Forest Hydrology for Climate Adaptation

Rolf Gersonde

Watershed Management Division

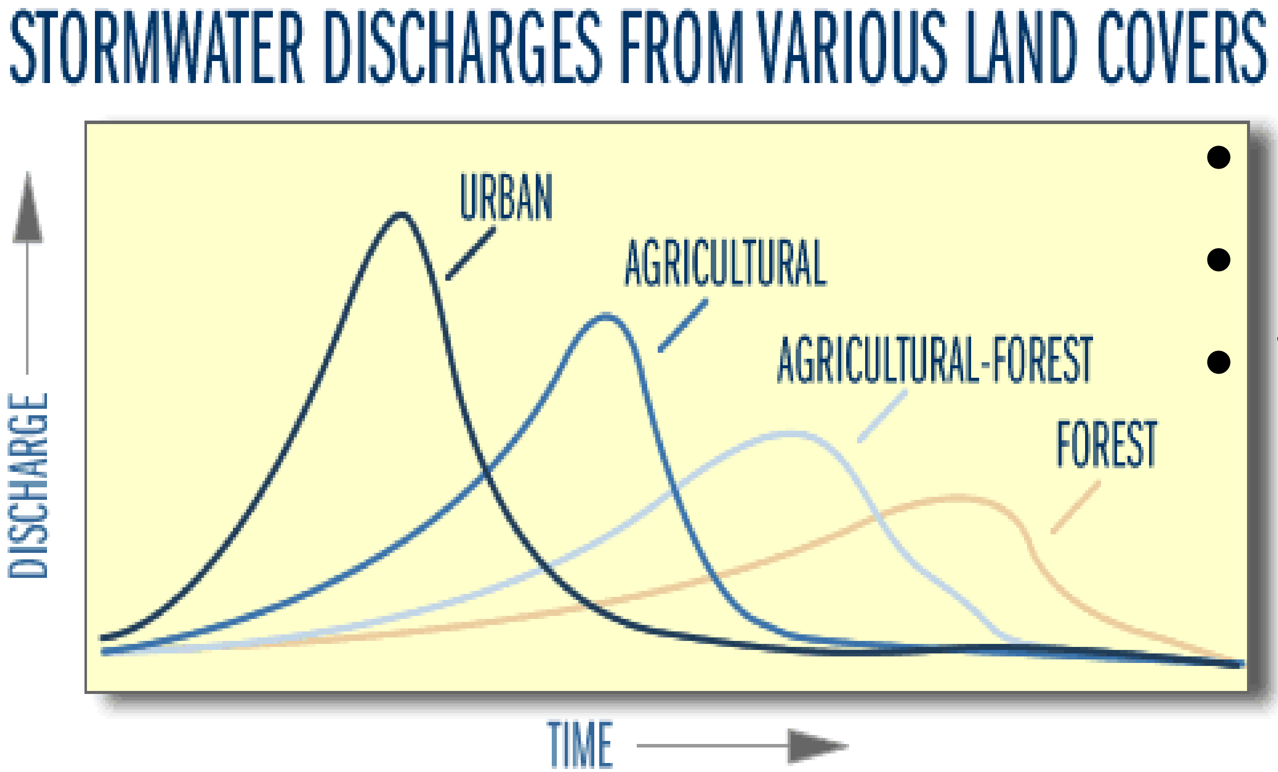
Seattle Public Utilities

City of Seattle

Forest Hydrology Objectives

- Regulate run-off from forested watersheds
- Improve in-stream habitat for fish
- Tree water status to increase resistance to disturbances
- Forest productivity and habitat functions

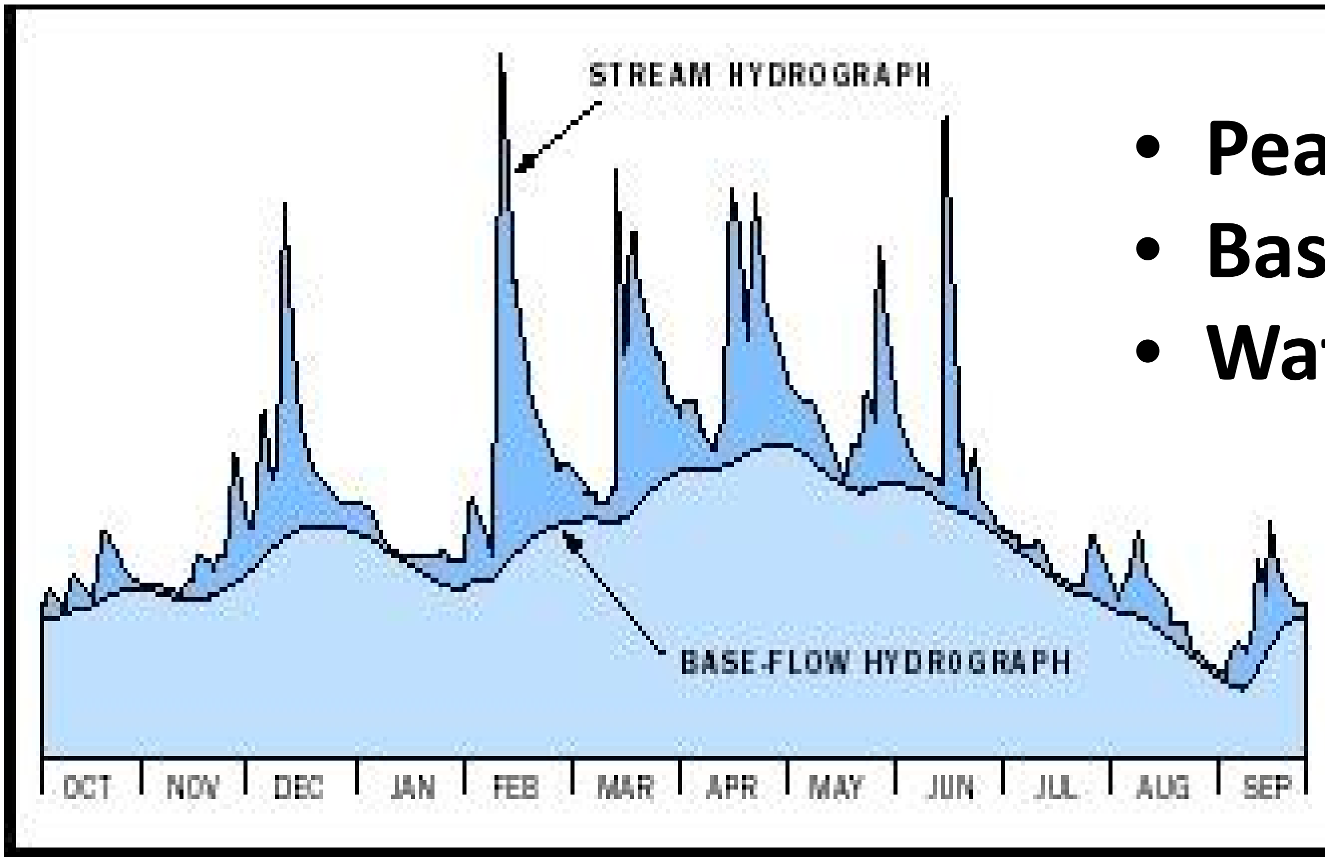
Water Cycle Regulation



- Peak Flow
- Base Flow
- Water Quantity

waterencyclopedia.com and waterontheweb.org

Water Cycle Regulation



- **Peak Flow**
- **Base Flow**
- **Water Quantity**

waterencyclopedia.com and waterontheweb.org

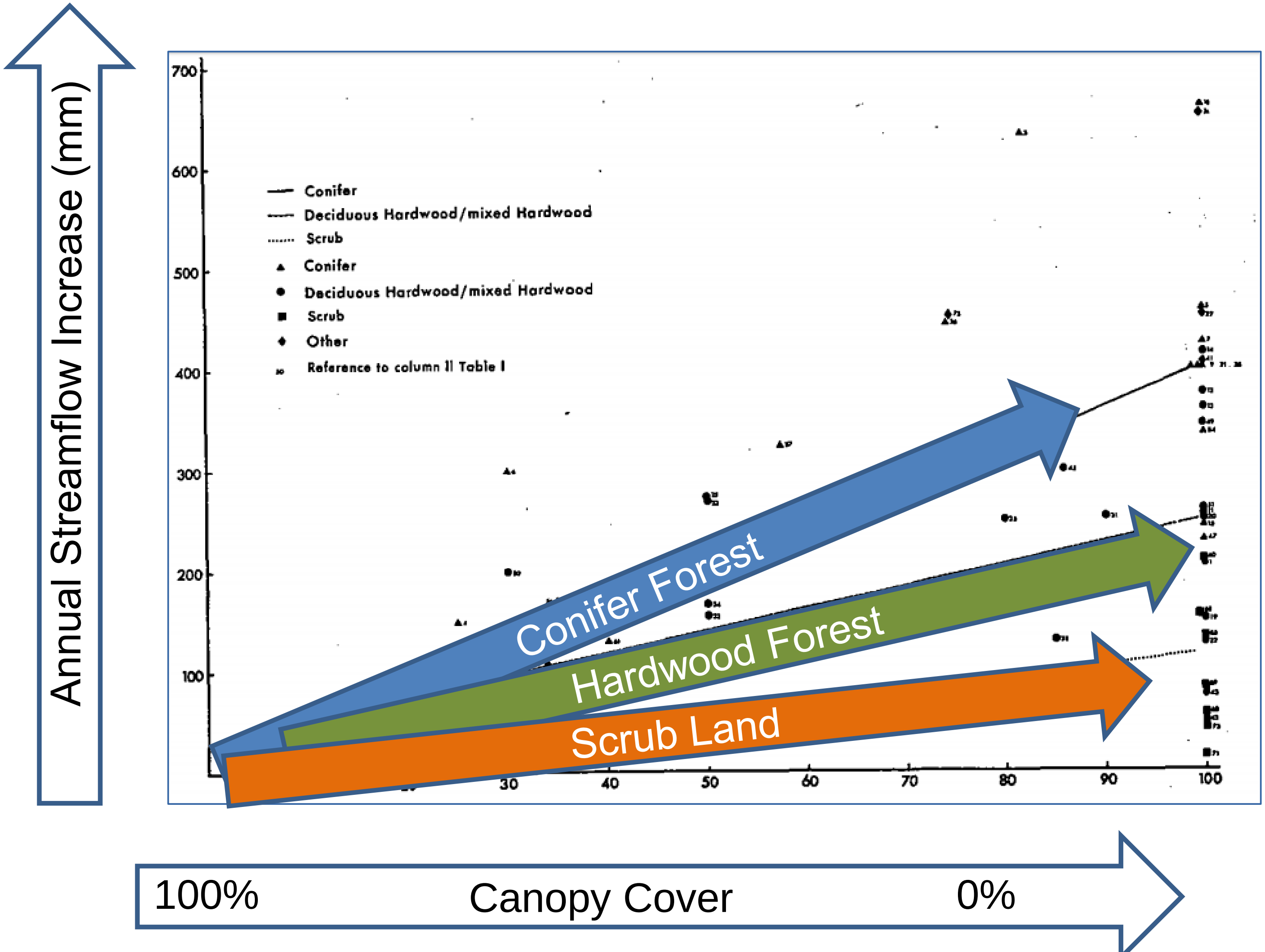
Regulating total Run-off:

