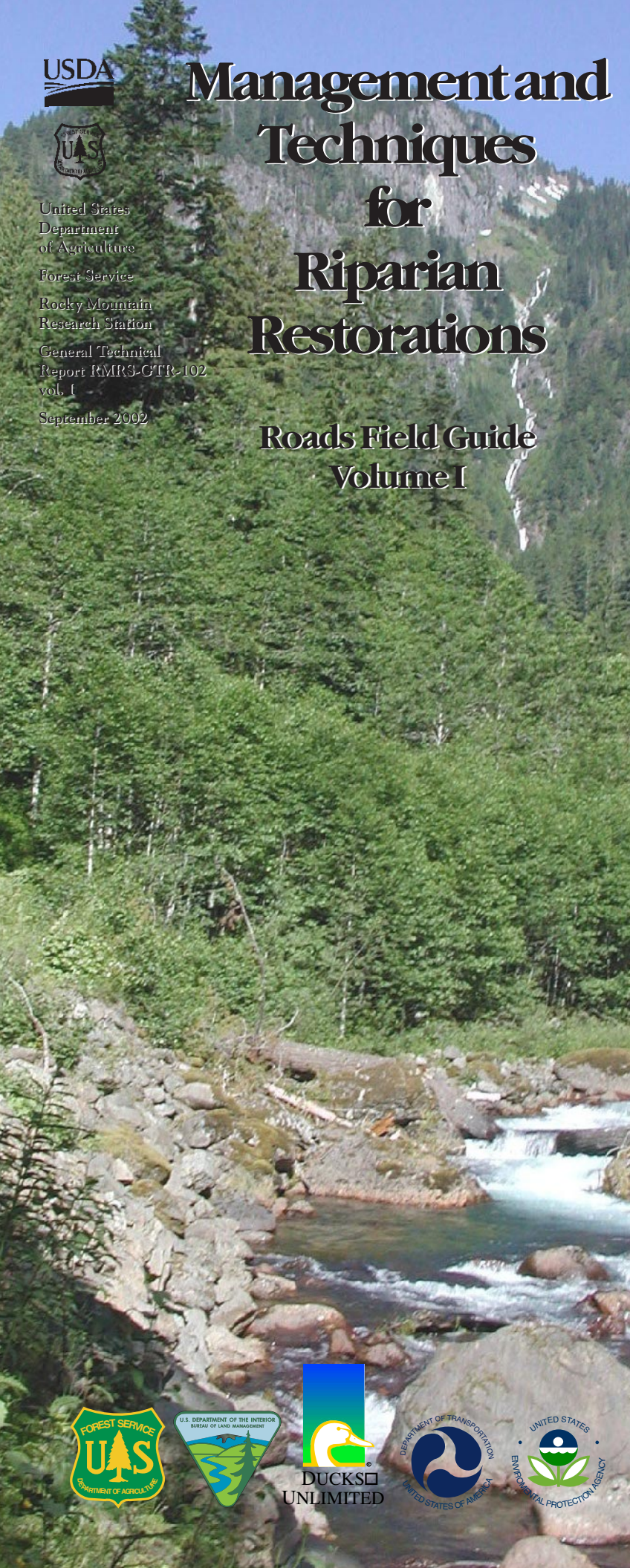

USDA

United States
Department
of Agriculture

Forest Service

Rocky Mountain
Research Station

General Technical
Report RMRS-GTR-102
vol. I

September 2002

Management and Techniques for Riparian Restorations

Roads Field Guide
Volume I

FOREST SERVICE
DEPARTMENT OF AGRICULTURE

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

DUCKS UNLIMITED

DEPARTMENT OF TRANSPORTATION
UNITED STATES OF AMERICA

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

The information in this publication has been assembled by the Members of the Roads/Riparian Restoration Team:

Steve Adair	*Phd., Director of Conservation Programs, Great Plains Regional Office, Ducks Unlimited*
Mary Lee Dereske	*P.E. Regional Water/Wastewater Engineer, Southwestern Region, Forest Service*
James Doyle	*Fish Biologist, Mt. Baker Snoqualmine National Forest*
Anthony Edwards	*Civil Engineer, Team Leader, San Dimas Technology & Development Center, Forest Service*
Sandra Jacobson	*Wildlife Biologist, Pacific Southwest Research Station, Forest Service*
Roy Jemison	*Phd., Research Hydrologist, Rocky Mountain Research Station, Forest Service*
Lisa Lewis	*National Riparian Service Team, Soil Scientist, Washington Office, Forest Service*
Wendy Melgin	*Deputy Branch Chief/Hydrologist, EPA, Region 5*
Carolyn Napper	*Soil Scientist, Lassen National Forest*
Tom Ratcliff	*Wildlife Biologist, Modoc National Forest*
Terry Warhol	*P.E., Assistant Forest Engineer, Umatilla National Forest*

List of authors is in alphabetical order.

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Fort Collins Service Center

Telephone	(970) 498-1392
FAX	(970) 498-1396
E-mail	rschneider@fs.fed.us
Web site	http://www.fs.fed.us/rm
Mailing Address	Publications Distribution Rocky Mountain Research Station 240 West Prospect Road Fort Collins, CO 80526

Rocky Mountain Research Station
240 West Prospect Road
Fort Collins, CO 80526

Management and Techniques for Riparian Restoration
Roads Field Guide
Volume I

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Introduction

Improperly constructed or maintained roads near riparian and wetland areas may degrade these valuable sites. Degradation affects many aspects of the riparian and wetland ecosystems: riparian vegetative cover decreases, bank and channel erosion increases, meadows become dewatered, sediment deposition into channels increases, flooding increases, water quality decreases, animal mortality or injury increases, and recreational opportunities decrease.

