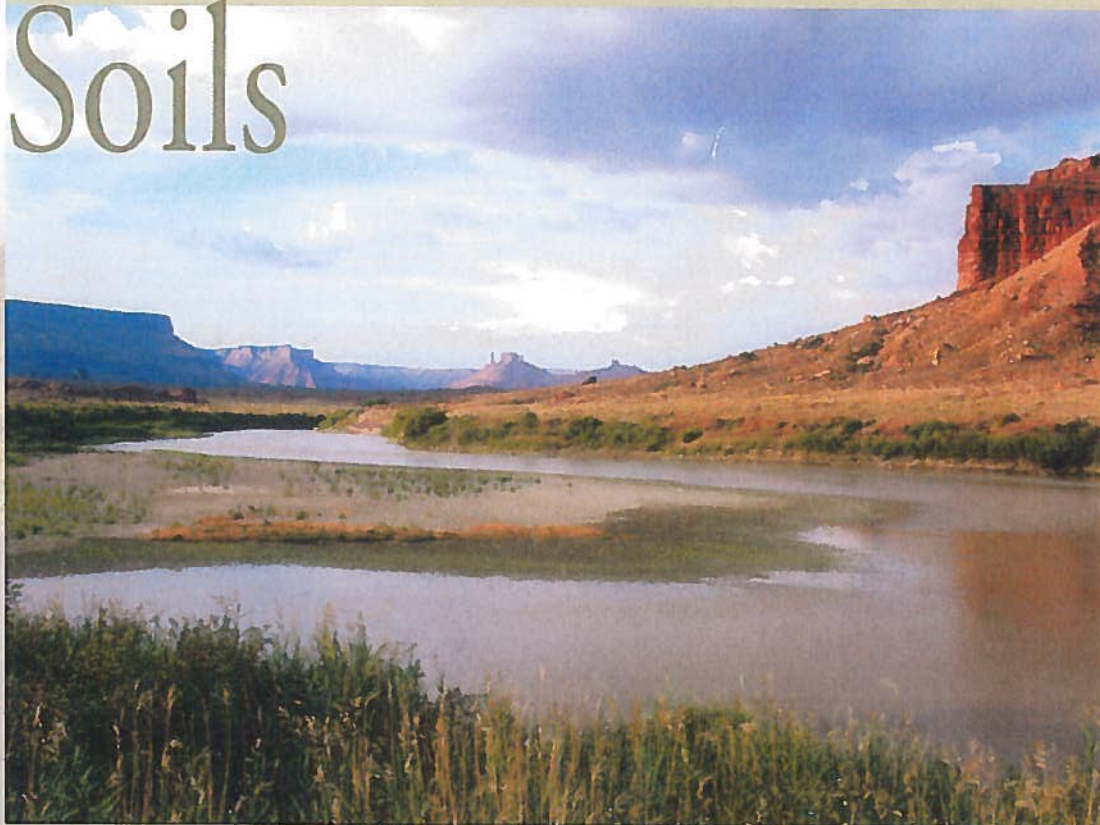


*Riparian Area Management*

# Riparian-Wetland Soils



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# Appendix D

## *Managing Riparian-Wetland Roads*

Management objectives change as soil properties, such as climate, elevation, steepness, and aspect, change. For example, north-facing slopes generally retain snowpack longer than south-facing slopes. The steeper the slope, the more it costs to build roads due to landslide and stability risks. The same principles apply to roadbuilding in riparian-wetland areas. Construction in or near riparian-wetland areas must account for saturated soils and possible flooding. Steepness of slope and elevation, accompanied by increased distance from the stream, will reflect in construction costs.

The role of soils in restoration and management of riparian-wetland roads is important relative to how roads change and modify soil attributes. For example, the presence of a road in a riparian-wetland area often modifies soil and soil water movement, which often reduces the amount, kind, and distribution of vegetation in a riparian-wetland area.

