3.3 - Watershed Studies

Several watershed related studies are ongoing in the East Fork drainage. In 1995 the Sequoia-Kings Canyon Field Station (USGS-BRD) began an evaluation of the effects of prescribed fire on stream chemistry, and hydrology. An additional study was also initiate by UC Davis to identify macro-invertebrate populations and assemblages in selected streams. The East Fork and six tributaries, located on the north side of the East Fork and Mineral King Road, were chosen to study the effects of fire on stream chemistry, hydrology and aquatic biota (**Fig. 3.3-1**).

MANAGEMENT IMPLICATION OF WATERSHED STUDIES

The report for the Sierra Nevada Ecosystem Project (SNEP 1996) states that "aquatic/riparian systems are the most altered and impaired habitats of the Sierra". According to the report, 64% of the aquatic habitat throughout the Sierra Nevada is declining in quality and abundance. Small streams and springs are more affected by adjacent land use and receive lower standards of protection than do larger streams. These streams are particularly vulnerable to impacts from grazing and other permanent land disturbance such as development and road construction, which lead to increased sediment delivery to these streams. They are also affected by both the presence or absence of fire.

Sequoia and Kings Canyon National Parks with a high level of land protection is not threatened by many of these factors. As a result, small watersheds in these parks can serve as a laboratory for learning about the dynamics and functioning of fragile systems in a largely natural settings. This information will be important in understanding our watersheds and for other land management agencies that are interested in restoring small watersheds.

However, many Sierran ecosystems have been severely altered by a century of reduced fire frequency (Kilgore and Taylor 1979; Pitcher 1987; Swetnam et al. 1992; Caprio and Swetnam 1995; SNEP 1996). This has resulted in unnaturally heavy fuel buildups and more homogeneous forests, which have almost certainly altered the riparian stream corridors that drain those forests. These changes have severely impacted many ecosystems within Sequoia and Kings Canyon National Parks. While it is not

