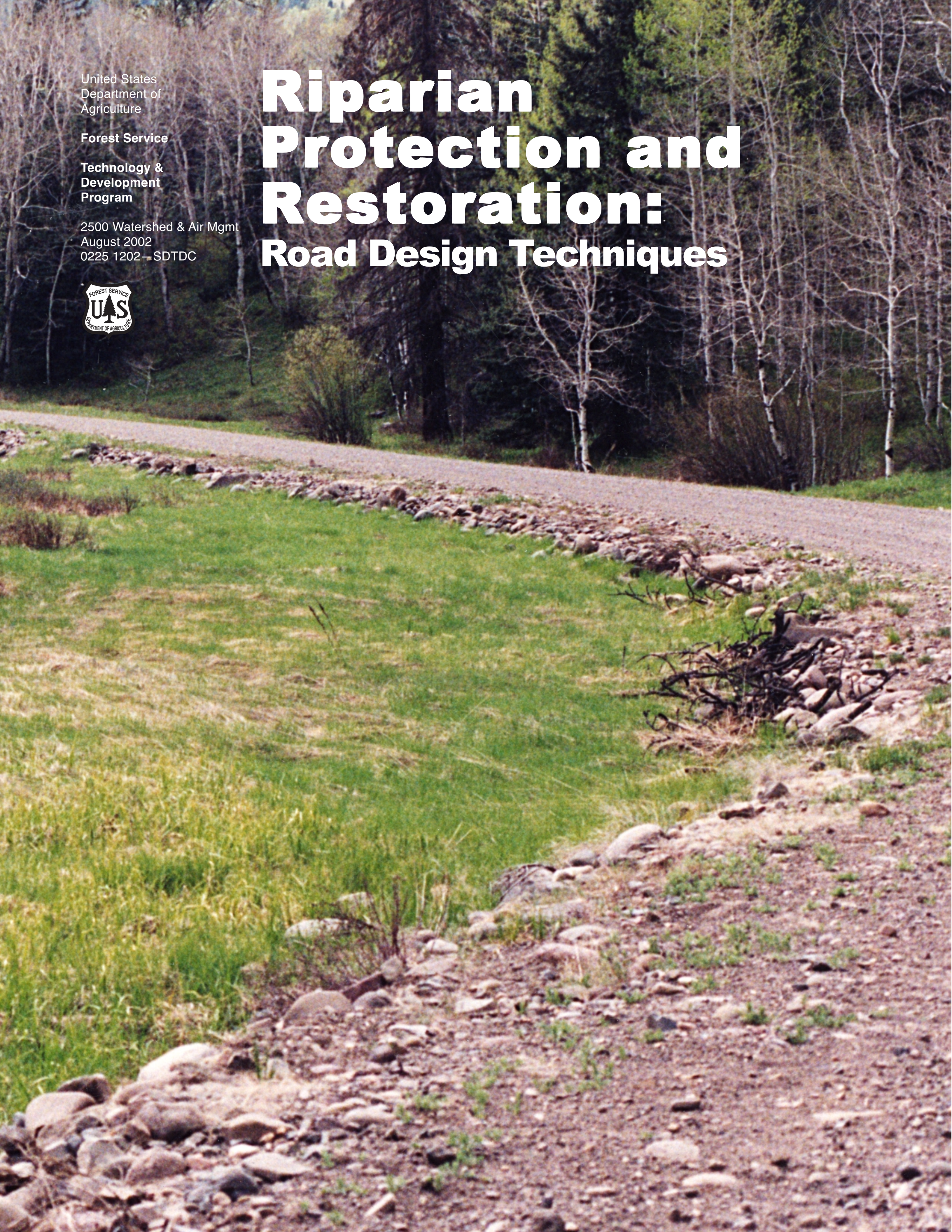

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Riparian Protection and Restoration:

Road Design Techniques

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Cover Photo: West Fork Road, San Juan National Forest, CO.

