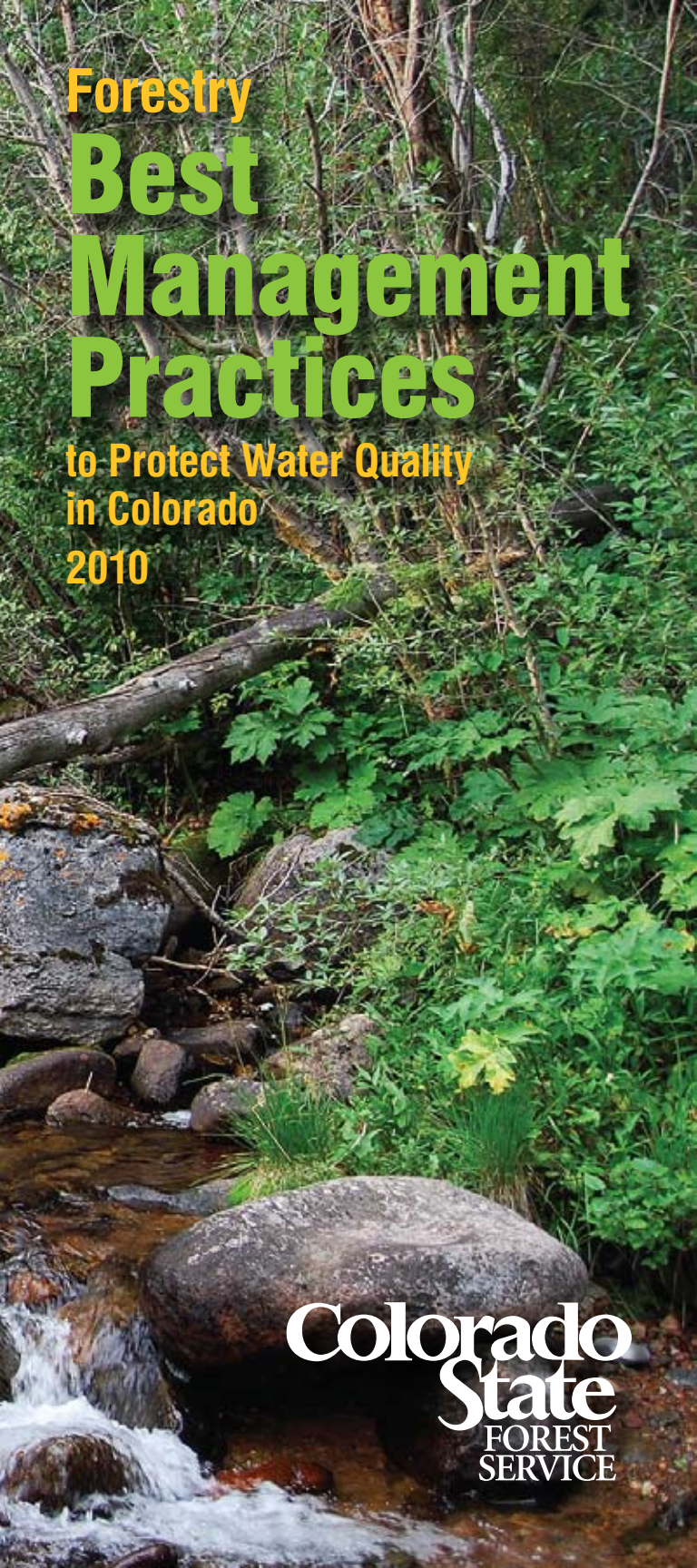

Forestry
Best
Management
Practices
to Protect Water Quality
in Colorado
2010
Colorado
State
FOREST
SERVICE

Contents

Introduction

Colorado's forest lands provide aesthetic value, clean water, abundant wildlife, minerals, recreation and renewable resources such as forage and timber, and forest-related jobs. This publication is dedicated to the stewardship of those resources – especially clean water. It outlines Best Management Practices (BMPs) for the protection of natural resources. These BMPs apply to all forest management activities, including product harvests, fuels mitigation projects and forest health treatments.

If you work in the forest or own forested land, the following guidelines will help you work responsibly in the forest. These guidelines are condensed from *Colorado Forest Stewardship Guidelines to Protect Water Quality: Best Management Practices (BMPS) for Colorado,* with additional recommendations from a 2008 BMP audit. The Colorado Timber Industry Association and Colorado State Forest Service (CSFS), with cooperative funding support from the Colorado Nonpoint Source Task Force and US Environmental Protection Agency, developed the original BMP publication above. It and the *Colorado Forestry Best Management Practices 2008 Field Audit Report* are available from the Colorado State Forest Service at http://csfs.colostate.edu/pages/forests-management.html.

The application of BMPs in the forest requires practice and personal judgment. While these BMPs are voluntary, they can be used to develop timber sale and forest treatment service contracts, which can make their application more binding.

BMPs include, but are not limited to, structural and nonstructural controls, operations and maintenance procedures. BMPs can be applied before, during and after pollution-producing activities to reduce or eliminate water pollution (40 CFR 130.2, EPA Water Quality Standards Regulation). Generally, BMPs are applied as a system of practices, rather than a single practice. BMPs are selected on the basis of site-specific conditions that reflect natural conditions and political, social, economic and technical feasibility.

