Sierra Nevada Adaptive Management Plan

Field Protocol and Study Plan
Water

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I. Background & Overview

Research will be carried out on the impacts of forest management, in the context of climate variability and change, in Sierra Nevada watersheds that are vulnerable to changes in their snowpack and thus water cycle. Work will consist of intensive field measurements in areas subject to treatment, and data analysis. These data will feed into modeling to interpret observed watershed response, and spatial scaling to estimate responses across larger areas. Two instrumented sites will be established in the Sierra National Forest, in the headwaters of the South Fork of the Merced River. Another two sites will be established in the Tahoe National Forest, in the headwaters of the North Fork of the Middle Fork of the American River. Each pair of sites will consist of a catchment subject to treatment and an untreated control catchment. Both of these will cross the rain-snow transition. This sampling regime provides both a before and after set of measurements and a parallel control set of measurements. Each catchment will be approximately 1-km^2.

Water quantity will be measured using continuously recording instruments for stream stage, soil moisture, precipitation, and snowpack. Meteorological measurements (temperature, relative humidity, solar radiation, precipitation, wind) will also be carried out. If feasible, we will install a control section (weir or flume) in the stream to enable more accurate discharge measurements for both high and low flow events. Otherwise, stream stage will be related to discharge by developing a site-specific rating curve. Soil moisture will be measured in instrument clusters covering a combination of different slope aspects, canopy openings, and tree species. In each location where soil moisture is measured, instruments will be placed at various depths to aid in understanding soil moisture levels throughout the soil profile. Precipitation will be measured at the meteorological station locations. Soil temperature will also be recorded. Snow depth will be measured using ultrasonic depth sensors, with soil moisture measured at multiple depths using time domain reflectrometry.

Autonomous stream water quality measurements will include stream stage, temperature, electrical conductivity, dissolved oxygen, turbidity, suspended sediment, and bedload. Temperature and electrical conductivity, together with discharge, will provide indications of stream response to runoff events, and facilitate inter-site comparisons. Turbidity, suspended sediment, and bedload will provide indications of erosion and sediment transport in the watersheds including their response to forest manipulations. Measurable responses for turbidity, suspended sediment, and bedload may be limited to periods during and immediately after storms, with interstorm periods having values below the detection limit.

Data will be retrieved, and if feasible, telemetered via radio to enable continuous monitoring of measurements. Quality control procedures will be established for the data, and the data made publicly available via the internet. It is proposed to make the data available through the California Data Exchange Center.

II. Location & Site Description

Field sites for this study will consist of two locations, a northern and southern site. For each site, one instrument cluster will be in a catchment subject to treatment and the second in an untreated control catchment. This provides both a before and after set of measurements and a parallel control set of measurements. Each instrument cluster will have an approximately 1-km^2 footprint, will include a perennial stream reach, and will consist of both aquatic and terrestrial measurements. It is desirable to choose a response reach of the stream for sediment and water quality measurements, one that is not too steep and is subject to sediment deposition and scour.

The southern site will be located on the Sierra National Forest near Fish Camp, California. The southern site is part of the SNAMP study area named Sugar Pine. The northern site will be located on the Tahoe National Forest near Foresthill, California (Figure 1). The northern site is part of the SNAMP study area named Last Chance. The study watersheds at the two site locations were chosen to be comparable in size, gradient, discharge, aspect, and vegetation cover.

The two southern watersheds chosen are Big Sandy Creek and Speckerman North Creek. The treatment watershed is Big Sandy Creek, which flows into Big Creek at Big Sandy Campground. The sediment basin and water quality instruments will be located approximately 500 meters upstream of the confluence with Big Creek. The control watershed is Speckerman North Creek, which flows off the north side of Speckerman Mountain above Jackson Road. The sediment basin and instrumentation for this site is located approximately 600 meters upstream of the Jackson Road crossing. Both watersheds are in Madera County, California and are part of the South Fork of the Merced River watershed (Figure 2).

Two meteorological stations will also be set up at the southern site. The lower elevation station will be located at Big Sandy Campground off Jackson Road and the higher elevation site will be located near Fresno Dome.

The two northern watersheds chosen are Frasier Creek and Bear Trap Creek. The treatment watershed for the northern site is Bear Trap Creek and the control watershed is Frazier Creek. Both watersheds are above Forest Service Road 44 (Cavanah Deep Rd.) and flow into the North Fork of the Middle Fork of the American River. Sediment basins and water quality instrumentation for these sites will be located approximately 50 meters from their respective Road 44 crossings. These watersheds are located in Placer County, California (Figure 3).

