Water implications of various forest management strategies

1. Research background
2. Forest management & water
3. Water information
4. Water security

Roger Bales,
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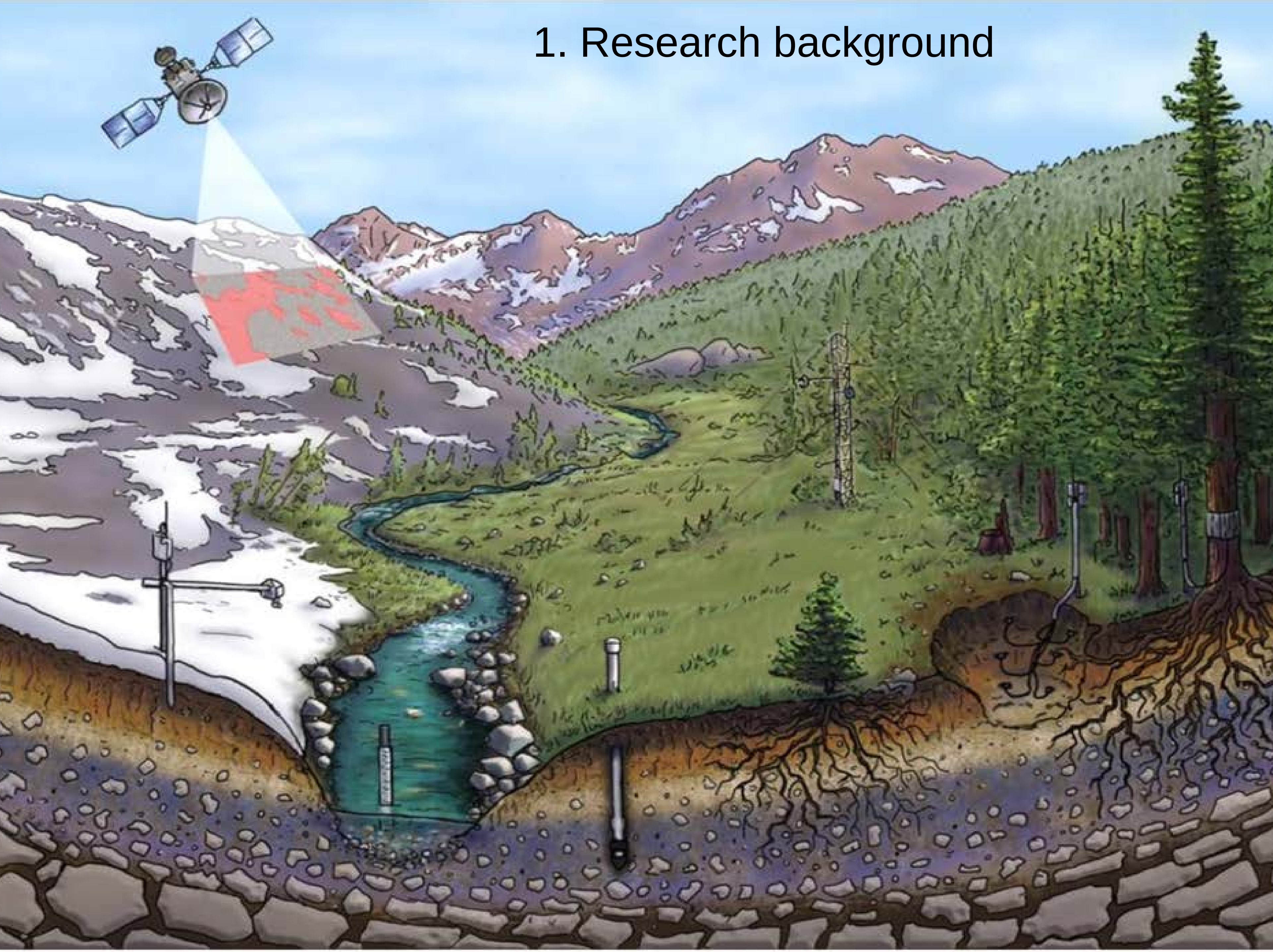
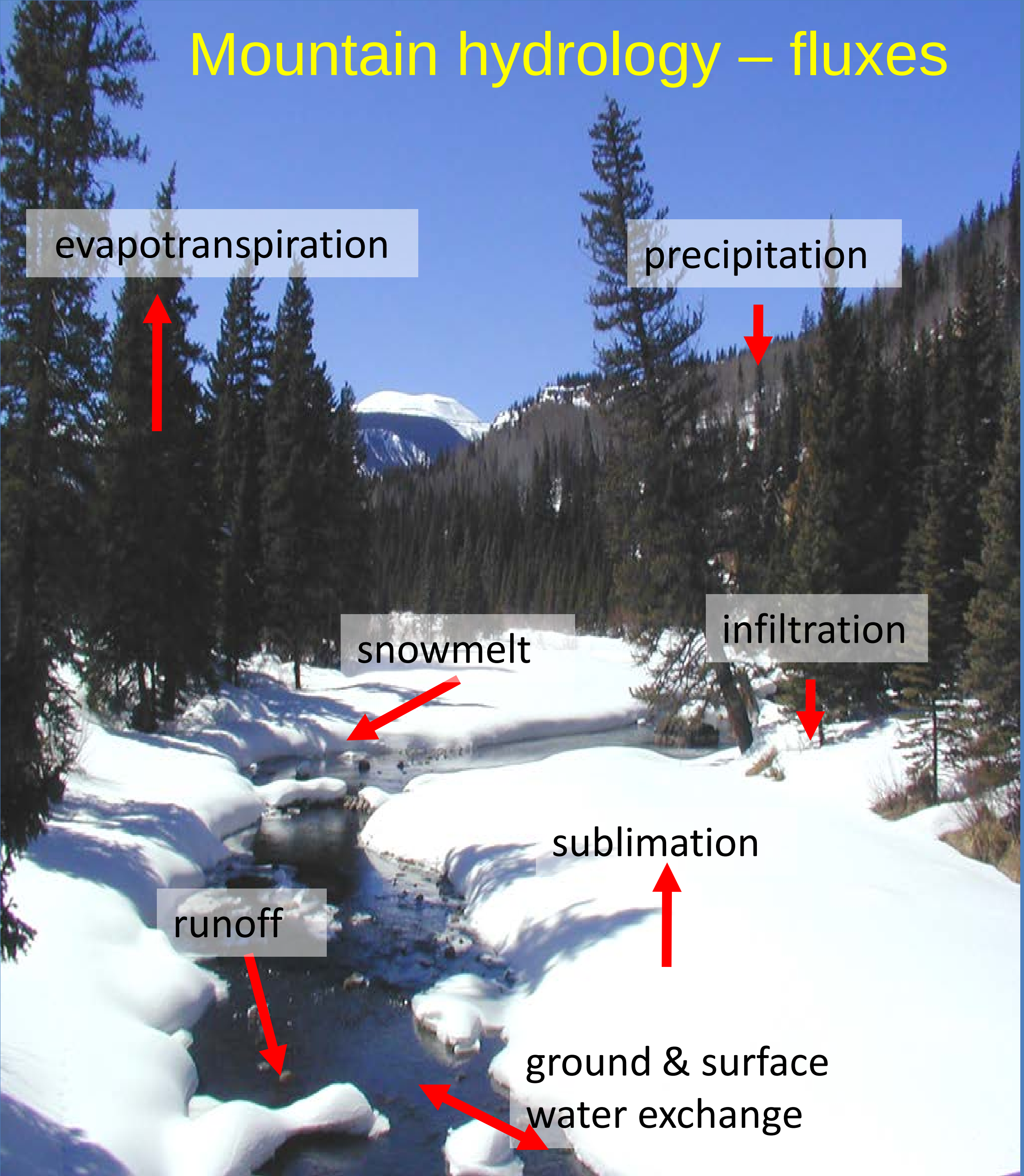
UC Merced