Riparian Protection and Restoration:

Road Design Techniques

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Background

Road systems on public land often have evolved from historic routes that followed the most accessible path to a particular area. American Indians often traveled existing game trails, which later became wagon routes for early settlers. These trails evolved into access routes for fire suppression, resource extraction/management, and recreation activities.

Many of these routes followed—and continue to follow—along riparian areas, across meadows, and through other sensitive locations where erosion and sediment impair the ecosystem. Roads often cause detrimental impacts on public and private land as a result of interactions between water and the road surface or at road and stream crossings. The road design techniques described here can prevent many of these adverse impacts.

Introduction

A partnership between public and private land managers, research and development specialists, and research scientists can improve road management. Through sharing general concepts and background information related to watershed science, road improvement efforts can reduce erosion and sedimentation in waterways, improve wildlife and fisheries habitat, and help preserve endangered species.

Road systems interact with a wide variety of different landscapes and physical and biological variables within the landscape. Road reconstruction, maintenance, and decommissioning are demanding tasks that involve many disciplines including hydrology, engineering, wildlife, fisheries, recreation, and forestry.

Specialists should participate early in project planning to develop a complete set of objectives and strategies to accomplish the defined tasks. Specialists will need to continue working together in the field to make necessary changes or to design site-specific solutions, such as those for stream crossings.

In natural landscapes, soil erosion is controlled by complex interactions between waterflow and the structural functional characteristics of the watershed. Vegetation, logs, and rocks combine to armor streambanks and protect soils from the forces of erosion. However, after vegetation has been removed and waterflow paths disturbed, a road can further disturb the land.

Road-related erosion often is caused by a concentration of water on a road. Concentrated flow from a diverted stream crossing can cut a gully as it washes over the fillslope onto unstable soils. Heavy runoff from a winter storm flowing down a recently excavated stream crossing can cause erosion. Gullies, caused by the concentration of water on a road, can contribute to large volumes of sediment in streams over time.

The descriptions of riparian restoration projects discussed illustrate how road projects can help protect, restore, and keep riparian areas intact. Road riparian management that incorporates interdisciplinary planning, design, implementation, and monitoring has proven to be highly successful. It also benefits both the resource and those who use the land for product extraction, recreation, and other sociological pursuits.

Riparian Protection and Restoration Efforts

Rail Hollow Road Project

The Rail Hollow Road, Forest Road 4440-180, is a 4-mi, single-lane road built in the early 1950s for transporting timber. Road drainage empties into the Eight-mile Drainage, a principal tributary of the Fifteen-mile Drainage, which empties into the Columbia River.

The road is located on the dry, eastern side of the Mt. Hood National Forest and the Cascade Mountains, adjacent to Rail Hollow. At many locations, the channel is directly below the fillslope of the road. The road's 25 small culverts, varying in width from 12 to 18 in, failed to handle the runoff from the road prism. All of the culverts were filled with soil and rocks and were not functioning.

Problem—The Fifteen-mile Watershed consists of alluvial material that is a relatively weak geologic unit. Surface erosion, a predominant disturbance in the watershed, could cause sediment to enter the Rail Hollow Drainage, ultimately depositing tons of sediment into the Fifteen-mile Watershed and destroying steelhead runs.

In the late 1980s, the road was closed through use of an earth berm. Although the road was blocked, vehicles continued to drive over and around the barrier, forming gullies in the road and causing sediment to enter the drainage during storms.

Solution—In fiscal year 1992, the Barlow Ranger District received funds to obliterate roads that deposited sediment in anadromous fisheries. The project goal was to eliminate surface runoff, massive landslides, and road washouts during large storms by pulling back most of the fill material and placing it into the cutslope sections to mimic the natural slope gradient.

