



When was the first “protection forest” established in Switzerland? 1342




NATIONAL SCHOOL OF WATER AND FORESTS
Est. 1824
Nancy, France

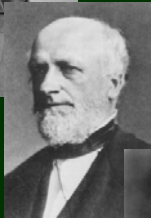
Steve Dunskey, USFS




Sir Deitrich Brandis, Gifford Pinchot, 1897, Germany



George Perkins Marsh
Man and Nature
Or, Physical Geography as Modified by Human Action
1864



Dr. Franklin Hough
Report upon Forestry
National Academy of Science
1878



Raphael Zon (US Forest Service)
Forests and Water in the Light of Scientific Investigation
US Senate Document
1912 and 1927

Forests [Cutover] and Floods



Henry Graves
Chief, USFS
1910-1920

Eastern National Forests ...and many State and Municipal Forests



"Forests on critical watersheds should be owned by the public for their protective value."

1911 WEEKS ACT

REP. JOHN WEEKS



2000



2007



2008



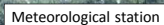
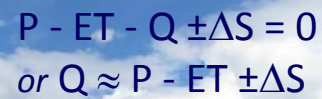
2013



2016

Forests and Water
Patterns, Processes,
and Management
Implications

Paul K. Barten, Ph.D., Professor, University of Massachusetts Amherst
Hydrology Module – Northeast Silviculture Institute for Foresters
Craftsbury Common, Vermont – May 23, 2017©

