

Publications Related to Caspar Creek

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Albright, Jeffrey S. 1992. **Storm runoff comparisons of subsurface pipe and stream channel discharge in a small, forested watershed in northern California.** Arcata, CA: Humboldt State University; 118 p. M.S. thesis.

Pipe discharge, stream discharge, and rainfall were measured for three winter storm seasons in the Caspar Creek watershed. Comparisons of pipe discharge and stream discharge for 22 storm events indicated that pipes respond dynamically to rainfall inputs. Pipes convey a substantial volume of runoff from study swales.

Key Terms: pipeflow, storm runoff, subsurface flow

Anderson, H.W. 1960. **Proposed program for watershed management research in the lower conifer zone of California.** Tech. Paper 46. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 21 p.

A 10-year program is proposed for California's Lower Conifer Zone that establishes experimental watersheds in four commercial timber areas: southern Sierra, northern Sierra, interior Douglas-fir, and coastal redwood-Douglas-fir regions. Caspar Creek became the experimental watersheds in coastal redwood-Douglas-fir region.

Key Terms: experimental watersheds

Anonymous. 1964. **Second progress report 1963-64, cooperative watershed management in the lower conifer zone of California.** Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 19 p.

Describes establishment and first year's data from the new Caspar Creek Experimental Watersheds, including the stream habitat study conducted by Dr. Kenneth Watt, University of California, Davis.

Key Terms: experimental watersheds, stream habitat

Anonymous. 1987. **Caspar Creek: discovering how watersheds respond to logging.** Forestry Research West, August 1987. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture.

This pamphlet provides a historical overview of the Caspar Creek watershed study, including results and future plans of the project. The findings greatly illuminate the extent and nature of the hydrologic impact, erosion, and stream sedimentation for a northern California basin undergoing a "typical" logging operation. Long-term investigations of logging effects on the Caspar Creek watershed will provide forest managers, public policy makers, and private enterprise an empirical basis on which to formulate sound logging practices.

Key Terms: streamflow, sedimentation, logging, roads, cumulative watershed effects, fisheries

Anonymous. 1988. **Caspar Creek: how a northwestern California watershed responds to logging.** [20-minute video.] San Francisco, CA: Luba Productions. Available from: U.S. Forest Service Video Library, 800-683-8366.

This video presents the hydrologic impacts of logging in the northern California watershed of Caspar Creek from the beginning of the Caspar Creek watershed study in 1962 to the ongoing research in 1988. The effects of road building and logging on sedimentation, streamflow, and cumulative effects are discussed as well as future studies on fisheries.

Key Terms: sedimentation, streamflow, cumulative watershed effects, fisheries, logging, roads

Baumann, R.W.; Bottorff, R.L. 1997. **Two new species of Chloroperlidae (Plecoptera) from California.** Great Basin Naturalist 57(4): 343-347.

Two new species in the family *Chloroperlidae* (stoneflies) are described. One species, *Sweltsa pisteri*, was initially identified after collection from South Fork Caspar Creek. Detailed illustrations, observations, and comparisons to similar species are provided.

Key Terms: stoneflies, biology, macroinvertebrates

Bottorff, R.L.; Knight, A.W. 1996. **The effects of clearcut logging on stream biology of the North Fork of Caspar Creek, Jackson Demonstration State Forest, Fort Bragg, CA—1986 to 1994.** Unpubl. Final Rept. prepared for the Calif. Dept. of Forestry and Fire Protection, Contract No. 8CA3802. Sacramento, CA. 177 p.

The objective of the North Fork Caspar Creek biological study was to determine whether logging treatments (1989-1991) within the drainage basin caused changes in three components of stream structure and function: (1) the benthic macroinvertebrate community, (2) leaf litter processing rates, and (3) the benthic algal community. This report describes the results of 8 years of study (1987-1994) on the stream biology of North Fork Caspar Creek, including three pre-treatment years and five post-treatment years.

Key Terms: stream ecology, logging

Brown, David Lawrence. 1995. **An analysis of transient flow in upland watersheds: interactions between structure and process.** Berkeley, CA: University of California; 225 p. Ph.D. dissertation.

Field observations of responses of pore pressure to rain events at two diverse experimental watersheds indicate that heterogeneous soil and geologic materials affect storm runoff responses. The results of a series of parametric simulations based on a physically based numerical subsurface flow model suggest that significantly macroporous soils may enhance the contribution of a soil horizon or geologic material to hillslope discharge. Antecedent moisture conditions, channel bank geometry, and lateral heterogeneities in soil hydraulic properties affect the subsurface flow paths.

Key Terms: subsurface flow, storm runoff, modeling

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Burns, J.W. 1970. **Spawning bed sedimentation studies in northern California streams.** California Fish and Game 56(4): 253-270.

Changes in the size composition of spawning bed materials in six coastal streams, including Caspar Creek, were monitored for 3 years to determine the effects of logging on the habitat of silver salmon (Coho), and trout (steelhead). Spawning bed composition in four test streams changed after logging, roughly in proportion to the amount of streambank disturbance. Sedimentation was greatest during periods of road construction near streams and removal of debris from streams, confirming the need for special measures to minimize erosion during such operations.

Key Terms: sedimentation, logging, channel morphology, fisheries

Burns, J.W. 1971. **The carrying capacity for juvenile salmonids in some northern California streams.** California Fish and Game 57(1): 44-57.

Standing crops of three species of juvenile salmonids were examined in seven coastal streams [including Caspar Creek] to define the natural carrying capacity of these streams, and to develop methods of population comparison and prediction that could be used to determine the effects of road construction and logging on salmon and trout production. Biomass per unit of surface area was found to be the best method of expressing carrying capacity. Not all streams reached carrying capacity, and salmonid biomass was highly variable, suggesting that it would be difficult to attribute a change in carrying capacity under 50 percent to anything but natural variation.

Key Terms: fisheries, roads, logging

Burns, J.W. 1972. **Some effects of logging and associated road construction on northern California streams.** Transactions, American Fisheries Society 101: 1-17.

The effects of logging and associated road construction on four California trout and salmonid streams were investigated from 1966 through 1969. This study included measurements of streambed sedimentation, water quality, fish food abundance, and stream nursery capacity. Sustained logging prolonged adverse conditions in one stream and delayed stream recovery. Other effects of logging on anadromous fish populations are discussed.

Key Terms: fisheries, sedimentation, logging, roads

Cafferata, P.H. 1984. **The North Fork of Caspar Creek: a cooperative venture between CDF and USFS.** Jackson Demonstration State Forest Newsletter, No. 15, August 1984. p. 1-2.

The California Department of Forestry (CDF) and the USDA Forest Service (USFS) continue to be equal partners in implementing the North Fork phase of the Caspar Creek Watershed Study. Parshall flume sites and pumping samplers have been installed in the North Fork to aid in measuring stream discharge and suspended sediment load, respectively. The cooperative link of CDF and USFS provides a broad, effective resource base for studying "cumulative effects" and sediment transport mechanisms operating in a small logged watershed.

Key Terms: instrumentation, cumulative watershed effects, sedimentation

Cafferata, P.H. 1987. **Update on the Caspar Creek watershed study.** Jackson Demonstration State Forest Newsletter, No. 27, October 1987. p. 1-4.

This article focuses on studies taking place in the North Fork of Caspar Creek following clearcutting in selected sub-basins between 1989 and 1994. The primary study is on cumulative effects, and includes the sediment impacts on the channel system that occur downstream from

the locations of the actual logging and are transmitted through the stream system. Studies on channel morphology, biology of the creek, and hillslope hydrology also are described.

Key Terms: cumulative watershed effects, channel morphology, stream ecology, subsurface flow

Cafferata, Peter. 1990. **Graduate theses produced from research conducted on Jackson Demonstration State Forest.** Jackson Demonstration State Forest Newsletter, No. 36, January 1990. p. 4-8.

A primary goal for Jackson Demonstration State Forest (JDSF) is to carry out research on the various aspects of forestry in the redwood region. In this article, graduate theses produced from research conducted on JDSF are cited and annotated. Research topics include watersheds, soils, stream ecology, redwood ecology, silviculture, forest entomology, and forest pathology.

Key Terms: redwood silviculture, watershed studies, stream ecology, terrestrial biology, soils

Cafferata, Peter. 1990. **Temperature regimes of small streams along the Mendocino coast.** Jackson Demonstration State Forest Newsletter, No. 39, October 1990. p. 4-7.

