3.3 - Watershed Studies

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Projects

Stream Chemistry and Hydrology Study: Lead: Claudette Moore, Jon Keeley; crew: Andi Heard and Ann Huber

Aquatic Macroinvertebrate Study: Lead: Ian Chan, Don Erman, and Nancy Erman; crew: Ann Huber and Claudette Moore

Executive Summary

Watershed monitoring was initiated in the East Fork Kaweah River drainage as part of the Mineral King Risk Reduction Project (**Fig. 3.3-1**). The study was designed to assess the effects of watershed-scale prescribed burning on stream chemistry, discharge and aquatic macroinvertebrate communities. Two separate projects were initiated in 1995 to address these issues; the stream chemistry and hydrology project, and the aquatic macroinvertebrate project. The first project follows similar protocol used in the Log Meadow watershed pilot study, in which stream chemistry and discharge were compared in paired watersheds before and after fire.

In 1998, we concentrated on 1) fine tuning stream discharge rating curves for Trauger's and Deadwood Creeks, 2) developing monthly and annual volume-weighted mean concentrations for solutes in the study streams, 3) developing preliminary mass balance yields for Deadwood Creek using NADP wet deposition data and precipitation data from Atwell Mill, 4) collecting storm samples from Trauger's Creek to improve accuracy of wet season stream chemistry concentrations, 5) analyzing macroinvertebrate data and, 6) preparing the final aquatic

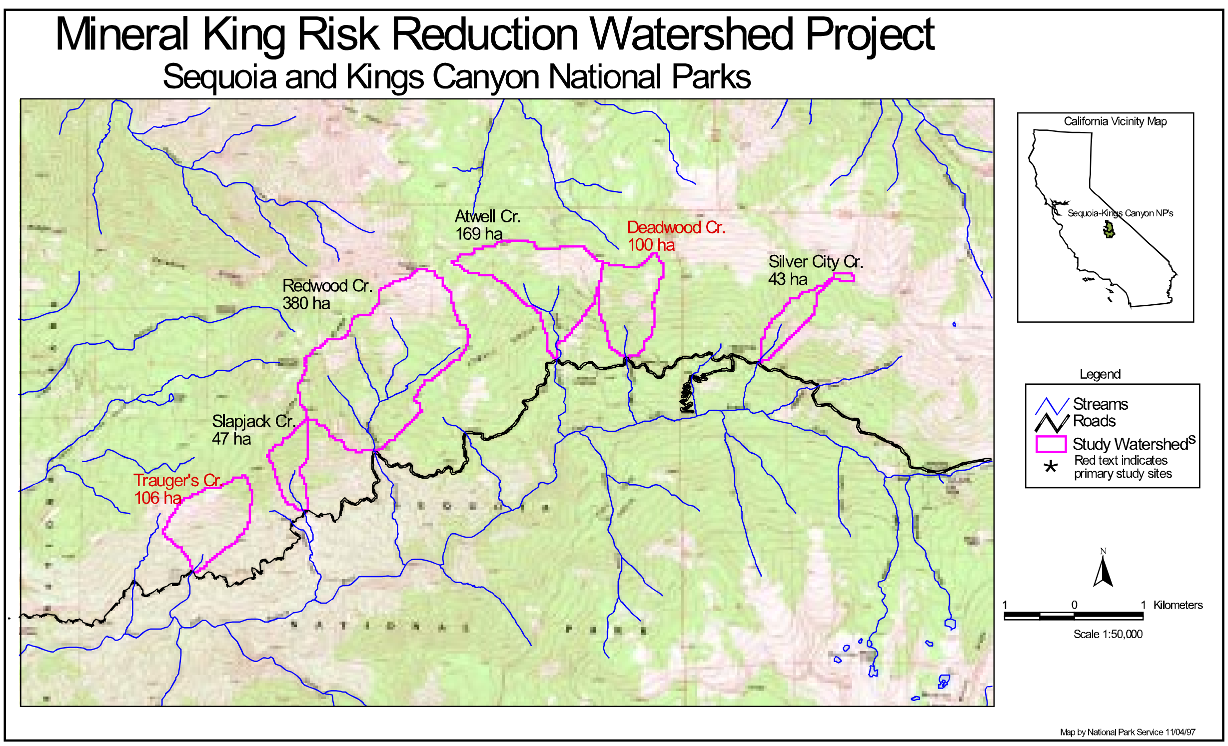

Figure 3.3-1. Tributaries of the East Fork used in the watershed studies.

macroinvertebrate report.

Stream discharge rating curves were developed based on two years of staff/discharge relationship measurements. To increase the accuracy of the rating curves, high and low flow data points obtained from other means were included in the regression analysis. The final rating curves were reviewed by UC Santa Barbara researchers and found to be derived under reasonable assumptions.

