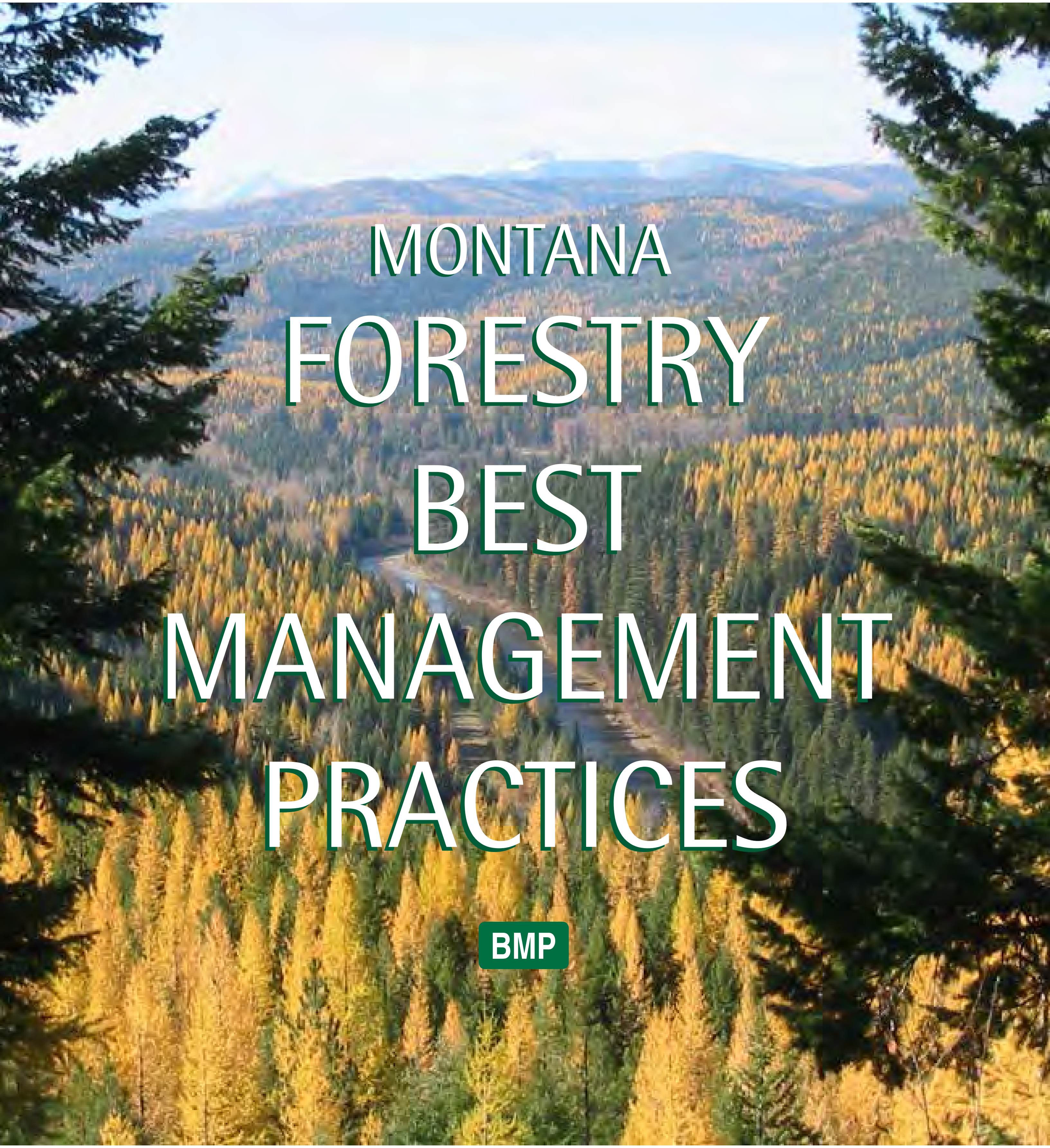
PROTECTING WATER QUALITY AND WATERSHEDS

MONTANA FORESTRY BEST MANAGEMENT PRACTICES

BMP



The Managed Forest of the Fisher River Basin, NW Montana

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Montana's forest lands supply beauty, water, wildlife, minerals, recreation, forage, timber, and jobs. This book is dedicated to the stewardship of those qualities – especially pure water. Humans have long understood that abundant, clean water is one of the forest's most important gifts. Described here are Best Management Practices (BMPs) that protect water quality and forest soils during timber harvest activities. Timber harvest is defined as the removal of any wood fiber from the forest for commercial purposes, and includes saw timber, pulp, and biomass materials such as slash, tops, branches, needles, and leaves.

BMPs are voluntary preferred ways to manage forest land that go beyond legally mandated Streamside Management Zone (SMZ) rules. BMPs have proven to be highly effective. Field audits by Montana DNRC over 20 years indicate greater than 90% effectiveness. BMPs are intended for all forest lands, including non-industrial private, forest industry, state-owned, and federal forests.

If you own forest land, work in the forest or are interested in forests, this publication is for you. It contains BMP guidelines and explains reasons for using BMPs, not just rules. However, reading these pages is not enough. Maintaining our forests' productivity and benefits can only be achieved by the on-the-ground application of BMPs and maintaining a current knowledge of forestry best practices.

How you apply BMPs in the forest will require practice and personal judgement. Two notations used in this book are intended to help:

The "do not" symbol indicates practices you should avoid.

BMP This symbol indicates BMPs, or portions thereof, written by the BMP Technical Committee and adopted by the State of Montana.

Montana Best Management Practices What Do They Mean To Me?

If you manage a forest, woodlot, or just the trees along your creek, this booklet will provide guidance on the do's and don'ts of modern forest management practices. There are several issues to consider once you decide to cut trees as part of your management plan. Take the time to familiarize yourself with forest management concepts, perhaps by taking a forest stewardship workshop (offered by MSU Extension Forestry), or attending a BMP/SMZ Workshop, (offered by the Montana Logging Association).

Montana DNRC Service Foresters can provide technical advice and assist with your management plan, or a professional forester or logging professional can discuss what the work will look like on-the-ground before the actual cutting begins. There are plenty of great resources available when considering forest management and timber harvest on your property. Visit the Montana DNRC website or your local service forester for information.

A little history... Montana's BMPs were developed as part of the state's response to the Federal Clean Water Act. After significant public input, the Legislature decided against a formal Forest Practices Act (Law) and instead opted for a voluntary approach on most forest lands. The BMPs have been refined over time to develop more effective approaches to protect water and soil resources and respond to public concerns. Montana's Forestry BMP Working Group oversees the BMP effort and makes changes as appropriate. In 1991, the Montana Legislature authorized the Streamside Management Zone Law which requires specific management practices when conducting a commercial harvest around streams, lakes, and other bodies of water. Rules have been written to compliment the law and are updated as necessary.

What is a BMP? A BMP is a voluntary guideline that defines the best methodology for a particular forest practice (operation) in the woods. In this case, "Best" means minimal to zero negative impacts and even improved condition of the natural resources if the practice is properly planned and applied.

Proper timber harvest techniques, combined with the BMPs, result in a healthy forest that supports fish, wildlife, clean water and healthy ecosystem processes. This goal is shared by Montana landowners, the forest industry, recreationists, and all those who recognize the value of sustainable, healthy forests. The "Clean and Healthy Environment" guaranteed by our state's constitution is vital to the Montana lifestyle. Best Management Practices help Montanans realize and maintain that goal.

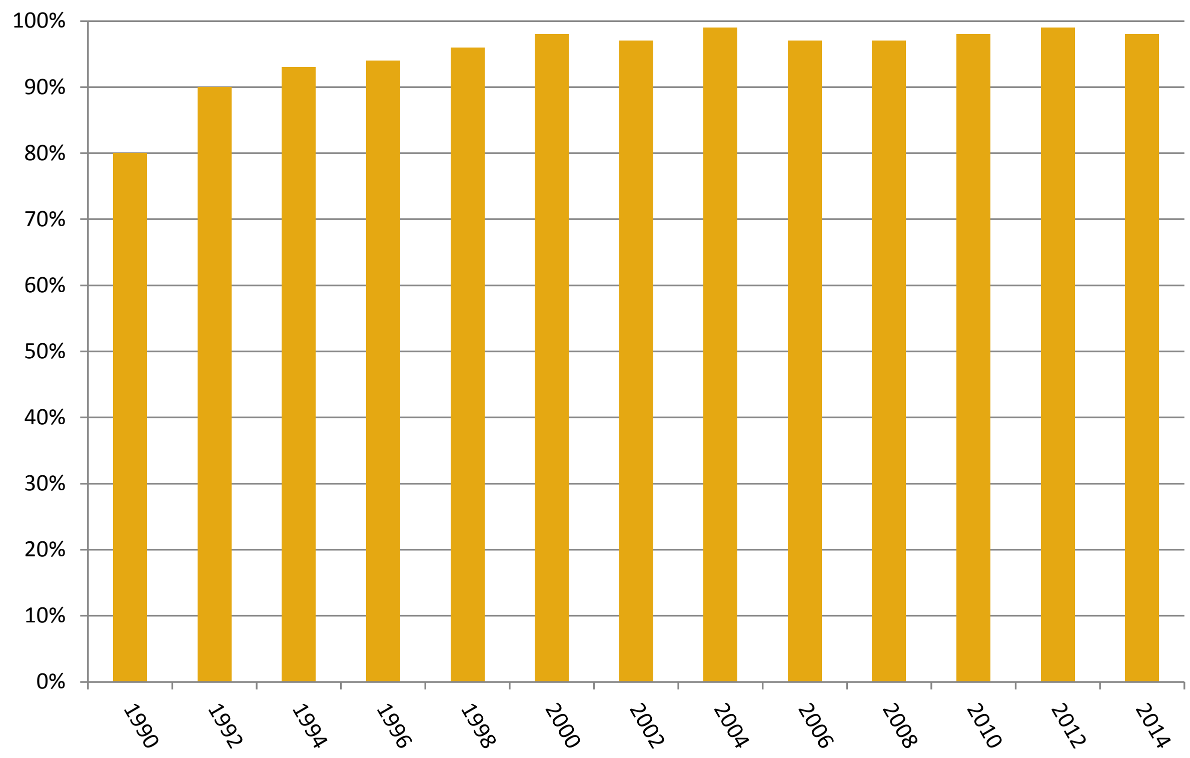
It has been more than 25 years since the implementation of Montana's BMP Program. How are we doing? Take a look around you. There are countless examples of forest management activities conducted responsibly, on all ownerships, leaving the land in as good – or better – condition than before. Montana's forests continue to provide high quality wildlife habitat, clean air, clean water, diverse recreational opportunities, and solitude for residents and visitors alike. Appropriate timber harvesting can compliment or even improve these amenities and Montana's forest products industry has provided the resources and jobs to support thousands of Montana families over the years.

