Water & Sierra Nevada forests

What we know
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 – runoff could go up or down
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
6. Sustained forest management that provides measurable benefits for water supply will require investment, verification & maintenance

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

Roger Bales, UC Merced Sept 21, 2015
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?

Upper Yosemite Valley from Columbia Point, 4800’

Photos from G. Gruell
Measuring forest effects on snow accumulation

1200 measurements

STEF snow survey
March 7, 2013

1200 measurements

open  drip_edge  closed

Stanislaus - Tuolumne Experimental Forest
Variable Density Thinning Study
Post-Harvest (2012)
Relevant UC watershed-scale field programs

**American R. & SNAMP - Last Chance**

**Potential sites**
- PSW - STEF
- YNP – Tioga corridor
- SNAMP - Sugar Pine

**E-W transect of flux towers**
- San Joaquin Experimental Range 400 m
- Soaproot Saddle 1100 m
- CZO P301 2000 m
- Shorthair Creek 2700 m
Extending flux-tower results to the King R. basin

Precip based on PRISM

Runoff by difference

ET extended using satellite indices

Extending flux-tower results to the King R. basin

Runoff

Goulden & Bales, 2014
- Runoff is lower in south, and in lower-elevation basins
- Note that current amount of ET (P – Q) in similar in most Sierra Nevada basins

Harrison & Bales, 2015
Reducing forest cover by 40% of maximum levels across a watershed could increase water yields by about 9% of ET. Sustained, extensive treatments in dense Sierra Nevada forests could increase water yield by up to 16%. These estimates are based on very limited data.

Adapted from Zhang et al., 2001

Bales et al., 2011
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 & RHESSys modeling
5-yr average, 2004-2008

What is the slope of this line in different forests???

Saksa et al., in prep
Runoff declines with higher temperature

- Longer growing season with temp. increase $\rightarrow$ more ET
- Average: 14% drop in runoff per $2^\circ$C
Evapotranspiration is currently lower in colder basins.

Goulden & Bales, 2014
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
Forests and water in the Sierra Nevada, next steps

Goals (what)
– Provide quantitative, credible assessments of the water-cycle impacts of forest vegetation density, structure, disturbance and management actions in the Sierra Nevada (and other forests)
– Develop data and tools for further assessments, of sufficient accuracy to guide investments and build partnerships

Context (why)
– There is indirect evidence that vegetation treatments and disturbance can have both ephemeral and longer-lasting effects on partitioning of precipitation between evapotranspiration and runoff
– Quantitative information to enable meeting the goals, across the heterogeneous landscape of the Sierra Nevada, is sorely lacking

Approach (how)
– Carry out intensive hydrologic and vegetation measurements, plus hydrologic modeling, of treatment and control catchments, following silviculture prescriptions that provide end-member information for assessments
– Extend assessments across the region using lower-intensity measurements, meta analysis, hydrologic modeling and economic studies
Field project

Goal
To quantitatively evaluate the effects of differences in stand structure on water yield from catchments in the snow-rain transition zone using a BACI (Before-After-Control-Impact) design.

Hypotheses
– Changes in stand structure to a lower stand density will enhance snow retention, affect runoff timing, and increase the overall water yield.
– The magnitude of these changes can be detected and verified using a combination of field measurements in paired catchments and hydrologic modeling.
– Periodic vegetation treatments will be required to sustain changes in water cycle.

Field program
– Install control structures & ground-based sensors in 3 catchments. Measure water cycle for 10 yr.
– Carry out vegetation surveys & design silvaculture treatments; including LiDAR.

Hydrologic modeling
– Set up RHESSys based on KREW/CZO & SNAMP parameterization
– Simulate effects of vegetation management
Node construction at Alpha site
Science summary

1. High evapotranspiration across a wide swath of mixed conifer forest
2. Higher water yield & resiliency to moisture stress in snow zone
3. Sustained forest management that provides measurable benefits for water supply will require both investment & verification
4. Better information is a critical foundation for water security, especially in a warming & more-variable climate

For bibliography of research presented see http://criticalzone.org/sierra
Contact: rbalesuc@gmail.com