

Land and Water

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Research News

Western Australian Steering Committee for Research on Land Use and Water Supply

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DR NICHOLAS J. SCHOFIELD

Surface Water Branch
Water Authority of Western Australia
P O Box 100
LEEDERVILLE WA 6007

Telephone: (09) 420 2961
Facsimile: (09) 328 2619

CONFERENCE REPORTS/STUDY TOURS

Visit to Caspar Creek, Northern California

*Dr Nick Schofield
Water Authority of
Western Australia
P. O. Box 100
LEEDERVILLE WA 6007*

As part of a brief study tour in California, I had the good fortune of spending a very pleasant day on the Caspar Creek watershed, ably guided by Peter Cafferata and Liz Keppeler. Amongst the many notable achievements of the Caspar Creek Study is its longevity. The study started in 1962 and has evolved over time. It is currently enjoying a resurgence of activity, riding on the

back of 'Cumulative Effects'. The study, being carried out by the Pacific Southwest Forest and Range Experiment Station and the California Department of Forestry and Fire Protection, is basically about the effects of logging on streams. The local importance of the study is emphasised by the fact that 70% of California's utilisable streamflow comes from commercial forest lands. Several aspects were of interest to me: impact on sedimentation, stormflow hydrology, stream fauna and of course cumulative effects. Following a brief description of its history and site characteristics, I will elaborate on some of the studies.

History and description of the Caspar Creek Study

Caspar Creek is located in the Jackson State Forest about 10 km south of Fort Bragg, California (Figure 1). Here the winters are mild and wet. The average annual rainfall is 1190 mm with 90% falling from October to April. The mean temperature in January (10°C) differs little from that in July (13°C). In summer the coastal fog often clings to the watershed (which I fortunately avoided).

The study commenced in 1962 as a typical paired watershed experiment,

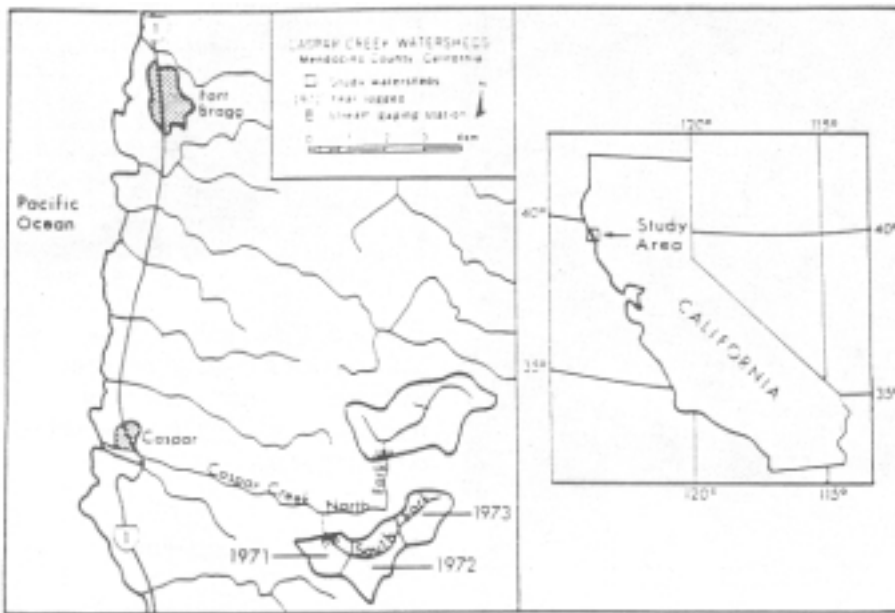


Figure 1: The study site, Caspar Creek in Jackson State Forest, about 10 km south of Fort Bragg, in northern California

the two watersheds being the North and South Forks of Caspar Creek. Both watersheds were clear-cut and burned in the late 1800s but by 1962 supported fairly dense stands of second growth Douglas-fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), western hemlock (*Tsuga heterophylla*) and grand fir (*Abies grandis*). A scattering of old-growth redwoods also remain. Slopes were moderate to steep, with 65% of the area >30% slope and 1-7% >70% slope. The soil profiles were relatively shallow, with depth to bedrock of 1-2 m being typical.