Effect of Forest Cover on Hydrology

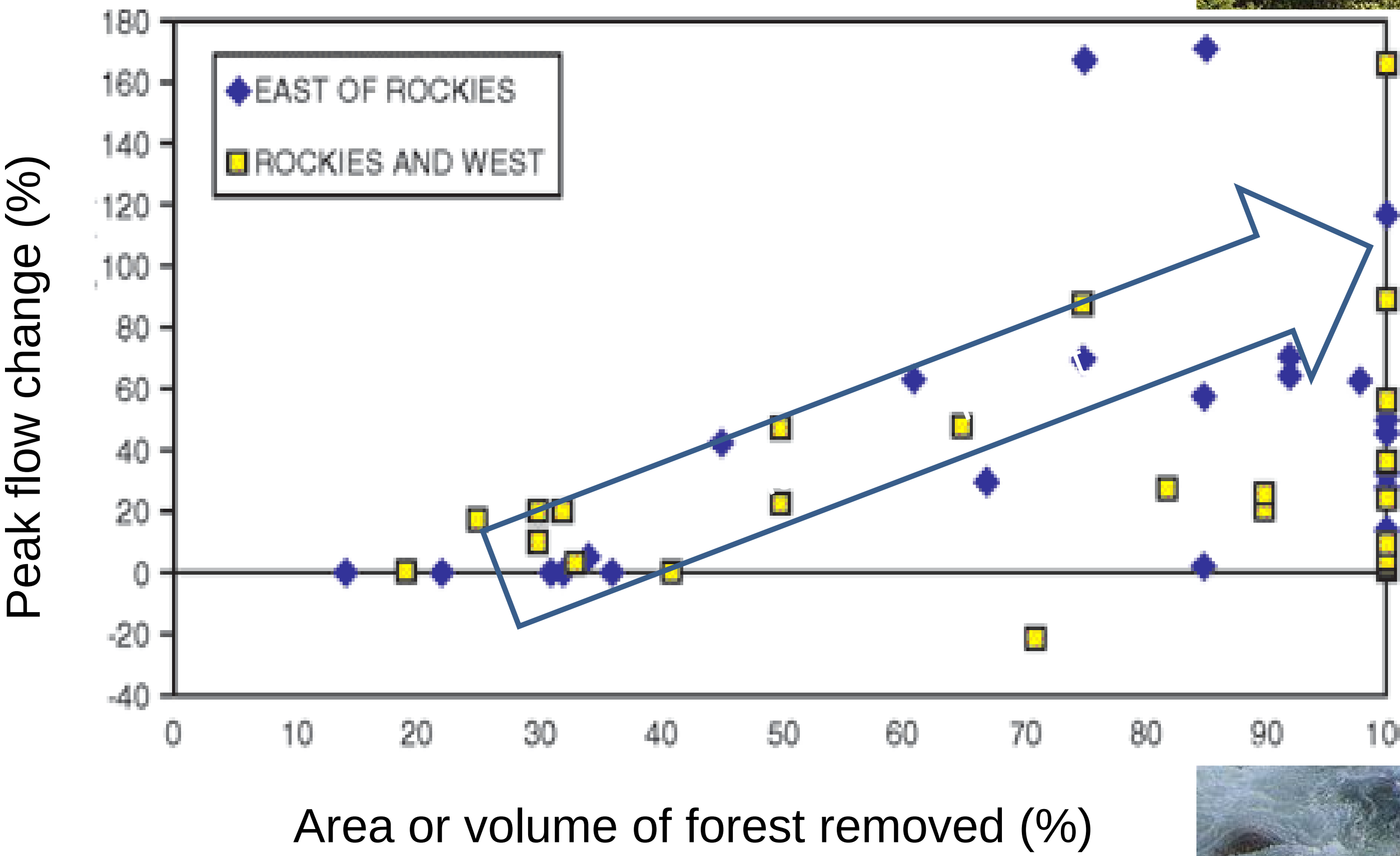
- **Watershed yield**
- **Peak-flows**
- **Hydrologic regulation**

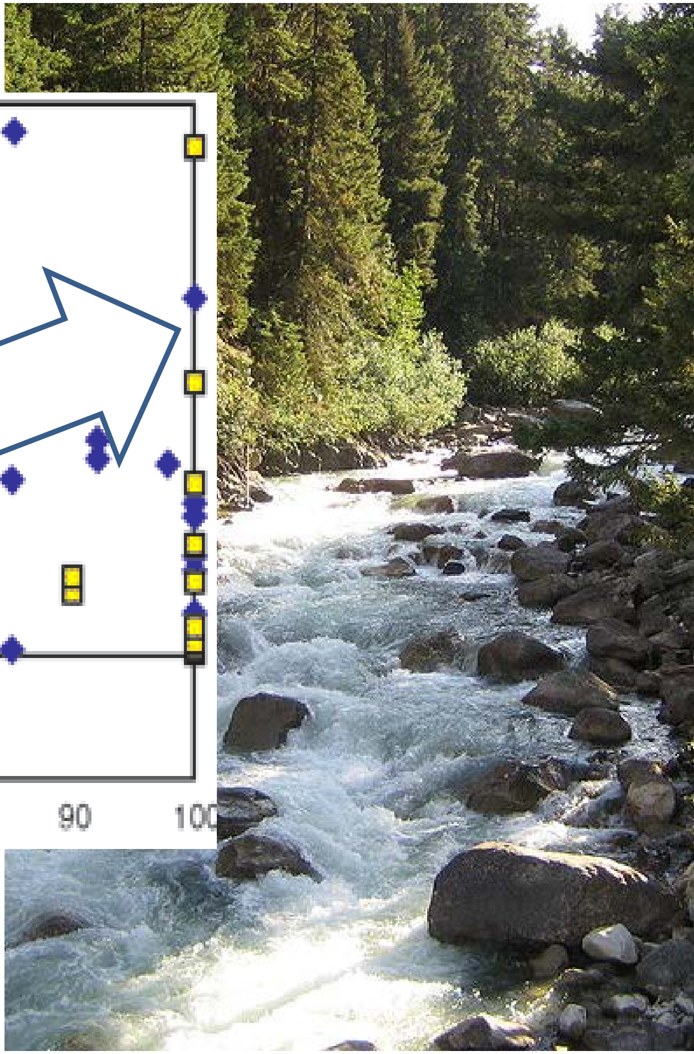
Reducing Canopy Cover Increases Annual Stream Flow

Modified after Bosch and Hewlett 1982, JoH



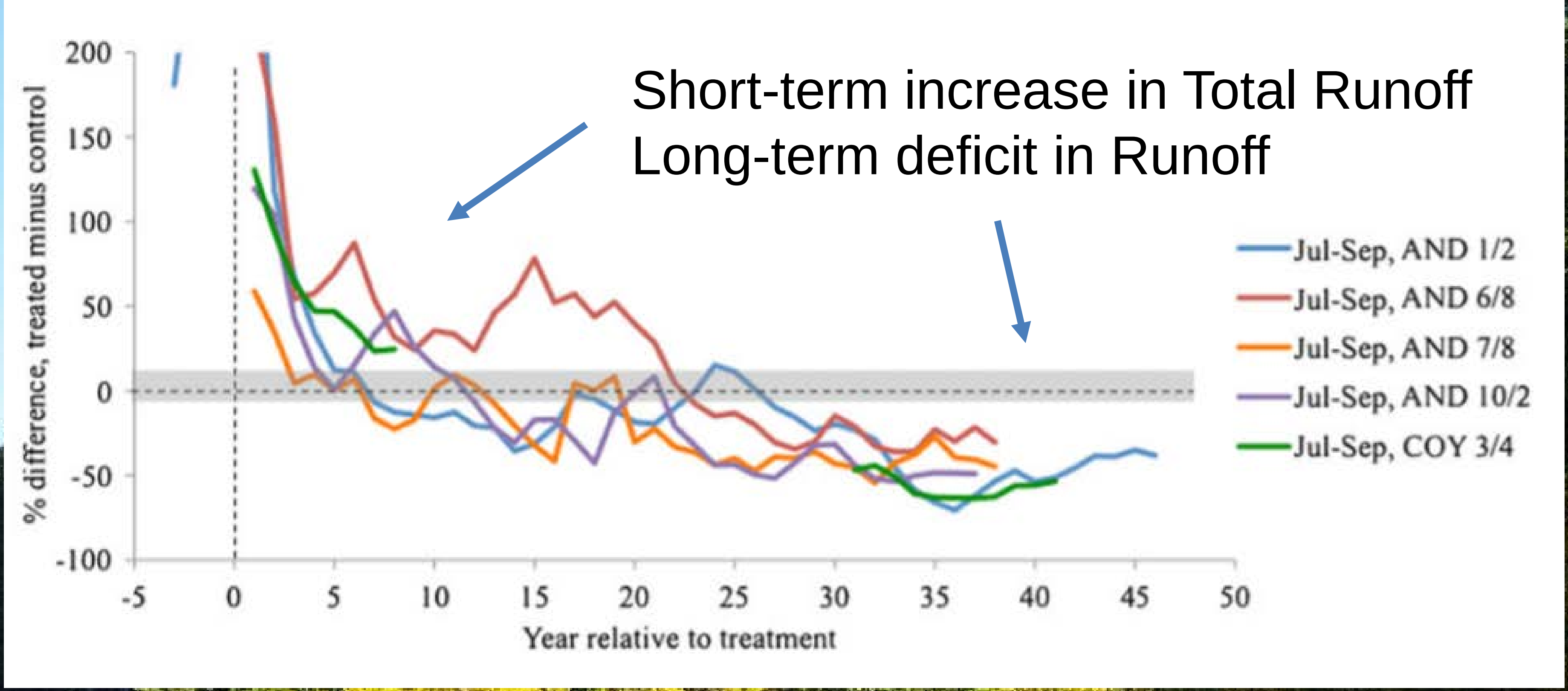
Forest Cover Removal and Increase in Peak Flows





Changes in peak flow above bankfull discharge in relation to forest removal by harvesting, fire, or insects in North America, adapted from Plamondon (1993, 2002).

