



Fig. 1. Old logging roads, such as this one in Whiskeytown National Recreation Area (California), are the primary source of sediment that washes into rivers and streams, degrading habitat for salmon and steelhead trout. To address the problem, the park and Shasta College teamed up to deploy innovative treatments for the restoration of watersheds and habitat recovery. This road was "outsloped" to reduce erosion and sedimentation.

Cooperative watershed restoration in Whiskeytown National Recreation Area

Innovative partnership provides a model for restoration of a scarred landscape

By JOHN McCULLAH AND GRETCHEN RING

Salmonid fisheries continue to decline in the Pacific Northwest. As a result, more populations of salmon and steelhead trout continue to be listed as endangered or threatened. A primary cause of this decline is loss of habitat due to impacts from upland erosion and sedimentation.

In many steep, forested watersheds old logging roads (fig. 1) are the primary source of the sediment that degrades rivers and streams. Roads cause erosion and greatly increase the potential for slope failure during large and episodic storm events. Roads alter the natural drainage patterns, and steeply cut slopes intercept subsurface flows, converting them to surface runoff. Drainage ditches and berms concentrate flows in channels, efficiently delivering sediment to streams. Most importantly, roads are frequently constructed by placing fill material in drainage channels. That fill becomes part of the drainage system and, given enough time, has a high probability of ending up in rivers and streams. Clearly, watershed restoration strategies are needed to deal specifically with road-related erosion and sedimentation.

The Whiskeytown situation

Located 8 miles west of Redding, California, Whiskeytown National Recreation Area primarily occupies the Clear Creek

watershed, an important tributary to the Sacramento River. With a history of past logging, this unit of the national park system has experienced many erosion and sedimentation problems. For example, roads were constructed by placing fill in runoff channels, which alters the natural drainage patterns and basin hydrology, and increases the potential for stream diversions and washouts. Poor road drainage and saturated fill can result in severe landslides. Two large debris flows in the park were initiated at the intersection of stream channels and roads during heavy rains in January 1997.

Solutions to these problems require specially trained watershed restorers such as geomorphologists and heavy equipment operators to identify and treat the numerous watersheds impacted by roads. The National Park Service is addressing these issues at Whiskeytown by cooperatively engaging in ecosystem restoration activities and encouraging education and technology transfer related to these experiences.

Cooperative agreement

In 1996, Whiskeytown and Shasta College entered into a cooperative agreement that enables them to share resources, including funds, for the completion of mutually beneficial projects, primarily watershed restoration. The cooperative restoration program blends education with technology and encourages adaptive management and

the use of innovative techniques to treat habitat degradation in the park caused by old roads. Furthermore, it trains students in restoration ecology, provides a potential employment venue for former timber workers, and improves habitat for salmon populations.

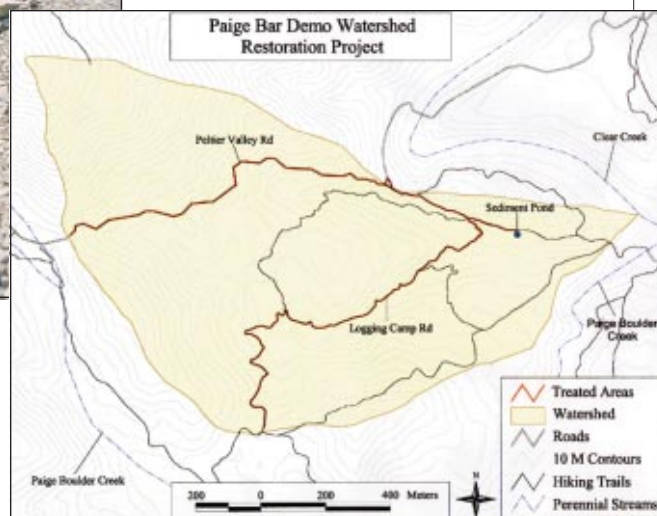
The park serves as a living laboratory in which students conduct actual watershed inventories, develop restoration techniques, engage in monitoring activities, and implement restoration plans. Shasta College provides expertise in various disciplines such as geographic information systems (GIS), watershed restoration, heavy equipment operation, and horticulture; a student workforce performs the work. As part of the agreement, Shasta College developed a watershed restoration class to prepare students for jobs in ecosystem management with practical experience coming from a pilot restoration project at the park. The class emphasizes the geomorphic or landform restoration approach to ecosystem restoration. The pilot sub-watershed restoration project was funded by the Bureau

¹In hilly terrain, roads typically slope inward toward the hill where a ditch and culvert system drains runoff. As culverts and ditches become plugged, runoff concentrates, drains across the road, and creates gullies. Outsloping reverses drainage to the downhill side of the road. Fill is excavated and placed into the uphill cut, resulting in a 2-5-degree slope to the downhill side. Water runs off without forming gullies and subsequent erosion and sedimentation.