Funding for this publication was provided through a grant from the Colorado Water Quality Control Division of the Colorado Department of Public Health and Environment. Members of the 2008 BMP Audit Team contributed through participation in the audit and represented the following organizations:

Colorado Water Quality Control Division, Colorado Department of Public Health and Environment
Colorado State Forest Service
US Forest Service
Colorado State University, Watershed Science
Colorado Division of Wildlife
Natural Resources Conservation Service, Colorado Office
Jefferson County Open Space
Colorado Tree Farmers
US Environmental Protection Agency
Intermountain Forest Association
Colorado Timber Industry Association

Watersheds

Many towns and cities depend on surface water collected from forested watersheds for domestic public water supplies. Throughout Colorado, forest lands act as collectors of clean water. Protecting these water sources is the responsibility of forest landowners, forest managers and timber operators. Logging, road construction and other forest activities disturbs vegetation and soil. This can cause erosion and sediment release downstream. Best Management Practices (BMPs) are guidelines to direct forest activities that protect natural resources – especially water quality.

Ephemeral areas drain water to intermittent stream channels. These channels carry the water to perennial streams, which then flow to watershed outlets. Ephemeral areas generally occur above the upper reaches of intermittent streams. It is important to minimize soil disturbance in these areas, as they can direct water into intermittent stream channels. Ephemeral areas used as skid roads and equipment turn-around areas can contribute to stream sediment.

Sediment is composed of fine particles of soil, sand and pebbles carried by moving water and later deposited when the flow slows or stops (e.g., in eddies or where a stream enters a lake or pond). Sediment created by soil erosion during logging or road-building activities can be carried by way of ephemeral, intermittent and perennial stream channels to a watershed outlet.

Improperly planned, located or constructed roads, skid trails and landings can act as man-made stream channels and carry sediment. Sediment can make its way to the watershed outlet and create problems downstream if appropriate BMPs are not followed.

Wetlands within a watershed include seeps, springs, wallows, marshes, bogs and riparian woodlands. Some drain into streams; others do not. Even when dry, wetlands generally can be identified by the presence of certain plants. It is essential to protect wetlands during forest activities in proximity to these areas.

Planning

- **Forest harvesting and forest treatments require advanced planning prior to proceeding.**

A timber sale plan or forest treatment plan is recommended for all operations, regardless of ownership. As part of the planning process, conduct an analysis to evaluate the potential for impacts to, and the cumulative effects on, soil, water and other natural resources. If the analysis reveals significant potential impacts : (1) consider how to minimize potential effects during and following the sale or treatment area layout and subsequent operations; (2) include mitigation of effects for these treated areas where impacts are unavoidable; and (3) identify sensitive areas where impacts from treatments cannot be mitigated to conform with standards.

- **Incorporate appropriate BMPs described in this document into planning documents.**

Include future monitoring of the harvest/treatment site in plans to evaluate the effectiveness of BMPS, and apply measures needed to mitigate failures.

Tree harvesting and other forest management activities such as site preparation, road construction and fuels

mastication have minimal impacts on forested watersheds if conducted with careful regard to soil and water resource quality. However, poor logging and treatment practices can cause excessive erosion. Excessive disturbance of vegetation and topsoil on the forest floor destroys filtering capacity, and soil compaction affects surface water infiltration. When surface water is allowed to flow onto roads and trails, it creates man-made stream channels. Runoff increases in speed and volume as it flows downstream. Concentrated runoff undermines slopes, tearing away soil, destroying roads, overloading streams with sediment, damaging stream-banks and destroying aquatic habitat.

Roads

Roads produce up to 90 percent of sediment from forest activities, so proper forest road planning, design and location are imperative. Roads and landing locations should complement each other to provide an efficient transportation system while minimizing logging costs and soil erosion.

Plans for permanent stream crossings must include calculations for maximum runoff; when ignored, this can cause flooding, and the potential for economic and water quality damage is enormous. Commonly, repair costs far exceed costs to properly install roads.

Planning, Design and Location

- Design roads and drainage facilities properly to prevent potential water quality problems due to road construction.
- Minimize the number of roads constructed in a watershed through comprehensive road planning, recognizing intermingled ownership and foreseeable future uses.
- Use existing roads where practical, unless use of such roads would cause or aggravate an erosion problem.
- Fit the road to the topography by locating roads on natural benches and following contours. Where practical, avoid long, steep road grades and narrow canyons.

- Review available information and consult with professionals as necessary to help identify erodible soils and unstable areas, and to locate appropriate road-surface materials.
- Locate roads on stable geology, including well-drained soils and rock formations that tend to dip into the slope.
- Attempt to avoid slumps and slide-prone areas characterized by steep slopes, highly weathered bedrock, clay beds, concave slopes, hummocky topography and rock layers that dip parallel to the slope. Rock layers that slant with, rather than into, the slope are a clue to potentially unstable bedrock conditions. Get expert advice when planning roads in these locations.
- Avoid wet areas, including moisture-laden or unstable toe slopes, swamps, wet meadows and natural drainage channels.
- Minimize the number of stream crossings and choose stable stream crossing sites.
- Locate roads to provide access to suitable (relatively flat and well-drained) log-landing areas to reduce soil disturbance.
- Locate roads a safe distance from streams when roads are running parallel to stream channels.
- Provide an adequate streamside management zone (SMZ) to trap sediment and prevent its entry into the stream.

Following these recommendations will reduce road maintenance costs and minimize failures.

Standards and Use

- Design roads to the minimum standard necessary to accommodate anticipated use and equipment. Temporary low-standard roads are designed for short-term minimal use during timber harvesting. They can be constructed, used and reclaimed during seasons when precipitation and erosion potential are minimal. Low-standard roads involve only the clearing of vegetation and require minimal construction. The need for higher standard roads can sometimes be alleviated through better road-use management and logging-system selection.

- Use portable bridges when stream crossings are needed. These temporary bridges are quick, economical, can be installed with less impact than other alternatives and can be reused at other locations in the future.
- Limit access by using locked gates for road-use management. Seasonal weather conditions also can restrict access.
- Cross only when the ground is frozen where access for forest activities requires crossing moist areas with a poor road base. Return during the dry season to do site preparation and slash treatment.