The two meteorological stations for the northern site will be located off Forest Service Road 44 between Frazier Creek and Bear Trap Creek (lower elevation station) and at Duncan Peak near Robinson Flat Campground (higher elevation station).

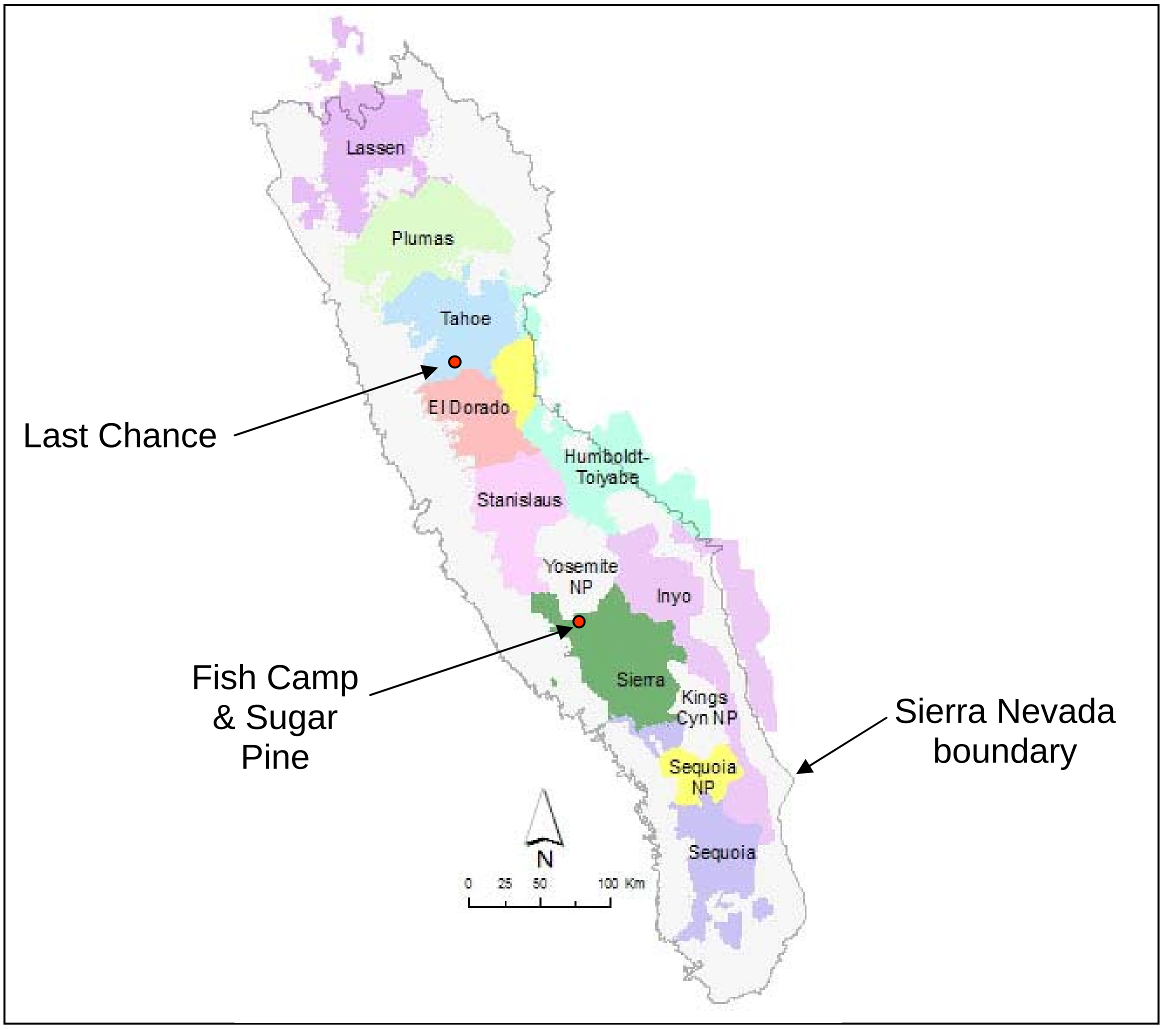
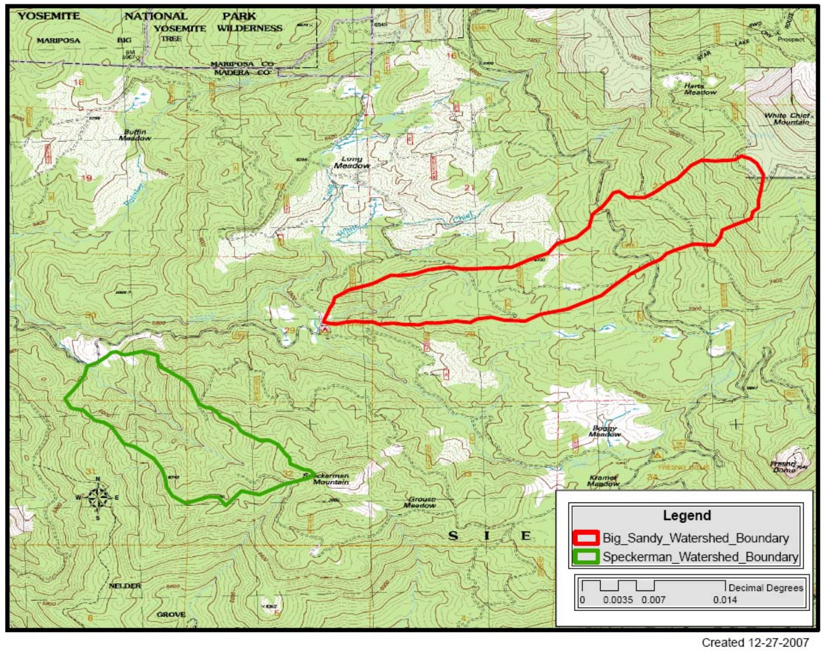