Vegetation plays an important role in raindrop interception. Once vegetation has been removed and road surfaces compacted, the impact of a raindrop is increased over preexisting conditions. Compacted surfaces have smaller pore size, which decreases infiltration and increases runoff and the potential for erosion. Roads located within riparian-wetland areas can transport sediments offsite into the fluvial system and adversely affect the aquatic habitat. Every road becomes an ephemeral stream channel that concentrates water energy. The addition of roads disrupts the original drainage pattern and has potential for serious alteration of the watershed.



## *A. Potential effects of roads to riparian-wetland areas*

Transportation systems provide tremendous opportunities and, if properly located on the landscape with well-designed drainage features, can remain stable for years with negligible effects to riparian-wetland areas.

Unfortunately, some roads adversely affect soil health and quality by accelerating erosion, modifying soil moisture regimes, and reducing the infiltration capability of soils due to compaction of the road travelway. Other impacts can include:

- Intercepting ground water or subsurface flows
- Acting as a dam, levee, or french drain
- Ditches draining water tables in wetlands and meadows
- Accelerating erosion in the form of surface (sheet, rill, and gully erosion) and mass wasting
- Changing soil moisture and vegetation
- Accelerating streambank erosion and deteriorating water quality and quantity
- Treating roads with oil can be toxic to riparian-wetland plants

## *B. Road restoration that addresses soil resources*

Prior to employing any road riparian-wetland restoration technique, an interdisciplinary team should identify the cause and effect relations of the current road and or crossing. Once the team has identified cause and effect, it is possible to identify resource objectives and best management practices (BMP) for the roads and crossings.

The first question is to determine the need for the road.

- Are there alternative access routes that exist or could be developed?
- Is there another location for the road or crossing that would mitigate the cause and effect the team had previously identified?

Once the team determines that access is needed, then the type of access should be pursued.

- Is access needed year-round?
- What types of vehicles require access?

Based on this information, the team can identify other resource goals and objectives for the road and or crossing. From the soil resource perspective,

the goal is to *restore and maintain soil health and quality*. This goal has the following objectives:

- Limit excavation and compaction while providing transportation.
- Reduce sheet, rill, and gully erosion.
- Reduce and minimize the adverse impacts of mass wasting and landslides.
- Maintain soil moisture and vegetative composition based on the inherent soil capabilities of the site.
- Reduce accelerated streambank erosion and altered water quality.

It is important to note the following techniques pertain primarily to the achievement of the soil resource objectives. These treatments may not meet other resource objectives and the interdisciplinary team needs to be able to clearly state which resource objectives a given treatment can meet.

### *C. Sheet, rill, and gully erosion*

In situations where there is sheet, rill, or gully erosion, there is a high probability of a water control issue either from the hillslope, ditch, or road surface.

To reduce sheet erosion, opportunities to minimize bare soil should be identified.

- Consider paving or rocking steep road pitches.
- Limit roadway width.
- Roll the grade to limit excavation and disturbance and provide backup surface drainage (rolling dips are built in).
- Provide frequent cross-drainage to effectively accommodate muddy runoff from roads.
- Limit excavation, cut and fill heights, and width of clearing.
- Establish effective soil cover on cut and fill slopes.
- Reduce soil compaction along road cuts and seed progressively to reduce the amount of bare soil exposed.
- Use outslope drainage template (with backup rolling dips) whenever feasible to reduce excavation, drainage problems, road maintenance, and ditch-related erosion.
- Mulch and revegetate cut and fill slopes.

To reduce rill and gully erosion efforts, minimize concentrated waterflows by using the following options.

- Pave bridge approaches to reduce sediment.
- Disperse concentrated flows by incorporating rolling dips in conjunction with road outslipping.
- Modify road drainage from being insloped to being outslaped.
- Install a multiple array of culverts.
- Pave or rock steep slopes and use curbs to control water.

## *D. Mass wasting and landslides*

In areas prone to mass wasting, there are several measures that can be taken to reduce the destabilizing effect of roads.

First, identify areas that are geologically unstable and avoid these in locating roads. Review the past management in the area and try to determine what type of response had occurred on similar soils. Many landslide areas are waiting for the right conditions to move and the lack of recent soil movement is not an indication of stability. It is necessary to look at previous records to identify when drainage structures or roads were put in place. Determine what type of management activity is associated with the road construction such as timber harvest, campground development, or alternate access.