Solute concentrations varied seasonally within each catchment. While flux patterns for like solutes were similar, concentrations varied widely by catchment, a likely function of differences in vegetation cover, precipitation type and frequency, and underlying geomorphology. Base cations, and alkalinity were negatively correlated with discharge, as they were the result of mineral weathering. Hydrogen-ion was more variable, but overall, was positively correlated with discharge, and appeared sensitive to precipitation events. Sulfate was negatively correlated with discharge in East Fork and Deadwood, and positively correlated with discharge in Trauger's Creek. Sulfate concentrations in East Fork were five times greater than those observed in the smaller catchments. Mineral springs are found throughout the upper East Fork catchment and appear to influence sulfate concentration many river miles downstream. Trauger's Creek had high sodium and chloride concentrations when compared with other Mineral King study sites, and other Sierran watersheds.

Preliminary solute yields were calculated for the Deadwood catchment. As in other Sierran watershed systems, base cations are exported. Acid anions were exported during the dry season and retained during the wet season. The exception was sulfate, which was predominately exported. This may be the result of naturally high sulfate in the catchment, or underestimated deposition values.

Results of the preliminary aquatic macroinvertebrate study indicated that the 1995 prescribed fire in the Atwell segment did result in some change in Atwell and Redwood Creeks. Decreases in aquatic benthic invertebrate diversity were observed in 1996, despite more intensive sampling. Further study is needed to determine if this is a short-term change in species composition. The fire also resulted in increased large woody debris (LWD) per unit stream length, and an increase in fine sediments in the treated streams. Canopy cover and insolation were not affected by the fire in the treated catchments.

Aquatic invertebrate diversity generally increased with an increase in elevation, and taxa richness was consistently higher in fall samples. The Shannon Diversity Index and Evenness scores were the best indicators of invertebrate differences among sites. The commonly used EPT/D (Ephemeroptera, Plecoptera, Trichoptera/Diptera) ratio was not a useful indicator among sites.

INTRODUCTION

This work was initiated to evaluate the effects of fire on watersheds at two scales: small ($\approx$ 100 ha) and large ($\approx$ 20,000 ha). The literature is lacking in carefully designed studies to evaluate the effects of fire on watershed processes. Generally, watershed studies are initiated after fire has already moved through a watershed, making it difficult to assess the resulting changes due to the lack of pre-burn data. Much of what we know about fire effects on Sierran watersheds is derived from a 1990 pilot watershed study conducted in Log Meadow (Giant Forest), in which biogeochemical processes were compared in paired watersheds before and after fire. The Tharp's watershed (13.1 ha) was burned and the Log watershed (49.8 ha) served as the control site.

The striking chemical response of the pilot experimental watershed in Giant Forest to a fire led to incorporation of further watershed studies on streams feeding the East Fork of the Kaweah River as an element of the "Mineral King Risk Reduction Project." This experimental effort to reduce fuels and restore more typical ecological function to an entire landscape provides a valuable opportunity to measure the physical, chemical, and biotic effects of landscape-scale burning on streams, and on the river systems they feed. For example, fire-induced changes in stream chemistry and sediment loading can have significant effects on fisheries and reservoirs, respectively. Alterations in forest structure result in changes in hydrodynamics that can significantly affect the efficiency of water-storage and release systems. As the Departments of Agriculture and Interior have recently ordered substantial increases in the area of wildland burned each year; the research in Sequoia and Kings Canyon National Parks will provide for more sound implementation of ecosystem management throughout the semi-arid West. Continued monitoring in the East Fork will allow us to evaluate recovery rates of affected parameters such as nitrogen and sulfur constituents, pH, and alkalinity. Additionally, results from the aquatic biota survey will enhance our understanding of the impacts of prescribed fire on the structure of macro-invertebrate communities in the Sierra. While pre-fire 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 fire, while further enriching our understanding of biological diversity along structural and temporal axes.

SITE DESCRIPTIONS

The East Fork Kaweah is a diverse 20,000 ha basin comprised of first to third order subcatchments ranging from chaparral and hardwood forests at the lower elevations, to mixed-conifer and Sequoia forests at mid elevations. Alpine vegetation is found above 3,100 m. Six subcatchments within the basin are monitored as part of the watershed studies. Trauger's Creek and Deadwood Creek are the primary focus for the stream chemistry and hydrology study. Both tributaries are first order perennial streams. They are separated by an elevation difference of approximately 600 meters.

Four additional streams were monitored through 1997 as part of the aquatic macroinvertebrate study: Slapjack, Redwood, Atwell and Silver City Creeks. Limited baseline stream chemistry samples were collected from these streams in 1996.

METHODS

Watershed research in the East Fork has three primary areas of study: 1) stream hydrochemistry, 2) stream discharge, and 3) aquatic macro-invertebrates. The aquatic macro-invertebrates was conducted by UC Davis graduate student Ian Chan under the direction of co-principal investigators Don Erman, and Nancy Erman.