According to Project Leader John Dodd, the Rail Hollow Road project used the following steps:

1. Straw and fertilizer were hauled in and placed every tenth of a mile along the roadway prior to any obliteration work. This method was chosen due to difficulty in transporting materials following excavation (figure 1).
2. An excavator dug up and removed existing culverts (figure 2).
3. A dozer ripped the roadbed 2- to 3-ft deep to loosen the compacted soil and alter the natural subsurface waterflow.
4. The Link-Belt 4300 excavator pulled back the road fill material from the end of the road and completed the project at the upper portion of the road. Large boulders and shrubs disguised the entrance to the obliterated road.
5. The district project crew seeded and broadcasted fertilizer and mulch (straw) to prevent erosion (figure 3).

Figure 1—The berm blocking the road was removed to allow fertilizer and bales of mulching straw to be placed every tenth of a mile.

Figure 2—The excavator pulled culverts from the front (junction) of the road to the back.

To transform the road back into a forest, the project engineer and contractor developed a "design-as-you-go" method. The excavator created bowls around the trees along the ditchline and on fillslopes and cutslopes to protect them from the dirt piles.

The contractor broke up woody debris and spread it on the disturbed ground to add nutrients to the soil and to

Figure 3—The district project crews seeded and broadcasted fertilizer and mulch (straw).

retain moisture for revegetation. Native shrubs removed during the restoration efforts were replanted on the new slope and old stumps were reset. Young ponderosa pine and Douglas fir were planted in the spring.

Results—Grass with mulch proved to be the fastest and cheapest method for controlling erosion, the primary objective of the Rail Hollow Road Project. Seeding was prescribed rather than using native plants to regenerate the area. The seeding mixture allows for good root development for erosion control, but still gives native vegetation an opportunity to reestablish itself (figure 4).

In comparing cuts to fills, the Rail Hollow Road is considered "well balanced." Most of the pulled backfill material fit into the adjacent cutslope section. On an "unbalanced" road, retrieving fill material is more difficult and more expensive.

Much of the excavated material was transported, or pushed by tractor, far beyond the cuts from which it came. Although contouring the land to a more natural slope was difficult, the road area now has a natural appearance.

During the winter of 1995 to 1996, one of the wettest winters on record in the area, the drainage handled all the precipitation without any large material washouts or slides. No evidence of a road exists. The rehabilitated road is one step closer to becoming a forest.

After reviewing the site, Dodd said, "Ripping performed on the cut side of the roadway could have been eliminated. It would have eliminated one piece of equipment, and it is questionable whether this process was necessary. The extra cost could have been saved for another project."

Figure 4—The district project crew hauled in seed and used it with fertilizer and mulch that was already onsite.

Six-mile Bridge Project

Background—The Little Manistee River, one of Michigan's premier steelhead fishing streams, is impacted by excessive sedimentation. The river, downstream from the bridge, is part of an important salmonid spawning habitat and a primary broodstock source for taking salmon and steelhead spawn, managed by the Michigan Department of Natural Resources.

Problem—According to Pat Fowler of the Huron-Manistee National Forest, the forest's watershed, like many in northern Michigan, is being degraded by excessive sedimentation. The major sources of sediment delivery are streambank erosion, road/stream crossings, and riparian recreation use. The U.S. Department of Agriculture (USDA) Forest Service completed a comprehensive restoration program for scheduling upgrades in the watershed.

Researchers have determined that the USDA Forest Service needs to restore degraded salmonid spawning and rearing habitat downstream of the Six-mile Bridge crossing and to reduce or eliminate sediment runoff in the Little Manistee River at that crossing. The old bridge's sand and gravel service approaches contributed an estimated 50 tons of sediment to the river each year.

Solution—Approaches with curbs and drainages to the Six-mile Bridge are paved to route sediment away from the river. To lessen the amount of loose material on the road, the length of the approaches started slightly past the two highest points on the road, just before the bridge approach (figure 5). In addition to paving, drainage, and erosion, control structures were installed to guide runoff away to prevent sediment from entering the river.

