

**Effect of forest management on water
yields & other ecosystem services in Sierra
Nevada forests
UCB/UC Merced/UCANR project**



Some motivating points

- **Water is the highest-value ecosystem service associated with Sierra Nevada conifer forests**
- **Precipitation & temperature trends are changing the timing & amount of runoff**
- **Many second growth forests have dense canopies & growing fire risks**



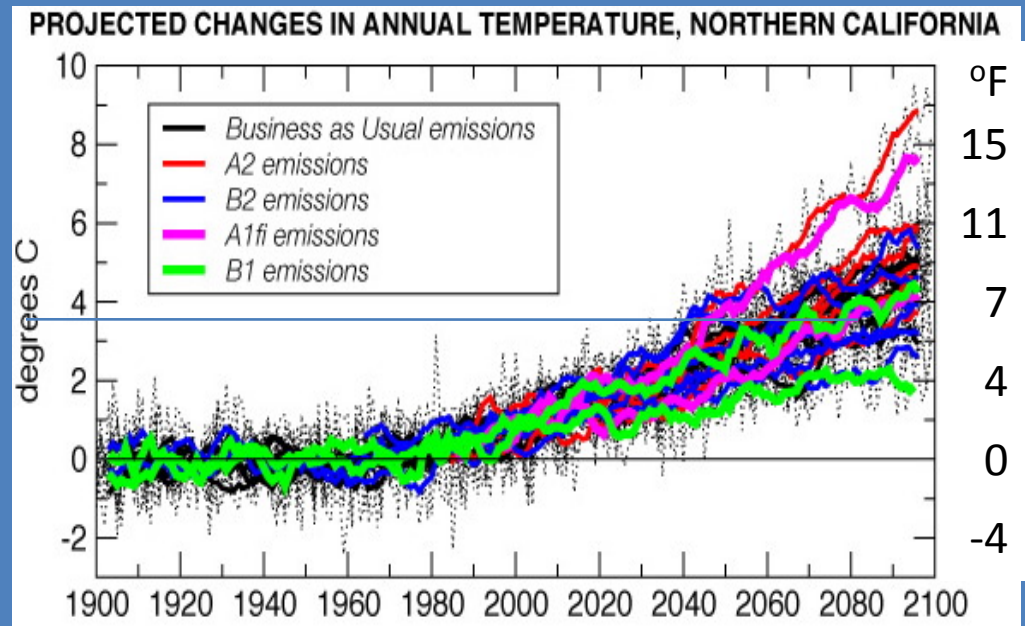
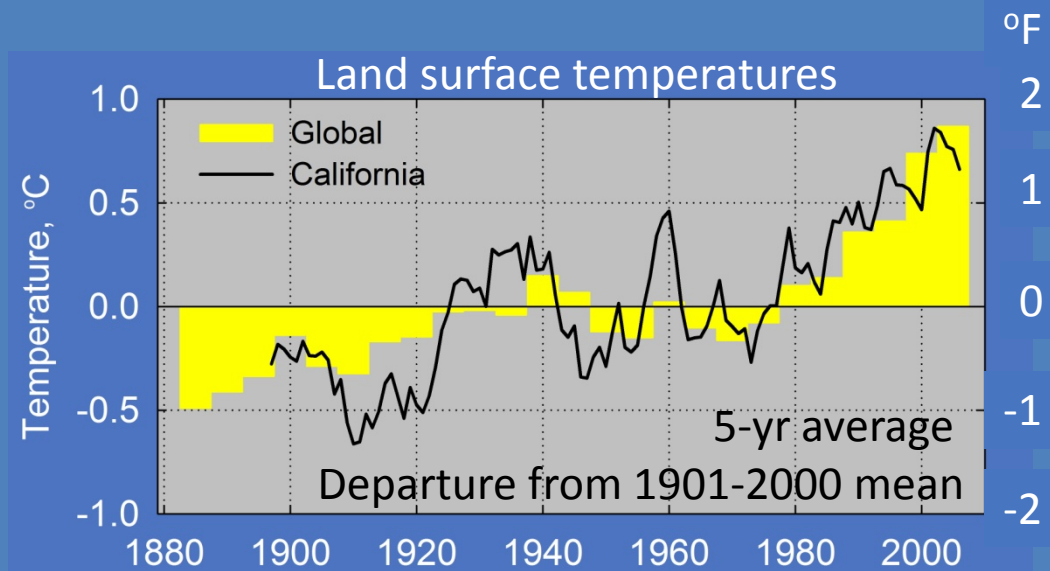
Mountain water cycle & climate warming

Warming by 2–6°C (4–11°F)
drives significant changes:

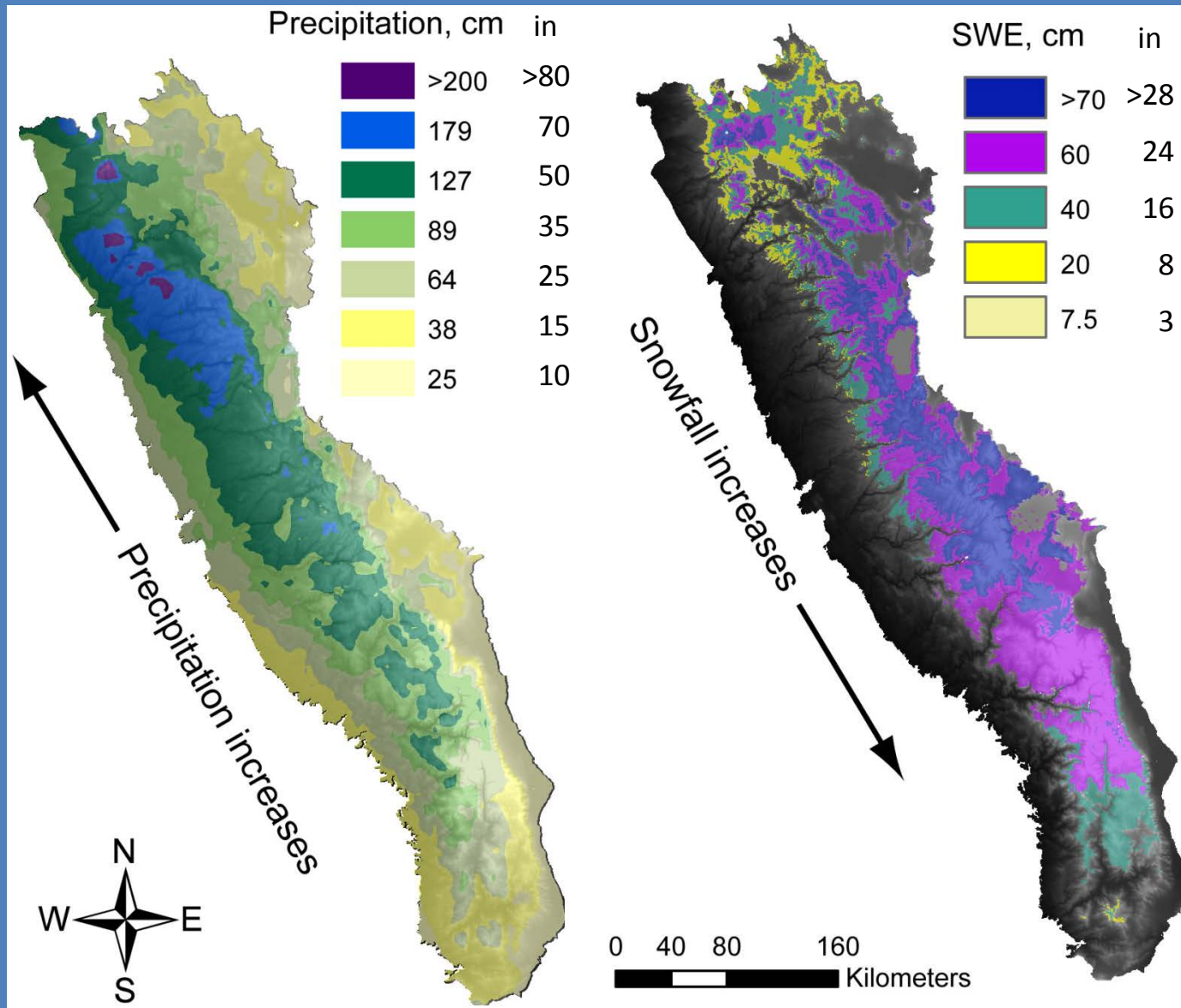
- rain-vs-snow storms *
- snowpack amounts *
- snowmelt timing *
- flood risk
- streamflow timing *
- low baseflows
- growing seasons *
- recharge?
- drier soil in summer