Stream temperature has been measured in the Caspar Creek drainage periodically over the past 25 years. Review of these data collected from western Mendocino County illustrates much about the temperature regimes of small coastal drainages, and how timber harvesting affects them. This article gives a synopsis of these studies and summarizes reasons for concern. Presented is a model currently in use by the USDA Forest Service to predict changes in maximum summer temperatures resulting from canopy reductions.

Key Terms: stream temperature, fisheries, logging

Cafferata, Peter H.; Spittler, Thomas E. 1998. **Logging impacts of the 1970's vs. the 1990's in the Caspar Creek watershed.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 103-115.

The frequency of landslides greater than 76 m³ to date has not been substantially different between the clearcut units and the uncut control subwatersheds for the North Fork of Caspar Creek. The volume of sediment discharged by landslides to date has been about the same, 21 m³ ha⁻¹ from the uncut units and 19 m³ ha⁻¹ from the harvested areas. Long-term monitoring will determine if these trends continue with much larger stressing storm events. For perspective, the largest landslide mapped in the North Fork watershed, a debris flow that dammed the creek for thousands of years, was on the order of 1,000,000 to 5,000,000 m³— over three orders of magnitude larger than the largest landslide observed during the study.

Key Terms: landslides, slope stability, logging, roads, sediment, geomorphology

Cafferata, P.; Walton, K.; Jones, W. 1989. **Coho salmon and steelhead trout of JDSF.** Jackson Demonstration State Forest Newsletter, No. 32, January 1989. p. 1-7.

Spawning and rearing habitat for anadromous fish is the dominant use of Jackson Demonstration State Forest's (JDSF) many miles of streams. Both Coho (silver) salmon and steelhead migrate from the ocean up the rivers to spawn. This article summarizes life histories of Coho salmon and steelhead and describes the fisheries activities on

JDSF. Fisheries activities on Caspar Creek include downstream migrant studies and standing crop surveys.

Key Terms: fisheries, stream restoration, stream ecology

Dahlgren, Randy A. 1998. **Effects of forest harvest on biogeochemical processes in the Caspar Creek Watershed.** Unpubl. Draft Final Rept. prepared for the Calif. Dept. of Forestry and Fire Protection. Agreement No. 8CA17039. Sacramento, CA. 151 p.

Forest harvest practices are often implicated as having adverse impacts on sensitive aquatic communities and on the long-term sustainability of forest ecosystems. The primary purpose of this research was to examine the effects of forest harvest and post-harvest management practices on biogeochemical processes. Results provide information to understand the complex interactions that occur in nutrient cycling processes at the ecosystem scale.

Key Terms: biogeochemical processes, logging, nutrient cycling, water quality

Dahlgren, Randy A. 1998. **Effects of forest harvest on stream-water quality and nitrogen cycling in the Caspar Creek watershed.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 45-53.

The effects of forest harvest on stream water quality and nitrogen cycling were examined for a redwood/Doug fir ecosystem in the North Fork, Caspar Creek experimental watershed. Stream water samples were collected from treated (e.g., clearcut) and reference (e.g., non-cut) watersheds, and from various locations downstream from the treated watersheds to determine how far the impacts of these practices extended. Additionally, a detailed nutrient cycling study was performed in a clearcut and reference watershed to gain insights into changes in nitrogen cycling following harvesting activities.

Key Terms: streamflow, cumulative watershed effects, nutrient cycling, logging, nitrogen, calcium

Dorn, R. 1969. **Evaluation of air and water temperatures on Caspar Creek from 1965-1968.** Unpubl. Rept. Cooperative Fisheries Unit, Humboldt State University, Arcata, CA. 17 p.

Key Terms: watershed studies, temperature, roads

Duan, J.; Ziemer, R.R.; Grant, G.E. 1997. **Hydrologic responses of large drainage to clearcutting: a modeling perspective.** EOS, Transactions, American Geophysical Union 78(46): F314.

Hydrologic responses of watersheds at the 100- to 1000-km² scale using a river routing model based on knowledge derived from paired-watershed studies at the 10- to 100-ha scale are presented. Primary results demonstrate both scale-independent and dependent changes in runoff volume, peak flow size, and timing in response to various scenarios of cutting pattern and proportion of area cut.

Key Terms: watershed studies, storm runoff, peak flow, logging

Eads, R.E. 1991. **Controlling sediment collection with data loggers.** In: Fan, S.; Kuo, Y.H., eds. Fifth Federal Interagency Sedimentation Conference Proceedings, 1991 March 18-21, Las Vegas, NV. Washington, DC: Federal Energy Regulatory Commission; 2-41 to 2-48.

Sampling efficiency in many types of hydrologic data collection can be improved using a programmable data logger. Low-power requirements, ease of programming, and the increased flexibility of connecting multiple

sensors also can improve data collection in remote locations.

Key Terms: instrumentation, sampling, streamflow, suspended sediment

Eads, Rand E.; Boolootian, Mark R. 1985. **Controlling suspended sediment samplers by programmable calculator and interface circuitry.** Res. Note PSW-376. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 8 p.

Automatic pumping samplers can improve the collection of data on suspended sediment when operated at fixed time intervals. A programmable calculator controls the collection of pumped suspended sediment samples and records streamflow data. Wiring schematic, component list, and program listing are included.

Key Terms: instrumentation, sampling, suspended sediment, streamflow

Eads, Rand E.; Boolootian, Mark R.; Hankin, Steven C., inventors; United States of America, assignee. 1987. **Means and method of sampling flow related variables from a waterway in an accurate manner using a programmable calculator.** U.S. patent 4,660,422. Apr. 28. 9 p. Int. Cl.4 G01N 1/44.

A programmable calculator connected to a pumping sampler by an interface circuit board runs a sediment-sampling program stored therein. Suspended sediment sample collection is controlled by a Selection At List Time (SALT) scheme in which the probability of taking a sample is proportional to its estimated contribution to total sediment discharge, or according to accumulated predicted sediment weight. Stage height is also measured and is recorded according to a set scheme.

Key Terms: instrumentation, sampling, suspended sediment, streamflow

Eads, Rand E.; Thomas, Robert B. 1983. **Evaluation of a depth proportional intake device for automatic pumping samplers.** Water Resources Bulletin 19(2): 289-292.

A depth proportional intake boom for portable pumping samplers was used to collect suspended sediment samples in two coastal streams for three winters. This equipment maintains the intake nozzle at the same proportion of water depth regardless of stage. Compared to data taken with depth integrated hand samples, the data taken by pumped samplers with boom-mounted intakes showed higher concentrations. Results suggested that cross-sectional sampling can give high precision with proper placement and calibration of a boom-mounted intake.

Key Terms: instrumentation, sampling, suspended sediment, streamflow

Fisher, Jason C. 1997. **A one-dimensional model of subsurface hillslope flow.** Unpublished Final Report. Redwood Sciences Laboratory, Pacific Southwest Research Station, USDA Forest Service, Arcata, CA. 62 p.

A one-dimensional, finite difference model of saturated subsurface flow within a hillslope was developed. The model uses rainfall, elevation data, a hydraulic conductivity, and a storage coefficient to predict the saturated thickness in time and space. The model was tested against piezometric data collected in a swale located in the headwaters of the Caspar Creek watershed and was limited in its ability to reproduce historical piezometric responses.

Key Terms: hillslope hydrology, subsurface flow, modeling

Graves, D.S.; Burns, J.W. 1970. **Comparison of the yields of downstream migrant salmonids before and after logging and road construction on the South Fork Caspar Creek, Mendocino County.** Inland Fisheries Admin.: Rept. 70-3. 11 p. Sacramento, CA: Calif. Dept. of Fish and Game.

Yields of juvenile steelhead and silver (Coho) salmon emigrants were compared in the South Fork of Caspar Creek, before and after the construction of a logging road along the stream. Numbers, lengths, and age-class structures of the juvenile salmonids were compared. The possible effects of stream disturbance on the size of migrants were also investigated.

Key Terms: logging, roads, fisheries, stream ecology

Hardison, Karen D. 1982. **Effects of timber harvesting on the lag time of a Caspar Creek watershed...a study in progress.** Jackson Demonstration State Forest Newsletter, No. 8, September 1982. p 1-3.

In this study, two measurements of lag time are analyzed for each storm in the Caspar Creek Watershed. One is the time separation between the center of mass of rainfall and the center of mass of total runoff, the other is the time separation between the center of mass of rainfall and the center of mass of rising limb runoff. Analysis of any change in lag time after roadbuilding and logging will indicate changes in the processes involved in stormflow at this site.