Stream Chemistry

The three study sites were sampled weekly throughout much of the water year. Grab samples were collected, with alternate replicates each month. This year, efforts were made to collect storm samples from Trauger's Cr. and the East Fork, and runoff samples during the snowmelt period at Deadwood Cr. Samples were filtered and processed at the Southern Sierra Laboratory within six hours of collection. On site analysis included pH (Beckman pH meter), alkalinity (Gran titration), conductivity (YSI 1.0 cm-1 cell), ammonium, phosphate and silica (colorimetric analysis). Additional base cation and acid anion analyses were conducted at the Rocky Mountain Station Water Analysis Laboratory in Fort Collins, CO.

Stream Hydrology

Continuous flow and stream temperature measurements have been collected at Trauger's and Deadwood Creeks using Omnidata 800 series data loggers since 1996. Each site is equipped with two pressure transducers, which enable us to monitor the sensors for drift over time, and provide continued coverage in the event that one sensor malfunctions. A thermistor records hourly stream temperature.

Data were downloaded and error-checked weekly. Flow data were calculated from October 1995 through February 1996 using weekly staff readings and precipitation records from Atwell Mill and Lookout Point. This time accounted for the period of WY 1996 prior to installing the data loggers.

Constant Injection Salt Dilution (Kilpatrick and Cobb 1985) measurements were conducted in Trauger's and Deadwood Creeks between spring 1996 and spring 1998 to capture the range of staff gauge/flow fluctuations. Replicate measurements were taken, and a rating curve was developed in July 1998. Slight changes in protocol were made in summer 199, and greatly improved the accuracy of our techniques. The rating curve was reviewed in Nov. 1998 by UC Santa Barbara researchers.

Aquatic Macroinvertebrates

The macroinvertebrate study focused on three areas of data collection: 1) benthic macroinvertebrates, 2) adult-stage insects, and 3) physical stream characteristics. Data collection commenced in the fall of 1995. Extensive sampling was conducted in the spring and fall of 1996. Adult-stage insects were collected through the fall of 1997.

Benthic Macroinvertebrates

Benthic macroinvertebrates samples were collected from three different habitat types: pools, riffles, and bedrock outcrops. Three different pools, riffles and bedrock outcrops were sampled. Analysis was based on a composite of four samples collected during each sample event between fall 1995 and fall 1996.

All invertebrate samples were preserved in 80% ethyl alcohol, and stained in a solution of rose Bengal dye to facilitate separation of invertebrates from collection debris. All of the 1995 samples and the 1996 bedrock samples were picked through, separated and identified in their entirety. Due to the large volume of debris in the 1996 riffle and pool samples, these samples were subsampled before identification was made.

To validate the lab subsampling and field composite samples, tests were carried out on all split fractions from three Trauger's Creek riffle samples collected on 21 September 1996. Several species richness and statistical tests were conducted to determine whether the subsampling and compositing methods accurately and adequately represented species richness and number of individuals. Results from these analyses showed no significant difference between subsamples from the sample riffle. Error from splitting samples was <5% for the total number of individuals.

Specimens were generally keyed to genus. Benthic samples were compared on the basis of diversity, evenness similarity, taxa richness, and number of individuals. Three indexes were used to determine the above: 1) the Shannon Index of Diversity, 2) the Jaccard Coefficient of Similarity, and 3) comparisons between Ephemeroptera, Plecoptera, and Trichoptera (EPT) and Diptera abundance. Samples were analyzed by habitat and season (spring and fall).

Adult-stage Aquatic Insects
Adult stage aquatic insects were collected using 1 m^2 pyramidal emergence traps. The traps were placed over pool habitats in the six study streams, and maintained from early April through late October during 1996 and 1997. Samples were collected weekly or biweekly. Collections were standardized into two week periods to allow comparison of samples collected on slightly different dates. Within standardized periods, adult insect emergence was described by average number of individuals collected per week/m^2 by insect order.

Physical Stream Characteristic
Stream order, elevation, slope and aspect were estimated from USGS 7.5 minute topographic maps. Watershed area was estimated using GIS (Resources Management, Sequoia NP). Discharge measurements from Trauger's and Deadwood Creeks were obtained from the USGS/BRD staff. Discharge for ungauged streams was estimated from the relationship between drainage area and mean annual discharge for streams in the Tulare Lake Basin (US Geological Survey). Solar insolation was calculated from three randomly selected sites for each stream.

The substrate surface layer was sampled using the random pebble count method (Wolman, 1954, Leopold 1970). Sub-surface bed sediments were collected using a modified excavated core (EC) sampler after McNeil and Ahnell (1964). Three cores were collected from three different pools. Large woody debris (LWD) surveys were conducted in each stream. Wetted width and bankful measurements were also collected.

RESULTS TO DATE

Due to the delayed turn around time in chemistry analysis, the following discussion is based on data from water years (WY) 1996 and 1997.

