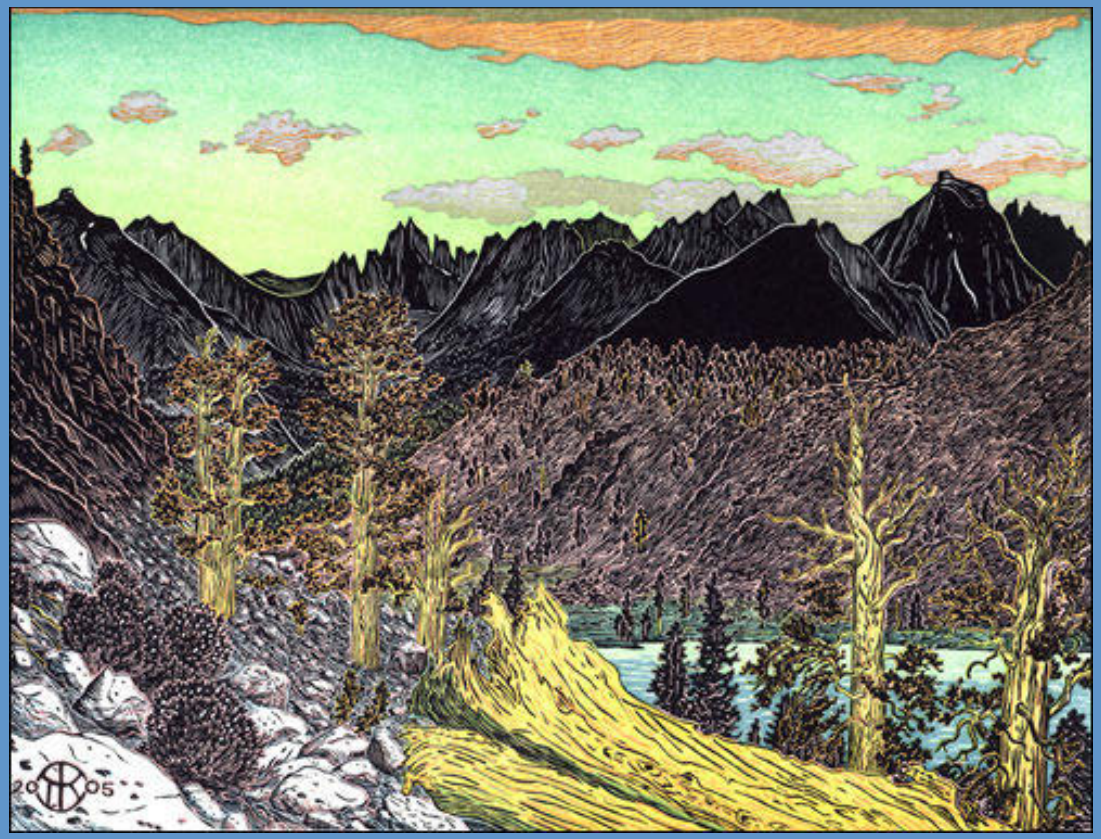
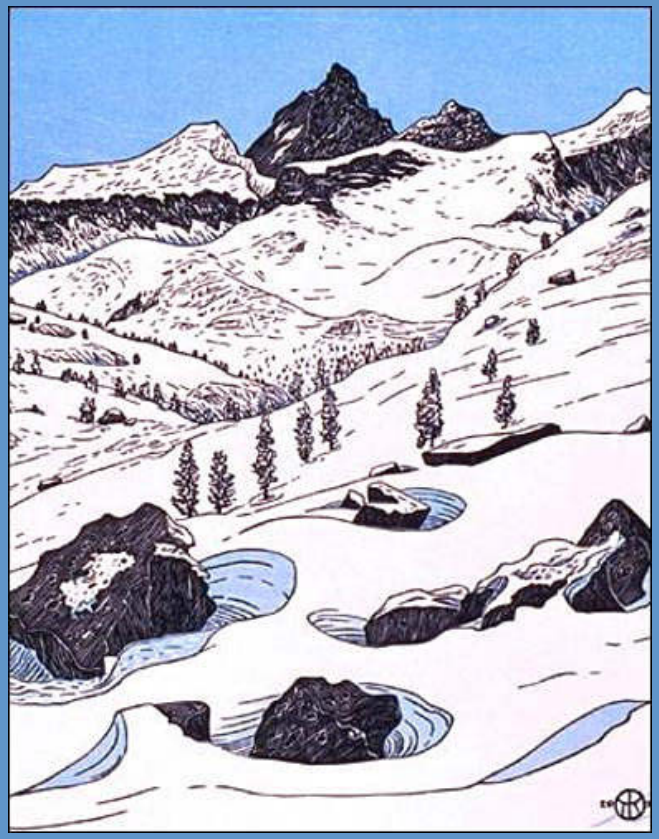
Mountain hydrology, forest management & water security in the Sierra Nevada

Phil Saksa
Sierra Nevada Research Institute, UC Merced



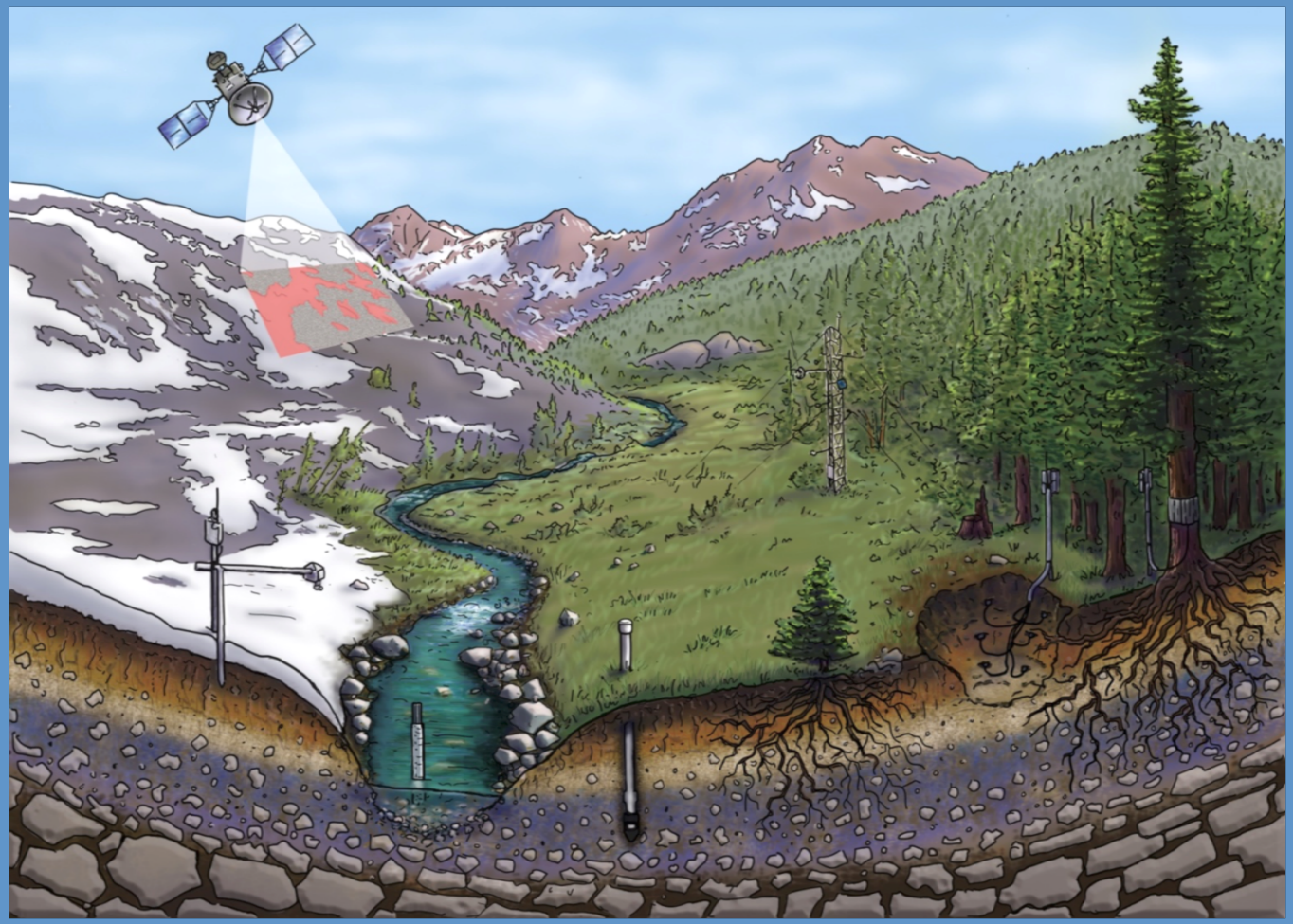
Whitney Crest from Kaweah Basin, copyright Tom Killion



Junction Peak, copyright Tom Killion

Topics in this talk:

1. Mountain hydrology background
2. Water & forest management
3. Water security & managing ecosystems



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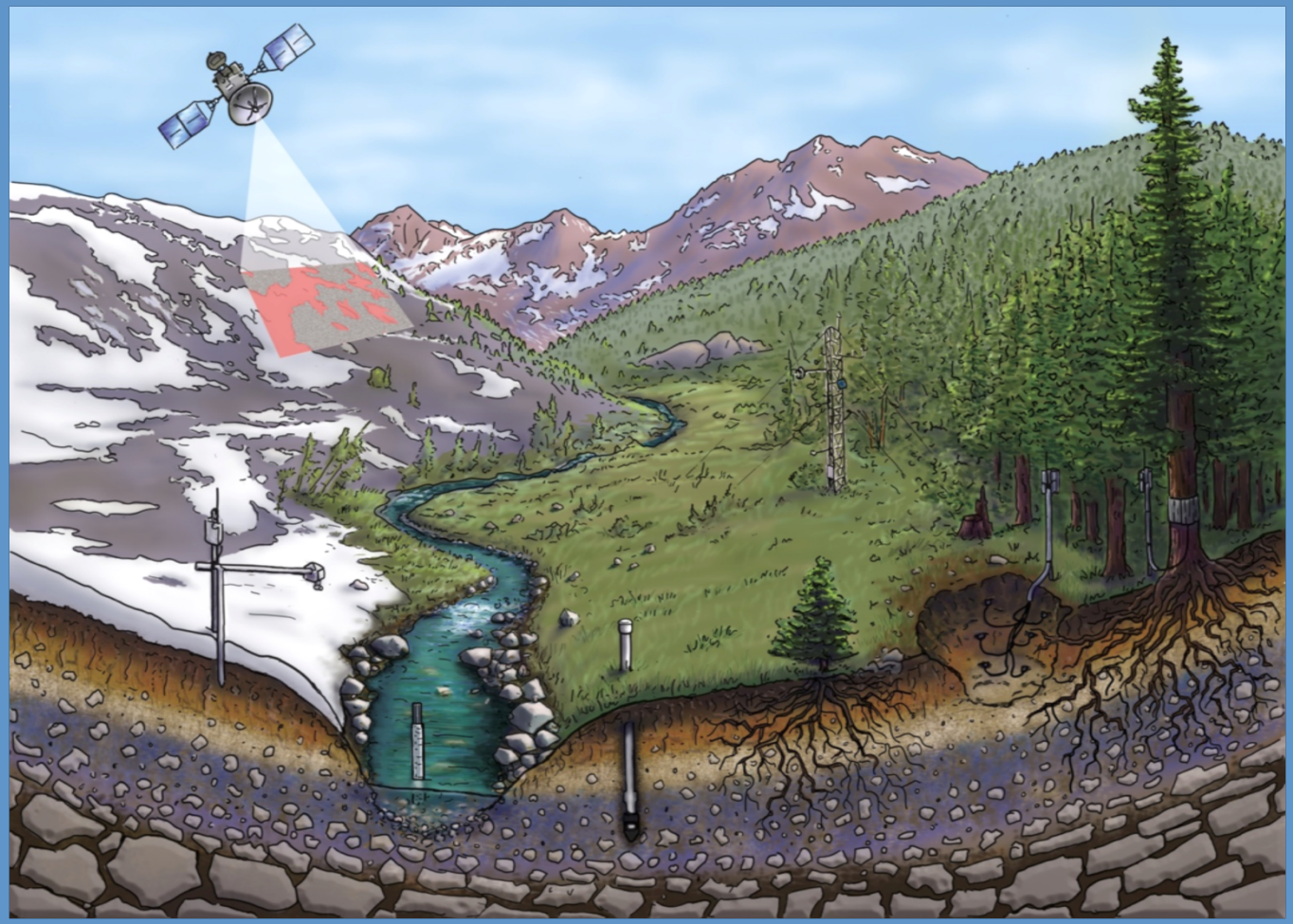
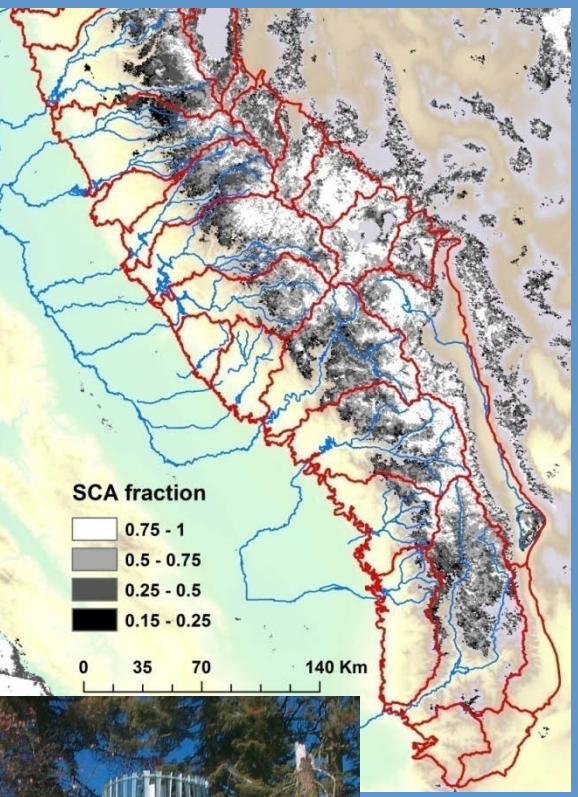
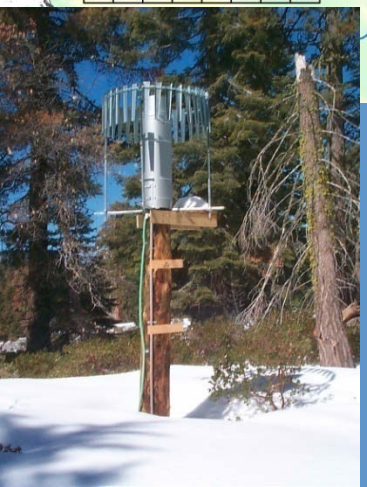


