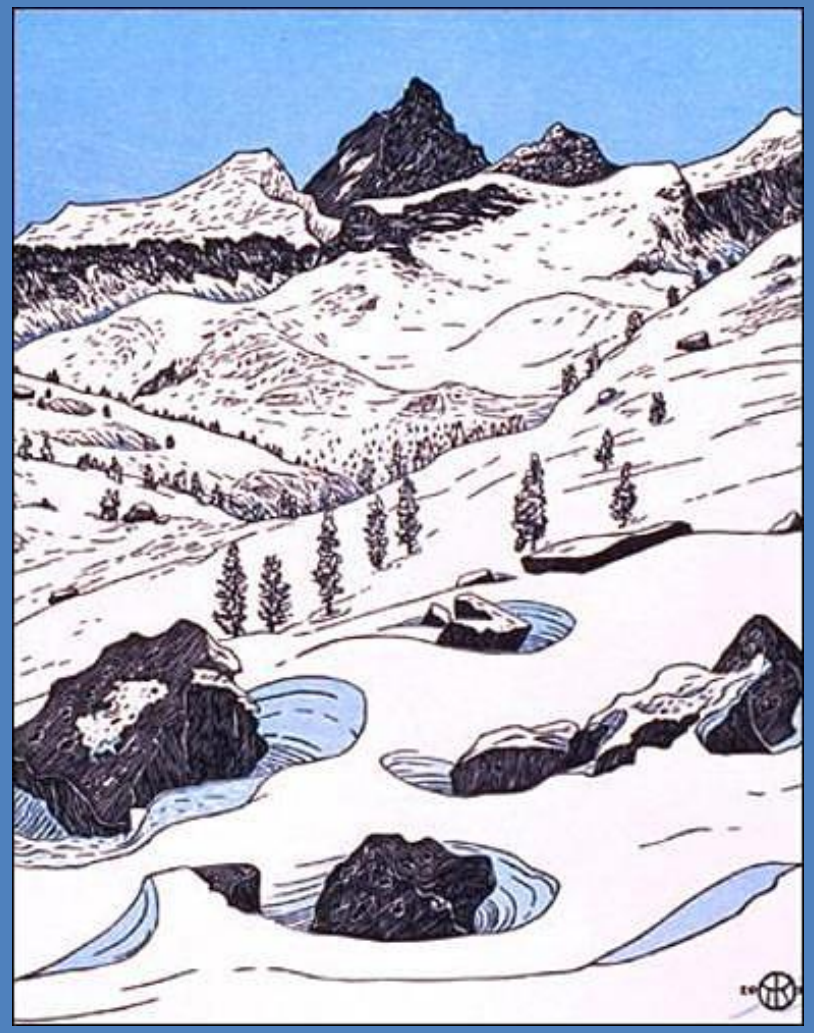
Forests, Water, Climate, and Disturbance in the Sierra Nevada

Phil Saksa, Sierra Nevada Research Institute, UC Merced



Junction Peak, copyright Tom Killion

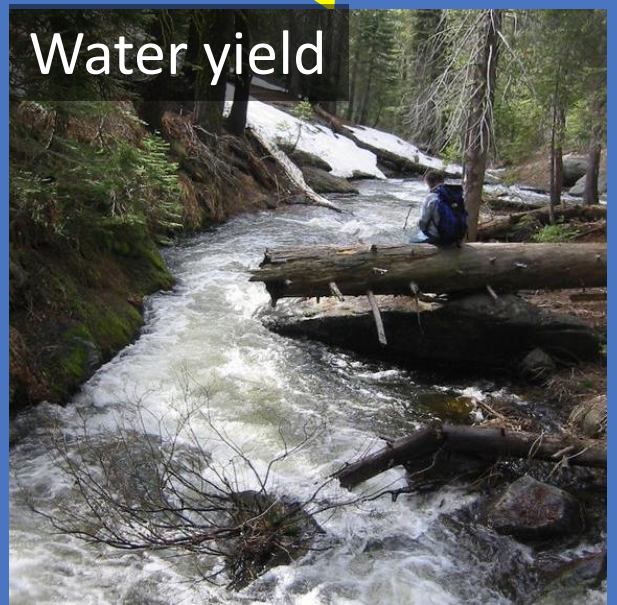
- Issues to consider
- What we know vs. knowledge gaps
- Next steps

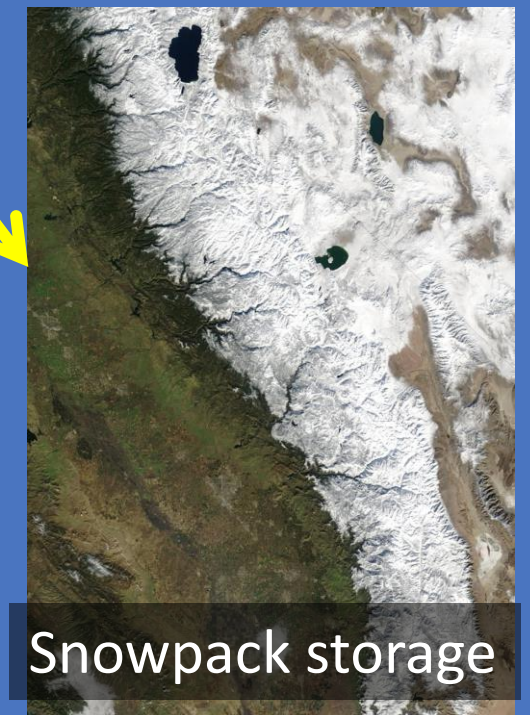
Recurring questions around water yield & forests

1. What will be the water yield w/ climate warming, vs. today?
2. How does wildfire affect water yield?
3. What was the historical water yield prior to fire suppression?

