Stabilizing Forest Roads to Help Restore Fish Habitats: A Northwest Washington Example

R. Dennis Harr and Roger A. Nichols

ABSTRACT

As part of total watershed rehabilitation to improve fish habitats and water quality and to reduce flood hazards, 30-40-year-old, unused, largely impassable roads and landings in the Canyon Creek watershed within the North Fork Nooksack River watershed were decommissioned by stabilizing fills, removing stream crossings, recontouring slopes, and reestablishing drainage patterns to reduce the landslide hazards. The average cost for decommissioning a road was $3,500 per kilometer (for earthmoving by excavator and bulldozer) where considerable amounts of alder brush were cleared and sidecast material was pulled back upslope. Lower costs were associated with lesser earthmoving jobs; the highest costs resulted when fills at stream crossings or landings had to be removed. In contrast to unused roads not treated, decommissioned roads and landings were largely undamaged by rain-on-snow runoff that produced a 50-year flood in the North Fork Nooksack River in November 1989 and sustained little damage during rain-on-snow runoff in November 1990 that severely damaged main haul roads in northwest Washington.

Introduction

Timber harvest often has conflicted with quantity and quality of fish habitats where harvest activities or related road construction has led to unstable soil masses. Such is the case in Canyon Creek, a tributary to the North Fork Nooksack River in northwestern Washington. Most of the Canyon Creek watershed is located on land administered by the Mount Baker-Snoqualmie National Forest.

A 1985 inventory revealed that landslides associated with forest roads have a failure rate (number of landslides divided by area and number of years) disproportionate to the land area roads occupy (Peak Northwest 1986). During 1968 to 1983 the failure rate for roads was 110 times greater than that of undisturbed forest and six times greater than the rate for logged areas. Most of these forest roads had been constructed in the 1950s and 1960s and, in contrast to more recently constructed roads, failure often resulted from poor design, location, and construction methods. Midslope locations were common, and excavated material had been sidecast (dumped over the edge of the road). Most of these roads were covered with alder trees and brush and had not received maintenance for perhaps 10-15 years.

Since the early 1950s, sedimentation caused by logging activities has progressively degraded habitats for anadromous fish in the Nooksack River system (Schuett-Hames and Schuett-Hames 1987). Sediment has not only inundated spawning gravel and smothered salmon eggs but also has caused stream channels to shift and isolate incubating salmon eggs from flowing water. Sediment-filled pools have reduced juvenile rearing habitat and adult holding habitat. The Nooksack native coho salmon, *Oncorhynchus kisutch*, stock is extinct, and the Nooksack spring race of chinook salmon, *O. tshawytscha*, has a high risk of extinction (Nehlsen et al. 1991) because by 1986, 70% of its spawning habitat had been lost (Schuett-Hames and Schuett-Hames 1987). Restoring the critically depressed spring run of the Nooksack River chinook salmon has been the goal of a rehabilitation program undertaken jointly by federal and state agencies and the Nooksack and Lummi Indian tribes. In 1987, largely because of concern for the cumulative effects of timber harvest on fish habitats, the U.S. Forest Service placed a moratorium on roadbuilding and logging in the Canyon Creek watershed until the condition of the watershed and the stream improved.

In the Pacific Northwest, fisheries biologists are assuming a role in fish habitat restoration that extends far beyond instream projects. The championing of watershed restoration may be left to fisheries biologists, and their efforts will be more successful if their familiarity with methods, equipment, and costs of restoration activities enables them to argue more effectively.

***R. Dennis Harr** is a research hydrologist, U.S. Forest Service, Pacific Northwest Research Station, Seattle, WA 98195. **Roger A. Nichols** is a watershed specialist with the U.S. Forest Service.*

Description of Area

Canyon Creek, a 21-km-long 5th-order stream draining a 60-km^2 basin, flows into the North Fork Nooksack River 37 km east-northeast of Bellingham, Washington, just south of the Canadian border. Soils in the Canyon Creek watershed are derived from overconsolidated till, recessional outwash, or lake deposits. Throughout the middle and upper basin, shallow, noncohesive soils derived from recessional outwash have been deposited in numerous steep-gradient streams that do not support fish but transport sediment to downstream fish habitats. Except for step-like topography associated with earthflows in the lower-middle part of the basin, sideslope gradients exceed 35%, and numerous landslides have occurred. The 1985 inventory identified 111 landslides that had occurred between 1940 and 1983 (Peak Northwest 1986).

About a third of the Canyon Creek basin lies within the transient snow zone, the range of middle elevations where both rain and snow are common (Harr 1981). U.S. Forest Service records, accounts in local newspapers, and other sources of information indicate most landslides and high streamflows in Canyon Creek have been associated with snowmelt during rainfall. Recent research shows that clear-cut logging, by increasing snow accumulation and the rate of melt, can increase the rate of water delivery to soil over what commonly occurs under forest (Harr 1986; Berris and Harr 1987). Increased water delivery can trigger landslides on steep, marginally stable slopes, particularly older road fills and stream crossings constructed before the mid-1970s.