1. Research background



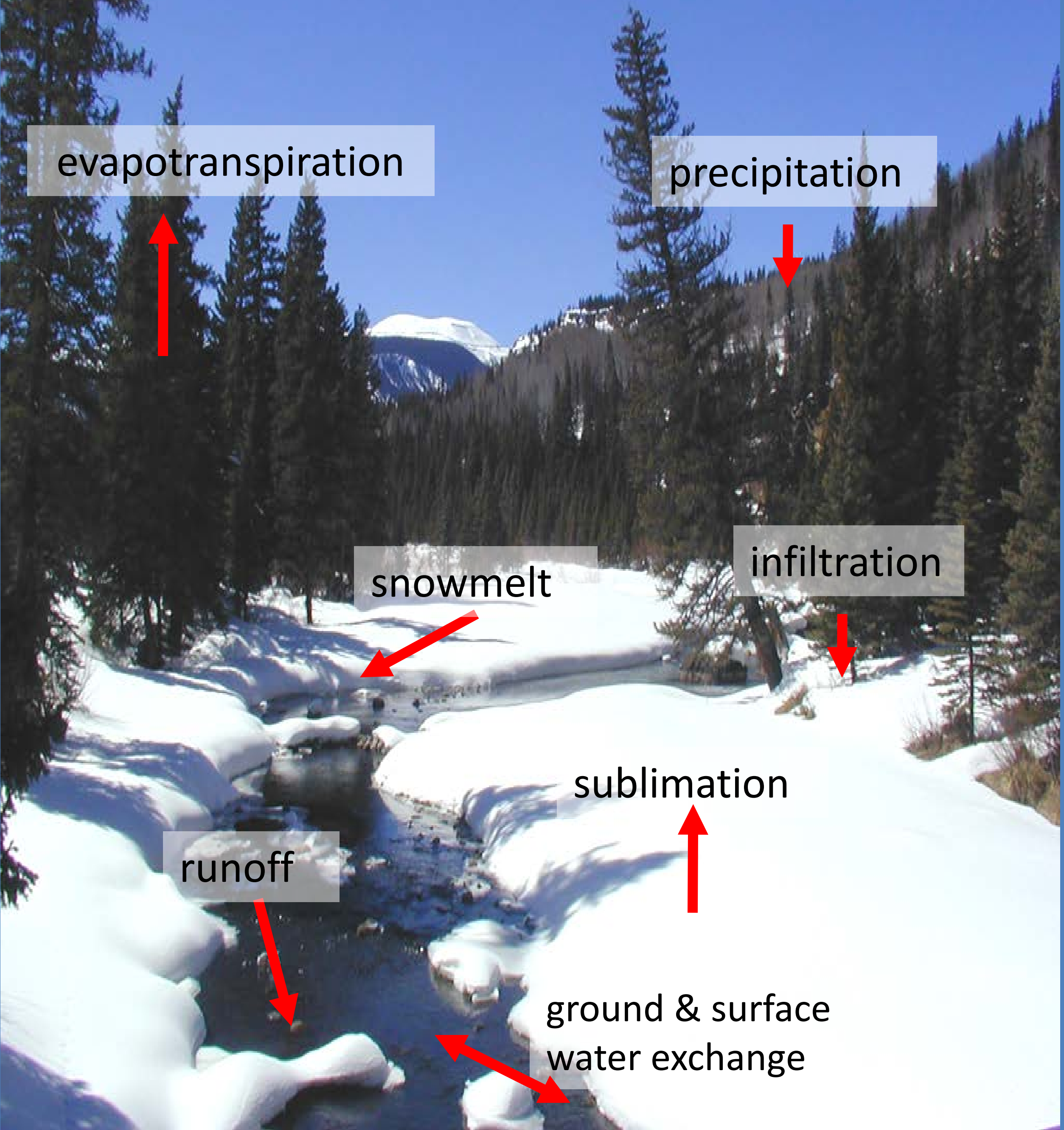
Mountain hydrology – fluxes



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

Reservoirs:
Snowpack storage
Soil-water storage

Mountain hydrology – fluxes



Myth:

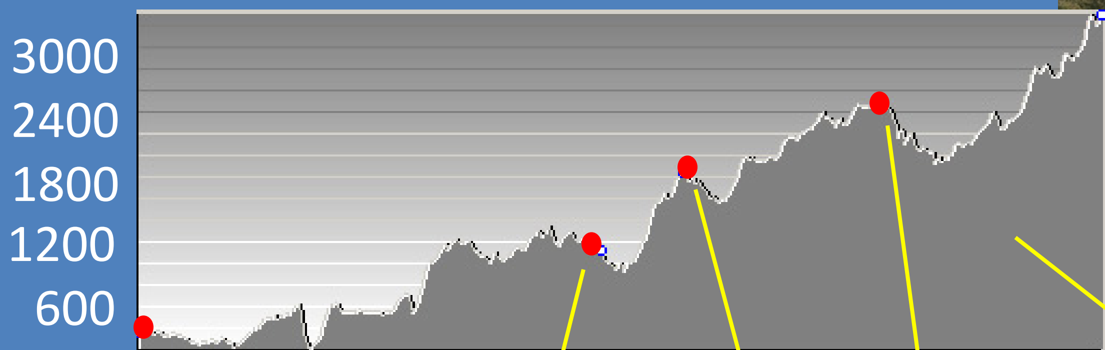
We can, with a high degree of skill, estimate or predict the magnitude of these quantities