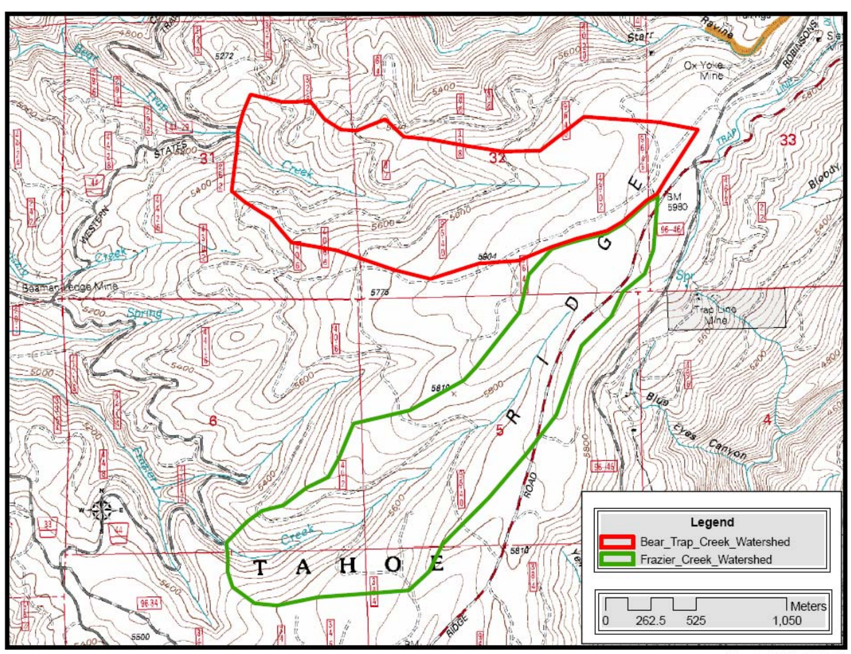
Figure 1. Project site locations.

Study Sites in Sugar Pine SNAMP Site –



a.)

Study Sites in Last Chance SNAMP Site – Watershed Boundaries



b.)

Figure 2. Watershed maps for Big Sandy Creek and Speckerman North Creek in Sierra National Forest (a), Beartrap Creek and Frazier Creek in Tahoe National Forest (b).