Key Terms: storm runoff, logging, streamflow, roads

Harvey, B.C.; Nakamoto, R.J. 1996. **Effects of steelhead density on growth of Coho salmon in a small coastal California stream.** Transactions, American Fisheries Society 125: 237-243.

Weight change in age-0+ Coho salmon (*Oncorhynchus kisutch*) at about natural density was negatively related to the density of juvenile steelhead (*O. mykiss*) in a 6-week experiment conducted in July-August 1993 in the North and South forks of Caspar Creek. In the North Fork, Coho salmon weight change was positive in zero density steelhead treatments, zero in 1X treatments, and negative in 2X treatments. Coho salmon weight change in the South Fork was less favorable than in the North Fork but also negatively related to steelhead density.

Key Terms: fisheries, stream ecology

Harvey, Bret C.; Nakamoto, Rodney J. 1997. **Habitat-dependent interactions between two size-classes of juvenile steelhead in a small stream.** Canadian Journal of Fisheries and Aquatic Sciences 54(1): 27-31.

The presence of small steelhead influenced the growth of larger juvenile steelhead during a 6-week experiment conducted in North Fork Caspar Creek in 1994. In fenced replicate deep-stream sections in this small stream, growth of the larger steelhead was greater in treatments in which small steelhead constituted half of the total biomass of fish than in treatments with an equal biomass composed entirely of larger fish. The advantage of large body size in intraspecific interactions among steelhead does not exist in all types of habitat, and interactions between the two size-classes may contribute to lower abundance of large juveniles in streams where aggradation reduces water depth.

Key Terms: fisheries, stream ecology

Henry, Norm. 1991. **Using global positioning system technology for watershed mapping in Caspar Creek.** Jackson Demonstration State Forest Newsletter, No. 43, October 1991. p. 4-6.

Global positioning system (GPS) technology is described, and GPS use in the Caspar Creek Watershed is demonstrated. The cumulative effects study and several other studies of the North Fork phase require accurate mapping and periodic map updating of the watershed

features and disturbances. The watershed features surveyed using GPS technology are now accurately located in relation not only to other objects in the watershed but also to a regional and global frame of reference.

Key Terms: instrumentation, mapping

Henry, Norm. 1998. **Overview of the Caspar Creek watershed study.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 1-9.

This paper describes the history, site characteristics, major events, equipment, and sampling systems used during the South Fork and North Fork phases of the Caspar Creek study from 1962 through 1998.

Key Terms: paired watersheds, research, streamflow, sediment, precipitation

Henry, N.; Sendek, K. 1985. **Caspar Creek Watershed Study—North Fork Phase, Jackson Demonstration State Forest, Status and Plans, 1983-1990.** Calif. Forestry Note No. 96. Sacramento, CA: Calif. Dept. of Forestry and Fire Protection; 9 p.

The North Fork phase of the Caspar Creek Watershed Study for 1983 to 1990 uses an extensive network of flumes with pumping samplers to monitor the impacts of clearcutting a portion of the North Fork. Principal objectives are to identify sediment sources, and evaluate the magnitude and movement of sediment through the watershed. A "cumulative" effects hypothesis tested as clearcutting progresses from the headwaters to the weir.

Key Terms: suspended sediment, streamflow, sampling, cumulative watershed effects, logging, roads

Hess, Lloyd J. 1969. **The effects of logging road construction on insect drop into a small coastal watercourse.** Arcata, CA: Humboldt State University; 58 p. M.S. thesis.

The purpose of this paper is to relate logging practices to fish management by ascertaining the effect of logging road construction on the drop of insects into a stream. On the South Fork of Caspar Creek, the number of insects falling into the stream greatly increased after a logging road was built. The family *Chironomidae* showed the most significant increase of the families studied.

Key Terms: stream ecology, roads, logging, fisheries

Hopkins, Walt; Bowden, Kenneth L. 1962. **First progress report, 1961-1962, cooperative watershed management in the lower conifer zone of California.** Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 10 p.

The Caspar Creek study, "Study 2-1, a study of logging effects upon streamflow, sedimentation, fish life and fish habitat in the north coast redwood-Douglas-fir forest type Jackson State Forest, Fort Bragg, California" was one of the first studies undertaken by the new Lower Conifer research project.

Key Terms: experimental watersheds

Kabel, C.S.; German, E.R. 1967. **Caspar Creek study completion report.** Marine Resources Branch Administrative Report No. 67-4. Sacramento, CA: The Resources Agency of Calif. Dept. of Fish and Game; 27 p.

This study evaluated the effects of logging on the stream and its

population of silver (Coho) salmon and steelhead trout. Changes in anadromous fish production were measured through counts of upstream and downstream migrants. Existing habitat in the stream was surveyed as well. Measurement of anadromous fish production was difficult owing to technical problems.

Key Terms: fisheries, stream ecology, logging

Keppeler, Elizabeth T. 1986. **The effects of selective logging on low flows and water yield in a coastal stream in northern California.**

Arcata, CA: Humboldt State University; 137 p. M.S. thesis.

Using a low flow season defined as a function of antecedent precipitation, streamflow data for a 21-year period were analyzed to determine the effects of selective tractor on the volume, timing, and duration of low flows, and annual water yield. Significant increases in streamflow were detected for both the annual period and the low flow season. Logging factors were found to be the most influential variables in describing flow differences between the control and treated watersheds. The enhancement of annual yield was well correlated to the percent of the watershed area converted to roads, landings, and skid trails.

Key Terms: streamflow, logging, roads

Keppeler, Elizabeth T. 1998. **The summer flow and water yield response to timber harvest.**

In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 35-43.

Selection/tractor logging of the South Fork increased annual yield by a maximum of 2053 m³ha⁻¹ during the seventh water year after harvest began. Increased yields were observed beginning the second post-harvest year and averaged 15 percent or 932 m³ha⁻¹. Following clearcut logging 50 percent of the North Fork watershed, annual yield increased by as much as 1032 m³ha⁻¹ eight years post-logging and averaged 15 percent or 608 m³ha⁻¹ beginning in the second post-harvest year. Summer flow increases were evident on the South Fork for seven years after logging. Minimum summer flow discharge increases averaged 38 percent after the South Fork selection logging and 148 percent after the North Fork harvest and site preparation.

Key Terms: streamflow, soil moisture, summer flow, logging

Keppeler, Elizabeth T.; Brown, David. 1998. **Subsurface drainage processes and management impacts.**

In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 25-34.

Storm-induced streamflow in forested upland watersheds is linked to rainfall by transient variably-saturated flow through several different flow paths. In the absence of exposed bedrock, shallow flow-restrictive layers, or compacted soil surfaces, virtually all of the infiltrated rainfall reaches the stream as subsurface flow. Subsurface runoff can occur within micropores (voids between soil grains), various types of macropores (structural voids between aggregates, plant and animal-induced biopores), and through fractures in weathered and consolidated bedrock. In addition to generating flow through the subsurface, transient rain events can also cause large increases in fluid pressures within a hillslope. If pore pressures exceed stability limits of soils and shallow geologic materials, landslides and debris flows may result.

Key Terms: soil moisture, pipeflow, saturated flow, landslide, macropore

Keppeler, E.T.; Cafferata, P.H. 1991. **Hillslope hydrology research at Caspar Creek.** Jackson Demonstration State Forest Newsletter, No. 41, April 1991. p. 4-8.

The latest technology is used for documenting variations in groundwater levels and soil moisture conditions from season to season and through storm events. Subsurface soil pipes are also monitored to observe changes in water movement.

Key Terms: hillslope hydrology, subsurface flow, logging, roads

Keppeler, Elizabeth T.; Ziemer, Robert R. 1990. **Logging effects on streamflow: water yields and summer low flows at Caspar Creek in northwestern California.** Water Resources Research 26(7): 1669-1679.

Streamflow data for a 21-year period were analyzed to determine the effects of selective tractor harvesting of second-growth Douglas-fir and redwood forest on the volume, timing, and duration of low flows and annual water yield in northwestern California. The flow response to logging was highly variable. Significant increases in streamflow were detected for both the annual period and the low-flow season.

