Forests, water & research in the Sierra Nevada

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E-W transect of flux towers

San Joaquin Experimental Range
400 m
1300 ft

Soaproot Saddle
1100 m
3600 ft

CZO P301
2000 m
6600 ft

Shorthair Creek
2700 m
8900 ft

Main CZO site

Southern Sierra Critical Zone Observatory

N-S transect of research catchments
Mountain hydrology – fluxes

**Motivating questions**

How will this landscape & the hydrologic processes connecting it alter w/ climate warming & land-use/landcover change?

**Reservoirs:**
- Snowpack storage
- Soil-water storage
Myth:
We can, with a high degree of skill, estimate or predict the magnitude of these quantities.

Reservoirs:
Snowpack storage
Soil-water storage
Mountain hydrology – fluxes

My biases:
Improved predictions require better process understanding
The basis for process understanding is new measurements
Processes are coupled & best studied together

Reservoirs:
Snowpack storage
Soil-water storage

evapotranspiration
precipitation
snowmelt
infiltration
sublimation
runoff
ground & surface water exchange
Basic water balance

Precipitation = Evapotranspiration + Runoff
Decreasing temperature → Increasing snow fraction → Decreasing vegetation → Coarser soils

50% more runoff in snow dominated vs. mixed rain-snow catchments

Implication for 2°C warmer climate:
Reduce runoff by 10-40% in mixed conifer forest (assuming ecosystems adapt)

0.1 increase per 350 m (1150 ft)

5°C

6000' 8000' 7000'

5°F

1800 1900 2000 2100 2200 2300 2400 2500

Elevation, m

Discharge/precipitation

2004 2005 2006 2007
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
Sierra Nevada precipitation & snow water equivalent (SWE) – climatological estimate?
Most snowmelt comes from elevations above most measurement of precipitation or snowpack.
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 (*)
Kings basin snowmelt w/ climate warming
Making a water-secure world – the three I’s

INFRASTRUCTURE
to store, transport & treat water

INFORMATION
Better & more-accessible

INSTITUTIONS
Stronger & more-adaptable

Water security: the reliable availability of an acceptable quantity & quality of water for health, livelihoods & production, coupled w/ an acceptable level of water-related risks
Water is fundamental to sustainable ecosystem services. Water management therefore translates into managing ecosystem services, and must be a fundamental goal of virtually all such efforts.
A new generation of integrated measurements

- eddy correlation
- embedded sensor networks
- isotopes & ions
- low-cost sensors
- sap flow
- satellite snowcover
- lidar
- sediment
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