Implementation of Montana's Best Management Practices ensures continued responsible stewardship of Montana forests. We measure the success of BMP implementation every two years. This oversight is mandated by state lawmakers; DNRC conducts field reviews (audits) on approximately 45 timber sales - large and small - throughout the state every other year. The sales are on federal, state, private, and industrial private forest lands and are chosen at random from sites that meet certain basic minimum harvesting criteria. Federal and State Agencies, as well as private forest managers, and the timber industry, invest in the BMP field review process and believe in the benefits of the program. The public is invited to participate in the reviews. To do so, contact the DNRC Forest Practices Specialist. Annual BMP Workshops are open to anyone and especially to anyone involved in logging operations working toward accreditation as an environmentally responsible operator. BMP reports are available to the public and feedback is welcome.

The chart below shows how well the program is working. It shows the effectiveness rates of Montana's BMPs, and the great improvements since the start of the BMP Program. It is important to all parties that the high standards have been maintained. The record of striving to do what is right is great for Montana's environment and for its timber industry as well. Please take the time to learn more about Best Management Practices by reading this booklet and help us keep the good work going. Thank you.

Effectiveness Rates of Montana's BMPs

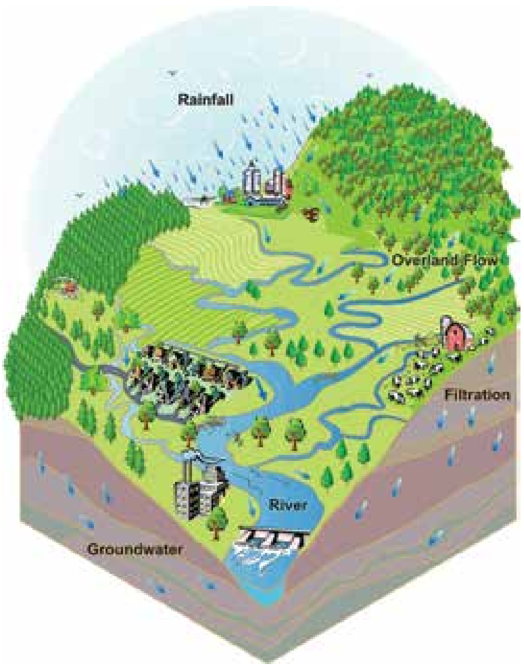
Percentage of Practices Providing Adequate Protection - 1990 to 2014



A WATERSHED AND ITS PARTS

What is a Watershed?

A watershed is an area of sloping land surrounded by ridges and drained by a watercourse. Watersheds collect rainfall and snowmelt and deliver it to a single outlet. They range in size from a few acres to thousands of square miles.



What are the Parts of a Watershed?

A watershed is a network of surface streams, underground water flows and other water bodies.

Surface streams that flow year-around are called **perennial streams**. Some streams are **intermittent**, often dry except for spring and early summer flows.

Ephemeral draws can flow water for short periods following rainstorms or snowmelt. They rarely carry large amounts of flow and generally do not have a defined stream channel. Some streams have interrupted flow and disappear underground only to reappear downstream.

Sediment from logging or road building can be carried by ephemeral, intermittent, and perennial stream channels to the watershed outlet.

PERENNIAL STREAM
Water flows year-round. These streams are essential for Montana fisheries.

INTERMITTENT STREAM
Whether wet or dry, intermittent streams have gravel bottoms and/ or identifiable banks. They connect ephemeral areas with perennial streams.

EPHEMERAL DRAW
Disturbed soils can be carried downhill during heavy rainfall or snowmelt by ephemeral draws. This ephemeral draw is in good condition after harvest.

RIPARIAN/ WETLANDS
Springs, vernal pools, marshes, and bogs all contribute to the watershed collection system and require protection.

Bull Trout

Other parts of the watershed collection system include:

- Surface and subsurface water source areas.

  Their location is not always obvious, but understanding their function is important (pages 4-5).

- Riparian and wetland areas.

These are special areas often located along streams, lakes and rivers. They include seeps, springs, vernal pools, marshes, and bogs.

Riparian and wetland areas need special protection because of the multiple ecological services they provide. In Montana this protection ranges from voluntary BMPs to the regulatory SMZ Law. These protections are usually in the form of modified practices when forest activities occur in or around these types of areas. Even during dry seasons of the year, riparian and wetland areas can be identified by the presence of certain plants (page 9).

Why are Forested Watersheds Important?

- They are the primary source of clean water - collecting, storing, and filtering rain and snowmelt.
- They recharge groundwater aquifers.
- They deliver clean water with a minimum of sediment to towns and cities as well as agricultural and range lands.
- They provide habitat for fish and wildlife.
- They connect uplands and headwaters with riparian and wetland areas.
- They provide clear, clean water to streams and lakes for everyone's recreation enjoyment.

A Watershed And Its Parts

What Can Go Wrong in a Watershed?

Road building, timber harvesting, and fuels treatment can affect the quality and quantity of water flowing through a watershed by creating sediment, changing water temperature, or adding nutrients.

BMP Minimize the number of roads constructed in a watershed through comprehensive road planning, recognizing intermingled ownership, and foreseeable future uses.

Improperly planned, located, or constructed logging roads and skid trails can become conduits to move sediment to streams. If BMPs are not followed, harmful erosion and sedimentation can occur. With proper planning and BMP implementation, site productivity and water quality will be maintained, and often can be improved.

Installing a road network in a watershed may affect stream hydrology in several ways. Compacted road surfaces generate overland flow. Ditches and relief culverts collect runoff and change natural water flow pathways. Road location and cut slopes may interrupt or divert water source areas. Road BMPs are designed to slow water flow with the objective of re-infiltrating water on hillslopes and minimizing hydrologic impacts.

Damage to roads and streams can result from poor crossings and lead not only to washed out roads but to heavy stream sediment loads and damage to streams and fisheries.

Ephemeral areas used as skid roads can become man-made streams.

Ignoring BMPs can result in damaged streams, unhappy downstream neighbors, impassible roads, and fines.

HOW WATER GETS TO A FOREST STREAM

In non-forested watersheds it is not uncommon to see water flowing across the soil surface during storms. But surface water flow rarely happens in undisturbed forested watersheds.

Why?

There is a layer of organic litter or duff on the surface and fine roots near the surface of forested watersheds. These factors encourage infiltration of water into the soil rather than as erosion-causing overland (surface) flow. Even during intense storms, overland flow is rare across forest soils.

Science has taught us that certain areas in a watershed contribute surface water flow to streams. These are called “water source areas” and are found at the toe of hillslopes. They change in size as soil moisture builds depending on rainstorm or snowmelt intensity and duration. During low intensity storms, that portion of the watershed near the stream channel may be the only area that contributes surface runoff. Areas further away from the stream make no surface contribution, but do contribute subsurface water that moves down slope relatively slowly. As rainstorms and snowmelt increases, the size of water source areas, both surface and subsurface, expands.

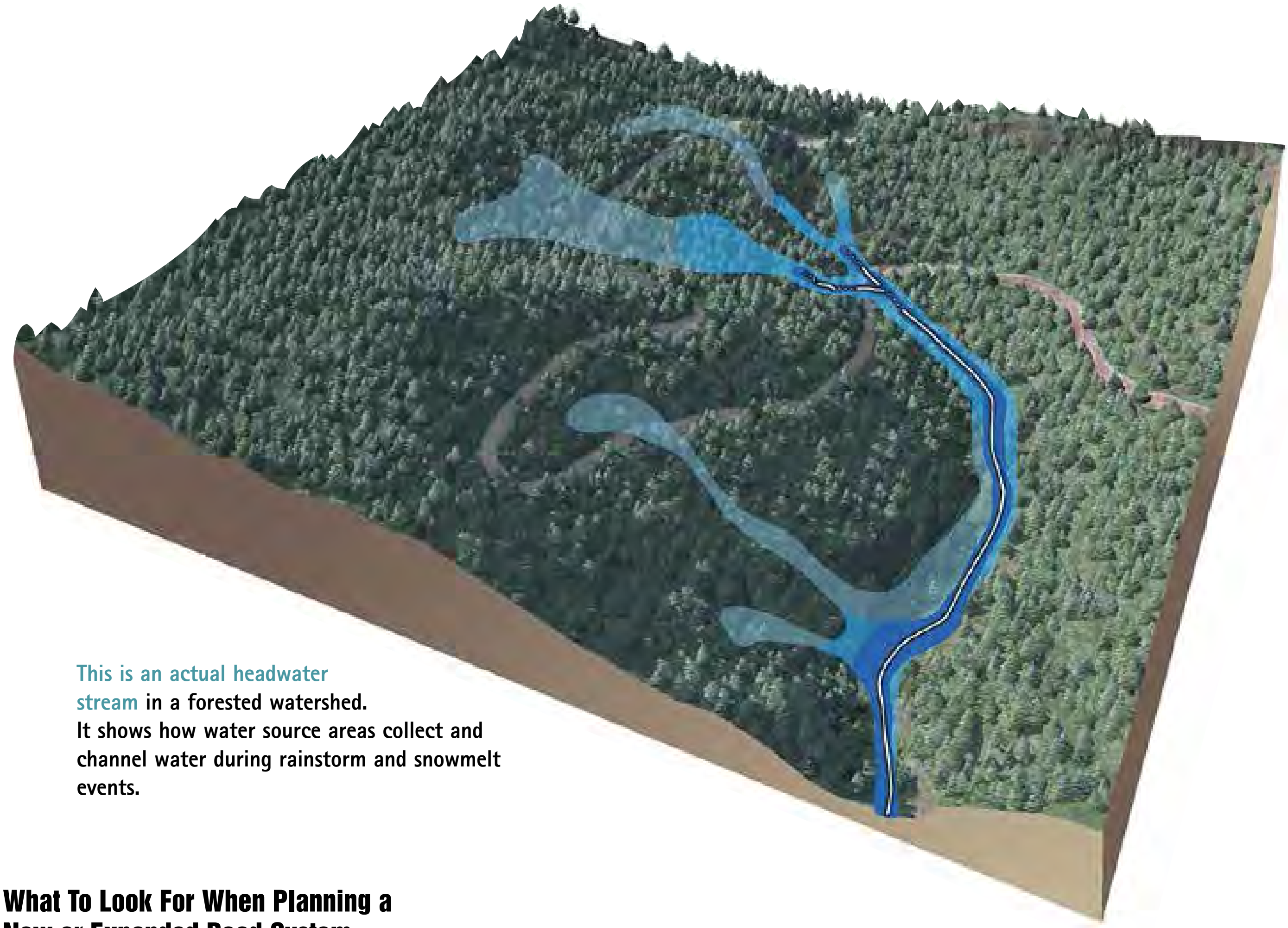
What This Means for Forestry Activities

Knowing about surface and subsurface water source areas around streams and headwaters makes the following BMPs easier to understand and it lets you plan harvest operations more appropriately.