Early studies (1962-76)

Effects on sedimentation

The early studies focused on the effects of roadbuilding and logging on sedimentation and stormflow. The South Fork was the treated watershed and the North Fork served as the control. After a 5-year calibration period, logging roads were built into the South Fork in 1967. The effects of roadbuilding were measured as local on-site erosion, suspended sediment loads in the streams, and sediment deposited in debris basins. Logging commenced in 1971 and ended in 1973 with the same parameters measured throughout. Sixty percent of the timber volume of the South Fork watershed was logged.

Project Scientist Raymond Rice and coworkers (Rice *et al.*, 1979) found that stream sediment increased 80% with

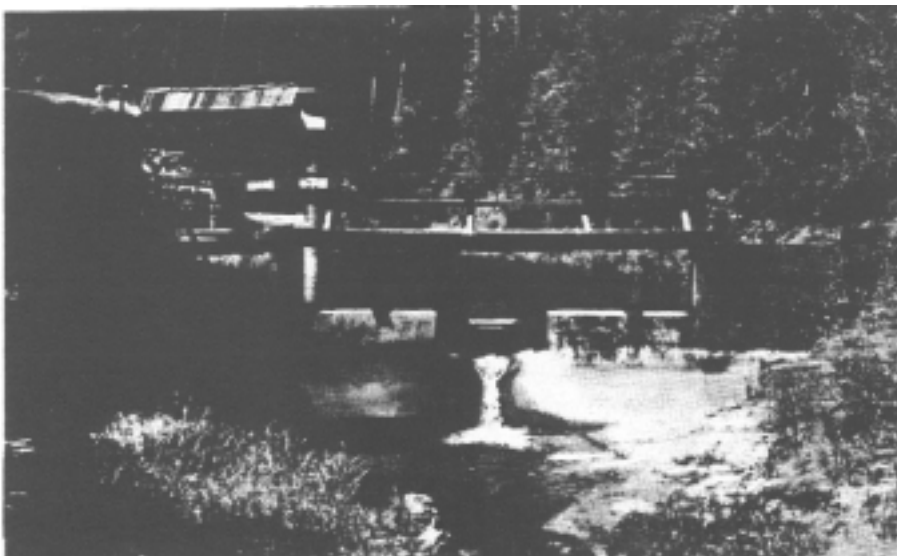


Photo 1: Flow and sediment sampling station on Caspar Creek

roadbuilding and 275% with logging.' Eighty one per cent of the sediment was transported during the highest flows occurring only 10% of the time.'

The authors also found that roadbuilding and logging changed the sediment discharge relationship of the South Fork from one which was supply dependent (depends on availability of sediment for transport rather than the power of the stream) to one which was stream power dependent (depends more on the capacity or power of the stream to transport the material than the availability of sediment). This effect is illustrated in Figure 2. Extrapolation of stream sediment rates, on the basis of logging every 50 years, showed that the soil in the area would be totally exhausted in 34 000 years! Turbidity values were also above those permitted by regional water quality regulations.

Effects on streamflow

After reviewing 11 years of Caspar Creek flow data, Ziemer (1981) found no change in any of several storm flow parameters following roadbuilding in South Fork. The roads occupied 5% of the watershed. More surprisingly the timber logging phase also had no major hydrological consequences. At the completion of logging 15% of the watershed had been compacted by roads, landings or skid trails.

There were two observed 'minor' hydrological changes. Streamflow peaks early in winter increased threefold but were small in magnitude. Later in the wet season stormflow peaks were unchanged. Ziemer attributed the higher early winter peak flows to decreased soil water deficit in the logged watershed after summer, relative to the fully forested watershed. However after early winter rains had equalised the soil water deficits of both catchments, no increases in stormflow peaks were observed on the logged watershed.

The second minor effect was a decrease in time to peak flow following the storm peak of 1.5 hours on average and 3 hours for large storms (Sendek, 1985). Thus the skid trails, landings and roads were increasing the rate of runoff but generally not affecting its magnitude. Logging in this environment, then, does not appear to have adverse hydrological effects such as channel destabilisation that might be caused by larger or more frequent floods.