Road Construction

See also Stream Crossing.

Control Erosion During the Construction Process:

- Reconstruct existing roads only to the extent necessary to provide adequate drainage and safety; avoid disturbing stable road surfaces. Evaluate the integrity of existing roads prior to utilization.
- Minimize earth-moving activities when soils appear excessively wet. Do not disturb roadside vegetation more than necessary to maintain slope stability and serve traffic needs.
- Keep slope stabilization, erosion and sediment control work as current as possible when constructing roads. This includes installing drainage features as part of the construction process.
- Complete or stabilize road sections within the same operating season to ensure that drainage features are fully functional prior to spring runoff, and that road sections are not left in an unstable condition over winter.
- If the road is a permanent installation that will experience considerable traffic, consider using gravel to minimize erosion and provide a superior running surface.
- When pioneering roads, use temporary crossings over streams and continue clearing. Several logs placed in the stream channel form a base that water can flow through while protecting stream banks. Replace promptly with a permanent crossing (culvert or bridge).
- Grass seeding of exposed cut-and-fill surfaces is an important erosion control practice. Proper seed mix-

tures and timing are important for success. Use seed of known purity that has a high germination rate and is free of noxious weeds. Private foresters and local Colorado State Forest Service, Colorado State University Extension and Natural Resources Conservation Service offices can assist in recommending an appropriate seed mix for your particular site. Several vendors in Colorado stock native and introduced grass seed.

Stabilize Slopes:

- Construct cut-and-fill slopes at stable angles to prevent sloughing and other subsequent erosion. A 1:3 slope is the maximum recommended for stable soils. A 1:1 slope may be necessary in sandy soils to avoid slumping.
- Stabilize erodible, exposed soils by seeding, compacting, rip rapping, benching, mulching or another suitable means prior to fall or spring runoff.
- At the toe of potentially erodible fill slopes, particularly near stream channels, pile two feet of slash in a row parallel to the road to trap sediment. When completed concurrently with road construction, this practice can effectively control sediment movement and provide an economical way of disposing of roadway slash. Limit the height, width and length of these “slash filter windrows” so as not to impede wildlife movement.
- Geo-textile silt fences can be used as sediment traps until more permanent measures such as reseeding become effective. Remove temporary traps when no longer needed.
- Avoid incorporating potentially unstable woody debris in the fill portion of the road prism. When possible, leave existing rooted trees or shrubs at the toe of the fill slope to stabilize the fill.

Most forest roads are built by excavating a road surface. Use road designs and on-the-ground layout to demonstrate proper cut slopes and to indicate cut slope steepness for machine operators. The bulldozer starts at the top of the cut slope, excavating and “side-casting” material until the desired road grade and width are obtained. Material from cuts often is pushed or “drifted” in front of the blade

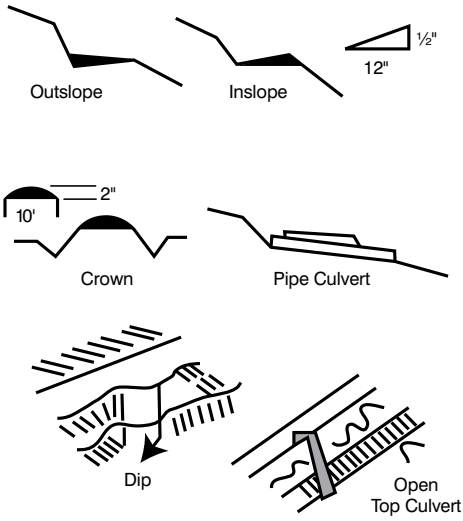
to areas where fill is needed. Use road fill to cover culverts and build up low areas. Spread and compact fill in layers to develop strength, as it must support traffic.

While cut-and-fill road construction is commonly used on gentle terrain, full-bench roads are nearly always built on steep terrain with slopes greater than 65 percent. In full-bench construction, the entire road surface is excavated into the hill. The excavated material is pushed or hauled to an area that needs fill or to a disposal area.

- Design roads to balance cuts and fills or use full-bench construction where stable fill construction is not possible.
- During the process of cut-and-fill, avoid allowing sidecast or waste material to enter streams, and do not place it on unstable areas where it might erode. Where possible, keep roads outside of streamside management zones to mitigate this problem.
- Borrow pits can contaminate surface water; take precautions to control drainage and escaping sediment.
- Burning can be used to dispose of root wads, slash and vegetative debris during road construction. Locate burning areas away from water sources to prevent water contamination.

Drainage from Road Surface

- Vary road grades to reduce concentrated flow in roadside drainage ditches and culverts, and on fill slopes and road surfaces.
- Provide adequate drainage from the surface of all permanent and temporary roads by using outsloped or crowned roads, drain dips or insloped roads with cross-drains. Use caution in constructing crowned or outsloped road profiles. Excessive crown or outslope may make it impossible to keep trucks on the running surface during icy and other low-traction conditions.



General Types of Surface Drainage

- **Outsloped Roads:** Outsloped roads provide a means of dispersing water in a low-energy flow from the road surface. Outsloped roads are appropriate when fill slopes are stable, as drainage will not flow directly into stream channels and transportation safety considerations can be met. A smooth surface is the key to an effective outsloped road. Smoothing and outsloping (from cutbank to outside edge of roadbed) should be kept current so that water can drain across the road without creating channels on the road surface.
- **Insloped Roads:** Insloped roads carry road surface water to a ditch along the cutbank. Plan ditch gradients that generally are greater than 2 percent, but no more than 8 percent for insloped roads to prevent sediment deposition and ditch erosion. The higher gradients may be suitable for more stable soils, but plan for sufficient culverts, drop structures or armor ditches. Use the lower gradients for less stable soils.
- **Drain Dips:** A drain dip is a portion of road sloped to carry water from the inside edge to the outside edge onto natural ground. Properly constructed drain dips can be an economical method of channeling surface flow off the road. Construct drain dips deep enough into the subgrade so that traffic will not destroy them;

length and depth must provide the needed drainage, but not present a driving hazard. The cross grade should be at least 1 percent greater than the original road grade.