Reservoirs:
Snowpack storage
Soil-water storage

Sierra Nevada watershed research infrastructure

Elev., m

E-W transect of flux towers

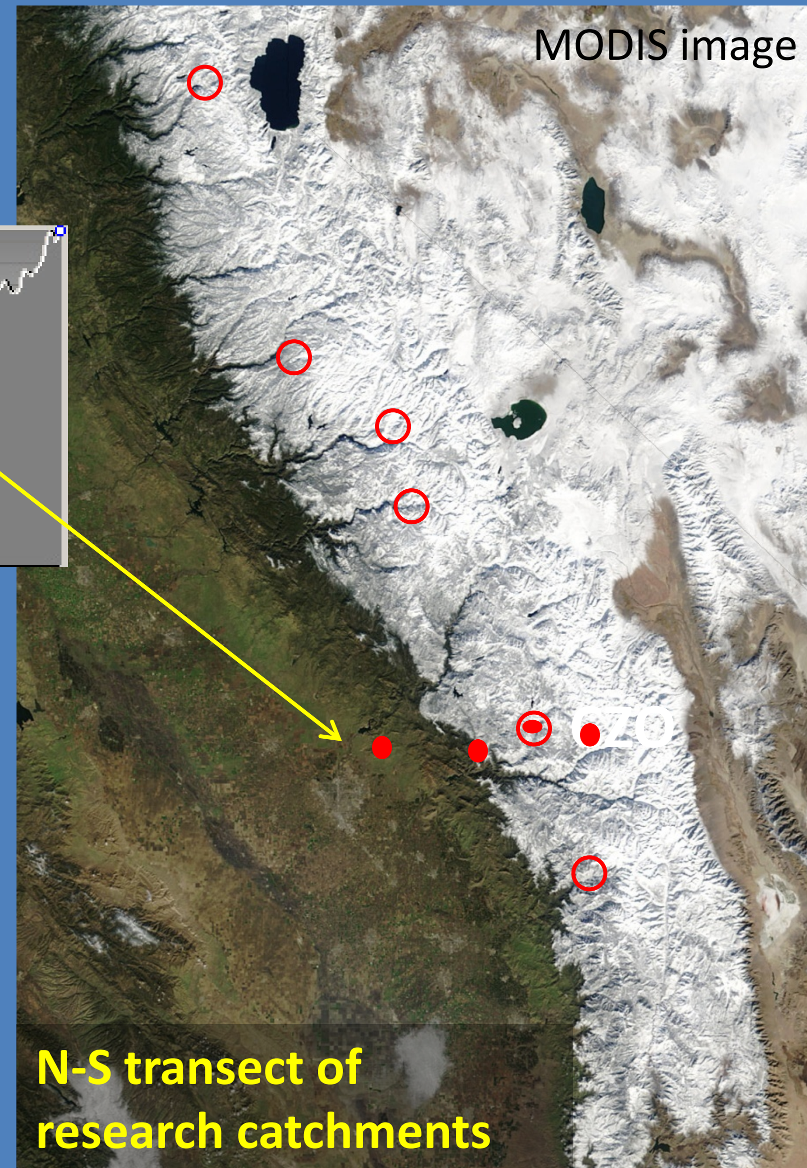


San Joaquin Experimental Range
400 m
1300 ft

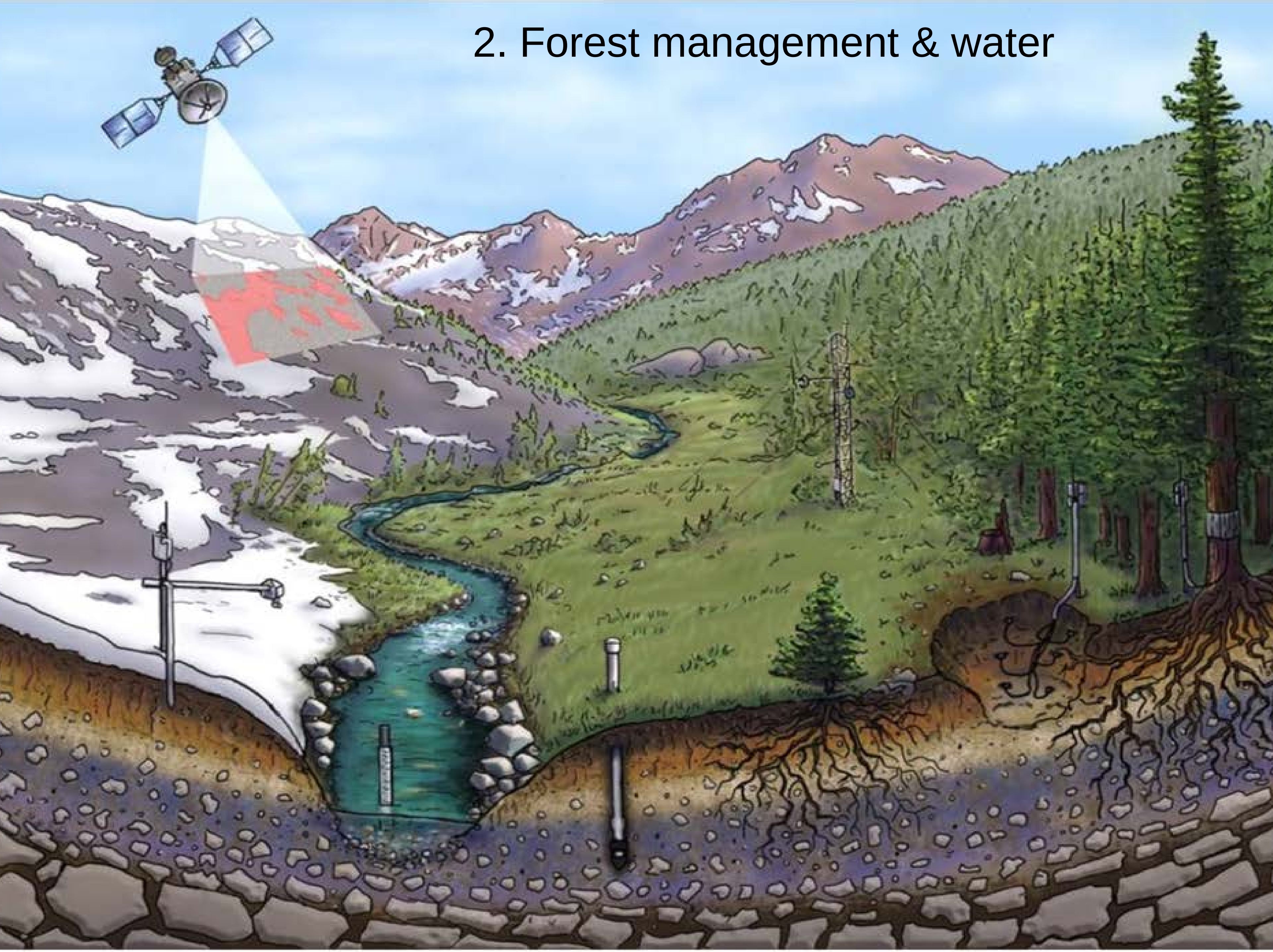
Soaproot Saddle
1100 m
3600 ft

CZO P301
2000 m
6600 ft

Shorthair Creek
2700 m
8900 ft



2. Forest management & water



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

Scoping report

Three issues

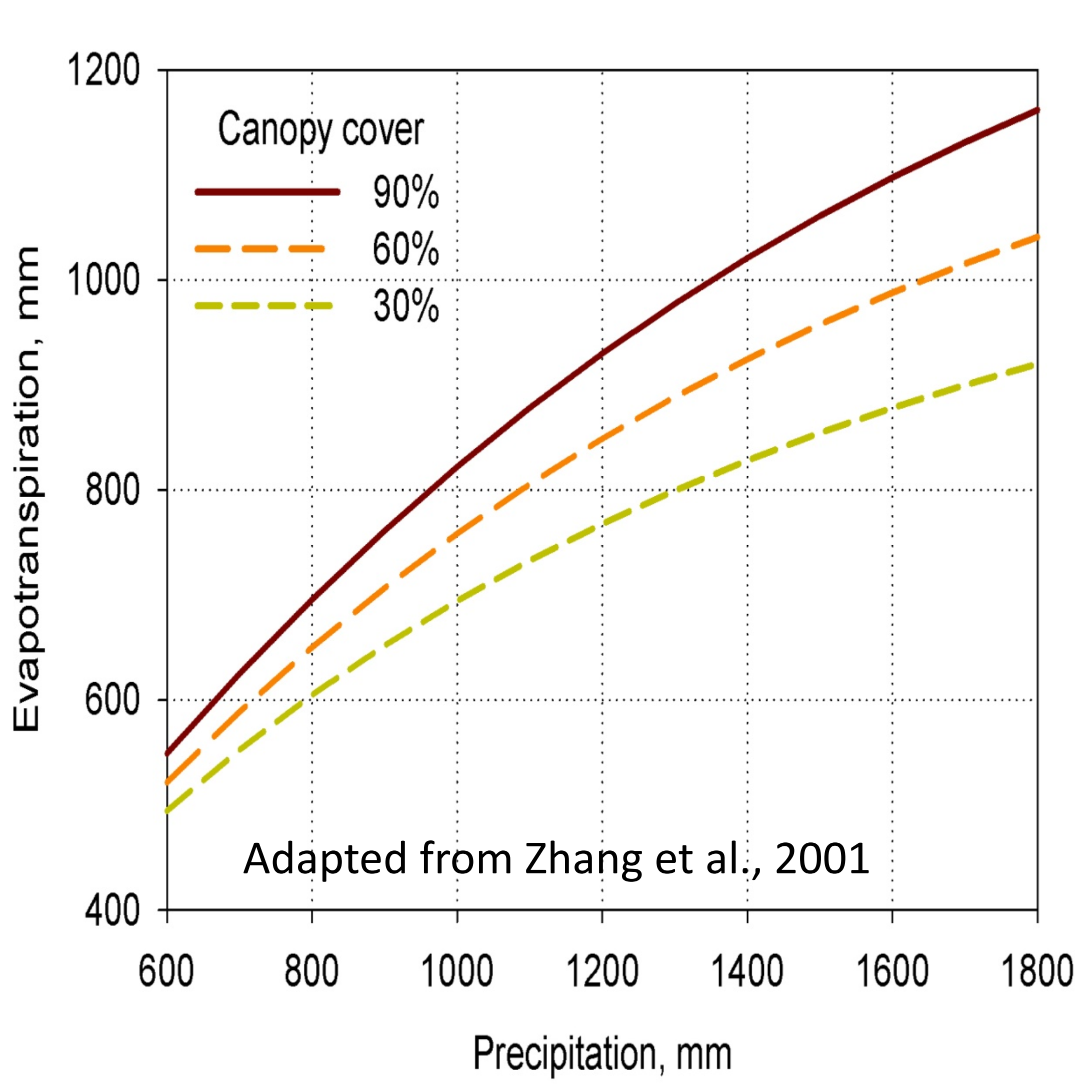
1. Water use by vegetation

   Runoff = Precipitation – Evapotranspiration – Interception

2. Interception losses

3. Timing of snowmelt & runoff

Vegetation water use: summary from literature



- Reducing forest cover by 40% of maximum levels across a watershed could increase water yields by about 9%
- Sustained, extensive treatments in dense Sierra Nevada forests could increase water yield by up to 16%
- These estimates are based on very limited data

Trees & snow

Trees block low-angle winter sun, retarding snowmelt …

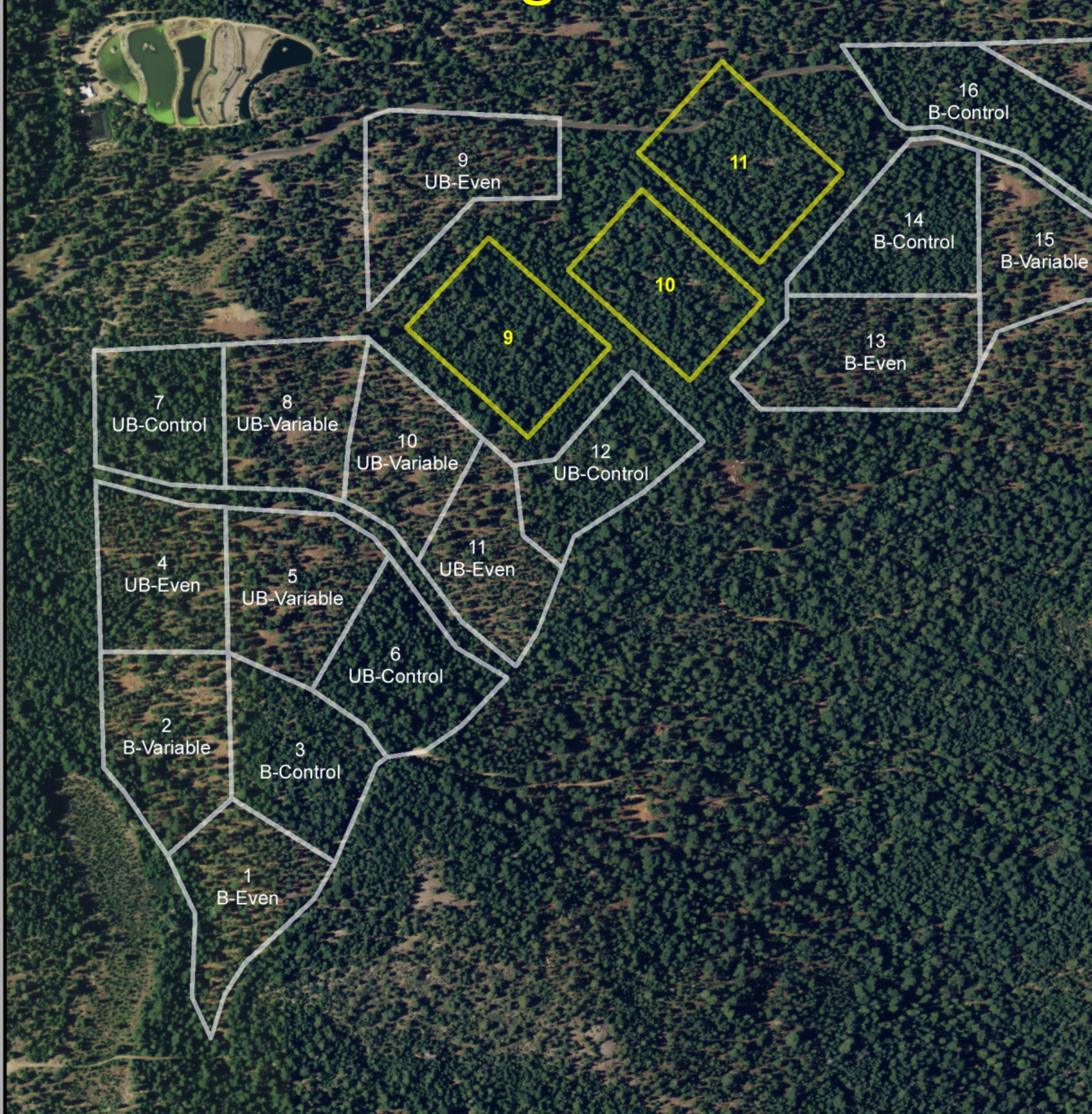
… but intercept snowfall, some of which sublimates …