Logging along Canyon Creek from the mid-1950s through the early 1970s, coupled with extremely high peak flows resulting from landslide-related floods, has led to insufficient large woody debris to maintain the number of deep pools required for holding habitat for adult chinook salmon, to trap sediment, and to protect streambanks from erosion. In some cases, the high flows have been caused by the failure of temporary dams formed by landslide deposits (dambreak floods) or by a moving dam of large woody debris.

Lower Canyon Creek is inhabited primarily by spring chinook but also by coho salmon, *0. kisutch;* chum salmon, *0. keta;* and pink salmon, *0. gorbuscha;* as well as by steelhead trout, *0. mykiss;* cutthroat trout, *0. clarki;* and Dolly Varden char, *Salvelinus malma.*

Watershed Rehabilitation

A moratorium on logging and roadbuilding does not reduce future delivery of sediment from past road construction and timber harvest. Any program to rehabilitate fish habitats in Canyon Creek, therefore, had to include reducing failures of old roads. To accomplish this, the U.S. Forest Service adopted a strategy of reducing landslide hazards. The sediment-reduction procedure is part of a total watershed rehabilitation program that includes reconstructing active roads, placing instream structures to deflect streamflow from erodible banks, managing large woody debris in the stream, and improving road maintenance. This paper focuses on reducing sediment from inactive roads and landings.

Rehabilitation of the Canyon Creek watershed began with a landslide inventory that related type and size of landslide to age of road, its position on the slope, and specific road-related problems such as poorly spaced or plugged relief culverts, culvert outflow onto unstable soil, unstable sidecast material, and unstable stream crossings (Peak Northwest 1986). Collectively, the information in the Canyon Creek landslide inventory pointed to roads constructed in the 1950s and 1960s as having the greatest chance of failing. The inventory also showed the site characteristics likely to result in a landslide that would be most damaging to fish habitats in Canyon Creek.

Road Condition Survey

The first step in the sediment-reduction procedure was a road log and condition survey of all roads. This consisted of closely examining every road in the watershed for its rehabilitation needs, marking each need by road milepost, and providing a narrative to describe the needed work in detail. An experienced surveyor considered results from the landslide inventory in deciding what work was needed. Work was summarized by road segment, costs were estimated, and work was prioritized in the field by a person experienced with road-related landslides and their potential for damaging fish habitats.

In all, 97 km of roads were surveyed. The estimated total rehabilitation cost was $179,000 in 1988. This figure has increased substantially since the rain-on-snow runoff of November 1989.

Some of the work to reduce sediment delivery to the Canyon Creek stream system involves fairly common procedures such as installing additional ditch-relief culverts and larger culverts at stream crossings, cleaning ditches, replacing culverts to improve gradient or alignment, and installing flexible downpipes on culverts. Active roads (those being actively used for hauling logs or for recreational access) are targeted for this work. Other procedures, including removing culverts, installing waterbars, and closing roads, were used on inactive roads (those no longer used for commercial hauling but still used for fire suppression, forest management activities, etc.). Still other work involved decommissioning 30-40-year-old roads. Decommissioning means reducing erosion hazard by controlling surface and subsurface drainage, pulling sidecast material upslope onto the stable portion of the road surface, and removing fill material in stream crossings to reduce the likelihood that they will contribute sediment to Canyon Creek. Pulling sidecast is the major difference between decommissioning a road and preparing it for abandonment in accordance with the Washington Forest Practices Rules (Washington State Forest Practices Board 1988).

Decommissioning Techniques

The most dramatic decommissioning work involved pulling back sidecast, reshaping roads and landings, and reestablishing natural drainage patterns. A tracked excavator was used to pull sidecast material onto the bench of the road and to construct frequent, deep waterbars (ditches dug diagonally across roads to divert water off the road surface). A small bulldozer equipped with a six-way blade then insloped (sloped the road surface away from the outer edge of the road and toward a ditch paralleling the road) and compacted this material.

Control of surface water is an essential part of the sediment-reduction program. Drainage water from waterbars was directed to natural watercourses or to areas where past landslides had already removed soil. Ditches were placed to keep water from saturating sidecast material already pulled up, piled, and compacted on the road surface. Where culverts were removed, fill slopes were sloped back to 2:l or 1.5:1 or stepped.

On one road, landings had been constructed by sidecasting excavated material. At these landings, sidecast was placed on the landing, and natural drainageways were reestablished. This work was similar to what was done to the roads, except the amount of material moved was considerably greater. All disturbed areas were grass-seeded and fertilized by the inspector as work progressed.