Design Roads for Minimal Disruption of Drainage Patterns:

- Prevent downslope movement of sediment by using sediment catch basins, drop inlets, changes in road grade, headwalls or recessed cut slopes.
- Where possible, install ditch-relief culverts at the gradient of the original ground slope; otherwise, use armor outlets with rock or anchor downspouts to carry water safely across the fill slope.
- Skew ditch-relief culverts 20 to 30 degrees toward the inflow from the ditch to improve inlet efficiency. Protect the upstream end of cross-drain culverts from plugging. Drop inlets installed at the head of a ditch-relief culvert slow the flow of water, help settle-out sediment and protect the culvert from plugging. Rock-armored inlets prevent water from eroding and undercutting the culvert and flowing under the road.
- Provide energy dissipaters (rock piles, logs, etc.) where necessary at the downstream end of ditch-relief culverts to reduce the erosion energy of the emerging water.
- Cross drains, culverts, water bars, dips and other drainage structures should not be discharged onto erodible soils or fill slopes without outfall protection.
- Route road drainage through SMZs, filtration fields or other sediment-settling structures that are large enough to accommodate the anticipated volume of water. Install road drainage features above stream crossings to route discharge into filtration zones before entering a stream. To avoid creation of new gullies, diffuse runoff through these filters, rather than allowing concentrated runoff.
- Ditch-relief culverts transfer water from a ditch on the uphill side of a road, under the grade and release it onto a stable area; these prevent water from crossing the road surface and softening the road bed. Install culverts at a 30-degree angle to enhance flow. Ensure

proper slope of at least 5 inches for every 10 feet (4 percent). Seat the culvert on the natural slope on bedding material that is free of rock or debris, which might puncture the pipe or carry water around the culvert. Cover with soil (avoiding puncture from large rocks) and compact the soil at least halfway up the side to prevent water from seeping around the culvert. (Rule of thumb for covering culverts: minimum of 1 foot or one-third the culvert diameter, whichever is greater.) Be sure that the outlet end extends beyond any fill and empties onto an apron of rock, gravel, brush or logs.

Maintenance

- Periodically inspect and maintain erosion control features, including cleaning dips and cross drains, repairing ditches, marking culvert inlets to aid in location, and clearing debris from culverts. Keep small water-collection points drained with a shovel to dry up potential mud holes and remove ice dams in drainage ditches during winter operations.
- Avoid using roads during wet periods if such use might permanently damage the road drainage features.

Road-grading Precautions:

- Grade road surfaces only as often as is necessary to maintain a stable running surface and to retain the original surface drainage.
- Avoid cutting the toe of cut slopes when grading roads or pulling ditches.
- Avoid grading sections of road that don't need it; this creates a source of sediment from the newly disturbed surface. Raise the blade where grading is not needed.

Road Closures

- When seasonal operations are completed, crown, outslope, inslope or water-bar the road surface . Remove berms from the outside edge where runoff is channeled.
- Leave abandoned roads in a condition that provides adequate drainage without further maintenance. Close these roads to traffic; scarify if required, and reseed. If necessary, recontour and provide waterbars or drain dips.

- Traffic control on forest roads can be an effective way to reduce road maintenance costs and provide protection of other forest resources. Traffic control can include full road closure, temporary or seasonal closure, or open road restricted to light use. Any degree of control requires maintenance inspections.
- Bridges may present special problems to road closures. Remove all bridge structures unless plans include regular inspections of abutments for erosion and other potential problems.
- If plans do not include regular maintenance of closed roads, plugged culverts will present erosion problems. Remove culverts and create waterbars to divert water on abandoned roads. Space waterbars closer in areas that are more likely to erode. When removing culverts, stockpile earth in a safe place where it can be recovered and won't erode. Reshape banks to a stable slope.
- If bridges and culverts are removed, all drainage features must be restored to their natural condition, including reseeding the road surface and all cut-and-fill slopes.

Streamside Management Zone (SMZ)

The function of an SMZ is to protect water quality along streams, lakes and other water bodies by maintaining a natural sediment filter. The riparian area "green zone" around streams, lakes, reservoirs, springs and seeps is an area that stays green long into the summer months. Riparian areas usually have wet soils and high water tables, and can be identified by the presence of water-loving plants such as alder, willow and cottonwoods. Recognizing these areas and knowing where they are located in the forest will make it much easier to protect water quality with an SMZ.

A 50-foot-wide strip on both sides of the stream is the minimum recommended by the Colorado State Forest Service and the Colorado Timber Industry Association for an SMZ. Even where the riparian area is narrow, the SMZ should be 50 feet. The 50-foot minimum SMZ often extends

beyond the riparian area green zone. This is critical where slopes near streams are steep and soils are unstable, or when the riparian area is narrower than 50 feet.

Legal Requirements

In some cases, it is necessary to secure certain permits prior to altering a stream channel or wet area. Compliance with Section 404 of the Clean Water Act is required if the activity has the potential to impact any water area considered "waters of the U.S." Consult with your local U.S. Army Corps of Engineers representative to determine the need for a 404 permit. The consequences for operation without a necessary permit could be significant and may include work stoppage and monetary fines.