Many solutions to these problems have been proposed and documented. Restoration techniques can be used to protect riparian areas during new road construction, or to restore riparian areas impacted by existing roads. Some techniques are valid to only one or two ecoregions, but others are applicable nationwide. Techniques may be used singly, or in concert with other techniques, depending on the road problem and the riparian objectives.

This field guide presents information in a practical, user friendly format to help resource managers and professionals. The Roads Riparian Restoration Team collected this information from site visits to several ecoregions, restoration literature reviews, and through their collective experience. Please refer to the Roads/Riparian/Restoration website (http://www.fs.fed.us/rm/RRR) for more details and treatment options.

Well-documented evaluation and monitoring strategies are critical in riparian road restoration projects. Learning from mistakes as well as successes helps to improve and protect valuable riparian and wetland sites.

This two-volume field guide covers the management and techniques for riparian restoration near roads. The field guides cover the following topics:

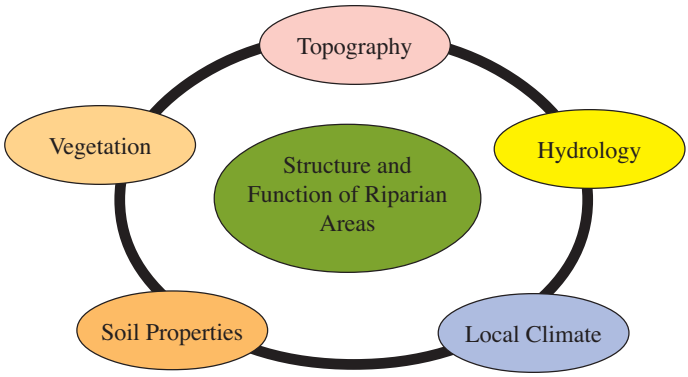
- Riparian Area Considerations
- Monitoring
- Planning projects
- Laws and Regulations
- Techniques to use in the field

Riparian Area Considerations

Riparian area ecosystems contain terrestrial and aquatic components. Terrestrial components include saturated soil and water-tolerant plants. Aquatic components include the water and the water body (stream, river, lake, pond, bog, wetland), and aquatic vegetation. In forest and rangeland landscapes, riparian areas contain the greatest number of terrestrial and aquatic animal species.

Riparian Area Values

Many forest ecosystem functions and processes occur in riparian areas. Riparian area attributes include water flow dispersal and energy dissipation, sediment detention, toxicant retention, groundwater recharge and discharge, erosion control, and the presence of a diversity of vegetative species. Because of these attributes, riparian areas provide food, water, cover, migration, and reproductive requirements for a vast number of terrestrial and aquatic animal species.



Riparian Area Elements

The diversity of riparian areas across the country and within an ecoregion is remarkable. It is important to identify physical and biological differences to successfully maintain, protect, and restore these areas. Five basic elements (above) that define the structure and function of riparian areas need to be assessed before restoration.

Impacts of Roads

Road construction and operation in and adjacent to riparian areas can cause negative impacts to riparian area processes, structure, and function. These road impacts can be reduced and riparian areas restored by using solutions in this field guide.

Soil Impacts
- erosion and deposition
- compaction and displacement
- sedimentation

Hydrologic Impacts
- hillslope drainage alterations
- baseflow alterations
- groundwater alterations (recharge/discharge)
- precipitation-runoff relationship alterations

Channel Impacts
- diversions
- morphology alterations
- alterations of organic debris

Vegetative Impacts
- invasion of exotic species
- decreased diversity of native species

Water Quality
- hazardous spills
- dust abatement
- herbicide use

Animal Impacts
- habitat fragmentation
- restricted movement
- direct mortality
- disturbance from human use

Monitoring

The degree of success or failure of road restoration efforts in riparian areas needs to be documented. Monitoring is an effective way to do this. Monitoring can: (1) indicate if the restoration efforts were designed and implemented properly; (2) determine if the restoration met the objectives of the project; (3) provide new insights into riparian area physical and biological processes; (4) provide justification for further work and research. Monitoring should not be an afterthought and must be identified as a cost component in the restoration project. Monitoring plans for restoration projects should use systematic processes and procedures. As examples, Kershner (1997) described the seven step template for restoration monitoring as shown above. MacDonald (1991) identified the following six types that are appropriate for monitoring aquatic resources. The type of monitoring used will depend upon the questions to be answered, and to the degree of certainty to which answers are needed. Adequate time, attention and input from others should be used to develop a monitoring plan that is appropriate for the given situation. There may be suitable monitoring designs and tools that others have developed which can be directly applied or used with minimal modifications for your project. Sources for this information on the Internet can be found at sites such as those below.

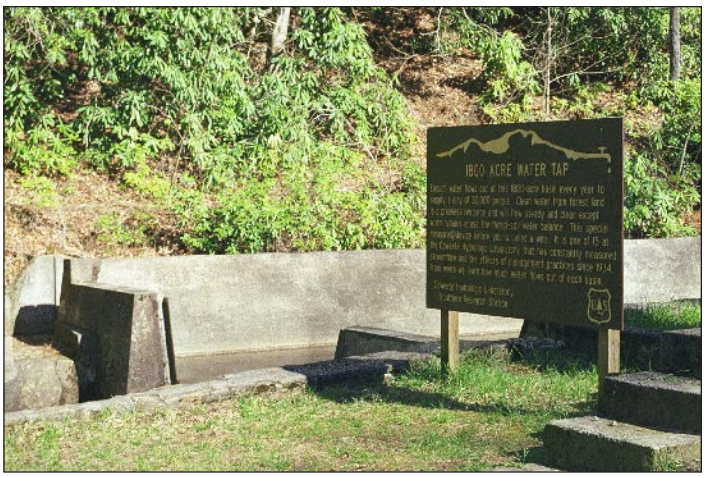
Seven Steps for Monitoring

1. Define participants and budget
2. Establish clear goals and objectives
3. Design monitoring to detect change
4. Prioritize monitoring activities
5. Implement field prescriptions and techniques
6. Analyze data and report results
7. Modify objectives based on new information

Six Types of Monitoring

1. Trend
2. Baseline
3. Implementation
4. Effectiveness
5. Project
6. Validation

- The Center for Transportation and the Environment
  http://www.itre.ncsu.edu/cte
- USDOT National Transportation Library
  http://search.bts.gov/ntl/



Planning Restoration Monitoring

1. **Restoration Objective:** A statement succinctly describing the purpose of the treatment, usually including an amount of change to be induced over a specified time period. Inclusion of both factors will allow for documentation of the degree of success or failure of the treatment.