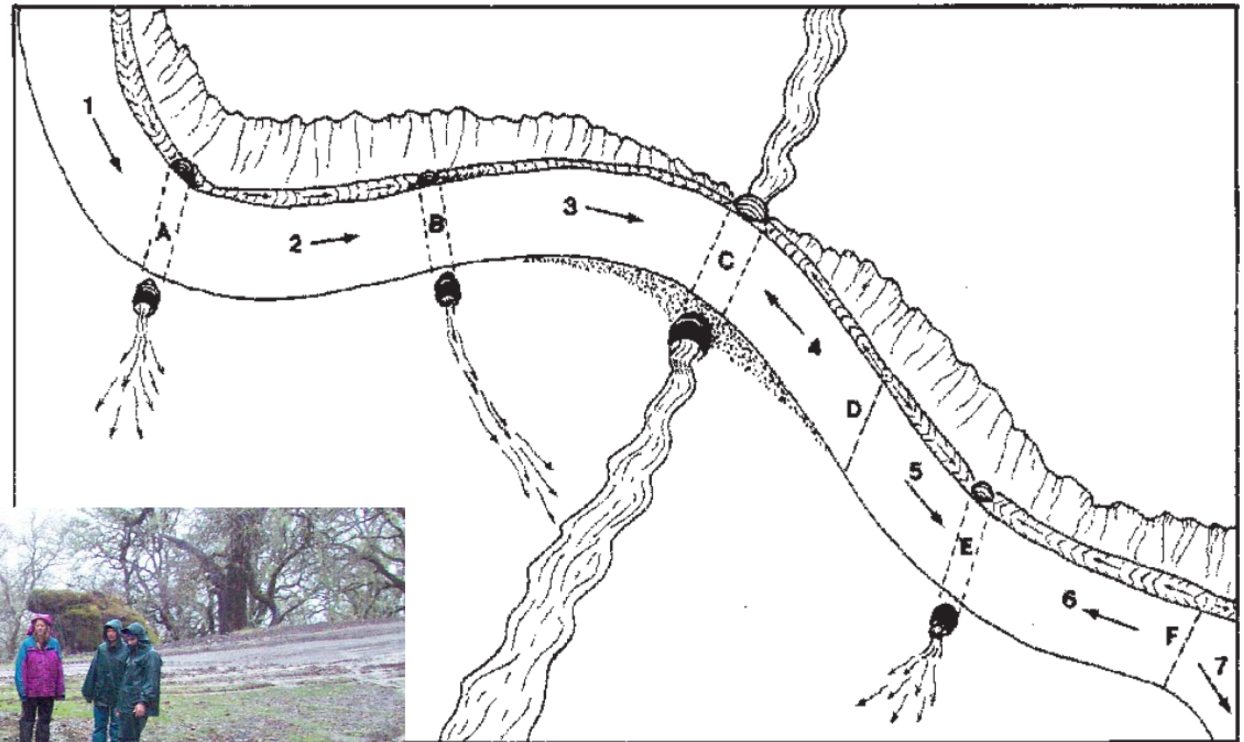
Difference in Runoff between Treated and Untreated Catchments - Recovery of Hydrologic Regulation



Perry and Jones
Ecohydrology 2016

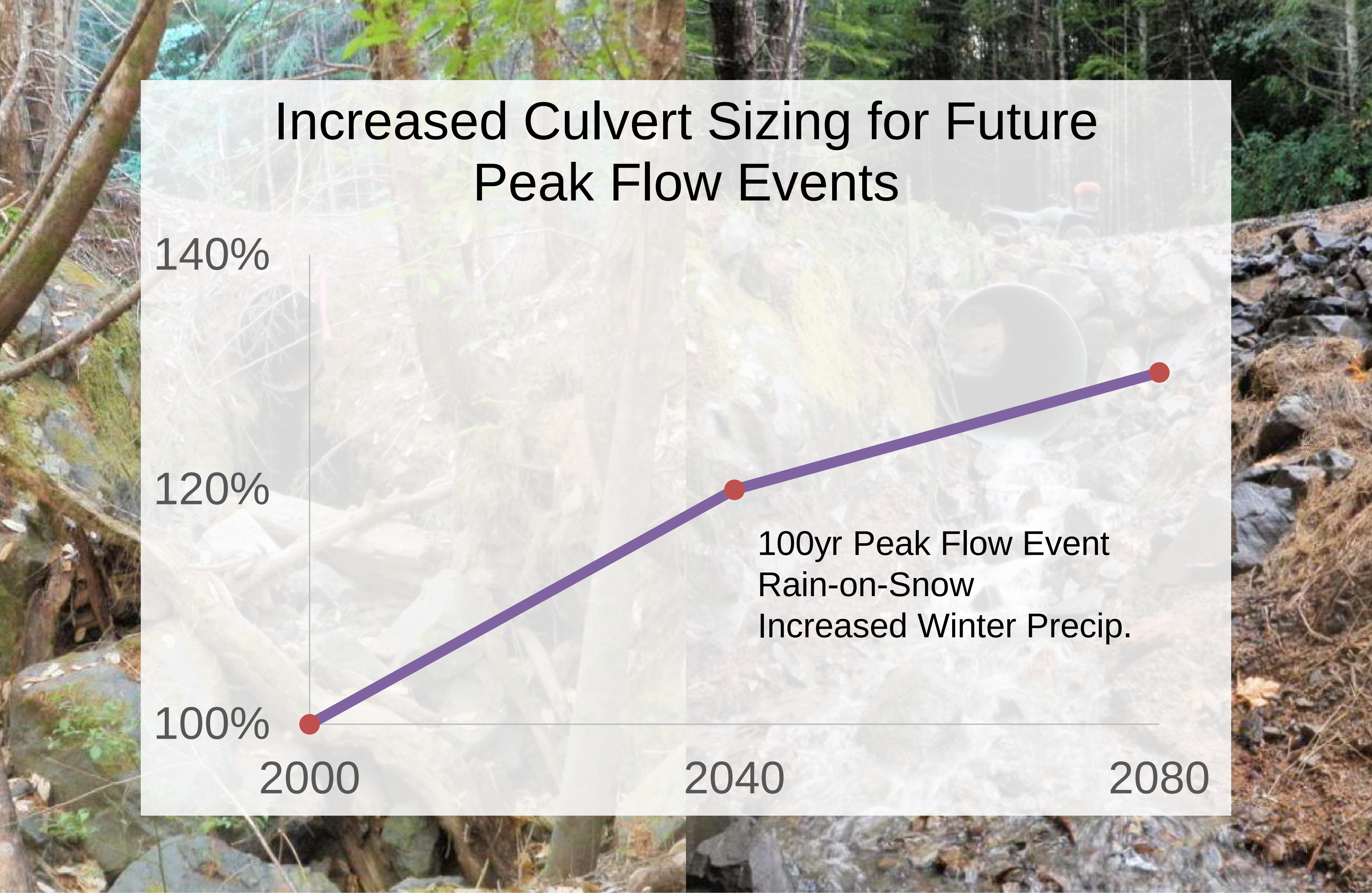
Managing Peak Flows:
Forest Management Effects

- **Hill slope flow** routing to streams
- **Culvert Sizing** for Peak Flow Events
- **Rain-on-Snow Events**

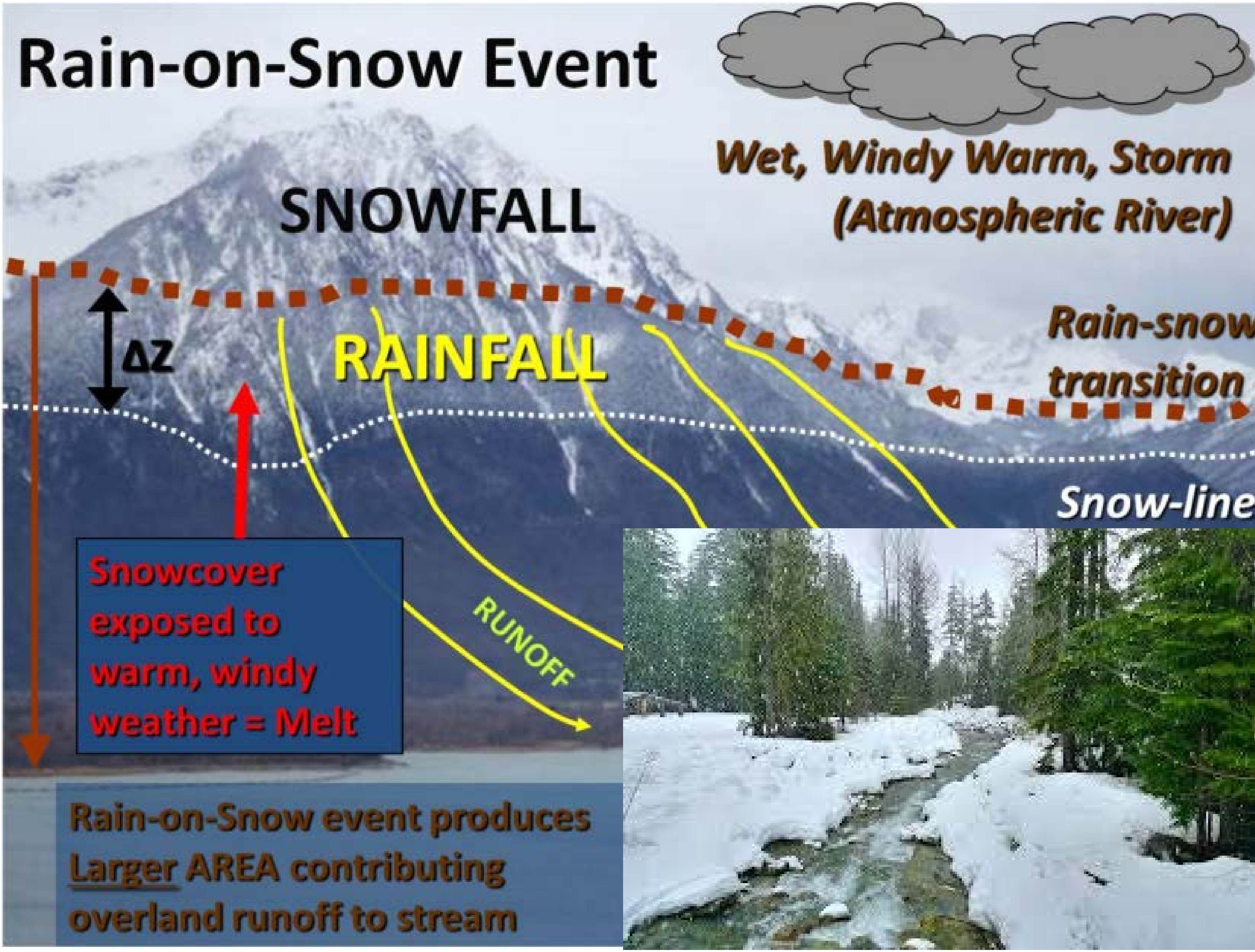


Hillslope Flow Routing with Road Drainage

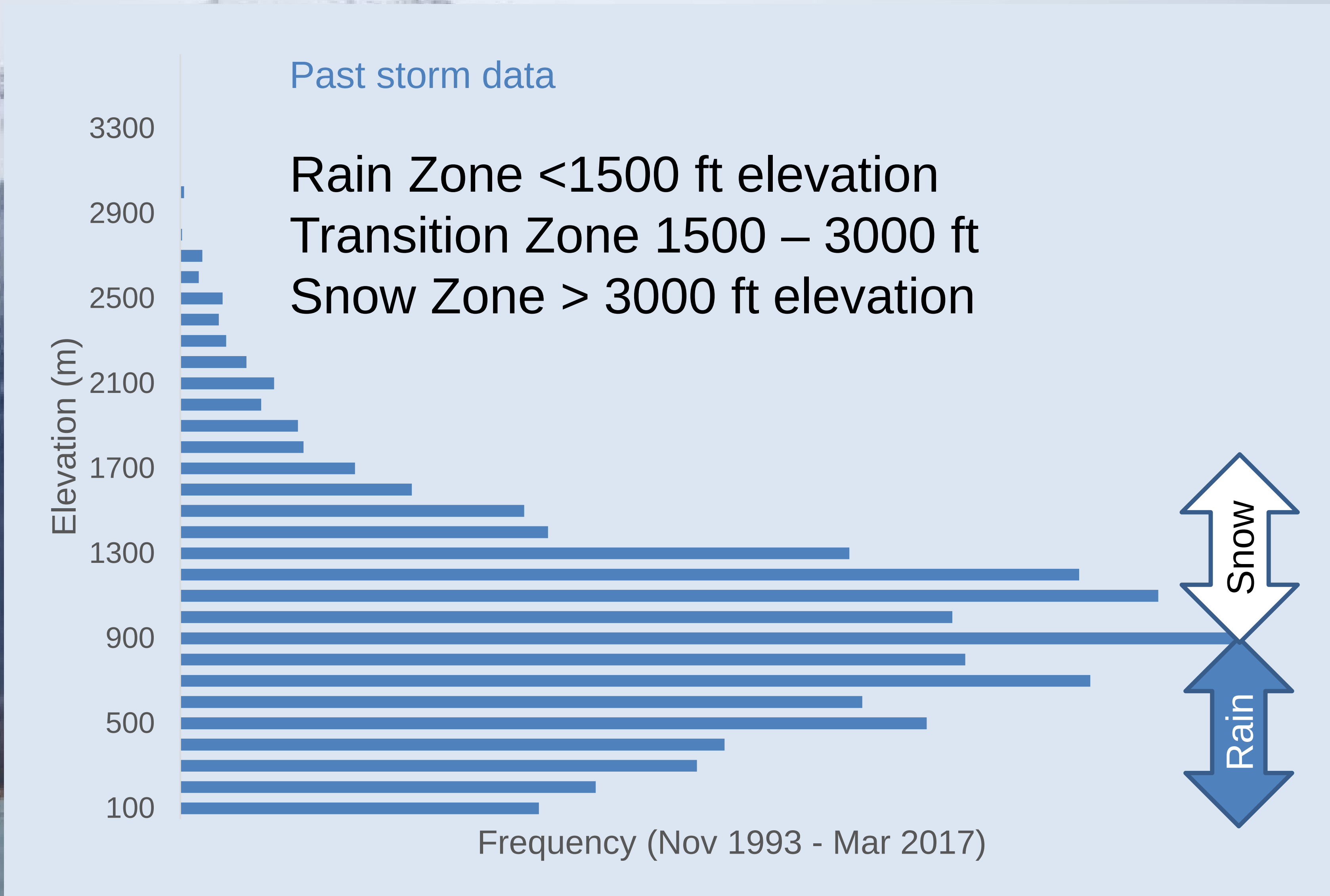
Perched Culvert Undersized for Peak Flow Events