SMZ Boundaries

- Designate SMZs to provide stream-shading, soil stabilization, sediment and water-filtering effects, and wildlife habitat. A stream is a natural water course of perceptible extent with defined beds or banks that confine and conduct continuously or intermittently flowing water. Defined beds have a sandy or rocky bottom caused by the scouring action of water flow. The SMZ encompasses a strip at least 50 feet wide on each side of a stream measured from the ordinary (yearly average) high-water mark of a definable bank. The width of the SMZ extends beyond the 50-foot suggested minimum to include riparian areas along the stream bottom, and to provide additional protection in areas of steep slopes or erodible soils. Consult with forestry professionals, soil and water conservation specialists or biologists if you need assistance in setting appropriate SMZ boundaries.

Setting SMZ Boundaries:

Clearly mark SMZ boundaries so that equipment operators know exactly where they are located. Use plastic flagging, degradable paint or signs at frequent intervals. A walk-through of the project with the operator may be appropriate before activities commence. Perennial streams are easy to identify; intermittent streams can be more difficult to identify during dry periods. Whether wet or dry, perennial or intermittent, during drought or wet years, streams should be protected with an SMZ. Ephemeral drainages

can be highly erosive and they typically direct water into stream channels. Ensure that mastication treatments do not result in disturbed soils or loss of vegetation that protects vulnerable valley bottoms from soil erosion and sediment transfer.

What is a Riparian Area?

- Riparian areas are sites near banks or natural watercourses, and lakes and ponds where water-loving vegetation may be found. Include these areas within the SMZ.

Harvesting and Other Activities

The SMZ is not a "keep out" zone; however, timber harvesting in the SMZ should be done with special care to protect these valuable areas.

Trees are Important to a Healthy SMZ

- Leave the following adjacent to streams: hardwoods and unmerchantable conifers and shrubs. Leave merchantable trees where there is insufficient vegetation to adequately stabilize stream banks. Streambank trees and shrubs are especially important, as they anchor the bank, shade the stream, and supply cover for fish and habitat for birds and other wildlife. Do not "clearcut" to the stream edge.

Protect SMZs

- Maintain or provide sufficient groundcover to trap sediment.
- Keep skidder, tractor and mastication equipment out of SMZs.

Harvesting in the SMZ

- Use directional felling for harvest operations in the SMZ or wetlands. Avoid felling trees in streams or water bodies.
- Avoid use of heavy equipment in the SMZ to minimize ground disturbance. Use winching or end-lining skidding techniques to remove logs from the SMZ and wetlands when ground-skidding systems are employed. Logs should be fully suspended when skyline skidding across a stream and immediately above streambanks.

- Keep slash out of water bodies by removing limbs and tops well above the stream high-water mark. Whole-tree or tree-length yarding can reduce the need for slash disposal in the SMZ.

Site Preparation near SMZs

- Pay special attention to steep slopes containing material that could roll down-slope and fall into a stream during controlled burning; the same is true when using mastication equipment on steep slopes.
- Protect the SMZ with a slash-free strip along the border.
- Use high stumps along the SMZ border to keep debris from rolling down steep slopes and reaching the stream.
- Retain trees necessary for bank stabilization as a future source of large woody debris to the stream channel, and as habitat for cavity-nesting birds and other snag inhabitants.
- Use low-intensity prescribed burns as appropriate in SMZs when needed to improve invasive species control efforts or to reduce fuel-loading. Slash piles should not be placed or burned within SMZs. Where practical, minimize high-intensity fire within densely vegetated draws by allowing fire to back down into draws, rather than allowing fire to build in intensity as it moves upslope through the draws. This ensures minimal soil exposure, allows rapid regeneration of ground cover, and maintains drainage bottom stability and resistance to high-intensity rain events. If danger of high-intensity fire exists in the SMZ due to a high volume of dead fuels, remove enough trees and potential fuels to reduce the risk. Leave enough dead and live trees to provide adequate habitat for wildlife species that depend on this area.

Mastication Near SMZs

- Avoid turns in the bottom of ephemeral areas to maintain vegetation and soil stability, limit the frequency of crossing drainages and cross at right angles when crossing is necessary.

Conifer Regeneration

- In some soil and drainage types, clearcutting can cause marked increases in the water table, as well as cold-air ponding and grass/shrub competition. All of these factors can inhibit conifer regeneration; leave some mature trees to avoid potential regeneration problems.

Timber Harvesting

Harvest Design

Timber-harvest planning involves more than deciding how to cut trees. The harvest design must consider the long-terms effects of harvesting on increasingly important resources.

Watershed Analysis

Conduct a watershed analysis to determine:

What the effects of this harvest will be when combined with other activities in the same watershed.

Will there be a combined detrimental effect on water yield and sediment?

What are the potential effects of the harvest on water quality/quantity? Snow can be scoured from patchcut or clearcut areas that are greater than five times the height of adjacent remaining trees, reducing the quantity of water stored on the site.

Soil erosion hazard: Some soils are more prone to erosion or slumping. Local conservation districts and other natural resources agencies can provide assistance to identify erosion and slumping hazards if needed.

Rainfall: What is the seasonal pattern and total amount?

Topography: Where are slopes, drainages, streams and other physical features located? Are there critical areas that will require special attention?

Work with neighboring landowners to maximize opportunities while protecting watersheds.

Use the logging system that best fits the topography, soil type and season, while minimizing soil disturbance and accomplishing silvicultural objectives as economically as possible.

Wildlife Habitat Protection

How will the harvest affect wildlife habitat? Eliminating elk habitat, for example, may displace elk in the area.