III. Meteorological Stations

Four meteorological stations (Figure 3) have been constructed, two each at the northern and southern sites. The stations are placed at the higher and lower elevation boundaries for the study watersheds, to catch the range of conditions present. Exact locations are governed by NWCG National Fire Danger Rating System Weather Station Standards. These standards state that sites should be "in large, open areas away from obstructions and sources of dust and surface moisture. The station should be on level ground where there is a low vegetative cover. Furthermore, it should be situated to receive full sun for the greatest possible number of hours per day. Security from animals and humans should also be considered when selecting a site." (NWCG National fire Danger Rating System Weather Station Standards) The following rules should also govern the location:

1. Locate the station in a place that is representative of the conditions existing in the general area of concern. Consider vegetative cover type, topographic features, elevation, climate, local weather patterns, etc.
2. Select a site that will provide for long-term operation and a relatively unchanged exposure. Consider site development plans, e.g., roads, buildings, parking areas; ultimate sheltering by growth of vegetation; and site accessibility during the intended operational period.
3. Arrange the station so as to give data that is representative of the specific area of concern. Consider exposure requirements for each instrument in relation to such things as prevailing winds, movement of the sun, topography, vegetative cover, nearby reflective surfaces, and wind obstructions.

Figure 3. Meteorological station located at Duncan Peak in the Tahoe National Forest.

Meteorological stations for this study will collect 24 hour data and will be in operation for 12 months of the year. Data will be transmitted remotely via GOES satellite on an hourly basis. A GPS unit is associated with the GOES antenna to locate and synchronize clock for transmission. Real-time data for each weather station is currently available through the California Data Exchange Center (CDEC) http://cdec.water.ca.gov/cgi-progs/staSearch?staid=&sensor=17&dur=&active=&lon1=&lon2=&lat1=&lat2=&nearby=&basin=ALAMEDA+CR&hydro=CENTRAL+COAST&county=ALAMEDA&agency_chk=on&operator=UC+Merced&display=staid.

The following measurements are recorded hourly at each weather station. If measurement is averaged, intervals are given below.

A. Precipitation (inches)

Precipitation is the amount of water falling upon the earth as rain or in frozen form as snow, sleet and hail. It is expressed as the depth of water that would cover a flat surface. Year-round precipitation amount & duration will be measured using a heated tipping-bucket precipitation gage.

B Wind Speed (mph)
Wind speed is the rate at which air passes a given point, recorded at 10 minute averages.

C. Wind Direction (degrees)
Wind direction refers to the direction from which the air is moving, recorded at 10 minute averages.

D. Air Temperature (°F)
Air temperature refers to the air surrounding the weather station instrumentation.

E. Relative Humidity (%)
Relative humidity is the percentage ratio of the actual amount of water vapor in the air to the amount of water vapor required for saturation at the existing temperature, recorded at 10 minute averages.

F. Battery Voltage (volts)
Battery voltage is the datalogger battery current voltage. This item is recorded for remote troubleshooting and data validation purposes.

G. Solar Radiation (W/m^2)
Solar radiation measure the amount of sunlight the area receives, recorded at 60 minute averages.

H. Snow Depth (inches)
Snow depth is the level of snow currently on the ground.

IV. In-stream Equipment

YSI 6920 V2 water quality sondes (Figure 4) will be placed in each stream, upstream of sediment basins (described later). These sondes will record 15 minute continuous measurements of the following parameters:

A. Stream Level (m)
Stream level is monitored and related to discharge to determine the total volume of water leaving the catchment, using a flume or stage-discharge method described below.

B. Dissolved Oxygen (mg/L)
Measures the amount of oxygen in the water available to aquatic plants & animals.

C. Turbidity (NTUs)
Turbidity is a measure of the amount of suspended sediment particles in the water.

D. Conductivity (µS/cm)
Conductivity is a measure of the amount of dissolved ionic species in a solution, such as Calcium, Magnesium, & Sulfates.

E. Temperature (°F)
Sensor records stream temperature, often needed to compensate or calibrate many of the other parameters measured.

Figure 4. YSI 6920 Water Quality Monitoring Sonde

Pressure Transducers

Other transducers may be placed in the stream above/below the sediment basins to better monitor the highest and lowest ranges of streamflow.

ISCO 3700 Automatic Stream Water Samplers

Samplers will be installed at same locations at YSIs, obtaining a 1-Liter stream water sample every two days for analysis.

Stream Discharge Determination

Stream discharge will be determined by either a stage-discharge relationship, or construction of multiple flumes in the stream channel. A stage-discharge relationship is developed at a stream location by measuring the discharge at different stages (levels) of the natural stream channel. This relationship can then be used to determine discharge for all stream level measurements. Flumes (Figure X) constrict the flow of stream water through a constructed channel with specified dimensions. The level of water flowing through a flume can then be converted to discharge using known relationship equations. A small flume upstream is paired with a large flume downstream to accurately determine discharge at both low and high flow periods.