Stream Hydrology

Stream rating curves were developed based on two years of Constant Injection Salt Dilution measurements made at Trauger's Creek and Deadwood Creek. Preliminary rating curves were developed using data from the salt dilution measurements, which represented low to moderate flows in both streams. The lack of high flow data points in the rating curve is a limitation that is faced by many and was difficult to overcome. Based on the continuous flow data, each stream only has one significant spike in staff height each winter, lasting only a few hours. In Trauger's Cr., this usually occurs during a large rain event in February or March. In Deadwood Cr., this occurs during peak snow melt, which is hard to predict. To account for this deficiency in the data, maximum discharge values were determined using engineering histograms for flow through a culvert. These data points enabled us to determine how well the rating curves predicted high flows. In addition, since salt dilutions are known to over predict flows by as much as 30% (Melack et al. 1998), flow measurements were made using a 3.5 gal. bucket and a stop watch for the lowest observed staff heights.

The preliminary rating curve for Deadwood Cr. under predicted peak flow by 8% and over predicted the lowest flow by 44%. To improve the accuracy of the rating curve, it was recalculated using the peak and low flow points derived from alternative sources. This improved the accuracy of the rating curve for both the upper and lower ends of the curve (r^2 0.95 and 0.85 with and without additional measurements, respectively).

The preliminary rating curve for Trauger's Cr. over predicted peak and low flows by 53% and 160%, respectively. Although salt dilution results have been shown to over predict flow, something else was apparently influencing the measurements. Recent analysis of solutes revealed high concentrations of both sodium and chloride in Trauger's Cr, which were likely influencing the outcome of our measurements. To account for this naturally high concentration of sodium, the flow values were adjusted by 65%. This adjustment resulted in a rating curve that under predicted peak flow by 10% and over predicted low flow by 80%. The final rating curve was developed based on 65% of the original flow values, and included peak and low flow values derived from alternative means. This rating curve produced the best overall flow values for both high and low flow conditions.

These rating curves were reviewed by UC Santa Barbara researchers and found to be derived under reasonable assumptions. The inclusion of the high and low flow values makes the rating curves more robust and reduces error in over predicting low flows, which can persist for several months during late summer and early fall. High flow estimates will also be more accurate.

The relationship between precipitation and discharge is as one would expect. Trauger's, a rain-dominated catchment, reaches maximum discharge rates during the month with the greatest precipitation (usually Feb. or March), and drops of steeply throughout the spring. In years with low to normal precipitation, late summer and fall discharge rates fall below 1 cfs. Deadwood and East Fork are snow-dominated systems, thus, maximum discharge rates correspond to snow melt runoff in these catchments. Discharge peaks in April or May in Deadwood. The flood event in Jan. 1997 resulted in anomalous spikes in discharge in both catchments, and produced a second peak in discharge for East Fork in water year 1997 (**Fig. 3.3-2a and 3.3-2b**). Maximum discharge in East Fork occurred in June for water years 1996 and 1997. The onset of peak discharge in East Fork most likely occurs during June in years of low to normal precipitation. Black (1994) found that East Fork headwater lake systems peaked in June during a 1993 study, and historic data (USGS, 1973) also shows peak discharge in June.

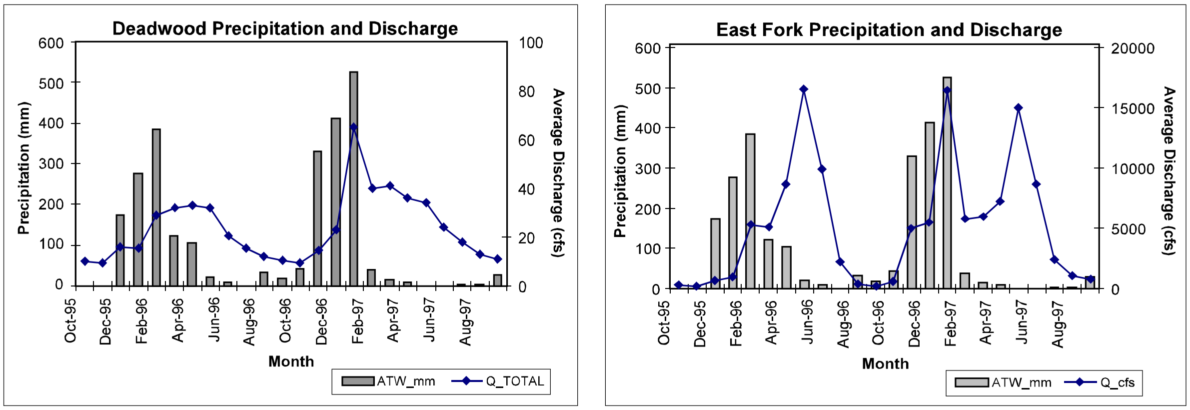

Figure 3.3-2a and 3.3-2b. Relationship between discharge and precipitation in East Fork Kaweah. The Jan. 1997 flood resulted in peak discharge for WY 1997, overshadowing the peak associated with snowmelt runoff in both catchments.

Stream Chemistry

Solute concentrations varied seasonally within each catchment. While flux patterns for like solutes were similar, concentrations varied widely by catchment, a likely function of differences in vegetation cover, precipitation type and frequency, and underlying geomorphology. The discussion below is based on volume-weighted mean (VWM) concentrations.