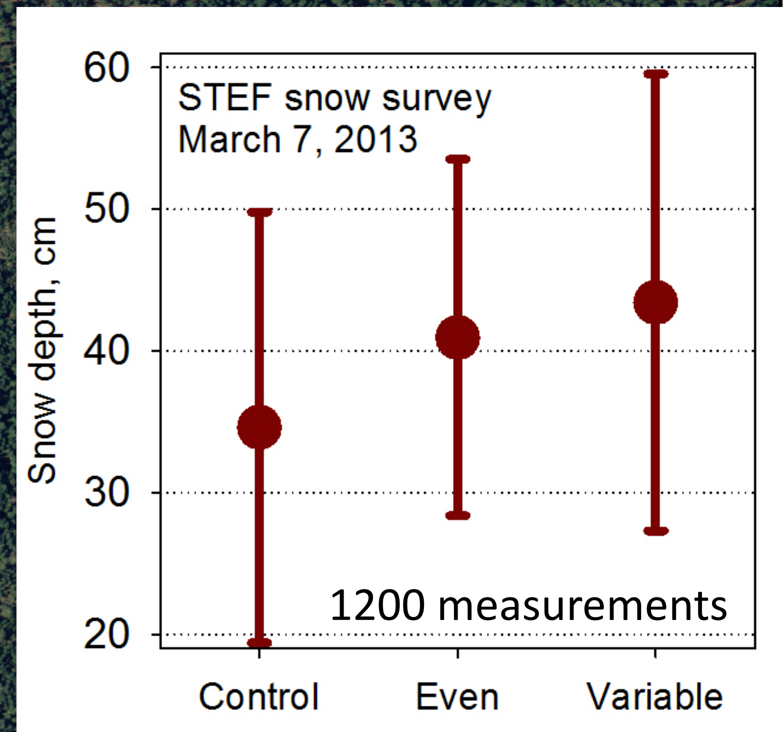
… and emit longwave radiation that melts snow …

… resulting in tree wells

In dense forests less snow reaches the ground
Under-canopy snow melts earlier than snow in canopy gaps

Measuring forest effects on snow accumulation





Legend

Variable Density Thinning Units

1929 Methods Of Cutting Units

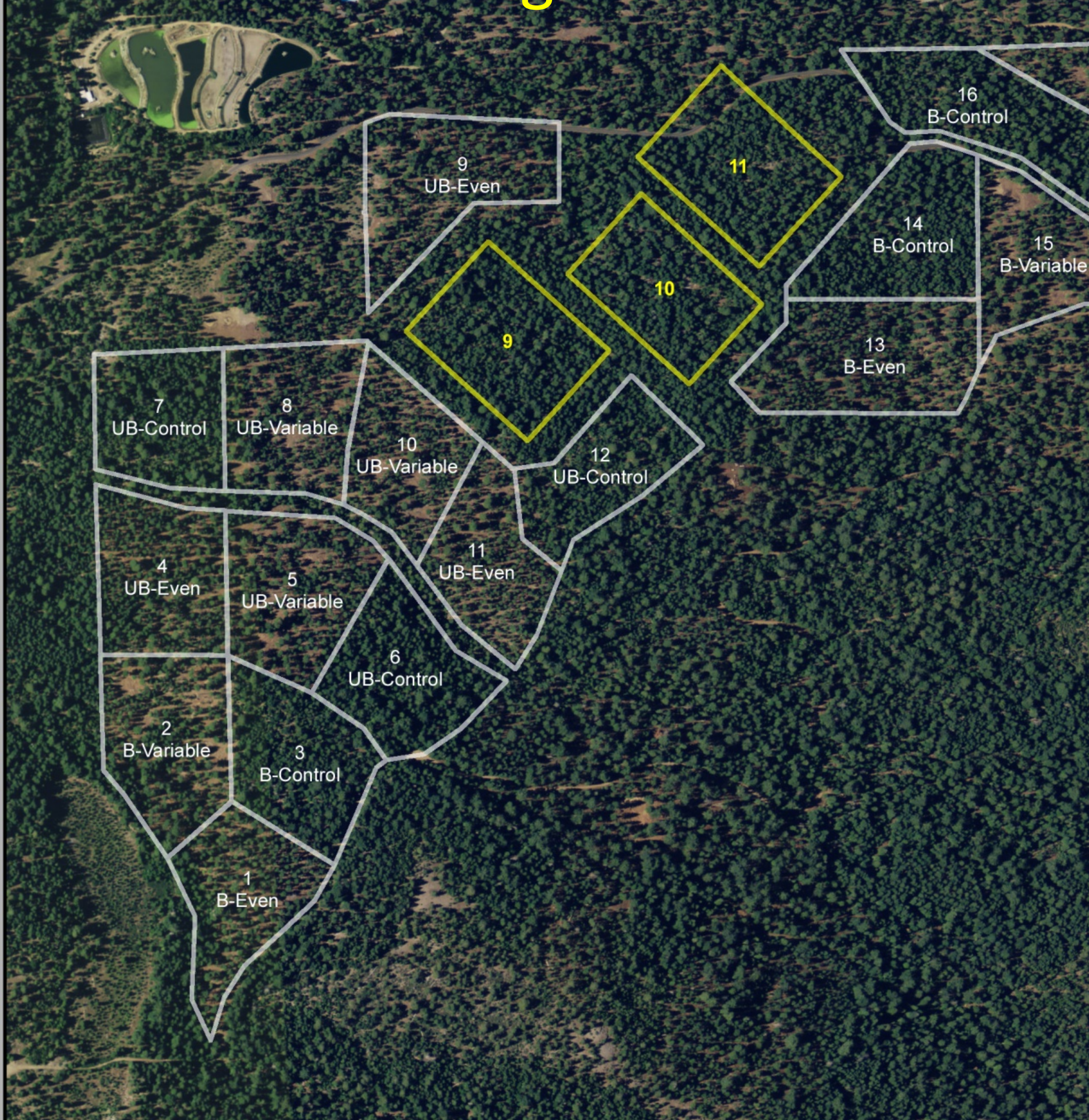
Stanislaus - Tuolumne Experimental Forest
Variable Density Thinning Study
Post-Harvest (2012)

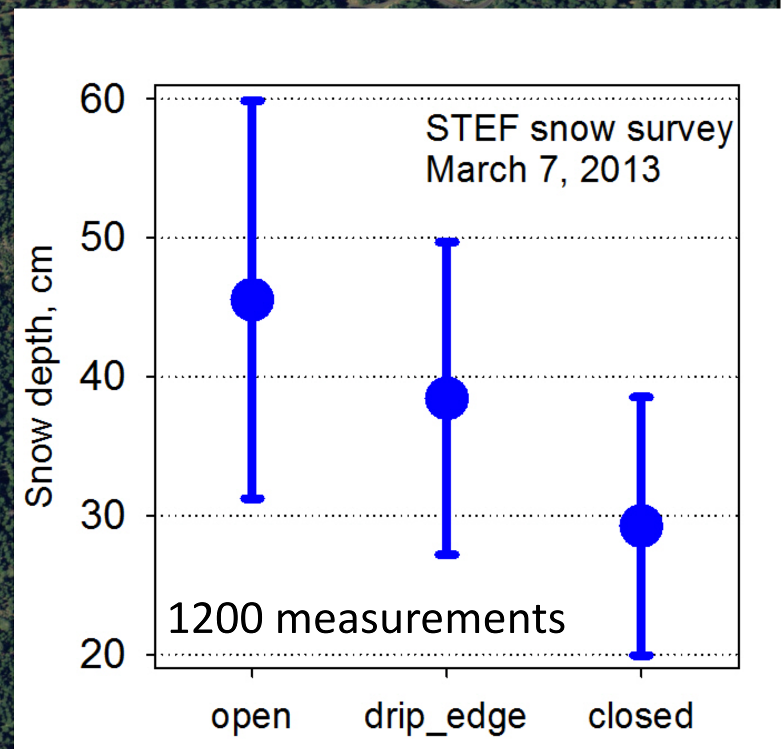
0 50 100 200 300 400 500 Meters

Pacific Southwest Research Station

N

Measuring forest effects on snow accumulation





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Variable Density Thinning Units