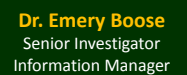


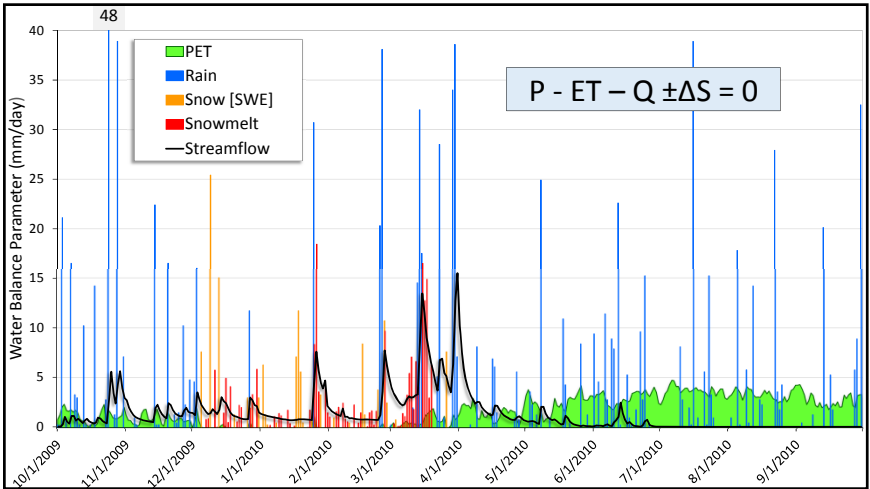
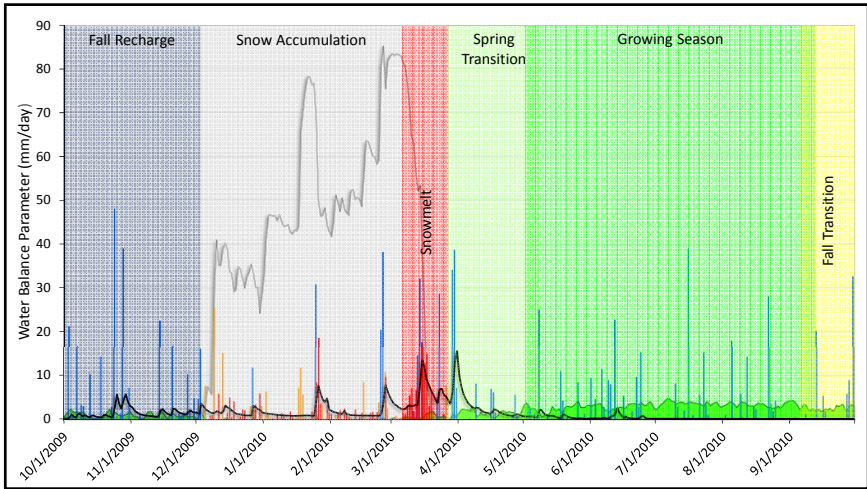
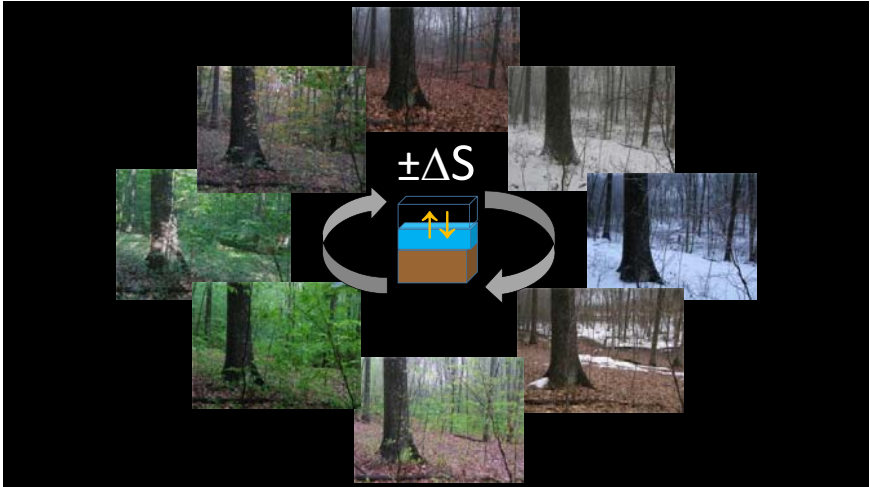
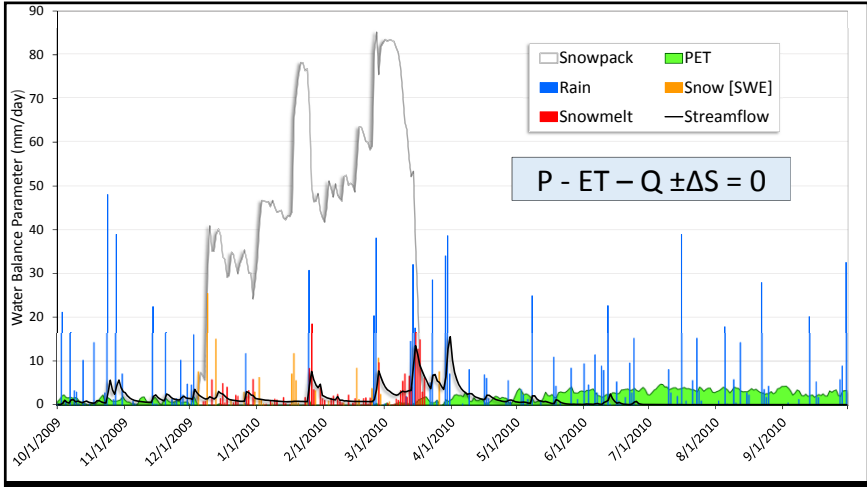
Eddy Flux Tower