BMP Avoid wet areas including moisture-laden or unstable toe slopes, seeps, wetlands, wet meadows, and natural drainage channels.

BMP Design roads to minimize disruption of natural drainage patterns.

Water Source Areas



This is an actual headwater stream in a forested watershed. It shows how water source areas collect and channel water during rainstorm and snowmelt events.

What To Look For When Planning a New or Expanded Road System

Recognizing water source areas is not always easy. Topographic maps and landforms can help. The identification of certain plants can be an additional clue. Taking a little extra time planning can make the process easier on the land and provide a more effective and cost-efficient road system.

1. The immediate area adjacent to the stream and the headwater areas of stream channels (in dark blue) can remain moist. These water source areas contribute surface water to the stream.

2. During heavier storms and periods of snowmelt, water source areas become larger (in medium blue). These bulb-shaped water source areas expand and contract with storm intensity, quantity or timing of snowmelt. Their surface water flow permeates underground or just beneath the layer of forest litter and duff and may not be obvious to the casual observer.

3. The subsurface water source areas (shown in light blue), carry water that has infiltrated into the soil. This water moves slowly, just below the surface, to the channel and feeds the stream between storms and periods of snowmelt. Forest roads, like the one shown crossing the water source areas, can show evidence of contact with water (cut slope seepage; ditch water) at various times of the year. Be sure that road design and drainage structures allow for adequate surface and subsurface water drainage.

Caution

Poorly designed and located roads can have lasting impacts on watershed hydrology. Of particular concern are roads and road ditches that route sediment and water directly to streams. These "connected" ditches can direct water to streams faster than normal or undisturbed conditions, impacting both the timing and magnitude of watershed runoff. These problems can be addressed with proper road drainage BMPs that direct runoff into vegetation filters, or by providing more frequent ditch relief. Making sure road runoff is "disconnected" from streams is a primary goal of the forestry BMPs.

R/W areas are common along streams and rivers but are also found around "other bodies of water," see page 8.

WHAT ARE RIPARIAN AND WETLAND AREAS?

Riparian and Wetland (R/W) areas have seasonally moist, sometimes wet soils, and high water tables where water-loving plants such as alder, spruce, willow, and cottonwood grow. Shrubs, grasses, and herbaceous plants like red-osier dogwood, sedges, and devils club can grow in thick hard-to-get-through patches or they can be scattered and sparse, but present depending on soil water content.

Where are they?

R/Ws occur along the shoreline of streams, lakes or ponds, and around springs, marshes, bogs, and seeps. Some take the shape of narrow bands hugging the edge of a stream. Others may stretch hundreds of feet beyond the water's edge, reaching out across broad floodplains Still others may be located in forested uplands, and are called "isolated" R/W areas (pages 12-13). Local geology plays a big role in where wetlands occur.

Forest Disturbance Ecology and Ecosystem Adjustment

Different forest habitats have evolved under differing types and frequencies of natural disturbance. In Montana forest disturbance types include: fire, drought, insect infestation, disease, wind, extreme cold, extreme heat, landslides, and floods. Climate change has increased the probability that both the severity and frequency of disturbance events will increase.

One approach to address anticipated changes and increase the potential for positive response and better resiliency is reestablishing forest stand mosaics typical across Montana landscapes before fire suppression and a relatively wet 20th Century allowed tree densities to increase. Mechanical treatment and prescribed fire are important tools that can be used to reduce unnaturally high tree densities and the risk of severe, uncontrolled wildfires. Reducing tree densities will result in greater soil moisture resources which will make forest stands more resilient to drought, insect infestation, and disease.

The Laird Creek Watershed, a tributary to the Bitterroot River in southwestern Montana, provides an example of the time frame needed for recovery of a small tributary stream following severe wildfire. In 2000, over 90% of the watershed burned at what was determined by the Post Fire Burned Area Emergency Response Team as having burn conditions that caused either moderate or severe effects to the soil.

Post fire view of Laird Creek in June 2001, ten months following the Bitterroot fires of 2000. The steep hillslope to the left of the stream had been hydro-seeded to reduce the risk of erosion.

The view June 2010, ten years after the fire. Rapidly growing riparian vegetation and the fire-killed trees that have fallen into the stream provide both improved fish habitat and improved channel stability.

Are Riparian and Wetland Areas the Same?

Technically, no.

Wetlands also include riparian areas, floodplains, lowlands, and shallow lakes and ponds. So, riparian areas are one type of wetland.

Many wetlands have the following characteristics:

1. Standing water, long enough each year to create oxygen-deficient soil. These oxygen-deficient soils are a permanent part of the wetland's soil profile.
2. Plants that require or tolerate oxygen-deficient soils grow during some part of the growing season.
3. Spongy, heavily organic soils are often located in topographic depressions.

Some riparian areas are found near running water such as rivers, streams, and drainages with recognizable channels and floodplains. Other riparian areas may be the fringe of land around ponds, lakes, and other water bodies. Riparian areas often act as the link between water environments and uplands.

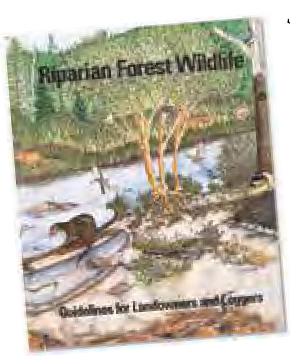
What makes Riparian and Wetland Areas Unique?

The mix of water, plant cover, and food found within a R/W area is different compared to the rest of the watershed.

For some animals, the presence of water makes R/W areas their preferred or sole habitat. Most amphibians live on land and return to water to breed, spending much of their lives in R/W areas. Open water and a high water table combine to produce higher humidity, more shade, and unique air movement resulting in a different habitat type.

Frequently, R/W areas support a greater number of individuals, as well as a greater number of species, when compared to other parts of the watershed.

For more information about R/W areas, look for the handouts: *Riparian Forest Wildlife* or *Voluntary Wildlife Guidelines for Streamside Management Zones*. Another option is to call MSU Extension Forestry at (406) 243-2773 and enroll in a class.



Riparian Forest Wildlife Guidelines for Landowners and Loggers

Why are Riparian and Wetland Areas Important?

R/W plants and soils serve as a filter, trapping pollutants and keeping them from entering streams, lakes, and other water bodies.

R/W organic litter and soil act like a sponge, collecting and holding water, reducing downstream floods, allowing water to gradually leak out, and replenishing streams and lakes.

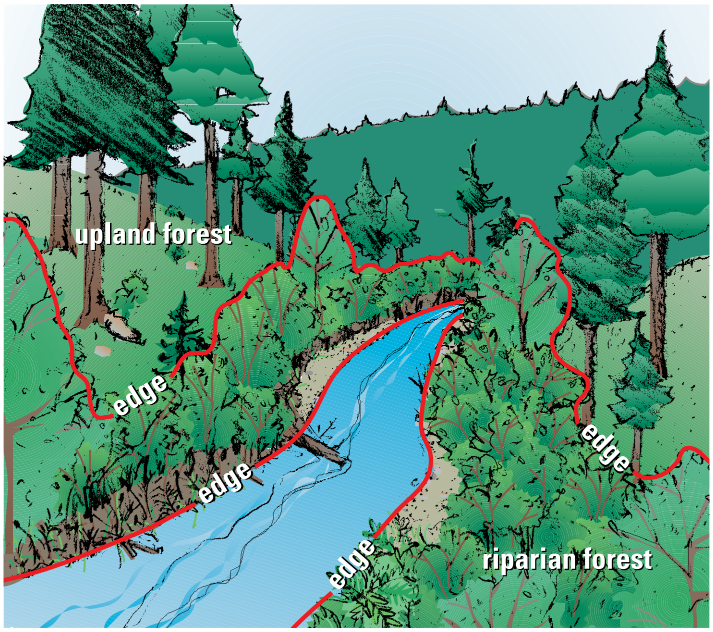
Many wildlife species rely on R/Ws for the necessities of life – food, water, protection from enemies, and a place to rear young.

R/Ws are popular areas for recreation, hunting, fishing, and camping.