Precipitation changes
uncertain

Already observed (*)

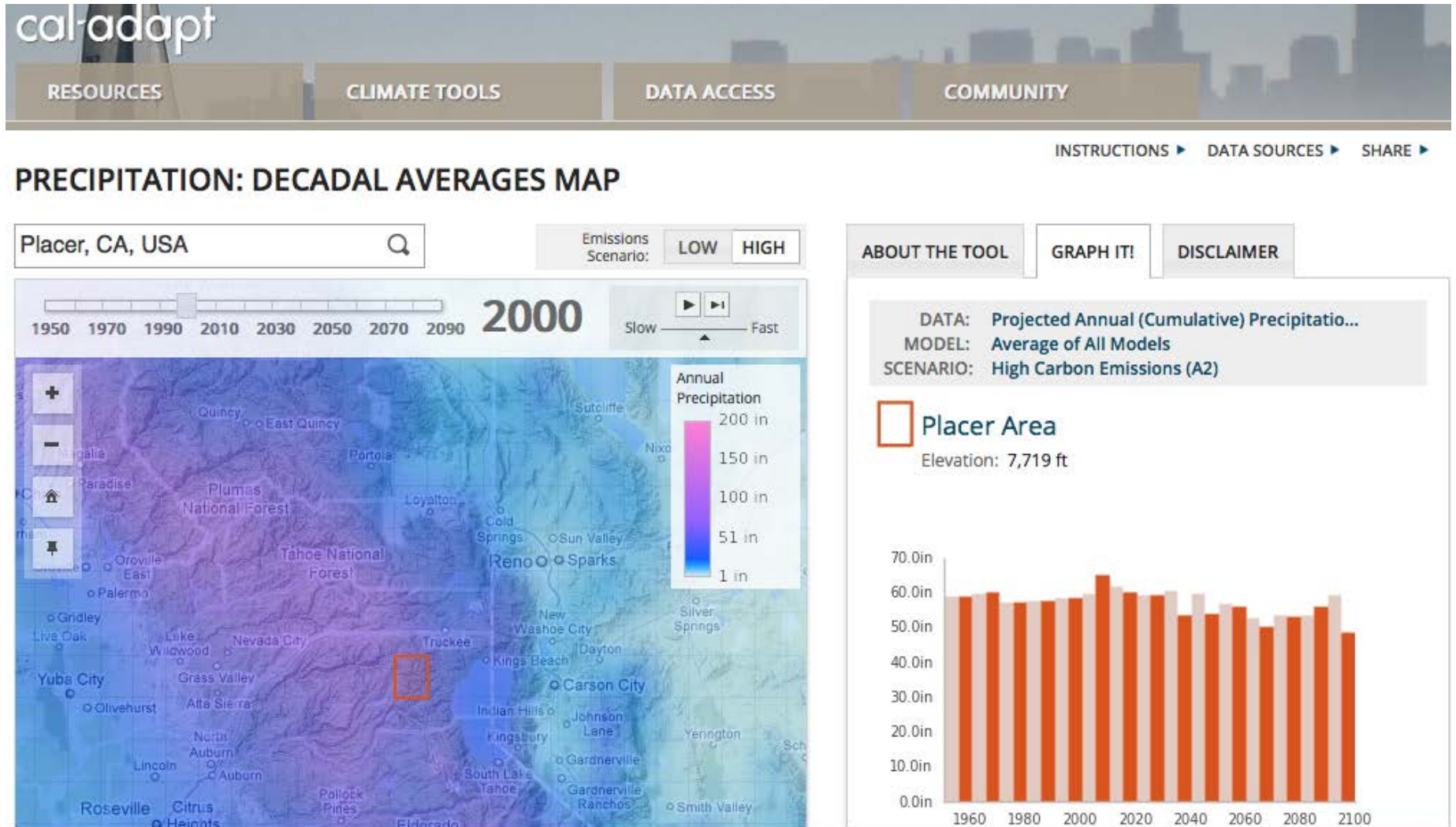


Sierra Nevada precipitation & snow water equivalent (SWE) – climatological estimate