Base Cations

Base cation concentrations were inversely related to discharge rates, and were therefore highest during low flow periods when surface waters contain the highest percent of ground water sources. East Fork solutes show the greatest seasonal flux of volume-weighted means, though not necessarily the highest concentrations. The dominant cation order was Ca>Na>Mg>K in Deadwood and East Fork, which is typical of Sierran systems in metamorphic terrain (Melack et al. 1985). Sodium and calcium were reversed in Trauger's, with sodium concentrations of 280-580 μEq (**Fig. 3.3-3**). Calcium had the largest magnitude in seasonal flux (278 uEq to 702 uEq) in the East Fork. In the late summer and early fall when calcium is high, the East Fork receives up to 50% of is volume from headwater lake systems with large calcareous inputs (Black 1994). In water year 1996, potassium concentrations fluctuated widely in the East Fork, however, the same pattern was not observed in WY 1997.

Alkalinity and pH

Buffering or acid neutralizing capacity (ANC) is a function of bicarbonate concentrations present in surface waters. In the Sierra Nevada, buffering capacity is derived from weathering processes, and is also negatively correlated with stream discharge. Peak concentrations are reached during the late summer and early fall and begin to decline as snow melt and other surface flow enters the streams. Trauger's Creek ANC recovered earlier than Deadwood and East Fork since the catchment did not receive snow melt runoff. Again, East Fork hd the greatest flux in ANC concentrations. Trauger's ANC had the lowest seasonal flux generally remaining between 0.47 and 0.75 mEq. Seasonal differences in East Fork and Deadwood ranged from 0.30 to 0.95 mEq and 0.38 to 0.74 mEq, respectively. These differences probably reflect differences in the amount of snow melt runoff received by each catchment, and the corresponding recovery time of ANC.

Hydrogen-ion concentrations tended to be positively correlated with discharge, and were more

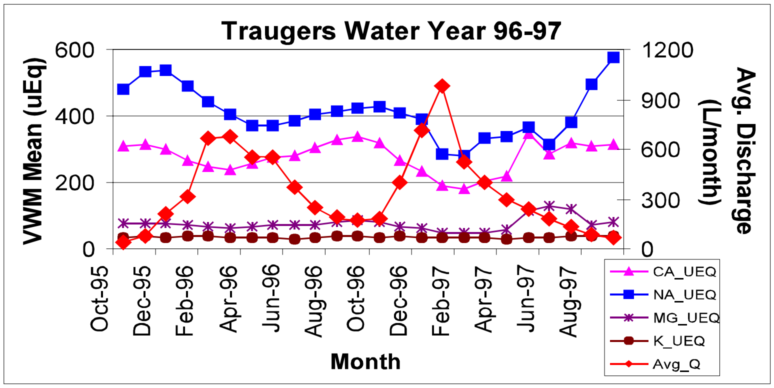

Figure 3.3-3. Base cations are negatively correlated to discharge in Trauger's Creek. In contrast to other Sierran systems, sodium VWM exceeds calcium VWM.

varied than ANC concentrations. In WY 1996, there was less fluctuation as weather patterns were more typical of normal. In WY 1997, the East Fork had two small peaks in H^+ (0.25 and 0.28 uEq) in the fall and Jan 1997 flood, and reached maximum peak (0.45 uEq) in June during peak discharge. Both Trauger's and Deadwood H^+ peaked (0.25 and 0.37 uEq, respectively) during the Jan 1997 flood event, which fell as rain in both catchments. Another smaller peak was observed in June, which was likely associated with rain events received during that month.

Changes in stream hydrogen-ion concentrations appeared to be highly sensitive to precipitation events and snow melt. pH values for summer precipitation events in the Middle Fork measured between 4.45 and 4.89 during WY 1996 and 1997. Summer rain events in Emerald Lake Basin have also resulted in short-term elevated H^+ concentrations (Melack et al. 1998).

Acid Anions

Sulfate was negatively correlated with discharge in East Fork and Deadwood, and positively correlated with discharge in Trauger's Creek. In Trauger's, peak concentrations averaged 14 uEq, and minimum concentrations averaged 6 uEq. These values were slightly higher than averages observed in Deadwood (5 uEq and 11 uEq, respectively). Sulfate concentrations in East Fork were on average five times greater (28 uEq and 77 uEq) than those seen in Trauger's and Deadwood Creeks (**Fig. 3.3-4**). Mineral weathering is the most likely source of sulfate in these basins (Melack et al. 1998).

In snow-dominated Sierran systems, sulfate is negatively correlated with discharge due to the dilution effect of snow melt runoff. However, since solute data from rain-dominated catchments in the Sierra is lacking, it's unknown whether sulfate is often positively correlated with flow in these catchments. This correlation may reflect the direct input of dry deposition into the stream following a precipitation event.