Key Terms: streamflow, logging, roads

Keppeler, Elizabeth T.; Ziemer, Robert R.; Cafferata, P.H. 1994. **Changes in soil moisture and pore pressure after harvesting a forested hillslope in northern California.**

In: Marston, R.A.; Hasfurther, V.R., eds. Effects of human-induced changes on hydrologic systems; 1994 June 26-29; Jackson Hole, WY. Herndon, VA: American Water Resources Association; 205-214.

From 1987 to 1993, soil moisture conditions were measured along a 0.83-ha zero-order swale using pressure transducers connected to a digital data logger. In August 1989, the 100-year-old second-growth forest in the swale was felled, and logs were removed by cable yarding. Increases in peak piezometric levels and soil moisture were observed after logging. After logging, soil pipes continued to efficiently route surplus stormflows through an existing piping network. No slope failures were observed.

Key Terms: hillslope hydrology, soil moisture, pipeflow, storm runoff, logging

Kinerson, D.; Dietrich, William. 1990. **Bed surface response to sediment supply.** Berkeley, CA: Dept. of Geology and Geophysics, University of California; 420 p.

Land use changes in watersheds often lead to increased sediment supply to streams and to reduced habitat quality for the fish that live in these streams. There are three separable components to this land use problem: (1) the relationship between management practices and sediment yield, (2) the relationship between sediment supply and the stream channel morphology and dynamics, and (3) the relationship between sediment load and fish productivity. This study was designed in part to quantify these relationships in order to predict how changes in sediment supply will affect stream habitat.

Key Terms: sedimentation, stream ecology, channel morphology, bedload

Kopperdahl, F.R.; Burns, J.W.; Smith, G.E. 1971. **Water quality of some logged and unlogged California streams.**

Inland Fisheries Administrative Rept. No. 71-12. Sacramento, CA: Calif. Dept. of Fish and Game; 19 p.

Water quality was monitored in 1968 and 1969 in six coastal streams in northern California, four of which were subjected to logging and/or road building (among them South Fork Caspar Creek), while the others remained undisturbed (including North Fork Caspar Creek). The purposes of this study were to characterize the water quality of the streams, to determine whether the logging and road construction drastically altered water quality, and to collect data on water quality that could be tested for predicting stream carrying capacities for salmonids. Conditions were generally suitable for salmonids during and after the logging.

Key Terms: water quality, fisheries, logging, roads

Krammes, J.S.; Burns, D.M. 1973. **Road construction on Caspar Creek watersheds — a 10-year progress report.** Res. Paper PSW-93. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, USDA Forest Service; 10 p.

Measured suspended sediment yields increased by four fold during the first winter after right-of-way clearing, road building, and bridge construction; subsequent winter yields were not as excessive. Other impacts of the road implementation include increased water temperature, decreased young-of-the-year fish populations, and changes in composition of streambed particle size.

Key Terms: roads, logging, streamflow, sedimentation, fisheries

Lewis, J. 1991. **An improved bedload sampler.** In: Fan, S.; Kuo, Y.H., eds. Fifth Federal Interagency Sedimentation Conference Proceedings, 1991 March 18-21, Las Vegas, NV. Washington, DC: Federal Energy Regulatory Commission; 6-1 to 6-8.

Improvements upon the Birkbeck bedload sampler were implemented in the North Fork of Caspar Creek, a gravel-bedded stream. Bedload sediment falls through a slotted plate covering a 0.125-m³ steel box set within a formed concrete pit in the streambed. In two seasons of experimentation, the pillow and hydraulic and mechanical linkages of the Birkbeck-like sampler were replaced with an electronic load cell, resulting in more trouble-free operation, greater precision, and reduced background noise.

Key Terms: bedload, sediment, instrumentation, sampling

Lewis, Jack. 1996. **Turbidity-controlled suspended sediment sampling for runoff-event load estimation.** Water Resources Research 32(7): 2299-2310.

For estimating suspended sediment concentration (SSC) in rivers, turbidity is generally a much better predictor than water discharge. Measurements of SSC and turbidity were collected at 10-minute intervals from five storm events in a small, mountainous watershed (Caspar Creek) that exports predominantly fine sediment. Samples were selected from each storm's record, and event loads were estimated by predicting SSC from regressions on turbidity. Using simple linear regression, loads were estimated with root mean square errors consistently lower than those of sediment rating curve estimates based on the same samples.

Key Terms: suspended sediment, turbidity, storm runoff, sampling

Lewis, Jack. 1997. **Changes in storm peak flows after clearcut logging.** EOS, Transactions, American Geophysical Union 78(46): F314.

Streamflow in a Caspar Creek watershed was monitored at 13 locations before and after 50 percent of the watershed was logged, primarily by clearcutting. The logarithm of unit area peak flow was statistically modeled as a function of control watershed peak flow, proportion of watershed cut, antecedent wetness, and time since logging. The

logarithm of unit area peak flow was found to vary linearly with the proportion cut, the slope decreasing with increasing antecedent precipitation. Peak flow increases are attributed to loss of evapotranspiration and interception in the treated watersheds.

Key Terms: storm runoff, peak flow, logging

Lewis, Jack. 1998. **Evaluating the impacts of logging activities on erosion and sediment transport in the Caspar Creek watersheds.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 55-69.

Suspended sediment has been sampled at both the North and South Fork weirs since 1963, and at 13 tributary locations in the North Fork since 1986. In the most conservative treatment of the data, suspended loads increased by 212 percent over the total predicted for a 6-year period commencing with the onset of logging in hydrologic year 1971. When the roles of the watersheds were reversed and the same analysis repeated to evaluate harvesting in the North Fork under California Forest Practice Rules in the 1990's, no significant increase was found at NFC in either annual suspended or bed load. Using a more sensitive analysis, for the 7-year period commencing with the onset of logging the North Fork, the sum of the suspended storm loads was 89 percent higher than that predicted for the undisturbed condition.

Key Terms: streamflow, suspended sediment, bedload, cumulative watershed effects, logging, roads

Lewis, Jack; Eads, Rand. 1996. **Turbidity-controlled suspended sediment sampling.** Watershed Management Council Newsletter 6(4): 1, 4-5.

In Caspar Creek, turbidity has been measured for estimating suspended sediment concentration (SSC). Results indicate that turbidity is generally a better predictor of SSC than water discharge. Turbidity also provides a more detailed picture of sediment transport than is normally available.

Key Terms: turbidity, suspended sediment, sampling, instrumentation

Lisle, T.E. 1979. **The Caspar Creek Experimental Watershed.** In: Guidebook for a field trip to observe natural and management-related erosion in Franciscan Terrane of northern California. Cordilleran Section of the Geological Society of America, 1979 April 9-11; San Jose, CA. Menlo Park, CA: Geological Society of America; XIV-1 to XIV-8.

This paper offers an overview of the Caspar Creek Experimental Watershed, including the project history, interpretations of the data, and future plans. Effects of logging and road construction on streamflow, erosion, and sedimentation are reported and discussed.

Key Terms: geology, streamflow, erosion, sedimentation, logging, roads

Lisle, T.E. 1989. **Sediment transport and resulting deposition in spawning gravels, north coastal California.** Water Resources Research 25(6): 1303-1319.

To relate sedimentation of spawning gravel beds to sediment transport, infiltration of fine sediment (<2 mm in diameter) into clean gravel beds, distribution of bed material size, scour-fill depths, and sediment transport during 10 storm flow events were measured in three streams of north coastal California. Great temporal and spatial variation in sedimentation in these streams suggests that individual storms of moderate size pose a threat to eggs in many but not all areas

selected by fish for spawning.

Key Terms: sediment transport, bedload, fisheries

Lisle, Thomas E.; Napolitano, Michael. 1998. **Effects of recent logging on the main channel of North Fork Caspar Creek.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 81-85.

The response of the mainstem channel of North Fork Caspar Creek to recent logging is examined by time trends in bed load yield, scour and fill at resurveyed cross sections, and the volume and fine-sediment content of pools. Changes in bed load yield were not detected despite a strong correlation between total scour and fill and annual effective discharge, perhaps because changes in stormflows were modest. The strongest responses are an increase in sediment storage and pool volume, particularly in the downstream portion of the channel along a buffer zone, where large woody debris (LWD) inputs are high.

Key Terms: sediment, bedload, large woody debris logging, pool volume

Maahs, Michael; Gilleard, Jim. 1994. **An evaluation of rehabilitation efforts based on carcass recovery and spawning activity.** Anadromous salmonid resources of Mendocino County coastal and inland rivers. Final Report, August 1994. Sacramento, CA: Calif. Dept. of Fish and Game; 60 p.