2. **Monitoring Objective:** A statement that clearly states the expected result of a restoration treatment. This statement must be linked to the restoration objective statement.

3. **Parameters Monitored:** One or more items to be measured repeatedly over time that when analyzed will provide direct or indirect evidence of the success or failure of the treatment.

4. **Methods Used:** A listing of procedures and methodologies to evaluate the monitored parameters. Many standard methods and procedures are available in current literature. Sometimes however, new procedures will need to be developed and tested.

5. **Where and When to Monitor:** A statement that outlines the spatial and temporal scope of the evaluation.

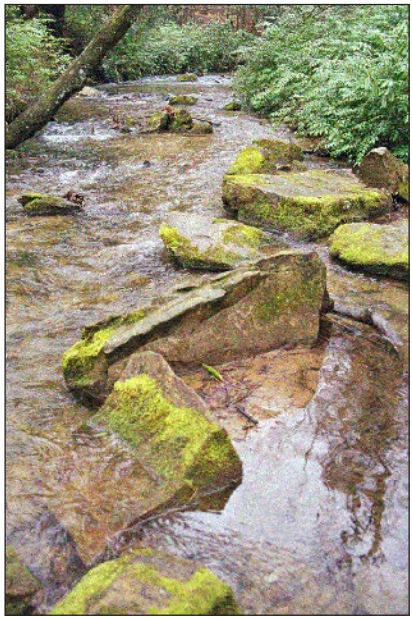
6. **Experimental Design:** Statements that outline how the monitoring will be laid out, implemented and analyzed.

7. **Expectations (Criteria to measure change, considering temporal and spatial factors):** Statements describing how the changed conditions compare to some other similar set of conditions having similar or different spatial/temporal scale factors.

8. **Assumptions and Data Limitations:** A listing of all the pertinent and relevant assumptions and data limitations that must be made in developing and implementing this monitoring.

9. **Distribution of Results:** The findings of the monitoring efforts should be made readily available to all interested parties through established channels, such as professional meetings, publications and the Internet.

10. **Archival of Results:** The results of the monitoring efforts should be well documented and stored for future reference. The documentation for each monitoring program should include copies of all the materials assembled above.



Project Checklist Questions

This section of the field guide is designed to help you analyze your site for issues and solutions.

Ideally, an interdisciplinary team will determine issues and appropriate treatments onsite, possibly with the help of this field guide. Because of the complex, interdisciplinary nature of riparian restoration, it is easy for jargon and functional interests to result in inadvertent misunderstandings. A 'Charter' that documents agreements onsite by participants can go a long way toward clarifying expectations. See the Roads Riparian Restoration website for a tested design you can use (http://www.fs.fed.us/rm/RRR). The field guide glossary may also help avoid misunderstandings by providing a common language base.

Try approaching your analysis in five steps:

1. *Identify the issues*

   What are the management objectives for the site?
   What is the riparian restoration objective for the site?
   Are there safety issues associated with the road?
   What is the land ownership?
   What are the public and internal access needs now or in the future?
   Is threatened, endangered or sensitive species habitat present?
   Does the road impact channel features such as pattern or meander?
   Does the road location or use level cause excess stream bank erosion or channel deposition?
   Does the road affect riparian vegetation composition or diversity?
   Are noxious weeds or invasive invertebrates present?
   Does the road cause movement problems for terrestrial wildlife?
   Does the road or its structures cause passage problems for aquatic organisms?
   Does the road have visual or scenic values?
   Are any of these problems recurring?

2. *Identify information needed to address the issues*

   What environmental documentation is required for this project?
   What permits are required?
   Is this a 303D-listed water body, and if so, what are the water quality parameters?
   Does the road have a current road analysis?
   What is the maintenance level of the road?
   What is the traffic volume?
   Is the stream flow intermittent or perennial?
   Are flow records available for the channels in question?
   What are the channel types?
   Has a riparian analysis been completed for the area, date completed.
   Has the channel been field-surveyed, date completed.

3. *Identify resources needed to resolve the issues*

   What specialists are needed to address issues and suggest solutions?
   What are the specific funding sources for needed treatments?
   What contract specialists are needed?
   How urgent is the restoration need and how can the timeline be met?

4. *Identify specific appropriate treatments*

   Does the road need to be repaired to address the issue?
   What does the next larger and smaller scale suggest as a treatment?

Does the site have recurring problems that may affect treatment selection now?

What previous treatments have been used at the site, if any, and when did they occur?

Have treatments used in similar sites and conditions been successful?

Which specific treatments suggested in this field guide may work?

Will your proposed treatment exacerbate any existing problems?

5. *Identify monitoring strategy*

What are the best and worst possible outcomes?

Have any previous treatments been monitored, and if so, what were the results?

Is monitoring required to be in compliance with any regulations?

What parameters should be monitored and how often?

What resources are available for monitoring?

Who will be responsible for monitoring?

How and where should monitoring information be stored?