Landowners and managers must take the following steps for appropriate wildlife management:

1. Inventory wildlife species and their habitats;
2. Establish a management goal;
3. Develop a management plan that includes precise species and habitat management objectives and prescriptions based on sound ecological principles that are necessary to accomplish these objectives;
4. Implement the management plan; and
5. Monitor results and adjust management prescriptions when necessary to better achieve objectives.

Leave adequate snags and den trees to meet wildlife management goals:

- Snags are standing dead or partially dead trees that are at least 6 inches in diameter at breast height (DBH) and 10 feet tall.
  1. Retain a minimum of four excellent to good-quality snags per acre. Den trees outlined below will serve as snag replacements.
  2. Provide six excellent to good-quality snag trees per acre within 300 feet of openings and water.
- Den trees are trees that possess a cavity large enough to serve as a shelter for birds and mammals, or as a den site to give birth and raise young. Den trees generally are 15 inches DBH or larger and have a cavity opening of 4 inches or more in diameter.
  1. Leave a minimum of one 15-inch or larger den tree per acre in all types of cuts.
  2. Retain at least two functional cavity trees per acre within 300 feet of water.
  3. Retain one tree per acre that shows potential for development as a den tree.

The management plan also must address other wildlife habitat needs such as cover and travel corridors. The Colorado Division of Wildlife, US Fish and Wildlife Service and the Natural Resources Conservation Service can assist in developing wildlife habitat management plans.

Plan for a New Forest

Additional plants, as well as trees, can serve as an indication that special precautions must be taken in the harvest area. What kind of forest will be grown after the harvest and how quickly will the site be reforested?

Leave trees for future harvest that are acceptable species and of sufficient vigor to ensure continuous growth and harvesting. Also, protect these remaining trees from damage to enhance their survival and growth.

Characteristics of the harvest site – in particular, terrain – influence the choice of a logging system. On gentle terrain, tractors and skidders, or even horses, are a logical choice.

In Colorado forests, ground-based skidding equipment is common.

Feller-bunchers are mechanical harvesters that move through the forest, harvesting and piling trees in bunches. They can be used in sensitive areas to thin individual trees with minimal damage to remaining trees, water, soils or wildlife habitat.

Skyline and cable harvesting are used on steep slopes where ground-based equipment cannot operate. These machines are capable of reaching a quarter mile, lifting logs off the ground and moving them to a landing where they are hauled away.

Whatever the chosen harvest system, it must protect the long-term resource values of the forest.

- Use an economically feasible yarding system that will minimize road densities.
- Consider erosion potential and possible alternative yarding systems prior to planning tractor-skidding on steep or unstable slopes.

As much as 40 percent or more of any area may be covered with skid trails if they are not planned and marked in advance. While this may be desirable in certain situations (e.g., when attempting to expose mineral soil to improve germination and survival of tree seedlings, or when disturbing aspen root systems to encourage coppice regeneration) it generally is wiser to limit ground disturbance by pre-planning skid trails to minimize potential erosion.

Proper planning will help avoid steep skid trails on slopes greater than 30 percent with highly erodible soils. Always install waterbars on skid trails when needed.

- Design and locate skid trails and skidding operations to minimize soil disturbance. Using designated skid trails is one means of limiting site disturbance and soil compaction.
- Minimize the size and number of landings to accommodate safe, economical operation.
- Avoid placing landings where skidding across drainage bottoms is required. Do not skid up or down drainage bottoms or use them as turn-around areas during fuels mastication activities.
- Locate skid trails to avoid concentrating runoff; provide breaks in grade.
- Limit the grade of constructed skid trails to a maximum of 30 percent on geologically unstable, saturated, highly erodible or easily compacted soils. Use mitigating measures such as waterbars and grass seeding to reduce erosion on skid trails.
- Tractor-skid when compaction, displacement and erosion are minimal.
- Avoid tractor or wheeled skidding on unstable, wet or easily compacted soils, and on slopes that exceed 40 percent unless operations can be conducted without causing excessive erosion.
- Avoid skidding with the blade lowered. Forest soils on steep slopes often are shallow. Scalping the litter layer removes the soil's protective cover and exposes it to erosion. Don't use the blade as a brake or to improve skidder traction on steep slopes.

What happens when the forest litter layer is scraped off?

- Nutrients for the next crop of trees are removed
- Mineral soil is exposed to erosion by rainfall and surface flow
- Soil does not retain moisture as well
- Ability of the soil to grow trees is reduced
- Runoff and sediment transport increase

Other Harvesting Activities

Camps

- Protect surface and sub-surface water resources from nutrients, bacteria and chemicals associated with solid waste and sewage disposal.
- Proper design and location of fire, spike and logging camps, and their attendant sewage and wastewater disposal facilities is critical to avoiding adverse effects.
- Dispose of garbage and other solid waste at a properly designated, operated and permitted landfill.

Drainage Management

- Stabilize or reclaim landings and temporary roads when operations are complete. Logging slash and other natural debris can be scattered, and disturbed areas re-seeded to grass. Ditches, waterbars or outsloping can prevent water accumulation on landings; waterbar skid trails leading down to landings.
- At every landing, skid trail or fire trail, create and maintain a drainage system to control water dispersal and prevent sediment from entering streams.
- Install necessary waterbars on tractor skid trails; appropriate spacing between bars is determined by soil type and trail slope. Timely implementation is crucial.
- Apply seed or construct waterbars on skid trails, landings and fire trails where natural revegetation is inadequate to prevent accelerated erosion before the next growing season. A light ground cover of slash or mulch will impede erosion.