High sulfate concentrations in East Fork are likely due to the presence of mineral springs that are present throughout the upper East Fork catchment. Sulfate concentrations were found to range between 12 and 240 uEq L^{-1} in the headwater lakes and springs of the East Fork (Black 1994). Sulfate obviously remains elevated many river miles down stream of its source.

Nitrate concentrations were also elevated in East Fork during high flows, whereas it has been undetectable in Deadwood and Trauger's for much of the study.

Nutrients

As in most Sierran systems, the East Fork catchments are nitrogen limited. Ammonium was undetectable throughout much of the year in Trauger's and Deadwood. Maximum concentrations averaged 0.37 uEq in both catchments. Maximum concentrations were positively correlated with flow, and tend to drop to below detection level during the growing season.

Phosphate was highest in Deadwood and lowest in the East Fork. There was no apparent seasonal pattern and did not appear to be strongly correlated positively or negatively with discharge. Phosphate was generally detectable throughout the growing season, and was, on average, 5.5 times greater in concentration than ammonium in Deadwood and Trauger's Creeks, and two times greater in East Fork.

Deadwood Creek Yields

Preliminary monthly solute yields were calculated for Deadwood Creek using NADP wet deposition chemistry data collected in Giant Forest, and Atwell Mill precipitation data. The NADP data were collected at a similar elevation from the next major drainage north. Deposition rates were slightly under estimated due to loss of sample during successional major winter events, and unaccounted deposition during summer events, which were very localized. Other sources of error included the lack of dry deposition data, and stream chemistry data from storm events. These limitations in the data set resulted in underestimated yields. However, trends in yields are still useful as a baseline to evaluate how fire may affect these trends. As expected, base cations were exported in concentrations relative to their dominant order. Sulfate and chloride were predominately exported throughout the year. Retention was observed during some wet months, which may reflect under sampling high flows. Hydrogen-ion, ammonium, and nitrate were retained during the wet months and exported during the dry months. However, exported concentrations were very low suggesting that Deadwood is primarily a sink for these solutes. This is a trend generally observed in other Sierran watersheds.

Annual solute yields for Tharp's and Log catchments in Giant Forest followed the same trends during a ten year study from 1984-1993 (Williams and Melack 1997). Cations were exported from these catchments, whereas anions tended toward negative yields. Sulfate and chloride also tended toward negative yields. However, sulfate and chloride were exported for a period of years following the 1990 fire in the Tharp's catchment. These solutes were also exported from Log during wet years.

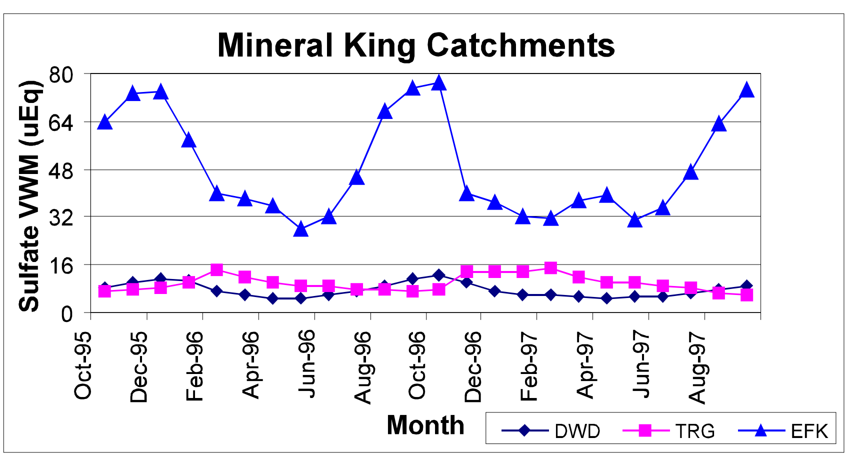

Figure 3.3-4. Sulfate VWM is significantly higher in East Fork due to the presence of mineral springs in the upper basin. Sulfate is positively correlate with discharge in Trauger's Cr., possibly due to the direct input of dry deposition, which is flushed into the stream during rain events.

Aquatic Macroinvertebrates

Results of the aquatic macroinvertebrate study provide valuable baseline data for understanding invertebrate diversity, abundance and evenness in small, steep headwater catchments in mixed-conifer forests.

Benthic Macroinvertebrates
A total of 136 taxa were identified from 109 benthic samples collected during 1995 and 1996. The Shannon Index of Diversity was expected to be higher in 1996 due to more intensive sampling. However, Atwell and Redwood Creeks, which were burned following limited 1995 sampling, decreased in diversity by 14% and 10%, respectively in pool habitats. In contrast, pool habitats in adjacent unburned streams increased by 23-40% for the same period (F**ig. 3.3-5**).

As expected, increased sampling in 1996 resulted in an increase in taxa richness. Unburned streams had the highest increases ranging from 75% to 150%. Redwood Creek had the smallest increase in richness, only 25%. Increases varied with habitat type. Pools showed the most consistent increases, and were the best indicators of taxa richness (**Fig. 3.3-6**).