What types of monitoring are appropriate for the restoration treatments being considered? (Refer to the monitoring section of this field guide.)

Glossary

Abutment: The structure that supports the end of a bridge or anchors the cables of a suspension bridge. (1)

Aggregate: Granular materials such as sand, gravel, crushed stone, slag, and cinders. Aggregate is used in construction for the manufacturing of concrete and asphaltic concrete. It is also used for leaching fields, drainage system, landscaping, and as a base course for pavement and grade slabs. Aggregate is classified by size and gradation. (1)

Apron: Erosion protection mat placed to protect against erosive energy of waterflow.

Arch: An open bottom road stream crossing structure usually formed from bolted structural plates.

Bankfull Discharge: Flow volume at which natural channel maintenance is most efficient, considering sediment transport, forming or removing bars, changing meanders, and performing work resulting in average channel morphology.

Base Flow: The proportion of stream flow that is derived from ground water.

Bed Load: Soil and rock material transported along the bottom of a stream combined with suspended load, comprising the total sediment discharge.

Berm: Curb or dike constructed to control or direct surface drainage.

Bollard: One of a series of short posts set to prevent vehicular access or to protect property from damage by vehicular encroachment. A bollard is sometimes used to direct traffic. (1)

Catastrophic Event: A significant natural disaster such as a major flood (50-100 year flood event), earthquake, or volcanic eruption. These disasters can cause major damage to roads and significantly alter/modify riparian area conditions.

Channel: A noticeable natural or artificial waterway, featuring periodic or continuous running water. It has a definite bed and banks that serve to confine the water.

Channel scour: Is the underwater erosion of a stream bottom or bank at a drainage structure outflow.

Clearing Limits: The limits of vegetation clearing for a road.

Cofferdam: Temporary enclosure built in a watercourse and pumped dry to permit work on a structure by separating the work from the water.

Corridor: A linear strip of land identified for the present or future location of transportation or utility rights of way within its boundaries; or in wild ecology terms, a large scale pathway animals use to travel from one area of suitable habitat to another.

Cross Drain: A ditch relief culvert or other structure or shaping of the traveled way designed to capture and remove surface water from the road.

Culvert: A conduit or passageway under a road or other obstruction for the passage of water, debris, sediment, and fish, backfilled with embankment material.

Depostion: The mechanical or chemical processes through which sediments accumulate in a resting place.

Ecoregion: A large area of land or water that contains a geographically distinct assemblage of natural communities that (a) share a large majority of their species and ecological dynamics, (b) share similar

environmental conditions, and (c) interact ecologically in ways that are critical for their long-term persistence.

Ecosystem: The total community of living species and its interrelated physical and chemical environment.

Embankment: A ridge constructed of earth, fill rocks, or gravel. The length of an embankment exceeds both its width and its height. The usual function of an embankment is to retain water or to carry a roadway. (1)

Ephemeral Channel: River and stream channels that flow seasonally and/or in direct response to runoff events.

Erosion: The wearing away of the land surface by detachment and movement of soil and rock fragments by water, wind, and other geological agents.

Exotic: Plants, animals or material non-native to the site.

Floodplain a): *Ecologists* define floodplains as areas that are periodically inundated (usually annually) by the lateral overflow of rivers or lakes, or by direct precipitation or ground water; the resulting physicochemical environment causes the biota to respond by morphological, anatomical, physiological, phenological, and/or ethological adaptations, and to produce characteristic community structures (2)

b): The flat area adjoining a river channel constructed by the river in the present climate and overflowed at times of high discharge.

Gabion: A woven galvanized wire basket sometimes lined with geotextile and filled with rock, stacked, or placed to form erosion resistant structures.

Geotechnical: Refers to the application of civil engineering technology to some aspect of the earth.

Geotextile: Synthetic fibers forming a woven, non-woven, or spunbonded fabric used to separate soil from engineered materials and add strength to a facility.

Grade Dip: Roll or undulation in the road's vertical alignment to facilitate surface drainage.

Habitat: Conditions essential for wildlife or fish life including sufficient water, food, space and reproductive needs.

Habitat Connectivity: Larger areas of suitable fish or wildlife habitat connected by smaller areas of suitable habitat.

Headcutting: Erosional process moving upstream from the location of initial downcutting.

Heeling: The temporary, severely angular planting of trees and shrubs, often in trenches, to facilitate their removal prior to permanent transplanting. (1)

Hydrologic Connectivity: Extension of the drainage network through connected flow paths (i.e., road and surface runoff become directly connected to the runoff channels).

Hydromulching a): Refers to composition of wood cellulose, paper pulp, and recycled newsprint/or cardboard fiber. They can be conveniently applied in a one-step application in which seed, fertilizer, soil amendments, and mulch may be placed in a single pass of a hydraulic mulcher.

b): Can be used to reach steep, inaccessible slopes, and a tackifier or synthetic fibers can be added to the hydraulic slurry to improve the tenacity of the fibers and their adhesion to the ground surface.

Inlet/Outlet Control: Culvert flow in which the cross sectional area of the barrel, inlet configuration, and amount of headwater or ponding are of controlling importance to hydraulics of flow.

Live Fascines: Elongated bundles of stems and branches from rootable plant material (e.g., willow, dogwood) that are tied together and placed in shallow trenches, partly covered with soil, and staked in place to arrest erosion and shallow mass wasting.

Morphology: Complex processes by which river and stream channels form as a function of the interactions between hydrology, lithology, vegetation and land uses. *Geomorphology* is the study of the Earth's landscapes and landforms, the processes by which the landforms originated, their age, and the nature of the materials underlying them. *Fluvial geomorphology* is the study of landforms and processes associated with rivers.

Native: Plants, animals, and materials indigenous to the site.