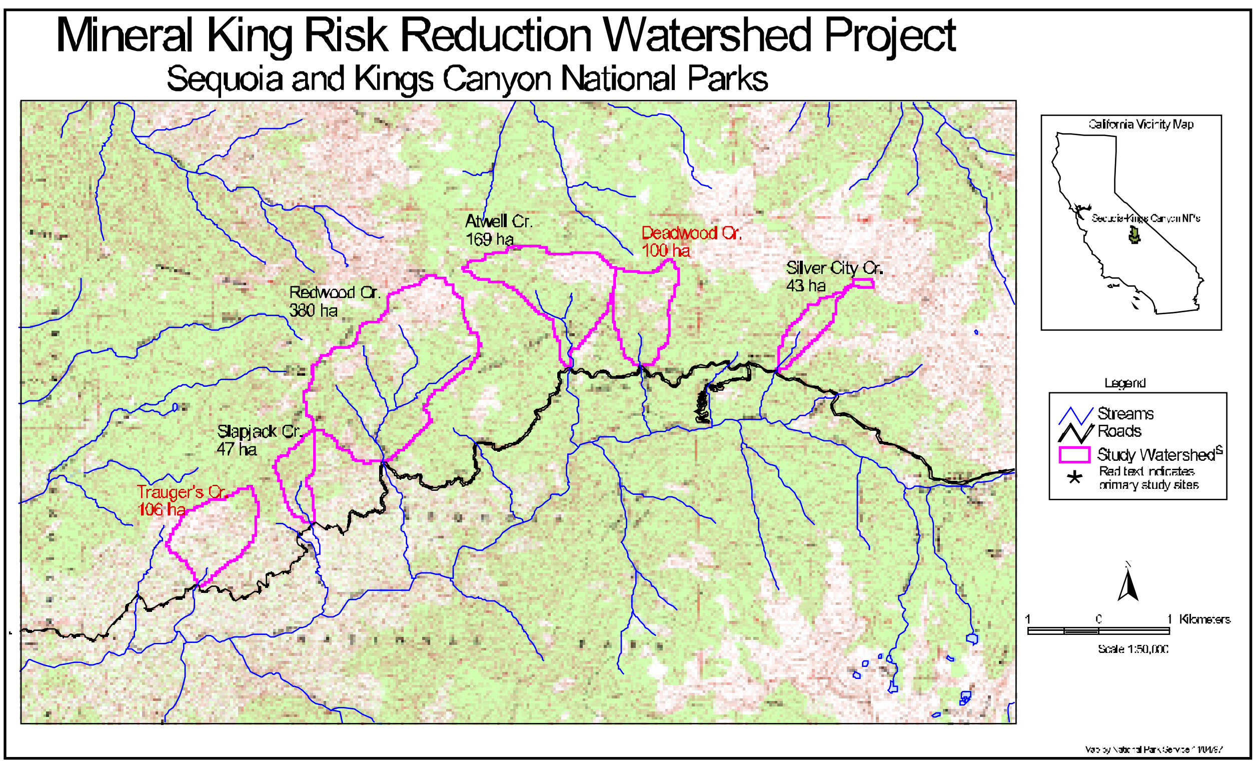

Figure 3.3-1. Tributaries of the East Fork used in the watershed studies.

possible to know what the stream chemistry and hydrology patterns were like 100 years ago, changes in the riparian corridor such as an increase in large woody debris in streams, a reduction in sediment pulses due to fire suppression, changes in snowmelt and evapotranspiration patterns, and the shading of the streams, have resulted in changes in stream dynamics over the last century. This study will also provide insight on how fire suppression influenced these watersheds. Preburn hydrochemsitry and hydrology results will provide a benchmark with which to measure the fluctuation of stream chemistry and discharge in postfire conditions.

Aquatic invertebrates, a key component of aquatic ecosystems, can be used to monitor the impacts of change in watersheds when spatial and temporal are also considered (Erman 1996). The aquatic macro-invertebrate research along the East Fork of the Kaweah River near Mineral King will determine the spacial and temporal distribution of aquatic species and assemblages. The results of this study will provide information on inter- and intra-stream variability in species diversity and abundance in undisturbed small order streams in the Sierra. Additionally, the results will enhance our understanding of the impacts of prescribed fire on the structure of macro-invertebrate communities in the Sierra once the drainages are burned. While prefire surveys of aquatic invertebrate communities provide a baseline for monitoring and developing a catalog of information on the parks' biological resources, post-fire long-term research will track the response and recovery time of communities to prescribed fire while supplementing biological inventory.

3.31) Watershed: Stream Chemistry and Hydrology

- Claudette Moore, Biological Resources Division of the USGS

Lead: C. Moore, A. Esperanza, D. Graber (NPS), Crew: A. Huber

As part of the MKRRP, the Sequoia-Kings Canyon Field Station (USGS-BRD) initiated a watershed study in 1995 to evaluate the effects of prescribed fire on stream chemistry, hydrology and aquatic macro-invertebrate communities. We are monitored ten 1^{st} and 2^{nd} order streams on the north side of the East Fork Kaweah River as a pilot study during the summer of 1995. Two primary streams and four secondary streams were then selected for long-term monitoring, which includes discharge measurements, solute analyses.

OBJECTIVES

One objective of the East Fork Watershed project are to evaluate the effects of prescribed fire on the hydrology, hydrochemistry and sediment transport of first order streams. Specifically, the study will quantify solute inputs for each watershed using wet deposition data from the NADP and CARB collection sites. Solute exports will be quantified using stream discharge and periodic chemical samples.

A second objective is to evaluate the effects of fire on the East Fork watershed as a whole. Solute exports will be determined from East Fork stream samples collected at Lookout Point and discharge measurements collected by Southern California Edison below Lookout Point. Solute inputs will be determined using wet deposition data from the NADP and CARB collection sites. The Mineral King burn project provides the opportunity to evaluate fire effects on watersheds at two scales - large (ca. 21,000 ha) and small (ca. 100 ha). Previous research has mainly focused on small (<100 ha) watersheds.