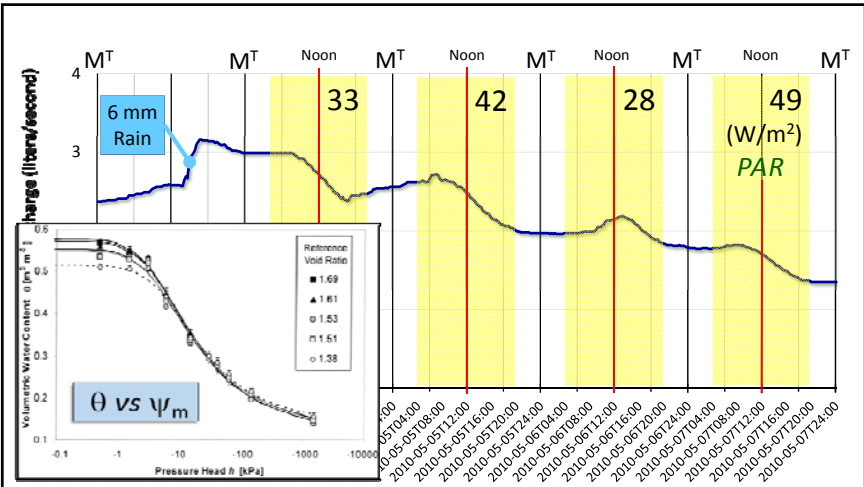
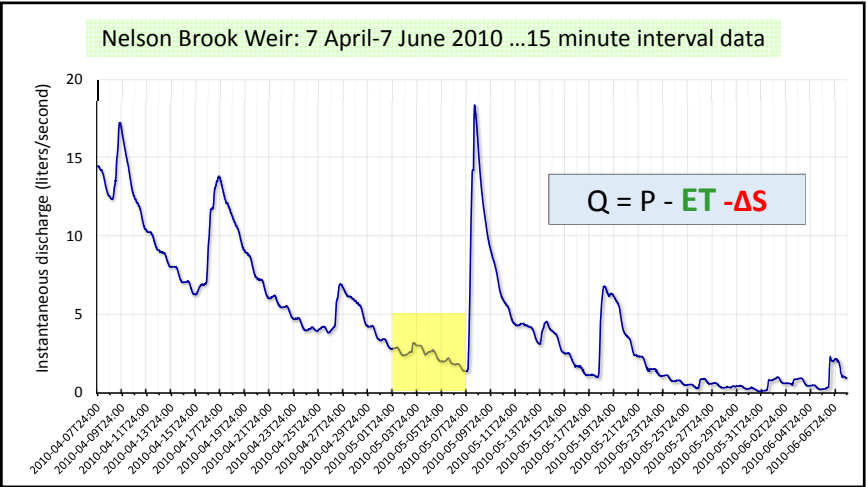
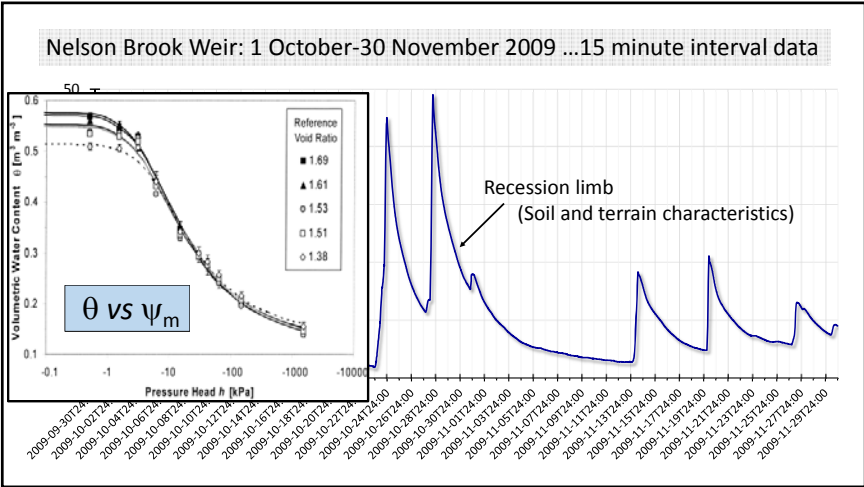