cal-adapt.org – steady precipitation

Note: limited data in Sierra



A lot of precipitation falling on dense forests never gets into the streams

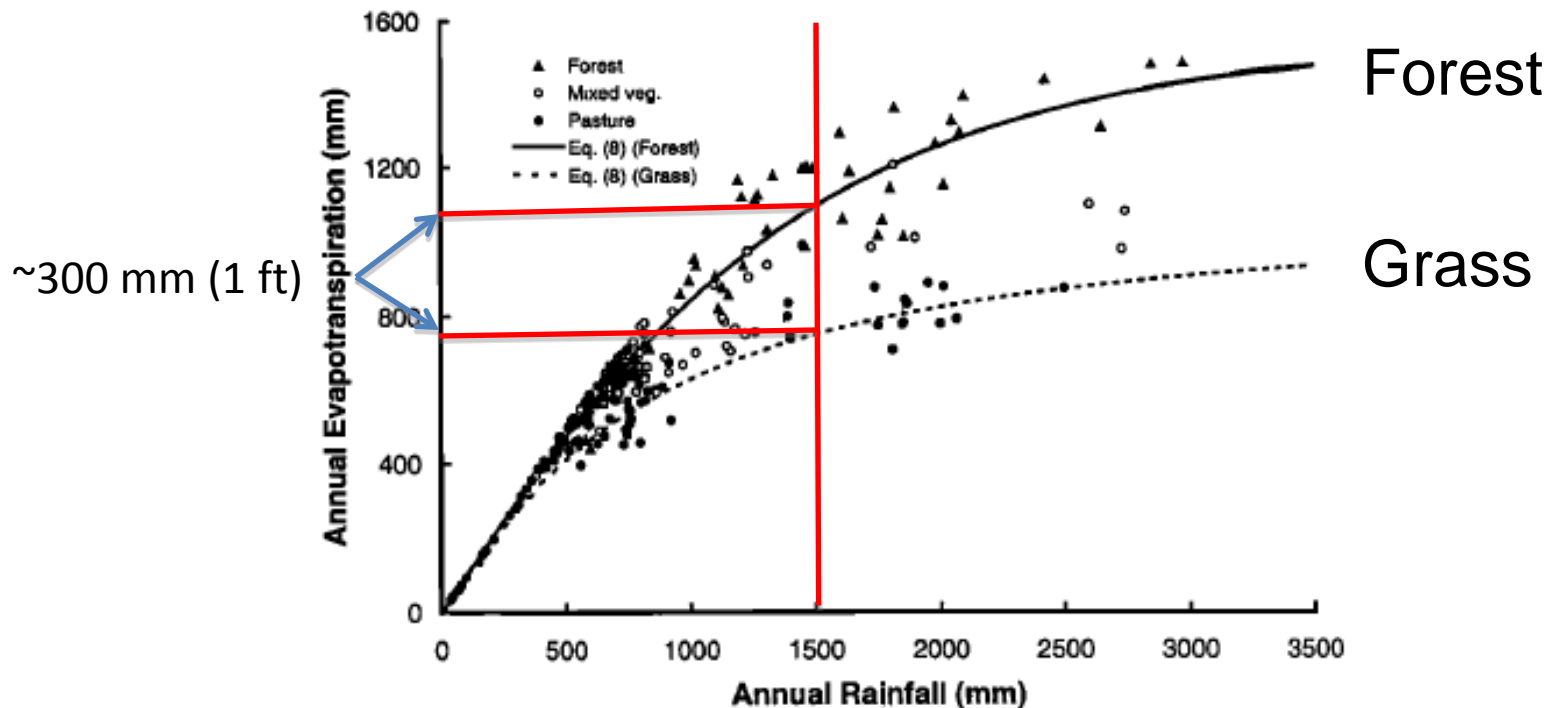
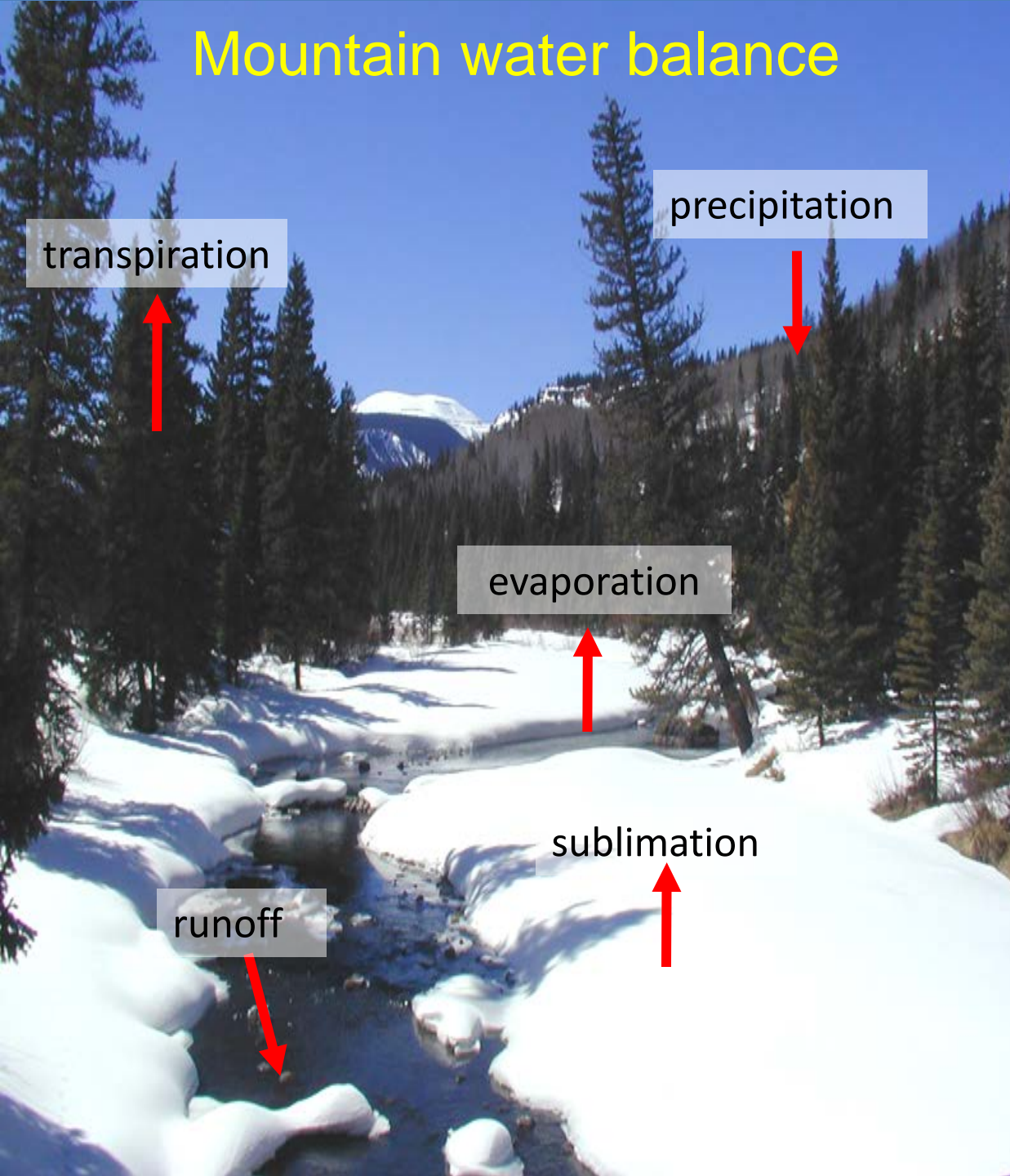


Figure 9. Relationship between annual evapotranspiration and rainfall for different vegetation types.

Every acre foot of water that runs through the full set of PCWA turbines generates about 2.8 MWh which is worth ~\$130 (5 yr avg price)

Mountain water balance



Myth:

We can, with a high degree of skill, estimate or predict the magnitude of these quantities

Forest management – principles & assumptions

- Produce different stand structures & densities across the landscape using topographic variables to guide varying treatments
- Higher density & canopy cover for local cool or moist areas, w/ less-frequent or lower-severity fire, providing habitat for sensitive species
 - Low densities of large fire-resistant trees on southern-aspect slopes
 - Thinning based on crown strata or age cohorts & species, rather than uniform diameter limits