The third objective is to compare the effects of fire in the Deadwood watershed with the observations made from the Log Meadow prescribe fire project– located in Giant Forest, Sequoia National Park– in which paired watersheds (Log and Tharp's) were monitored. Geomorphology and stream characteristics in the East Fork watershed are different from those in the Log Meadow watershed. These differences will allow us to generalize our characterization of response to fire and compare responses in watersheds with different landscape features. Preliminary stream studies in Yellowstone (Minshall and Robinson, 1992) show that slope and stream order affect how fire affects streams. Continued monitoring in the East Fork will allow us to make a comparatively evaluation of recovery rates of parameters such as nitrogen and sulfur constituents, pH, and alkalinity.

EAST FORK SITE DESCRIPTIONS

Trauger's Creek and Deadwood Creek are the primary focus for the stream chemistry and hydrology study. Both tributaries are first order perennial streams. Their riparian areas are distinctly different as they are separated by an elevation difference of approximately 600 meters.

1. **Trauger's Creek** is a low elevation (1400 m) watershed (106 ha) with mixed chaparral/oak-woodland in a transition zone between the lower mixed-conifer zone and the upper chamise-chaparral zone. Dominant species include California live oak (***Quercus*** spp.), incense cedar (***Calocedrus decurrens***), maple (***Acer macrophyllum***), California laurel (***Umbellularia californica***), spicebush (***Calycanthus occidentalis***), and willow (***Salix*** spp.). Precipitation is measured by a tipping bucket at Lookout Point, two miles west of the study and is operated by the National Park Service.

2. **Deadwood Creek** is a mixed-conifer forest (2000 m) watershed (100 ha) characterized by white fir (***Abies concolor***), red fir (***Abies magnifica***), giant sequoia (***Sequoiadendron giganteum***), and incense cedar (***C. decurrens***). Precipitation measurements for this site are recorded at the Atwell Mill stables, approximately one mile west, by the Army Corps of Engineers.

Both streams are equipped with stilling wells, constructed of 10 inch diameter PVC pipe, that enclose two pressure transducers and a thermistor at each site. Stage and temperature data are recorded every five minutes on Omnidata portable data loggers. The data loggers were installed in February 1996. Weekly chemical samples are collected from each stream. Stream sampling commenced in May 1995. Weekly grab samples are also collected from the East Fork at Lookout Point and discharge data are collected by Southern California Edison below Lookout Point.

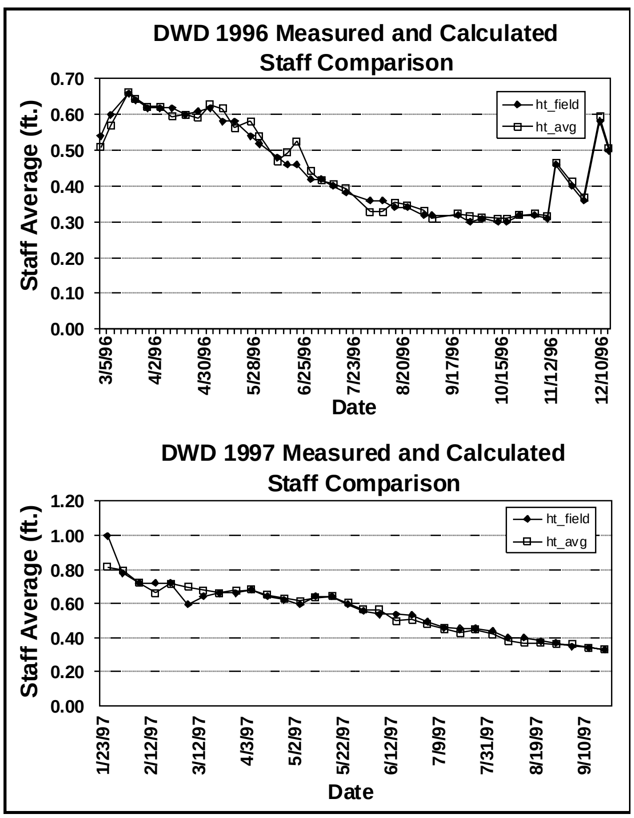

Figure 3.31-2a. Comparison of measured and calculated staff values at Deadwood Creek for WY 96 and WY 97.