Adjusting Culvert Size to Projected Peak Flow Increase


Rain-on-Snow Event
Wet, Windy Warm, Storm
(Atmospheric River)
SNOWFALL
ΔZ
RAINFALL
Rain-snow
transition
Snow-line
Snowcover
exposed to
warm, windy
weather = Melt
RUNOFF
Rain-on-Snow event produces
Larger AREA contributing
overland runoff to stream

Freezing Level Elevation during Winter Storms:



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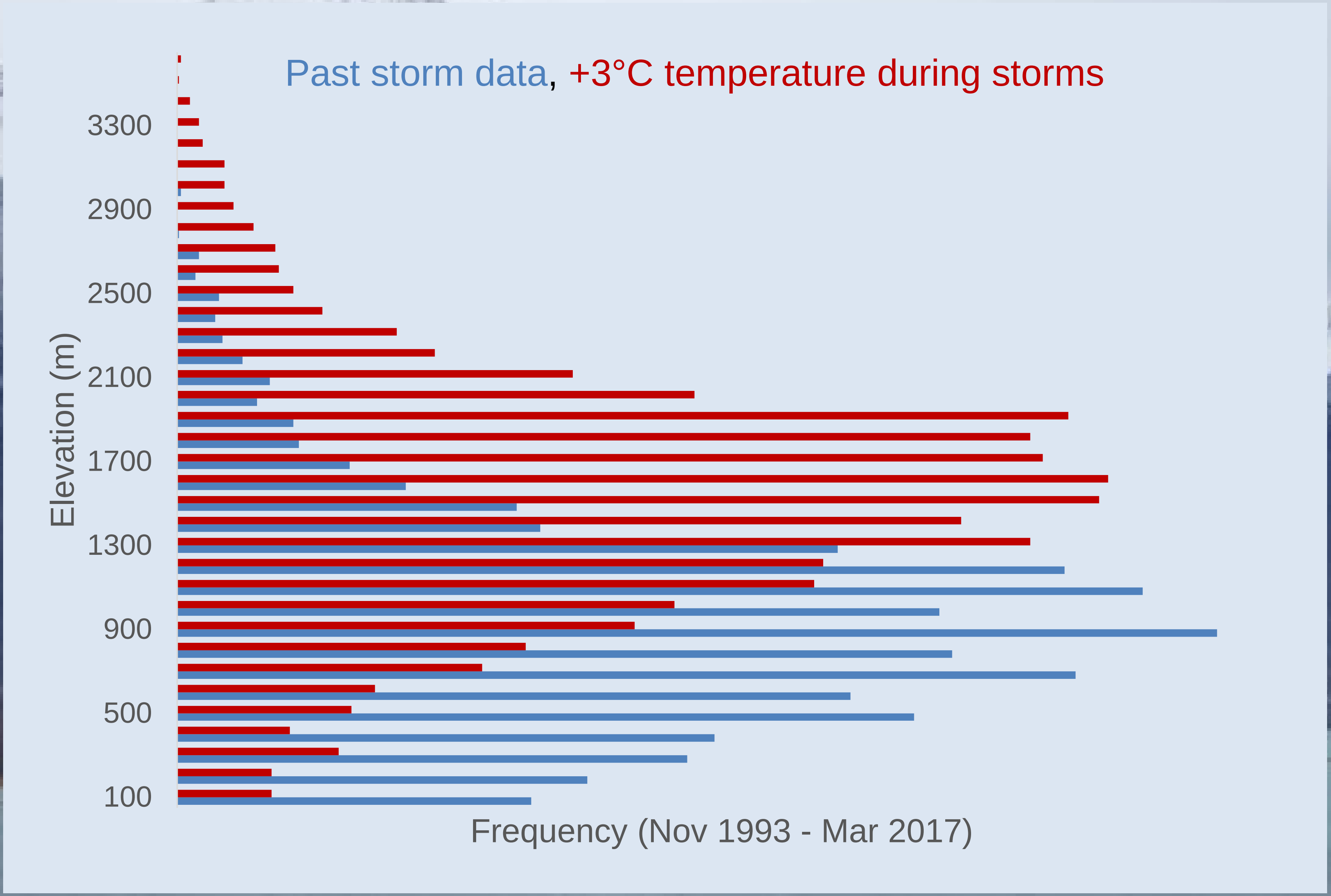

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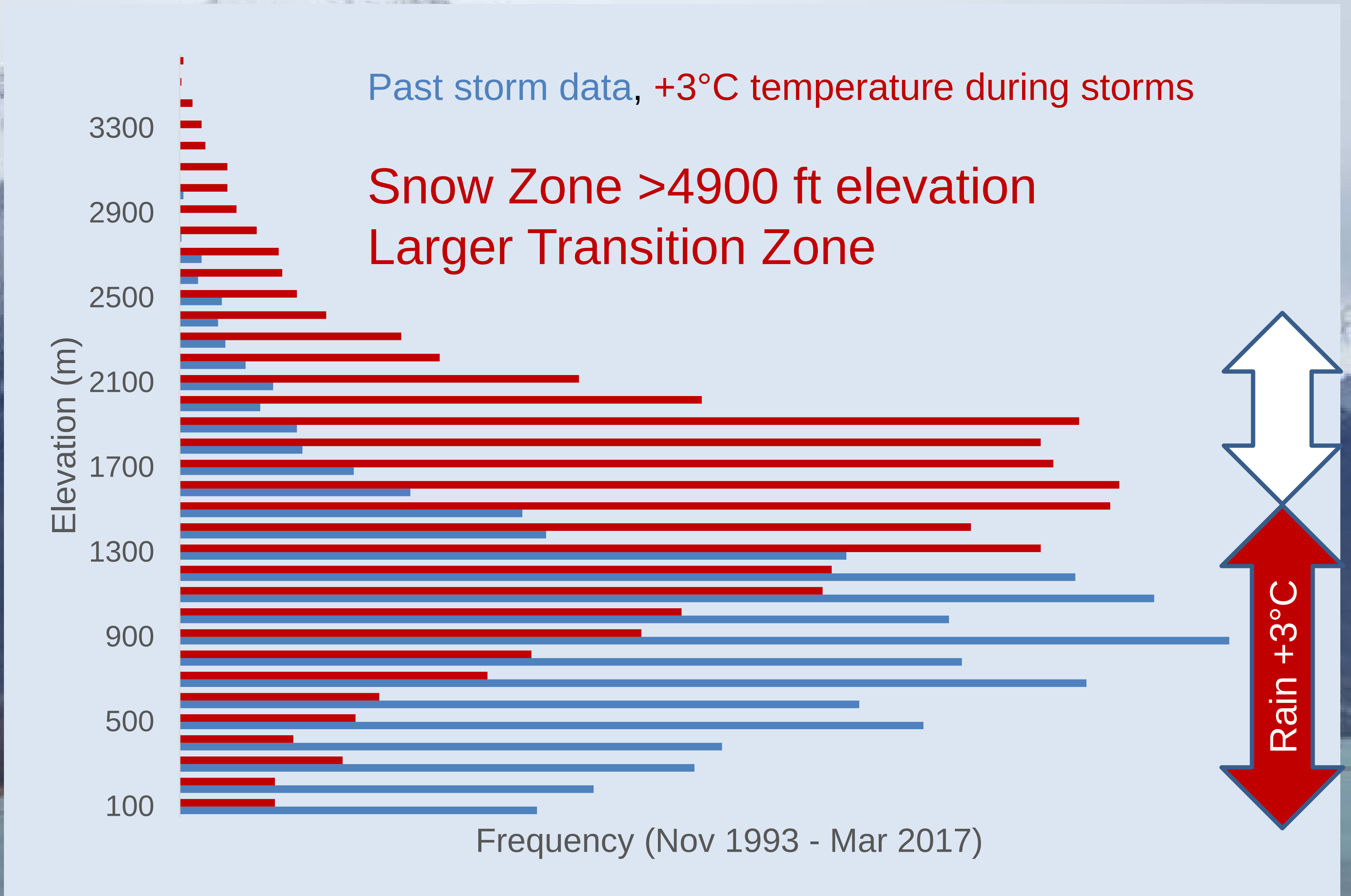
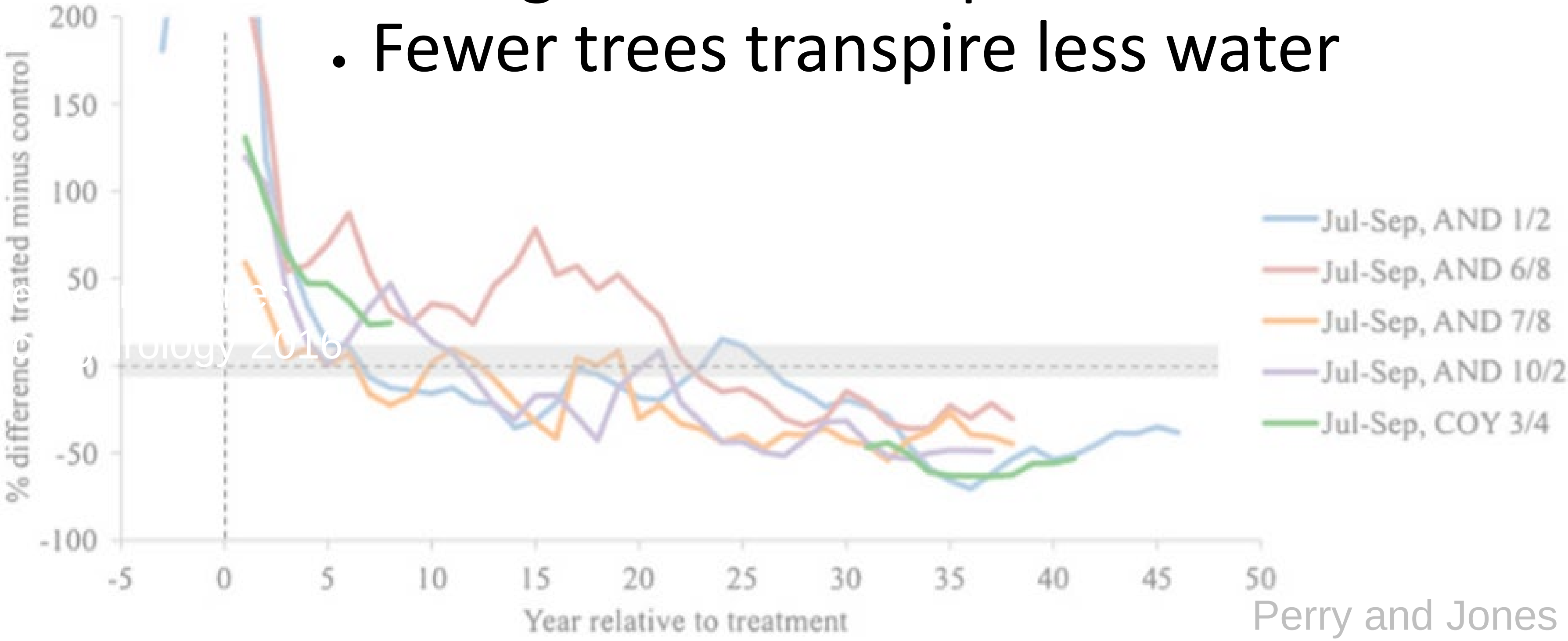