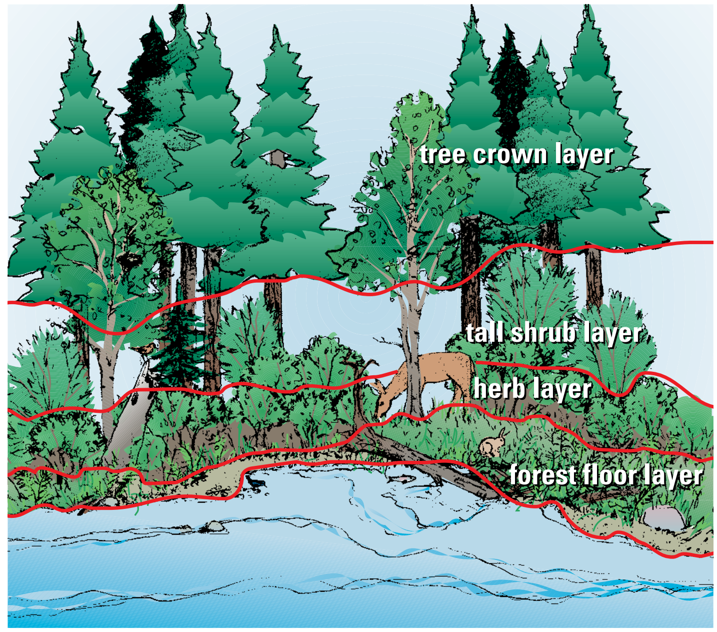
EDGES AND LAYERS IN RIPARIAN/WETLAND AREAS

An "edge" is where two different plant groups come together. In R/W areas there are two obvious edges. One occurs where R/W plants meet aquatic plants at the water's edge. The other is where R/W forest plants end and upland forest plants begin.

Edges give animals simultaneous access to more than one environment. They offer greater variety of plant cover and more abundant food sources. Deer, elk, and other wildlife often utilize edge habitat which provides both forage and hiding cover.



Two edges in stream R/W areas.



The multi-layered, vertical and horizontal plant canopy offers a variety of nesting, resting, feeding, and wildlife reproduction areas. The tree canopy layer shades the water, keeping it cold -important to cold water species like cutthroat trout. The canopy is also the source for large, organic, submerged debris for fish habitat cover.

An "Other Body of Water": A pond or pothole where poor drainage creates peat deposits, acidic water, and floating aquatic plants such as pond lilies. Their water comes from precipitation and has standing water most of the year.

Other Bodies of Water

The SMZ law protects areas called **"Other Bodies of Water" (OBW)**. These are ponds and reservoirs greater than 1/10 acre in size that do not support fish and generally are not connected to a stream. OBWs may dry up rarely or briefly. Log skidding or road building through such areas is prohibited.

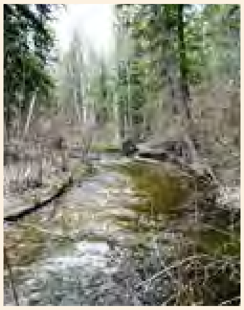
Differences between R/W areas and a SMZ

- R/W areas often have boundaries that are not discrete like SMZs.
- SMZs are legally mandated distinct minimum boundaries.
- SMZ boundaries are extended to protect R/W areas "adjacent" or connected to the SMZ of a stream.

EXAMPLES OF FORESTED RIPARIAN AND WETLAND AREAS

Specific plants can help locate and indicate the extent of a R/W area. Shown here are three common forested R/W areas identified by tree name and at least one understory plant. In each case, specific understory plants must be present. Remember, a R/W area does not always have standing water or wet soils, but can still be identified by its plants.

Skunk Cabbage



Engelmann Spruce with a Skunk Cabbage understory

This is an imperiled plant community. In this R/W forest, other tree species present include: grand fir, Douglas-fir, western red cedar, and water birch. Visit Montana Natural Heritage Program for more information: www.mtnhp.org.

Spruce with Field Horsetail and/or Blue-joint Reed grass understory

In this R/W forest, other tree species often found include: subalpine fir and lodgepole pine on drier, elevated soil mounds.

Blue-joint reed grass, commonly grows three feet tall and has flat dull bluish-green leaves that are rough to touch. Its purplish-red seed head droops with age. Seed heads are not always present when the plant grows in shade.

Field Horsetail has a green sterile form which grows after the tan-to-white fertile stems die off.

Douglas-fir with red-osier dogwood understory. Other trees include black cottonwood and quaking aspen.

Spruce, Douglas fir, or Ponderosa pine with a Red-osier Dogwood understory

In this R/W forest, other tree species present include: western larch, lodgepole pine, cottonwood, and quaking aspen.

Other understory plants include mountain alder.

The red stem of red-osier dogwood is very distinctive and shows up well in summer and against winter snow. Recognizing this plant can be a big help in locating R/W areas during winter. Woods rose and common chokecherry can be found with red-osier dogwood.

HOW SEDIMENT ACCUMULATES IN A WATERSHED

What is Sediment?

Erosion is the process of moving soil particles by the action of wind, water, gravity, or human activity. Eroded soil that enters a stream is called sediment. It can be suspended in the water or deposited as bed load on the channel bottom. It is generally granular in appearance.

Sediment Origins and Effects

Sedimentation, in general, is the transport and deposition of soil particles to a new location. It originates from mud slides, flooding, rain, and weathering erosion. Water quality and stream health problems can occur when sediment is transported into streams.

Chronic sediment is usually from a continuous source such as a road, landslide, or highly erosive soil with limited protective vegetative cover. Episodic sediment can be caused by heavy rainfall hitting disturbed or bare soils and generally has only short term effects. Chronic sediment sources are considered the most damaging to fish and other aquatic life. The risk of management-caused sedimentation is greatly decreased when proper BMPs are applied. Where existing problems are present before BMP implementation, BMPs may serve to reduce the risk of erosion and sedimentation and improve the overall site condition when operations are finished.

What can happen?

Each of the soil erosion problems shown here creates sediment that can move into the network of streams in a watershed. All of these source combined, natural and man-made, can have significant negative cumulative impacts on a drainage system.

Landowners and Loggers can help to Minimize Cumulative Effects

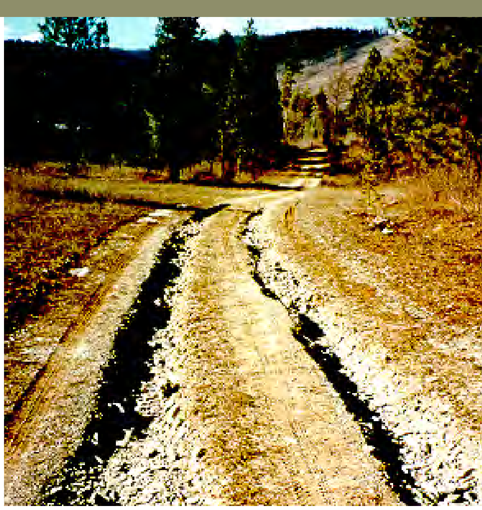
Ensuring clean water and stable soils in a watershed is the result of proper BMP implementation by landowners and loggers when they construct roads, build stream crossings, harvest timber, and prepare those locations for new forests. Every effort to reduce sediment will lower the cumulative effect of sediment on water quality.

Naturally Caused Sediment

The force of rain splashing **on bare soil can loosen and detach soil particles that can become sediment.**

Landslides **move tons of sediment and debris into rivers and streams.**

Man-made Sources of Sediment



Water runoff **formed these long narrow chutes or rills, running down-slope on the surface of this road. It is a source of sediment.**

This ditch flowing directly into a stream **has resulted in sediment delivery. An additional drain culvert or rolling dip should be installed.**

This plugged cross-drain culvert **and washed-out catch basin can be a source of sediment.**

A preventative maintenance program **for a road system will minimize or solve many of the problems before they start.**

THE FOUR C'S OF FISH HABITAT

Montana trout - particularly native strains of cutthroat and bull trout - have very specific habitat requirements, which can be called the "Four C's." These stand for Cold and Clean water and Complex and Connected habitats. Montana's Forestry BMPs and SMZ Law ensure these habitat requirements are met.

Cold

Trout are cold-water species. Ideally, maximum summer water temperatures are below 60-65 degrees Fahrenheit. Water temperature can be controlled by maintaining shade over streams, and by protecting streambanks from damage during timber harvesting. Both of these riparian functions (shading and bank protection) are provided through requirements of SMZs under Montana law.

Clean

Fish do better in cleaner streams – with relatively small amounts of fine sediment (sand and silt sized particles). Clean spawning gravels allow incubating fish eggs to be well oxygenated and allow hatched fish to emerge from gravels. Clean streams also have space for small fish to wiggle between larger cobbles to escape extreme temperatures and predators. BMPs that prevent erosion and sediment delivery to streams, particularly at stream crossings, help maintain clean streams.

Complex

Streams that are complex exhibit a variety of habitat characteristics, such as deep pools, undercut streambanks, and large wood. These streams are often very difficult to walk up because of the number of obstacles. This habitat diversity makes for good rearing habitat for juvenile fish, deep pools for fish to overwinter when streams are ice-covered, and provides hiding spaces from predators.

Connected

Many fish have migratory life forms. That is, young fish reside in the small streams where they were born for a few years, but then migrate downstream to a larger river or lake to grow to maturity. Adult fish return to the small stream where they were born to spawn. Fish may also need to move up- and down-stream to seek cooler water during the summer or warmer water in winter. As such, it is essential that these upstream and downstream habitats are connected. Connectivity can be maintained through the proper design and installation of stream crossings on forest roads and by avoiding excessive sediment accumulation in streams.

Westslope Cutthroat Trout

Sac fry **growing in oxygen-enriched water, hiding from predators among rocks and boulders on the bottom of a stream.**

STREAMSIDE MANAGEMENT ZONE DEFINITIONS

BMP The Streamside Management Law provides minimum regulatory standards for forest practices in streamside management zones (SMZs). ***Montana Guide to the Streamside Management Zone Law & Rules*** 2006 describes management opportunities and limitations within SMZs.

The Streamside Management Zone or "SMZ," means the stream, lake, or other body of water and an adjacent area of varying width where management practices that might affect wildlife habitat or water quality, fish, or other aquatic resources need to be modified. The SMZ is a strip of ground at least 50 feet wide on each side of a stream, lake or other body of water, measured from the ordinary high-water mark, and extending from the high-water mark to include wetlands and areas that require additional protection in zones with steep slopes or erosive soils.

"Stream" is defined as a natural water course of perceptible extent that has a generally sandy or rocky bottom or definite banks and that confines and conducts continuously or intermittently flowing water.

"Wetlands" are defined as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands include marshes, swamps, bogs, and similar areas.

"Adjacent wetlands" are defined as wetlands within or adjoining the SMZ boundary. They are regulated under the SMZ law.

"Isolated wetlands" are defined as wetlands that lie within the area of operation (timber harvest), but outside of the SMZ boundary. They are not regulated under the SMZ law but are addressed through voluntary BMPs.