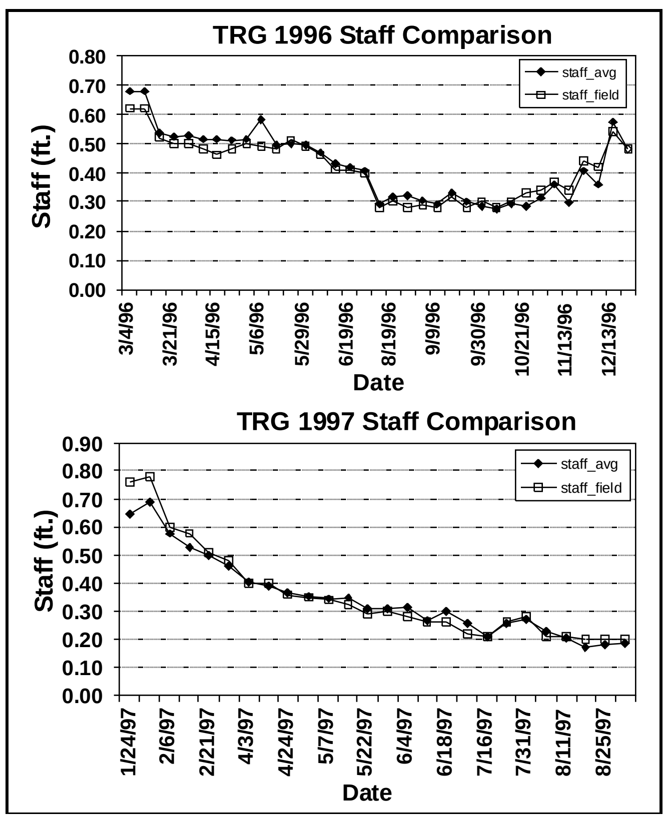

Figure 3.31-2b. Comparison of measured and calculated staff values at Trauger's Creek for WY 96 and WY 97.

Stream chemistry and discharge data were also collected from four secondary stream sites (Slapjack, Redwood, Atwell and Silver City) used in the macro-invertebrate study (see section 3.32) on a rotational basis. Sampling ended at these streams in October, 1997.

CURRENT STATUS

Preliminary data analysis was initiated for pre-burn hydrochemistry and discharge data from the Trauger's and Deadwood watersheds. The discussion below is based on data from wateryear 1996.

Hydrology

Discharge data were calculated from salt dilution and pressure transducer data. Two regression equations were required to make these calculations. First, a regression was derived using the pressure transducer data and corresponding measured staff heights. This equation produced a very good fit, r^2 of 0.93 and 0.91 for Deadwood (DWD) and Trauger's (TRG), respectively. Transducer data were converted to staff data, and a comparison of measured staff values and calculated staff values was made for each creek for 1996 and 1997 (**Fig. 3.31-2a** and **Fig. 3.31-2b**). The average calculated values were derived from an average of transducer 1 and 2. There was better correlation in 1997 between the measured and calculated staff heights because we had fewer problems with the data loggers, however both years showed good correlation. The measured staff heights were recorded weekly in most instances.

The second part of the discharge calculation involved developing a regression equation from the salt dilution (SD) data. The DWD stream rating curve was based on 12 salt dilution measurements ranging from staff heights of 0.35' to 0.65'. The TRG rating curve was based on 16 readings with staff heights ranging from 0.20' to 1.32'. These rating curves produced r^2 values of 0.78 and 0.89, respectively. These were preliminary rating curves, as more salt dilution data are needed during high flow periods.

The discharge measurements from TRG and DWD were used to determine runoff coefficients (the ratio of runoff to precipitation) for water year 1996 (**Fig. 3.31-3**). The DWD ratio of 0.90 was an overestimated. Generally, coefficients were in the range of 60-70 percent for small forested watersheds (Williams 1997, Melack et. al., 1998). The ratio for Trauger's Creek was 0.62. For comparison, the Log Creek runoff coefficient for water year 1996 is included. This is the control watershed in the Log Meadow study area.