Basic water balance

Precipitation = Evapotranspiration + Runoff

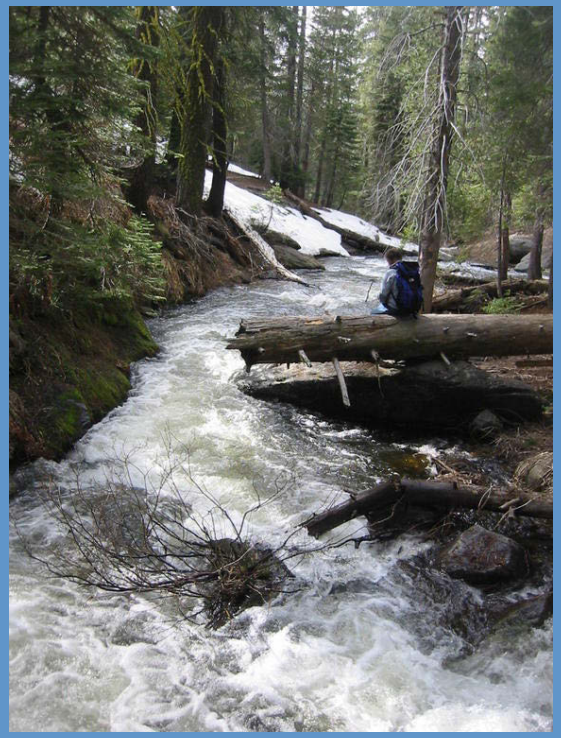




snow
& rain

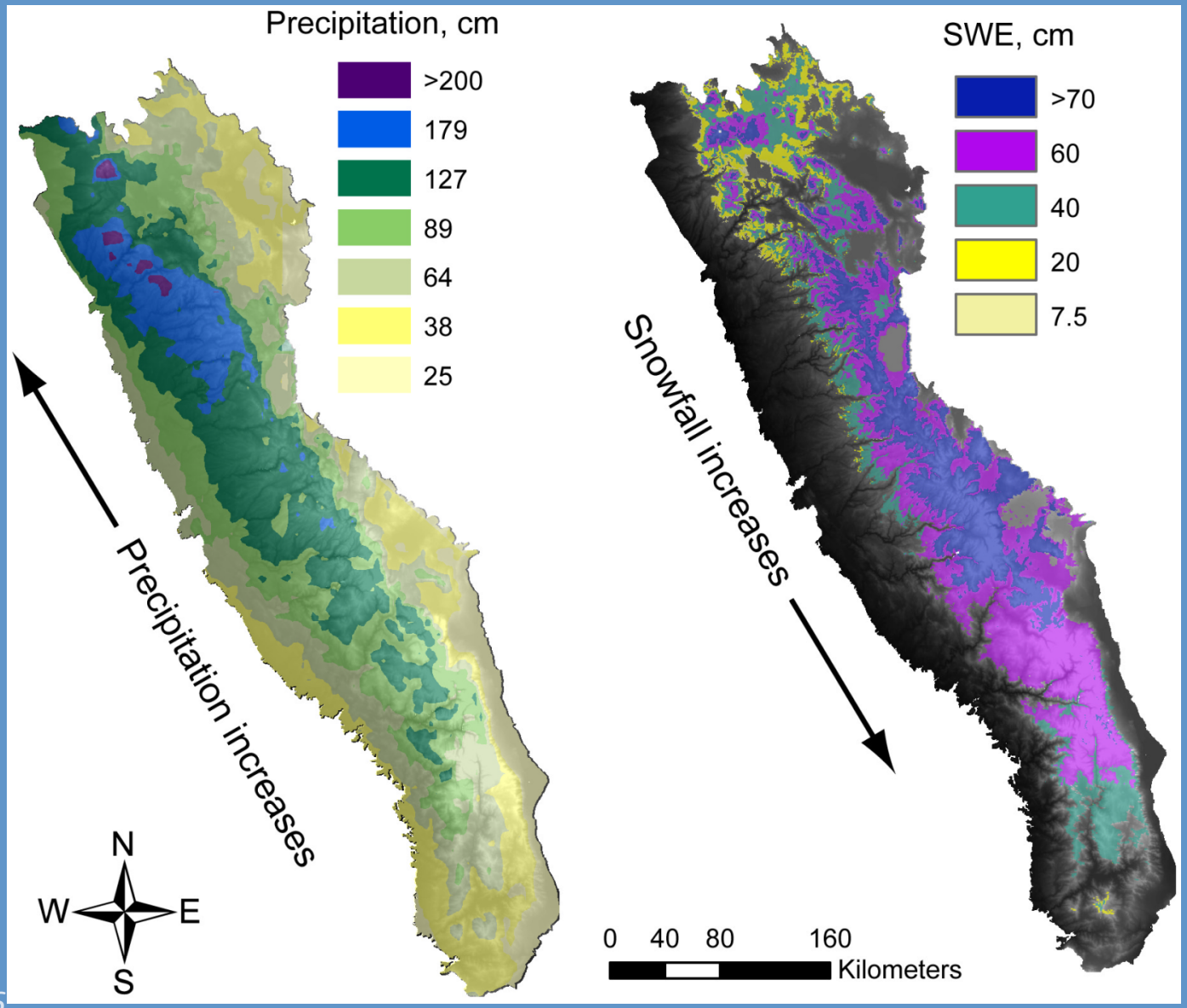
=

+



Evapotranspiration refers to evaporation, sublimation plus water use by vegetation

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



Bales et al., 2006

Relevant UC watershed-scale field programs

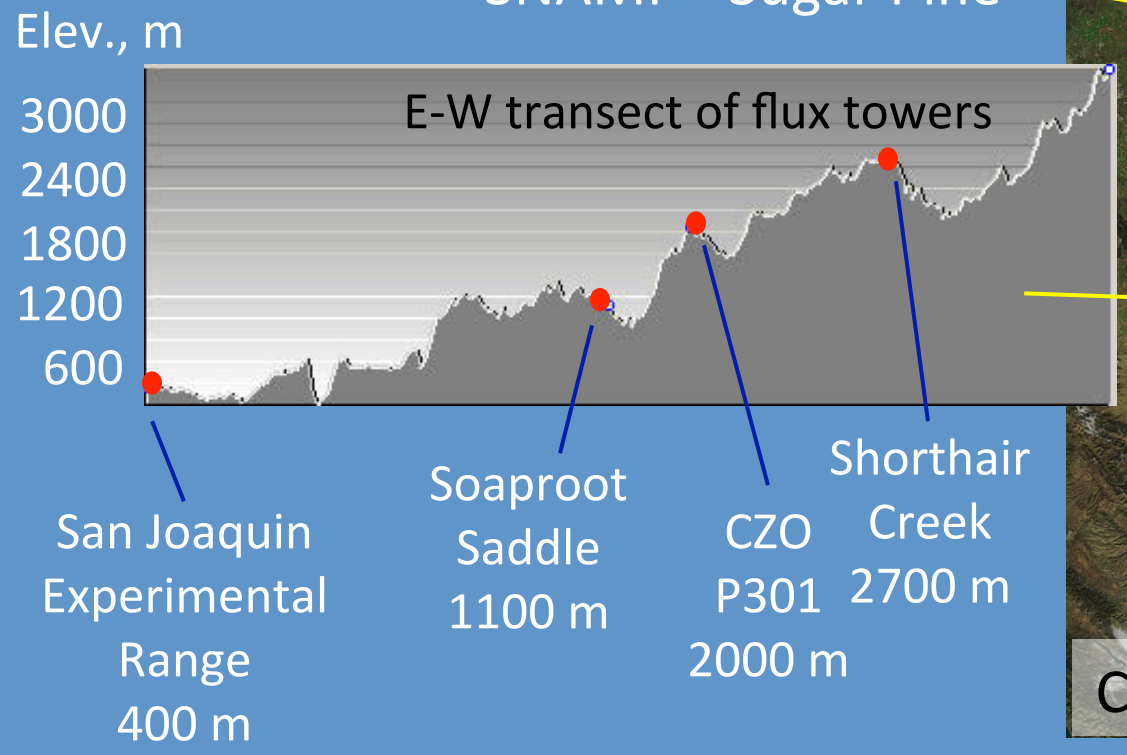
American R. & SNAMP - Last Chance

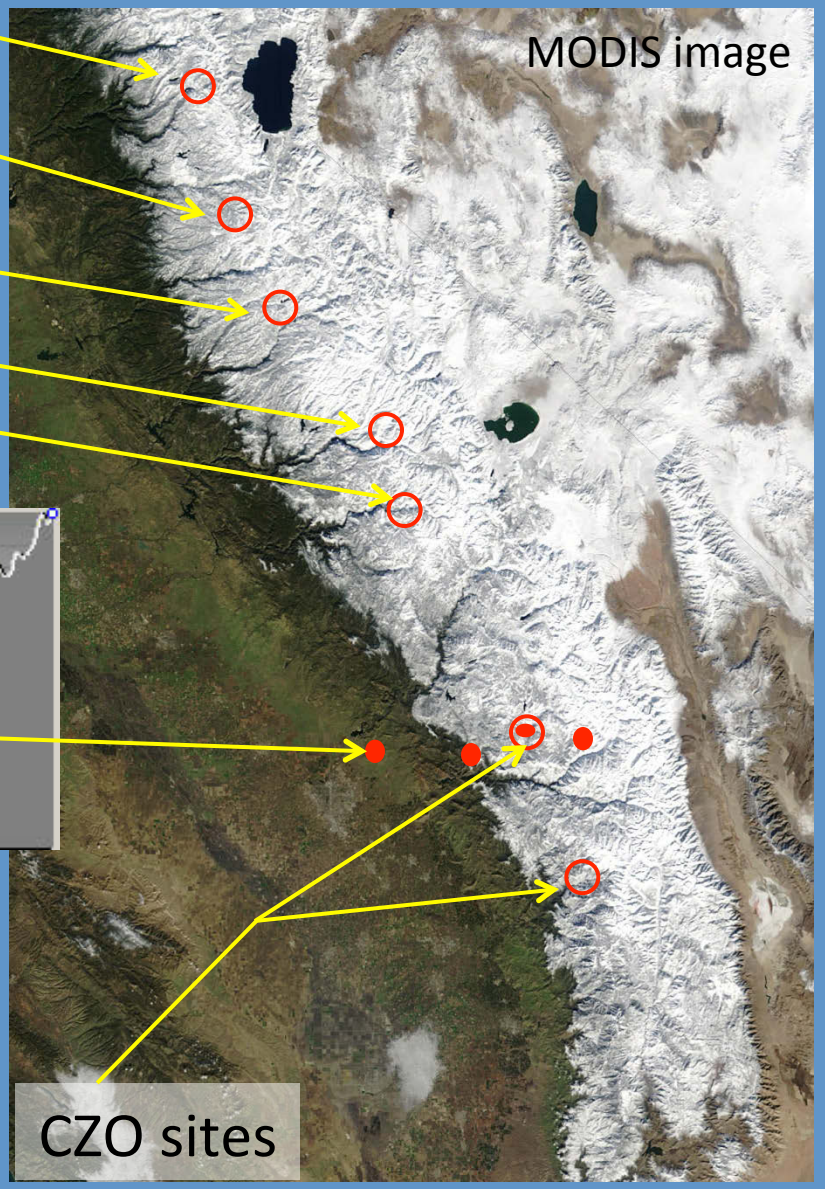
Hemlock & SPI

PSW - STEF

YNP – Tioga corridor

SNAMP - Sugar Pine





Evapotranspiration measurements

Pine/oak forest
E: 4000’
P_{ave} : 28”
ET: 33”

Oak savannah
E: 2000’
P_{ave}: 16”
ET: 20”

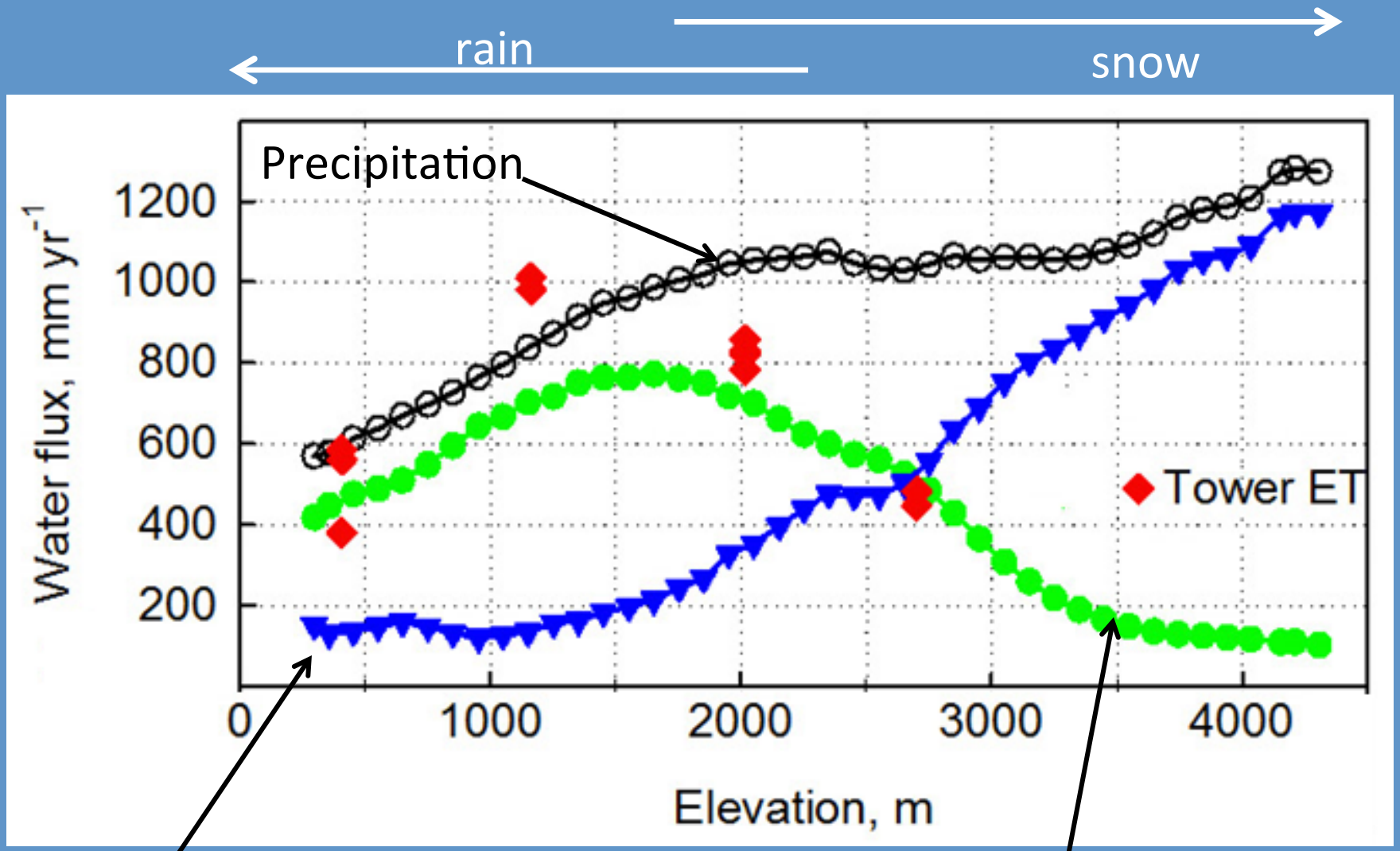
Mixed conifer forest
E: 7000’
P_{ave} : 33”
ET: 30”