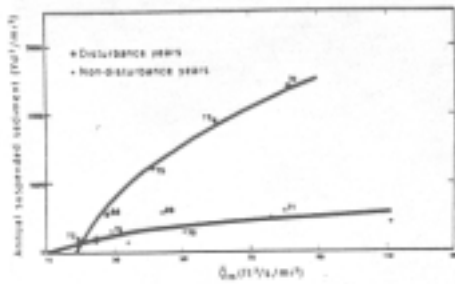


Figure 2: Annual sediment discharge of the South Fork as related to stream power as indexed by Q_{25} (the mean discharge for the top 25% of the flow volume) for disturbed and non-disturbed years

Recent studies

Since the early Caspar Creek studies were carried out (1962-76), forest practices have changed. Selection cutting has changed to clearcutting to improve regeneration and growth rates. Timber removal has changed to predominantly skyline yarding, with less than 30% being removed by tractor. This should lead to much less ground disturbance and soil compaction. Also forest practice legislation has changed substantially in the US and California. New requirements were placed on forestry by the National Environmental Policy Act (NEPA) and the Clean Water Act (CWA) and analogous laws in California. NEPA directs government agencies to consider cumulative effects of pollution when assessing environmental impacts and CWA mandates the development of plans to reduce nonpoint source pollution from activities such as timber harvesting.

Planning for the second phase of the Caspar Creek study commenced in 1979. Data collection started in 1985 and is intended to continue to 1994. In this phase the roles of the two watersheds have been switched. The South Fork has stabilised and will be used as the control. On the North Fork 60% of the timber will be logged. Thirteen subcatchments of the North Fork will be gauged, each being either clearcut, clearcut and burnt or left unlogged.

One of the most impressive aspects of the new programme (to me) was the determination to obtain high quality stream sediment data. In particular considerable attention was paid to the pump sampling, recognising the episodic nature of sediment discharge.



Photo 2: Logging operations in progress in Caspar Creek

The group's statistician, Robert Thomas has designed two variable probability sampling schemes called SALT (Select At List Time) and PSALT (Piecewise Selection at List Time) that provide unbiased estimates of suspended sediment yield and its variance (Thomas, 1985, 1986, 1988). The approach is more costly and requires more field effort—field crews are dispatched on every storm, which may involve spending several days (and nights) at stations! However the benefits of obtaining an unbiased estimator of sediment yield and having an estimate of variance for every sample is considered worth the effort in this study. Underestimates of sediment yield as great as 50% are known to occur with conventional sampling methods.

Cumulative effects

A 'cumulative effect' is when one acceptable activity interacts with another acceptable activity to produce something unacceptable. Cumulative effects may conceivably occur in a watershed subjected to logging when stream responses from subcatchments combine in such a way to cause some greater effect downstream.

The initial problem was to define cumulative effects in such a way that hypotheses could be tested experimentally. To do this, the assumption was made that cumulative effects always occur.



Photo 3: Clearfelling taking place upslope of the stream buffer -- where selective logging is permitted

On Caspar Creek the cumulative effects study will test whether the watershed response (in terms of stormflow volume, peak lag and sediment discharge) will increase with watershed area. If it does it will be concluded that cumulative effects are occurring.

Hillslope hydrology and pipeflow dynamics

Water movement to streams in Caspar Creek takes place primarily by

subsurface pipeflow (Ziemer and Albright, undated). In a preliminary study these authors found that nearly all the stream discharge was derived from pipeflow while very little moved through the soil matrix. The soil pipes have diameters in the range 1 to 100 cm and are observed in the swales at depths between 1 and 2 metres. The piping is thought to be caused by processes including root decay, animal activity, zones of weakness in the soil and seepage forces. Piping is being studied by digging trenches to expose seepage faces across the swales and collecting and measuring flow rates and sediment discharge. The research is being conducted to determine the importance of piping to basic hydrologic processes in these areas. This will include identifying morphological characteristics of pipes and swale systems, relating pipeflow to other hillslope hydrologic components, and correlating pipeflow hydrographs with timing and intensity of precipitation and with downslope channel flow.