More salt dilution data points and improved technique will enable us to produce more refined and accurate stream rating curves for these streams. Additional calculations using the culverts at each site will also be used to determine discharge, and will be correlated with the salt dilution results to refine the regression equation.

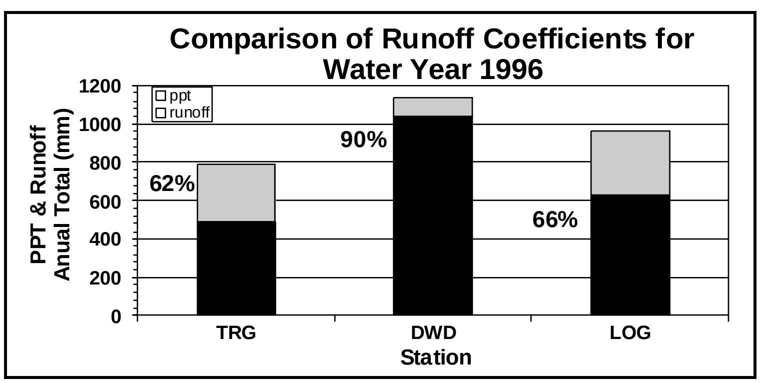

Figure 3.31-3. Runoff coefficients for Trauger's, Deadwood and Log Creeks for Water Year 1996.

Hydrochemistry

Solute data were summarized by watershed for Trauger's and Deadwood for water year 1996 (**Table 3.31-3**). More years of data are needed to fully describe the variability and range of solute concentrations in these watersheds. Vegetation and elevation differences were likely contributing factors to the differences in stream chemistry between these sites. The watersheds showed similar temporal responses to shifts in flow, pH and ANC when compared with other Sierran watersheds (Black 1994; Melack and Sickman 1995).

Table 3.31-3. Summary of Trauger's and Deadwood Creeks solute outputs in kg/ha/yr for Water Year 1996.

Site	H^+	NH_4^+	Na^+	K^+	Ca^{2+}	Mg^{2+}	ANC	SiO_2	PO_4^{3-}	NO_3^-	SO_4^{2-}	Cl^-
TRG	0.00	0.00	46.55	6.43	26.77	4.24	182.32	59.24	0.10	0.00	2.32	5.27
DWD	0.00	0.00	49.32	12.32	59.68	11.54	86.30	84.96	0.05	0.01	3.56	3.81

Stream temperature values were reviewed for the available data for water year 1996 for Deadwood and Trauger's Creeks, along with the highest recorded temperatures (**Fig. 3.31-4a** and **Fig. 3.31-4b**). There were some gaps in the Trauger's data set due to equipment failure in the summer of 1996, however, the trend is evident. Winter and fall temperatures were less variable and range between 5°C to 8°C in Deadwood, and 6°C to 14°C in Trauger's Creek. Stream temperature peaked in June at Deadwood, with an average of 13.5°C and a max of 16°C. While the fall and winter stream temperatures varied by >1°C, summer temperatures varied more than 4°C. Monthly stream temperatures in August at Trauger's Creek also varied more than 7°C and had 6 days with temperatures exceeding 20°C.

These baseline stream temperatures will be important in assessing postfire impacts on these streams. Since many aquatic biota have upper stream temperature limits, additional information on insolation collected as part of the macro-invertebrate study (Erman et al. 1996), will provide additional insight for determining how changes in canopy cover along the stream corridor affect stream temperature.

GOALS FOR 1998

The plans for 1998 are to continue collecting pre-burn hydrochemistry and discharge data at Trauger's and Deadwood Creeks, and in the East Fork. Additional samples are also being collected during storms to capture variability in solute concentrations during high flows. This will increase accuracy in determining annual loads in these watersheds. Additional time will also be spent fine tuning

