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Effect of forest management on water yields and other ecosystem services in Sierra Nevada forests

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Project Summary

The Sierra Nevada harbors globally distinctive forest resources that deliver a wide variety of benefits to the citizens of California and elsewhere. These benefits derived from natural ecosystems – also called ecosystem services – include recreation, biodiversity-, conservation, water, and forest product-related services. These ecosystem services often pose competing aims relative to forest management, but there are few mechanisms to evaluate the tradeoffs and complements related to different strategies.

Water is arguably the highest-value ecosystem service associated with the conifer forests of California's Sierra Nevada. Yet the provision of this essential service is vulnerable to changes in the energy and water balance associated with climate warming. To date, we have observed more precipitation falling as rain versus snow, earlier snowmelt, and greater summer water deficits. Such climate forcing will impact the water balance for the foreseeable future. However there is the potential to manage the water balance in forest ecosystems. The dominant vegetation (i.e., trees) is highly productive, forms dense canopies, and consequently, uses a great deal of water. There is a strong positive correlation between annual net primary productivity (the ultimate measure of the photosynthetic capacity of the ecosystem) and evapotranspiration (the primary cause of water loss).

Any manipulation that reduces the productivity (i.e., removes trees) reduces evapotranspiration, shifts the balance of energy driving snowmelt, and thus may affect soil-water storage and streamflow. Water from the Sierra Nevada provides both hydropower and water supply to downstream users. Reducing and restructuring the forest vegetation density can also mitigate the negative impacts of wildfires as well as accomplishing important forest-restoration.

Research Program

Project Objectives

1. Determine rates of evapotranspiration in Sierran mixed-conifer/true fir forests;
2. Determine the water use efficiency of trees and shrubs in Sierran mixed-conifer/true fir forests;
3. Determine the potential for forest management to delay snow melt in Sierran forests;
4. Determine the potential economic tradeoffs of forest management treatments to affect water yield and ecosystem services; and
5. Involve stakeholders in decision-making regarding forest management and watershed effects.

Summary of Activities/Outcomes to Date

This long-term project has completed two years of field work and is active in outreach and site selection for future work. This involves four areas:

1) Developing leaf area prediction equations for Sierra Nevada conifers. This work is complete and we now have a set of equations for both prediction of leaf area on intensive research plots and for leaf area prediction from inventory data;

2) We have placed sensors in streams in control and burned areas, as well as in areas scheduled for future forest vegetation treatments to develop streamflow and stream temperature records. We have also placed soil-moisture, temperature, humidity, snow-depth and solar radiation sensors in strategic locations to develop spatial estimates of these quantities (Figure 1).

We have initiated hydrologic modeling to estimate the effects of forest vegetation treatments on the water cycle in mixed-conifer mountain forests. This modeling involves extensive analysis of field data and calibration of spatially explicit models using snow, soil moisture and streamflow data. The scales of modeling extend from 300-10,000 ac scale (Figure 2). The initial modeling is being leveraged from ongoing work in the study area.

3) Involvement of stakeholder groups through newsletters and a social media presence: http://ucanr.edu/sites/cff/Sierra_Nevada_Watershed_Ecosystem_Enhancement_Project/Newsletters_204/;

4) We have narrowed our search for field implementation sites to two areas on the Tahoe and Stanislaus National Forests. It is possible both areas will be used. Additionally, a private forest products company, Sierra Pacific Industries, has approaches us about installing similar studies on several of their watersheds.

We continue to anticipate that this work will provide new insights into the effects of forest structure on snow retention and water yields from Sierra Nevada mixed-conifer forests. The region continues to experience controversy over wildlife management, threats from fire, and water shortages are becoming a greater threat as we understand more about potential climate change in California. This work is as timely as when it was first proposed.

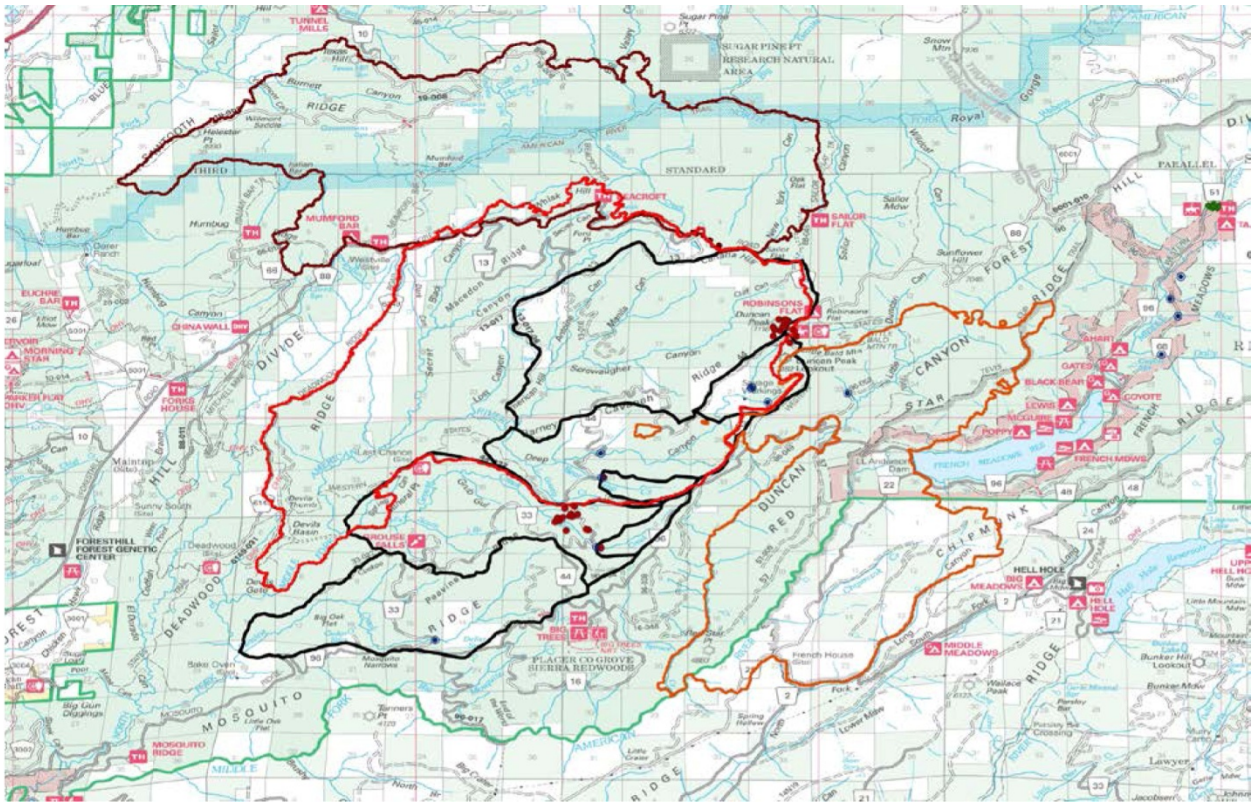

Figure 1. Map showing perimeters of watersheds and fires. Red dots are locations of snow, temperature and soil moisture sensors. Blue circles are stream level sensors.

Figure 2. Watershed surrounding unnamed steam in El Dorado County, California.

Information Transfer/Outreach Program

We have developed an annual newsletter that is posted on our website: http://ucanr.edu/sites/cff/Sierra_Nevada_Watershed_Ecosystem_Enhancement_Project/Newsletters_204/?newslist=4051. We also have a mailing list for distribution of these newsletters as well as a social media presence.