Subalpine forest
E: 9000’
P_{ave} : 36”
ET: 18”

rain

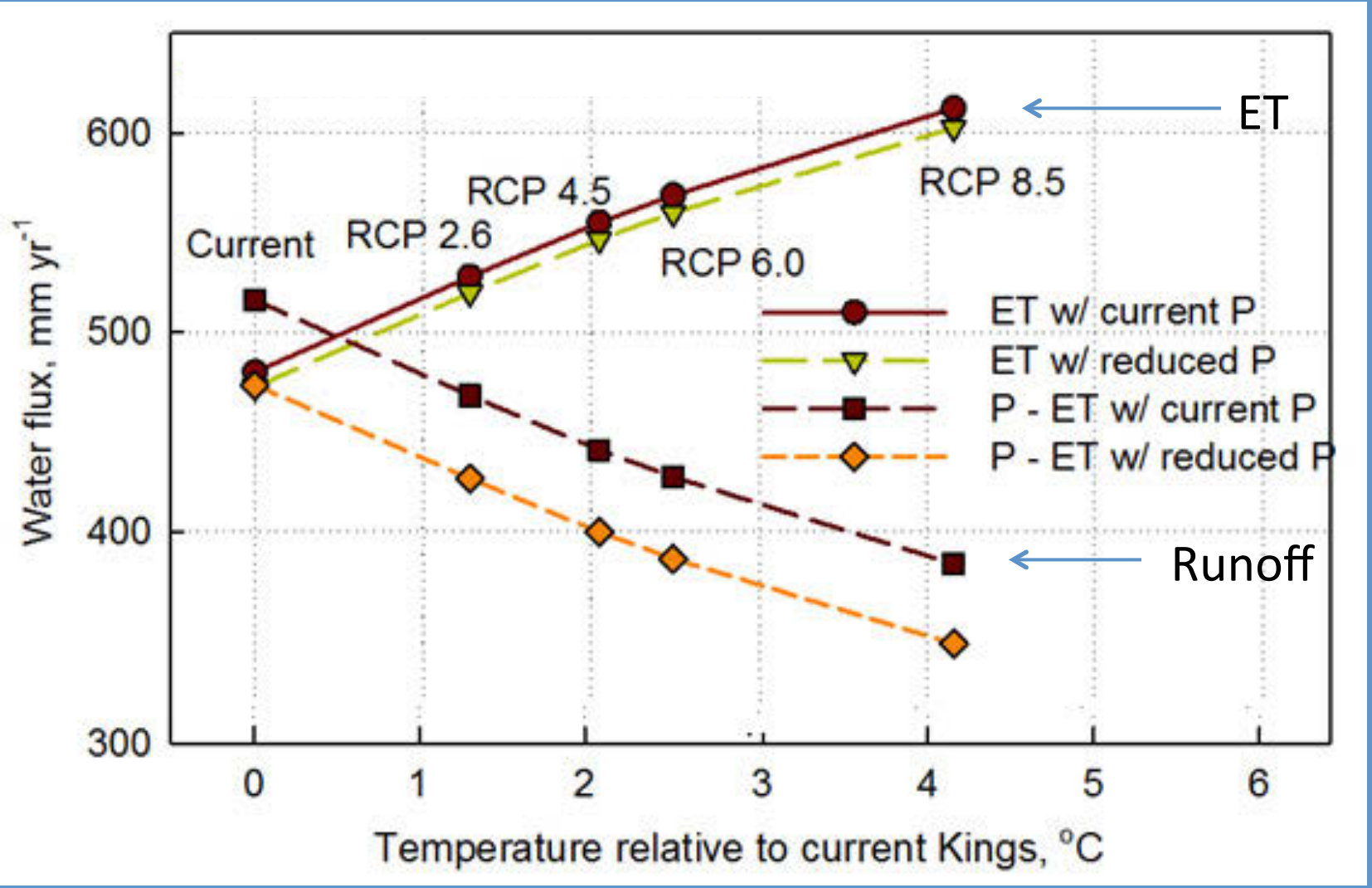
snow

Water balance – Kings R. basin



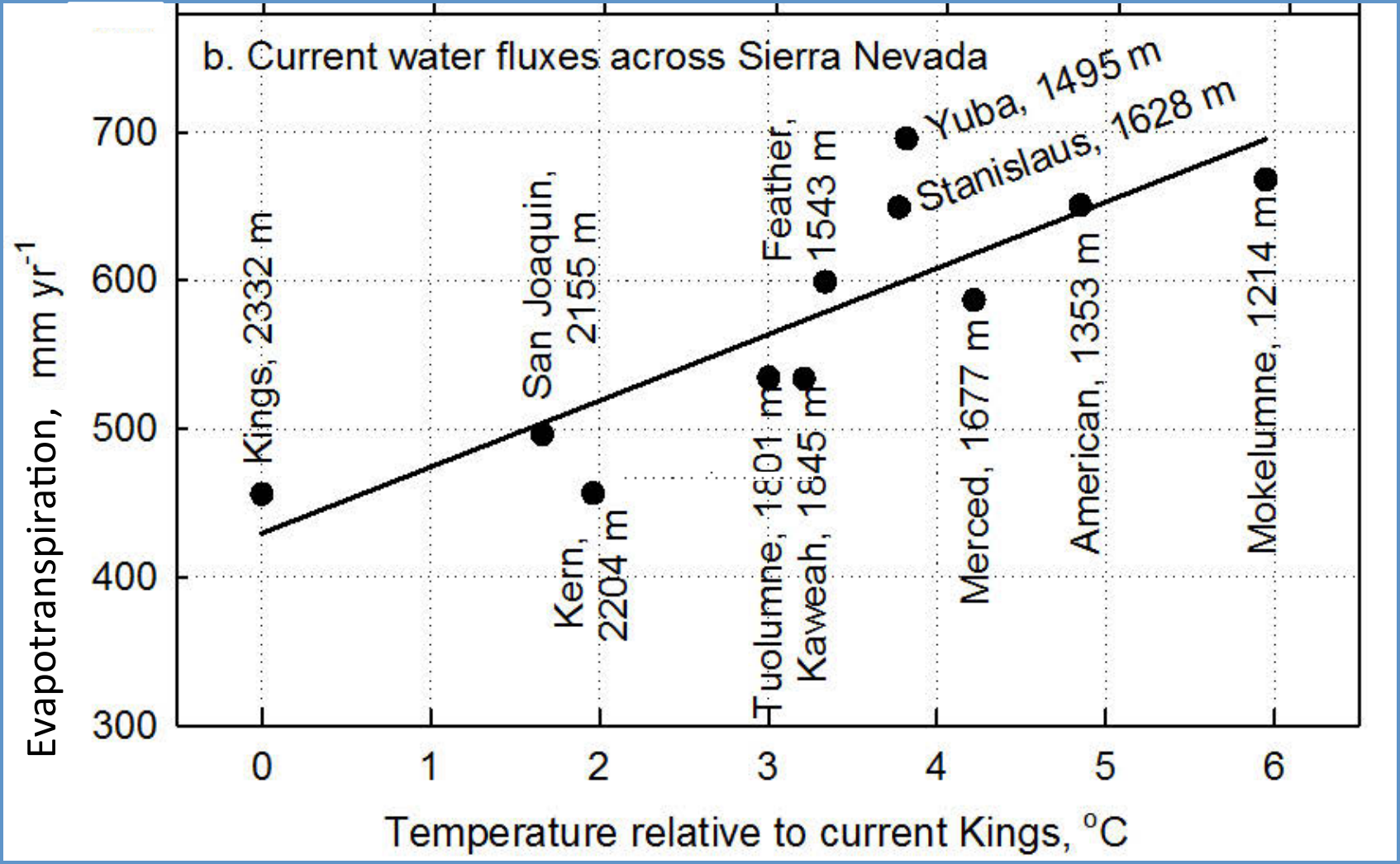
Goulden & Bales, 2014

Runoff declines w/ higher temperature



- Longer growing season w/ temp. increase → more ET
- Average: 14% drop in runoff per 2°C

Evapotranspiration is currently lower in colder basins



Goulden & Bales, 2014

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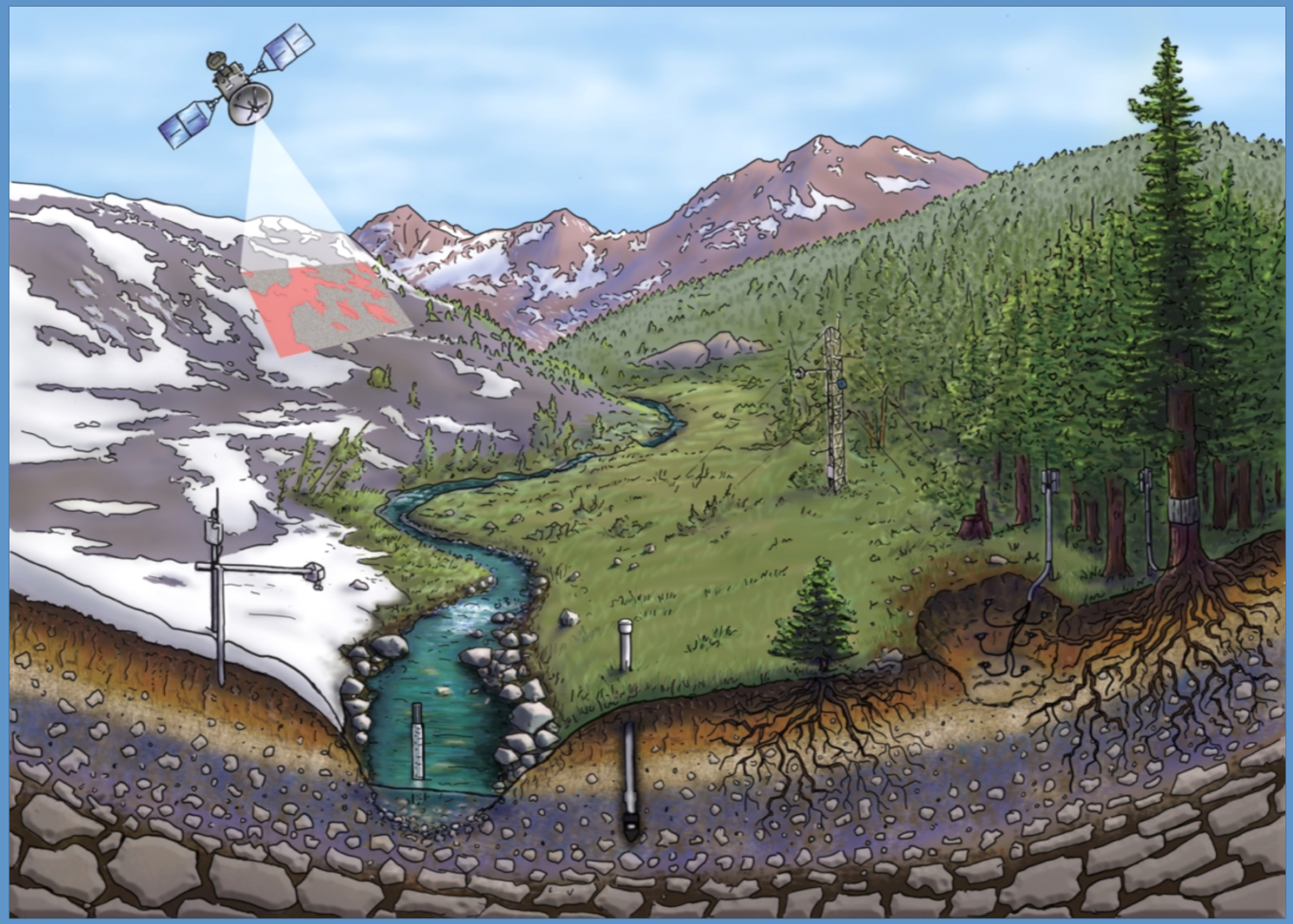

Some recurring questions around water & forests

1. How will the the post-fire water yield differ from before?
2. What will be the water yield w/ climate warming, vs. today?
3. What was the historical water yield prior to fire suppression?

Rim fire photos: J. Power & D. Buckley, USFS

Some background questions

1. How different were forests prior to fire suppression vs. today, pre-fire and post-fire?
2. Can we take forests back to pre-fire-suppression conditions?