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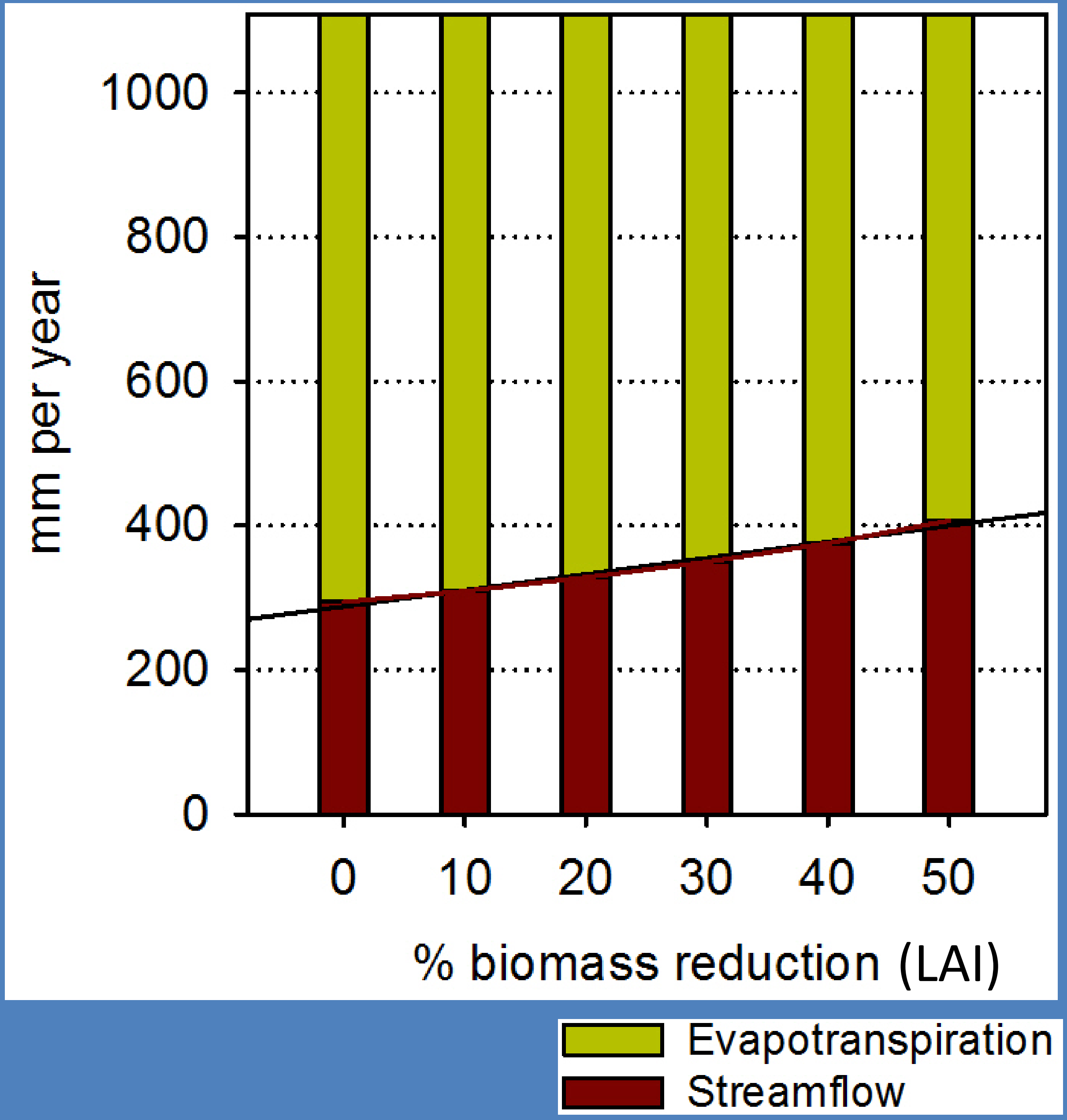
N

Thinned unit w/ control in background

Even thinning

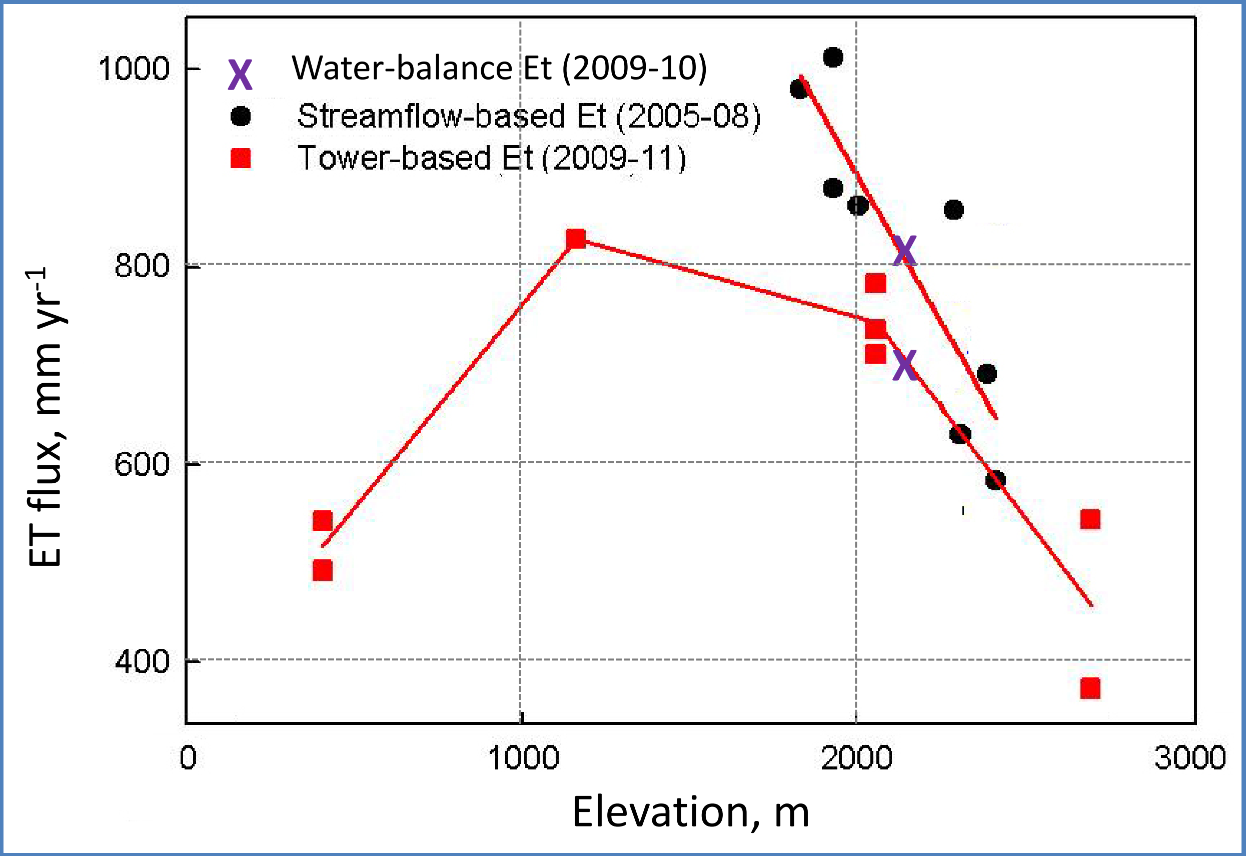
Variable thinning

Impact of thinning on evapotranspiration & streamflow



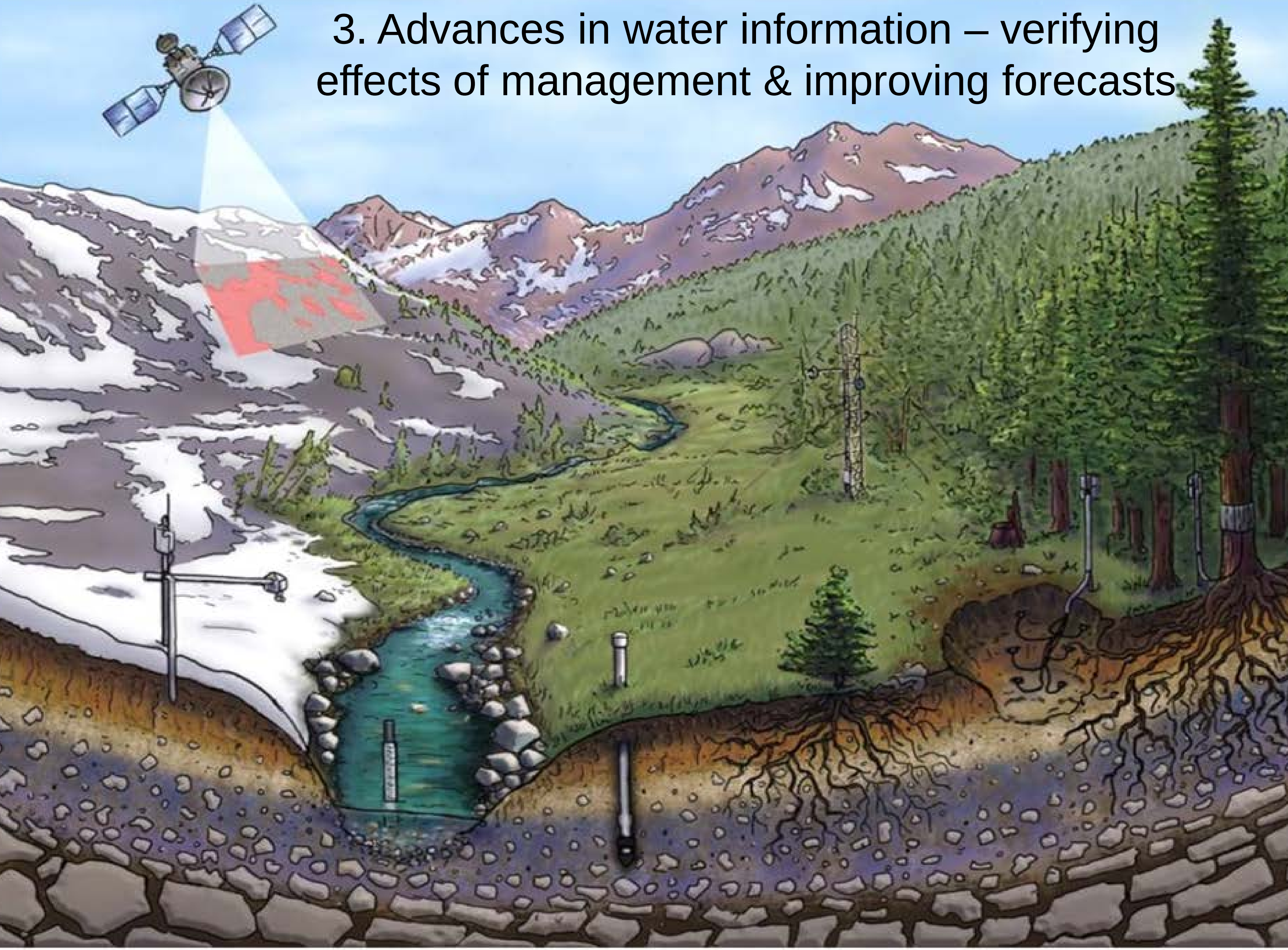
- P303 headwater catchment, Southern Sierra CZO/KREW, Sierra NF
- Rain-snow transition, 2000 m elev
- Results based on very-detailed pre-treatment data & hydrologic modeling
- 5-yr average, 2004-2008
- Indicates steeper gain from thinning than do Zhang curves