To evaluate the effectiveness of salmon-restoration efforts, spawning surveys were conducted in Mendocino County streams (including Caspar Creek) in 1991-1992 and in 1990-1991. Restoration activities were shown to be related to salmon production in several ways.

Key Terms: fisheries, stream ecology, stream restoration

Messer, Dean F.; Donaldson, Catherine L.; Parker, Michael S.; Knight, Allen W. 1994. **Effects of clear-cut logging practices on benthic communities of the North Fork Caspar Creek Watershed, Jackson State Demonstration Forest: Interim Report, Spring 1987 to Spring 1992.** Land, Air, and Water Resources Paper No. 100024. Davis, CA: University of California; 28 p.

The goal of this research has been to determine whether changes in physical processes related to clearcut logging are translated into changes in the structure and function of in-stream floral and faunal assemblages. This study obtained considerable data on benthic macroinvertebrate densities, relative abundance of common taxa and functional feeding groups, litter decomposition rates and benthic macroinvertebrates inhabiting leaf litter accumulations, and benthic algal standing crop and taxonomic structure at several sites along North Fork Caspar Creek. Although this study did uncover significant changes in several parameters, the specific reasons (drought or logging effects) for such changes remain unclear.

Key Terms: sedimentation, stream ecology, logging

Morken, Ingrid; Ziemer, Robert R. 1998. **Publications related to Caspar Creek.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 137-149.

Annotated bibliography of 107 papers produced during 36 years of research in the Caspar Creek Experimental Watershed.

Key Terms: paired watersheds, bibliography, monitoring, land management, resource issues

Nakamoto, Rodney. 1998. **Effects of timber harvest on aquatic vertebrates and habitat in the North Fork Caspar Creek.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 87-95.

An increase in large woody debris volume resulting from blowdown in the buffer zone following timber harvest increased the availability of pools and changed channel sediment storage characteristics. These changes suggest that yearling steelhead, Coho, and Pacific giant salamanders may benefit via increased living space and increased feeding efficiency.

Key Terms: aquatic vertebrates, steelhead, Coho, salamander, habitat, riparian

Napolitano, Michael Brent. 1996. **Sediment transport and storage in North Fork Caspar Creek, Mendocino County, California: water years 1980-1988.** Arcata, CA: Humboldt State University; 148 p. M.S. thesis.

A sediment budget for mainstem North Fork Caspar Creek was developed for water years 1980-1988 to evaluate controls on sediment storage changes. Sediment budget findings, Caspar Creek logging history, and research on large woody debris (LWD) were reviewed together to evaluate persistence of historical logging impacts. Comparison of LWD loading on North Fork Caspar Creek to similar streams in old-growth redwood basins suggests that this creek may not have recovered from 19th-century logging.

Key Terms: sedimentation, large woody debris, logging

Napolitano, Michael. 1998. **Persistence of historical logging impacts on channel form in mainstem North Fork Caspar Creek.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 97-101.

The old-growth redwood forest of Caspar Creek was clearcut between 1864 and 1904. Transportation of logs was by splash dam in the headwaters. Water stored behind the dam was released during large storms to sustain log drives. Before log drives could be conducted, all obstructions, including large woody debris (LWD) jams were removed from the channel. Comparison of present-day LWD loading on North Fork Caspar Creek (24 kg m²) to physically similar streams in old-growth redwood basins (49 to 268 kg m²) suggests that LWD loading and stability were greatly diminished by historical logging activities and change to second-growth cover.

Key Terms: historic logging, large woody debris, stream channel, redwood

Napolitano, Michael; Jackson, Francis; Cafferata, Peter. 1989. **A history of logging in the Caspar Creek basin.** Jackson Demonstration State Forest Newsletter, No. 33, April 1989. p. 4-7.

This article traces the history of logging in the Caspar Creek basin since the time of its first European settler, Siegrid Caspar, who was a trapper near the mouth of Caspar Creek before 1860. In 1860 the Caspar Lumber Company purchased 5,000 acres of forested terrain in the Caspar Creek basin. By 1890, logging had been completed over

most of the watershed with the help of crib dams, skid (or corduroy) roads, and steam donkeys. The tramway, crib dam, corduroy roads, and other historic artifacts of early logging days are easily observed in the North Fork basin today.

Key Terms: history, logging

O'Connor, Matthew D.; Ziemer, Robert R. 1989. **Coarse woody debris ecology in a second-growth *Sequoia sempervirens* forest stream.** In: Abell, Dana L., technical coordinator. Proceedings of the California Riparian Systems Conference: protection, management, and restoration for the 1990s; 1988 September 22-24; Davis, CA. Gen. Tech. Rep. PSW-110. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 165-171.

Coarse woody debris (CWD) volume, species, and input mechanisms were inventoried in North Fork Caspar Creek to assess rates of accumulation and dominant sources of CWD in a 100-year-old second-growth redwood forest. CWD accumulation in the active stream channel and in pools was studied to identify linkages between the forest and fish habitat.

Key Terms: coarse woody debris, channel morphology, stream ecology

Parker, Michael. 1991. **North Fork Caspar Creek stream biology study.** Jackson Demonstration State Forest Newsletter, No. 43, October 1991. p. 1-3.

Since spring 1987, a group of aquatic ecologists have been studying the effects of timber harvesting on stream biota in North Fork Caspar Creek to determine how current logging practices within a relatively undisturbed second-growth redwood forest influence the distribution and abundance of algae and invertebrates. Important invertebrates in North Fork Caspar Creek include mayflies, true flies, caddisflies, and stoneflies. Preliminary results indicate that small, relatively fast-growing mayflies and midges are more abundant after logging, probably owing to increases in algae abundance.

Key Terms: stream ecology, logging

Pearce, Richard B. 1993. **Caspar Creek: discovering how watersheds respond to logging.** Berkeley, CA: Pacific Southwest Research Station, USDA Forest Service; 6 p. (Revised from August 1987 issue of *Forestry Research West*).

This pamphlet provides a historical overview of the Caspar Creek watershed study, including results and future plans of the project. The findings have illuminated the extent and nature of the hydrologic impacts of logging operations "typical" for the time period.

Key Terms: streamflow, sedimentation, logging, roads, cumulative watershed effects, fisheries

Pert, Heather Anne. 1993. **Winter food habits of coastal juvenile steelhead and Coho salmon in Pudding Creek, northern California.** Berkeley, CA: University of California; 65 p. M.S. thesis.

Diets of juvenile Coho salmon and steelhead and the composition and density of drift were examined from November 1990 to April 1991 in the coastal stream Pudding Creek located to the north of the Caspar Creek drainage. Using some Caspar Creek data, drift density, antecedent precipitation, and water temperature were correlated to steelhead stomach fullness, whereas stomach fullness of Coho salmon was generally low and not well correlated with any of the variables measured. Winter floods may be important for food supply and sustaining salmonid growth and condition at these sites.

Key Terms: fisheries, storm runoff, stream ecology

Reid, Leslie M. 1998. **Cumulative watershed effects: Caspar Creek and beyond.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, U.S. Department of Agriculture; 117-127.

Cumulative effects are the combined effects of multiple activities, and watershed effects are those which involve processes of water transport. Past approaches to evaluating and managing cumulative watershed effects included the use of mechanistic predictive models, indices of land-use intensity, and open-ended analysis. None has yet proved successful for averting cumulative impacts. Approaches being discussed now include requirements for "zero net increase" of sediment, linkage of planned activities to mitigation of existing problems, use of more protective best management practices, and adoption of thresholds either for land-use intensity or for impact level. Future impact analysis methods probably will be based on strategies for watershed analysis.

Key Terms: cumulative effects, erosion, sediment, watershed, predictive models

Reid, Leslie M.; Hilton, Sue. 1998. **Buffering the buffer.** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 71-80.

Riparian buffer strips help to sustain aquatic ecosystems and to protect downstream resources and values in forested areas, but controversy persists over how wide a buffer strip is necessary. Although most tree-fall-related sediment and woody debris inputs to Caspar Creek are generated by tree fall within a tree's height of the channel, trees falling from upslope of the contributing tree trigger about 30% of those tree falls.

Key Terms: riparian, buffer, woody debris, cumulative watershed effects, logging

Rice, R.M. 1987. **Cumulative impacts: current research and current opinions at PSW.** In: Proc. Impact '87, Annual Convention of California Licensed Foresters Association; 1987 March 6-7, 1987; Pioneer, CA; 1-12.