Passage (Fish or Wildlife): A structure to allow fish or wildlife to safely cross from one side of the road to the other.

Perennial Stream: A watercourse that runs all year, as opposed to an *intermittent* stream that has dry periods.

Permeability: The ability of wildlife, fish or water to cross a road without hinderance.

Pier: (a) A short column to support a concentrated load. **(b)** Isolated foundation member of plain or reinforced concrete. (1)

Road Template: The shape and cross-sectional dimensions of the roadway to be constructed, as defined by the construction staking notes and the characteristics of the typical sections. (4)

Riparian Area: Area containing moist soils and hydric vegetation along and interacting with a stream comprised of two ecosystems, riparian and aquatic.

Riparian Ecosystem: Terrestrial ecosytems characterized by hydric soils and plant species dependant on the water table and/or its capillary fringe.

Sedimentation: The detachment, transport, and deposition of sediment particles in streams and other water bodies.

Sediment Loading a): The total sediment in a stream system, whether in suspension (suspended load) or on the channel bottom (bedload).

b): Addition of sediment to water flowing in streams and rivers from adjoining soil surface areas and roads.

Spawning Bed: A habitat used by fish for producing or depositing eggs.

Stream Integrity: The state when a stream system is able to process the range of water, sediment and organic debris supplied while maintaining a balanced relationship between channel width, velocity, depth, and the floodplain within a normal dynamic range for the local geology, soils, vegetation and climate.

Shot-crete: Mortar or concrete pneumatically projected at high velocity onto a surface.

Soil Permeability: The ease of movement of liquid or gas through a mass of soil.

Stop-log structure: A partially submerged log spanning a portion or the entire channel having the objectives of pooling water and retaining bedload on the upstream side of the structure and preventing channel bank scouring on the downstream side. In many cases, the most effective treatments require a series of these structures above or below a road and channel crossing site.

Subgrade: The layers of roadbed that bring it up to the top surface, upon which subbase, base, or surface course is constructed. For roads without base course or surface course, that portion of roadbed prepared as the finished wearing surface.

Surface Course: The top layer of pavement structure, sometimes called the wearing course, usually designed to resist skidding, traffic abrasion, and the disintegrating effects of climate.

Surface Drainage: The concentration and flow of surface water on roads and related surfaces and in ditches.

Suspended Load: Fine materials eroded from locations higher in the watershed and transported buoyantly, which along with bed load, comprises the total sediment discharge.

Tackifier: Binder for vegetative mulch. (3)

Tailwater: The area just downstream of a drainage stucture.

Vented Ford: A crossing where the road grade is above the stream channel bottom and all of the water passes through the structure during periods of low flow. Most flow overtops the structure during floods.

Waterbar: Combination of ditch and berm installed perpendicular or skewed to road centerline to facilitate drainage of surface water, sometimes nondrivable and used to close the road.

Weir: Small dam for impounding water, sometimes with a notch to control flow.

Windrow: A ridge of loose soil, such as that produced by the spill off of a grader blade. (1)

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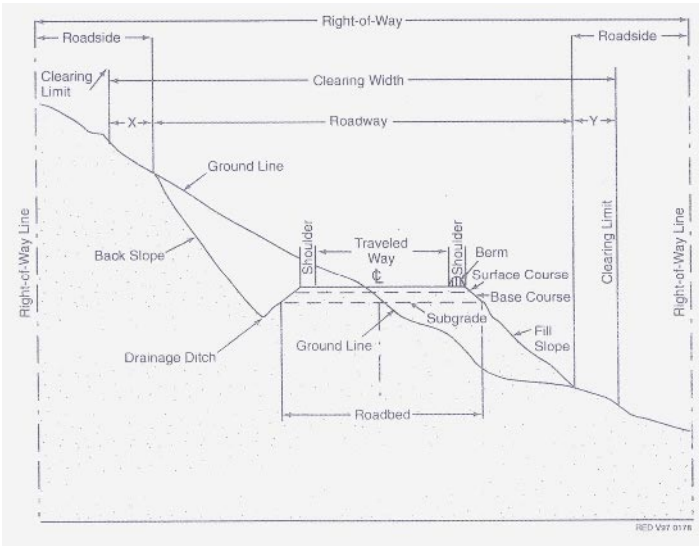
(1) Definition from "Means Illustrated Construction Dictionary". Kornielis Smit, 1st Edition, 1985
(2) The National Research Council's Restoration of Aquatic Ecosystems Report, 1989
(3) "Forest Service Specifications for Construction of Roads and Bridges", USDA Forest Service, EM-7720-100, August 1996.
(4) Definition from "Forest Service Specifications for Construction of Roads and Bridges", USDA Forest Service, EM-7720-100, August 1996



Laws and Regulations

Work on roads in riparian areas on Federal lands may require a Federal permit or compliance with State laws and regulations. This is a brief overview of the most common Federal laws and regulations pertaining to wetlands and waters of the U.S. Contact the appropriate agency before project work begins for information about permitting and compliance, especially your State agency since State laws and regulations vary.