E. Branch, N. Fork Feather R., 3400’

Photos from G. Gruell

Water & Sierra Nevada forests

What we know

1. Vegetation removal generally results in more runoff, initially

Water & Sierra Nevada forests

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2. Vegetation regrowth means less runoff

Water & Sierra Nevada forests

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Water & Sierra Nevada forests

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4. Less-dense forests (up to a point) can retain snow longer

Water & Sierra Nevada forests

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4. Less-dense forests (up to a point) can retain snow longer

5. Colder, snow-dominated areas produce more runoff than lower, rain-dominated areas

Forests and Water in the Sierra Nevada: Sierra Nevada Watershed Ecosystem Enhancement Project

Roger C. Bales, John J. Battles, Yihsu Chen, Martha H. Conklin, Eric Holst, Kevin L. O'Hara, Philip Saksa, William Stewart

November 7, 2011

Sierra Nevada Research Institute, UC Merced

Center for Forestry, UC Berkeley

Environmental Defense Fund

Forest-water scoping report

Three issues

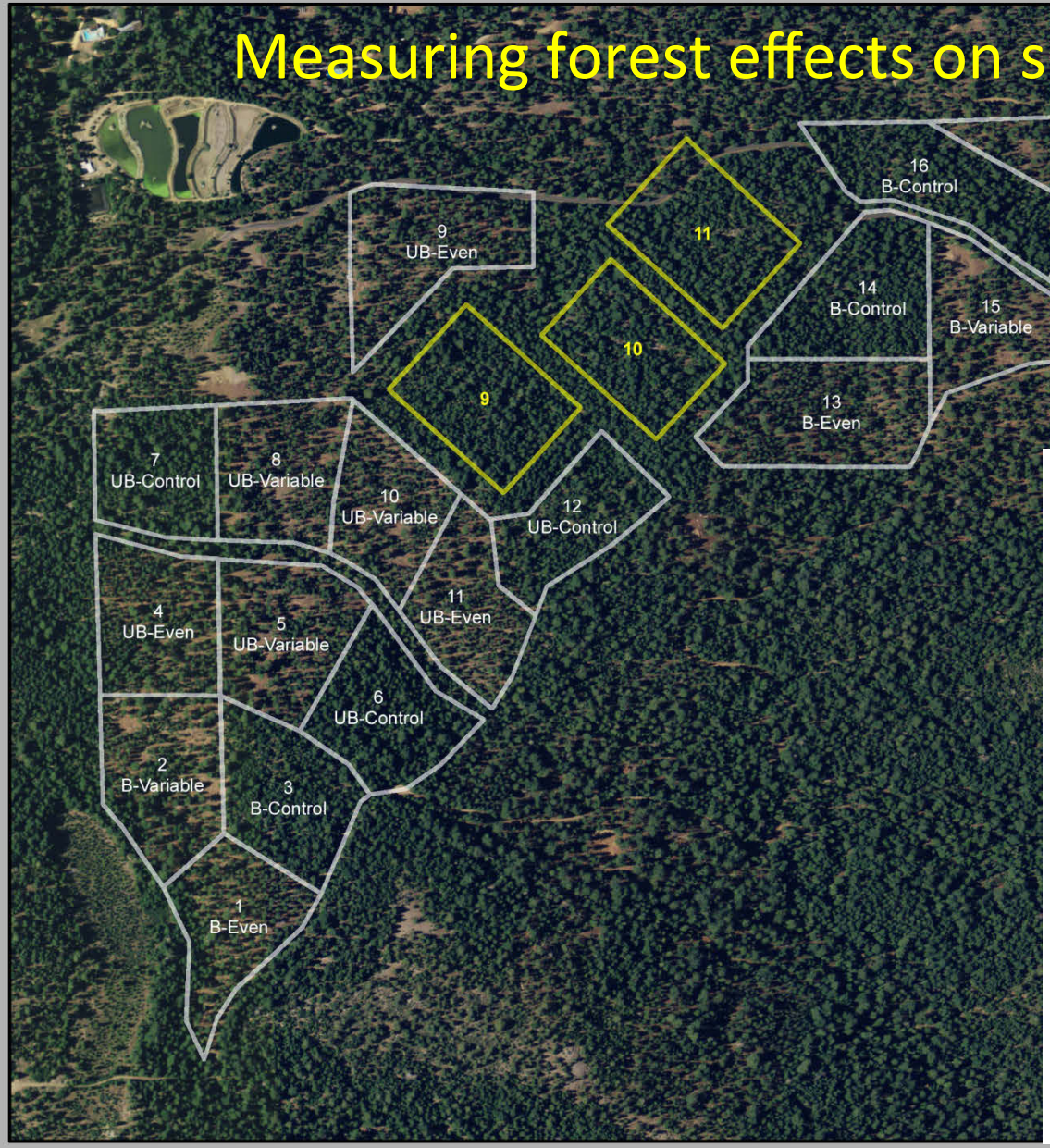
1. Water use by vegetation
2. Interception losses
3. Timing of snowmelt & runoff

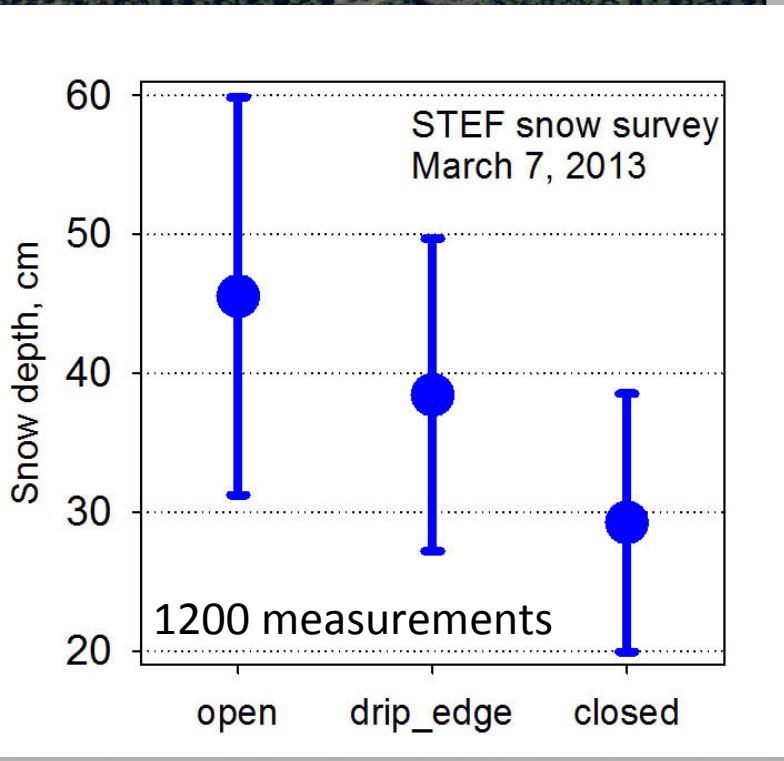
Also climate-warming context

Thinned unit w/ control in background

Stanislaus-Tuolumne Experimental Forest
Photo: Eric Knapp

Measuring forest effects on snow accumulation





Legend

Variable Density Thinning Units

1929 Methods Of Cutting Units

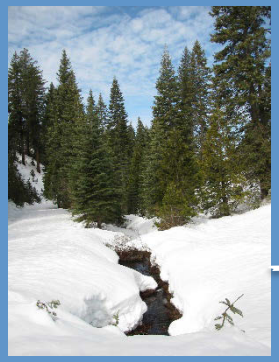
Stanislaus - Tuolumne Experimental Forest
Variable Density Thinning Study
Post-Harvest (2012)

0 50 100 200 300 400 500 Meters

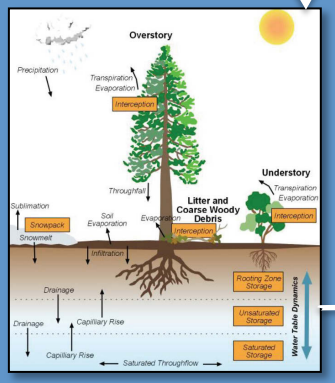
N

Pacific Southwest Research Station

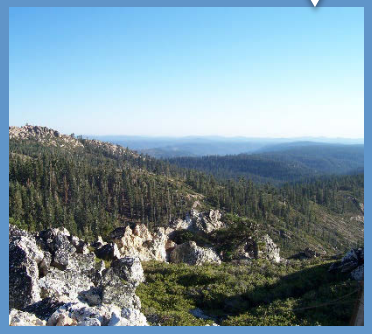
SNAMP water-team approach



1. Measure water-balance: response to forest treatments

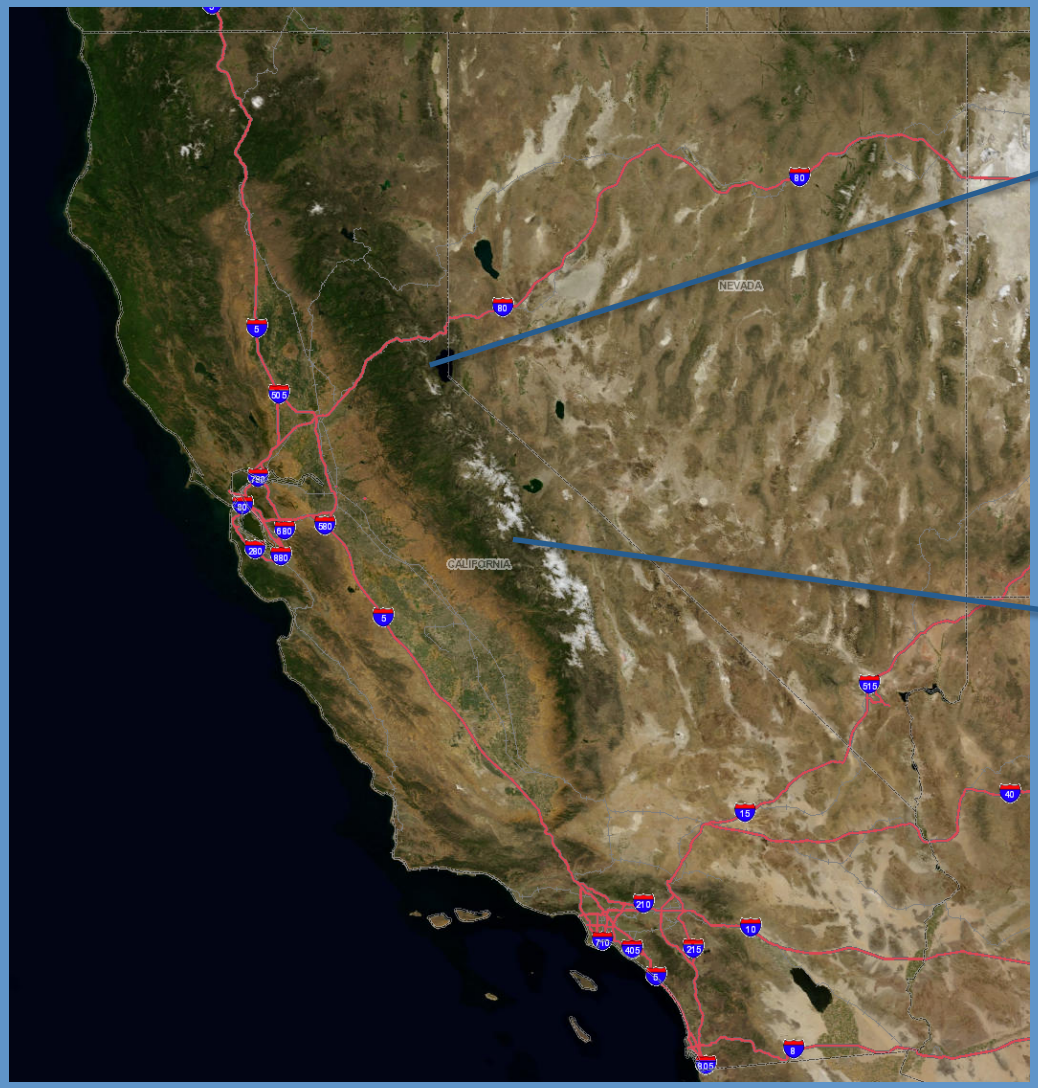


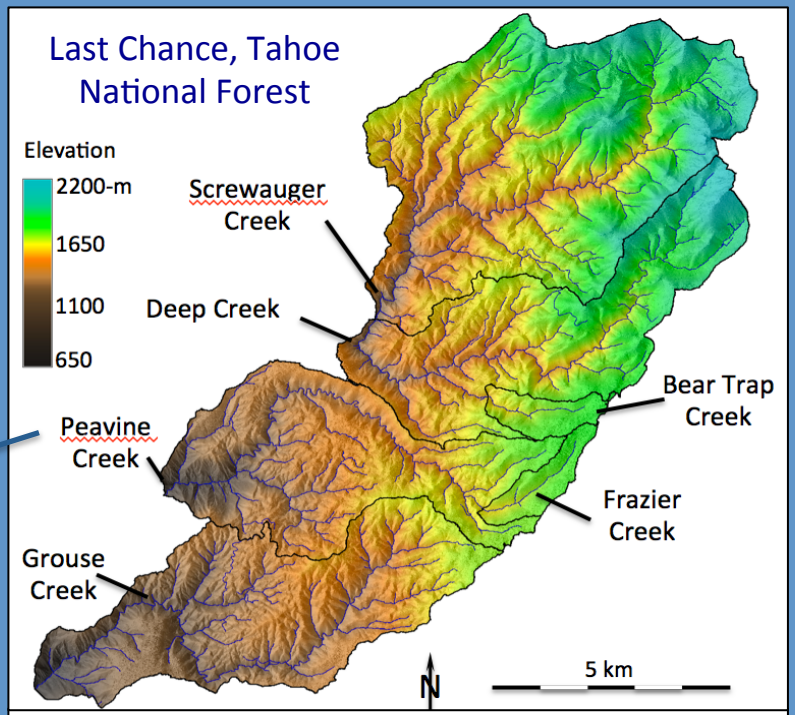
2. Model headwater processes: control, treatment & projected forest density