An Ecosystem Management Strategy for Sierran Mixed-Conifer Forests

Malcolm North, Peter Stine, Kevin O'Hara, William Zielinski, and Scott Stephens



Pacific Southwest
Research Station

General Technical Report
PSW-GTR-220
March 2009

Such treatments can also enhance water yield & timing of runoff

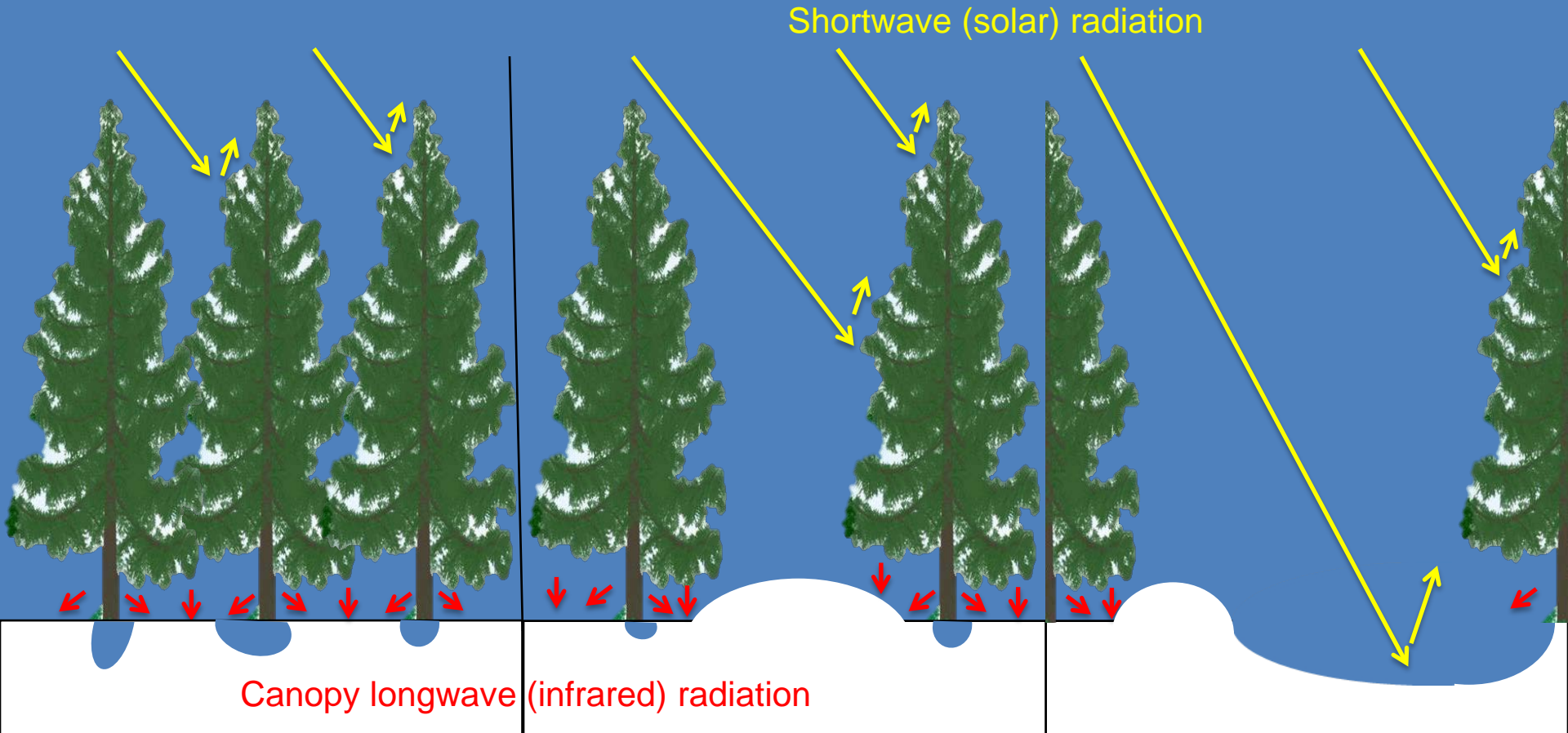
How much snow gets to the ground & how fast does it melt?