120° V-Notch Weir

Snow Pillow







Soil – Plant – Atmosphere Continuum

Atmosphere

↕

Forest

↕

Tree

↕

Leaf

↕

Stomata

↕

Xylem & phloem

↕

Roots

↕

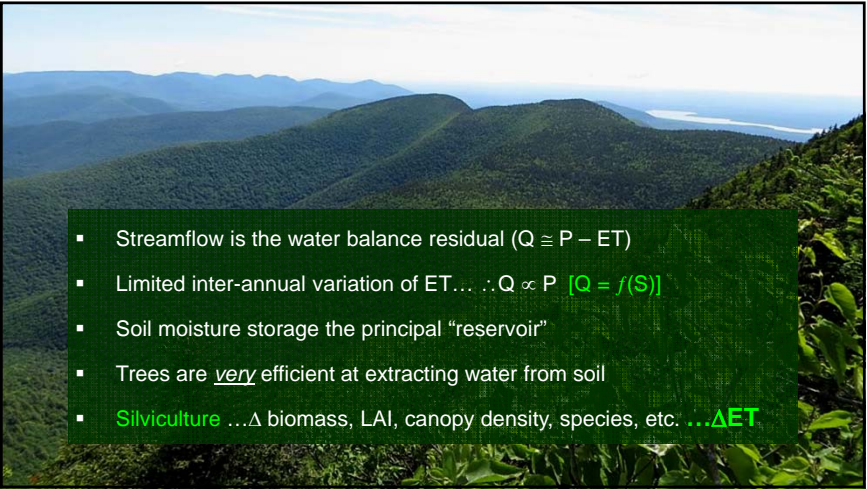
Soil



Trees are highly evolved, adaptable organisms—not passive wicks.

Spencer Woodlot
Conway, Mass.

- Streamflow is the water balance residual ($Q \cong P - ET$)
- Limited inter-annual variation of $ET \dots \therefore Q \propto P$ [$Q = f(S)$]
- Soil moisture storage the principal “reservoir”
- Trees are very efficient at extracting water from soil
- Silviculture $\dots \Delta$ biomass, LAI, canopy density, species, etc. $\dots \Delta ET$