We wish to emphasize the importance of properly directing water flow on restored or decommissioned sites. During a large storm, subsurface water, as well as surface water, can quickly undo excellent work and good intentions. Because sidecast material pulled back and piled against the cutbank can fail if it becomes saturated, extreme care must be taken to ensure that water is kept away from this material. Similarly, water from culverts or waterbars must drain onto stable soil rather than onto sidecast material.

Access always will present special problems for decommissioning roads and landings. For example, the prudence of crossing unstable areas (i.e., rebuilding a failed stream crossing in order to treat additional road segments) probably always will be questioned. For the road segments described here, reducing landslide hazards far outweighed the disturbance caused by reconstructing a few failed stream crossings to reach more distant road segments needing treatment. Where isolated road segments are inaccessible to conventional equipment, other techniques such as blasting road fills at stream crossings and other areas of high hazard should be considered. In a test in July 1990, the U.S. Forest Service successfully used a Spyder walking excavator to decommission a half-mile of road that was inaccessible to other equipment. This machine, which is small enough to be ferried by helicopter, could eliminate the need to reconstruct failed stream crossings for access to distant road segments.

Similar techniques were used to rehabilitate that part of Redwood Creek watershed located in Redwood Creek National Park in northern California (Weaver et al. 1987). In the Redwood Creek case, however, another objective was to encourage the return of natural vegetation on roads, skid trails, and stream crossings. Sidecast was pulled back, the road was outsloped (sloped toward the outer edge of the road), and return of forest vegetation was encouraged through planting. In the Canyon Creek case, the intent was not to remove logging roads completely, but rather to reduce their chance of failing. In the future, decommissioned roads in the Canyon Creek watershed could be reconstructed for access for timber harvest.

Costs

Table 1 summarizes the costs of decommissioning 11 road segments. Segments A-D were grouped together because they had similar physiography and needs, they required only minimal removal of alder trees less than 150 mm in diameter and brush for access, and all had been previously waterbarred. Because of the amount of subsurface water present, all of these segments needed insloping, rebuilding of waterbars, dipping the road grade through draws, and some pulling back of sidecast. The 11.3-km of road work required 232 hours to complete. Time was divided about evenly between the excavator and bulldozer.

Segments E-G (Table 1) are grouped together because of similar physiography and needs and because they required extensive clearing of alder trees larger than 150 mm in diameter from the road surface. All these road segments required more sidecast be pulled back than did segments A-D. The 2.6-km of road work required 135 hours to complete, and, again, time was divided about evenly between the excavator and the bulldozer. The high cost for segments E-G resulted from extensive pulling back of sidecast and recontouring landings.

Segments H-K all required removing trees and brush for access, pulling sidecast, and constructing waterbars. The high cost of work on segment H was due to reconstructing a stream crossing to gain access for decommissioning high-priority, more distant sections of the road. Later, this stream crossing was decommissioned also.

Decommissioning costs ranged from $1,328 to $6,625 per

Table 1. Costs of operating **equipment to decommission road segments at Canyon Creek, Washington, in 1987 and 1988.**

Road segment	Length of segment (km)	Time required (h)	Cost	Cost/km
A,B,C,D[1]	x1.3	232	$18,250	$1,615
E,F,G[2]	2.6	135	10,800	4,154
H[3]	3.25	240	17,445	5,368
I[3]	0.53	23	1,825	3,443
J[3]	0.24	21	1,590	6,625
K[3]	1.31	24	1,740	1,328

[1]Segments A-D had similar needs and required only minimal removal of alder trees <150 mm in diameter. These segments were decommissioned in 1987.

[2]Segments E-G had similar needs and required extensive clearing of alder trees >150 mm in diameter. These segments were decommissioned in 1987.

[3]Segments H-K all required removing trees and brush, pulling sidecast, and constructing waterbars. These segments were decommissioned in 1988.

kilometer. A cost of $3,500 per kilometer was average for roads that needed clearing of alder and pulling back of sidecast. Lower costs were associated with minimal clearing of alder and no major earthmoving jobs; highest costs resulted when landings had to be decommissioned or stream crossings had to be removed. A full-time inspector at about $18 per-hour should be included in planning and budget-per hour should be included in planning and budgeting.

Administration can influence the cost of work in decommissioning roads and landings. In the work we have described, contracts were for equipment rental rather than for construction because quotes for the latter to do the same work have been about 30% higher due to bonds and other requirements. Requiring the excavator operator to be experienced likely will increase the cost of the equipment rental contract, but the higher production rate usually compensates for this. Conversely, soliciting bids and awarding contracts well in advance of the construction season also could result in lower costs.