Results—Paving the approaches has eliminated most of the runoff caused by rainfall. The curbs help channel the water into drainage structures. The drainage structures allow runoff to flow off the roadway, away from the river, and into fields or sediment beds (figure 6). Researchers estimate that this upgrade eliminates 50 tons of sediment per year. The upgraded road has also restored degraded salmonid habitat for approximately 4 mi downstream.

Figure 6—Curbing and drainage structures channel runoff flows off the roadway and into fields or sediment beds.

As a result of this upgrade, the USDA Forest Service was able to construct a designated barrier-free parking area near the bridge that provides fishing opportunities for physically challenged individuals (figure 7).

Figure 7—Another positive result of paving is a barrier-free parking area near the bridge that provides fishing opportunities for physically challenged individuals.

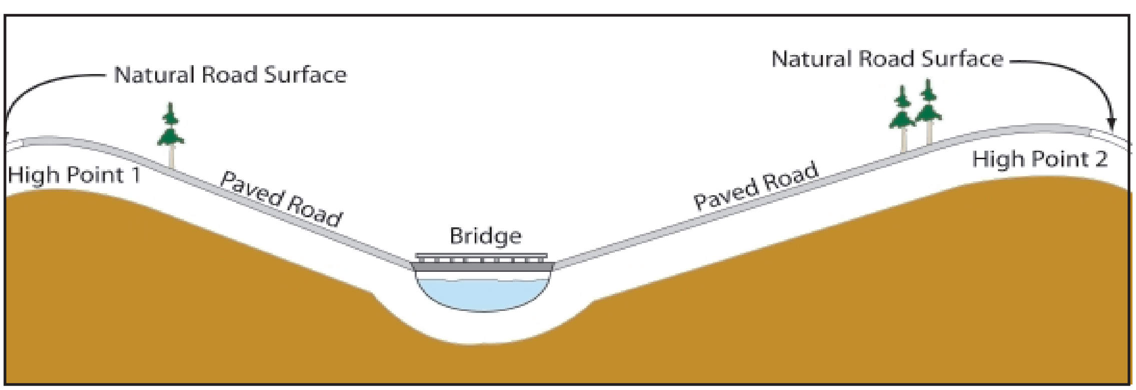

Figure 5—Paved approaches started at the two high points on the road.

Corduroy Road Project

Background—Within the Chippewa National Forest boundary, the USDA Forest Service manages about half of the 1.6 million acres located at the headwaters of the Mississippi River. Water is abundant with over 1,300 lakes, 923 mi of river and streams, and 400,000 acres of wetlands.

The water table in this area is almost at ground level. The drop in elevation of the forest is about 250 ft from the highest to the lowest point. Approximately 75 percent of the land within the forest boundary is aquatic. Water movements throughout the forest are very slow and move through streams, lakes, and wetlands in a random order.

Problem—According to Forest Hydrologist Brenda Halter-Glenn, the Chippewa National Forest does not have the same water- and road-related issues as most forests where the road is falling or sliding into anadromous fish-filled streams. Researchers recognized the Chippewa's need for construction of a low-volume, low-standard road with a dry roadway, which maintained the hydrologic flow of ground and surface water.

Solution—The Minnesota Forest Resources Council (MFRC) developed Timber Harvesting and Forest Management Guidelines. One of the chapters, "Construction of Wetland Forest Roads," explains different techniques on how to construct roads over various materials. These guidelines can be downloaded from the MFRC website at www.frc.state.mn.us.

One technique, "Road Design for Peat Wetlands with Continuous Cross-Drainage," is practiced for crossing wetlands with peat soils greater than 4-ft deep. When no excavation or backfill is required, a corduroy technique is used.

To protect the woody rot mat on roadbeds that use geotextile fabrics, trees, and brush should be flush cut leaving unsaleable material in place. The first geotextile fabric should be laid loosely over the cut material with trees placed parallel to each other and perpendicular to the roadbed direction. The trees are then covered as needed with clean roadfill or gravel (figure 8).

If log corduroy is used for cross drainage, geotextile material should be applied above and below the corduroy (figure 9). If log corduroy is not used, other cross-drainage structures should be considered.