Photos: J. Power & D. Buckley, USFS

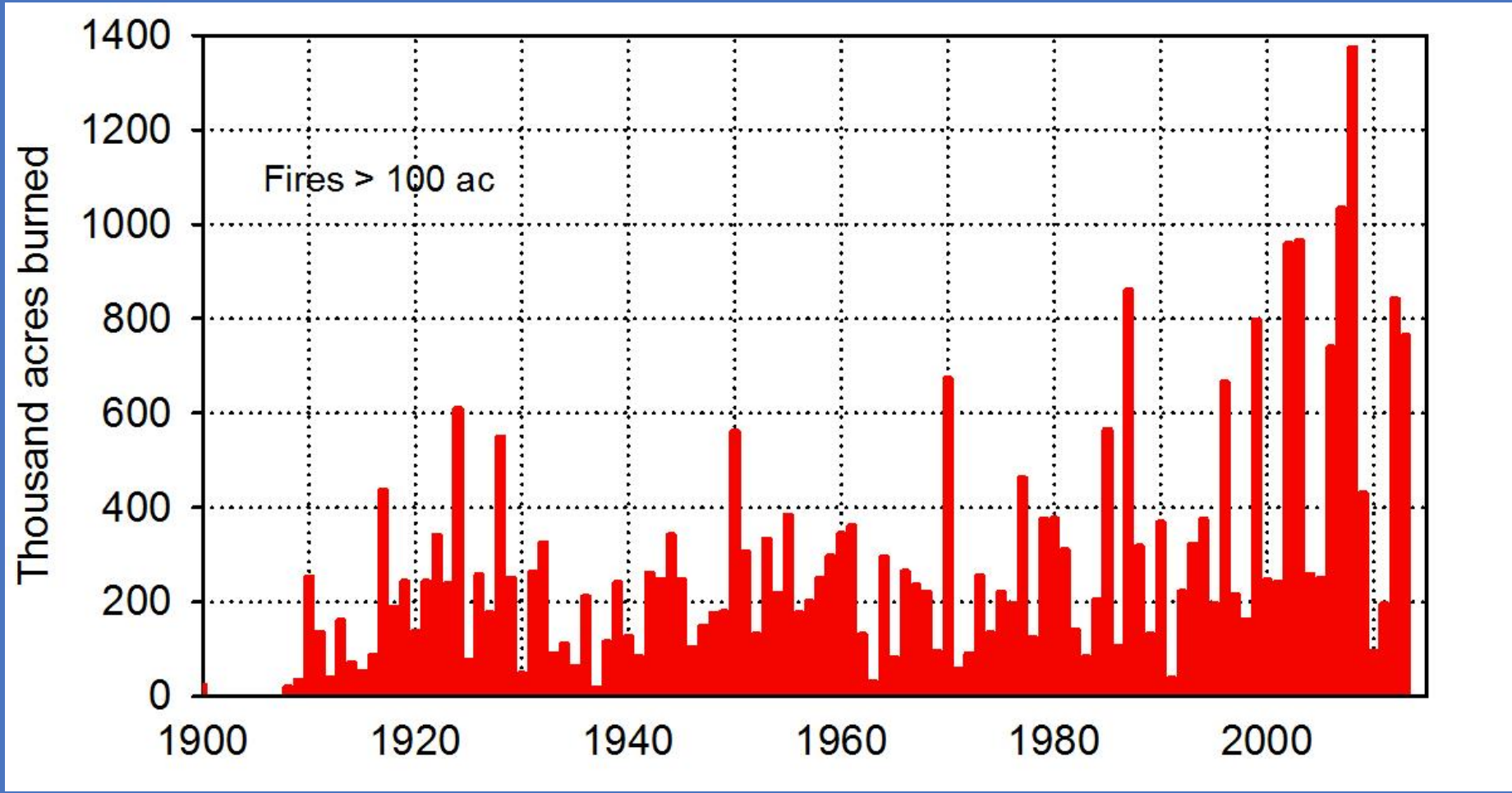
Issues to consider





Wildfire – area burned per year

Given dense forests & climate warming, we expect future years to follow an increasing trend