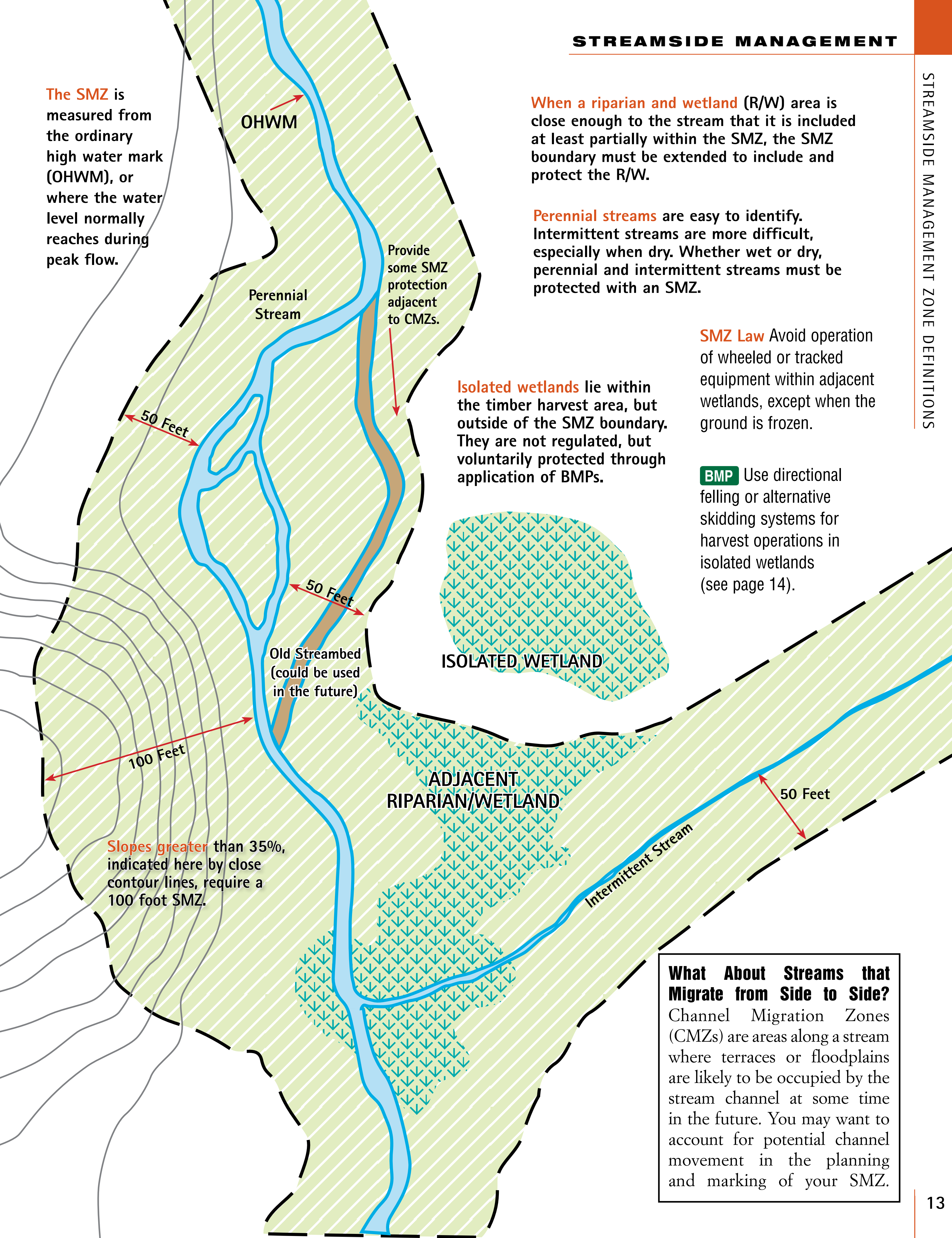
What is a stream?
A stream can be identified in one of two ways. A stream must have a sandy or gravel bottom—the result of flowing water. Or a stream must have definite banks that restrict water. When no definite bank is apparent, watch for evidence of where sand or gravel stops and soil begins at the edge of a stream.

Is this a stream?
No. There is no rocky bottom or identifiable banks. But it is an ephemeral area, part of the watershed collection system, that may carry water during wet periods. Disturbing these soils can create sediment. Whenever possible, avoid these areas with equipment.

Clearly mark the SMZ boundary for equipment operators. Use plastic flagging, paint or signs at frequent intervals. Marking the SMZ is mandatory. Use caution when marking SMZs in winter as snow may obscure side channels or wet areas that also require protection.

Steep slopes, over 35% require a 100 foot wide SMZ. SMZ width is measured from the high water mark to a point 50 or 100 feet (slope distance) perpendicular to the stream

For complete details on SMZ rules see the Montana Guide to the Streamside Management Zone Law & Rules 2006. Call DNRC Forestry Division in Missoula, (406) 542-4300.



The SMZ is measured from the ordinary high water mark (OHWM), or where the water level normally reaches during peak flow.

When a riparian and wetland (R/W) area is close enough to the stream that it is included at least partially within the SMZ, the SMZ boundary must be extended to include and protect the R/W.

Perennial streams are easy to identify. Intermittent streams are more difficult, especially when dry. Whether wet or dry, perennial and intermittent streams must be protected with an SMZ.

Isolated wetlands lie within the timber harvest area, but outside of the SMZ boundary. They are not regulated, but voluntarily protected through application of BMPs.

SMZ Law Avoid operation of wheeled or tracked equipment within adjacent wetlands, except when the ground is frozen.

BMP Use directional felling or alternative skidding systems for harvest operations in isolated wetlands (see page 14).

Slopes greater than 35%, indicated here by close contour lines, require a 100 foot SMZ.

What About Streams that Migrate from Side to Side?
Channel Migration Zones (CMZs) are areas along a stream where terraces or floodplains are likely to be occupied by the stream channel at some time in the future. You may want to account for potential channel movement in the planning and marking of your SMZ.

WHEN HARVESTING IN AND AROUND THE SMZ

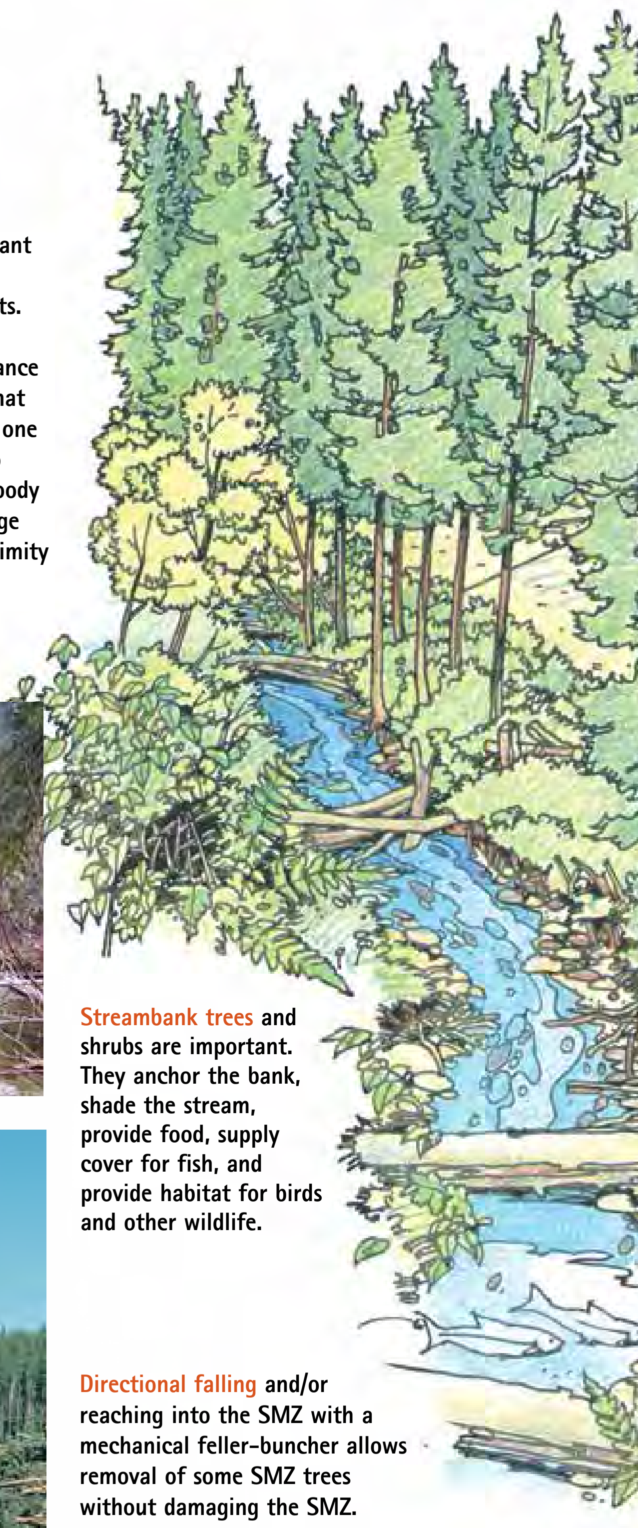
The SMZ is not a "no touch" zone, but due to its values (habitat, shade, filtration, stream stability), timber harvesting in and around an SMZ requires special care including a planned approach.

What are Streamside Management Zone Rules?

The Streamside Management Law provides minimum regulatory standards for implementing forest practices in streamside management zones (SMZs).