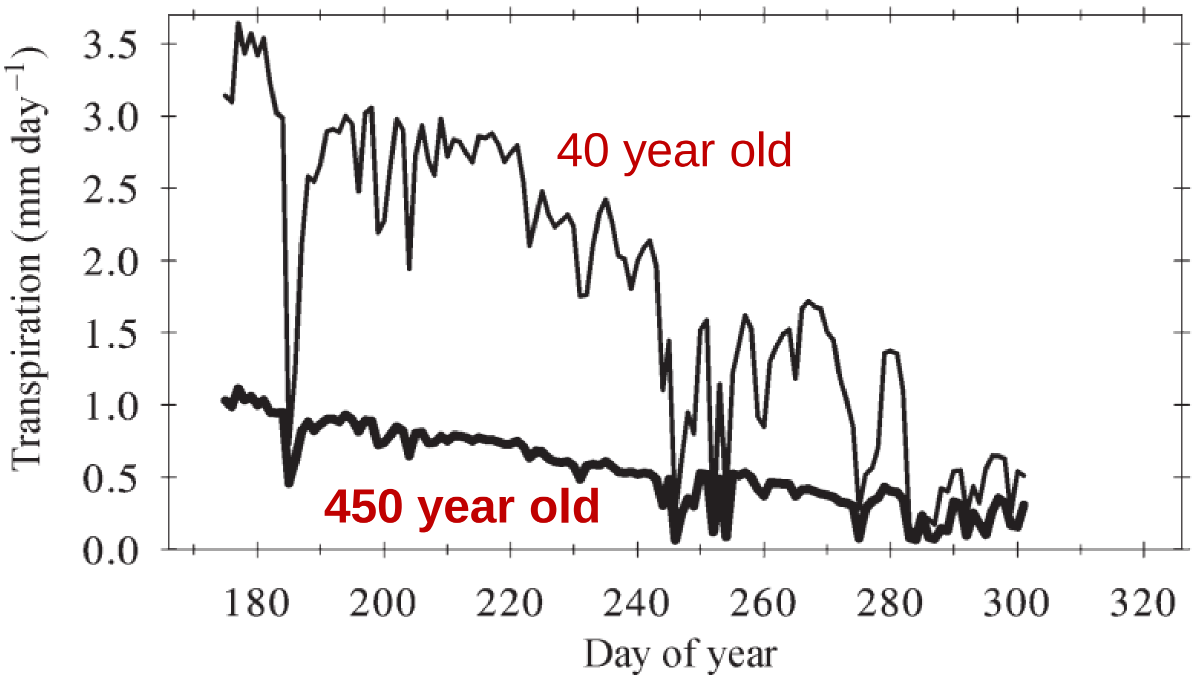
Managing Base Flows:
Hydrologic Effects of Stand Age and Structure

- Younger trees transpire more water
- Fewer trees transpire less water

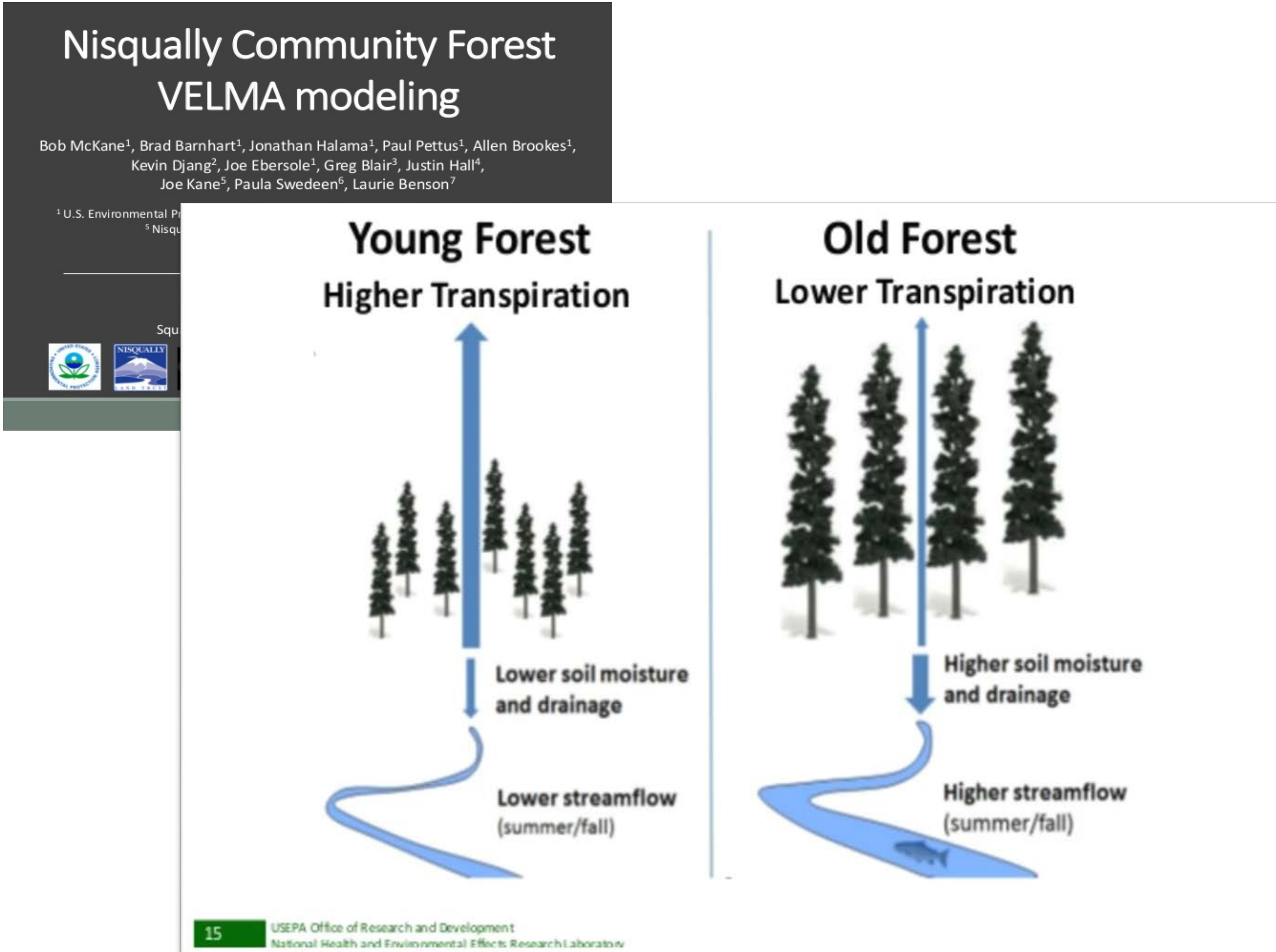


Perry and Jones
Ecohydrology 2016

Water Use of Young and Old Riparian DF/WH Forests



Moore et al. 2004, Tree Physiology

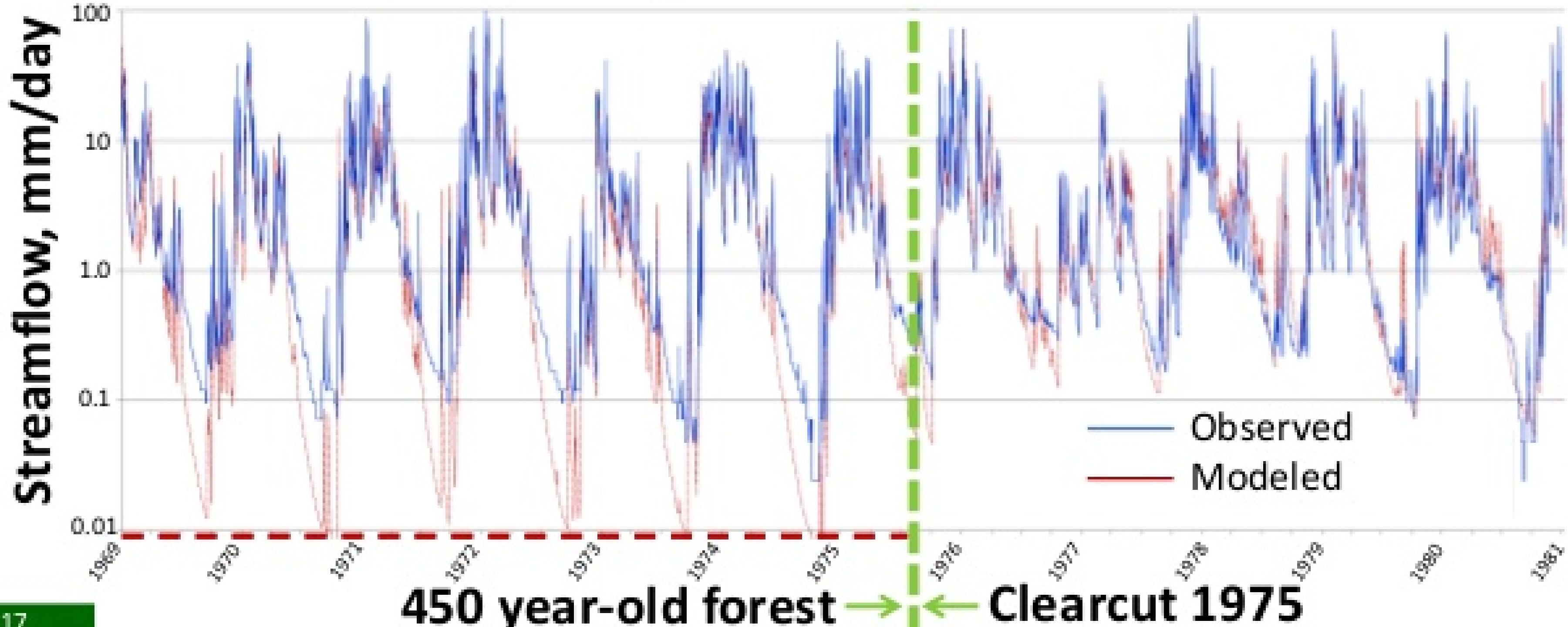


Slide credit: Bob McKane, USEPA

Watershed 10, HJ Andrews, OR

- $0.1\ km^2$ headwater catchment
- 450 year-old conifer forest
- Clearcut in 1975
- Stream discharge data 1969-present