Clean Water Act

The intent of the Clean Water Act (CWA) is to restore and maintain the chemical, physical and biological integrity of the Nation's waters. These sections of the CWA apply to riparian and wetland areas:

Section 303(d) The Total Maximum Daily Load (TMDL) Program: A TMDL or Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a waterbody can receive.

http://www.epa.gov/owow/tmdl/

Section 319(b) The Nonpoint Source Pollution Program: Requires that States develop management programs for the control of nonpoint source pollution.

http://www.epa.gov/owow/nps/cwact.html

Section 401 For Federally-permitted or licensed activities that involve discharges to waters of the U.S.

http://www.epa.gov/owow/wetlands/facts/fact24.html

Section 402 The National Pollutant Discharge Elimination System (NPDES): Regulates the discharge of a pollutant (other than dredged or fill material) from a point source into waters of the U.S.

http://cfpub1.epa.gov/npdes/

Section 404 The wetland regulatory program: Establishes a program to regulate the discharge of dredged or fill material into waters of the U.S., including wetlands. The basic premise of the program is that no discharge of dredged or fill material can be permitted if a practicable alternative exists that is less damaging to the aquatic environment or if the nation's waters would be significantly degraded. Section 404(f) exempts some activities from regulation under Section 404. These include many ongoing farming, ranching, and silvicultural practices. Questions can also be directed to EPA's Wetlands Hotline at 1-800-832-7828 or send e-mail to wetlands.helpline@epa.gov.

http://www.epa.gov/owow/wetlands/

http://www.usace.army.mil/inet/functions/cw/cecwo/reg/

http://www.epa.gov/owow/wetlands/40cfr/part232.html

Coastal Zone Act Reauthorization Amendments of 1990, Section 6217(g) (CZARA): Requires states to develop and implement State Coastal Nonpoint Source Pollution Programs.

http://www.epa.gov/owow/nps/czmact.html

Endangered Species Act

The 1973 Endangered Species Act (ESA) provides for the conservation of ecosystems necessary for threatened and endangered fish, wildlife and plants. It requires Federal agencies to ensure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat.

http://endangered.fws.gov/

National Environmental Policy Act (NEPA)

NEPA requires Federal agencies to make informed, environmentally responsible decisions when considering Federal actions that may have a significant impact on the environment (e.g. issuing a Section 404 permit). Agencies must evaluate potential environmental consequences of proposed actions using Environmental Assessments and/or Environmental Impact Statements.

http://ceq.eh.doe.gov/nepa/nepanet.htm

Forest Service Manuals

Forest Service Manual 2526: Riparian Area Management

Forest Service Manual 2527: Floodplain Management & Wetland Protection

Forest Service Manual 7700: Transportation System Management with the appropriate laws and regulations as outlined in Sections 7701.3 (TSM), 7701.4 (Cooperation & Coordination), and 7701.5 (Executive Orders)

USDA Forest Service Road Maintenance Levels

The USDA Forest Service recognizes five road maintenance levels (Source: Forest Service Handbook 7709.58.10):

Level 1: Is assigned to intermittent service roads during the time they are closed. The closure period must exceed 1 year. Basic maintenance is performed to keep damage to adjacent resources to an acceptable level and to perpetuate the road for future use. The road may be of any type or construction standard or may be managed at any other maintenance level when open. When at level 1, roads are closed to vehicular traffic, but may be open and suitable to non-motorized uses.

Level 2: Roads are for high clearance vehicles only. Passenger cars are not a consideration. Traffic levels are minor and usually consist of administrative, permitted, recreation, or other dispersed use.

Level 3: Roads are open and maintained for a prudent driver in a standard passenger car. User comfort and convenience are not considered priorities. These roads are typically low speed, single lane with turnouts and spot surfacing.

Level 4: Roads provide a moderate degree of user comfort and convenience at moderate travel speeds. Most roads are double lane and aggregate surfaced. Some roads may be single lane, paved, or dust abated.

Level 5: Roads provide a high degree of user comfort and convenience. These roads are normally double lane and paved. Some may be aggregate surfaced and dust abated.

Construction Methods and Sequencing

Description: Designing construction methods and sequencing into a project can minimize road construction impacts to riparian or wetland areas. Some common design techniques are described below.

Compaction: Vary routes to disperse compaction from equipment, or use fewer haul routes to reduce overall compaction. After use, rip temporary haul routes to reduce compaction and help infiltration.

Clearing Limits: Avoid rock formations, trees, and other unique features at the edge of the clearing. Minimizing clearing limits will generally reduce disturbance and cost.

Access: Require contractors to maintain and repair access routes to project sites. Possible contract maintenance requirements include, but are not limited to, signing, watering, dust abatement, surface wear replacement, maintenance collections, and traffic control (flaggers).

Seeding: Require contractors to seed and/or mulch disturbed areas as soon as possible, either yearly or during construction. Use native plant species when possible.

Water: Allow contractors to find alternative sources of water for construction needs. Limit water use from riparian areas. Use other dust abatement products when water is limited.

Backfilling Culverts: Lean concrete (slurry) as backfill for culverts can save time and money. Slurry backfills do not require compaction and allow for narrower trenches.

Cushion Blasting: Cushion blasting provides a natural look in areas needing blasting. The roughened surface does not show the straight, neat appearance resulting from drilling boreholes. Vegetation establishes more readily on the roughened surface.

Application: These techniques have broad applications in all types and sizes of road projects. New construction, reconstruction and maintenance projects will benefit from these approaches.

Considerations: These techniques often require more prescriptive specifications to control timing and methods of work. These specifications may result in higher bids and require more intensive inspection.

Consider affordable long-term maintenance costs as well as low initial cost. These techniques, and others, have proven to provide long-tem maintenance savings.

Potential Outcome/Benefits: These techniques can result in immediate and long-term resource protection and reduced impacts to riparian areas.

Controlled Public Access

Description: Controlled public access removes or modifies recreational use within a riparian area. The following methods help to reverse the effects of unrestricted public access:

- Provide designated areas for recreational use
- Restrict public access in riparian areas through management policies including seasonal closures
- Restrict public access in riparian areas by placing physical barriers (gates, fences, bollards, boulders)
- Harden sensitive locations by developing recreational sites
- Provide sanitary facilities.