Area burned has implications for water & other ecosystem services

2. Water & forest management

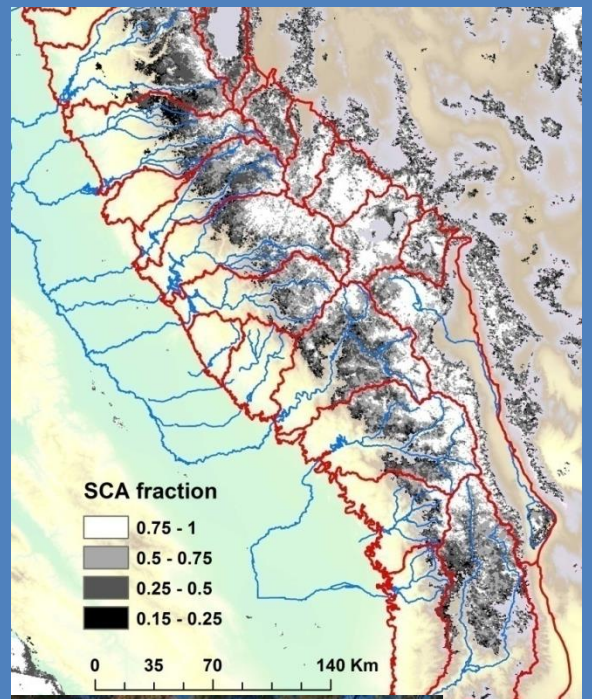
Some background questions

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

Basic water balance



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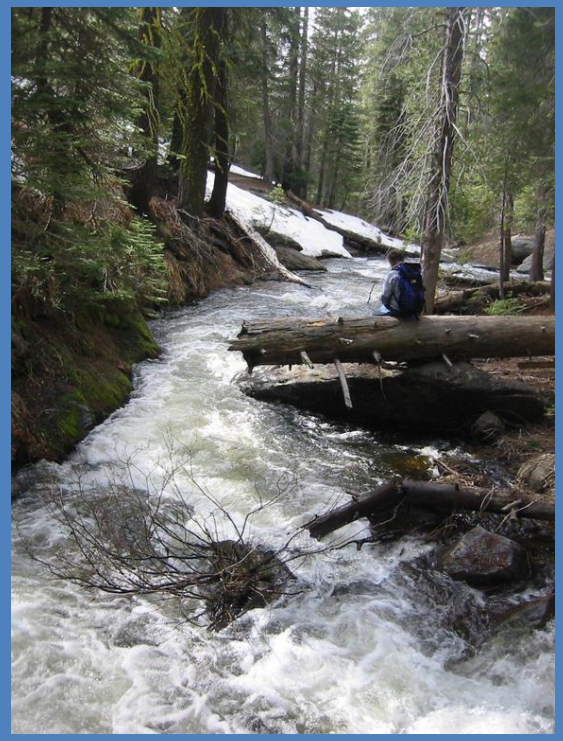


Precipitation = Evapotranspiration + Runoff

(Evapotranspiration is mainly water use by vegetation)

Evapotranspiration

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

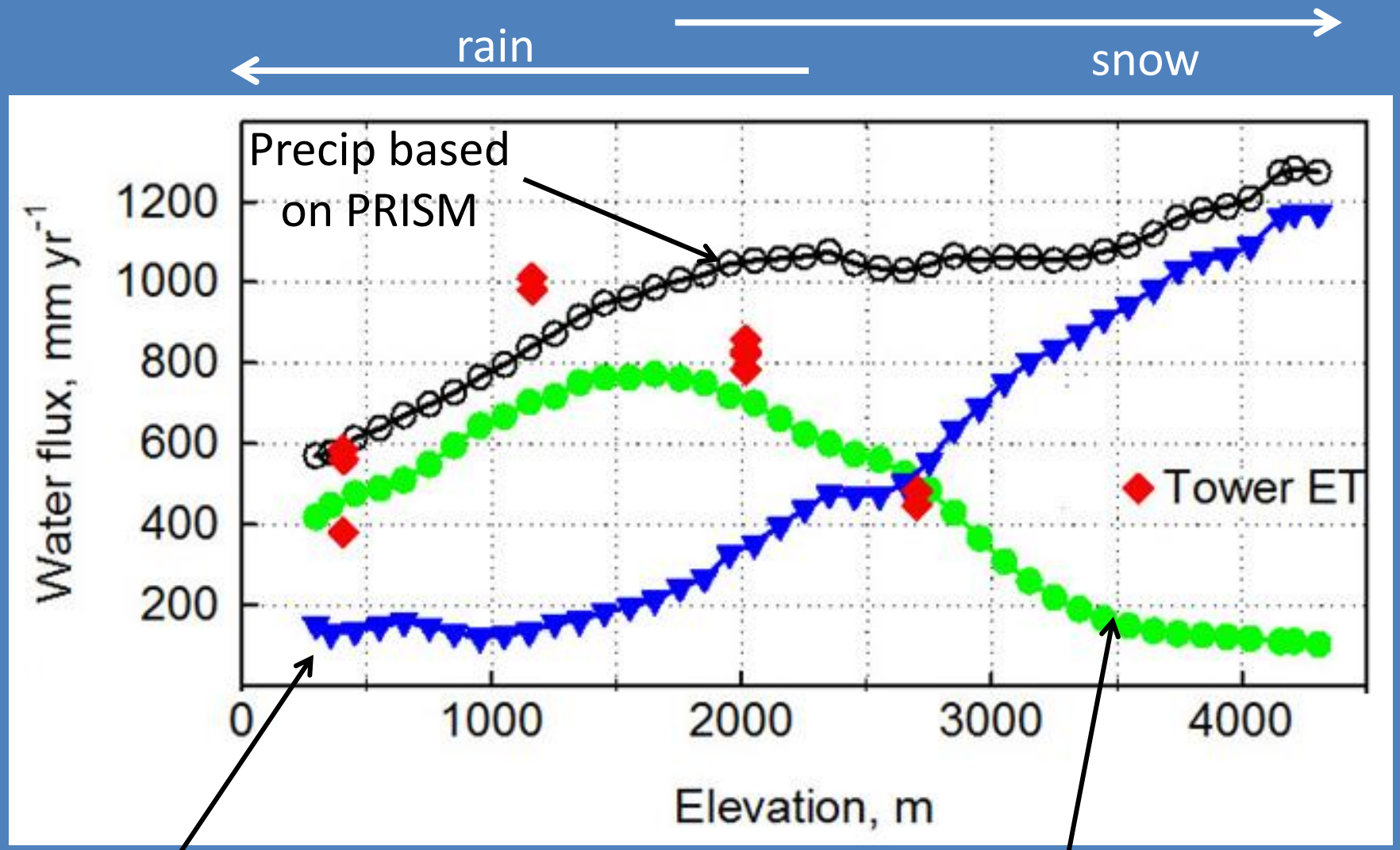
Oak savannah
E: 2000’
P_{ave}: 16”
ET: 20”