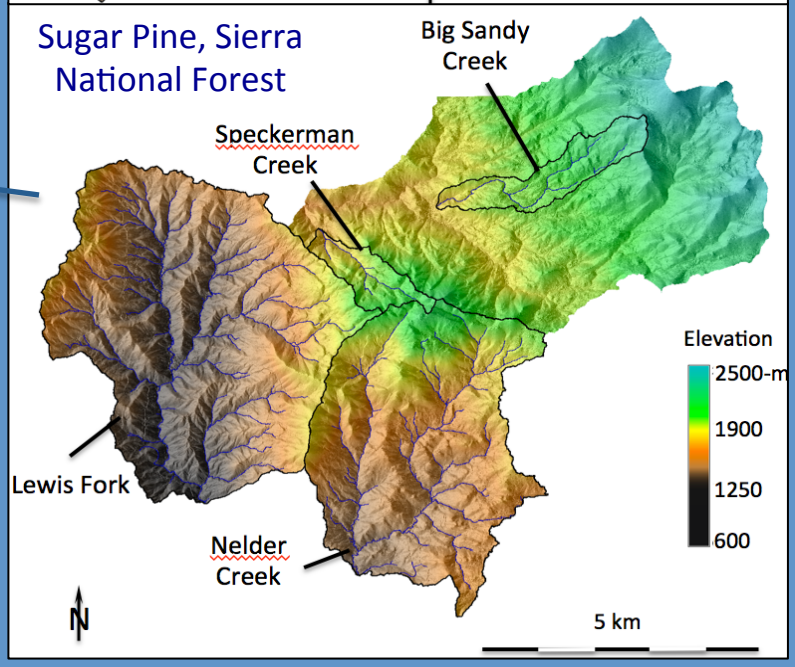


3. Transfer to large watersheds

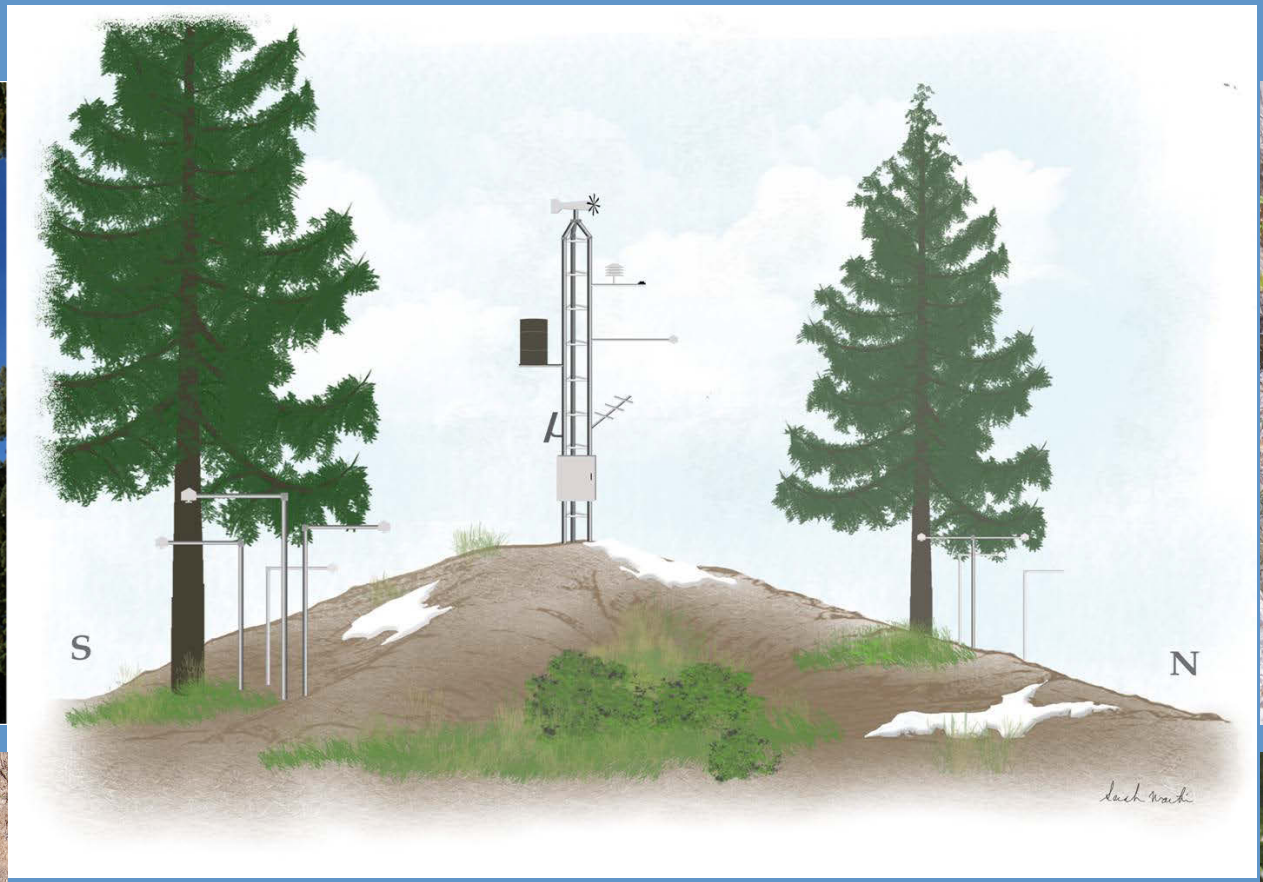
SNAMP study sites

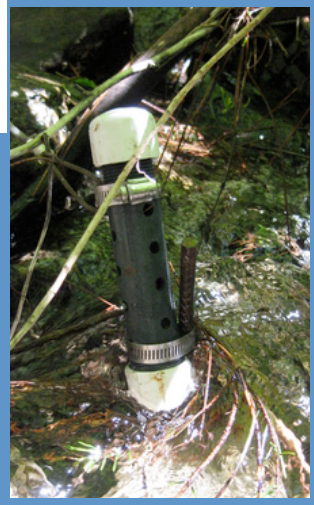






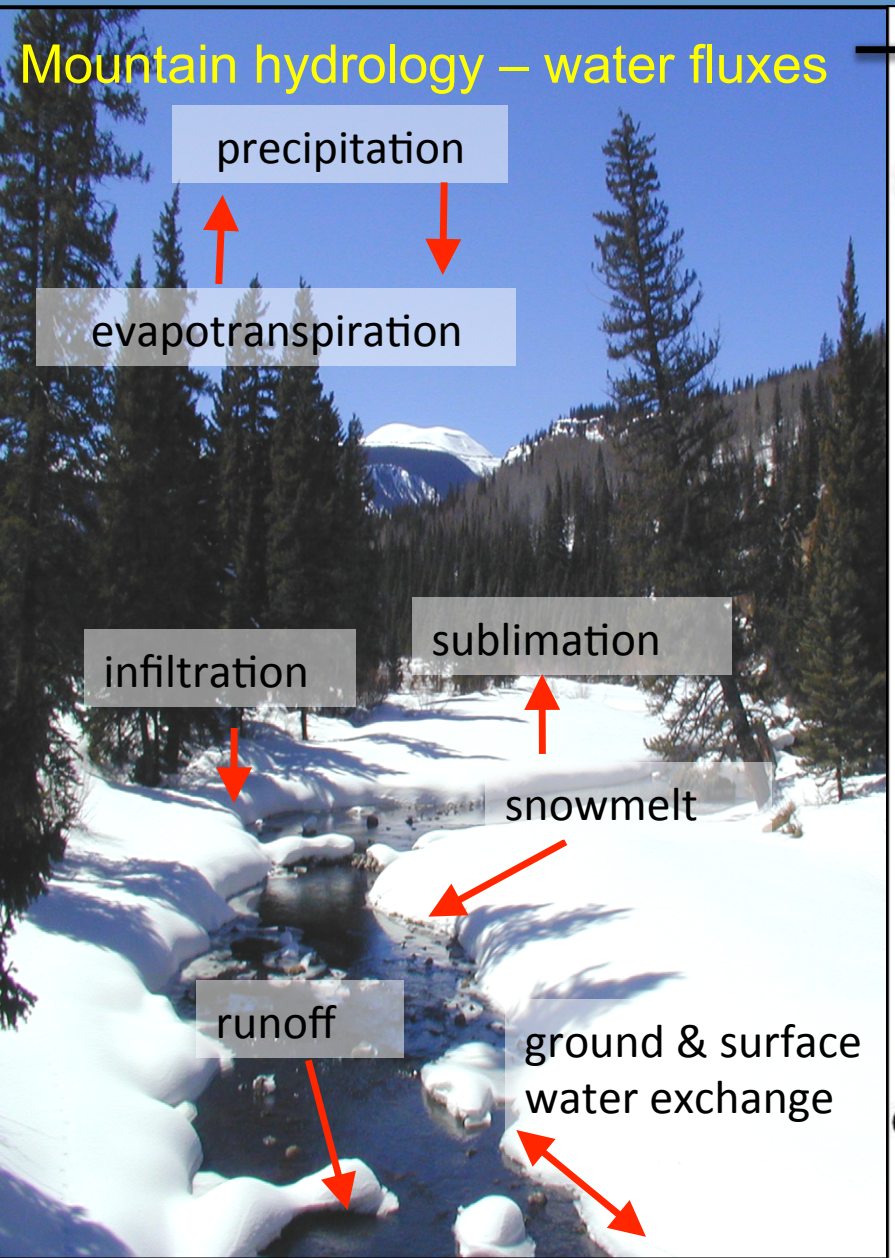
Field methods

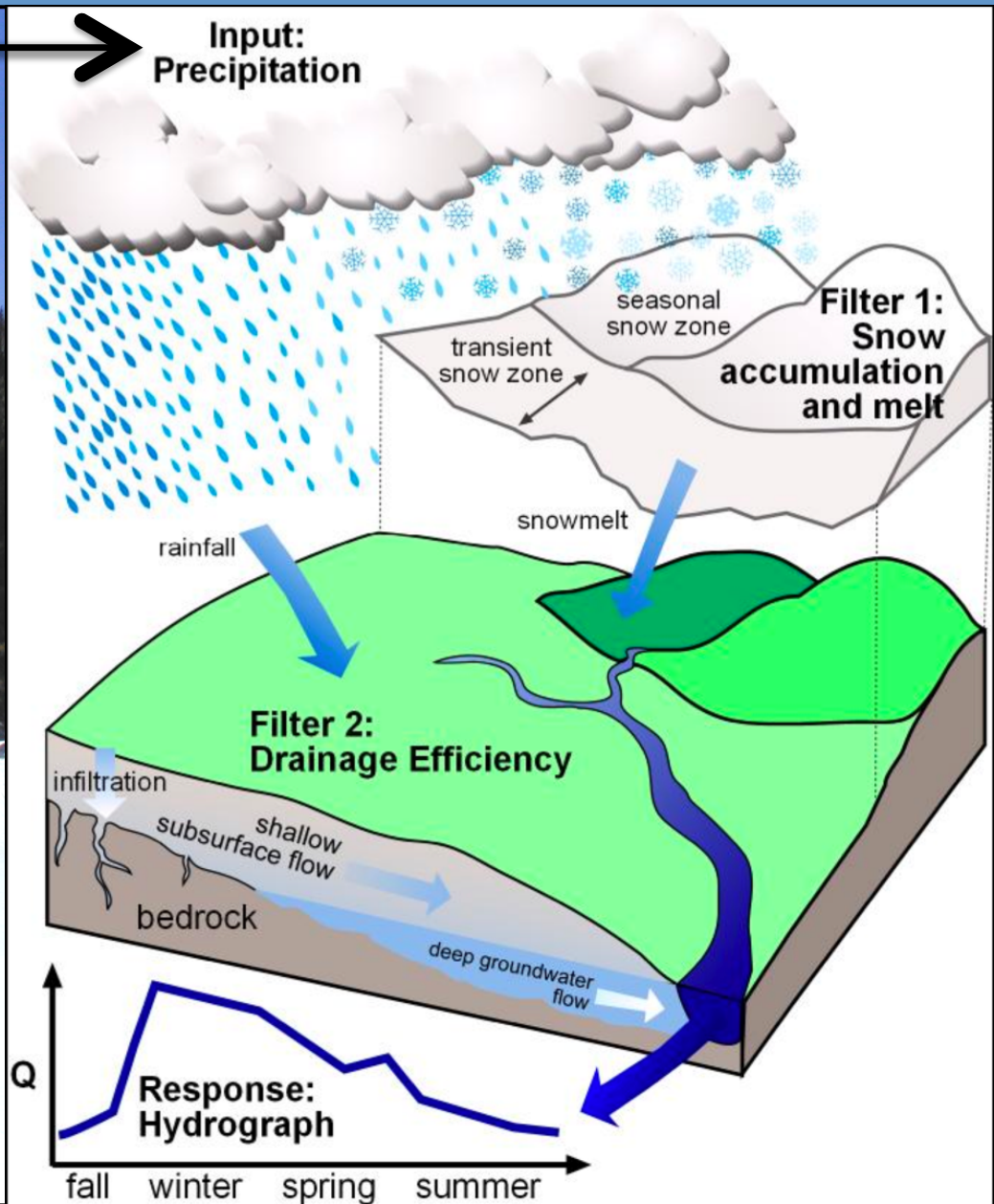




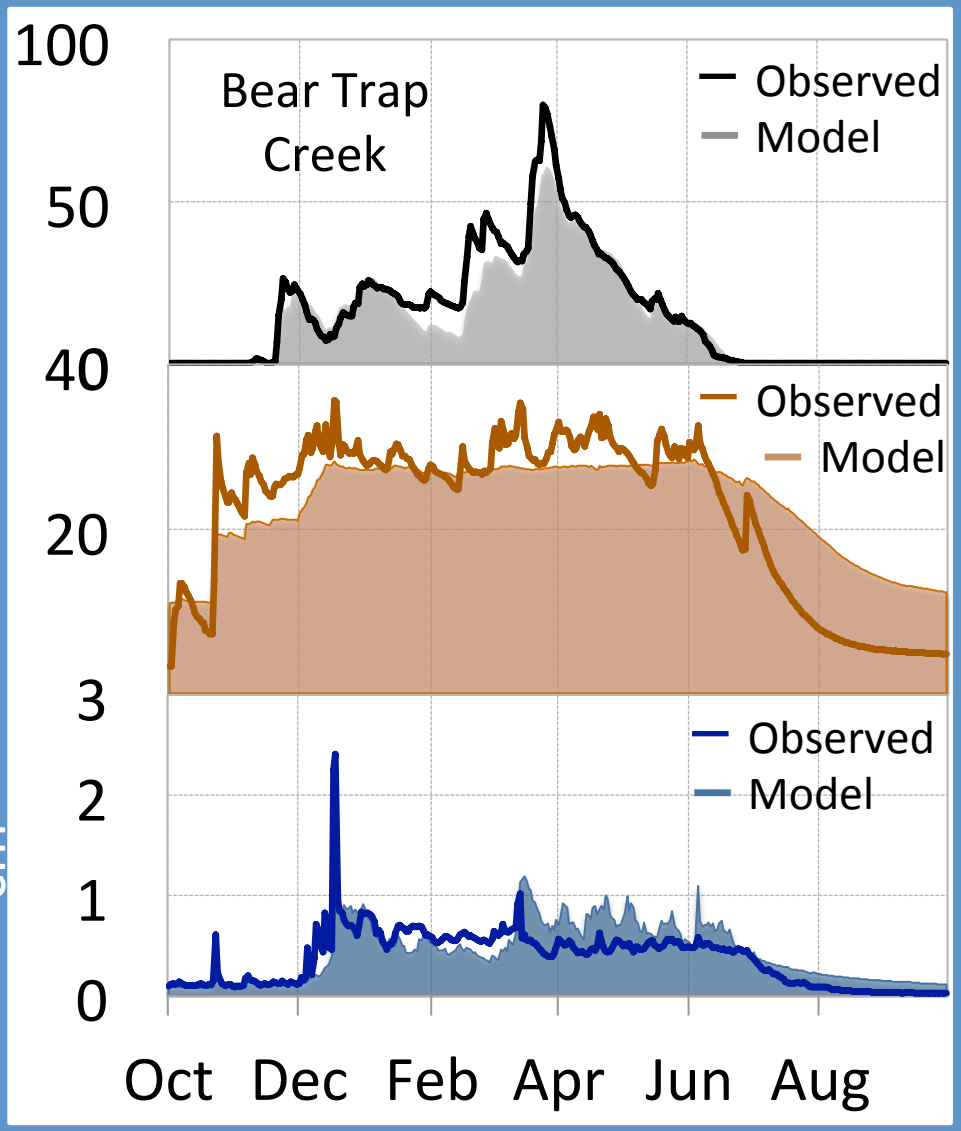
- Upper, lower elevation met stations (4)
- North, south facing sensor nodes: snow depth (62), soil moisture (164), temperature