Ole

Oa

E

Bh

Bs1

Bs2

C

$P - ET - Q \pm \Delta S = 0$

B
Zone of Accumulation
 \therefore Impeding Horizon

Litter layer

O

A

E

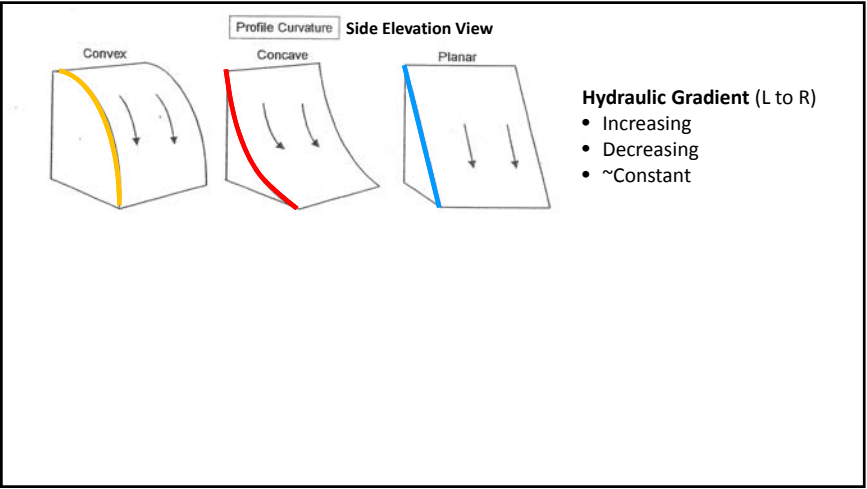
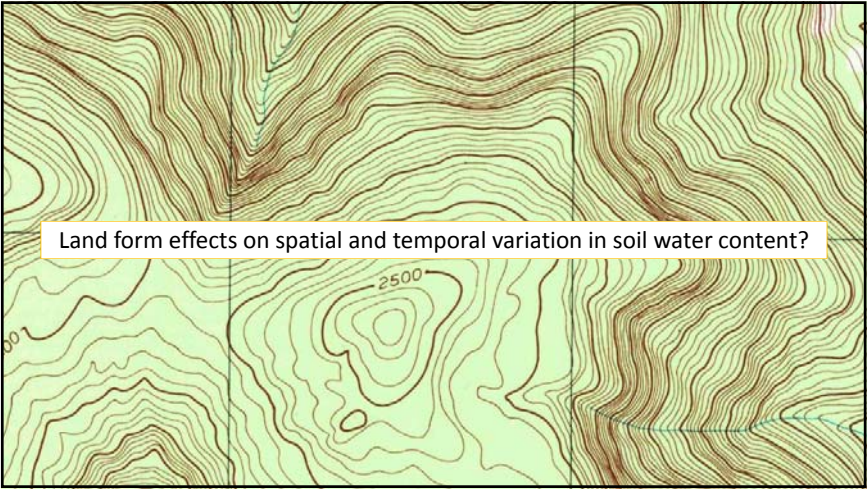
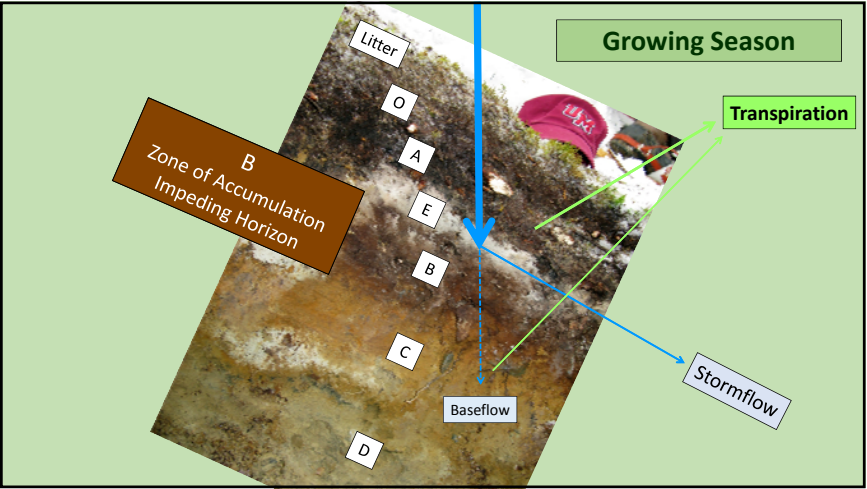
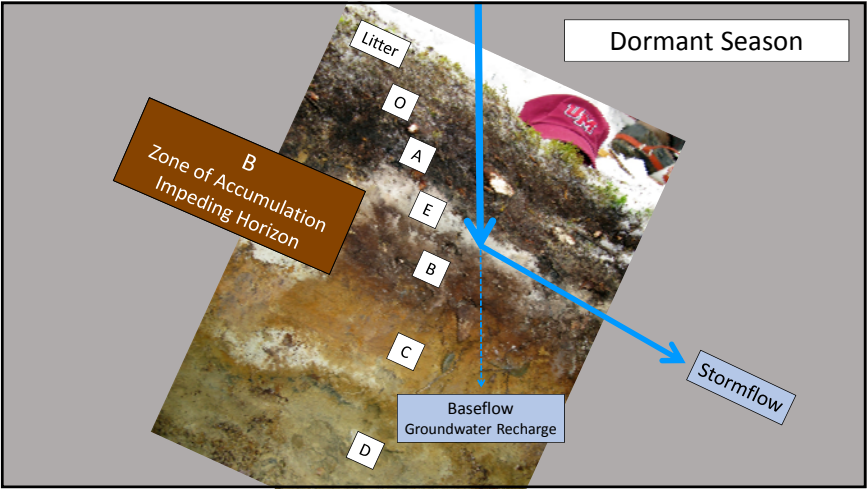
B