Application: Unrestricted public access can cause the following impacts and require controlled access:

- Vegetation loss
- Accelerated erosion
- Trash accumulation
- Loss of plant diversity and understory
- Soil compaction
- User-made roads and trails

This encroachment into riparian and streamside areas compromises properly functioning streamside/riparian conditions, and can negatively affect sensitive plant and animal habitat. Emphasize controlled access in sensitive plant, animal, and fish habitat.

Developed campgrounds and boat launches help attract users away from undeveloped areas and facilitate management prohibitions on dispersed camping. Vehicle and pedestrian barriers (such as fences, boulders, woody debris, bollards, or guardrails) prohibit access and help damaged riparian areas recover.

Considerations: Public input and education is vital to help recreationists used to having unrestricted access understand why accessibility of a site may change.

Potential Outcome/Benefits: Appropriate public access may help improve or restore vegetation diversity and vigor, improve water quality, decrease erosion and sediment transport to streams, maintain or restore wildlife and fisheries habitat, and improve riparian function.

Alternate and Complementary Techniques: Complement access control with signing and public information systems. If it is not possible to close a road, then *surfacing (30)* the road may reduce impacts.

Road Relocation or Realignment

Description: Road relocation or realignment completely removes a road from areas of concern, or changes the placement to reduce or eliminate negative impacts caused by the road on the surrounding ecosystems. Negative impacts of roads on stream and river corridors include:

- Restricted floodplain functions (i.e., meandering and transporting of materials)
- Increased flood frequency and damage
- Eroded sediments and runoff washed into channels
- Blocked fish passages
- Increased wildlife/vehicle collisions
- Reduced numbers of riparian species
- Fragmented wildlife habitat

Considerations: Realigning or relocating a road requires removal of enough of the old road prism to allow the surface and subsurface water drainage networks to regain natural function. Heavy equipment is typically used for road construction (i.e. dozers, compactors, graders, and excavators). Risks associated with a new road location must be seriously considered.

Potential Outcome/Benefits: Benefits of relocating or realigning a road include:

- Improved fish and wildlife habitat
- Restored floodplain structure and function
- Reduced risks of road failures from catastrophic events such as road generated debris torrents and debris avalanches
- Creation of recreational use areas on closed road surfaces for hiking, biking, and ATVs
- The possibility of reduced vehicular speeds by changing vertical and horizontal road alignments

Alternate and Complementary Techniques: Road relocation and realignment can cause considerable disturbance to an area during construction. Techniques to help reduce negative effects are *soil bioengineering (18), revegetation (17),* and *landslide mitigation strategies (21).*

In these photos, the roads were relocated out of the riparian areas to higher ground. In California (top) the old road was converted to a trail. In Oregon (bottom), the old road was ripped and seeded.

old road alignment

Temporary Erosion Control

Description: Temporary sediment control devices slow runoff and trap small amounts of sediments, or trap and store sediment produced on disturbed areas and delivered to the structures by runoff. Temporary sediment control devices are usually associated with construction activities, but can be used wherever erosion from exposed soil is a concern.

Application:

Barriers: Sediment barriers intercept and detain sediment and decrease runoff velocity. The most common are filter fences, straw bales, and straw wattles.

Retention Structures: The most common type of retention structure is the sediment basin, especially if large storm events are a concern. Typically used as mitigation measures during construction, sediment basins are constructed below known sources of sediment.

Mulches: Straw, woodchips, and soil adhesives can protect bare soil or recently seeded areas. Gravel can be used on temporary roadways or parking areas.

Considerations: In general, a filter fence can last about twice as long as a straw bale and is more effective in trapping sediment. However, in areas with snow, filter fences may not be practical because the weight of the snowpack can collapse the fence. Since the fences are designed to intercept surface runoff, they are effective for areas of about 1–2 acres and where the maximum slope length behind the barriers is 100 feet. Straw bales can remove the bulk of coarse sediment from runoff and prevent sediment damage to adjacent property or waterways. When the bale deteriorates, it can be broken up and used as mulch. Useful duration of straw bales is between 3 to 6 months. Straw wattles make good contact with the ground surface and provide effective and low risk barriers to soil movement. Straw wattles are primarily used in the upper end of swale areas and have a life expectancy of 2 to 4 years. Sediment basins can be effective in removing sediment, however, it may not be reasonable to construct temporary sediment basins for small projects with small runoff areas and limited sediment production. If chemical mulches or tackifiers are used, be sure they are non-toxic.

Potential Outcome/Benefits: Protection of water quality is the main benefit of temporary erosion control. Sediment barriers constructed around wetlands and riparian areas will help ensure vehicle and access control.

Alternate and Complementary Techniques: Filter strips, geotextile and jute mats, sediment traps, slope *revegetation (17), biotechnical stabilization (20),* and *soil bioengineering (18).*

Outsloping

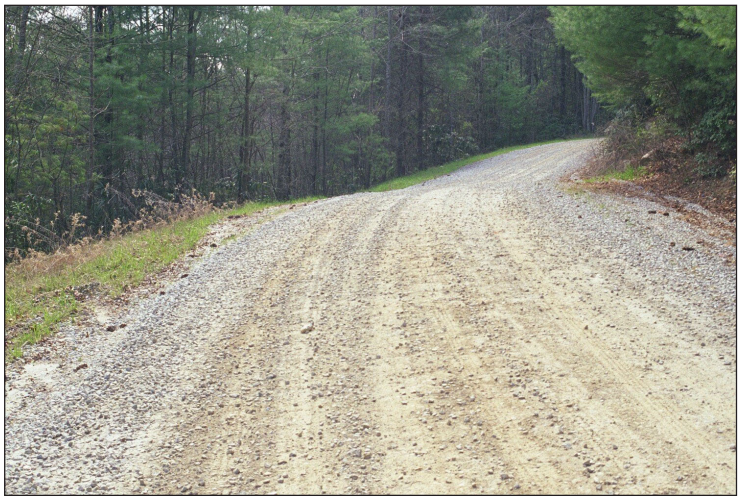
Description: Outsloping reduces erosion by minimizing concentration of surface runoff. Outsloped roads are shaped to drain all surface water to the downhill side. The cross slope of an outsloped road varies from 3–5% and can be up to 7% depending on road profile, maintenance level, and traffic service level.