Discussion

From the initial road condition survey to the earthmoving activities, projects like this have to compete for funds within the U.S. Forest Service as in any other forest land management organization. This method of reducing sediment is not traditional, so it requires a champion to work aggressively to ensure that the project is approved and funded. Once roads have been treated in several drainages, the program becomes established, and the work becomes more systematic. Also, documenting its successes helps the program gain recognition and support. The chance occurrence of extreme runoff and resultant damage, as occurred in November 1989, aids immeasurably in raising awareness and selling additional projects of this nature.

Effectiveness of decommissioning roads in this case study is difficult to evaluate because of the extent of the decommissioning work. From 1967 to 1983, 17 road-related landslides deposited 191,000 m^3 of sediment into streams (Peak Northwest 1986) during four episodes of rain-on-snow runoff with recurrence intervals of 2 to 5 years. After decommissioning work only one road-related landslide occurred during the record rain-on-snow runoff of 1989 and 1990, and none of its sediment reached a stream.

In some cases, alder brush had not been removed from unused roads primarily because of the belief that brush will stabilize the road. Although brush may decrease surface erosion, its shallow root system does little for deep mass wasting of sidecast material, a major source of sediment from roads at Canyon Creek. Rather, brush-choked roads are likely to be forgotten and poorly maintained and will not receive due consideration as sediment-producing hazards.

The survey to determine needed work, scheduling work, and project execution all are critical steps in the sediment-reduction procedure. The person making the survey of road deficiencies must be trained or experienced in recognizing road-related problems and must be able to understand and express concerns for aquatic resources. This person should work with a construction supervisor who is experienced in estimating costs and familiar with equipment capabilities.

A self-evident yet easily overlooked aspect of this type of work is the need to have one construction supervisor follow the project through from start to finish. For the work described earlier, design, costing, and inspection were done by three different people. This required frequent orientation of the project inspector to ensure that objectives for specific sites were accomplished.

Traditional survey, design, and inspection techniques are unsuitable because of the number of small, site-specific details involved in making the project successful. Many possible treatments and variation in the road prism necessitate a full-time inspector. Preferably, the same inspector and equipment operators should be assigned to the project from beginning to end, so that as they gain experience, they become more efficient.

The work described here is only the first round at treating old, inactive, largely impassable roads and landings. Follow-up inspectionsand corrective actions must be made to ensure that the decommissioning work remains effective in eliminating old, unstable roads and landings as sources of sediment to streams. Proper design, execution, and follow-up inspections all help ensure that decommissioning these roads and landings will be an important part of an effective program to reduce stream sedimentation and improve fish habitats.

Renewed and intensified environmental awareness and concern likely will carry into the next century, and society will continue to make its views known through environmental activism and the political and judicial arenas. Results of a recent court case (Wilson versus Georgia-Pacific Corporation and Washington State Department of Natural Resources, Skagit County, Washington, 86-2-00X4-9 "Failure To Inspect and Maintain Logging Roads") affirm that landowners are responsible for ensuring that all roads are safe from potential landslides in the state of Washington. Apart from legal requirements to do so, properly treating old, unstable, inactive, and abandoned roads is good land stewardship.

Many of the native naturally spawning Pacific salmon and steelhead stocks that appear to be facing a high or moderate risk of extinction are endangered because of habitat loss and damage (Nehlsen et al. 1991). Where habitats have been degraded by human-induced sedimentation, reducing sediment delivery to streams will require a basin-wide approach as in the Canyon Creek case described here. In such cases, decommissioning old, unused, largely impassable roads could be a key element in reducing landslide hazard and increasing the likelihood that endangered native salmon stocks will be able to survive.

References

Berris, S. N., and R. D. Harr 1987. Comparative snow accumulation and melt during rainfall in forested and clear-cut plots in the western Cascades of Oregon. Water Resour. Res. 23(1):135-142.

Harr, R. D. 1981. Some characteristics and consequences of snowmelt during rainfall in western Oregon. J. Hydrology 53:27-304.

——. 1986. Effects of clearcutting on rain-on-snow runoff in western Oregon: a new look at old studies. Water Resour. Res. 22(7):1095-1100.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries (Bethesda) 16(2):4-21.

Peak Northwest. 1986. Nooksack River basin erosion and fisheries study. Peak Northwest, Inc., Talent, OR.

Schuett-Hames, D., and J. Schuett-Hames. 1987. North Fork nooksack spring chinook surveys: 1986 survey results, a historical count review, and habitat observations. U. S. Fish and Wildlife Service, Olympia, WA, and Lummi Tribal Fisheries Department, Bellingham, WA.

Washington State Forest Practices Board. 1988. Washington forest practices rules and regulations. Washington State Forest Practices Board, Olympia, WA.

Weaver, W. E., M. M. Hektner, D. K. Hagans, L. J. Reed, R. A. Sonnevil, and G. J. Bundros. 1987. An evaluation of experimental rehabilitation work at Redwood National Park. National Park Service, Redwood National Park Rehabilitation Technical Report No. 19, Arcata, CA.