3 scenarios for solar & infrared radiation

1. Dense canopy

2. Small gaps

3. Large gaps

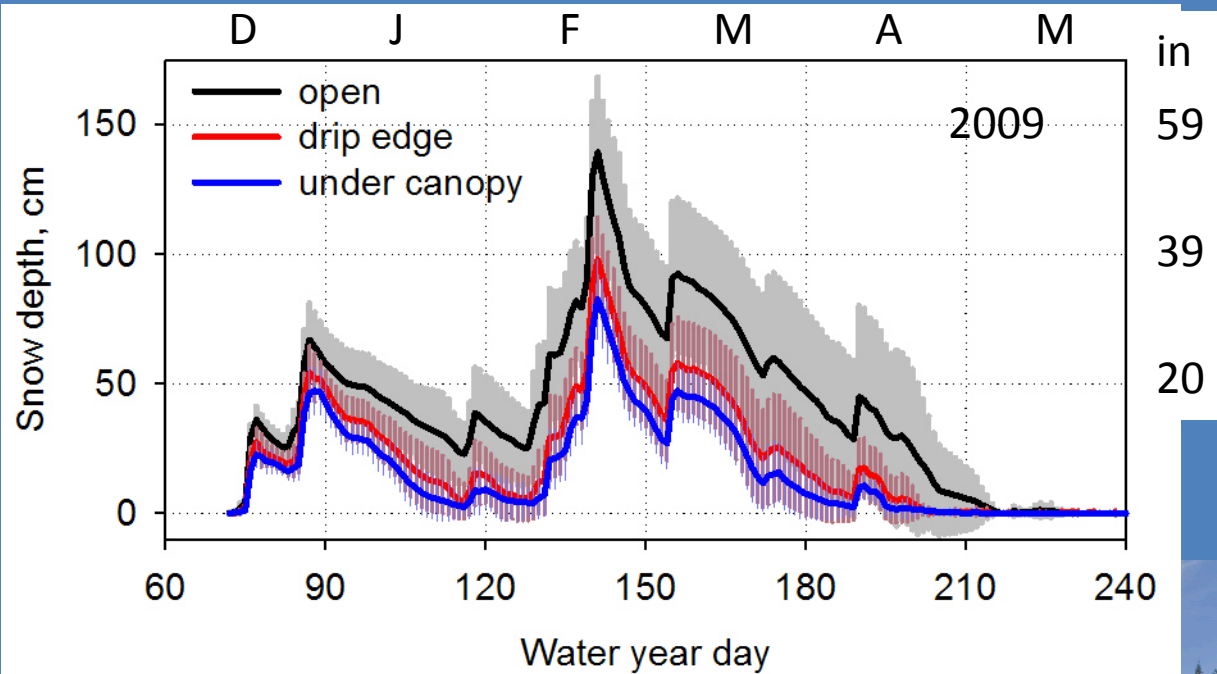


Lowest shortwave
High longwave

Low shortwave
Low longwave

High shortwave
Lower longwave

Snow depths in mixed-conifer forest

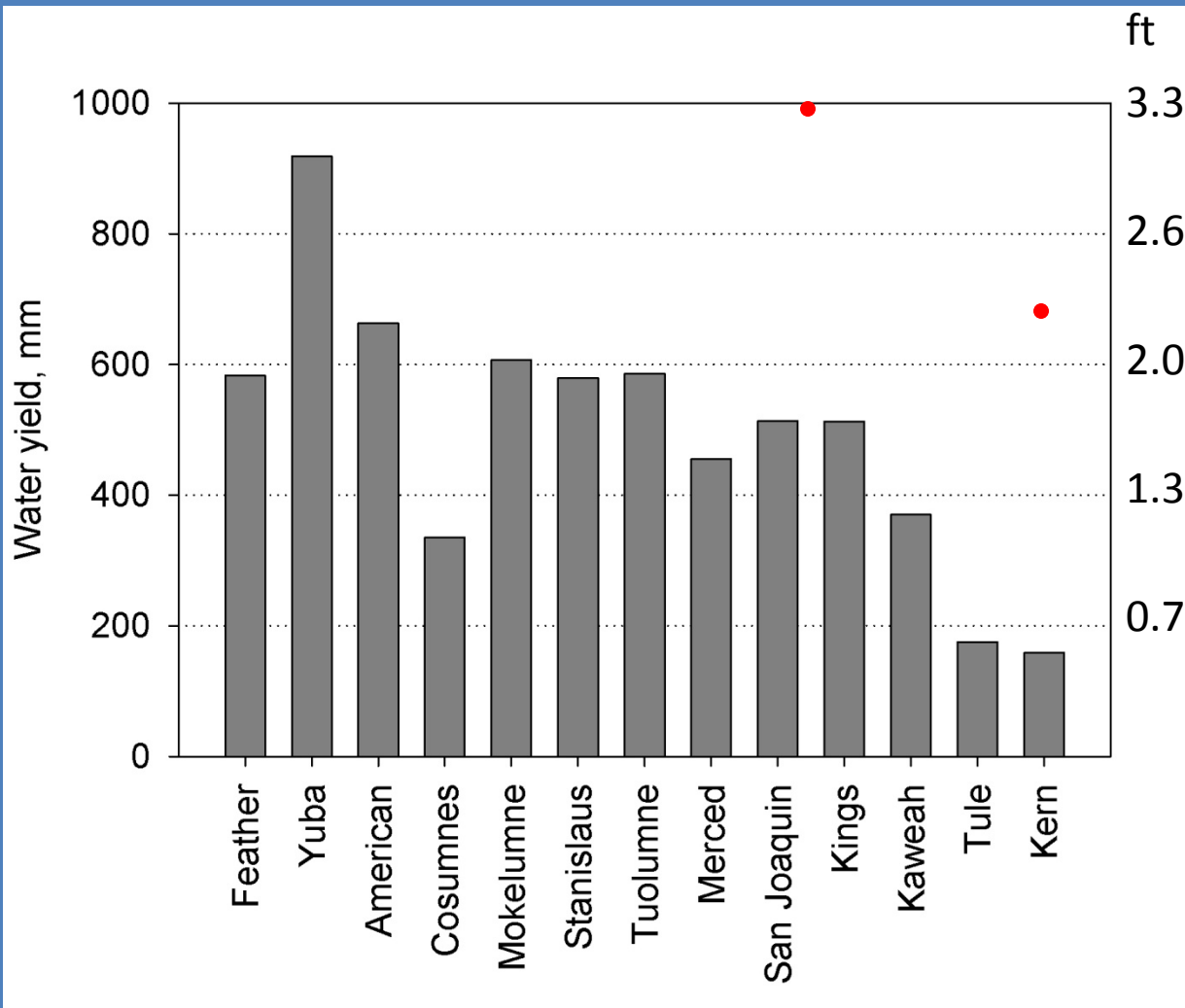


- Snow depth under canopy only about half to two thirds of that in the open
- Differences of about 40 cm (16 in)

Mean & standard deviation of snow depth over 6-mo period, Southern Sierra Critical Zone Observatory



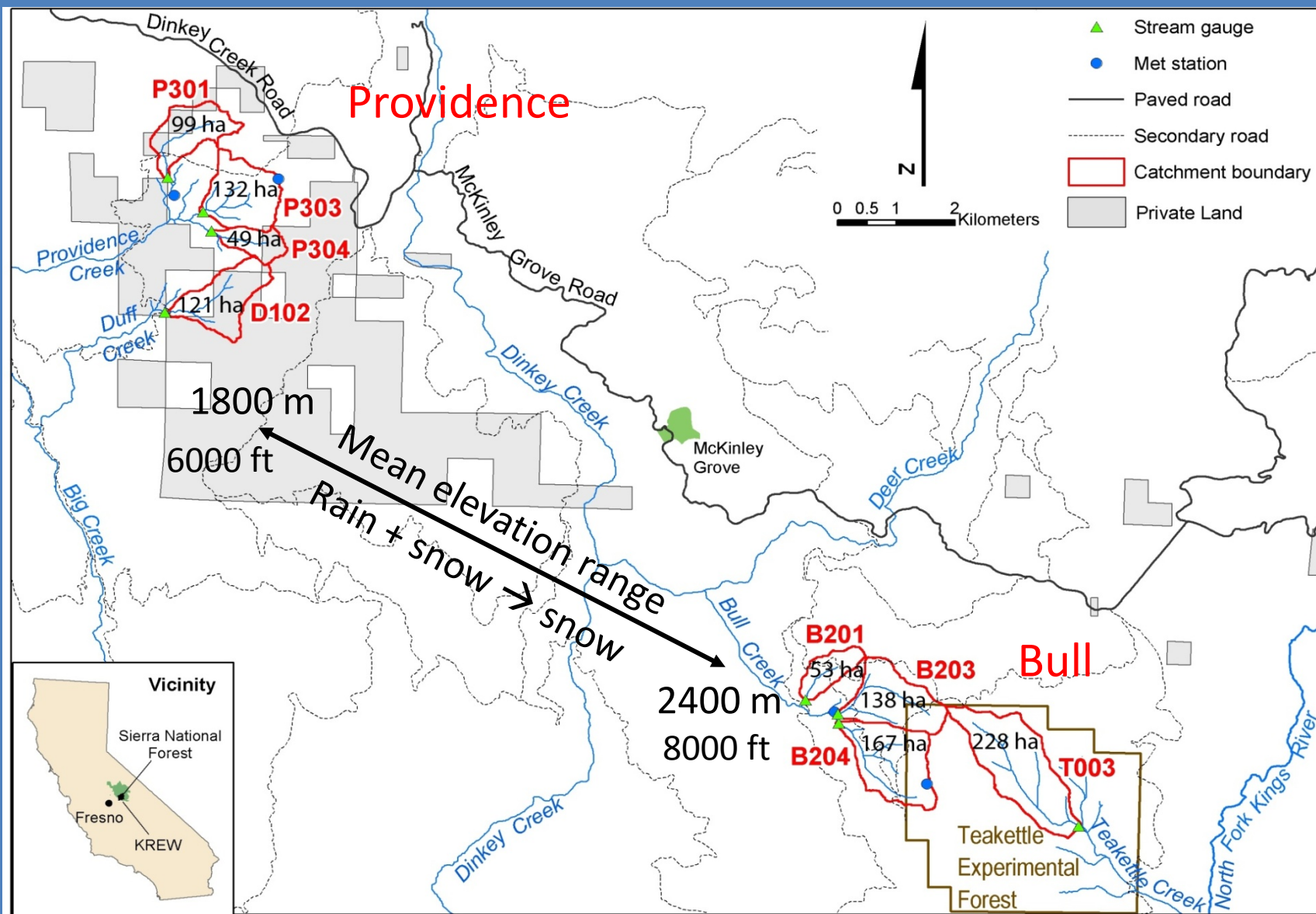
Sierra Nevada long-term average water yield