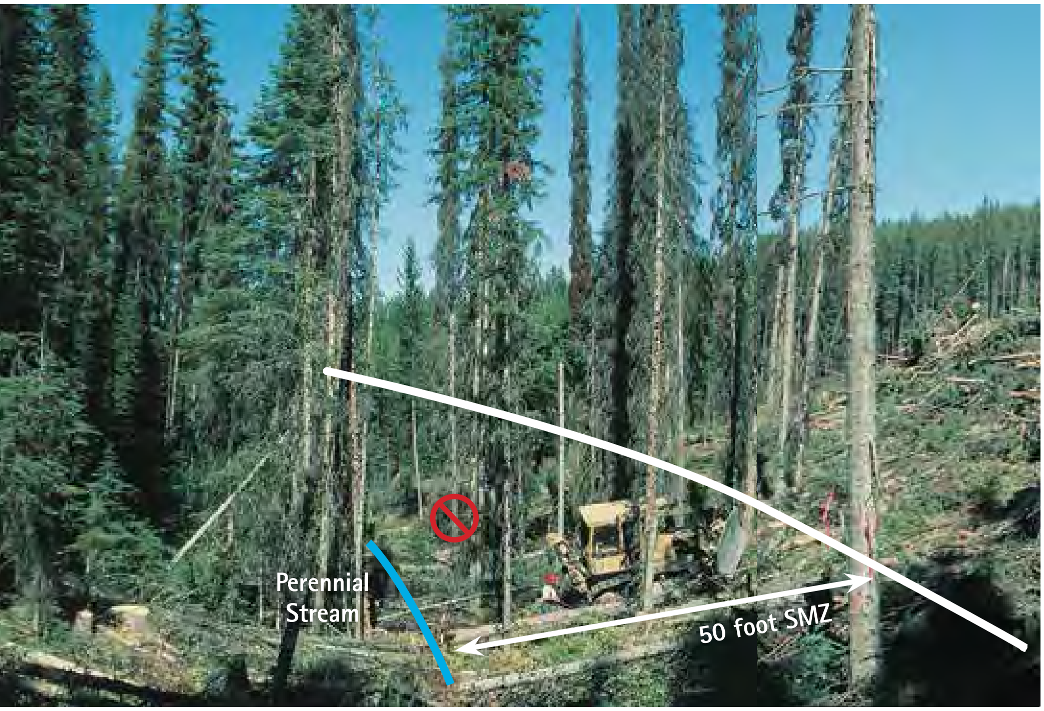
What is the Difference Between BMPs and SMZ Law/Rules?

- Compliance with BMPs is voluntary.
- SMZ law/rules are mandatory.
- SMZ rules pertain specifically to areas adjacent to streams, lakes, wetlands, and other bodies of water.
- BMPs include the entire forest, wherever forest management is happening.



The trees left after harvest are important to a healthy SMZ. See SMZ rules for specifics on retention tree requirements. The probability of a tree falling into a stream depends on its height and distance from the stream. Research indicates that approximately 1/3 of the trees within one tree height of the stream will fall into the stream and that 80% of Large Woody Debris originates within 1/2 the average tree height for trees within close proximity of the stream channel.

Streambank trees and shrubs are important. They anchor the bank, shade the stream, provide food, supply cover for fish, and provide habitat for birds and other wildlife.



Ground vegetation is the filter that keeps sediment from reaching the stream. If torn up during harvesting, it cannot do its job. All ground-based equipment must stay out of SMZs. This tractor is violating the law.

Directional falling and/or reaching into the SMZ with a mechanical feller-buncher allows removal of some SMZ trees without damaging the SMZ.

Logs must be fully suspended when skyline skidding across a stream and streambanks.

Snags and live trees are habitat for many birds and animals. Conks on the trunk of trees indicate internal heart rot. Woodpeckers test snags for heart rot by listening for a certain sound as they peck. Nest holes are common in trees with heart rot. Heart rot trees, especially those with conks, generally no longer contain merchantable wood and may be most valuable as wildlife habitat.

The SMZ Rules require you to keep slash out of streams and other water bodies. Rotting slash uses up oxygen, needed by fish and other aquatic animals. Move harvested tree limbs and tops to locations well above the stream high-water mark.

Trees leaning toward the stream are important. Large diameter, fallen tree stems with attached root wads are most likely to remain permanent in a stream channel. These woody "anchors" promote the development of persistent pools, control sediment, and create fish habitat.

Actively Managing Streamside Zones and Riparian Areas

Montana's Streamside Management Zones and Riparian Areas are incredibly valuable resources for many reasons: use by various wildlife species; Montana's most productive timber growing sites; the greatest number of plant species per acre; and our most effective areas to protect our water resources by filtering sediment and shading our streams, keeping them cool and clear.

In order for SMZ and R/W areas to continue to provide their valuable benefits to our forested ecosystems long term they require active management in a careful and thoughtful way. Treatments demand long term, comprehensive plans which recognize unforeseen catastrophic damage from windthrow, insects and disease, and wildfire. These areas are not historically prone to frequent wildfire, so prescribed fire and wildfire can have both a positive and negative impact on the health of our SMZ and R/W areas.

Shrubs, forbs, grasses, and aspen trees can be stimulated by fire with an increased release of nitrogen and root suckering which provides for younger, healthier plants. Other common species in these moist environments have evolved with very thin bark and are easily killed by fire. Species such as Engelmann Spruce, Western Red Cedar, Grand Fir, and Alpine Fir would be categorized as not fire resistant. Therefore, a long term plan which prescribes gradual removal of a percentage of these trees each entry and incorporates the regeneration/planting of appropriate tree species would provide long term sustainability of functioning SMZs and Riparian Areas.

Removing a percentage of other tree species can also be beneficial by providing increased sunlight and available nutrients to residual trees, shrubs, forbs, and grasses. Harvest practices within these sensitive areas must be well designed in advance of treatment. Consider such things as the season of the operation, the type of logging system needed, and what slash management options are available when planning harvests within SMZ and riparian areas. The treatments chosen need to meet landowner goals, but they must also comply with the rules that govern forest operations in these sensitive areas. All treatments within the SMZ should be designed to protect sub-merchantable trees and shrubs.

FOREST ROAD TYPES AND STANDARDS

In general, roads are essential to provide access for forest management, but are also the number one source of harvest-related stream sediment. Roads produce roughly 90% of all sediment from forest activities.

With proper location on gentle and moderate slopes with stable topography, proper construction techniques, and maintenance, roads have a minimal potential for contributing sediment to streams.

However, if not well-planned, well-constructed, or maintained, roads located next to streams, on steep slopes, or on unstable topography have a high potential to produce sediment for a long time. Roads on steep slopes cost more to build and maintain and generally have greater risks of detrimental environmental impacts.

Road Design

Forest roads are built to different standards depending on the service they are designed to provide. General categories range from high to medium to low service levels. Standards to consider include traffic load, surfacing, width, grade (steepness), sight distances, and vehicle speed.

Most forest landowners want roads as narrow as possible to reduce the environmental footprint as well as construction and maintenance costs. A 12-foot minimum width road is needed for log truck traffic, and a 14-foot road width may be needed for line logging systems. Roads used as log landings will need wider sections to allow for traffic to pass.

High service level forest roads are those that can accommodate two-lane traffic, usually have a gravel driving surface, and can accommodate longer visibility distances. While beneficial, high service level roads have a larger footprint on the land. Medium and low service level roads are much more common.

BMP Design roads to the minimum standard necessary to accommodate anticipated use and equipment.

High service level roads accommodate two-lane traffic, public use, and usually have a gravel driving surface. They are capable of year-round use and heavy truck traffic.

Single lane, medium service level roads with pull-outs to accommodate two-way traffic, are common in the forest. To reduce the impact of roads always build the narrowest road that will serve the need. A 12-foot-wide running surface is standard for log truck traffic.

Temporary or long-term low service level roads are designed for minimal use but are essential to conduct forest management operations including fire suppression. Low service level roads involve clearing vegetation and minimal earthwork or excavation. They can be built, used, and reclaimed when rainfall and erosion potential is minimal and with minimal expense.

Restoration or Obliteration of temporary roads includes pulling up roadside berms, ripping compacted surfaces, restoring natural drainage, and reseeding with appropriate grasses (see pages 34-35 for more on road restoration).

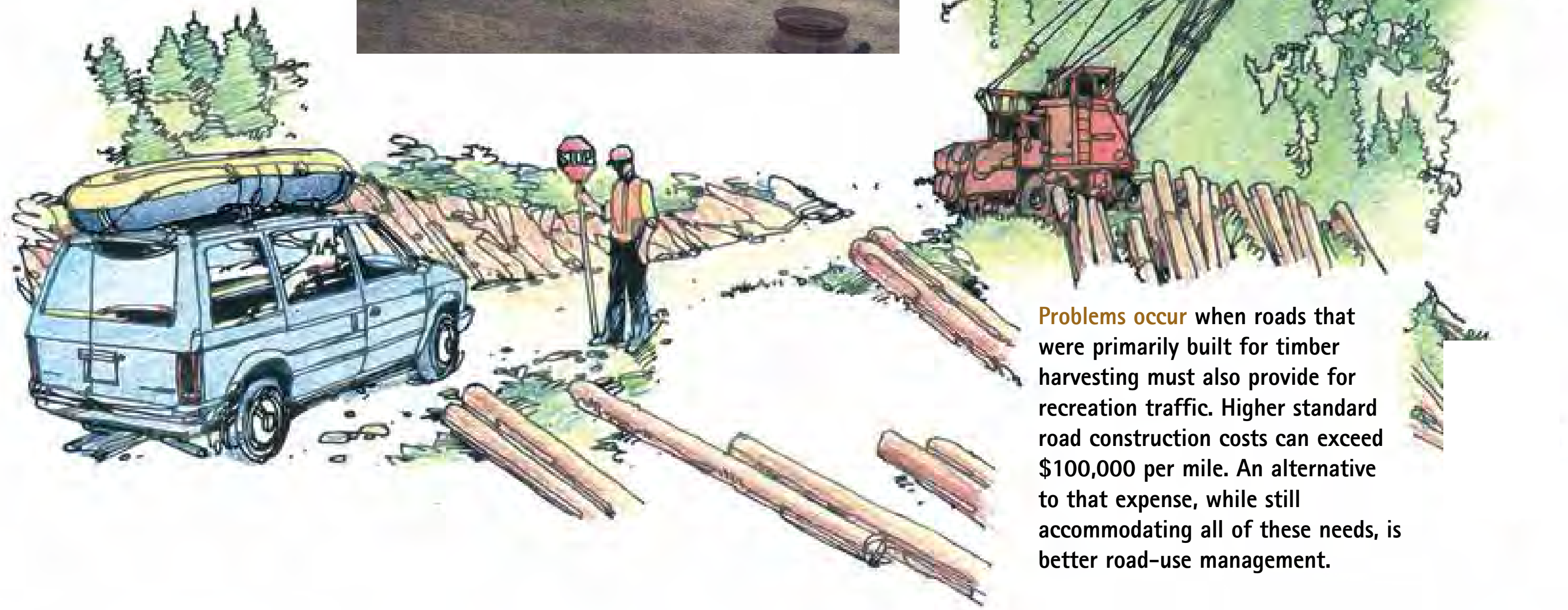
ROAD USE MANAGEMENT

BMP Design roads and drainage facilities to prevent potential water-quality problems from road construction.