The following options may help reduce and minimize the effect of a landslide.

- Design structures to accommodate potentially large amounts of material.
- Use bridges at sites prone to debris torrents.
- Use a hardened crossing that includes box culverts with concrete aprons and metal grates.
- Build new and upgrade existing crossings so that they do not have the potential to divert streamflows should they become plugged.
- Decommission unnecessary roads that are altering hillslope hydrology and concentrating waterflow onto the landslide.
- Armor crossing by incorporating large boulders and providing a dip to enable the material to pass over the road with minimal impact.

## *E. Change in soil moisture and effects to vegetation*

Two common changes in soil moisture and vegetative composition include:

- Conversion of a wet meadow site to a drier meadow through headcuts within the channel.
- Change in soil moisture regime where wetlands had been created by road structure improvements.

Treatments to reduce adverse impacts to wet meadows

- Relocate the road to minimize the impact on the meadow or wetland.
- Disperse flows by using a multiple array of culverts across a meadow or wetland.
- Cross the meadow, wetland, and riparian area with a bridge.
- Use a low-water crossing.
- Restore cutoff meanders that may have existed previously.

- Use permeable fills, which allow for water movement across the meadow.
- Change the type of access to the area to reduce the amount of compacted surfaces in or adjacent to the meadow or wetland.

In areas where the intent is to improve or create a wetland with a road, the following techniques have been successfully applied.

- Multiple arrays of culverts set at a predetermined height.
- Drop inlet structure that impounds water on ephemeral systems.

An important caveat that needs to be considered with the above treatments is that the team needs to clearly identify the stream type associated with the meadow or wetland type and the attributes and processes necessary for that stream type to function properly. In addition, whether the channel is seasonally flowing or perennial will often dictate what type of structure would work best. There are numerous guides that provide information to interdisciplinary teams, including the Stream Corridor Restoration handbook (FISWRG 1998). The hydrologist and engineer on the team can help develop this type of information.

## *F. Accelerated streambank erosion*

Streambank erosion often occurs from channel confinement due to the location of the road within the floodplain. Several treatments have been successfully employed to reduce accelerated streambank erosion on a variety of systems ranging from headwater treatments to major rivers.

- Identify opportunities to relocate roads out of the floodplain.
- Restore cutoff meanders that allow for the stream to dissipate its energy at higher flows.
- Redesign the stream and road to allow for an increased stream channel.
- Armor the road (fill slope and travelway) with larger boulders and smaller surface material to reduce the consequence of finer road material entering the stream channel.
- Use engineered logjams to redirect stream energy away from the road.
- Define access for vehicles and recreationists to reduce compaction along the streambank.

The treatments identified above are all tools that can and have been used successfully across the nation. The treatments can help to maintain soil health and productivity while minimizing the adverse effects of roads to soils in riparian areas.



"Like winds and sunsets, wild things were taken for granted until progress began to do away with them. Now we face the question whether a still higher "standard of living" is worth its cost in things natural, wild, and free."

Aldo Leopold

## 2. Case study #2

This area was being assessed for proposed restoration work within the local creek. The purpose of the assessment was to determine the historic, current, and potential health of this stream; develop natural alternative solutions to accelerate recovery of this valuable urban creek to a near historic condition; develop a draft project design; and refine the final restoration design.

Restoration of the creek was being guided by collaborative efforts among local action groups. Due to the size of the task, they were initially focusing on specific segments of the creek. The experience and knowledge gained would then be applied to the remaining segments of the creek.

### *a. PFC assessment*

Many materials were reviewed prior to beginning fieldwork, including maps, aerial photographs, and other background information such as:

- documentation of land uses
- erosion and sediment source inventory
- preliminary hydrologic analysis
- analysis of riparian conditions and stream habitat
- watershed analysis and action plan
- project restoration philosophy and mechanisms

As described in the watershed analysis and action plan, human influences from mining activities, railroad and road construction, urbanization, stream realignment, and other activities have all played a role in defining this stream's current health status.