Differences in the Shannon Index of Evenness were evident in burned versus unburned streams. Burned streams generally had a lower index of evenness. Slight differences in community similarity were also detected between burned and unburned streams. Burned-to unburned comparisons averaged lower similarity than unburned-to-unburned comparisons. Pool habitats were once again the best indicator of these differences. In same stream comparisons by season (spring and fall), unburned streams were more similar overall than burned streams, ranging from 45-64% to 34-40%, respectively.

Based on number of individuals, members of the dipteran family Chironomidae frequently dominated samples from all habitat types. *Baetis* spp. mayflies, the cased caddisfly, and freshwater mites (Hydracarina) were also present in large numbers. Riffle habitats were dominated by nemourid (Zapada spp.), and chloropelid stoneflies. Pool habitats were most abundant in lepidostomatid caddisflies (*Lepidostoma* spp.), ostracods, and small clams

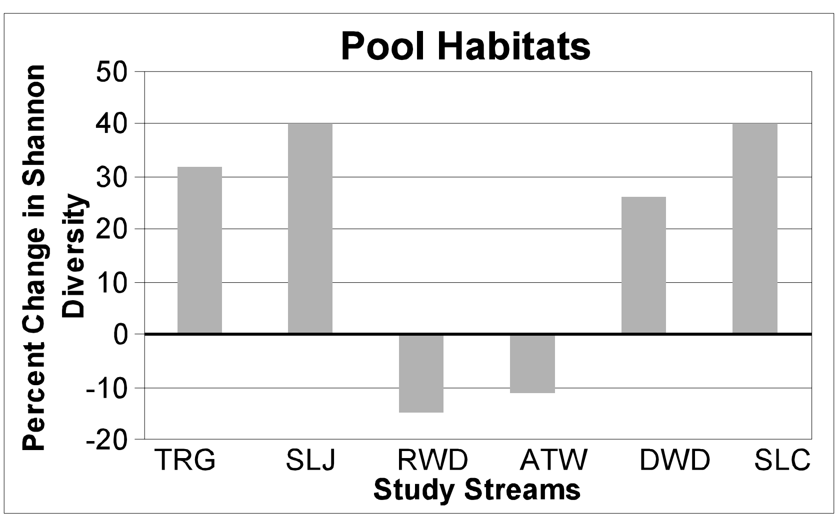

Figure 3.3-5. The Shannon Index of Diversity and Evenness decreased for Atwell and Redwood Creeks between fall 1995 and fall 1996 samples despite increased sampling efforts in 1996.

(Pelecypoda). Bedrock outcrops were abundant in blackfly larvae (Simuliidae), heptageniid mayflies (*Ironodes* and *Rithrogena*), and rhyacophilid caddisflies (*Rhyacophila* spp.).

Some endemic and unusual species were identified within the study area. The caddisfly *Yphria califonica* was frequently collected in pools at elevations above 1700 m (Redwood Cr. and above). Known only from the Sierra Nevada, Siskyous, and Cascades, *Yphria califonica* is possibly the most primitive living species of the tube-case-making caddisfly in the world (Wiggins 1962, and Anderson 1976). The unusual caddisfly genus *Cryptochia* was also found in pools throughout the study area. Symbiotic associations of *Cricotopus* midges and *Nostoc* cyanobacteria were commonly found in bedrock outcrops.

Overlap of taxa between habitat types, especially riffles and pools ranged between 23% to 43%. This pattern held true for both ubiquitous and less common taxa. This may be due in part to poorly defined riffle and pool habitats in these small streams.

Adult Insects
Data from adult collections revealed no distinct trends between burned and unburned streams. In general, Atwell and Redwoods Creeks had higher average emergence rates for all taxa. This may be a function of catchment size, as these were to two largest catchments in the study.

True flies (Diptera) were collected in most abundance. This finding is consistent with other work on small streams in the Sierra (Erman and Erman 1990). Peaks in emergence for stone flies (Plecoptera, mayflies (Ephemeroptera) and caddisflies (Trichoptera) also occurred in most streams. The total average number of invertebrates collected per week/m^2 (from all orders combined) increased consistently with stream size during 1997.

Fire Effects on Streams

Erosion of fine sediments from fire-treated hillslopes resulted in increased sedimentation of aquatic habitats, particularly in depositional areas such as pools. Large deposited of fine sediments were observed behind debris jams, on stream banks, along margins of the bankful channels, and in pool habitat in Redwood and Atwell Creeks in 1996. Median particle size (D_{50}) was smallest in the two burned streams, despite the fact that they were the largest steams in the study area. Plots of sediment size versus watershed area for the study streams illustrate that smaller particle size would not be predicted on the basis of underlying watershed characteristics.

Pebble counts were found to adequately document changes in sediment size in the study streams. More elaborate excavated core analysis detected similar changes, but required substantially more sampling and processing effort. Strong correlation between surface and subsurface sediment sizes in the study streams suggests that the surface layer serves as an adequate proxy for overall substrate character. Thus, surface sampling may be sufficient for detecting relative changes in channel substrate sizes.

