Field methods used for monitoring erosion and sedimentation processes in steeplands of northwestern California, USA

WILLIAM WEAVER, RONALD SONNEVIL & RANDY KLEIN
Redwood National Park, 1125 16th Street, Arcata, California 95521, USA

The Redwood Creek drainage basin in northwestern California has been widely reported as one of the most rapidly eroding non-glaciated watersheds of its size in North America. It is also one of the most intensively studied large catchments. For nearly two decades the U.S. Geological Survey and the U.S. National Park Service have conducted a number of research projects to quantify the causes and effects of erosion and sedimentation processes.

A variety of monitoring and measurement techniques for steepland areas have been successfully employed in these efforts. On persistently active mass movement features, such as earthflows and forested blockslides, mechanical strip chart recorders and inexpensive solid state data loggers are used to continuously record downslope movement rates.

Sensing mechanisms in strip chart water level recorders and custom built "slope movement indicators" employ electronic multiple-turn potentiometers to monitor downslope movement of landslides. Each mechanism allows various levels of measurement precision. These records are correlated with data from tipping bucket rain gages and a network of inexpensive storage rain gages fitted with overflow containers. Annual movement of selected slides and of slide subunits are monitored by resurveying stake lines and grids of monumented survey points.

A portable gasoline powered rock drill has proven effective for installing small diameter drill holes to a depth of 40 feet in remote locations. Within these cased holes a small diameter, solid state pressure transducer, interfaced with a solid state analog data recorder, is used to monitor piezometric levels and groundwater elevations on blockslides and at incipient debris flow sites. Piezometric data are used to model the effects of logging roads on pore water pressures beneath road fills in headwater swales. A low displacement crest staff gage with a curved cross section is ideal for retaining a clear, undamaged record of crests at non-recording sites. A small hand-built electric indicator is used to measure water levels during each field visit. Finally, a very inexpensive "depth-of-failure indicator" is installed in the same hole to indicate the location and thickness of the zone of failure.

Fluvial erosion has also been closely monitored on cutover lands. Such commonly used techniques as erosion pins, erosion bridges, and impervious caps have been used to document surface erosion with limited success. Erosion plots with sediment collection troughs have proven much more effective, though more labor-intensive and costly to install and maintain.
Runoff from fluvial erosion plots is measured using storage barrels or large tipping bucket mechanisms connected to the troughs with common garden hoses. Mechanical counters or solid state pulse-counting data loggers can be used to continuously record runoff rates and permit an evaluation of rainfall/runoff relationships.

In small streams draining less than 100 hectares, traditional and modified stream gaging techniques are employed to monitor stream hydrographs. Steep, cascading flows are often measured using a salt dilution method. Irregular channel dimensions typically require the construction of special flumes or channel boundaries for accurate flow measurements using current meters.

A variety of continuous stage recorders have been employed to monitor gauge height and stream discharge. These include standard strip chart recorders with float/pully sensing mechanisms, solid state EPROM recorders using multiple turn potentiometers geared to existing float/pully mechanisms, and solid state analog data loggers using temperature compensated pressure transducers.

Gully erosion has been extensively documented by detailed geomorphic mapping on thousands of hectares of logged land. Using enlarged aerial photographs with mylar overlays as field base maps, exceptional detail is achieved. Based on this work and detailed landslide mapping, magnitude/frequency relationships between gully and landslide dimensions and associated sediment production have been clearly established. Knowledge and use of these relationships in sediment budget studies in similar terrain can substantially reduce field work and improve sediment production estimates.

Finally, a variety of techniques have been used to monitor stream channel changes. Low level aerial photography from helicopters produces vastly superior images of channel conditions compared to those obtained from fixed wing aircraft. For detailed planimetric mapping, hydrogen filled weather balloons are used to suspend a remote controlled, 35mm camera up to 100m above the ground surface.

Stereo ground photography from permanently monumented photo stations is routinely used to provide historical scene documentation not possible with single images. Permanently monumented tag lines and survey cross sections are used to document annual channel changes. Relocatable scour chains reveal the annual depth of channel bed scour and fill. Pebble counts, grab sampling, freeze core sampling and digitization of close-up vertical photographs have all been successfully used to quantify particle size characteristics of channel bed and bank materials.

The relatively long, well funded research effort on erosion and sedimentation processes on logged land in the Redwood Creek basin has permitted experimentation and evaluation of a variety of field research methods. Although many of the techniques have been employed elsewhere, their extensive and continued use on steeplands in Redwood Creek have provided for an extended evaluation and comparison of many methods. A number of inexpensive, innovative techniques and modifications to published methodologies have resulted and should be useful to researchers working in similar settings elsewhere. Many of the less sophisticated, more straightforward techniques have provided the most reliable, accurate and cost-effective data. Most of these methodologies and designs are available from the authors.