Exposed soils in eroded streambanks provided evidence that the creek was once a perennial system. Today, this intermittent stream flows only at certain times of the year. Landform and channel features also provided clues that the creek had channel and floodplain characteristics (rocks, overflow channels, and large woody material) adequate to dissipate stream energy associated with high waterflows. Remnants of riparian-wetland vegetation still exist and suggest large, diverse communities of plant species with the capability of withstanding high streamflow events.



The benefits of a road management plan and subsequent projects would include:

- A reduction in sediment entering waters where current road conditions pose a high risk of sediment delivery.
- The potential to reduce sediment entering streams, allow for a higher level of road maintenance, and reduce long-term road management costs through the more efficient allocation of limited resources for road repairs and maintenance.
- The opportunity to develop a road management model for public land with local, regional, and national implications and to provide continuing education for landowners and operators specific to road construction and maintenance practices.
- A systematic means for remedying road problems (Figure 51).

Additional road information can be found in Appendix D.

Figure 51. A hypothetical example from a road management plan.

#### INADEQUATE SURFACE DRAINAGE



#### EXAMPLE

##### Problem

Road X, milepost XX - located in the XXX section of the project area. Water has been running directly down the 10-percent-grade road. Previous maintenance efforts to smooth out ruts have left the road slightly below grade, encouraging surface water runoff to concentrate into erosion channels and deliver sediments to the adjacent riparian area. The road, as originally located, will continue to suffer needless erosion and rutting. Any future maintenance efforts to smooth the rutted road surface will only tend to lower the road further below grade, causing increased erosion problems, new ruts, and increased sediment input to the adjacent riparian area.

##### Solution

The solution proposed for this situation is to relocate the existing downslope road so that it contours around the hillside at a gentle 2 to 3 percent grade.

##### Results

The relocated road has adequate grade changes to divert water off of the surface. The 4 to 6 percent outslope of the new road prevents water from accumulating. There should no longer be a need for annual maintenance to smooth out the irregular ruts that develop during rain events. The original road would heal more quickly if rehabilitated and converted back to productive pasture. The relocated road was constructed with a medium-sized loader scraper in about 3 hours at a cost of \$200.

"As soils are depleted, human health, vitality, and intelligence go with them."

Louis Bromfield

## Riparian-Wetland Soils

"We know more about the movement of celestial bodies than about the soil underfoot."

Leonardo da Vinci

Road improvement recommendations for open roads are listed in Table 11.

A road management plan would identify other travelway improvements, as well as presenting standards for permanent and temporary closures. The plan and subsequent projects would increase short-term road management operating costs.

Figure 50. Without maintenance and proper management, roads will continue to degrade and supply sediment to adjacent riparian areas.