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

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

rain ← → snow

Extending flux-tower results to the basin scale

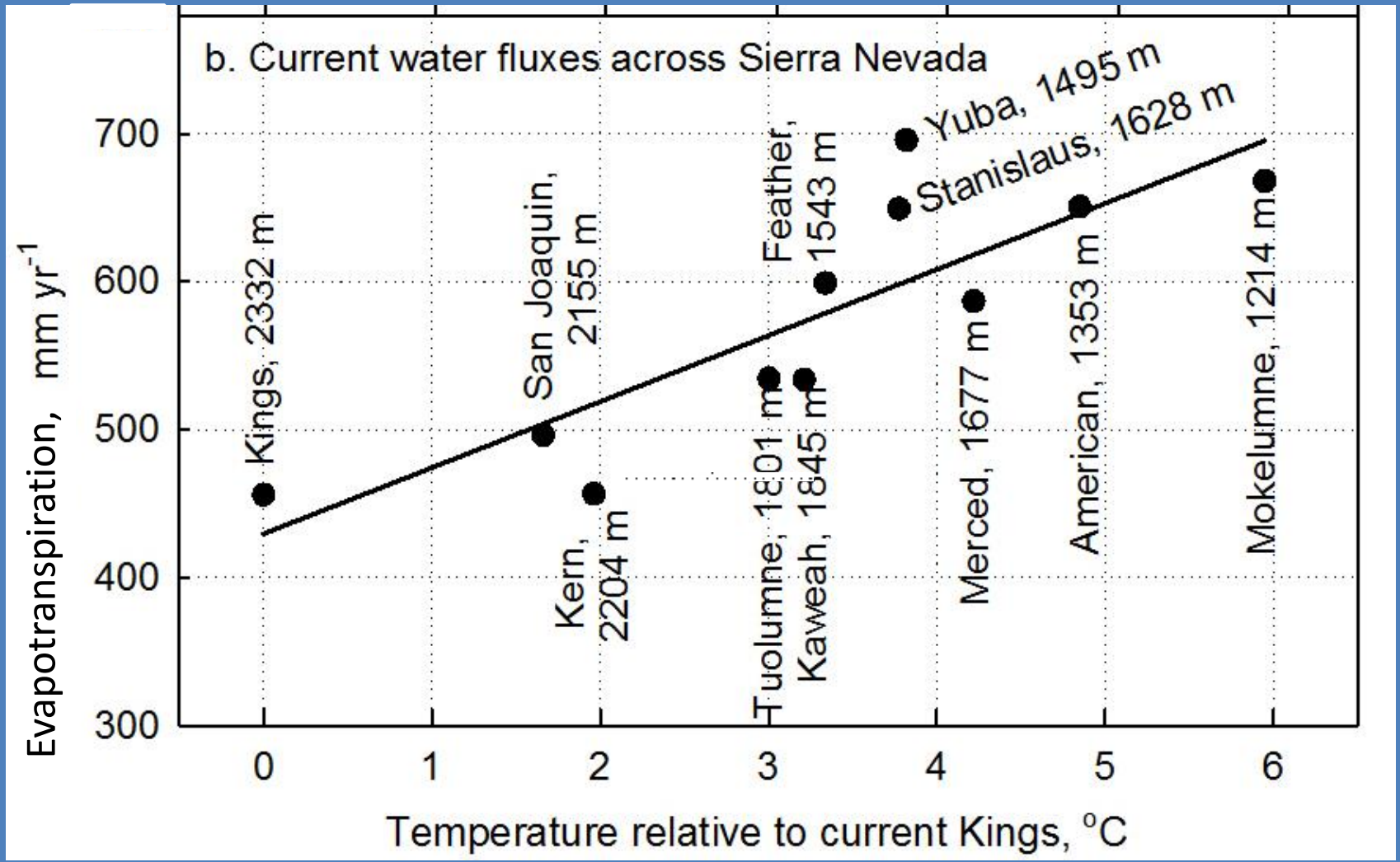


Runoff by difference

ET extended using satellite indices

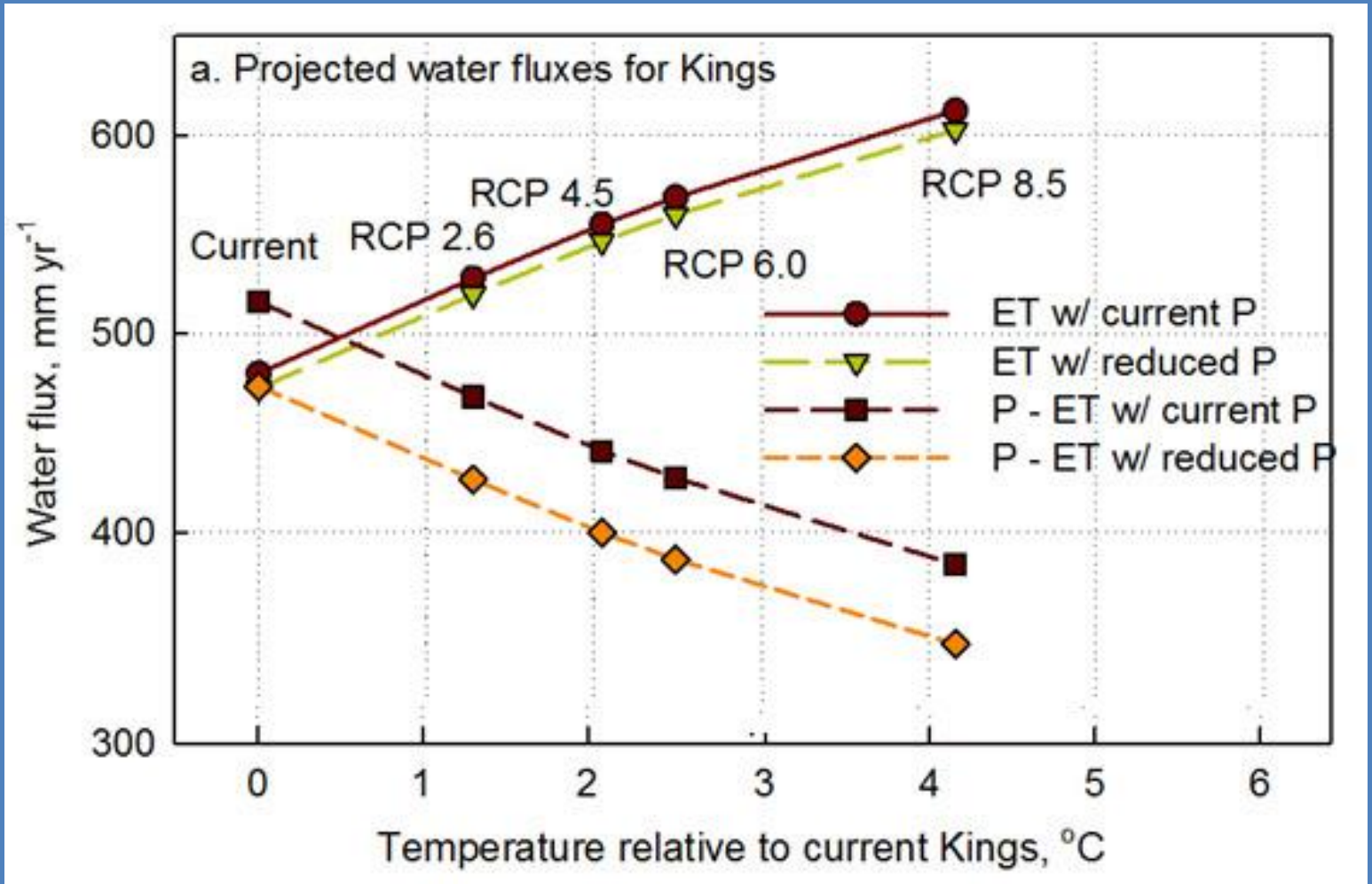
Goulden & Bales, in review

Evapotranspiration is currently lower in colder basins



Goulden & Bales, 2014

Runoff declines w/ higher temperature



- Longer growing season w/ temp. increase → more ET
- Average: 14% drop in runoff per 2°C
- Recall 10-40% drop at rain-snow transition catchments

Water & Sierra Nevada forests

<u>What we know</u>

1. Vegetation removal generally results in more runoff, initially
2. Vegetation regrowth means less runoff
3. Clear cutting or wildfire means more sublimation & earlier snowmelt
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