V. Sediment Basins

Sediment basins structures will consist of a dam, pool/ponding area, upstream cross-vane structure, and rock spillway. Basins are designed to be roughly 40-60 feet in length and 10-20 feet in width. Low gradient reaches were selected to keep the dam height as low as possible while maintaining this ponding length. The dam will be built from logs gathered locally from the hillslopes. The logs will be held in place using 5/8 inch rebar rods placed roughly 2-3 feet apart. Approximately 4-8 feet of log will extend into each bank to further anchor the dam. A notch will be cut in the top of the dam and sized to each stream's cross-sectional area at bankfull flows. The pool behind the dam will be excavated to the required dimensions. They will have log and sandbag sides and will be lined with standard pond liner fabric that will be nailed to the dam and sides to hold in place. A cross-vane structure will be placed at the upstream end of the pool to direct flow into the sediment basin and prevent seepage under the pond liner undermining the basin structure. The filter fabric will be laid under the cross-vane structure and secured on the upstream side. Construction specifications for the cross-vane structures are from Rosgen, 2006. A boulder spillway will be constructed directly below the dam to reduce below dam scour. Boulders will be collected locally.

Construction will take place during late summer or early fall when low flow conditions exist in the streams. Flow will be temporarily diverted through corrugated drain pipe while construction is in progress. Following construction, sediment basins will be maintained through yearly excavation of accumulated sediment which will be collected and characterized. Excavation and sediment characterization will also take place in late summer or early fall during base flow conditions.

Scour pans may also be place at the upstream and downstream ends of the basin as well as a turbidity meter at the outlet of the basin. USGS Load Cell Scour Sensors will be used for the scour pans. These sensors contain a pressure transducer that measures the weight of sediment sitting on the pan. Measurements will be taken every 15 minutes. A YSI 600 OMS Sonde with optical turbidity sensor (see description above) will be used to measure turbidity at the outlet of the basin. The upstream scour pans will help gather information about the timing of sediment entering the basin, while the downstream scour pans and turbidity meter will allow us to monitor any suspended sediment or bedload not captured by the basins.

VI. Hillslope Measurements

Soil moisture/snow depth nodes will be placed on the hillslopes near the meteorological stations and the sediment basin/water chemistry sites. At the meteorological stations, the nodes will be placed in clusters on the north and south facing slopes adjacent to the towers. These clusters will consist of 2 to 6 hillslope nodes placed under the canopy, under the drip edge and in the open for 1 to 2 tree species. Each south facing slope node will have a counterpart (same species and canopy location) on the north facing slope.

At the sediment basin sites, two nodes will be placed on each hillslope above the stream. On the right bank/hillslope, one node will be located directly above the bank, at or near the floodplain, and a second node will be placed no more than 10 meters upslope from the first. The same setup will be repeated for the left bank. Care will be taken to place the corresponding left and right bank nodes under the canopy of the same tree species.

Each hillslope node will consist of automatically logging snow depth and soil moisture instruments placed in a vertical transect. Soil moisture instruments will be installed at 10 cm, 30cm, 60 cm, and where possible 90 cm depths. Snow depth sensors will be mounted to posts directly above the soil moisture instruments. Decagon ECH_2O-TM sensors will be used to measure soil moisture. These instruments obtain the volumetric water content by measuring the dielectric constant of the soil. Judd Ultra Sonic Depth Sensors will be used to measure snow depth. Both measurements will be taken every 15 minutes.

Sap flow measurements may also be added and placed in individual trees that the hillslope nodes are clustered around. These instruments will also be automatically logging.

VI. Current Status

As of May 2008, the four weather stations are the only instruments that have been installed and are actively taking measurements. During summer 2008, it is expected that all other instrumentation will be installed and working. This process involves creating four stream monitoring sites, each one consisting of a sediment basin, automatic stream sampler, water quality sonde, and one or more water level loggers. In addition, 36 snow depth/soil moisture nodes will be installed near the weather stations and stream monitoring sites. Installation is planned to be completed by the end of the year, ideally in time to completely measure the winter season snowpack.

References:

1. *NFDRS* is available online at the following link
   http://www.fs.fed.us/raws/standards.shtml

2. *Rosgen, D.L., 2006. Cross-Vane, W-Weir, and J-Hook Vane Structures (Updated 2006), Wildland Hydrology, Ft. Collins, Colorado p1-22.*

   and is available online at the following link.

   http://www.wildlandhydrology.com/assets/The_Cross_Vane_W-Weir_and_J-Hook_Structures_Paper_Updated_2006%20.pdf