Waterbars divert surface water from bare soil to areas where it will not cause erosion; construct waterbars on roads, landings and skid trails. Waterbars can be constructed with a shovel, but mechanical equipment is most common. Cut the waterbar into solid soil to a depth of at least 8 inches. Shape the berm parallel to the cut at least 12 inches above the skid-trail grade. Construct the cut downward, but at no more than a 45-degree angle so that water runs to the outlet. Make sure the waterbar is open at the lower end so water runs out onto slash, vegetation or rocks. When temporary spur roads are waterbarred, connect the waterbar into “cutslope” to intercept all surface flow.

Recommended Waterbar Spacing Distance for Roads and Skid Trails

Grade of Road or Trail (Percent)	Unstable Soils (High Erosion Hazard)	Stable Soils (Low Erosion Hazard)
2 –	135’	170’
5	100’	140’
10	80’	115’
15	60’	90’
20	45’	60’
25+	30’	40’
		Intervals in feet

When in doubt, reduce the spacing. Soils are non-renewable, and waterbars are inexpensive.

Slash Treatment and Site Preparation – Reforestation

The question “How much soil exposure is enough?” is common when preparing a site for a new forest; as clean as a parking lot is too much. New forests need the nutrients and protection supplied by logging slash. Soil compaction is another problem associated with sweeping the forest clean.

Well-planned site preparation techniques will promote a vigorous start for the new forest. Afterward, the site is either planted or allowed to seed-in naturally. In Colorado, natural regeneration generally provides more than adequate restocking of harvested areas.

- Reduce slash to decrease fire hazard.
- Do not place slash from log processing in the SMZ.
- Use brush blades on equipment when piling slash.
- Scarify the soil only to the extent necessary to meet reforestation objectives. Use site-preparation equipment that produces irregular surfaces. Take precautions to preserve the surface soil horizon.
- Low slash and small brush should be left to slow surface runoff, return soil nutrients and provide shade for seedlings. Work around existing small trees and low brush.
- Carry out brush piling and scarification when soils are frozen or dry enough to minimize compaction and displacement.
- Carry out scarification on steep slopes in a manner that minimizes erosion.

- Remove all logging machinery refuse to a proper disposal site (tires, chains, chokers, cable and miscellaneous discarded parts).
- Limit water quality impacts of prescribed fire: 1) construct waterbars in firelines; 2) do not place slash in drainage channels; and 3) maintain the streamside management zone. Avoid intense fires unless required to meet silvicultural goals.
- Broadcast burning and/or approved selective herbicide applications are preferred means for site preparation, especially on slopes greater than 40 percent. Herbicide and insecticide use requires special training and state licensing of applicators. For additional information, contact the Colorado Department of Agriculture.
- Reestablish protective vegetation by rapidly reforesting harvested areas.

Winter Activities

Winter Harvesting Considerations

Colorado's freezing winter temperatures allow opportunities for low-impact logging. With proper precautions, even work in sensitive areas can be done without negatively affecting water quality. Consider snow-road construction and winter harvesting when logging sites characterized by wet meadows, high-water tables, sensitive riparian conditions or other potentially significant soil erosion and compaction hazards. Winter thaws can occur quickly; don't take chances with soil disturbance and possible erosion. Expect to shut-down temporarily.

- Conduct winter logging operations when the ground is frozen or snow cover is adequate (generally more than one foot) to minimize site disturbance.
- Before logging, mark existing culvert locations. During and after logging, ensure culverts and ditches are functional.
- Prior to felling in wet, unfrozen soil areas, use tractors or skidders to compact the snow for skid-trail locations. Avoid steeper areas where frozen skid trails may be subject to erosion the following spring.
- SMZs can be obscured by heavy snow; avoid confusion by marking boundaries before the first snow.

- Do not leave slash and tops in streams.
- Suspend operations if conditions change rapidly and when erosion hazards increase.
- Waterbar all skid trails prior to spring runoff. If prohibited by frozen ground, install erosion barriers during dry summer months. Temporary erosion-control barriers consisting of slash can be used until waterbars are installed.

Road and Drainage Considerations

- For road systems that have a poor foundation, haul only during frozen periods.
- During cold weather, plow any snow cover off of the roadway to facilitate deep freezing of the road grade prior to hauling. Use compacted snow for road beds in unroaded, wet or sensitive sites. Construct snow roads for single-entry harvests or for temporary roads.
- After snow-road use is done, restore stream crossings to near pre-road conditions to prevent ice dams. Except for crossing, do not use the stream channel for the roadway. Waterbars placed on winter roads just above drainage crossing will divert snowmelt onto vegetative filters, rather than directly into stream courses.
- Lay logs in streams so that water flows through the spaces between and serve as a temporary stream crossing when soils are frozen.
- Suspend operations if conditions change rapidly and when the erosion hazard becomes high.
- Provide breaks in the snow berms when plowing snow for winter timber harvest, prior to spring breakup, to allow road drainage.

Hazardous Substances

- Be aware of and comply with all regulations governing the storage, handling, application (including licensing of applicators) and disposal of hazardous substances. Pesticide use requires special training and state licensing of applicators. For additional information, contact the Colorado Department of Agriculture.
- Properly handle and apply fertilizers to reduce or eliminate adverse effects on water quality.

- Prevent water contamination and risk to humans and aquatic life by properly cleaning and disposing of pesticide containers. (Cleaning and disposal of containers and equipment must follow federal, state and local laws. Records should document how and where containers are disposed.)
- Improper storage and handling of oil products and fuel can be a water-quality hazard. Locate facilities away from riparian areas and clean up spills.
- Machine maintenance in the forest can result in water contamination. Do not allow waste oil and anti-freeze to drain on the soil; instead dispose of used oils, filters and parts responsibly–pack it out.
- Develop a spill contingency plan, including clean up, to manage accidental spills.