Forest age effect turned **OFF**



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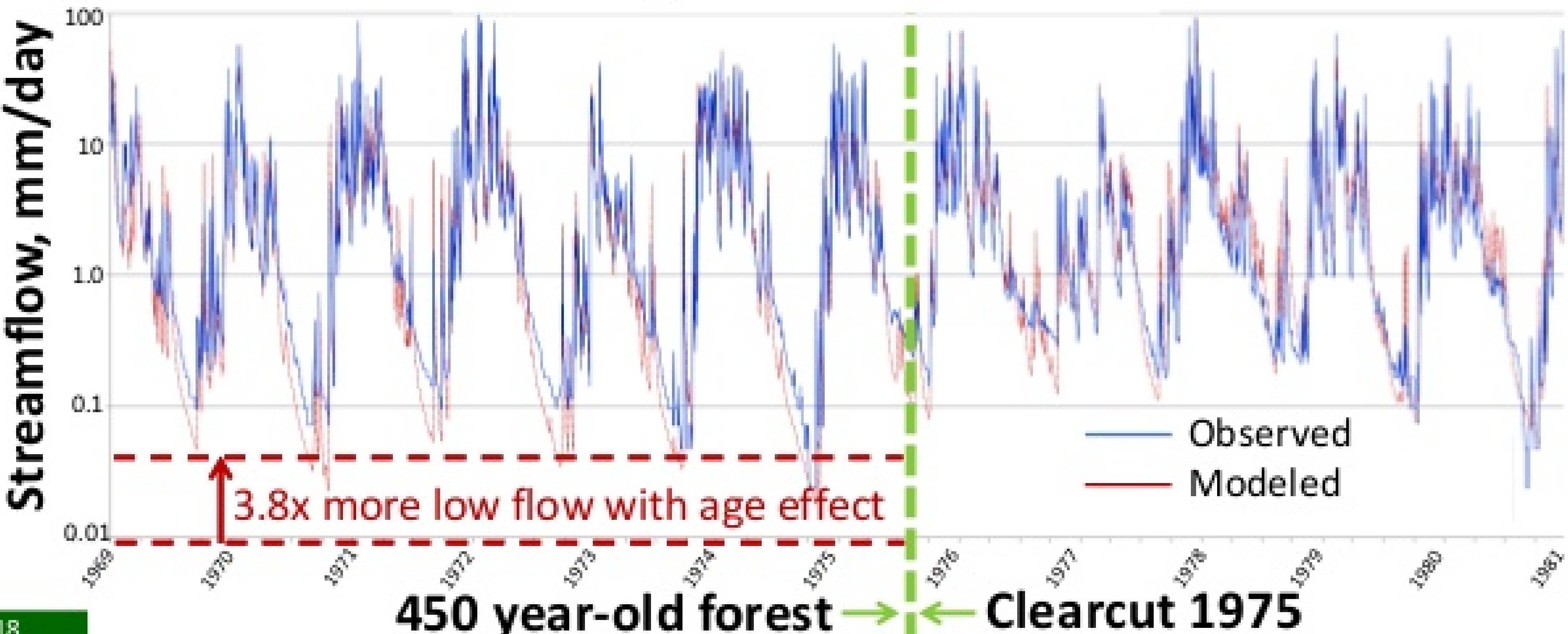
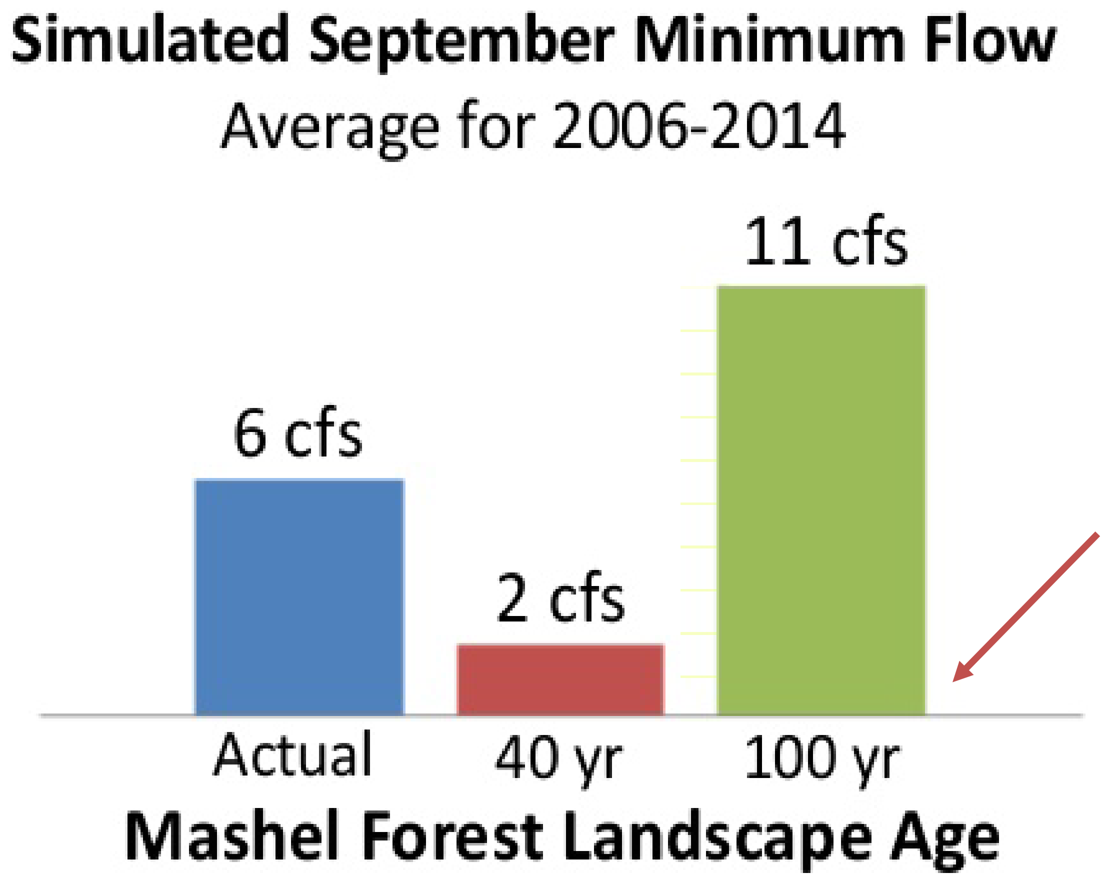
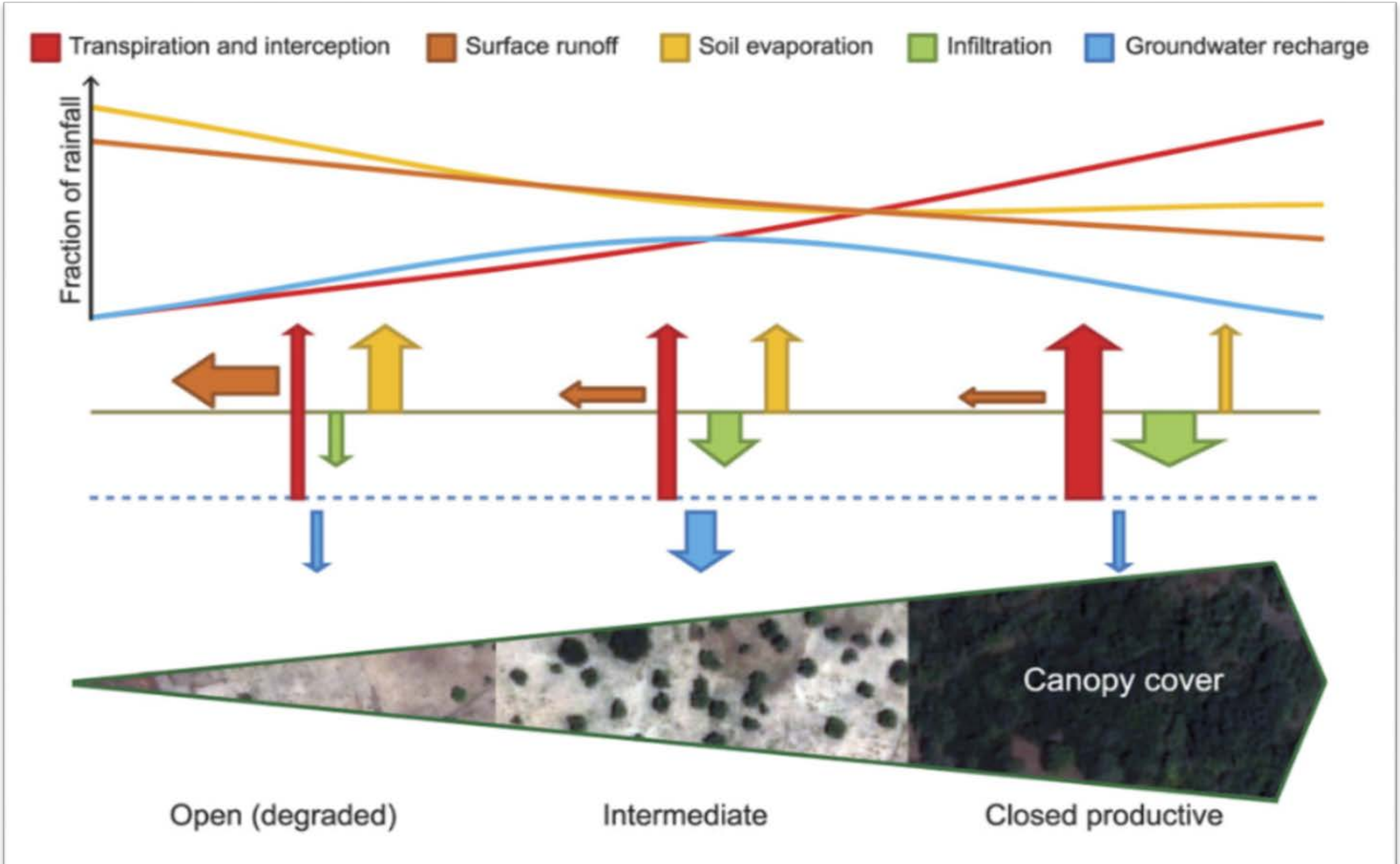