In 1985, scientists at the USDA Forest Service, Pacific Southwest Forest and Range Experiment Station (PSW) began collecting data in the Caspar Creek watershed for a study specifically designed to address cumulative watershed effects (CWEs).

Key Terms: cumulative watershed effects, sedimentation, logging, roads

Rice, R.M. 1991. **Cumulative watershed effects: can they be measured? What have we learned from the Caspar Creek studies in northern California?** In: The 1990s—challenging our profession and professionalism. Summaries of the proceedings of the 1990 western forestry conference, 1990 December 2-5; Coeur d'Alene, ID. Portland, OR: Western Forestry and Conservation Association; 92.

Cumulative Watershed Effects (CWEs) may be additive or synergistic. Additive CWEs are the sediment accumulation downstream caused by various activities (such as road construction). Synergistic effects are aggregates of additive CWEs. Even though Best Management Practices (BMP) are applied, synergistic CWEs may result in an unacceptable amount of suspended sediment in a stream and trigger additional impacts. Current research at Caspar Creek is aimed at estimating the magnitude of synergistic CWEs.

Key Terms: cumulative watershed effects, sedimentation, logging, roads

Rice, R.M. 1996. **Sediment delivery in the North Fork of Caspar Creek.** Unpubl. Final Rept. prepared for the Calif. Dept. of Forestry and Fire Protection, Agreement No. 8CA94077. 11 p.

Sediment delivery was estimated for 13 tributary watersheds and the North Fork of Caspar Creek. The median ratio of sediment to erosion was 6.3 percent. Data analyses suggest that more research is needed for estimating sheet erosion and stream channels as sediment sources. Compared to an earlier study in the South Fork of Caspar Creek, logging of the North Fork resulted in erosion that was about half as large and a sediment delivery ratio that was also about half of the 1979 estimate.

Key Terms: sedimentation, erosion, logging, roads

Rice, Raymond M. 1998. **Where do we go from here?** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 135-136.

Suggests that future research in the North and South forks of Caspar Creek is to make of them a continuing study of the two main opposing silvicultural systems: even- and uneven-aged management. The South Fork has had one partial cut more than 25 years ago and is ready for another. The North Fork already has no adjacency problems; therefore, additional clearcuts could be made at any time. Hopefully, these analyses would include biological concerns as well as hydrologic effects.

Key Terms: paired watersheds, future study, monitoring, land management, resource issues

Rice, Raymond M. 1998. **Why Caspar Creek—then and now?** In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 11-13.

The results of every watershed experiment are a unique combination of the site, the weather, the questions asked, the quality of the data produced, and the quality of the analysis made of those data. These results narrow the scope of the environmental debate, but they will not alter the value systems of the debaters. By availing themselves of the available scientific information both sides can make their cases more persuasive to the courts, to the regulators, and *perhaps* to the public.

Key Terms: paired watersheds, research

Rice, R.M.; Tilley, F.B.; Datzman, P.A. 1979. **A watershed's response to logging and roads: South Fork of Caspar Creek, California, 1967-1976.** Res. Paper PSW-146. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 12 p.

A paired-watershed study in the North and South Forks of Caspar Creek demonstrates the effects of logging and road building on streamflow and sedimentation. On-site erosion, annual suspended sediment loads, and debris basin accumulations were estimated in order to evaluate the effects of road construction and the timber harvest. The South Fork watershed produced a threefold increase over that which would have been expected had the watershed remained undisturbed. Analysis of the sediment/stream power relationship of

Caspar Creek strongly suggests that the increase in sedimentation is due to the additional availability of logging and road-related sediment for transport.

Key Terms: roads, logging, erosion, sedimentation

Rodriguez, Albert; Jones, Weldon. 1993. **Investigations of salmon and steelhead trout: downstream migrations in Caspar Creek and Little River, Mendocino County, March-July, 1993.** Unpublished Rept. Calif. Dept. of Fish and Game, Sacramento, CA, 14 p.

Two coastal streams were compared in order to observe the different trend patterns of juvenile out-migrations for Coho salmon and steelhead trout. The size, timing, growth rate, and age classifications of salmonids were determined. Analysis of the 1993 trapping season indicates, at Little River, a decrease of steelhead trout yearlings but an increase in Coho yearlings. At Caspar Creek, Coho and trout yearlings were similar in magnitude and simultaneously tapered in late May.

Key Terms: fisheries, stream ecology

Sendek, Karen Hardison. 1985. **Effects of timber harvesting on the lag time of Caspar Creek watershed.** Arcata, CA: Humboldt State University; 46 p. M.S. thesis.

Hydrograph lag time was analyzed to determine changes after road construction and after selective, tractor-yarded logging in the Caspar Creek watershed. Six hydrologic variables were examined as predictors of the effect of logging on lag time. Proportion of area logged and the ratio of proportion of area logged divided by the storm sequence number were the best predictors. Other variables examined were North Fork peak flow, storm sequence number, storm size, and antecedent precipitation.

Key Terms: storm runoff, peak flow, logging, roads

Spittler, T.E. 1995. **Pilot monitoring program: geologic input for the hillslope component (includes a discussion of Caspar Creek geology and geomorphology).** Unpublished report prepared for the Calif. Dept. of Forestry and Fire Protection, Contract No. 8CA38400, Sacramento, CA. 18 p.

The development of hillslope monitoring techniques needed to evaluate the effectiveness of the Forest Practice Rules in protecting water quality is explained. The major component of Division of Mines and Geology (DMG) work involved defining the physical characteristics of the pilot watersheds, among them the North and South Forks of Caspar Creek above their weir dams. DMG also participated in the Monitoring Study Group to aid in developing analysis techniques for evaluating hillslope processes as well as procedures for selecting and evaluating monitoring locations for a possible long-term monitoring program.

Key Terms: hillslope processes, geology, stream ecology, logging

Spittler, T.E.; McKittrick, M.A.. 1995. **Geologic and geomorphic features related to landsliding, North and South Forks of Caspar Creek, Mendocino County, California.** Open File Rept. OFR 95-08, scale 1:12,000. Available from: Calif. Dept. of Conservation, Division of Mines and Geology, 801 K Street, MS 14-34, Sacramento, CA 95814-3532.

This set of two maps provides information about geology and geomorphic features of the watersheds of North and South Fork, Caspar Creek. The mapping for these areas was done at a scale of 1:12,000.

Key Terms: geology, geomorphic process, landslides, mapping

Surfleet, Christopher G.; Ziemer, Robert R. 1996. **Effects of forest harvesting on large organic debris in coastal streams.** In: LeBlanc, John, ed. Conference on coast redwood forest ecology and management; 1996 June 18-20; Arcata, CA. Berkeley, CA: University of California; 134-136.

Large organic debris (LOD) was inventoried in two coastal streams (the North and South Forks of Caspar Creek) to assess the impacts of forest harvesting on LOD recruitment in 90-year-old second-growth redwood and fir stands. LOD levels increased after harvest because residual trees were left adjacent to the stream or in streamside buffer strips. Windthrow of fir provided the largest input of LOD in these stands owing to the stand age and structure of the residual trees adjacent to the stream.

Key Terms: large woody debris, logging, buffer strips, channel morphology

Thomas, R.B. 1985. **"Artificial intelligence" at streamgaging stations.** EOS, Transactions, American Geophysical Union 66(46): 912.

Stream measurement involves technical/logistical problems of collecting and transferring data and questions of time-related sampling. Field microprocessors using sampling algorithms and real-time sensing of stream variables can substantially improve the quality of stream data collection.

Key Terms: streamflow, instrumentation, sampling

Thomas, Robert B. 1985. **Estimating total suspended sediment yield with probability sampling.** Water Resources Research 21(9): 1381-1388.

The "Selection At List Time" (SALT) scheme controls sampling of concentration for estimating total suspended sediment yield. The probability of taking a sample is proportional to its estimated contribution to total suspended sediment discharge. When applied to real data with known yield, the SALT method underestimated total suspended sediment yield by less than 1 percent, whereas the flow duration sediment rating curve method underestimated total suspended sediment yield by 51 percent.

Key Terms: suspended sediment, instrumentation, sampling

Thomas, R.B. 1985. **Measuring suspended sediment in small mountain streams.** Gen. Tech. Rep. PSW-83. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 9 p.

This report describes the problems in measuring suspended sediment in small mountain streams. The factors that govern the quality of data collected in a monitoring program are discussed.