Pesticides and Fertilizers

To prevent the entry of hazardous substances into surface waters:

- An adequate vegetative buffer zone is needed to ensure that the chemicals are not sprayed or drained into any surface water, either directly or through water runoff. A buffer area of at least 150 feet is recommended for most applications.
- If aerial application of pesticide is required, check the label for restrictions.
- Develop a spill contingency plan to handle accidental spills and clean up.
- Always follow chemical label instructions for additional guidance on use near water and buffer zones.
- To enhance effectiveness and prevent transport into streams, apply chemicals during appropriate weather conditions (generally calm and dry), and during the optimum time for control of the target pest or weed.

Stream Crossings

Streams can be crossed with culverts, bridges or fords. Culverts are the most common stream-crossing structure. Bridges are best for large streams and areas with floatable debris problems. Bridges also have less effect on fisheries than other methods. Fords are less desirable because

of continued disturbance to the stream bed. Choosing the correct stream-crossing method depends on the following:

- Stream size
- Cost of construction and maintenance
- Amount and years of road use
- Lie of the road approach with respect to the stream
- Soil foundation conditions
- Available equipment and materials
- Applicable permit requirements

The improper stream-crossing method or sizing can result in major damage to both the immediate site and downstream water uses. Well-designed approaches will allow even heavy equipment to use stream crossings with only limited sedimentation.

Legal Requirements

- In some cases, it is necessary to secure certain permits prior to altering a stream channel. Compliance with Section 404 of the Clean Water Act is required if the activity has the potential to impact any water area considered "waters of the U.S." Consult with your local U.S. Army Corps of Engineers to determine the need for a 404 permit. The consequences for operation without a necessary permit could be significant and may include work stoppage and monetary fines.

Design Considerations

- Design stream crossings for adequate passage of fish, minimum impact on water quality, and to handle peak runoff and flood waters.
- Cross streams at right angles to the main channel, if practical.
- Adequately size culverts for the application. For most applications, use culverts with a minimum diameter of 18 inches for permanent stream crossings and cross drains.
- Adjust the road grade to reduce the concentration of water carried by drainage ditches to stream crossings.
- Direct drainage flows through an SMZ and away from the stream-crossing site.

- Avoid unimproved stream crossings. When a culvert or bridge is not feasible, place drive-throughs on a stable, rocky portion of the stream channel.

When a stream cuts off short-term access to forest land, portable bridges may be a solution. These bridges offer convenience at a relatively low cost. Timber harvesting and other forest activities can be implemented over a short period of time, and the crossing can easily be restored to its original condition.

Installation of Stream Crossings

Construction of stream crossings has the greatest potential to cause immediate sediment pollution. Complete the work as fast as possible during a time of year when the least damage can occur.

- Minimize stream-channel disturbances and related sediment problems during construction of road and installation of stream-crossing structures.
- Time construction activities to protect fisheries and water quality. Complete the work as fast as possible during a time of year when the least damage will occur.
- Do not place erodible material into stream channels. Remove stockpiled material from high water zones.
- Locate temporary construction bypass roads where the stream course will receive minimal disturbance.
- When using culverts to cross small streams, install them to conform to the natural stream bed and slope on all streams that support fish.
- Place culverts slightly below normal stream grade to avoid culvert outfall barriers. Do not alter stream channels upstream from culverts unless it is necessary to protect fill or to prevent culvert blockage.
- Install culverts to prevent erosion of fill. Compact the fill material to prevent seepage and failure. Armor the inlet and/or outlet with rock or other suitable material where needed. The culvert foundation and trench walls must be free of logs, stumps, limbs or rocks that could damage the pipe.
- Consider dewatering stream-crossing sites during culvert installation.

- To prevent crushing from traffic, use 1 foot minimum cover for culverts 18 to 36 inches in diameter and a cover of 1/3-inch diameter for larger culverts.

Wildfire

Firelines and Roads

Stabilize all areas that have significantly increased erosion potential or drainage patterns altered by suppression activities.

Treatments for damage include, but are not limited to:

- Installing waterbars and other drainage diversions in fire roads, fire lines and other clear areas.
- Seeding, planting and fertilizing to provide vegetative cover.
- Spreading slash or mulch to protect bare soil.
- Repairing damaged road-drainage facilities.
- Clearing stream channels of debris deposited by excessively burned soils.
- Scarifying areas where necessary to encourage percolation on excessively burned soils.

Fire Camps

- Protect surface and sub-surface water resources from nutrients, bacteria and chemicals associated with solid waste and sewage disposal.
- Properly design and locate fire, spike and logging camps, and their attendant sewage and wastewater disposal facilities to avoid adverse effects.
- Dispose of garbage and other solid waste at a properly designated, operated and permitted landfill.

Reclamation

Minimize soil and site productivity loss, threats to life and property, and deterioration of water quality both on and off site by:

- Seeding grasses or other vegetation to provide a protective cover as soon as possible.
- Fertilizing.
- Fencing to protect new vegetation.
- Clearing debris from stream channels.
- Constructing channel-stabilization structures and debris-retention structures.

Conclusion

It is critical that we safeguard the future of our water resources. With the cooperation of all forest users and adherence to the guidelines described in this publication, we can protect the quality of water that flows from Colorado's forested lands.

Best management practices will improve as knowledge of our forests increases over time. Forest managers and timber industry professionals are continually developing new techniques and equipment to meet various needs.

Thank you for doing your best to put BMPs to work in Colorado's forests.

For information about ordering this publication contact:

Colorado State Forest Service
Colorado State University
Fort Collins, CO 80523-5060
(970) 491-6303

or your local Colorado State Forest Service office
listed in the phone book

Photo by Ingrid Aguayo