Fig. 2 (left). Heavy equipment is used to treat the drainage problems posed by the old logging roads. Here, a culvert is installed to restore natural drainage patterns and reduce erosion of the fill.

Fig. 3 (below). The 300-acre Paige-Bar sub-watershed was the site of the demonstration restoration project at Whiskeytown. The project represents a significant start to the many thousands of acres of Clear Creek watershed in need of restoration at the national recreation area.



of Reclamation (\$40,000) through the Central Valley Improvement Act, and by the National Park Service through a Challenge Cost-Share Grant (\$30,000).

Goals and treatment philosophy

The restoration goals for Whiskeytown National Recreation Area include restoring naturally functioning ecosystems by treating and removing scars on the landscape such as roads. Other management tools, such as prescribed fire and exotic plant removal, can then be employed to enhance biodiversity.

Previous restoration work and studies in Redwood National Park (Spreiter 1994) and Grass Valley Creek Watershed (McCullah 1994) indicate that the primary source of erosion and cause of sedimentation of streams is the extensive road network left over from past logging. These projects clearly demonstrate that physical treatments to restore the hydrologic systems, recover soil from stream channels, and remove road scars set the stage for recovery of the biological systems, and these methods are probably the most cost-effective way to prevent erosion and sedimentation, and reduce the maintenance burden.

These physical treatments frequently include the use of heavy equipment such as hydraulic excavators (fig. 2) and bulldozers to repair and restore the drainage patterns that existed before roads were built. A new axiom is emerging among watershed restorers: for cost-effective road restoration, employ the same type and size of

equipment that caused the problem. The key to cost-effective sediment reduction, however, is prevention, not treatment of what already happened. Erosion inventories, therefore, must evaluate all existing and potential problems along roads and document the amount of erosion that may potentially occur, particularly at road and stream crossings.

The demonstration project

The 120-ha (300-acre) Paige-Bar sub-watershed (fig. 3) was chosen as the demonstration pilot project. It is located in the lower Clear Creek watershed near the Whiskeytown National Environmental Education Development Camp. Proximity to the camp is significant in that 3,000 fifth

ing, and horseback riding. Additionally, numerous old landings built in the stream channels are eroding and producing sediment.

Inventory

Before beginning field inventories, students from the Shasta College Watershed Restoration class drew the entire micro-drainage network of the Paige-Bar sub-watershed onto a 7.5-minute topographical map. They also delineated roads and streams on clear mylar, laying it over aerial

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and sixth graders visit it every year and see the restoration work that has been accomplished as part of their restoration education. The site was extensively logged in the 1960s and most recently in 1973, just before NPS acquisition of the lands. Approximately 2 km (1.2 mi) of main-use road (Peltier Valley Road) and several kilometers of old haul roads, including the badly eroded Logging Camp Road, exist on the site. These old roads are currently used for recreation, primarily hiking, mountain bik-

photos and orthophotos. Both recent and older stereo aerial photos were studied in order to identify eroding sediment sources; erosion is often hidden by dense vegetation but may be clearly visible in photos taken immediately after a disturbance. Historic aerial photo analysis is an efficient way to become thoroughly familiar with the drainage network, history of road construction, timber harvest, and other disturbances.

See "Whiskeytown" on page 28

The inventory work was completed in the summer and fall of 1996. During this phase groups of students worked as an interdisciplinary team, inventorying the landforms and exploring answers to the question, "why is the landscape like this?" The geomorphic perspective is especially

road segment between two sites. Consequently, the road erosion inventory form featured a section for sites (swale or stream crossings) and a section for road segments. As the teams inventoried the road, they filled out the appropriate section of the form. Photographs were taken of each site or segment. Road condition, accessibility, width, and length were also noted and recorded on the data sheet.

Data were collected for the sites, including the type of site, i.e., stream crossing, headwater swale crossing, spring, crossroad drain, or other. The amount of fill in the site was estimated as an order of magnitude ranging from "small" (1-5 m³; 1.3-6.5 yd³) to "extra-large" (greater than 50 m³; 65 yd³). Potential for future erosion was evaluated and treatments recommended. Possible treatments for sites included a shallow dip (10% of the fill removed), culvert replacement (see fig. 2, previous page), a large dip (50% of the fill removed), or complete crossing removal (100% of the fill removed).

Justifications for the treatment recommendations were also recorded. Students also collected data for the road segments. The amount of fill in the road was estimated, and the potential for future erosion was assessed as high, moderate, or low. Based on this information a potential treatment was recommended for segments. Possible treatments included outslope, outslope with rolling dip, or recontour (partial or complete road removal).

The information collected was entered into a database and linked to a GIS. The Shasta College engineering and GIS students got involved at this point and developed GIS maps; thus, the attributes for each site and segment could be queried using ArcInfo software. A total of 27 sites and 29 segments were identified on Peltier Valley Road; 31 sites and 19 segments were identified on Logging Camp Road. Segments and sites and the degree of erosion potential for each road are listed in Tables 1 & 2.