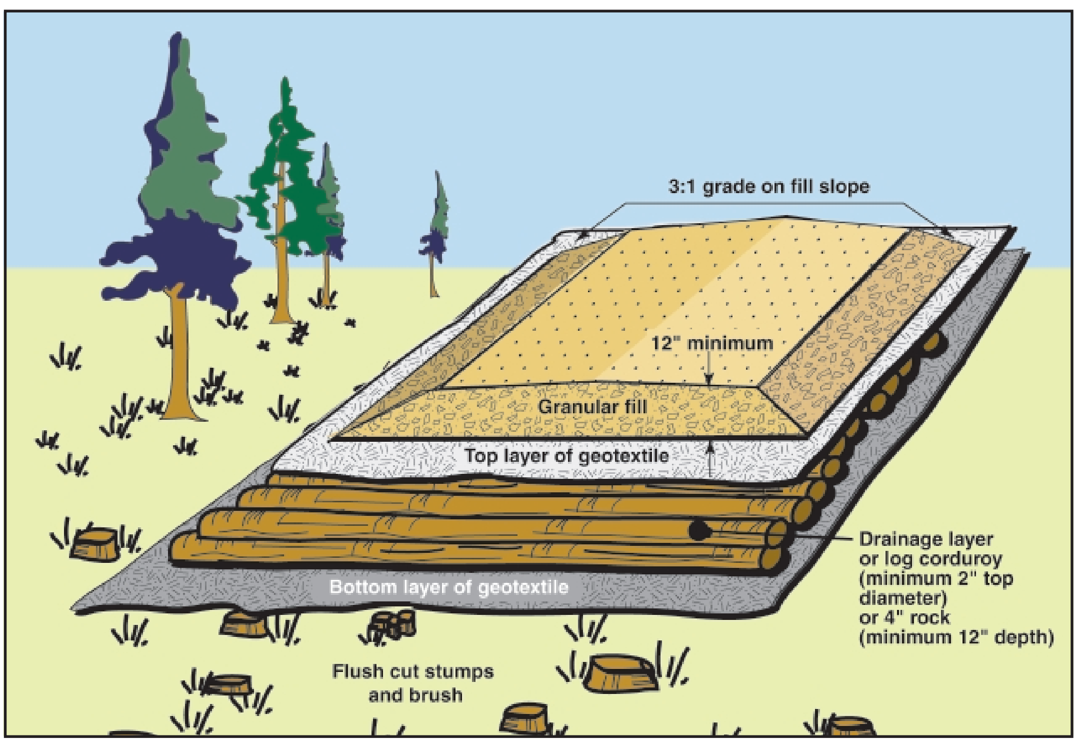

Figure 8—Road design for peat wetlands with continuous cross drainage. Drainage layers may be used as an alternative to culverts, or in combination with culverts, to provide adequate cross drainage.

Figure 9—Log corduroy (selected area) was used for cross drainage on this road.

If improperly constructed, road failures can range from gradual sinking to a sudden loss of the road into the wetland. When such failures occur, the peat water flowing through the wetland is greatly disturbed, and large areas of flooding can result.

Cross drainage through the roadbed in a deep peat wetland is normally slowed or halted as a result of the compression of the peat layers from the road embankment, equipment rutting of the peat surface, or road failure. This can cause flooding on the upslope side of the wetland and drying on the downslope side.

Effective cross drainage, the main goal for all of these techniques, can be maintained by proper installation of a culvert and drainage layer. In all cases, the construction objective is to provide a stable road surface while maintaining free flow of water though the roadbed.

Results—In most cases this technique works well. The site shown is 20 years old and is still maintaining the free flow of water through the roadbed while providing a stable road surface (figure 10).

Figure 10—This road still maintains a free flow of water through the roadbed while providing a stable road surface.