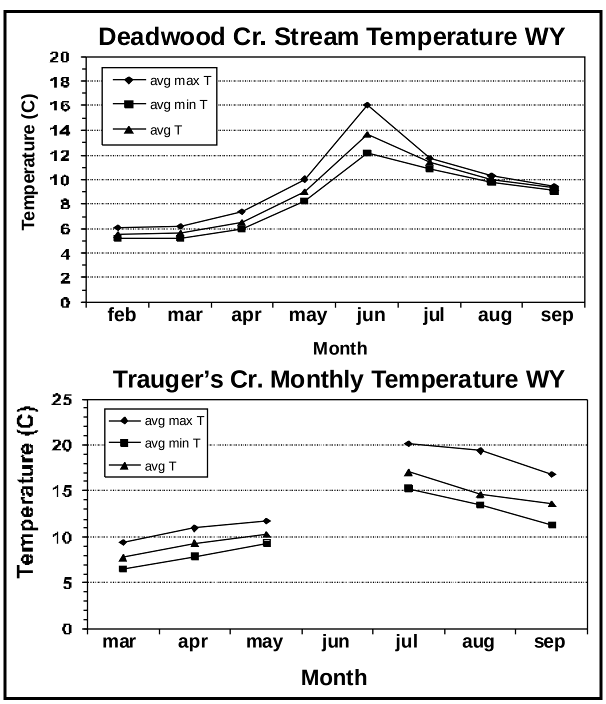

Figure 3.31-4a. Comparison of stream temperatures at Deadwood Creek (top) and Trauger's Creek (bottom) for WY 1996.

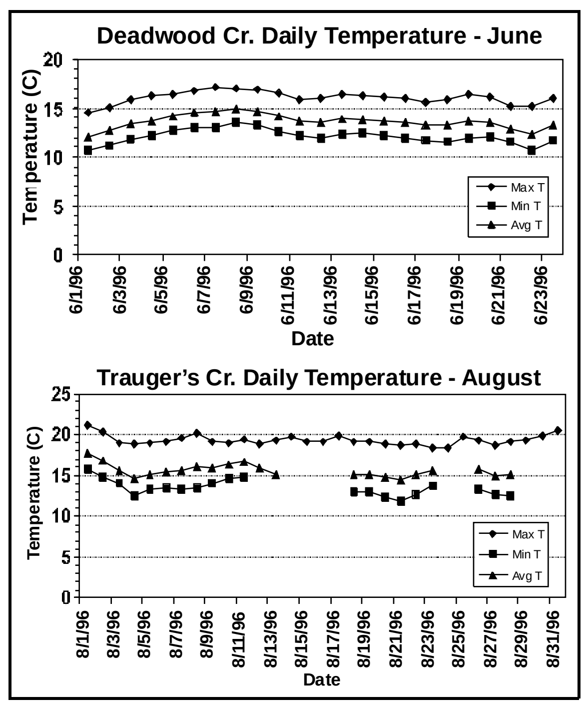

Figure 3.31-4b. Comparison of daily stream temperatures at Deadwood Creek (top) during June 1996 and Trauger's Creek (bottom) during August 1996.

the rating curves for Trauger's and Deadwood Creeks with additional high flow salt dilution measurements. Data analyses will continue and preburn solute ranges during low flow and high periods will be determined.

We are also very interested in conducting a sediment project in conjunction with the on going physical and biological research. We have established contacts to pursue a sediment project and hope to have a proposal and budget for research this year.

3.32) Watershed: Macro-invertebrate Study

- Ian Chan, Graduate Research Assistant, Department of Wildlife, Fish, and Conservation Biology at University of California, Davis under the direction of Dr Don C. Erman and Dr. Nancy A. Erman.

Summarized from 1997 annual report by D. Erman, N. Erman, and I. Chan (Erman et al. 1997)

INTRODUCTION

Watershed monitoring is necessary for ecosystem-scale management, and baseline and reference information are essential to this objective. Understanding the variability in natural systems, and then how management practices affect physical and biological resources, provide knowledge of ecosystem function and improve management choices. Biological monitoring of headwater ecosystems is an important component of understanding linkages between hillslope and instream processes. As such it represents an indispensable tool for watershed management. Information such as population size, species richness, or community diversity provide an better biological picture of the larger ecosystem. This study examines aquatic macro-invertebrate communities of tributaries of the East Fork of the Kaweah River as part of the monitoring efforts to assess the impacts of large scale prescribed burning. Such information allows consideration of the status of aquatic biota in management processes that determine the fate of aquatic habitats.