Project design & implementation

Peltier Valley Road

The watershed restoration students completed designs and prepared implementation plans for work on Peltier Valley Road based on the existing and potential problems identified in the inventory. The work was performed by the Watershed Restoration class and the Heavy Equipment Operations class. Shasta College also contracted the services of a heavy equipment operator with restoration experience in Redwood National Park and Grass Valley Creek watershed. The heavy equipment consultant provided on-site supervision and demonstrated equipment use. Altogether, Shasta College performed the following work on Peltier Valley Road:

1. Reconstructed approximately 2,000 m (1.2 mi) of the Peltier Valley Road using outsloped road design
2. Excavated rolling dips at each of the 23 swale and stream crossings
3. Replaced or installed seven appropriately sized and redesigned culvert crossings to reduce erosion
4. Treated all disturbed soil by seeding with native grasses and mulching

Sediment pond

Using remnants of an old logging road as an embankment, the students designed and constructed a sediment pond in the lower reaches of the watershed. The pond is used to monitor and measure sediment production before and after treatment. The drainages of both the Peltier Valley Road and Logging Camp Road converge at the location chosen for the sediment pond. The pond has an expected life of three years after which it and the old road will be removed and the stream returned to its natural course.

The pond weir was constructed with layers of continuous berm (fig. 4) stacked in a triangular shape. MBW, Inc., donated the use of their Continuous Berm Machine and demonstrated its use. This machine can encapsulate soil, sand, or rock in filter fabric to make a berm that is 0.4 m high by 0.3 m wide (~1.3 ft x 1.0 ft). In this situation the berm was filled with existing channel material; no nonnative sediment was introduced to the stream. The berms conform tightly to the stream bottom because they are very heavy with a density of 1,600 kg/m³ (2,691 lb/yd³). The berms can be

Table 1. Summary of Segments and Sites on Peltier Valley Road

Type	Number	Erosion Potential
Road segments	5 segments	High
Road segments	16 segments	Moderate
Road segments	8 segments	Low
Stream crossings	15 crossings	High
Stream crossings	1 crossing	Low
Swale crossings	5 crossings	High
Headwater	1 headwater	Low
Skid trails	2 trails	High
Springs	2 springs	Moderate
Other	1 culvert pull	Moderate
Springs	1 spring	Moderate
Other	1 slump	High

Table 2. Summary of Segments and Sites on Logging Camp Road

Type	Number	Erosion Potential
Road segments	11 segments	High
Road segments	7 segments	Moderate
Road segments	1 segment	Low
Stream crossings	12 crossings	High
Stream crossings	2 crossings	Moderate
Swale crossings	2 crossings	High
Swale crossings	2 crossings	Moderate
Skid trails	9 trails	High

important; therefore, the students were given some training in geology and fluvial processes. As part of their training, they toured the nearby Grass Valley Creek watershed to evaluate the efficacy of the treatments used there.

The students developed inventory forms based on advice from Redwood National Park geologists. Their strategy divided the inventory into two distinct areas: the *site* where the road crosses a drainage and the



Fig. 4. A sediment pond was constructed within the lower reaches of the watershed to monitor erosion before and after restoration work. After three years, it will be removed and the stream restored to its natural course.

stacked much steeper than the angle of repose without slumping, and they can be used as spillway weirs without stream erosion because of the support provided by the fabric (Ellis 1997). The continuous berms were reinforced by driving willow stakes through the fabric.

The sediment pond has performed well. The weir has been through a number of rainstorms and it has been subjected to a variety of flows. The vegetation around the pond is well established. The willows planted within the berms have achieved heights of over 2 m (6.6 ft) and are rooting both inside and below the berms.

Logging Camp Road

As already mentioned, Whiskeytown and Shasta College received a \$30,000 Challenge Cost-Share Grant from the National Park Service in 1997. This grant funded removal of the Logging Camp Road. Although the road was decommissioned, a single-track, multiuse trail was left in its place. Stream crossings have been completely excavated and recontoured (except for the trail) by pulling back all fill.

The Shasta College Watershed Restoration class supervised the work. The Heavy Equipment Operation class and the experienced heavy equipment consultant performed the work, which was completed in October 1998. Costs associated with complete road removal were closely monitored,

and the sediment pond facilitated erosion monitoring during the construction activities.

Conclusion

This pilot project provided an invaluable opportunity for the National Park Service to work with Shasta College in further developing watershed restoration strategies for Whiskeytown National Recreation Area. Park staff participated in the Watershed Restoration class and worked alongside students in inventorying the roads and developing treatment plans. Grant funding from the National Park Service and the Bureau of Reclamation (total of \$70,000) allowed the students to perform actual roadwork that will benefit the Sacramento River fisheries. Our experience gained in this cooperative, pilot restoration project holds great potential as a model for erosion and sediment source inventories, watershed restoration designs, and road treatments for use by the multiple federal, state, and local agencies now involved in restoration activities in the Clear Creek and Sacramento River watersheds. **P**

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