Baseflow for different Forest Landscape Age using the VELMA Model



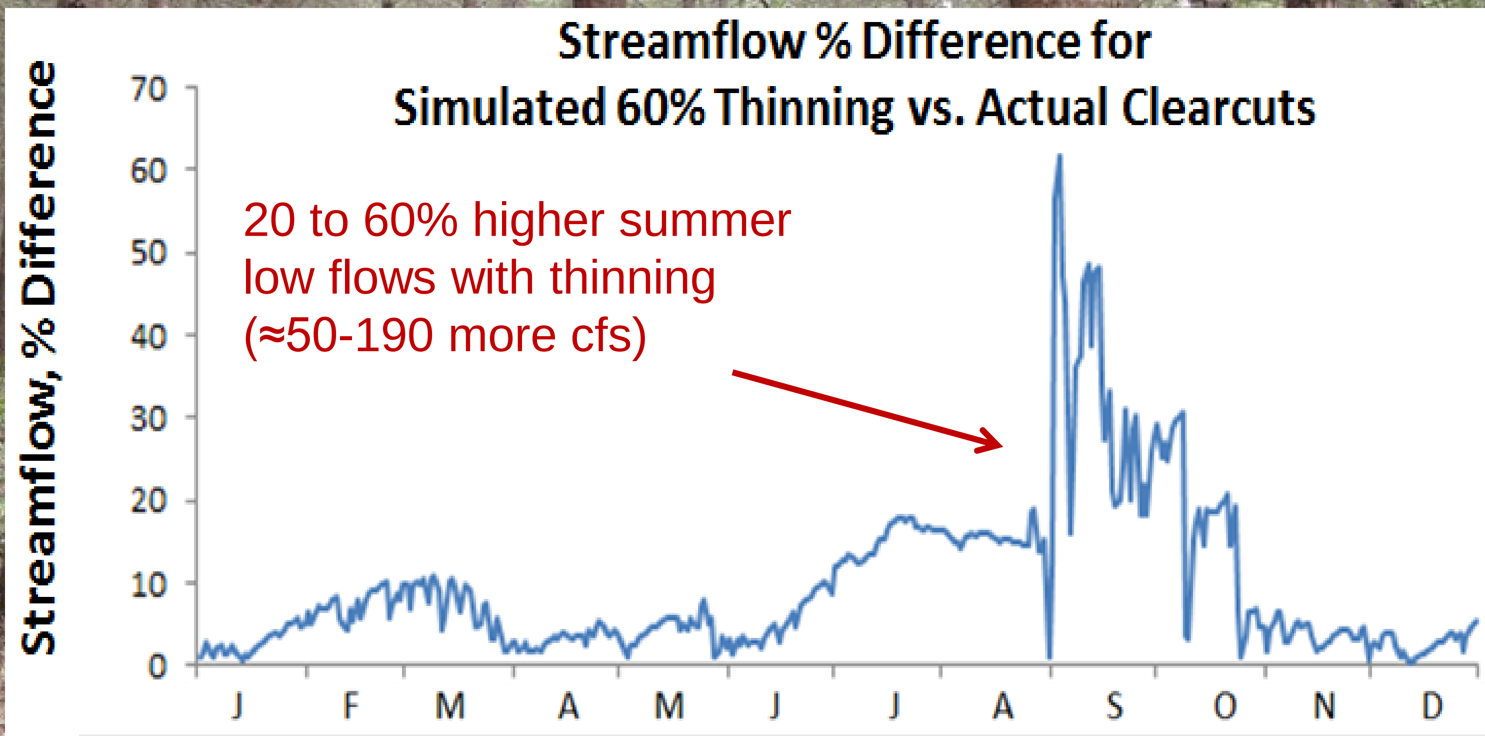
Longer Rotation Age has 2-5 times greater Base Flow

Effect of Canopy Cover on Hydrologic Processes



Ilstedt et al. 2016, Nature

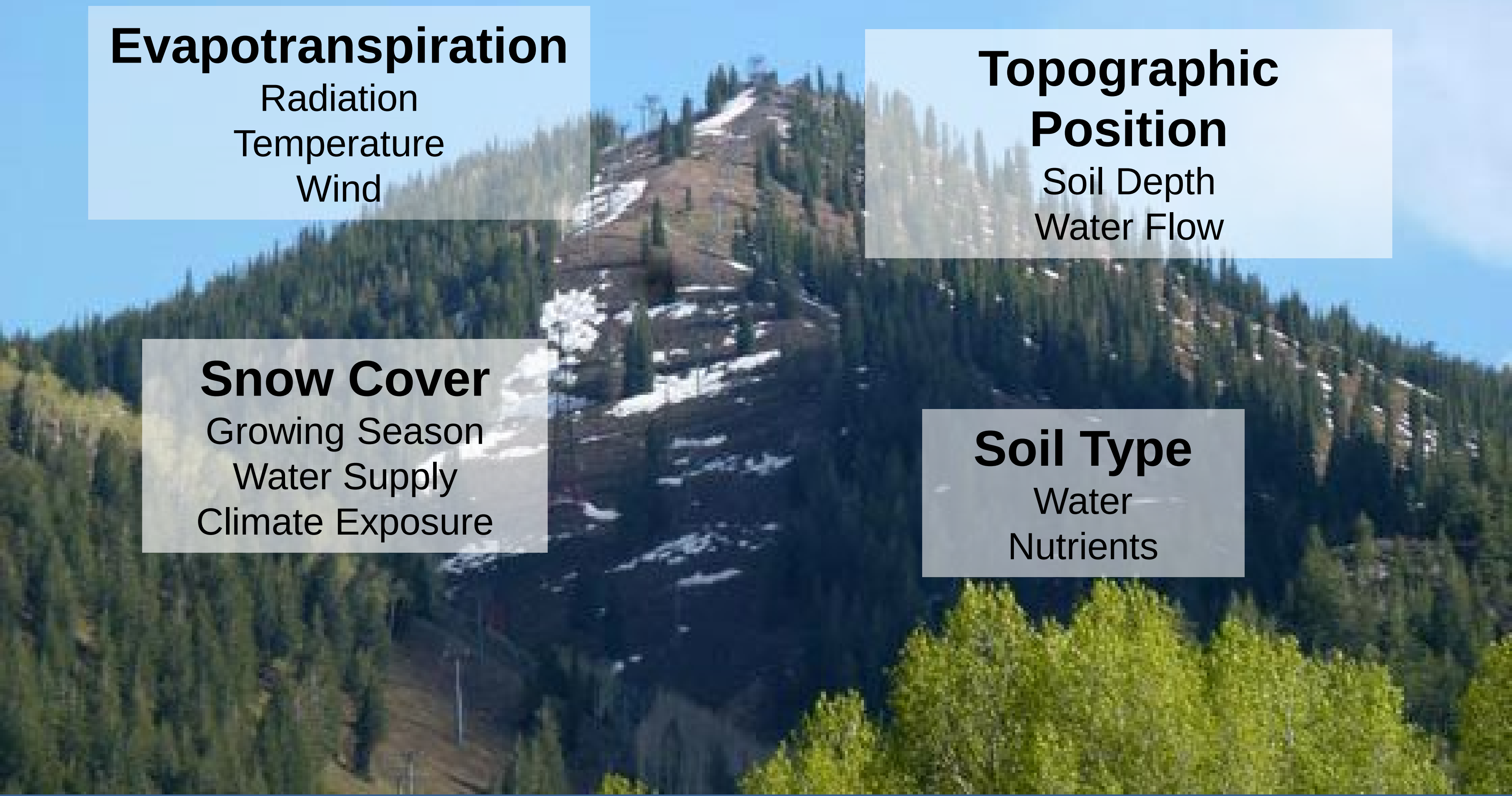
Streamflow responses to alternative forest practices (Tolt Watershed, VELMA Model)



Slide credit: Bob McKane, USEPA

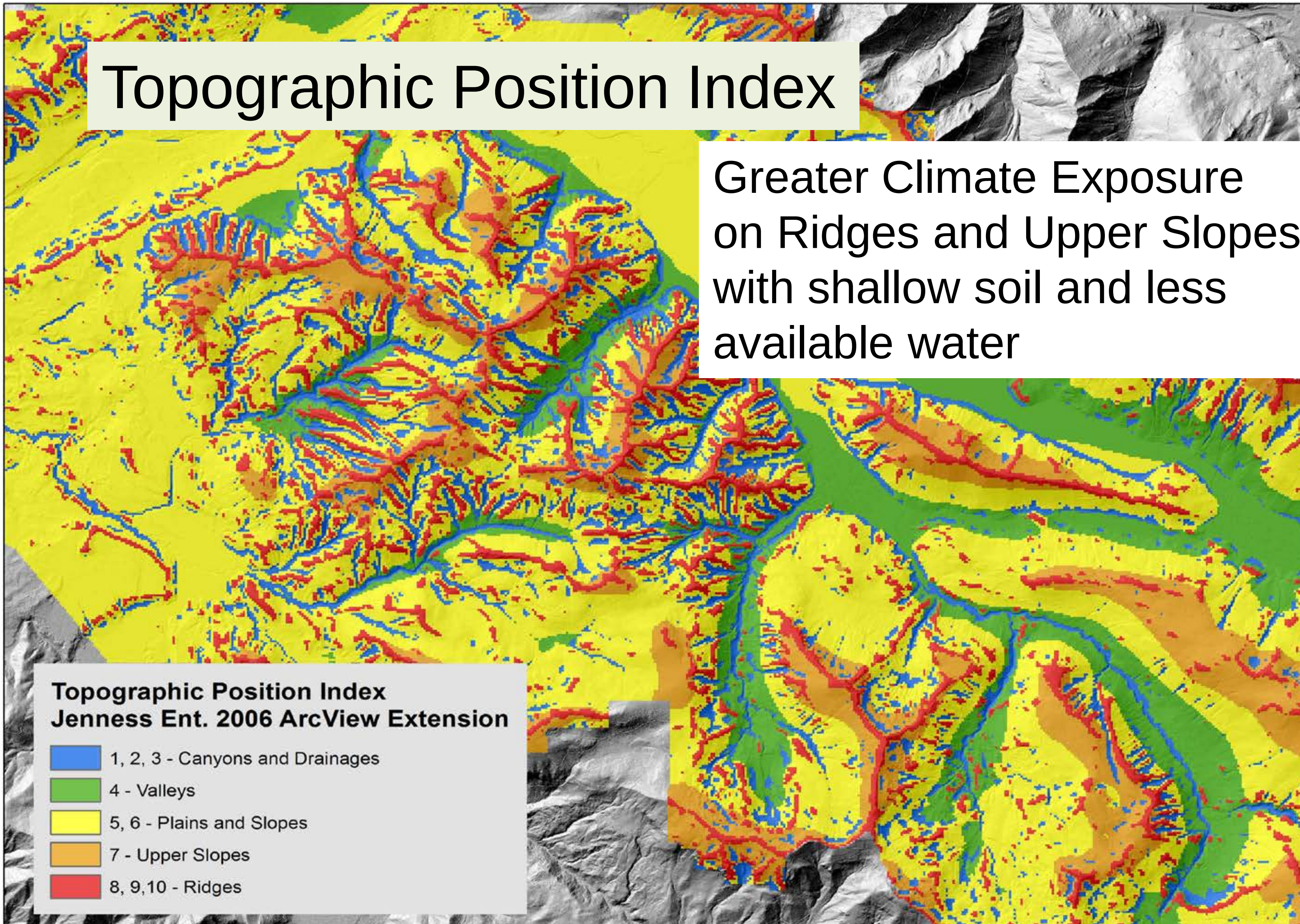
Photo: Karen Iwachow.