Santa Ana River Road Project

The headwaters of the Santa Ana River are located in the San Bernardino Mountains of the San Bernardino National Forest. The river, which flows year round, is one of the few rivers in the forest with native fish. Because the Santa Ana River Road follows the river, allowing access to different types of diverse recreation, (i.e., summer cabins, diverse campgrounds, organizational campgrounds, fishing sites, hiking trails, etc.) it generates a high volume of traffic on this single-lane road.

Problem—One 3-mi segment of this road has four natural river crossings with no previous approaches or riverbed improvements. Assistant Forest Engineer Bill Crane said, "Vehicles passed through the river agitating the river with road grime and sediments. The water crossings are a problem for engineering because of maintenance and damage to the resources which result in poor fish habitat." The following problems were identified at the crossings (figure 11).

- Vehicles using the crossings disrupt streamflow, import contaminants, agitate sediments, and degrade the environment for aquatic life.
- The road cut interrupted the natural flow of ground and surface water through the meadow.

Figure 11—One of the natural river crossings (roadbed in background) that agitates sediment in the stream.

Solution—The USDA Forest Service replaced the natural river crossings with four precast concrete, single-lane bridges that are designed to improve aquatic life (figure 12). The bridges keep vehicles out of the river, with less maintenance required on the approaches. When the bridges were being planned, improvements were also implemented to relocate the river crossing approach that was running through a meadow and to install a subsurface drain (french drain) under a wet, unstable portion of the road.

Figure 12—Four precast, 40-ft concrete, single-lane bridges were constructed to replace the natural water crossings and improve aquatic life.

To relocate the approach out of the meadow, the planner located the bridge a short distance downstream from the river crossing. The old approach was blocked with multiple 4-ft-high dirt mounds and the remainder of the approach was scarified and raked and left unseeded, allowing the native vegetation to reestablish itself (figure 13).

Figure 13—The reestablishment of native vegetation hid all evidence of the original water crossing into the meadow.

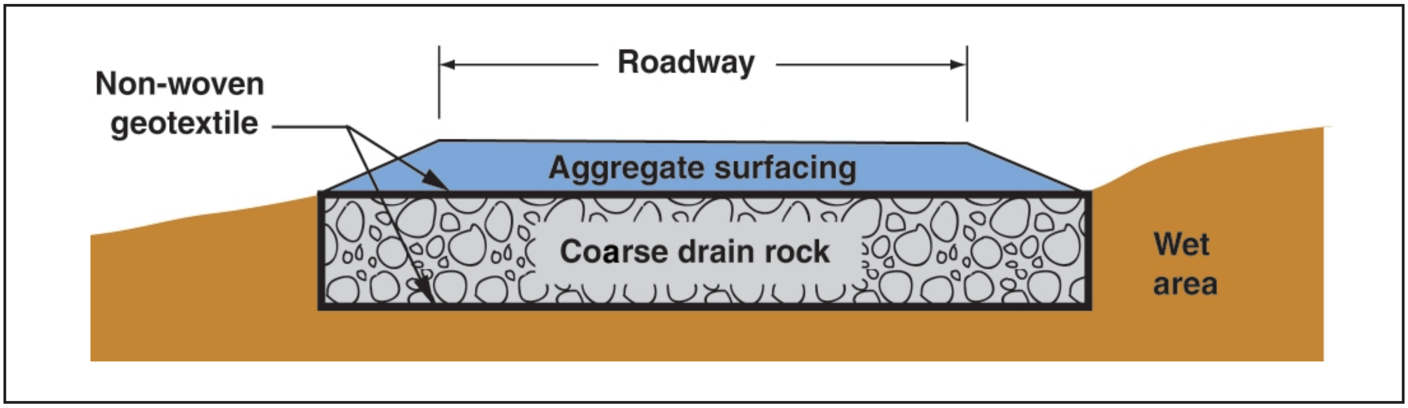

Figure 14—French drain. Not to scale.