BMP The need for higher-standard roads can be alleviated through proper road-use management.

This road is too close to the stream. There is no SMZ to trap road sediment and keep it from entering the stream. Sidecasting of material into a stream is an SMZ violation and must be avoided when grading or working on roads.

More forest roads now provide access to favorite recreation areas.



Problems occur when roads that were primarily built for timber harvesting must also provide for recreation traffic. Higher standard road construction costs can exceed $100,000 per mile. An alternative to that expense, while still accommodating all of these needs, is better road-use management.

Access through locked gates is one method of road-use management. Seasonal weather conditions may also require restricted access.

Temporary road blockage by logging equipment is sometimes necessary.

When access requires crossing moist areas with a poor road base, cross only when the ground is frozen or dry, otherwise a trenched, poorly drained road results.

PLANNING AND LOCATING

Design road systems to facilitate what you want to do. Address access to particular areas, the type of harvesting equipment that will be used, and the cost of construction.

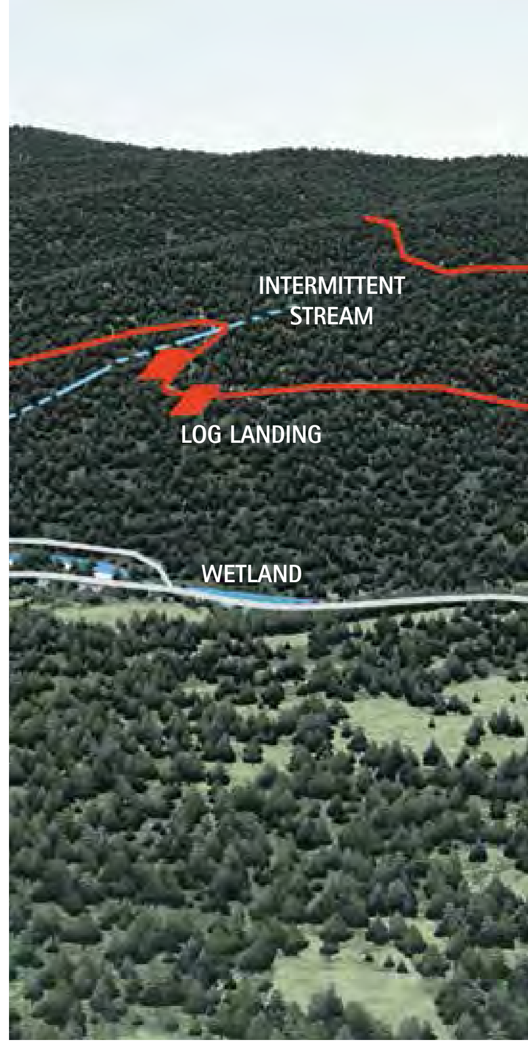
BMP Minimize the number of roads constructed in a watershed through comprehensive road planning, recognizing intermingled ownership, and foreseeable future uses. Use existing roads where practical, unless use of such roads would cause or aggravate an erosion problem.

Unacceptable hillsides like this are evidence of excessive roading. Cooperation and planning among adjacent landowners within a watershed can reduce roads and road sediment.

BMP Locate roads on stable geology, including well-drained soils and rock formations that tend to dip into the slope. 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. Avoid wet areas including moisture-laden or unstable toe slopes, seeps, wetlands, wet meadows, and natural drainage channels.

BMP Review available information and consult with professionals as necessary to help identify erodible soils and unstable areas and to locate appropriate road-surface materials. NOTE: Road construction within the SMZ is prohibited unless crossing the stream or there is an Alternative Practice in place. Cross streams as perpendicular as possible and in stable locations in order to minimize roads within the SMZ.

Rock layers that slant with, rather than into, the slope are a clue to potentially unstable bedrock conditions.

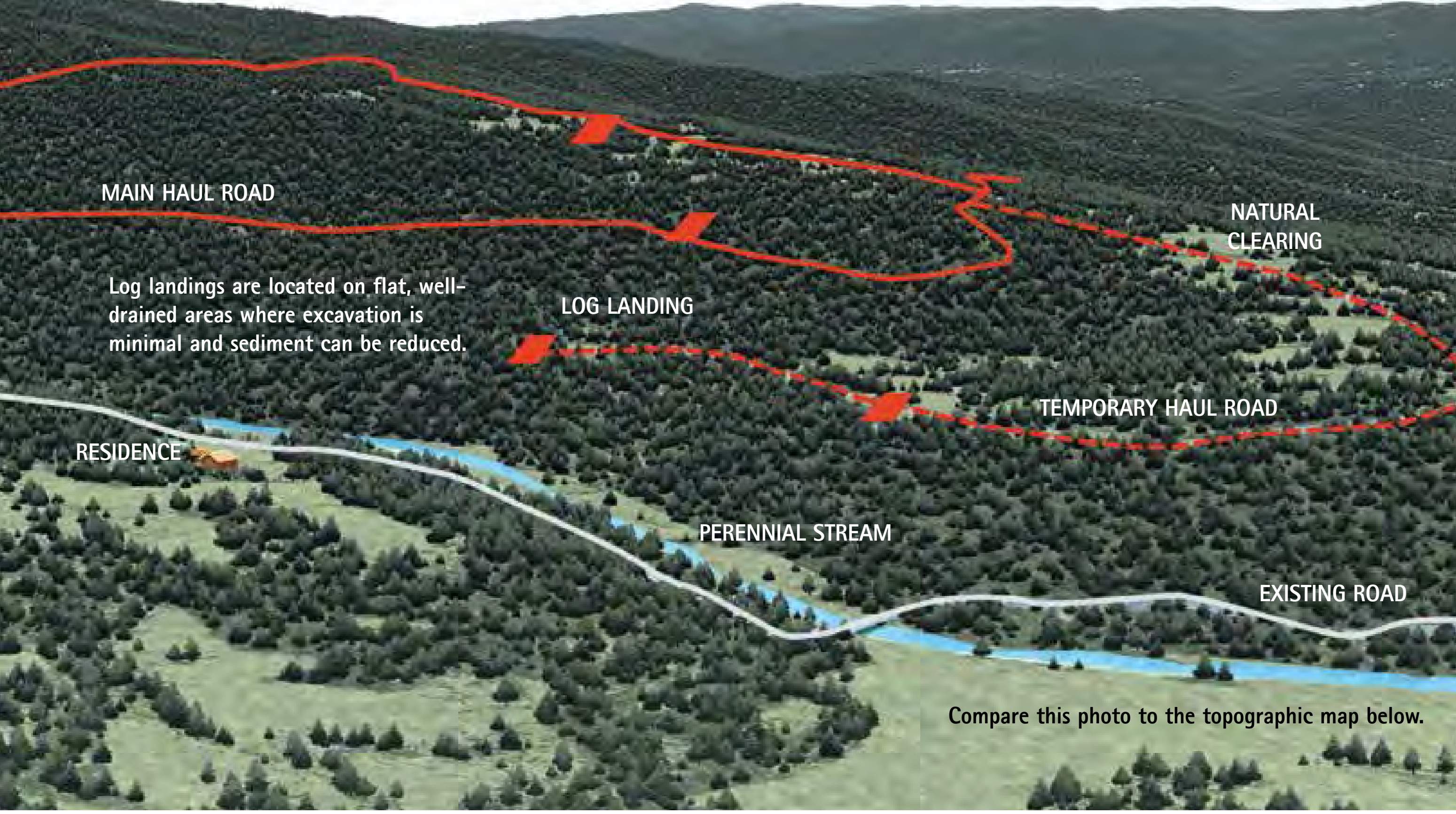


BMP Fit the road to the topography by locating roads on natural benches and following natural contours. Avoid long, steep road grades and narrow canyons.

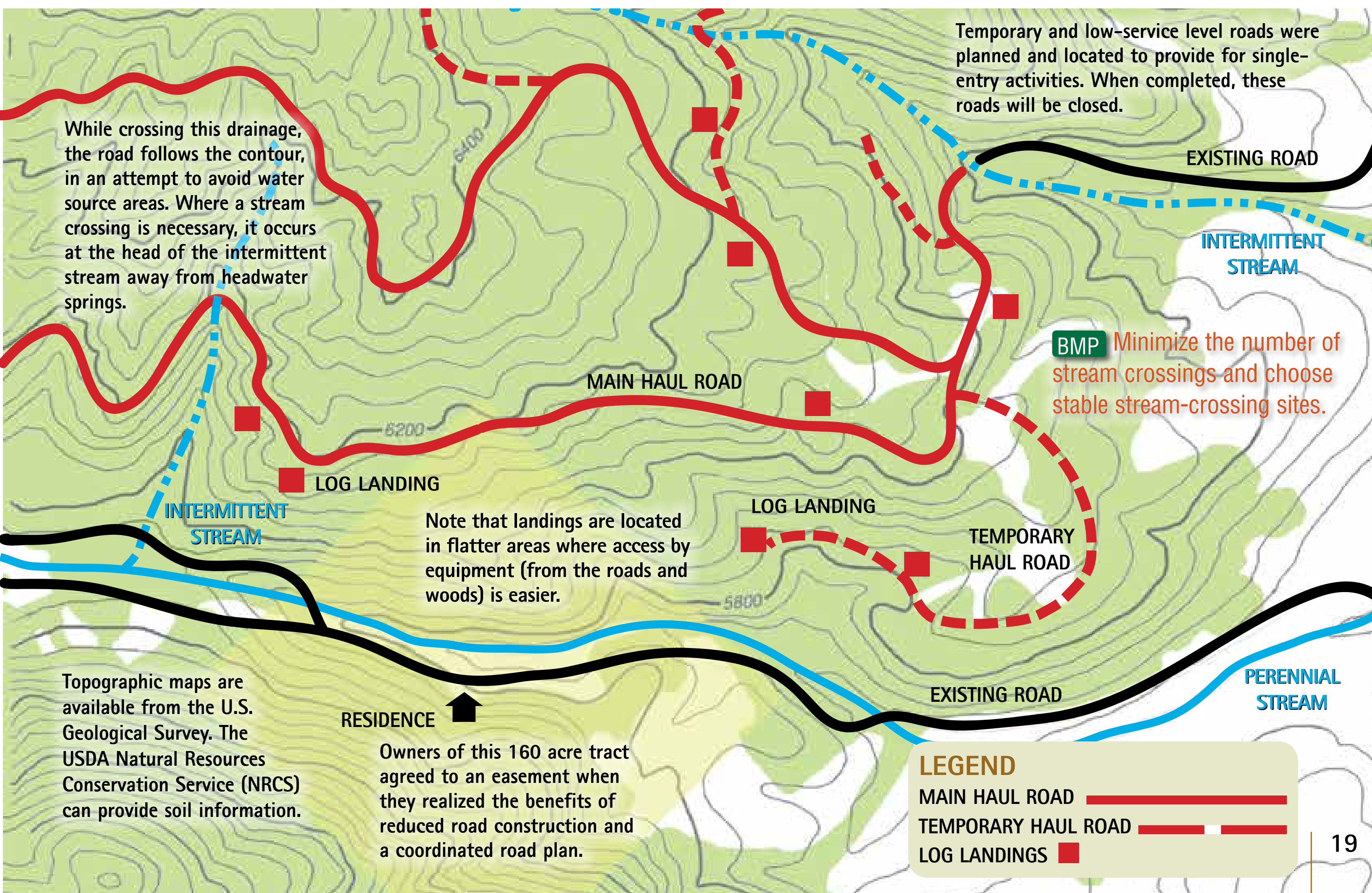
BMP Locate roads to provide access to suitable (relatively flat and well-drained) log landing areas to reduce soil disturbance.