Major issues facing forest management

1. Information needs
   a. Studies to understand the effects of forest management on water over the wide range of physiographic conditions in California
   b. Pathways for precipitation reaching stream channels
   c. Methods for estimating evapotranspiration across vegetation types
   d. Erosion and sediment transport

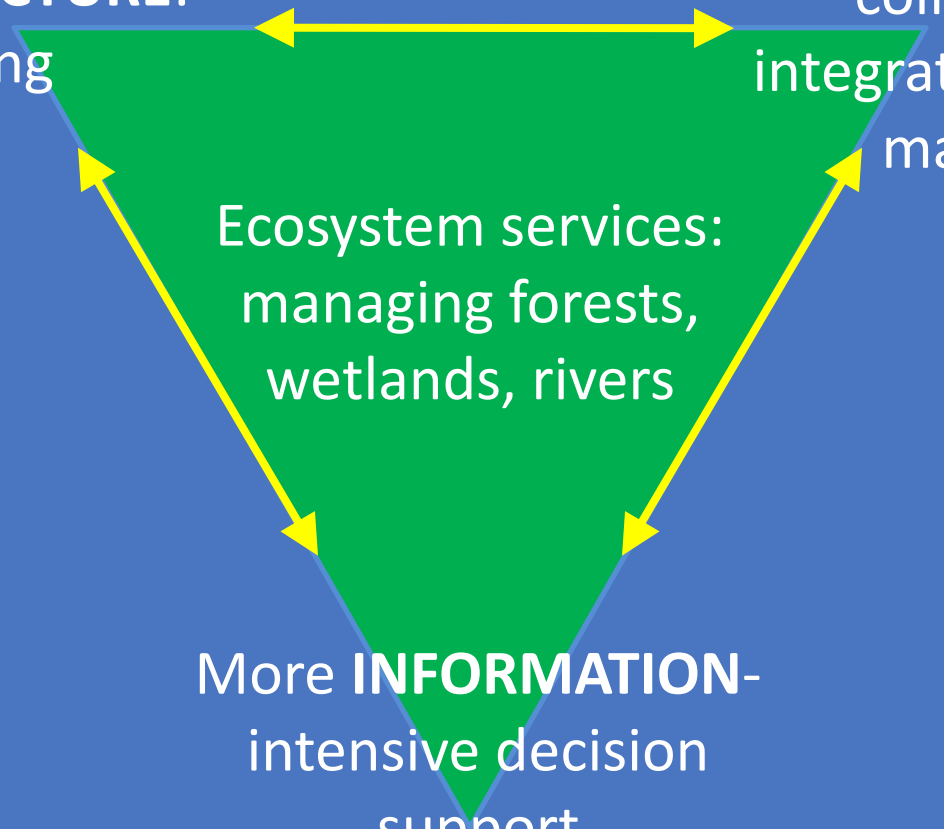
2. Coordination between land owners

3. Limited funding for forest watershed restoration

4. Regulatory requirements

CA Water Plan Update 160-09, vol 2, ch 23

Making a water-secure California



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

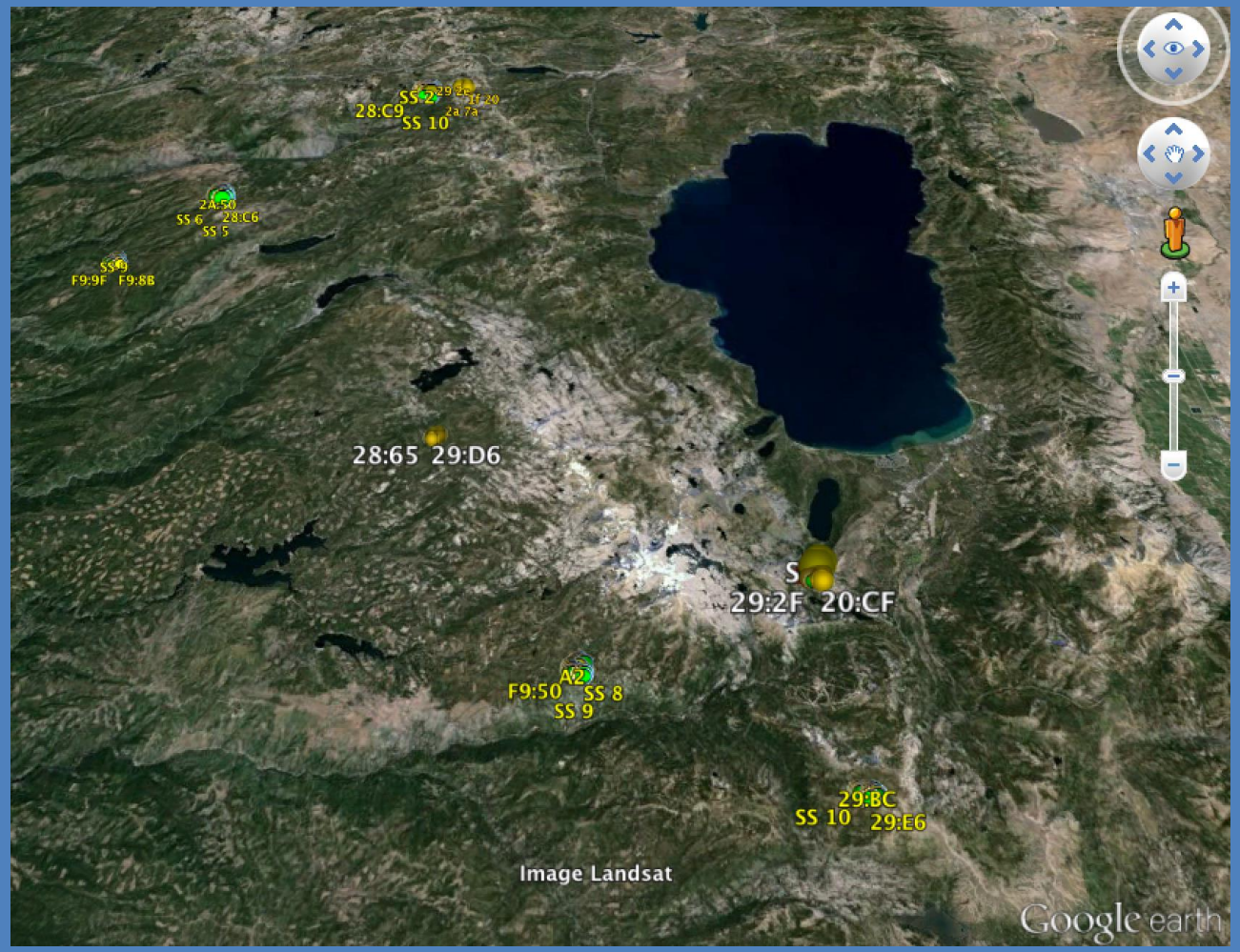
Envisioning a new water information system for California