Evapotranspiration (ET) across an elevation transect



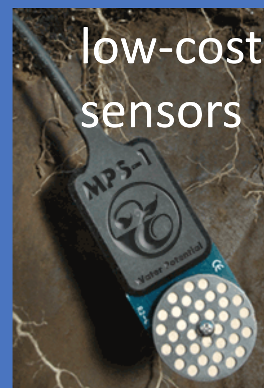
- Lower elevation is water limited
- Higher elevation is cold limited
- Highest current ET in rain to rain-snow-transition region of mixed conifer forest – year-round growth

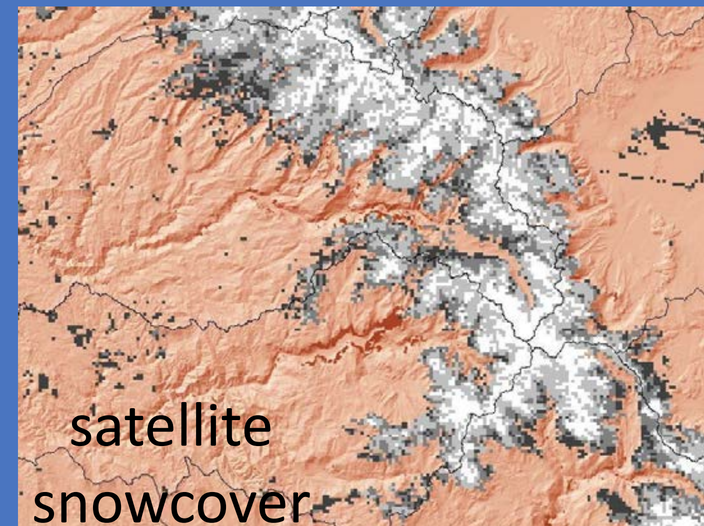
3. Advances in water information – verifying effects of management & improving forecasts

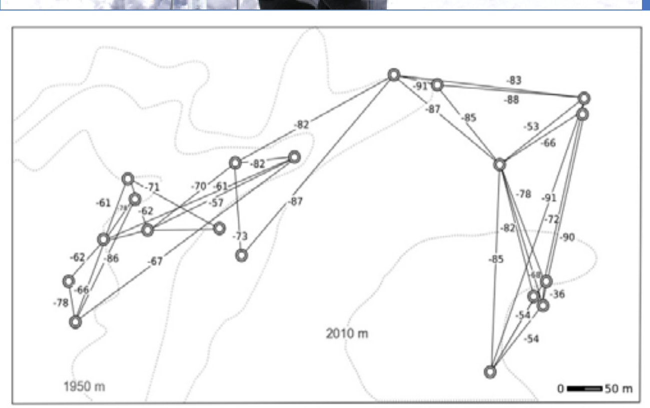


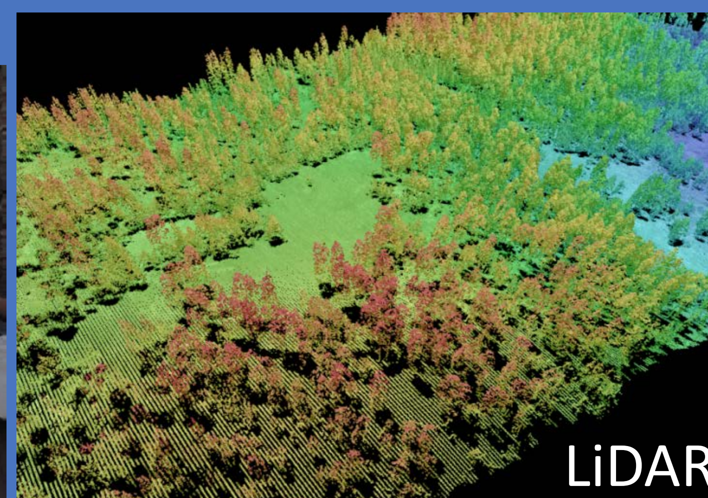
Measurement technology – verification & forecasts

Available now: blending data from satellites, aircraft, wireless sensor networks, advanced modeling tools