Key Terms: suspended sediment, instrumentation, sampling

Thomas, R.B. 1988. **Measuring sediment yields of storms using PSALT.** In: Bordas, M.P.; Walling, D.E., eds. Sediment budgets, proceedings of the Porto Alegre Symposium; 1988 December 11-15; Brazil. International Association of Hydrological Sciences Publication No. 174. Wallingford, UK: IAHS; 101-109.

To sample and estimate sediment yields in Caspar Creek, PSALT (Piecewise Selection At List Time) — a probability-based method for sampling that enhances data collection during high flows — has been used. Because PSALT data are independent they can be combined to give unbiased estimates of suspended sediment yield and its variance during storms. Problems of applying the method to a large number of basins are discussed along with their solutions.

Key Terms: suspended sediment, sampling, storm runoff

Thomas, R.B. 1989. **Piecewise SALT sampling for estimating suspended sediment yields.** Gen. Tech. Rep. PSW-83. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 11 p.

SALT (Selection At List Time) is a method for collecting data on suspended sediment concentration and estimating total suspended sediment yield. The SALT estimates can consist of composites or portions of several SALT-monitored periods, known as "piecewise SALT sampling." This paper describes how to collect data and estimate sediment yield and its variance by piecewise SALT sampling, and discusses another method for setting sample size which is particularly appropriate for piecewise SALT sampling.

Key Terms: suspended sediment, sampling

Thomas, R.B. 1990. **Problems in determining the return of a watershed to pretreatment conditions: techniques applied to a study at Caspar Creek, California.** Water Resources Research 26(9): 2079-2087.

Using a previously treated basin as a control in subsequent paired-watershed studies requires the control to be stable. Recovering from logging and road building in the early 1970's, the South Fork of Caspar Creek was assessed for basin stability. The results of studying three storm-based discharge characteristics (peak discharge, quick flow, and total storm flow), daily flows, and concentration of suspended sediment indicate that the South Fork has returned to near pretreatment conditions.

Key Terms: storm runoff, suspended sediment, sampling

Thomas, Robert B.; Lewis, Jack. 1993. **A comparison of selection at list time and time-stratified sampling for estimating suspended sediment loads.** Water Resources Research 29(4): 1247-1256.

Time-stratified sampling of sediment for estimating suspended load is introduced and compared to selection at list time (SALT) sampling. The two methods are compared using five storm populations of suspended sediment flux derived from turbidity data. Both methods provide unbiased estimates of load and variance but vary in efficiency according to storm size and duration.

Key Terms: suspended sediment, sampling

Thomas, Robert B.; Lewis, Jack. 1993. **A new model for bedload sampler calibration to replace the probability-matching method.** Water Resources Research 29(3): 583-597.

In 1977, extensive data were collected to calibrate six Helley-Smith bedload samplers with four sediment particle sizes in a flume at the St. Anthony Falls Hydraulic Laboratory at the University of Minnesota. A new calibration model was developed that regresses transformed individual sampler measurements on daily means of transformed trap data and incorporates within-day variation in trap rates to explain part of the sampler variation. Results of this study can be used to design a more rigorous calibration experiment.

Key Terms: bedload, sampling, modeling, sedimentation

Thomas, R.B.; Lewis, Jack. 1995. **An evaluation of flow-stratified sampling for estimating suspended sediment loads.** Journal of Hydrology 170: 27-45.

Flow-stratified sampling is a new method for sampling water quality constituents such as suspended sediment to estimate loads. It is a statistical method requiring random sampling and yielding unbiased estimates of load and variance. Flow-stratified sampling is described

and its variance compared with those of selection-at-list-time (SALT) and time-stratified sampling.

Key Terms: sampling, suspended sediment, storm runoff

Tilley, F.B.; Rice, R.M. 1977. **Caspar Creek watershed study—a current status report.** State Forest Notes No. 66. Sacramento, CA: State of Calif., Department of Forestry; 15 p.

The primary objectives of the project are to measure the sediment produced by a north coastal watershed in an undisturbed condition and to measure the degree to which water quality, flood peaks, suspended sediment, and bedload are affected by road construction and logging when practices are designed to minimize excessive runoff and erosion. The most apparent effects of logging the South Fork were the increased amounts of suspended sediment and the greater responsiveness to precipitation.

Key Terms: peak flow, suspended sediment, bedload, roads, logging

Walton, K. 1988. **Downstream migrant trapping on Caspar Creek and Little River, March-June 1988.** Calif. Dept. of Fish and Game Unpublished Rept. Sacramento, CA. 8 p.

This study was conducted to observe the different trend patterns of juvenile out migrations for Coho salmon and steelhead-trout. The size, timing, growth rate and age classifications of salmonids for 1988 are reported.

Key Terms: fisheries, stream ecology

Wosika, Edward Pearson. 1981. **Hydrologic properties of one major and two minor soil series of the Coast Ranges of northern California.** Arcata, CA: Humboldt State University; 150 p. M.S. thesis.

The following properties of the Hugo, Mendocino, and Caspar soil series were analyzed at various depths: bulk density, porosity, particle density, saturated and unsaturated hydraulic conductivity, particle-size distribution, pore-size distribution, and water retention characteristics. The main factor producing differences between these three series and within the Hugo series is the degree of colluvial mixing, which is closely related to slope position. Also, the unsaturated hydraulic conductivity of the three series are sufficiently high at all soil depths to preclude the large-scale development of saturated subsurface flow.

Key Terms: soils, geology, subsurface flow

Wright, Kenneth A. 1985. **Changes in storm hydrographs after roadbuilding and selective logging on a coastal watershed in northern California.** Arcata, CA: Humboldt State University; 55 p. M.S. thesis.

The effects of road building and selective tractor harvesting on storm peak flows and storm volumes were assessed for the Caspar Creek watershed. Only the very small storm peaks or volumes were increased after roadbuilding and logging. The increases in small storm peaks and volumes are not considered significant to the stream's stability or sediment regime.

Key Terms: peak flows, storm runoff, logging, roads

Wright, Kenneth A.; Sendek, Karen H.; Rice, Raymond M.; Thomas, Robert B. 1990. **Logging effects on streamflow: storm runoff at Caspar Creek in northwestern California.** Water Resources Research 26(7): 1657-1667.

The effects of road building and selective tractor harvesting on storm runoff were assessed at Caspar Creek. Findings suggest no significant increases in storm volumes and peaks of large storms by either roads

or logging. In a rain-dominated hydrologic environment, logging and forest road construction (as carried out in this study) are not likely to change the flow regime of a stream adversely.

Key Terms: peak flows, logging, storm runoff

Ziemer, Robert R. 1968. **Fifth progress report, 1967, cooperative watershed management research, flood and sediment reduction in the lower conifer zone of California.** Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 9 p.

Describes work on the Caspar Creek study during 1967.

Key Terms: experimental watersheds

Ziemer, Robert R. 1981. **Stormflow response to roadbuilding and partial cutting in small streams of northern California.** Water Resources Research 17(4): 907-917.

To assess the influence of roadbuilding and logging on storm flow response, the North Fork and South Fork of Caspar Creek were studied from 1963 to 1975. Selection cutting and tractor yarding of 85-year-old second-growth redwood and Douglas-fir forest did not significantly affect large peak flows. The effect of logging on peak flow was best predicted by a variable that represented the percentage of the area logged divided by the sequential storm number within the year.

Key Terms: streamflow, roads, logging

Ziemer, R.R. 1990. **The Caspar Creek Watersheds—a case study.** In: Callahan, R.Z., ed. Case studies and catalog of watershed projects in western provinces and states. Report 22. Davis: University of California Wildland Resources Center; 17-19, 81.

A synopsis of the Caspar Creek Experimental Watersheds, from their inception in 1962 to their status in 1990. The history, problems, objectives, and planning of the study are discussed.

Key Terms: streamflow, suspended sediment, bedload, cumulative watershed effects, logging, roads

Ziemer, R.R. 1992. **Effect of logging on subsurface pipeflow and erosion: coastal northern California, USA.** In: Walling, D.E.; Davies, T.R.; Hasholt, B., eds. Erosion, debris flows and environment in mountain regions, Proceedings of the Chendu symposium; 1992 July 5-9; Chendu, China. International Association of Hydrological Sciences Publication No. 209. Wallingford, UK: IAHS; 187-197.