Climatic Exposure
Effects of Topography and Aspect



Topographic Position Index

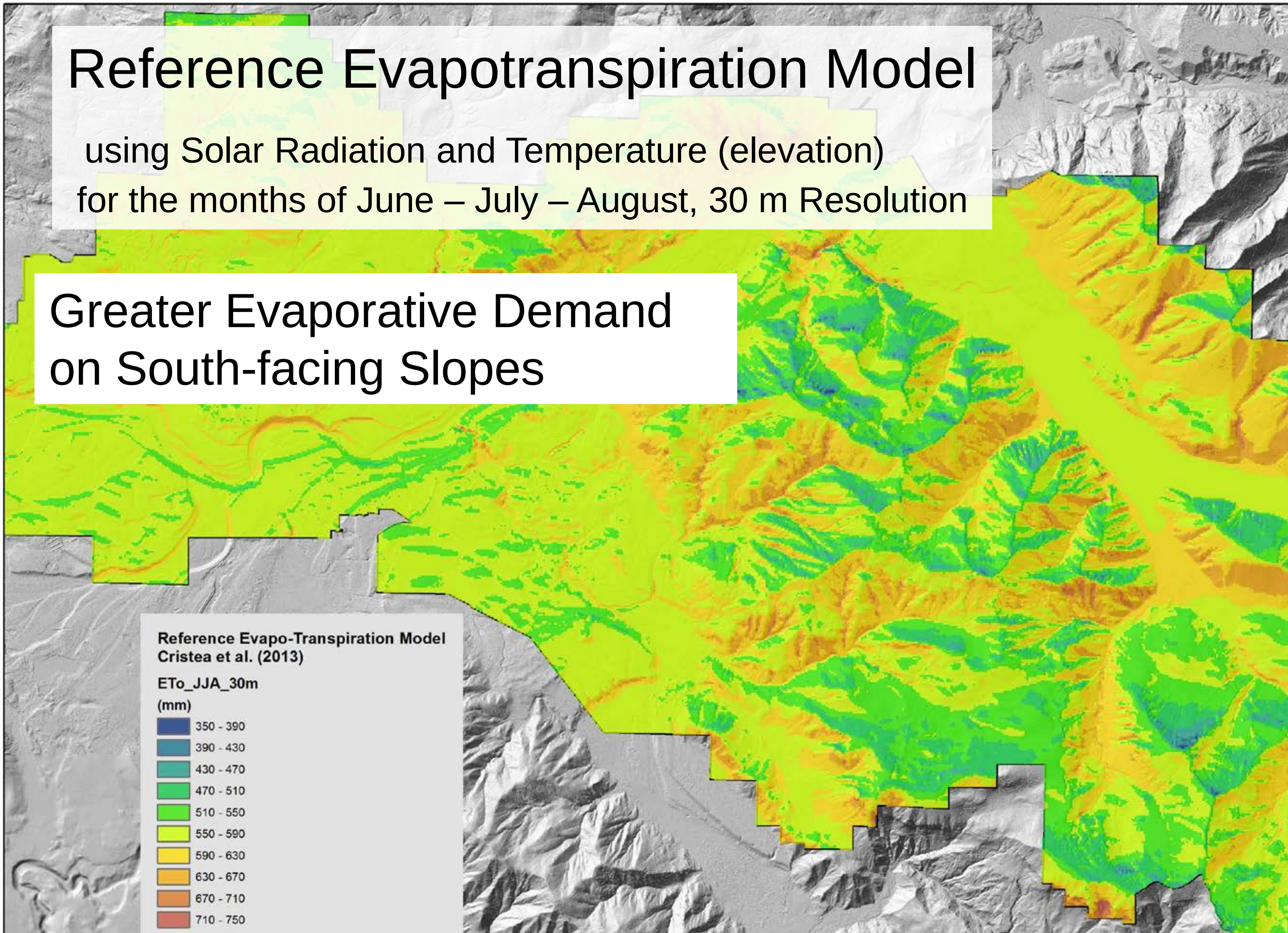
Greater Climate Exposure on Ridges and Upper Slopes with shallow soil and less available water



Reference Evapotranspiration Model

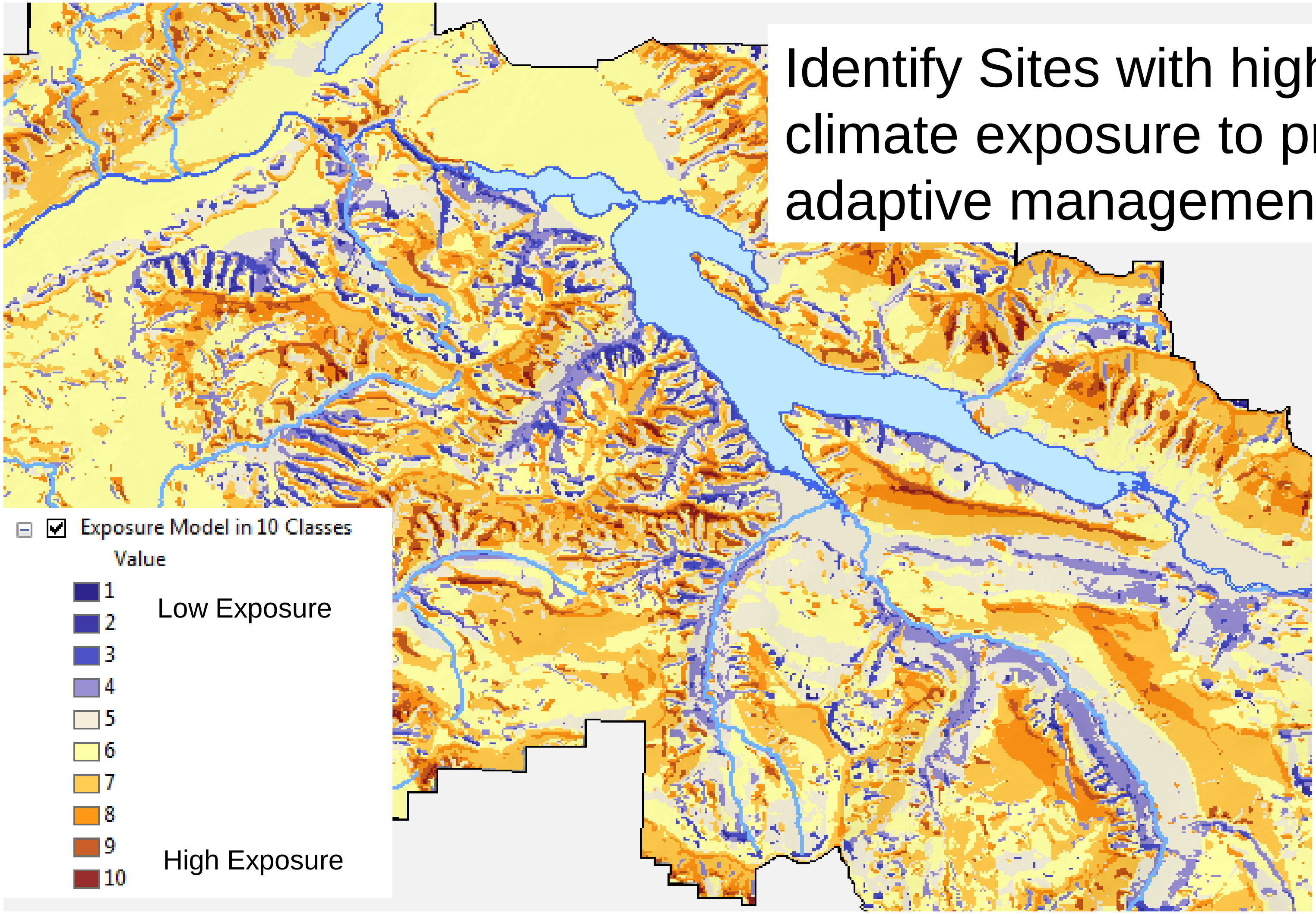
using Solar Radiation and Temperature (elevation)
for the months of June – July – August, 30 m Resolution

Greater Evaporative Demand on South-facing Slopes



Climatic Exposure Model

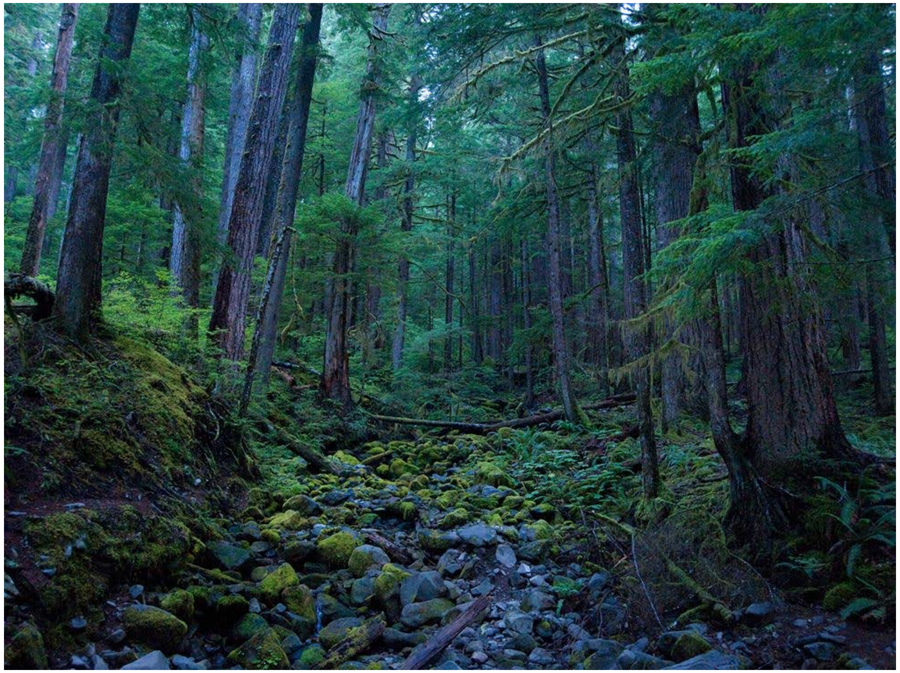
using ref. Evapotranspiration, Topographic Position, Snow Cover, and Soil



Identify Sites with high and Low climate exposure to prioritize adaptive management

Adaptation Strategies for Forest Hydrology

- **Older forest** for hydrologic regulation and reduced transpiration
- Adjust **culvert size** to future peak flow events



Adaptation Strategies for Forest Hydrology

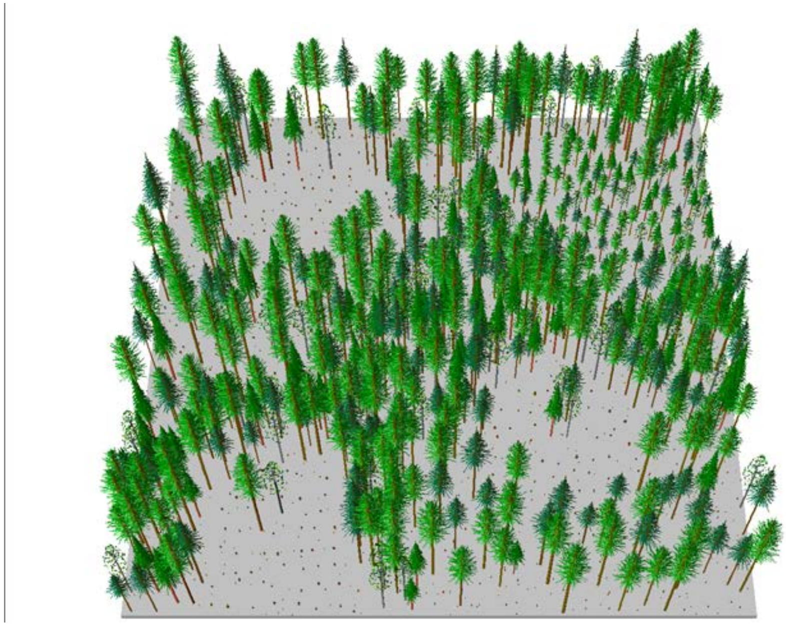
- **Lower stand density** for reduced transpiration and resource competition
- Regenerate trees in **canopy gaps** to reduce water stress

Adaptation Strategies for Forest Hydrology

- **Canopy gaps** to increase snow accumulation and limit snow-on-rain events
- **Mixed-species** stands and **variable canopy** for resilient water cycle regulation

Adaptation Strategies for Forest Hydrology

- **Group Selection Regeneration System** for:
  - Snow retention in canopy gaps
  - Regeneration in gaps to reduce moisture stress
  - Regenerating mixed species
  - Matrix thinning to reduce transpiration and interception
  - Dispersed opening to reduce effects of Rain-on-Snow



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