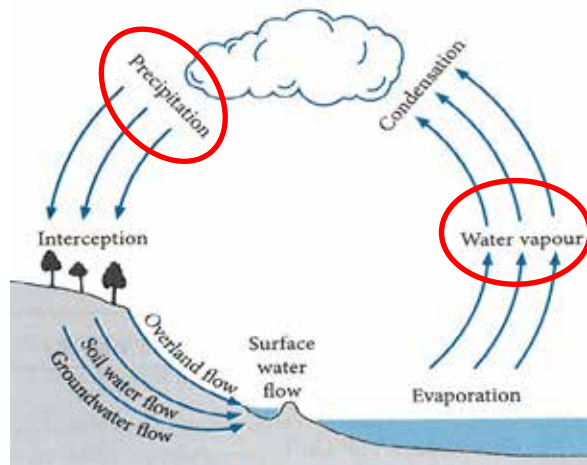
- 3 climate scenarios to characterize an uncertain future (IPCC);



- Monthly air temp & precipitation from the Coupled Model Inter-comparison Project;
- Input into hydrologic model calibrated using historical data (1950-2005) to predict future hydrology;

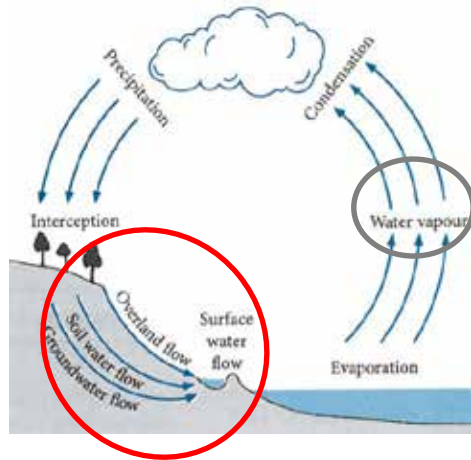
What did we learn?

Air temp

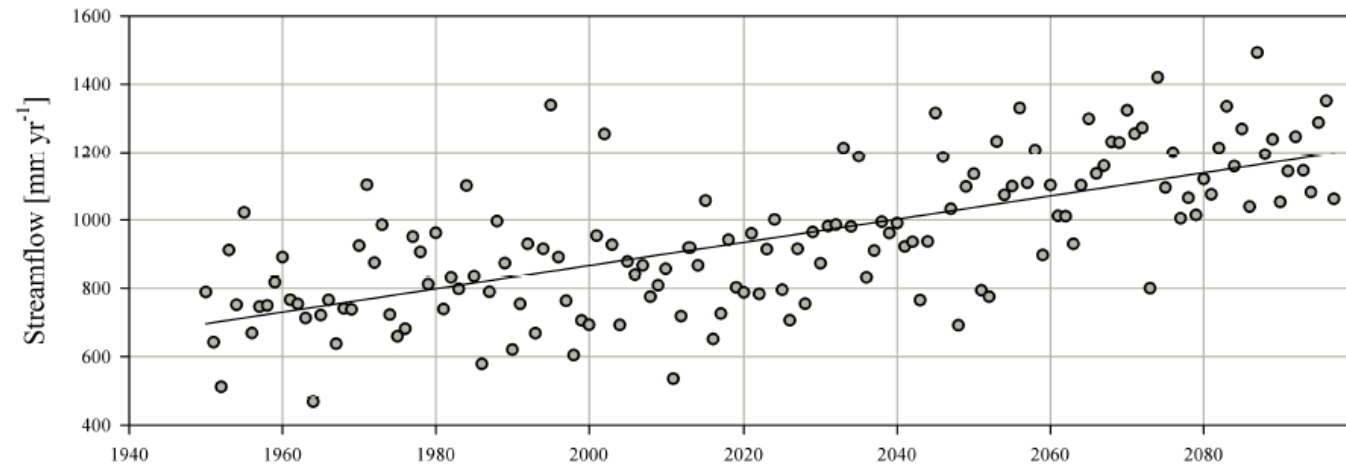
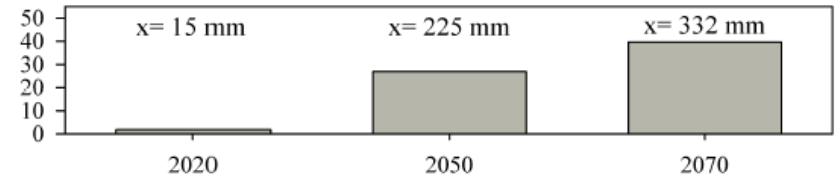


Precipitation

Streamflow



Relative Change
Decadal Mean
Streamflow [%]



Warmer air means *more* rain & more runoff

Implications of Intensification

Ecological

- Resilience;
- Species changes (transpiration, soil chemistry);
- Nutrients, sediment, water quality;
- BMP's, TMDL;
- Aquatic habitat;
- Carbon sequestration;
- Etc.

Societal

Forest ecosystem services;

- Flood attenuation;
- Nutrients, CO₂;
- Drinking water, irrigation, electricity, etc.;
- Fiber & food;
- Forest productivity, management, industry;
- Infrastructure;
- Etc.

Figure 6. Projected forest communities under (a) current climate, (b) the Hadley climate scenario, and (c) the Canadian climate scenario, based on the results of individual analyses of 80 tree species shifts (see Prasad and Iverson, 1999-ongoing <http://www.fs.fed.us/ne/delaware/atlas/index.html>)

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Mountain Hydrology Lab
Davis College
West Virginia University

[http://www.mountainhydrologylab.com/
nicolas.zegre@mail.wvu.edu](http://www.mountainhydrologylab.com/nicolas.zegre@mail.wvu.edu)



Closing thoughts

“We realize we need to prepare for a future when carbon dioxide emissions must be reduced”.



“Cutting greenhouse gas emissions while keeping the lights on for a growing population is a huge but critical challenge. We have to believe it is a challenge we can meet.” - Ben van Beurden, CEO



“Energy and climate represent two of the most important business challenges of this century.”



Closing thoughts

“The impacts of climate change may increase the frequency, scale, and complexity of future missions”.

“Climate change is a national security challenge...it will affect the type, scope, and location of future Navy missions”.