For the subsurface drain, the forest road crew excavated 12 in below the road surface. A nonwoven geotextile served as the bottom layer, with 6 in of coarse drain rock above the layer of geotextile, and another geotextile layer on top of the rock. The road crew finished with a 6-in layer of 3/4-in aggregate surfacing (figure 14). The finished french drain is shown in figure 15.

Figure 15—The roadbed was rebuilt using nonwoven geotextile, coarse drain rock, and 3/4-in surfacing aggregate to make a dry road surface.

Results—The bridges keep traffic out of the river, resulting in less sediment and allowing for better aquatic life. The old approach in the wet meadow was removed and no evidence of the four natural water crossings remains. With the regrowth of native vegetation, little evidence of a road remains.

The under-the-road drain dried the roadway's surface, while allowing the meadow groundwater to flow freely under the road. This is an excellent example of keeping a riparian area intact. The traffic has a good aggregate surface and the functional integrity of the meadow was not destroyed (figure 15).

Greenwater River Road Relocation

Background—The Greenwater River, on the west side of the Cascade Mountains, drains into the White River. The watershed is approximately 75 mi^2 and is part of the salmon restoration project in the White-Puyallup River Basins. About two-thirds of the road is located on national forest land and the other one-third is owned by private timber companies. Over the past 40 years, the area has been managed intensively for timber production.

In 1995, USDA Forest Service resource managers changed the management objectives in the watershed from timber production to year-round recreation. This resulted in high recreation use.

The Greenwater River Road, constructed in the 1960s as a cost-effective construction project suitable for transporting products easily, continues to serve as a major artery for both the USDA Forest Service and the Washington State Highway Transportation System. However, a portion of the road was built in the inner gorge of the river, resulting in steep, unstable grades and sideslopes.

Problem—Winter storms during 1995 to 1996, caused extensive flooding of the Greenwater River, triggering several massive landslides along the Greenwater River Road and dumping a torrent of debris into the river. The largest slide removed 300 ft of road in the inner gorge (figure 16) and delivered an estimated 23,000 yd^3 of sediment into the river channel. Massive amounts of sediment from the landslides and debris torrents moved the river from its established channel and floodplain. As a result, the USDA Forest Service closed the road to traffic.

Figure 16—The largest slide on the Greenwater River Road removed 300 ft of roadbed in the inner gorge.

Solution—According to Forest Representative Wayne Hamilton, the damaged road was relocated to the outside of the inner gorge because of the high risk and probability of future failures in the inner gorge. The newly constructed road portion is a two-lane, asphalt-paved road with very few shoulders or turnouts (figure 17). A new portion of road was constructed using a timber-hauling road for a short distance and the remainder of the 3.2-mi section is on virgin land.

Figure 17—The newly relocated Greenwater River Road.

Only 2.9 mi of the old existing road was closed. It was abandoned by blocking the upper entrance, pulling all culverts, and seeding and mulching the roadbed and sideslopes (figure 18). While removing the culverts, the crew ensured that the trench matched the slope and width of the original ground to maintain the identical stream hydrology.

Figure 18—By blocking the two entrances, pulling all culverts, and seeding and mulching the roadbed and sideslopes, the upper road closure affected only 2.9 mi of the existing road.

Results—The first attempt to close the road failed. Initially, road relocation and construction crews built a large berm to keep out traffic and close the upper section of road. Four-wheel drive recreational traffic still used the road by going over or around the berm.

The following summer, the crew came back, dug deep trenches, and made a larger berm, which proved successful. Researchers discovered that it is important, after initial closure of entrances, to follow up soon afterward to ensure that blockages are intact. The road's lower end was not closed because it was used to access dispersed camping (figure 19).

The final Greenwater River Road relocation was a success. The upper portion of the closed road does not allow motorized traffic. Because there is no motorized traffic, no sediment is added to the river. Also, forest users have accepted the new road relocation.

Figure 19—The beginning of the road relocation. The old road (to the left) goes to a dispersed campground.

Seed and mulch treatment placed on the rehabilitated roadbed was successful (figure 20). After two growing seasons, no evidence of erosion remains and native vegetation is growing. The culvert removal sites are functioning with no signs of erosion.