Above the swale system the hydrology of a hillslope is being studied by Peter Cafferata to describe how subsurface drainage is routed to the swale and soil pipes. To do this five transects of piezometers and tensiometers have been installed to monitor saturated and unsaturated water movement. The impact of roading and harvesting on this system will also be studied.

Biological studies

Biological evaluations of the effects of logging on fish habitat and survival are being carried out by Lynn Deeker. The impact on coho salmon and steelhead trout has always been an important issue. In an effort to link the effects of watershed processes to fish survival and habitat, fish have been introduced in equal numbers to the North and South Forks. Their response to habitat before, during and after logging will be monitored. Ways in which logging could degrade habitat include sediment filling (reducing habitat volume) or altering the quality of the stream bed. Alternatively increased scouring from a fallen tree could improve habitat. In addition to these studies Allen Knight is investigating macroinvertebrate (aquatic insect) densities and diversity in the North Fork.

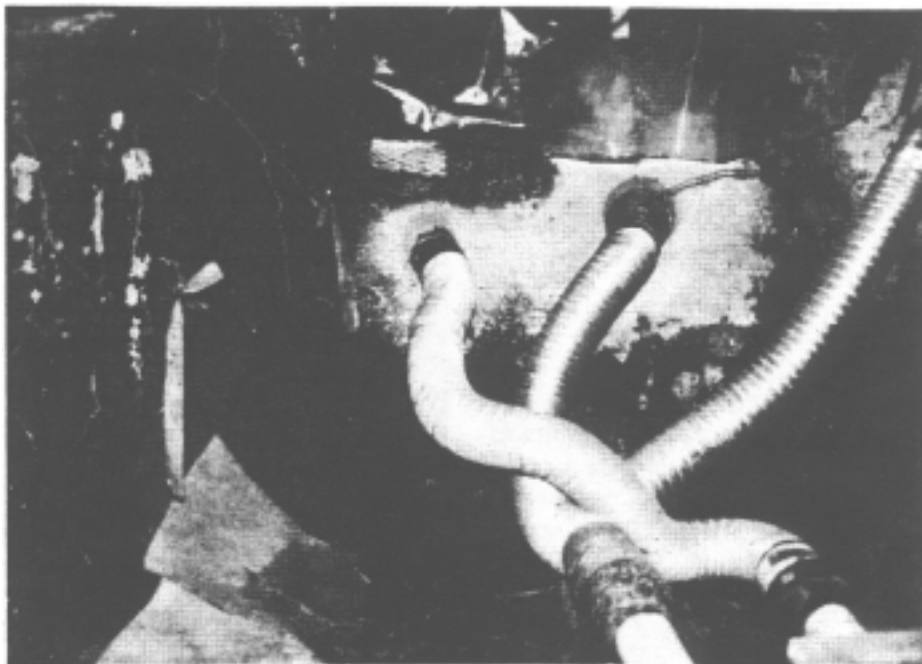


Photo 4: Pipeflow measurement in the swales-tubes feed into continuous water flow measurement devices

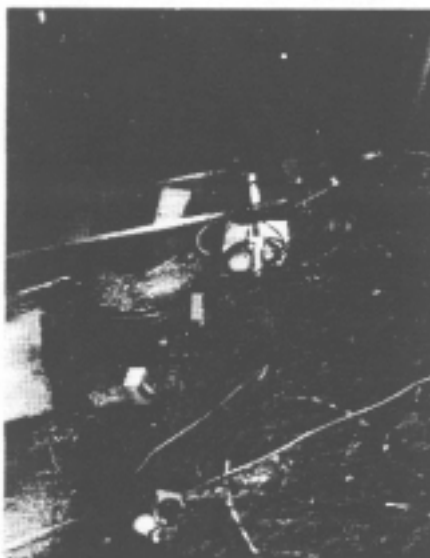


Photo 5: Rows of tensiometers and piezometers traverse a steep hillslope to monitor subsurface flow dynamics

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