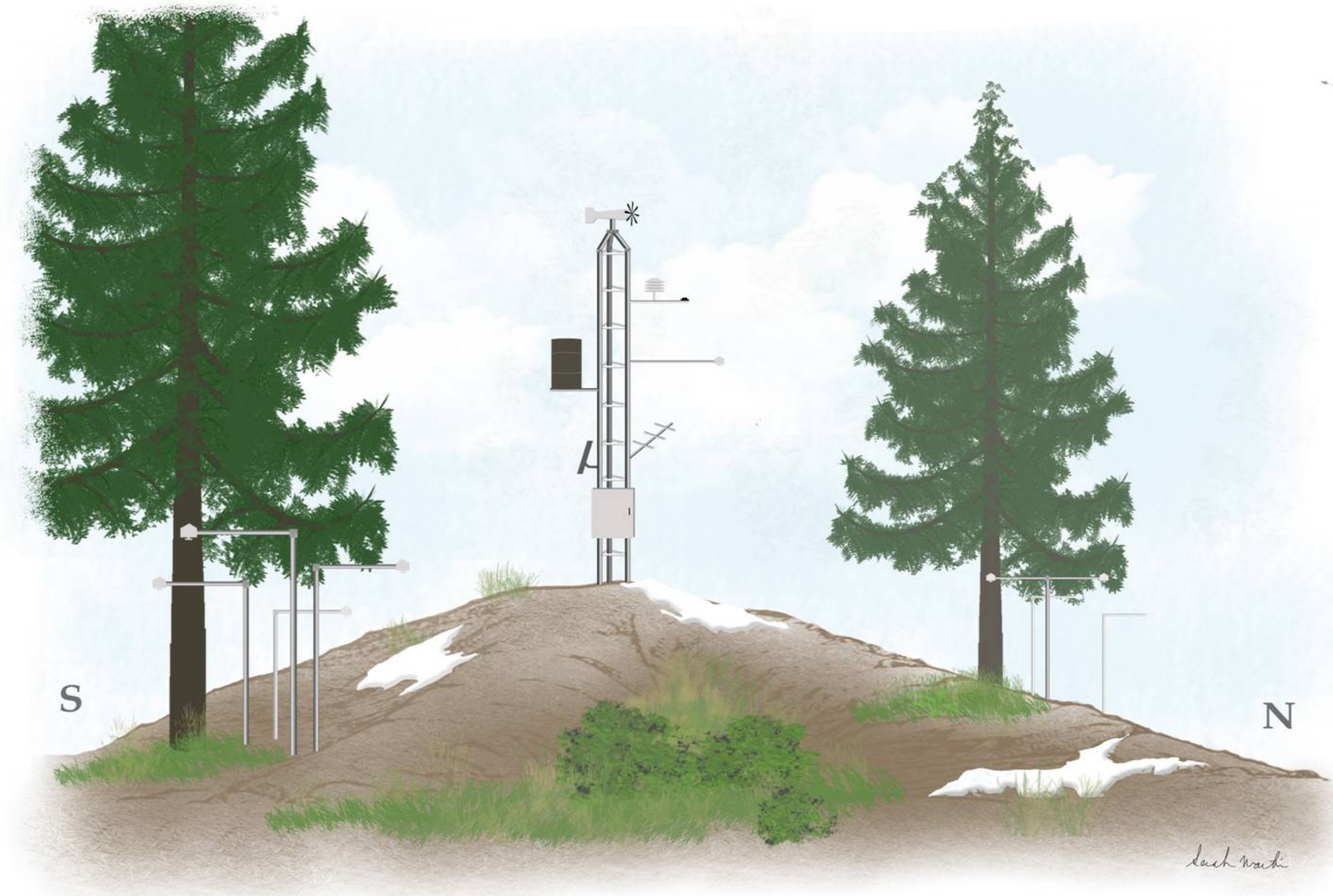






Together these add up to Big Data challenges

Sensor networks: 5-10 yr ago, wired sensor networks



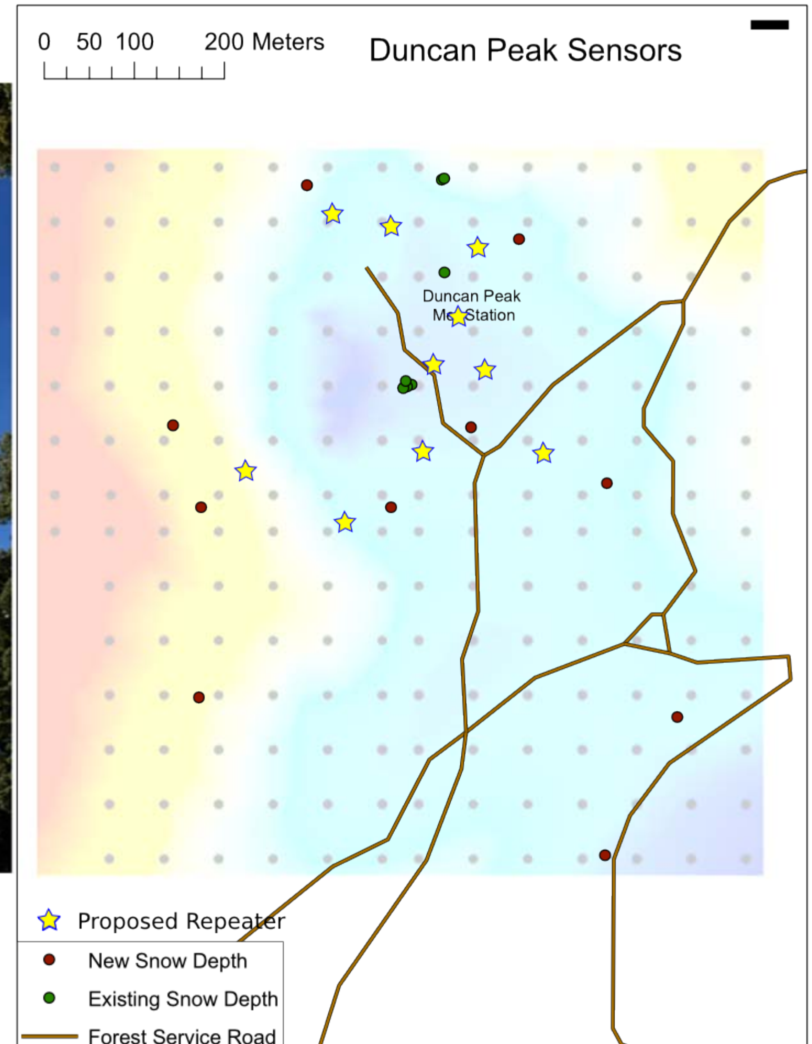
Met station

North, south facing sensor nodes; <45 m wire lengths

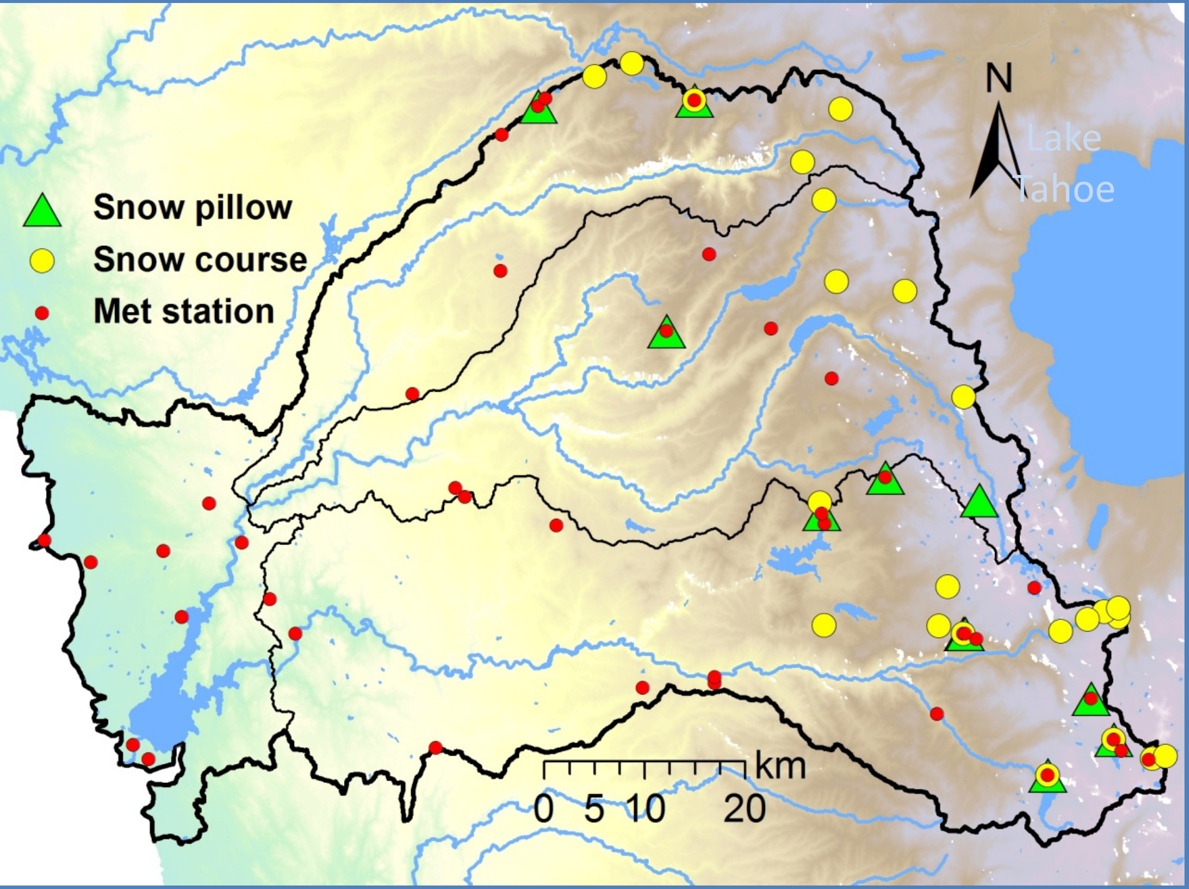
– snow depth, temp, soil moisture

Current setup: *wireless* nodes

Improved representation of the landscape: topography & vegetation

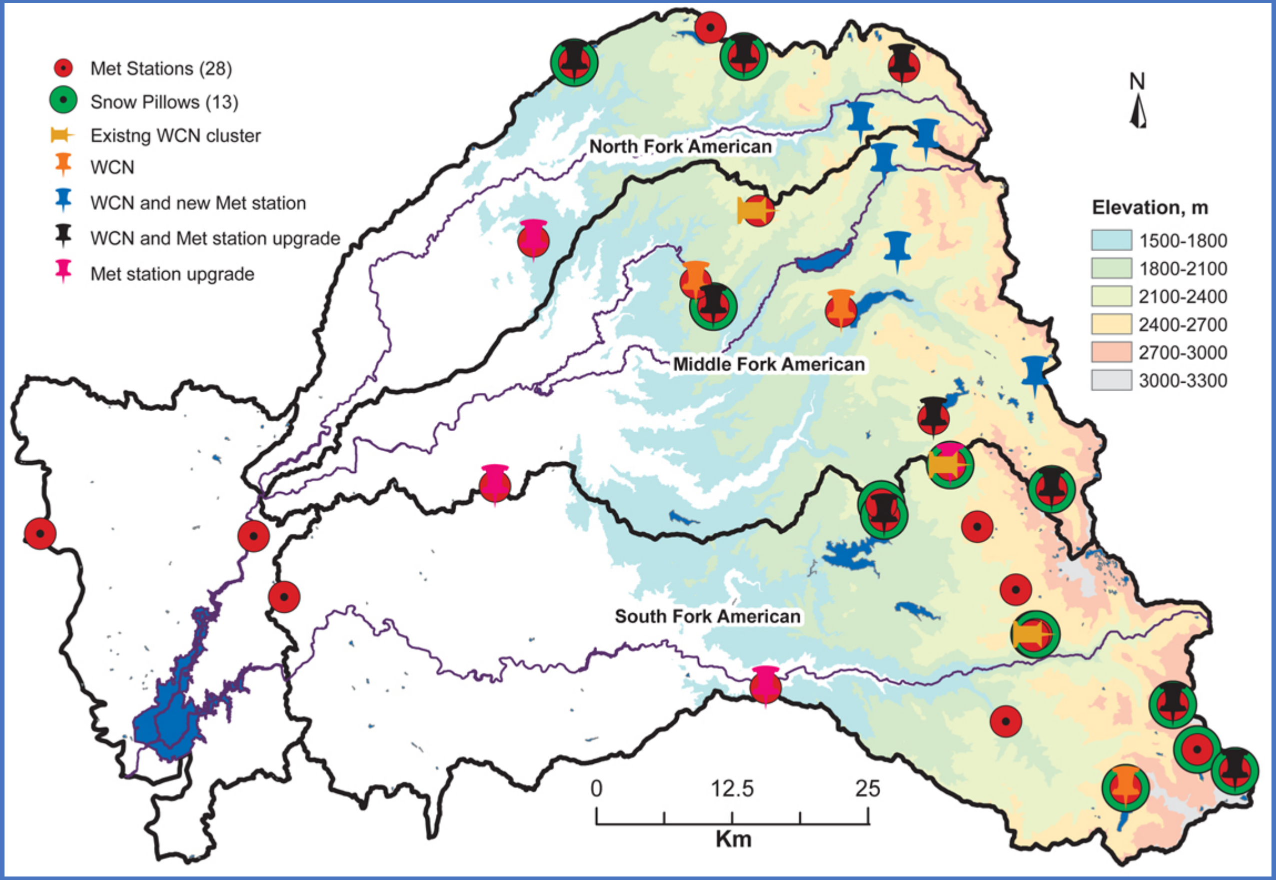


American River basin – current hydrologic measurements



- 2 snow pillows in N. Fork, 1 in Middle Fork, 8 in S. Fork
- Non-representative network
- Stations are on flat ground, in clearings, at mid elevations