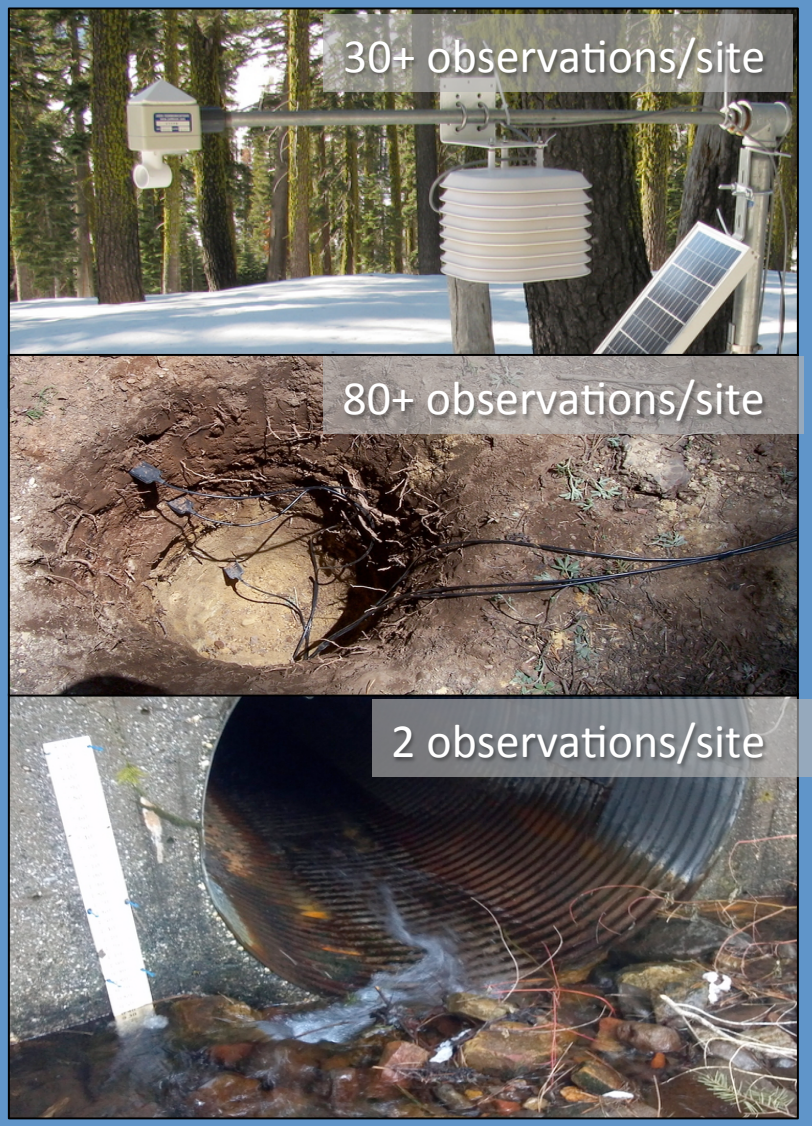
Regional Hydro-Ecological Simulation System (RHESSys)





Headwater model - calibration



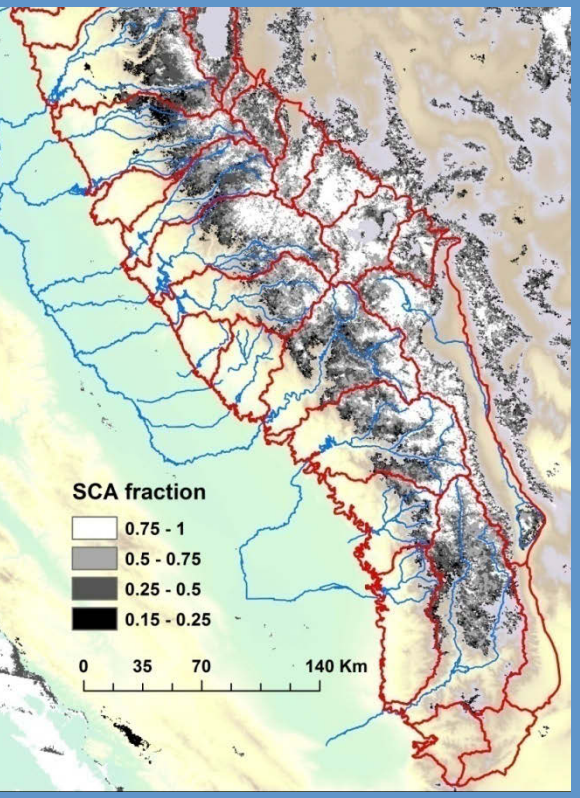


Water Year Day 2011

Work in progress – Phil Saksa

SNAMP Modeling – in progress

Precipitation	=	ET	+	Runoff
190 cm (75 in)	=	65%	+	35%



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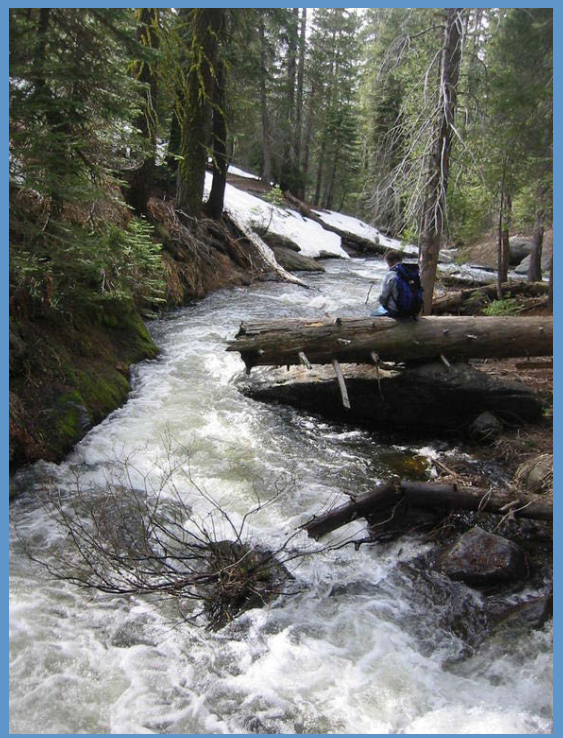

Average Precipitation Year (2010)

Bear Trap Catchment, Tahoe NF

SNAMP Modeling – in progress

Precipitation	=	ET	+	Runoff
190 cm (75 in)	=	65%	+	35%

Restoration Thinning
(remove 55% vegetation)

190 cm (75 in)	=	56%	+	44%

Average Precipitation Year (2010)

Bear Trap Catchment, Tahoe NF

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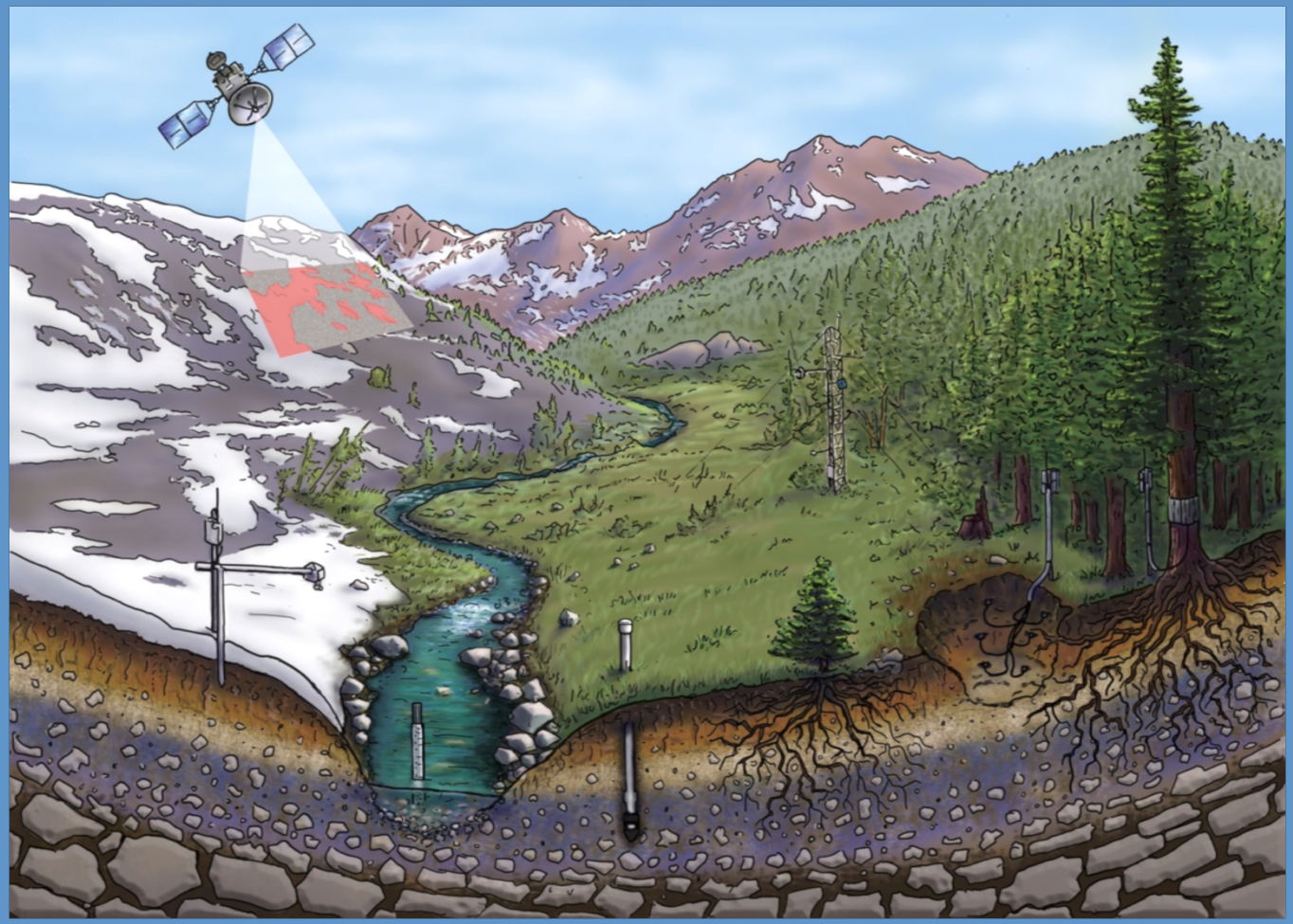
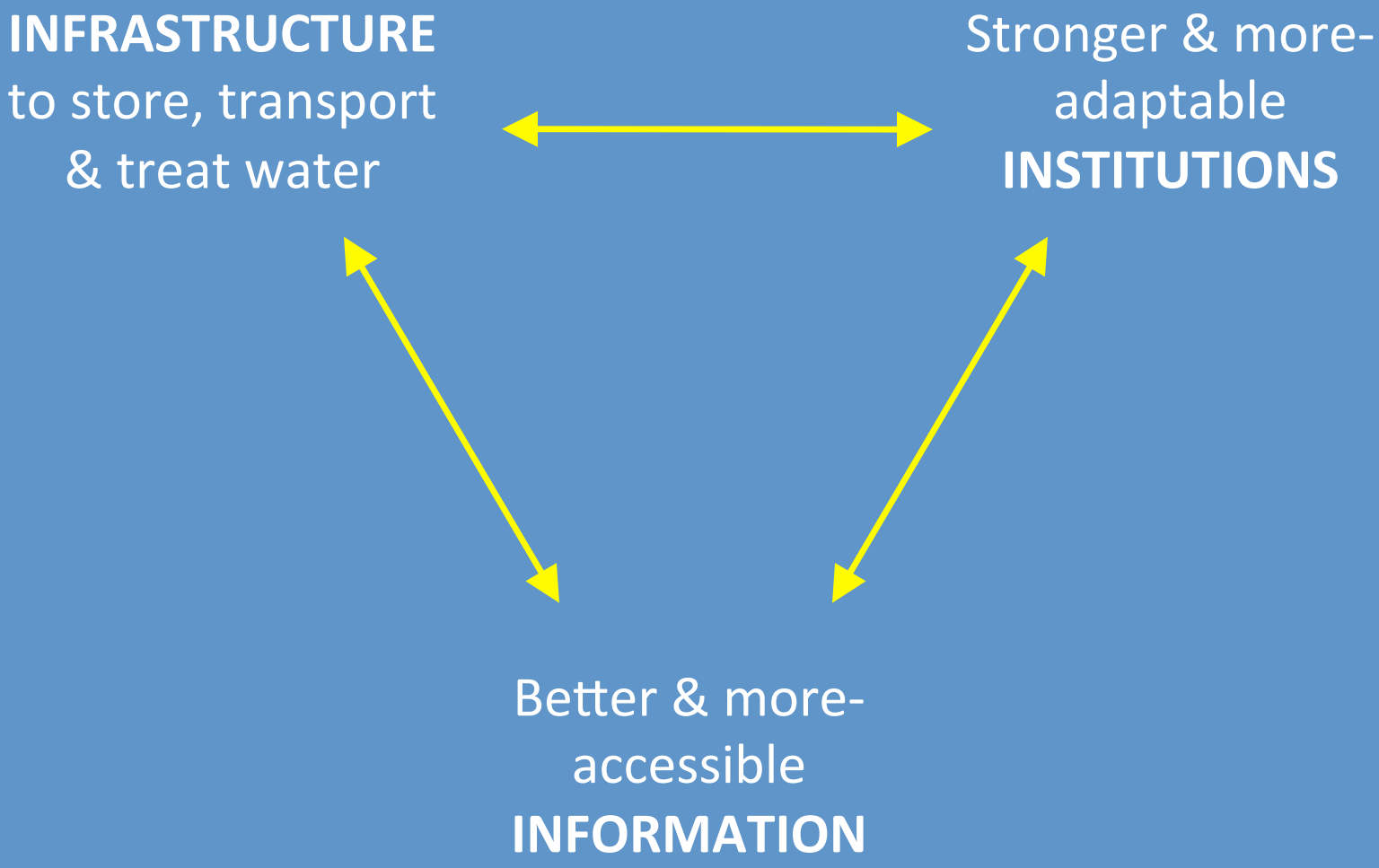