The 1995 prescribed fire had little effect on canopy cover, insolation or stream temperature in Redwood and Atwell Creeks. Variation in solar radiation was associated with stream width. Stream temperature followed climatic trends associated with stream elevation.

Large woody debris (LWD) surveys conducted on the study streams in 1996 indicated increased debris per unit stream length in the treated streams. This was evident based on the number of LWD pieces found with recent char markings. The literature suggests LWD decreases in streams following fire due to increases in discharge velocities, which can transport large materials down stream. However, increase in peak and annual discharge may be delayed several years due to delayed mortality in large trees. Decreases in LWD were observed in Trauger's Creek in 1998. These data are still being analyzed, but suggest that the January 1997 flood removed a lot of woody debris that was previously measured in the 1996 survey.

1999 GOALS

In 1999 we will begin evaluating the relationship between precipitation and snowmelt runoff, and discharge in each of the study areas. In the smaller catchments, detailed analysis of responses to precipitation events will be conducted. Presently, raw data indicate that precipitation events in the Trauger's catchment result in short-term increases in discharge. More analysis is necessary to understand how the magnitude of the event and the antecedent conditions affect discharge response. The Deadwood catchment shows little response to early season rain events, as evidenced by the raw flow data. This lack of response needs more investigation, as changes in litter and duff levels after fire may result in increased discharge following early season rain events and snowmelt runoff.

Using historic flow data collected by USGS, Southern California Edison, and the US Army Corps of Engineers, we would like to 1) determine the contribution of the upper East Fork catchment to the East Fork water budget and, 2) determine the contribution of the East Fork Kaweah to the overall Lake Kaweah budget. This information will allow us to piece together how the burned subcatchments within the East Fork will change the overall water budget, and, in turn, how these changes affect the Lake Kaweah water budget.

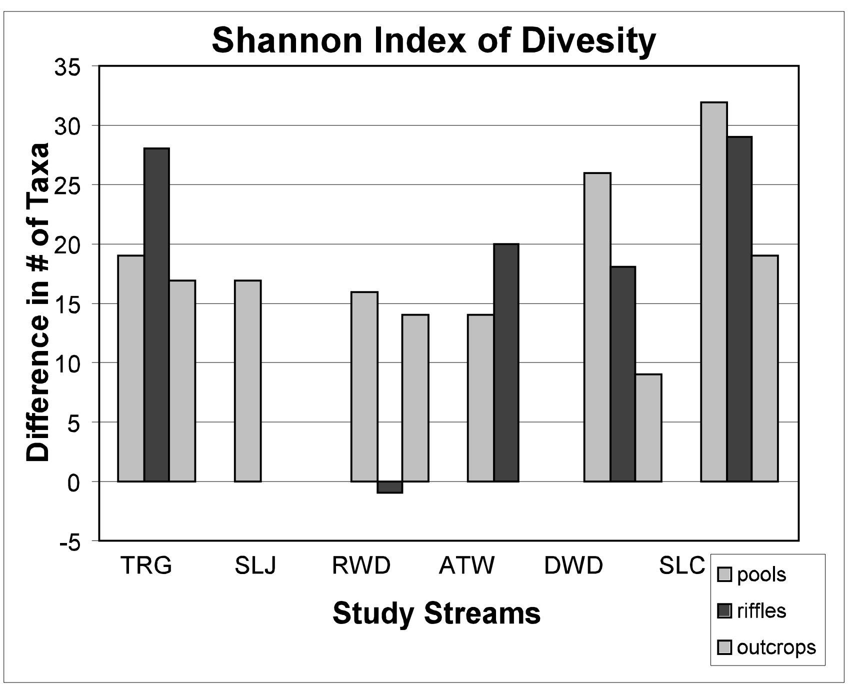

Figure 3.3-6. Overall, there was a greater increase in taxa between the fall 1995 and fall 1996 samples for all habitats in the unburned streams. Only pool habitats were sampled in Slapjack Cr.

In addition, we will work on calculating more accurate yields from the study sites by including dry deposition data collected from the NOAA station at Wolverton, and installing an Aerochemetrics collector at Lookout Point.

Due to the stable nature of most solutes during the summer base flow season, sampling will be reduced to biweekly, and possibly monthly depending on the budget. Reduced sampling during this period will free up dollars to conduct intensive sampling in the fall when Trauger's and Deadwood catchments are scheduled to burn. We will also analyze the storm samples collected in 1998 to quantify solute concentrations transported during these events. This information will increase the accuracy of our monthly and annual load calculations for the study sites.

Large woody debris surveys will be conducted and analyzed in Deadwood Creek, and analysis of the Trauger's data collected in 1998 will continue. These results are important to determine how weather patterns affect LWD distribution. Since the original measurements were made, the study area has experienced two significant weather events: the Jan.1997 flood and the 1998 El Niño.

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