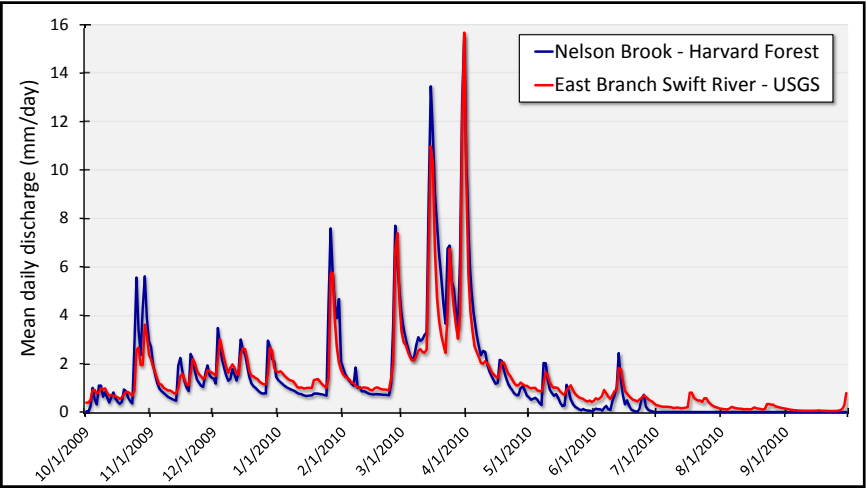
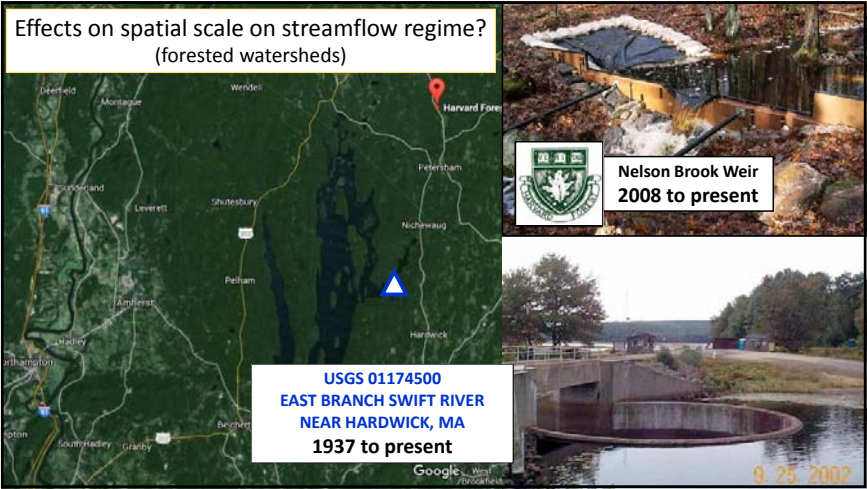
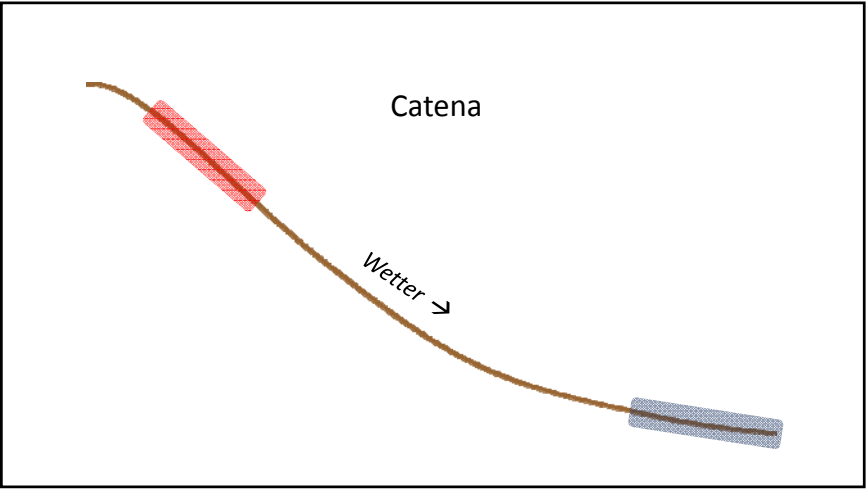
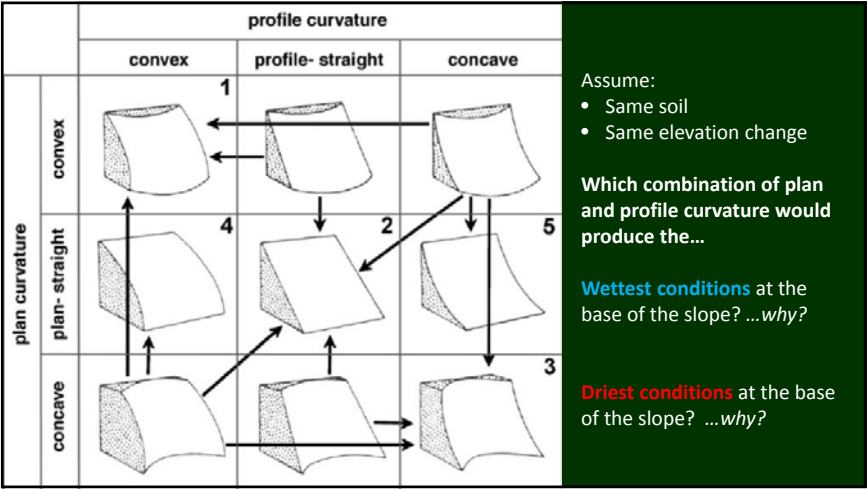
C