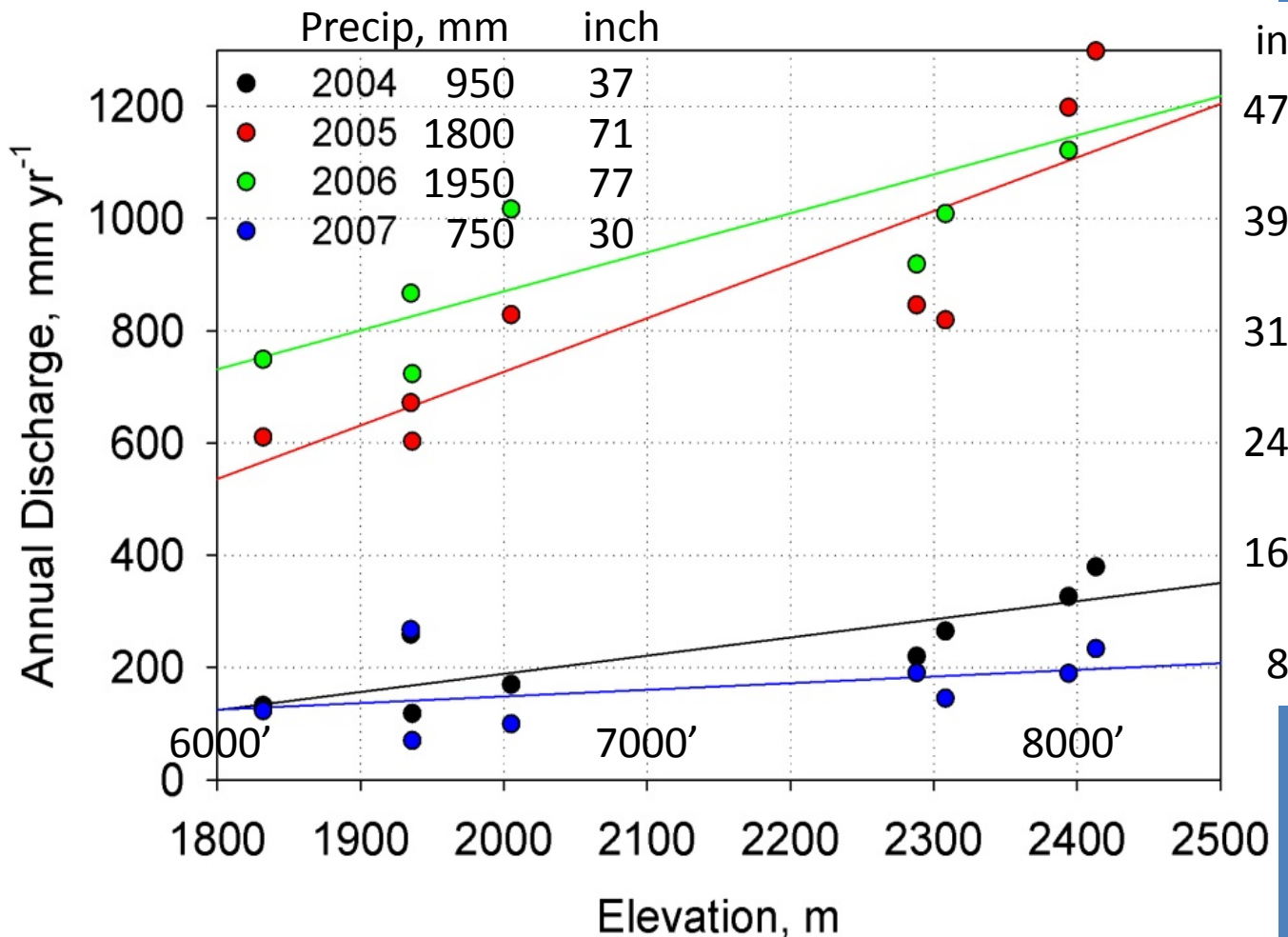


In order to verify the impact of forest management, need to accurately estimate the precipitation, discharge & evapotranspiration