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

American R. basin hydrologic observatory (in progress)



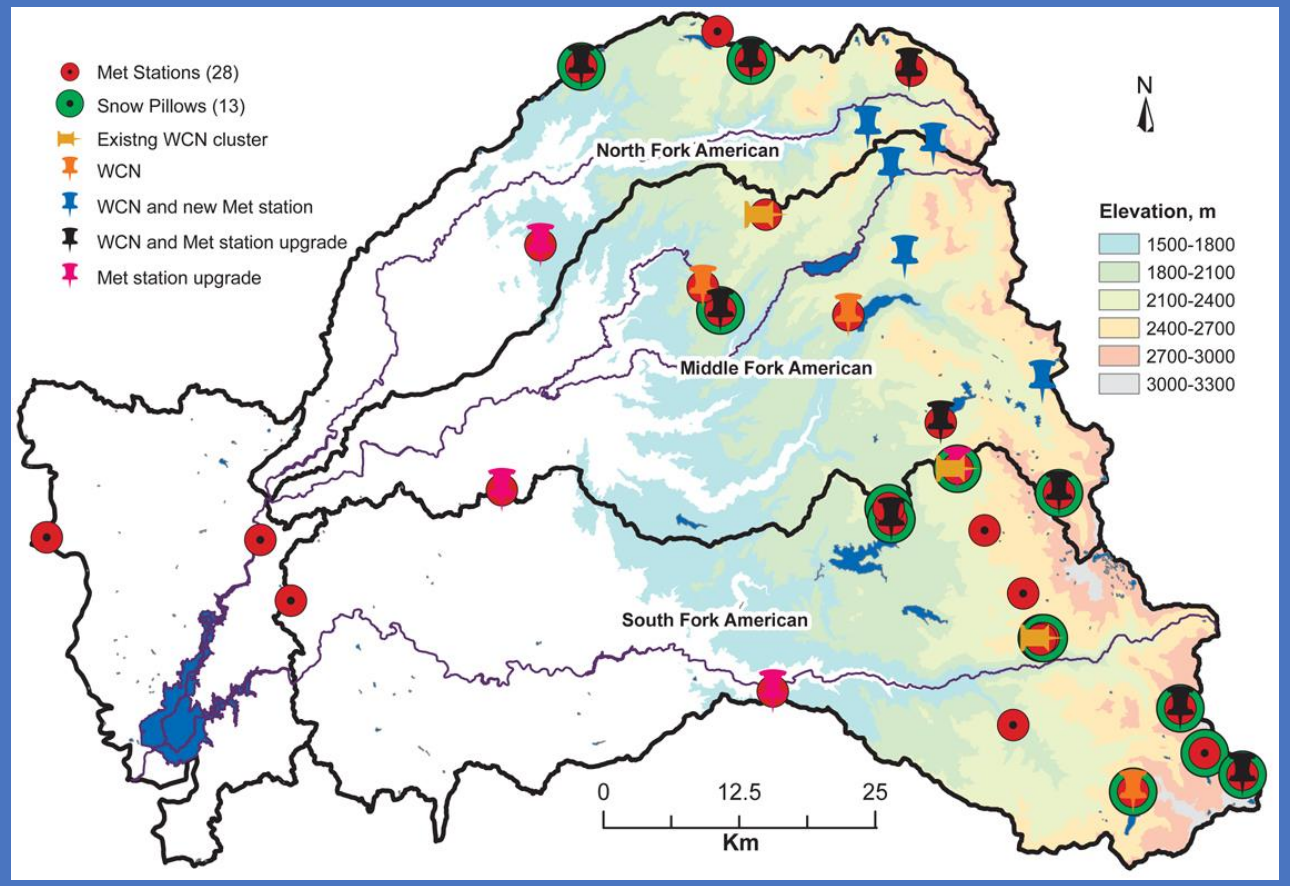
Platform for research & core element of new water information system