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

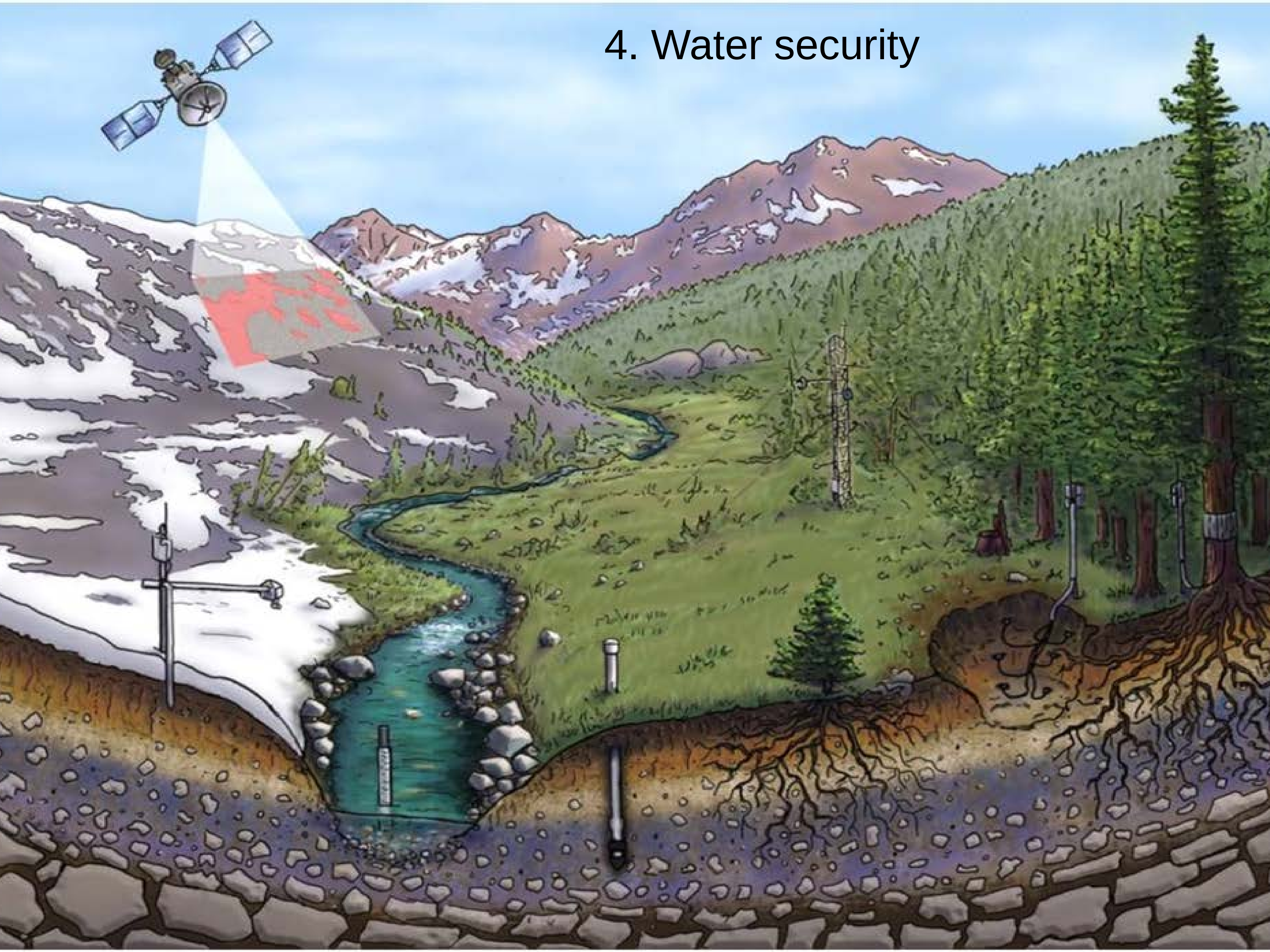


Strategically place low-cost sensors to get spatial estimates of snowcover, soil moisture & other water-balance components

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

Node construction at Alpha site

4. Water security



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

INFRASTRUCTURE
to store, transport
& treat water

HARD

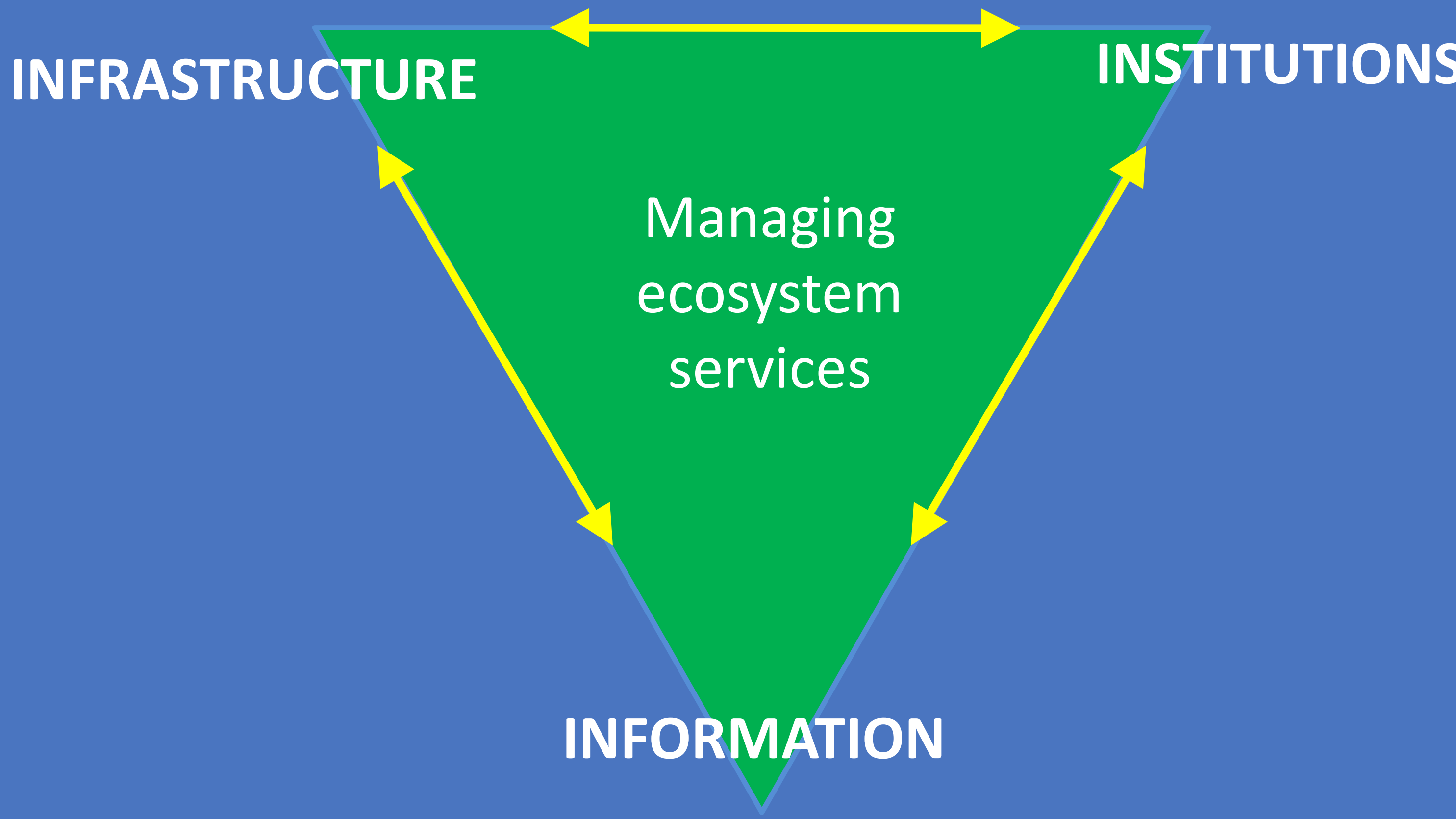
Stronger & more-
adaptable
INSTITUTIONS

SOFT

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

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



Managing water is central to climate preparedness; and water management translates into managing ecosystem services (e.g. forest vegetation management).

Concluding points

1. Sustained forest management that provides measurable benefits for water supply will require both investment & verification
2. Better information is a critical foundation for water security, especially in a warming & more-variable climate
5. Research is still needed on several basic engineering, hydrologic-science, social-science questions, e.g.:
   - Effect of sustained forest restoration & management
   - Systems design for accurate spatial measurements
   - Blending of data w/ modeling tools to improve forecasts
   - Economic value & use of better information