General N – S decrease →
Decreasing precipitation →
Increasing snow →

A closer look at water yield: 8 KREW instrumented headwater catchments





Increase in
water yield w/
elevation, from
rain to snow
dominated

Kings River basin



Decreasing temperature →

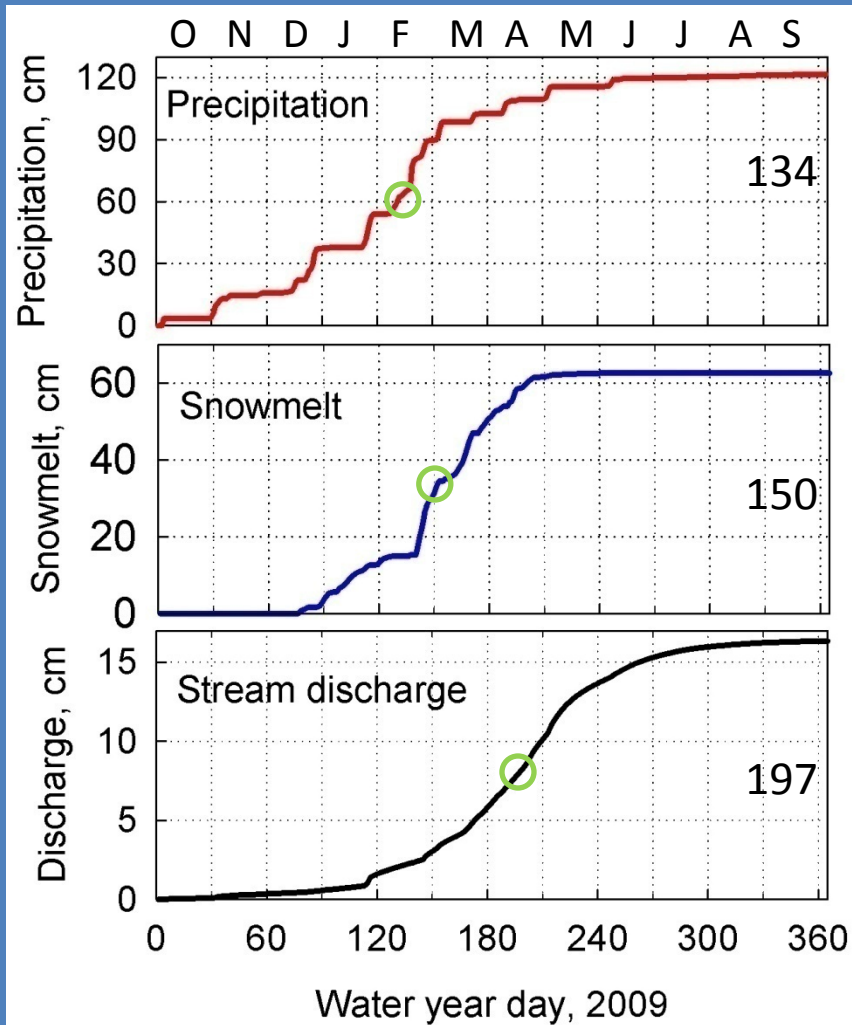
Increasing snow fraction →

Decreasing vegetation →

Coarser soils →

The effect of snowpack storage on runoff timing

Cumulative over one water year

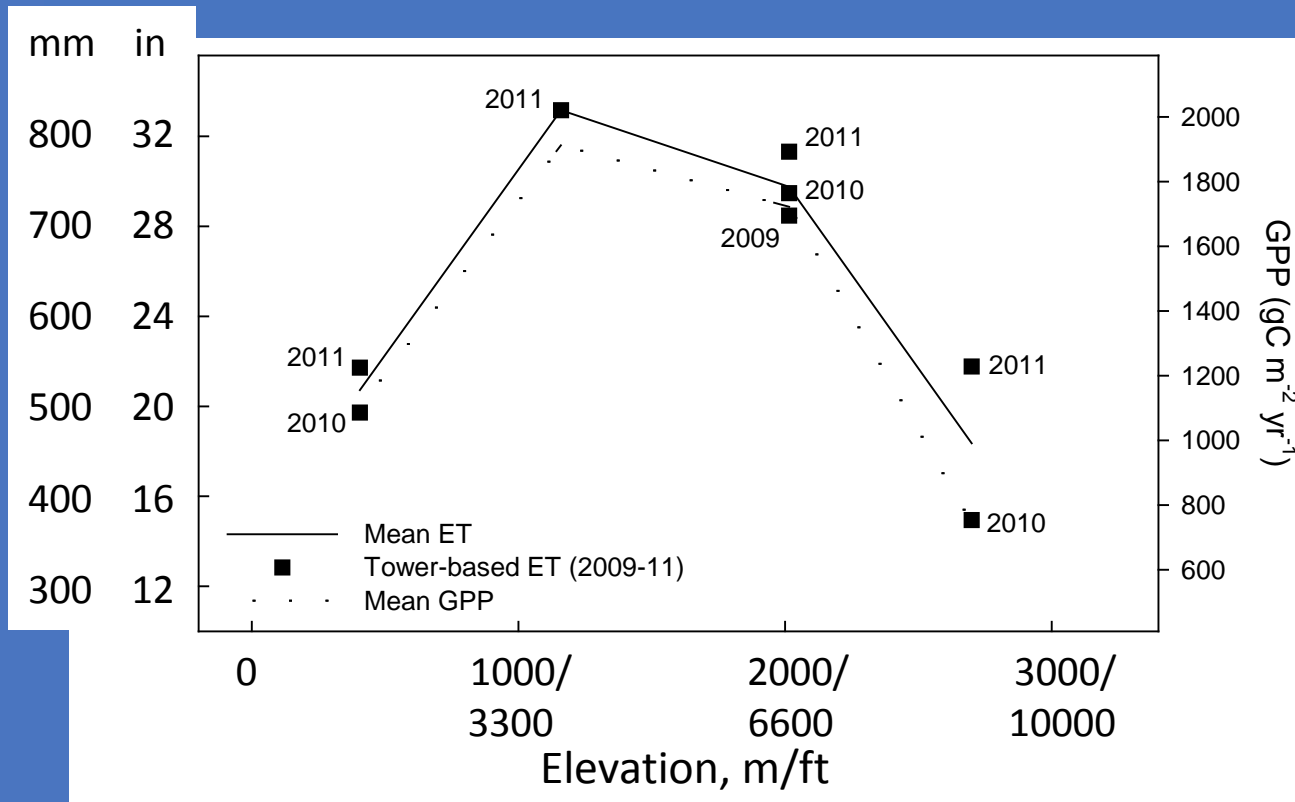


In this rain-snow transition catchment, stream discharge lags precipitation by about 2 months

This lag is expected to decrease by about 1-2 weeks per 1°C (2°F) of warming

How forest management will affect the lag depends on how the energy balance changes

Annual evapotranspiration



- Highest current evapotranspiration in rain to rain-snow transition region of mixed conifer forest – year-round growth
- Lower elevation is water limited
- Higher elevation is cold limited

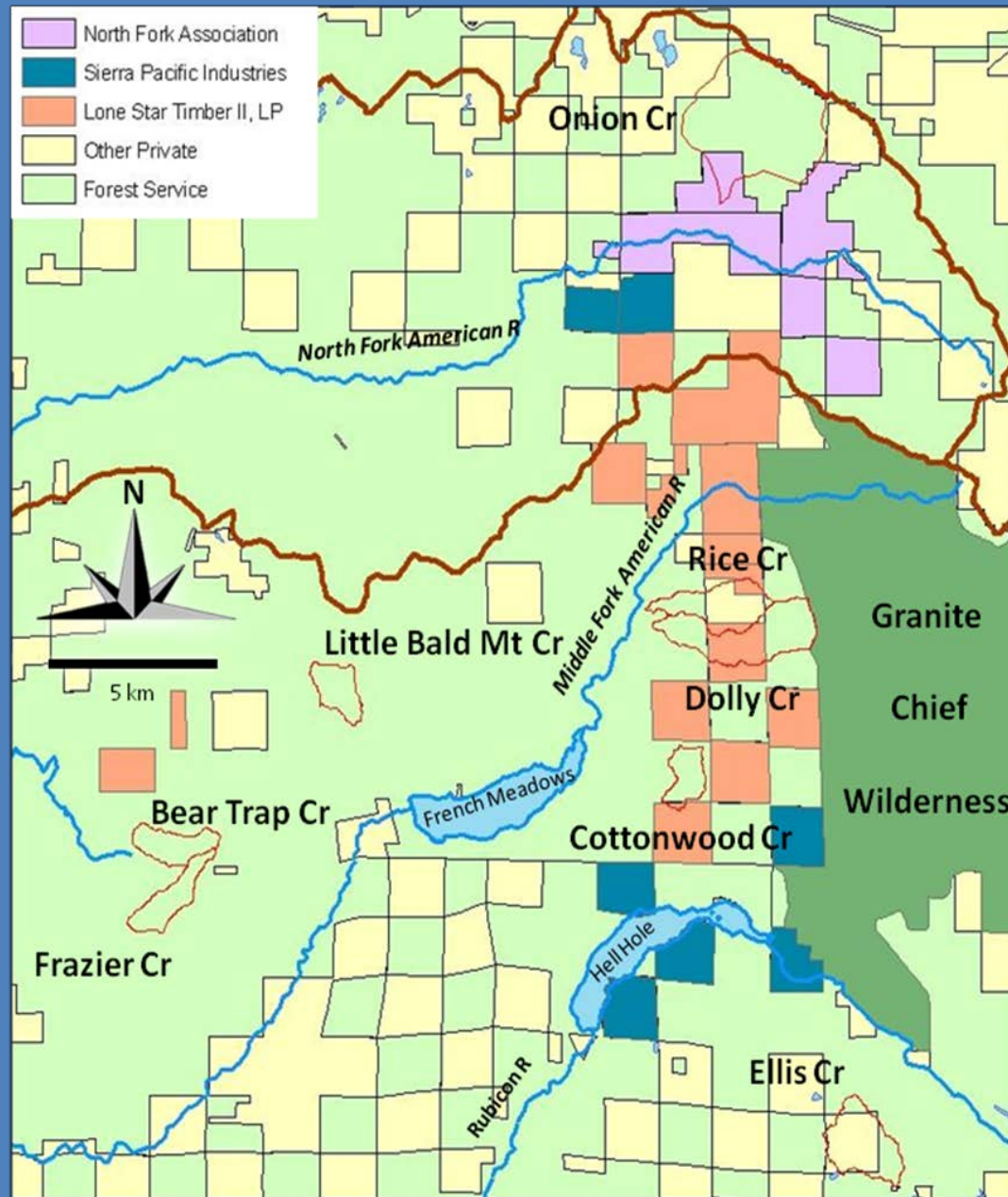
UC ANR work plan 2012-15

- Determine rates of ET in Sierran mixed-conifer/true fir forests
- Determine water use efficiency of trees & shrubs in these forests
- Determine the potential for forest management to delay snowmelt in Sierran forests
- Determine potential economic tradeoffs of forest management treatments to affect water yield & ecosystem services
- Involve stakeholders in decision-making regarding forest management & watershed effects
- 2012 summer season – start measurements needed to calibrate the ‘forest/water’ model