Making a water-secure world – the three I's

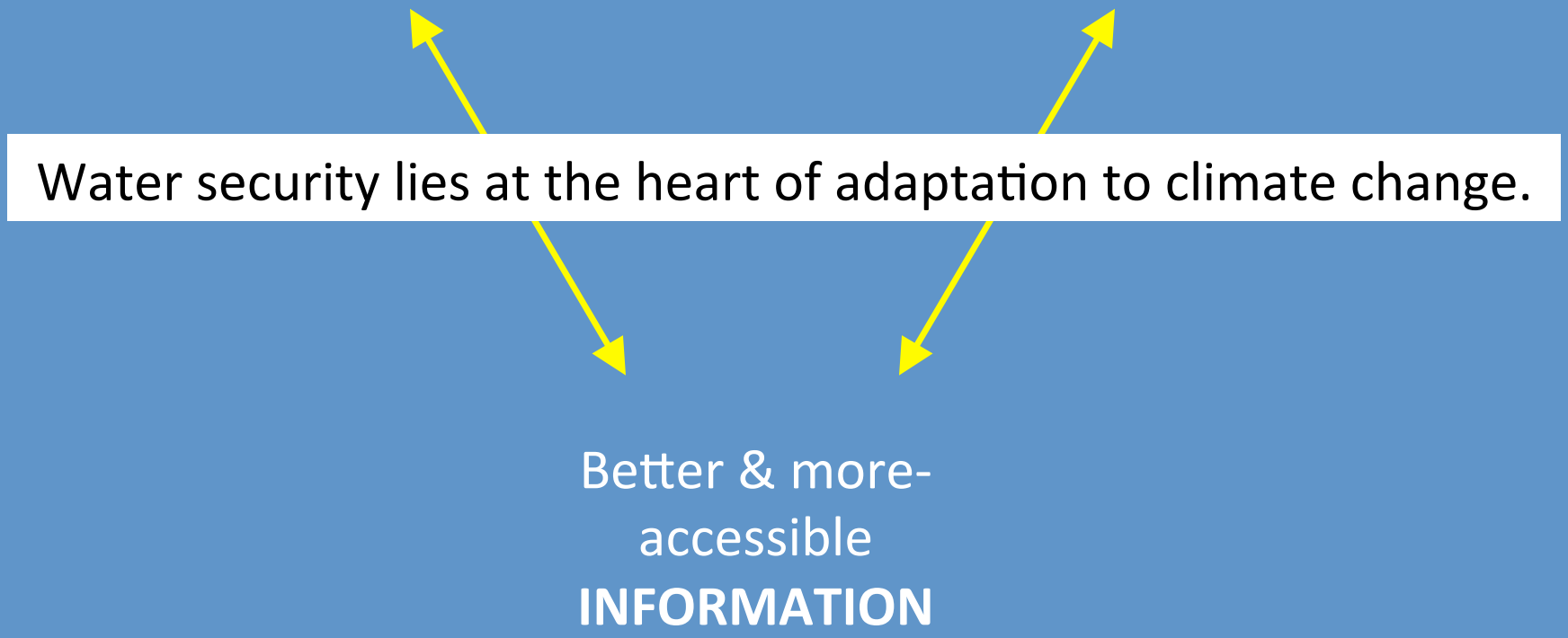


Water security: the reliable availability of an acceptable quantity & quality of water for health, livelihoods & production, coupled w/ an acceptable level of water-related risks

Making a water-secure world – the three I's

INFRASTRUCTURE
to store, transport
& treat water

Stronger & more-
adaptable
INSTITUTIONS



Water security lies at the heart of adaptation to climate change.

Better & more-
accessible
INFORMATION

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

Envisioning a new water information system for California

Example – seasonal forecasts – uncertainty can be high

- Mainly monthly, manual measurements
- Few automated, but non-representative measurements
- Statistical forecasts, vs. hydrologic models

New, mature technology available now: blending data from satellites, aircraft, low-cost wireless sensor networks, advanced modeling tools

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New, mature technology available now: blending data from satellites, aircraft, low-cost wireless sensor networks, advanced modeling tools

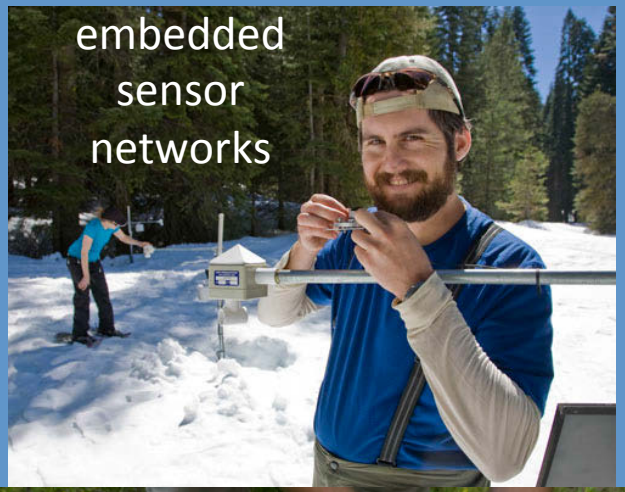
American R. basin hydrologic observatory (in progress)

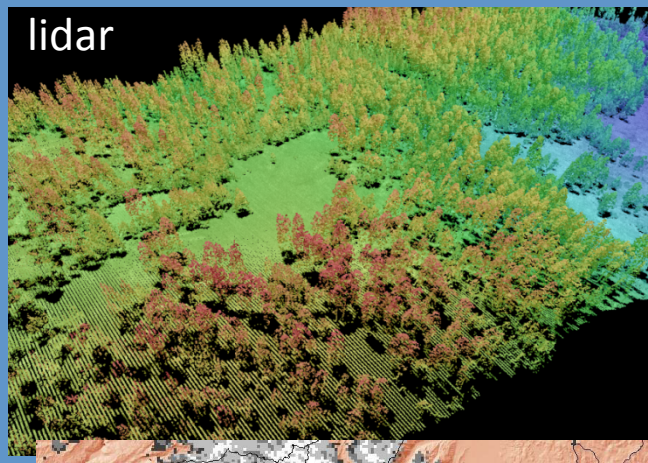
- Platform for research & core element of new water information system
- Strategically place low-cost sensors to get spatial estimates of snowcover, soil moisture & other water-balance components

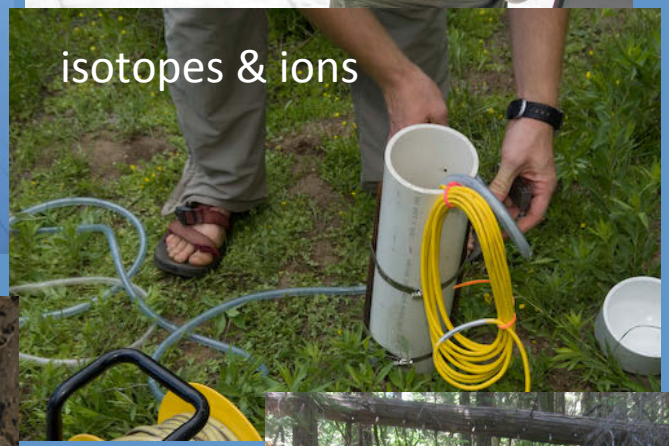
Integrate these sensors with remotely sensed data, forecasting tools & decision support

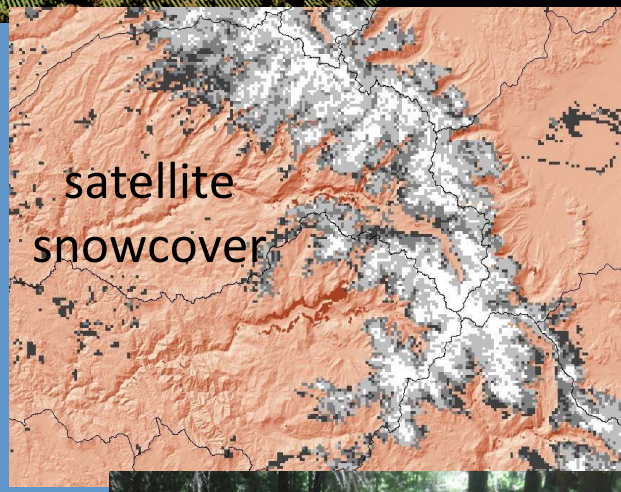
Node construction at Alpha site

A new generation of integrated measurements

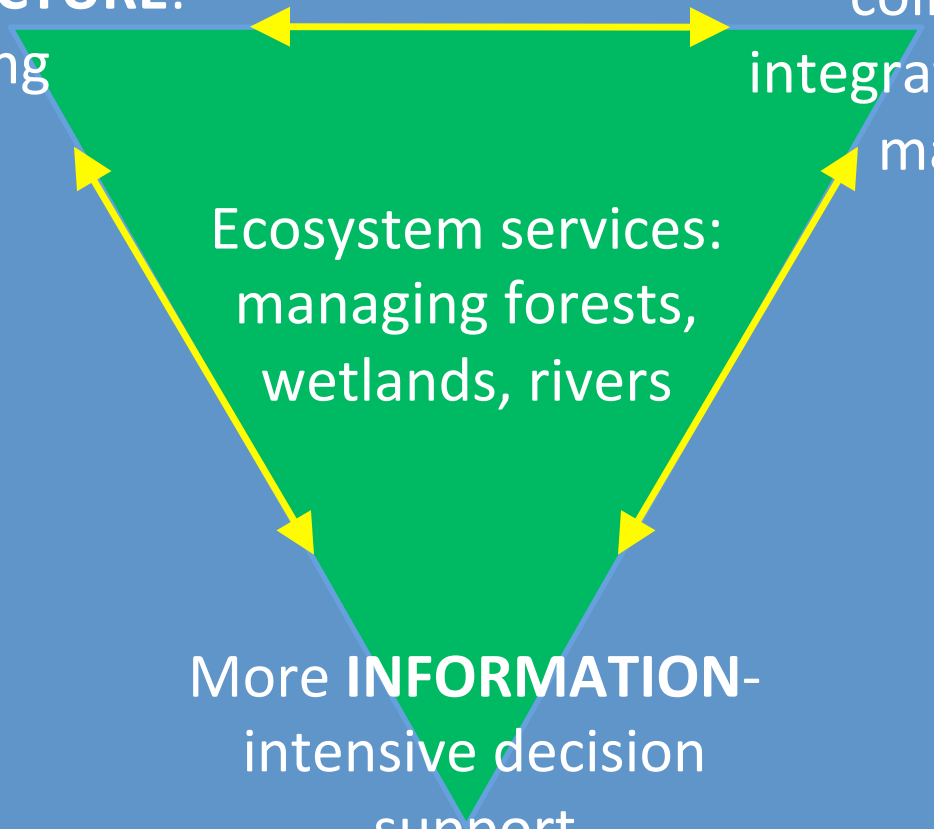








Making a water-secure California



Water management translates into managing ecosystem services. Adapting to climate change also means managing ecosystem services.

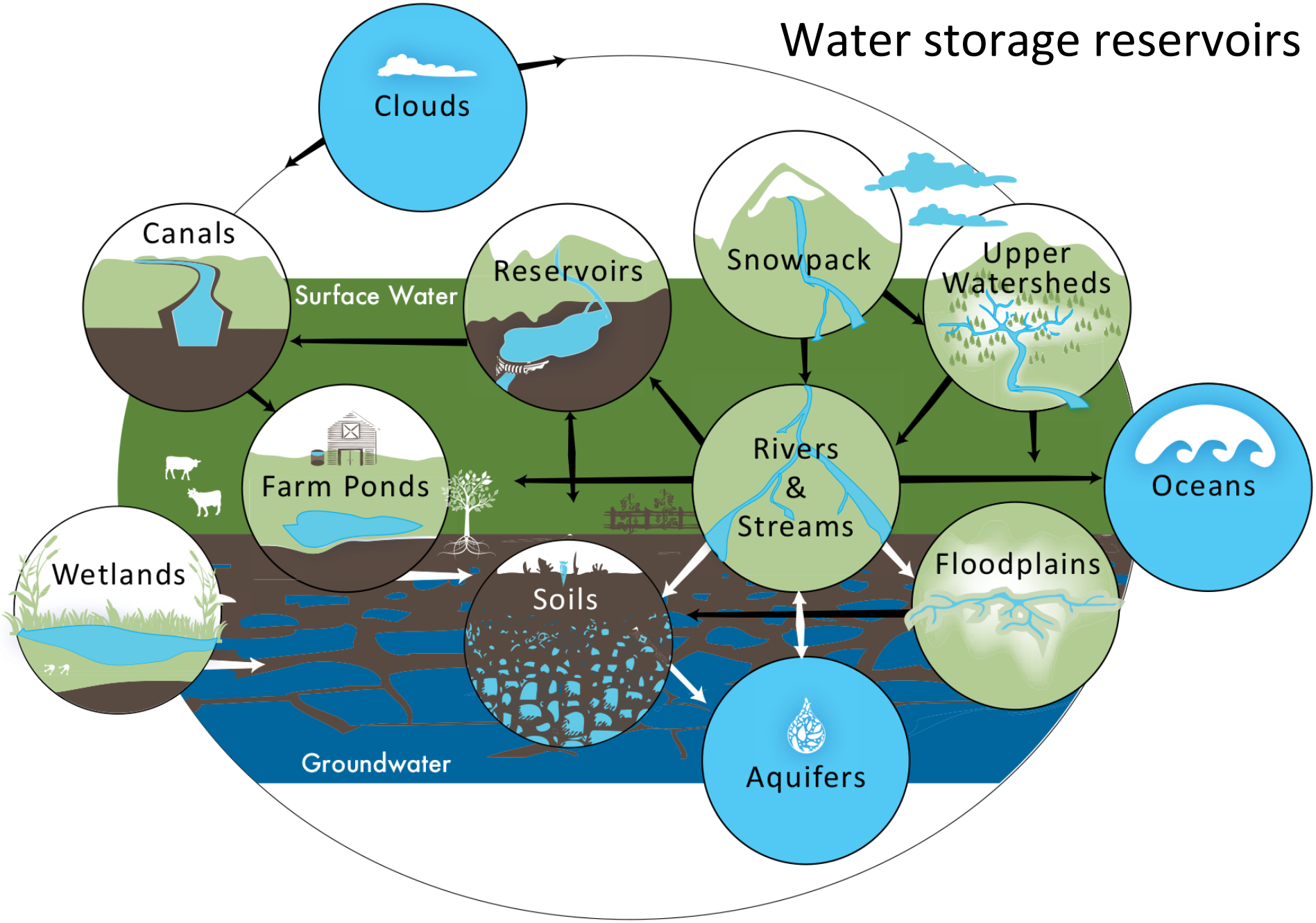
ACWA Policy Principles on Improved Management of California's Headwaters

"… managing California's headwaters is integral to optimizing … water supplies … Increasing water yield and quality; reducing the risk and impacts of catastrophic wildfire; and enhancing natural features and functions; are all benefits to be derived, locally and statewide, from improved headwaters stewardship. Enhancing the resiliency and adaptability of headwaters is overdue.