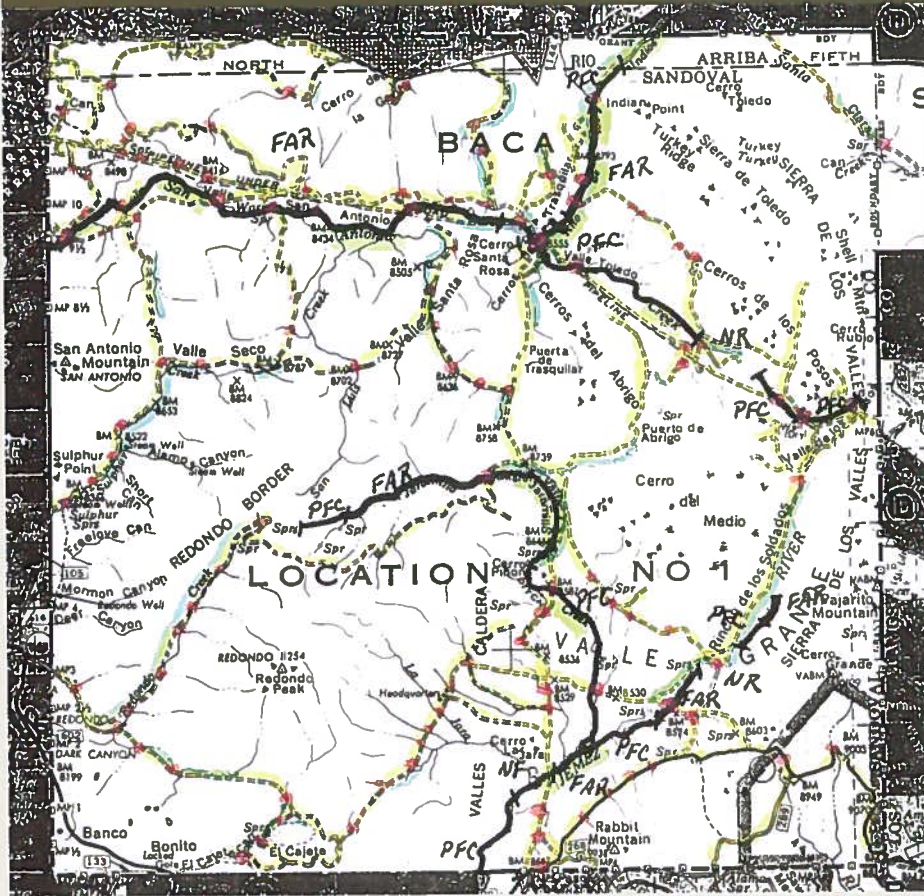


Table 11. Road management recommendations for open roads.

Road Problems	Improvement Recommendations
Inadequate surface drainage	<ul style="list-style-type: none"> <li>• Remove water from the travelway surface. Surface sloping (raising roads above grade, turnpiking, outloping, and crowning travelways) and cross-drainage installation are recommended.</li> <li>• Surface roads with crushed rock mulch.</li> <li>• Limit use during wet or thawing periods.</li> <li>• Maintain and repair culverts and cross-drainage structures.</li> <li>• Grade the road surface when it no longer drains properly.</li> <li>• Remove berms that channel water.</li> <li>• Use minimum road width.</li> </ul>
Ditch or lead-out ditch problems	<ul style="list-style-type: none"> <li>• Upgrade culverts and install cross drains and lead-out ditches.</li> <li>• Replace failing drainage structures.</li> </ul>
Channel impacts and increased drainage density	<ul style="list-style-type: none"> <li>• Avoid and remove multiple crossings of the same stream.</li> </ul>
Road and stream crossing problems	<ul style="list-style-type: none"> <li>• Design culverts, bridges, and low-water crossings to withstand high flows.</li> <li>• Armor fills below high water levels.</li> <li>• Design culverts to limit water velocity.</li> </ul>
Channel encroachment from road alignment in channel and floodplain	<ul style="list-style-type: none"> <li>• Avoid new roads parallel to streams.</li> <li>• Relocate or realign roads away from streams.</li> <li>• Minimize road length in these locations and limit size of fills.</li> </ul>

stream-crossing structure failures. These types of sediment sources are episodic and often result from significant rainfall events. High risk factors for the roads include surface erosion, road fill failure, and the proximity of road segments to streams (Figure 49).

Figure 49. Yellow highlights major roads within the area, red indicates road stream crossings, and blue identifies areas of channel encroachment from road alignment.



**Definitions:**

- “Surface erosion” is the removal of soil surface layers by wind, water, and ice.
- “Sheet erosion” is the removal by wind, water, and ice from sloping land in thin soil layers.
- “Rilling” is soil removal by water from very small (inches) but well-defined visible channels.
- “Gullying,” is an intermittent channel, larger than rills and too deep to be crossed in a wheeled vehicle.

***b. Recommendations***

Within the 89,000-acre area, there are approximately 1,000 miles of roads, of which 100 miles have been surveyed. The watershed condition assessment validated the need for a full road assessment within the management site. A comprehensive road plan would establish what roads are needed. The road management plan on the adjoining national forest is a good example to follow and would provide long-term management guidelines for open roads and recommendations for temporary and permanent road closures. Defining a base road network should be the first step in managing roads within the area (Figure 50).

riparian segments have even completely recovered. However, the watershed condition assessment report from the summer of 2000 and the watershed concerns report from the summer of 2001 identified several basic categories of road problems that were slowing or reversing recovery of these riparian systems. Field reconnaissance revealed several specific road problems and management opportunities (Table 10).