Hydrologic research in progress – American River

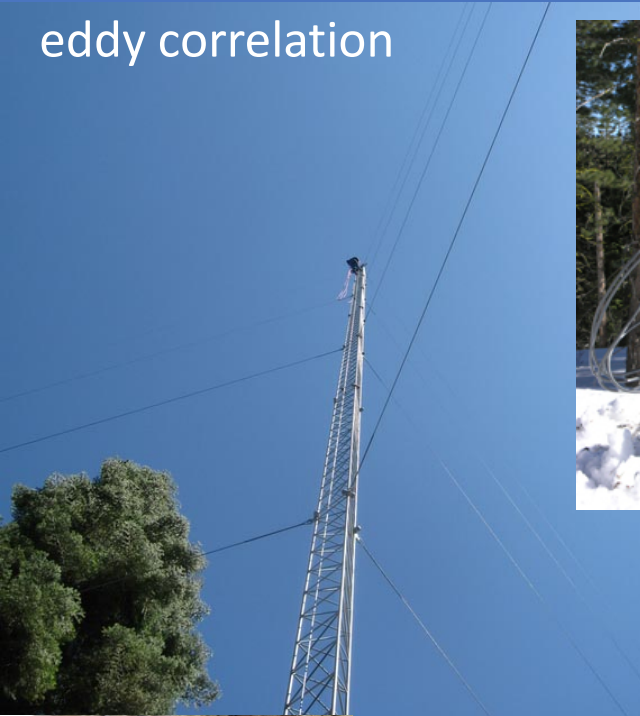
1. Sierra Nevada Adaptive Management Project (SNAMP)
 - Two instrumented headwater catchments in Forest Hill/Duncan Peak area
 - Sierra Nevada Framework treatments
2. Sierra Nevada Watershed Ecosystem Enhancement Project (SWEEP)
 - Phase 2 research to develop treatments & project effects
 - Phase 3 to carry out & evaluate treatments
 - Additional phase 2 planning needed
3. American River basin hydrologic observatory
 - National Science Foundation (NSF) supported infrastructure
 - CA-DWR supported infrastructure

Potential SWEEP catchments



A new generation of integrated measurements

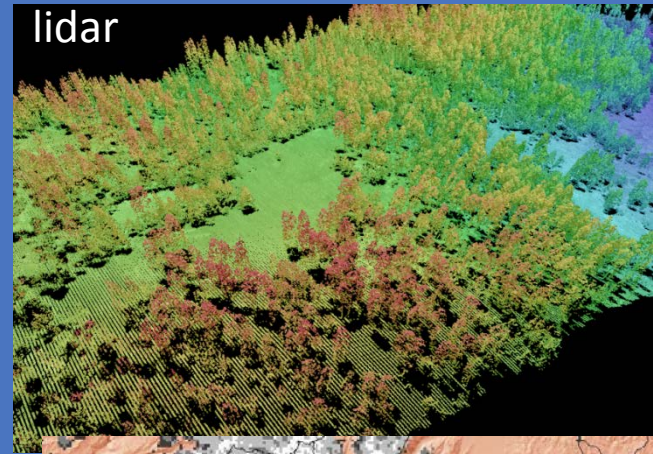
eddy correlation



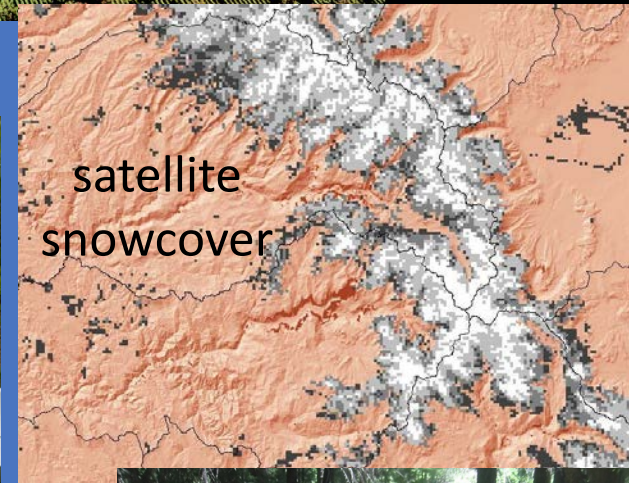
embedded
sensor
networks



lidar



satellite
snowcover



isotopes & ions



low-cost
sensors



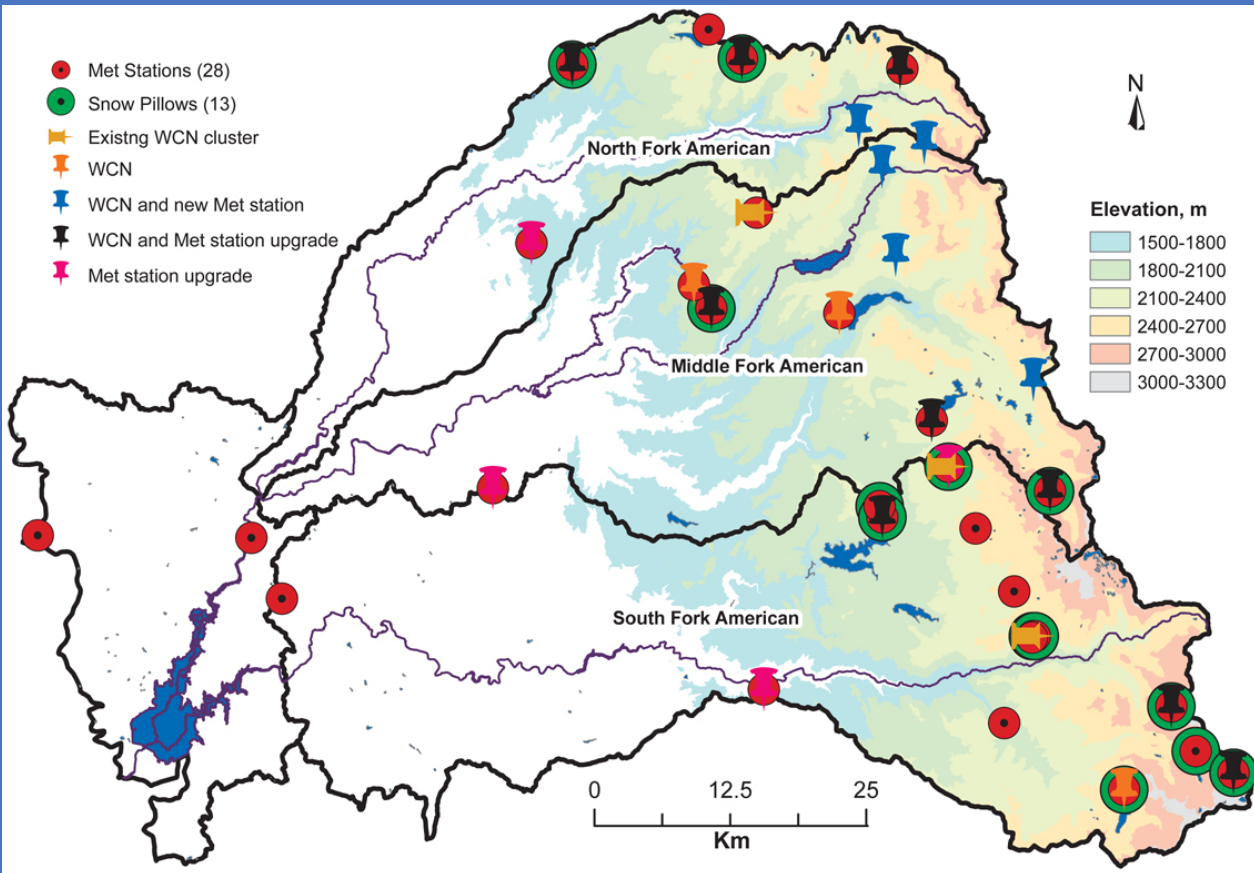
sap flow



sediment



Basin-wide deployment of hydrologic instrument clusters – American R. basin



Strategically place
low-cost sensors to
get spatial
estimates of
snowcover, soil
moisture & other
water-balance
components

Network & integrate these sensors into a single
spatial instrument for water-balance
measurements.

Building the knowledge base to enhance
forest & water management