Figure 20—Native vegetation has started to grow back after two growing seasons.

The road, removed from the inner gorge, reestablished the riparian area (figure 21). Removing a log stringer bridge from over the river allowed a larger amount of bedload movement in the river during high flows and flood events. Culverts that impede fish passage are being removed and other improvements continue. A plan to reconnect the stream channel to its original channel and restore the riverbanks is in the design stage.

Figure 21—The river below the landslide. The removal of the road from the inner gorge provided an opportunity for riparian restoration.

Hickory Ridge Road Project

Background—The Shawnee National Forest, adjacent to the Ohio and Mississippi Rivers, has 1,250 mi of paved, gravel, dirt, and grass roads accessible to foot travelers, equestrians, and mountain bike riders. Most of the gravel roads contribute heavily to sediment in the fisheries.

To reduce stream sedimentation, USDA Forest Service crews are paving many of these roads. The Hickory Ridge Road was chosen to be upgraded with a chip seal.

Problem—Major problems facing forest resource managers are how to improve the riparian area, how to accommodate both residents and recreationists, and how to protect the timber rattlesnake—an endangered species.

The Hickory Ridge Road passes through an area where timber rattlesnakes reside. A major concern of several wildlife organizations is that more reptiles—including snakes—would be killed on the newly surfaced road. Apparently, the snakes like to rest on these warm "oiled" roads. Traffic would increase on the road resulting in an increase of snakes and other reptiles killed. However, area residents wanted the oil-paved-road surface to eliminate most of the dust from the gravel road.

Solution—To accommodate the diverse interests surrounding the proposed road project that surfaced during the public involvement process, mitigation measures were developed. The Illinois Department of Transportation (IDOT) and the Illinois Department of Natural Resources (IDNR) researched crossing installations for reptiles. With the approval of the USDA Forest Service, area residents, and concerned organizations, the IDOT and IDNR selected an installation that was modified from a European frog crossing.

According to Cynthia Morris, Shawnee National Forest, three crossings were installed during the road resurfacing at locations where there was evidence of heavy snake activity. The installations are similar to an 18-in culvert with a 12-in extended slot. The culvert was installed under the road and the slots were placed on top. The slots penetrate the roadbed, allowing sunlight and air to enter the culvert used by the reptiles (figure 22). Plastic webbing was installed for 50 ft along the side of the roadbed to funnel the reptiles into the crossing (figures 23 and 24).

Figure 22—Closeup view of the slot in the roadbed.

Figure 23—A culvert was installed under the road with plastic webbing to guide the reptiles into the culvert.

Figure 24—Plastic webbing and slot as viewed from the road.

Results—Two years after the snake crossings were installed, the IDNR monitored snakes using the crossings. Because snakes use traditional routes, snake usage is expected to increase.

The chip seal is still functioning and reducing streatm sedimentation. The residents and recreationists are enjoying the improved road surface and lower traffic-generated dust.

Figure 25—A multiagency interdisciplinary team monitors the road and wildlife crossing.

Appendix

USDA Forest Service offices in project areas

Chippewa National Forest
Supervisor's Office
200 Ash Avenue NW
Cass Lake, MN 56633
218–335–8600

Huron-Manistee National Forest
Supervisor's Office
1755 South Mitchell Street
Cadillac, MI 49601
231–775–2421

Mt. Baker-Snoqualmie National Forest
White River Ranger District
450 Roosevelt Avenue East
Enumclaw, WA 98022
360–825–6585

Mt. Hood National Forest
Barlow Ranger District
780 N.E. Court St.
Dufur, OR 97021
541–467–2291

San Bernardino National Forest
Forest Supervisor's Office
1824 South Commercenter Circle
San Bernardino, CA 92408
909–383–5588

Shawnee National Forest
Supervisor's Office
50 Highway 145 South
Harrisburg, IL 62946
618–253–7114