Aquatic habitats are one of the most altered and threatened biotic communities in California (SNEP 1996) with small freshwater habitats among the most understudied and undervalued aquatic resources. These habitats are often overlooked when considering watercourse protection, in spite of the fact that unique and rare species frequently occur only in these areas (Erman 1996). Headwater and low order streams are transitional zones between terrestrial and aquatic ecosystems (Naiman and Decamps 1990) and biological monitoring is an important part of understanding linkages between hillslope and instream processes within these streams. Gregory et al. (1987) state, “The landscape and biotic communities of terrestrial and aquatic ecosystems are intricately linked, and effective management must acknowledge and incorporate such complexity.”

Fire is a integral ingredient of the complexity of aquatic habitats in many locations, affecting physical and biological characteristics (Tiedemann et al. 1979; Schindler et al. 1980; Minshall et al. 1989). Most studies on the impact of fire on these habitats have been from the perspective of wildfire. Wildfire impacts on streams may cause short-term and long-term effects. Short term impacts may include sudden increases in temperature, deposition of wood ash, changes in pH, increases in ionic composition and nutrients, and possibly increased sedimentation if watershed conditions promote erosion (Johnson and Needham 1966; Schindler et al. 1980; Amaranthus et al 1989; Spittler 1989). Long-term changes may include reductions in canopy, loss of large near-stream or instream woody debris, reduction in wood recruitment, and changes in flow (Roby 1989; Amaranthus et al. 1989; Nasseri 1989). Limited research on macroinvertebrate communities has shown the potential for both short and long-term effects (Albin 1979; Roby 1989) with these communities acting as sensitive indicators of the impacts of fire.

This study utilizes the opportunity to make before-after comparisons in combination with treatment-reference comparisons to provide conclusions about aquatic community responses and recovery. The multi-year scope of the prescribed fire operations will allow treatment-reference pairing of adjacent burned and unburned streams within target burn areas. Specific objectives of the study are to:

- Provide biological and physical resource data to compliment the stream hydrology and chemistry data necessary to assess the affects of fire on small streams.
- Begin a basic biological inventory of macroinvertebrates.
- Develop biological and physical sampling methodology for small bedrock streams.

- Determine the degree of natural similarity required between control and impact sites to learn what parameters make streams suitable for treatment-reference pairing in the Sierra.

STUDY AREA

Six first and second order tributaries in the northern portion of the East Fork drainage were studied– Trauger's, Slapjack, Redwood, Atwell, Deadwood, and Silver City Creeks (**Fig. 3.3-1**). Study reaches were located within the Lookout (segment #1), Atwell grove (segment #3), and Purple Haze (segment #7) burn segments. Portions of only the Redwood and Atwell Creek drainages have been burned (fall 1995) to date. All streams were small, high gradient, headwater tributaries with channels largely dominated by bedrock (granite) outcrops. Longitudinal profiles were typically sequences of cascades, plunge pools, and short riffles at pool ends. Where substrate was not bedrock, sediments were fine granite gravels and sands, with abundant allochthonous material in depositional areas. Streams were relatively well-shaded by a canopy of mixed conifers or mixed oak/chaparral and a variety of riparian vegetation along stream corridors.

METHODS

Benthic macroinvertebrates were collected from three habitat types: pools, riffles, and slickrock substrate (**Fig. 3.32-1**). Standard sampling methods, designed for larger freestone rivers, were modified or replaced for these habitats. Data was also collected on channel substrate, solar radiation along each study reach, and large woody debris (≥10 cm and ≥1 m length).

CURRENT STATUS

All field work has been completed and data analysis is in progress for publication. Field work was conducted from September 1995 through November 1997. This knowledge about the distribution and abundance of macro-invertebrates in pre-burn conditions will aid park managers in understanding both real and potential impacts resulting from fire on aquatic communities, an important but poorly studied ecosystem. The information will allow stronger conclusions about the types of responses and recovery can be expected in these habitats. Postfire sampling plans are being developed to continue this project.

Figure 3.32-1. Pyramidal trap used for sampling macroinvertabrates. Trap is placed within stream.