Three zero-order swales, each with a contributing drainage area of about 1 ha, were instrumented to measure pipeflows within the Caspar Creek Experimental Watershed. After two winters of data collection, the second-growth forest on two of the swales was clearcut logged while the third swale remained an uncut control. After logging, peak pipeflow and suspended sediment load increased.

Key Terms: subsurface flow, pipeflow, suspended sediment, logging

Ziemer, R. 1996. **Caspar Creek streamflow and sediment records: 1963-1995.** CD-ROM, 200 MB. 1996 July. Arcata, CA: Pacific Southwest Research Station, USDA Forest Service, and Fort Bragg, CA: California Department of Forestry and Fire Protection.

This CD-ROM contains data records for the North and South Forks of Caspar Creek from 1963-1995, including annual precipitation, streamflow and sediment records, daily and 10-minute streamflow records, and a compilation of all suspended sediment samples collected.

Key Terms: streamflow, suspended sediment, precipitation, temperature, logging

Ziemer, R. 1998. **Caspar Creek hydrologic and climatic data: 1963-1997**. CD-ROM, 545 MB. 1998 May. Arcata, CA: Pacific Southwest Research Station, USDA Forest Service, and Fort Bragg, CA: California Department of Forestry and Fire Protection.

Detailed data files on this expanded CD-ROM include streamflow (1963-1997), suspended sediment (1963-1997), rainfall (1963-1997), solar radiation (1988-1997), channel cross-sections (1987-1997), and air and water temperatures (1989-1997). In addition, detailed streamflow and sediment data are included for 13 tributary stations that were installed in the North Fork in August 1985.

Key Terms: streamflow, suspended sediment, precipitation, solar radiation, channel morphology

Ziemer, Robert R. 1998. **Flooding and stormflows**. In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 15-24.

The effects of road building and timber harvest on storm flow were evaluated by studying 174 storms from 1963 through 1975 that produced peak discharges in the untreated North Fork larger than $0.016 \text{ L s}^{-1}\text{ha}^{-1}$. These smallest storm peaks occur on average about 14 times each year. Flows this size and larger occupy about 10 percent of the time, are responsible for 83 percent of the annual water discharge, and transport 99 percent of the suspended sediment. In 1985, an additional 13 gaging stations were installed in the North Fork. From 1985 through 1996, 526 peakflow observations were made, representing 59 storms. There was a mean peakflow increase of 35 percent in entirely clearcut and 16 percent in partially clearcut watersheds for the class of flows greater than $4 \text{ L s}^{-1}\text{ha}^{-1}$.

Key Terms: paired watersheds, peak streamflow

Ziemer, Robert R. 1998. **Monitoring watersheds and streams**. In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 129-134.

Regulations increasingly require monitoring to detect changes caused by land management activities. Successful monitoring requires that objectives be clearly stated. Once objectives are clearly identified, it is important to map out all of the components and links that might affect the issues of concern. Each issue and each component that affects that issue has a set of spatial and temporal scales within which they operate. These scales are not consistent between and amongst one another. For many issues, unusual events are more important than average conditions. Regulations developed from the consequences of small "normal" storms will be inadequate in that the data will not include the critical geomorphic events that affect the physical and biological concerns.

Key Terms: paired watersheds, peak streamflow, monitoring, land management, resource issues

Ziemer, Robert R. 1998. **Preface**. In: Ziemer, Robert R., technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story, 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; iii-iv.

The Conference was held May 6, 1998 at the Mendocino Community College in Ukiah, California, and was attended by about 400 persons. On May 7, 75 individuals participated in a field trip through the North Fork of Caspar Creek. There is keen interest in the effect of forest practices on the hydrologic response of watersheds. Attendance at both the Conference and the field trip was limited by seating capacity and a large number of potential registrants were turned away because of lack of space.

Key Terms: paired watersheds, conference, coastal watersheds

Ziemer, Robert R., technical coordinator. 1998. **Proceedings of the conference on coastal watersheds: the Caspar Creek story**. 1998 May 6; Ukiah, CA. Gen. Tech. Rep. PSW-GTR-168. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 149 p.

Proceedings contain a preface, 15 papers, and a detailed annotated bibliography of papers produced during 36 years of research in the Caspar Creek Experimental Watershed.

Key Terms: paired watersheds, streamflow, sediment, nutrient, riparian, cumulative effects, soil moisture

Ziemer, R.R.; Albright, J.S. 1987. **Subsurface pipeflow dynamics of north-coastal California swale systems**. In: Beschta, R.; Blinn, T.; Grant, G.E.; Swanson, F.J.; Ice, G.G., eds. Erosion and sedimentation in the Pacific Rim, Proceedings of the Corvallis Symposium, 1987 August. International Association of Hydrological Sciences Publication No. 165. Wallingford, UK: IAHS; 71-80.

Pipeflow dynamics at Caspar Creek is discussed. During storms, pipeflow up to 8 L s^{-1} has been measured, whereas, within the same swales, no surface channel flow occurred. Pipeflow discharge has been correlated with antecedent precipitation.

Key Terms: pipeflow, storm runoff, subsurface flow, hillslope hydrology

Ziemer, R.R.; Cafferata, P.H. 1992. **The Caspar Creek watersheds: a case study of cumulative effects in a small coastal basin in northern California**. In: Proceedings 1991 SAF National Convention; 1991 August 4-7; San Francisco, CA. San Francisco, CA: Society of American Foresters; 2 p.

This paper gives an overview of the Caspar Creek experimental watersheds from 1962 to 1992. In 1985 the study was modified to evaluate the cumulative watershed effects of logging the North Fork. Intensively measured were precipitation, soil moisture, groundwater, subsurface pipeflow, streamflow and suspended sediment discharge at 15 gauging stations, bedload movement, stream channel stability, large woody debris, and anadromous fish habitat.

Key Terms: cumulative watershed effects, streamflow, storm runoff, sedimentation, logging, roads

Ziemer, Robert R.; Kojan, Eugene; Thomas, Robert B. 1965. **Third progress report, 1965, cooperative watershed management in the lower conifer zone of California**. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 33 pp.

Describes instrumentation and presents data on streamflow, precipitation, and sedimentation collected between October 1, 1963 and September 30, 1965. Discusses the stream ecology study conducted by John DeWitt, Richard Ridenhour, and James Andrews of Humboldt State College.

Key Terms: experimental watersheds, stream ecology

Ziemer, Robert R.; Kojan, Eugene; Thomas, Robert B.; Muller, Robert A. 1966. **Fourth progress report, 1966, cooperative watershed management research, flood and sediment reduction in the lower conifer zone of California.** Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 88 p.

Describes instrumentation and presents data on streamflow, precipitation, and sedimentation collected between October 1, 1963 and September 30, 1965. Discusses the stream ecology study conducted by John DeWitt, Richard Ridenhour, and James Andrews of Humboldt State College.

Key Terms: experimental watersheds, stream ecology

Ziemer, Robert R.; Lewis, Jack; Keppeler, Elizabeth T. 1996. **Hydrologic consequences of logging second-growth watersheds.** In: LeBlanc, John, ed. Conference on coast redwood forest ecology and management; 1996 June 18-20; Arcata, CA. Berkeley, CA: University of California; 131-133.

Streamflow, suspended sediment, and bedload have been gauged continuously since 1962 in the 473-ha North Fork and the 424-ha South Fork of Caspar Creek. During the course of the study, logging

roads were built and approximately 65 percent of the timber volume was selectively cut in the South Fork and clearcut in the North Fork. Large peak flows did not change significantly in either watershed. To date, the effect on sediment loads of logging in the North Fork has been much smaller than that following logging in the South Fork.

Key Terms: streamflow, peak flow, suspended sediment, bedload, logging

Ziemer, R.R.; Rice, R.M. 1990. **Tracking rainfall impulses through progressively larger drainage basins in steep forested terrain.** In: Lang, H.; Musy, A., eds. Hydrology in mountainous regions. I - Hydrological measurements; the water cycle, proceedings of two Lausanne symposia, 1990 August. International Association of Hydrological Sciences Publication No. 193. Wallingford, UK: IAHS; 413-420.

The precision of timing devices in modern electronic data loggers makes it possible to study the routing of water through small drainage basins having rapid responses to hydrologic impulses. By using such means as digital tipping bucket rain gauges, naturally occurring soil pipes, streamflow gauging stations, and piezometers, stream discharge and routing can be measured. Peak lag time increased significantly downstream, and peak unit area discharge decreased downstream.

Key Terms: precipitation, storm runoff, subsurface flow

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