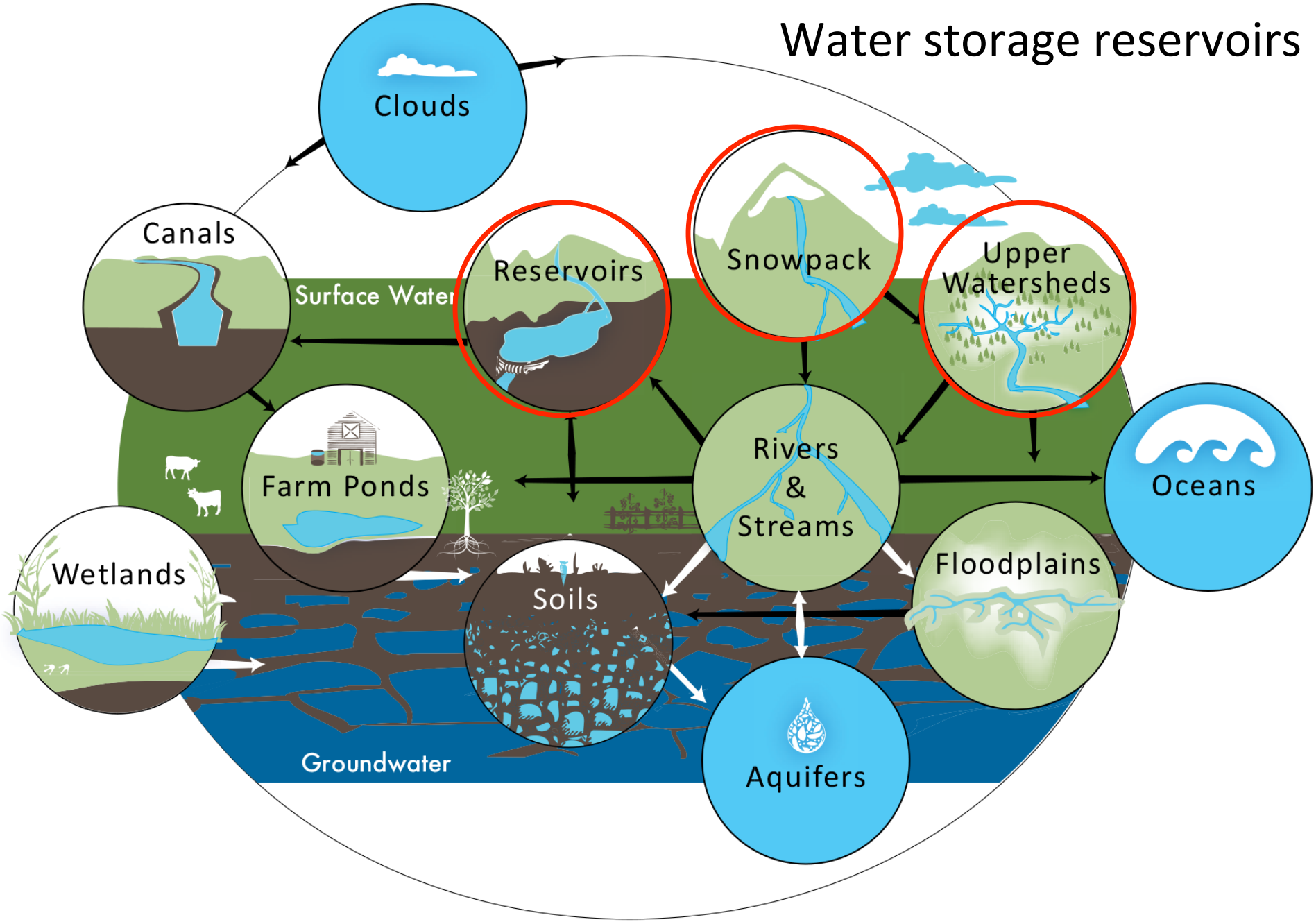
California can no longer afford to relegate management of its headwaters to the margin."

Association of California Water Agencies
Since 1910
Leadership • Advocacy • Information • Service

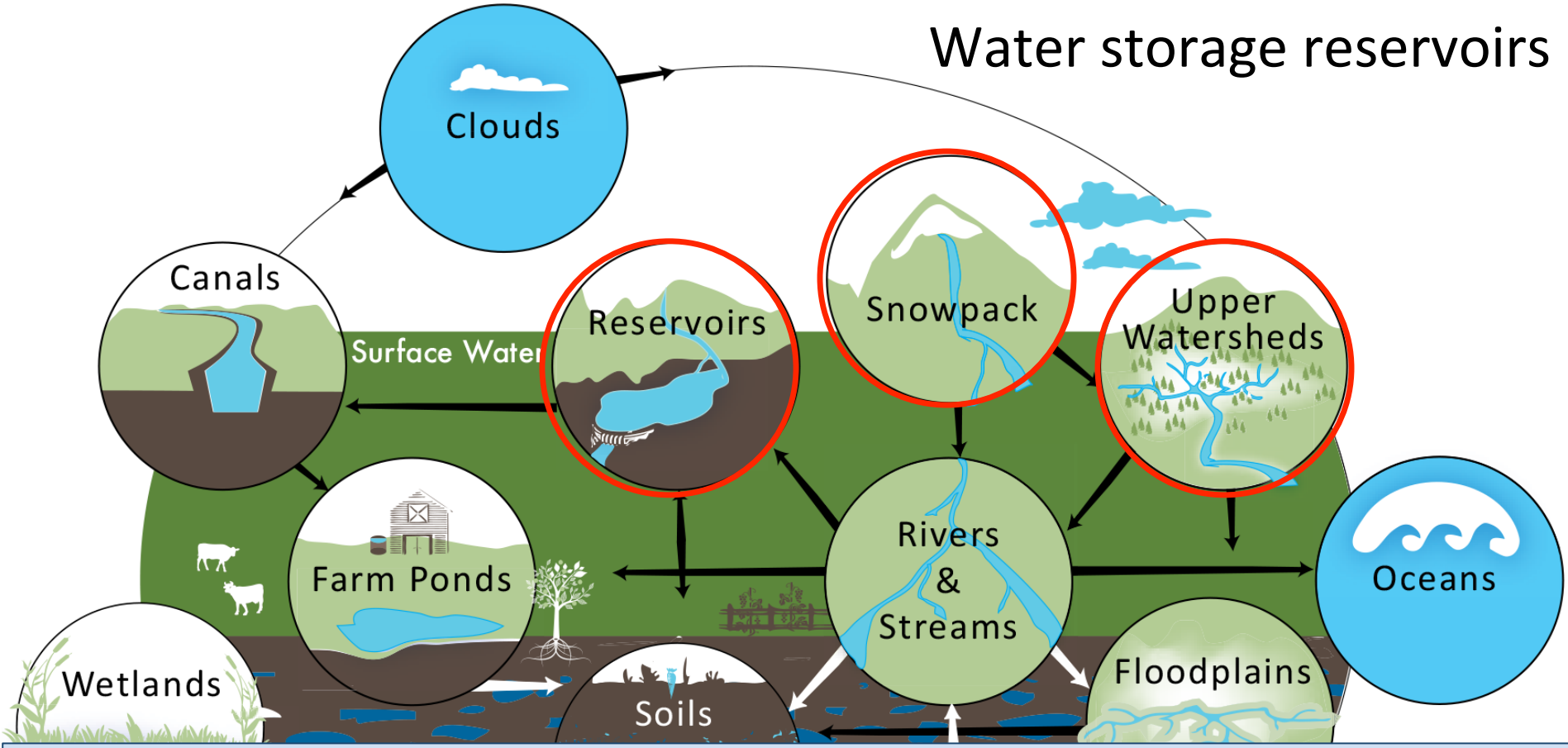
Water storage reservoirs



Water storage reservoirs

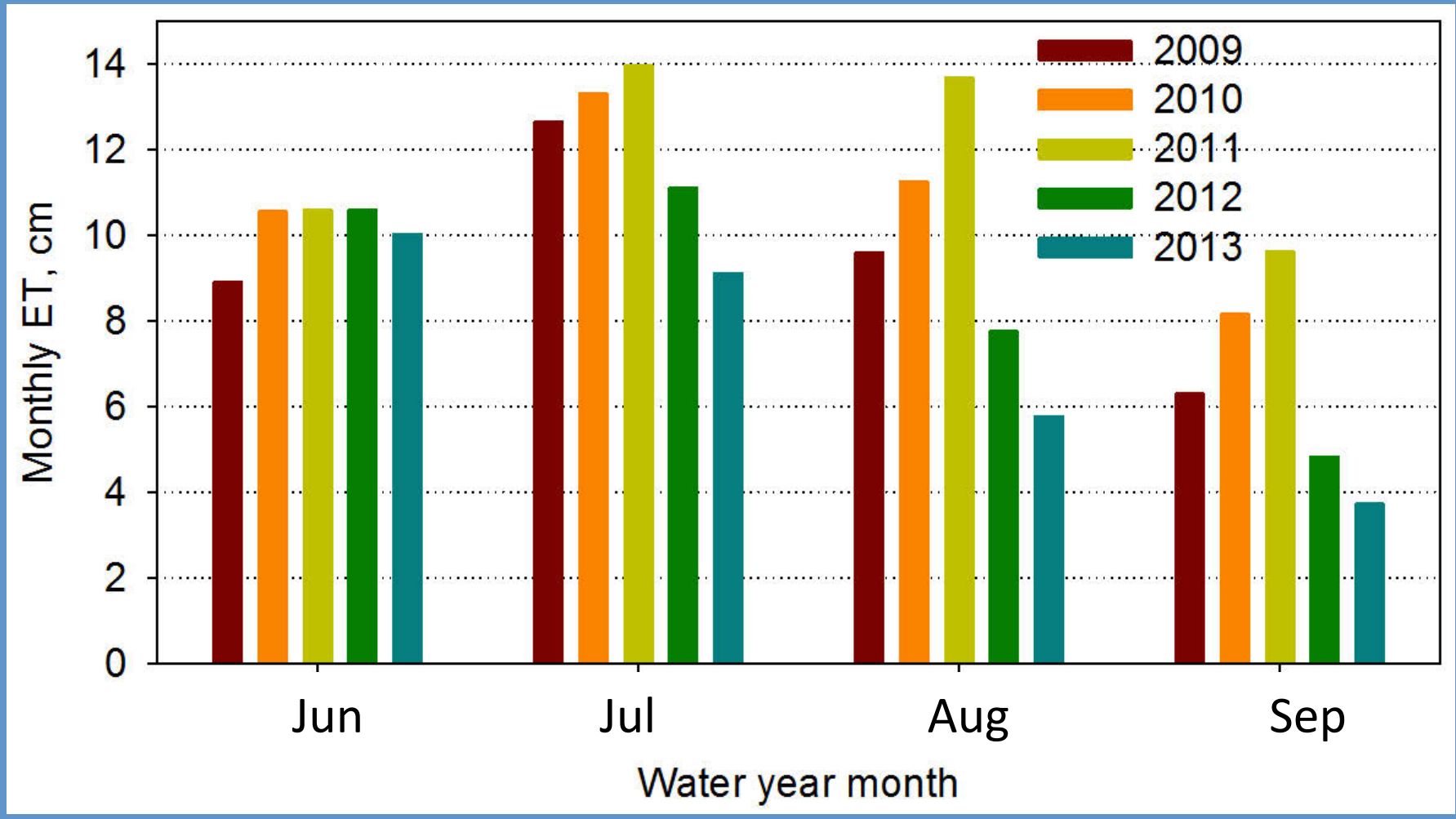


Water storage reservoirs



Comprehensive, timely, accurate, accessible, and transparent data and resulting information about our water resources is an essential foundation for effectively managing water storage in California.

Monthly dry season evapotranspiration at mixed conifer site (Providence Creek) – drought effects



R Bales, paper in progress

Concluding Points

1. High ET across a wide swath of mixed conifer forest

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2. Low water yield in rain zone, much higher in snow dominated

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2. Low water yield in rain zone, much higher in snow dominated

3. Sustained forest management can provide measurable benefits for water supply – will require both investment & verification

4. Better information is critical for water management, especially in a warming & more-variable climate

Acknowledgements

NSF Critical Zone Observatory (CZO) program, Sierra Nevada Adaptive Management Project, California DWR, U.S. Forest Service, UC-CITRIS, many collaborators

For more information see:
criticalzone.org/sierra
or email:
psaksa@ucmerced.edu
rbales@ucmerced.edu

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SIERRA NEVADA RESEARCH INSTITUTE