D

Northern Hardwoods
Hubbard Brook, NH

White Spruce
Northern Québec

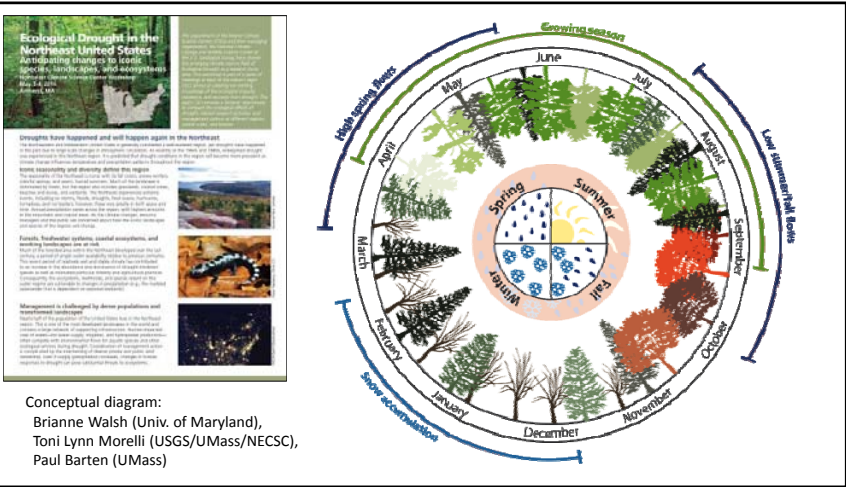




Potential effects of climate change on streamflow regime?
[GCMs forecast warmer, wetter conditions in New England]

- Timing and duration of [relative to 30-year "Normals"]?
- 1. Snow accumulation
 - 2. High spring flow(s)
 - 3. Growing season
 - 4. Low summer and fall flow(s)

$$P - ET - Q \pm \Delta S = 0$$
$$Q = P - ET \pm \Delta S$$



Conceptual diagram:
Brienne Walsh (Univ. of Maryland),
Toni Lynn Morelli (USGS/UMass/NECSC),
Paul Barten (UMass)

Hydrological effects of silvicultural treatments?
...response thresholds? ...duration? [set aside inter-annual variability]

$$P - ET - Q \pm \Delta S = 0$$

or $Q \approx P - ET \pm \Delta S$

$$P - (E + T + I) - (Q_{OF} + Q_{SSF} + Q_{GW}) \pm \Delta (S_{SOIL} + S_{SNOW} + S_{BIOMASS} + S_{LAKES, STREAMS, WETLANDS}) \pm L \pm \epsilon = 0$$

Hydrological effects of regeneration methods?
...response thresholds? ...duration? [set aside inter-annual variability]

$$P - (E + T + I) - (Q_{OF} + Q_{SSF} + Q_{GW}) \pm \Delta (S_{SOIL} + S_{SNOW} + S_{BIOMASS} + S_{LAKES, STREAMS, WETLANDS}) = 0$$

- Unmanaged (control or reference condition)
- Single tree selection (<10%)
- Small group selection (20-30%)
- Patch cut (<50%)
- Patch retention (~50 to 70%)
- Shelterwood (~60-80%) → Red Oak – White Pine (50:50) → Red oak regeneration? → White pine regeneration?
- Seed Tree (~90%)
- Clearcut (100%)

Hydrological effects of intermediate treatments?

...response thresholds? ...duration? [set aside inter-annual variability]

$$P - (E + T + I) - (Q_{OF} + Q_{SSF} + Q_{GW}) \pm \Delta (S_{SOIL} + S_{SNOW} + S_{BIOMASS} + S_{LAKES, STREAMS, WETLANDS}) = 0$$

- *Unmanaged* (control or reference condition)
- Low thinning (Suppressed and Intermediate trees)
- Crown thinning (Intermediates and Co-dominant trees)
- Crop-tree thinning (any crown class adjacent to crop trees)
- Dead, diseased, and dying trees (any crown class)