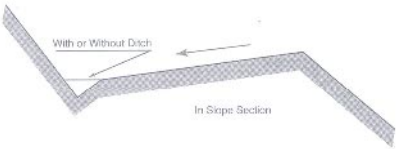
Application: Outsloping has been used effectively where it is important to maintain dispersed surface runoff for ecological reasons. Outsloping can lower costs and reduce risks associated with culvert maintenance or failure in areas with frequent cross-drains. Outsloping may be preferred where insloping may cause increased erosion of the toe of the slope, or on closed or obliterated roads to facilitate dispersed hillside drainage. Roads with high ditch and culvert maintenance can also benefit from outsloping.

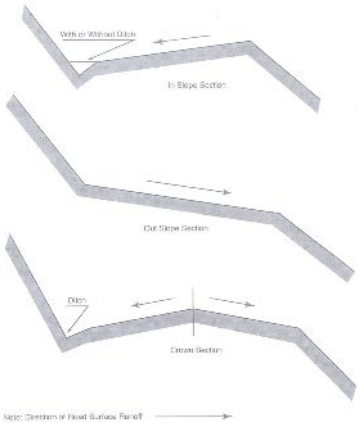
Considerations: Outsloped templates can become unsafe to use if surfaces are slick, icy, or snow covered. In highly unstable and erosive soils outsloping may result in excessive erosion and shallow slides. Travel speeds, design vehicles, season of use, steepness of fill slopes, and soil texture, factor into the decision to outslope the road template. Dry culverts may be used to facilitate small animal passage across smaller roads, even when outsloping carries runoff.

Potential Outcomes/Benefits: Outsloping disperses surface runoff and reduces erosion and potential sediment from entering the fluvial system. This helps to reduce adverse impacts on fish and wildlife habitat. Outsloping eliminates inside ditches, decreases road maintenance, and occupies less land on the landscape. Outsloping lowers initial costs associated with road clearing and construction.

Alternate and Complementary Techniques: *Road relocation/realignment (11)*. Outsloping may be used with *roadway dips (23)* or broad-based dips. In situations where an out-sloped template does not achieve safety or resource objectives, insloped or crowned templates (see graphics below) may be considered.







Bibliography

Listed below are references to help you plan, implement and monitor your roads projects. Additional references and links to road related sites on the Internet are listed on our website at: http://www.fs.fed.us/rm/RRR.

A Guide to Road Closure and Obliteration in the Forest Service. USDA-FS, Technology & Development Program, San Dimas, CA. 1996.

Dust Pallitive Selection and Application Guide. USDA-FS Technology & Development Program, San Dimas, CA. 1999.

Effects of Roads on Hydrology, Geomorphology, and Disturbance Patches in Stream Networks. J.A. Jones et al. In: Conservation Biology, Volume 14, No. 1, February 2000.

FishXing, Software and Interactive Learning for Fish Passage Through Culverts. Water/Road Interaction Toolkit, USDA-FS, Technology & Development Program, San Dimas, CA. 2000.

Forest Roads: Synthesis of Scientific Information. H. Gucinski, M.J. Furniss, R.R. Ziemer and M.H. Brookes (eds.). USDA-FS. 2000.

Influences of Forest and Rangeland Management. W.R. Meehan, (ed.). American Fishery Society, Spec. Pub. 19, Bethesda, MD. 1991.

Large Woody Debris Jams, Channel Hydraulics and Habitat Formation in Large Rivers. T.A. Abbe and D.R. Montgomery. In: Regulated Rivers: Research Management, Volume 12. 1996.

Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington. USDA-FS, PNW Region. 1985.

Managing Roads for the Wet Meadow Ecosystem Recovery. USDA-FS, SW Region, FHWA-FLP-96-016. 1996.

Monitoring and Adaptive Management. Kershner, J.L. In: Watershed Restoration: Principles and Practices. Williams, J.E., C.A. Wood, and M.P. Dombeck (eds.). American Fisheries Society, Bethesda, MD. 1997.

Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. MacDonald, L.H., A.W. Smart, and R.C. Wismarr. EPA 910/9-91-001. US EPA, Region 10, Seattle, WA. 1991.

Monitoring the Vegetative Resources in Riparian Areas. USDA-FS. 2000.

Response of Road-Stream Crossings to Large Floods in Washington, Oregon, and Northern California. USDA-FS, Technology & Development Programs, San Dimas, CA. 1998.

Review of the Ecological Effects of Roads on Terrestrial and Aquatic Communities. S.C. Trombulak and C.A. Frissell. In: Conservation Biology. 2000.

Riparian Management in Forests of the Eastern United States. E.S. Verry, J.H. Hornbeck, and C.A. Dolloff. Lewis Publishers. 2000.

Road Analysis-Informing Decisions About Managing the National Forest Transportation System. USDA-FS. 1999.

Soil Bioengineering: An Alternative for Roadside Management. USDA-FS. 2000.

Stream Corridor Restoration. Federal Interagency Stream Restoration Working Group. 1998.

Temporary Stream and Wetland Crossing Options for Forest Management. C.R. Blinn et al. USDA-FS, North Central Research Station. 2000.

Water/Road Interaction Technology Series. Technology & Development Center, USA-FS. 1998.

Watershed Restoration: Principles and Practices. J.E. Willaims, C.A. Wood, and M.P. Dombeck (eds.). American Fisheries Society, Bethesda, MD. 1997.

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