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

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

Node construction at Alpha site

American R. basin hydrologic observatory



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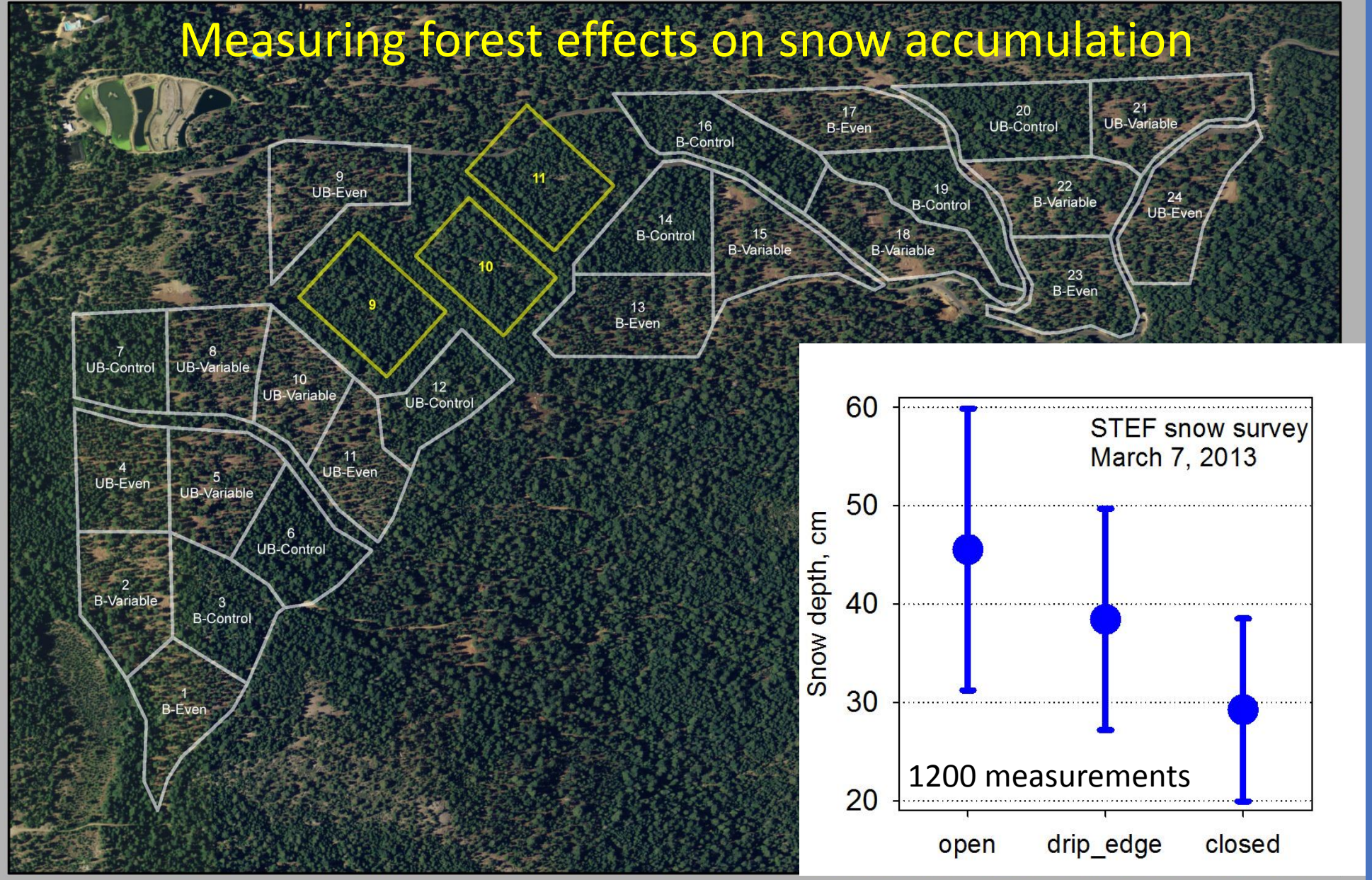
Measuring forest effects on snow accumulation



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

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Pacific Southwest Research Station

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."

Natural Infrastructure

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

Some concluding points

1. Sustained forest management that provides measurable benefits for water supply will require investment, verification & maintenance
   - Next step: demonstration project in Sierra Nevada

2. Better information is a critical foundation for water security, especially in a warming & more-variable climate
   - Next step: scale research products into statewide water information system

3. With better management, California's existing water supply could go further to meeting the needs of the state's urban & agricultural uses.