**Table 10. Road management opportunities.**

Road Problems	Resulting Damage
Inadequate surface drainage	<ul style="list-style-type: none"> <li>• inadequate filtering of surface drainage between roads and riparian areas</li> <li>• breached, damaged, and bypassed drainage structures</li> <li>• roads worn away to below grade, concentration of surface flow, direct water and sediment connection to riparian areas</li> <li>• loss of road surface material</li> <li>• standing water saturation of surface and subsurface, reduction of bearing strength, and deterioration of road surface</li> <li>• formation of berms</li> </ul>
Ditch or lead-out ditch problems	<ul style="list-style-type: none"> <li>• erosion, sedimentation, and deposition</li> <li>• undermining of fill and back slopes</li> <li>• drop inlets covered with sediments</li> </ul>
Channel impacts and increased drainage density	<ul style="list-style-type: none"> <li>• erosion, sedimentation, and deposition</li> <li>• increased drainage density and extension of the stream network</li> <li>• multiple crossings of the same stream</li> </ul>
Road and stream crossing problems	<ul style="list-style-type: none"> <li>• wood bridges rotting and falling apart</li> <li>• rusting and decomposing culverts</li> <li>• enlarged inlet basin</li> <li>• increased hydraulic energy</li> <li>• inadequate capacity</li> <li>• culvert inlets plugging</li> </ul>
Channel encroachment from road alignment in channel and floodplain	<ul style="list-style-type: none"> <li>• stream straightening and confinement</li> <li>• loss of road prism</li> <li>• channel erosion</li> <li>• isolation of floodplain</li> </ul>

The effects of increased sediment delivery from these roads depend on numerous factors. Most sediment is from surface erosion (sheets, rills, and gullies) delivered during normal annual rainfall events and is relatively chronic. Also noted, but to a lesser degree, were road-related landslides and

## 1. Case study #1

In October 2001, a PFC assessment of this area was done to provide technical management information to land managers on vegetation, grazing, and the transportation system relative to watersheds and riparian values.

### *a. PFC assessment*

The site had a history of use, which is reflected in the assessment findings. Old wagon routes, for example, followed stream corridors since they offered water and forage for horses and other livestock, housed fish and game for food supplies, and provided wood for fire and building materials.

Early roads followed old established routes along stream bottoms, where construction was easier and less expensive (Figure 47). Drainage structures and maintenance practices were designed to move water away from the road to keep the travelway's surface and subsurface dry. Infrequent drainage structures, augmented with extensive ditch networks, were preferred over numerous small structures to save effort and expense. Maintenance practices commonly routed water and sediments from the road surface and ditches directly into stream courses for rapid removal. This benefited the transportation system, but commonly caused unintentional harm to other resources by fostering extensive road surface erosion, sediment transport and deposition, and erosion of riparian areas.

Figure 47. Road following old, established wagon route.

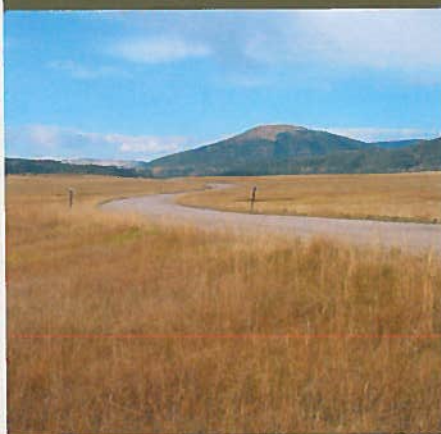


Figure 48. Inadequate surface drainage is a common problem across the area.



Over time, riparian areas in poor condition became a common sight and people grew to accept these conditions as normal. Land managers, whose livelihoods were most directly affected by riparian losses, recognized problems, spurring on-the-ground improvements. Many well-designed roads are evidence of this. Unfortunately, there are also problems associated with the roads that can be observed today (Figure 48).

As noted in the PFC assessment, most streams within the management area have downcut, widened, and are in some level of improved health. Some