Roads, terrain, and logging system dictate the location of landings where logs are processed and loaded on trucks. When roads use natural benches and flat areas, log landing excavation and sediment is reduced.

The road system planned for this mixed ownership forest is detailed on the topographic map below. All landowners agreed to a coordinated road plan to minimize the number of roads. Many of the problems that had to be dealt with during road location planning are noted.



Compare this photo to the topographic map below.



ROAD CONSTRUCTION

The Basics of a Constructed Road

Once a route is identified, the road is marked on the ground with survey stakes or plastic flagging. Then...

1. Road construction begins with cutting merchantable trees within the road right-of-way. Here the merchantable timber has been felled and bucked.

2. An excavator clears the right-of-way. It digs soil, removes stumps, decks logs, etc. The excavator cab and hydraulic arm can rotate 360 degrees while the machine sits in place. This motion allows the operator to move and stack logs on both edges of the road. After the road is constructed, these logs will be hauled to a sawmill.

3. The excavator's primary job is to clear vegetation and obstacles. It generally moves only enough earth to build its own running surface. A rough road shape is now visible. The remaining construction can be completed with a bulldozer. However, excavators can be used to dig cuts and fills and may do substantial earthwork on steep slopes.

4. Stumps and root wads may be included in the windrow. They are shaken to remove soil and placed in a disposal area outside the roadway. Small trees, brush, and other woody debris are lifted and piled on the down-slope edge of the new road in a slash filter windrow to provide erosion control. This material should NEVER be buried in the road itself.

5. A bulldozer follows the excavator. This D7 has a 12 foot, U-shaped blade that prevents excavated material from spilling off the road edge. Bulldozers begin by digging into the cut slope side of the road and drift the material to the outside edge as they build the fill slope of the road.

6. Here the operator is moving soil, using it as fill, to build up a low spot and support the planned road curve.

7. With each pass of the dozer, the grade is lowered and fill is built up.

8. When the curve and its 35 foot turnout are finished the dozer moves on to the next road segment.


1


2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9. Cross-drain culverts are installed before the final smoothing of the road surface.

10. The final step in the surface construction of a low or medium service level road is to smooth, shape, and ditch the road with a motor grader. This allows water to drain off and away from the road.

11. Here is the finished low service level roadbed. It has a 14 foot driving surface. Vegetation is cleared to a 30-40 foot width, depending on the slope. Steeper slopes require more clearing width than gentler slopes.

HS-1. High service level forest road construction involves additional steps. A compactor may follow the bulldozer or grader to compact and stabilize the new roadbed. Compacting increases the density of the road surface for improved support for heavy vehicles and for erosion resistance.

HS-2. High service level roads are often surfaced with non-native material. Surfacing material, excavated from a gravel pit, is trucked to the new road. Separate layers of material may be used on the road surface to improve drainage and provide a more stable road surface. Each layer is compacted. Water trucks may wet the material to improve compaction. Chemicals can be added to road gravel to control dust and harden the surface.

12. After construction, ALL roadsides are seeded with the appropriate grass seed mixture. Grass on exposed soil reduces erosion and limits weeds.

13. Both cut slopes and fill slopes should be revegetated.

14. The finished road.

Rules of Thumb for Road Grades

• Try to keep road grades less than 8% on most soil types, less than 6% in loose granitics.

• Try to avoid road grades greater than 12% for distances over 300 feet.

• When necessary, short steep pitches under 300 feet long are acceptable.

• Roads with ditches require more constructed drainage features.


10

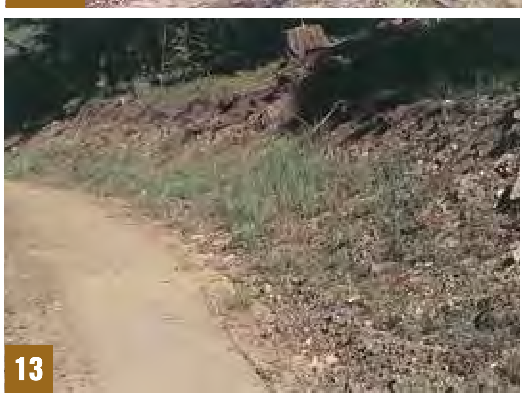

11

BMP Keep slope stabilization, erosion and sediment-control work current with road construction. Install drainage features as part of the construction process, ensuring that drainage features are fully functional.


HS-1


HS-2


12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14

More on Cuts and Fills

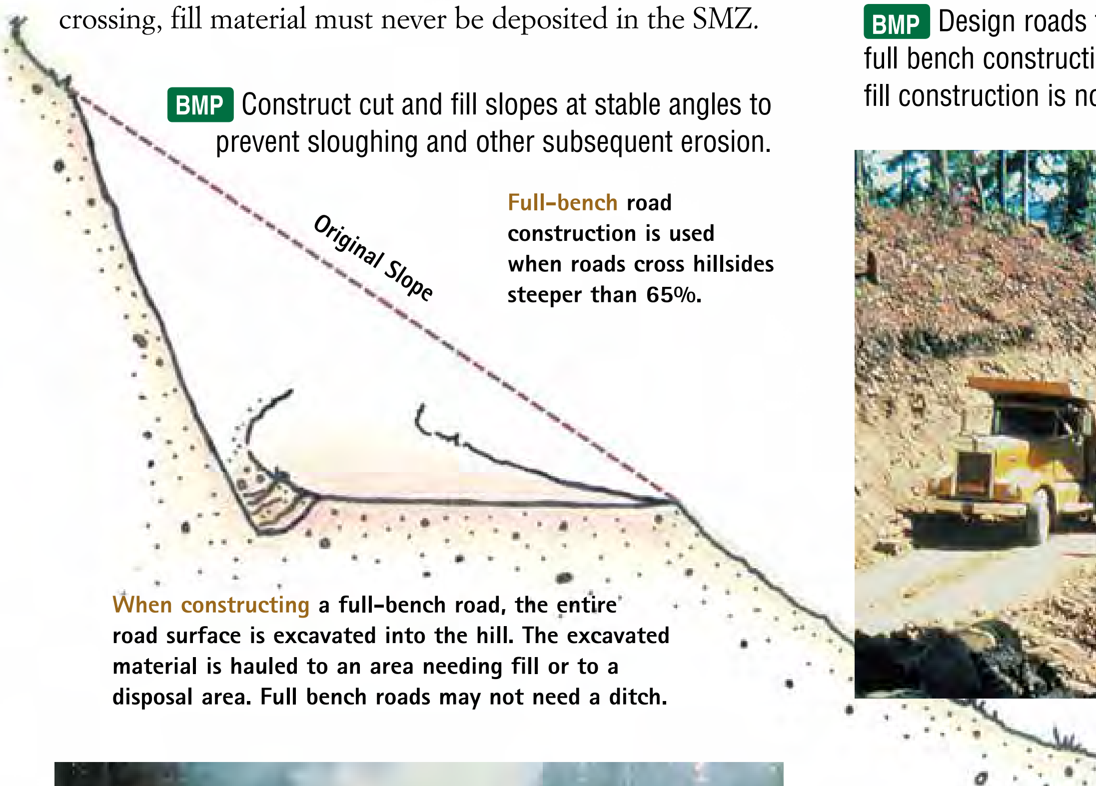
Forest roads on sloped areas are built by constructing a road bed. The design of a road and its layout on the ground indicates to machine operators the proper cut slope location and grade. A bulldozer or excavator starts at the top of the cut slope, excavating and side-casting material until the desired road grade and width are obtained. Roads that cross steep slopes may require a full bench design with end haul of excavated material. Soil taken from cuts is often pushed or "drifted" in front of the blade to areas where fill is needed. Road fill is used to cover culverts and build up low areas. Since fill must support the weight of traffic, it needs to be spread and compacted in layers in order to develop strength.

During the process of cut-and-fill, never let side-cast or waste material enter streams and never place it on unstable areas where it might erode. Also, unless constructing a stream crossing, fill material must never be deposited in the SMZ.

Cut-and-fill road construction is common for most terrain in Montana.

BMP Design roads to balance cuts and fills or use full bench construction (no fill slope) where stable fill construction is not possible.

BMP Construct cut and fill slopes at stable angles to prevent sloughing and other subsequent erosion.



Full-bench road construction is used when roads cross hillsides steeper than 65%.

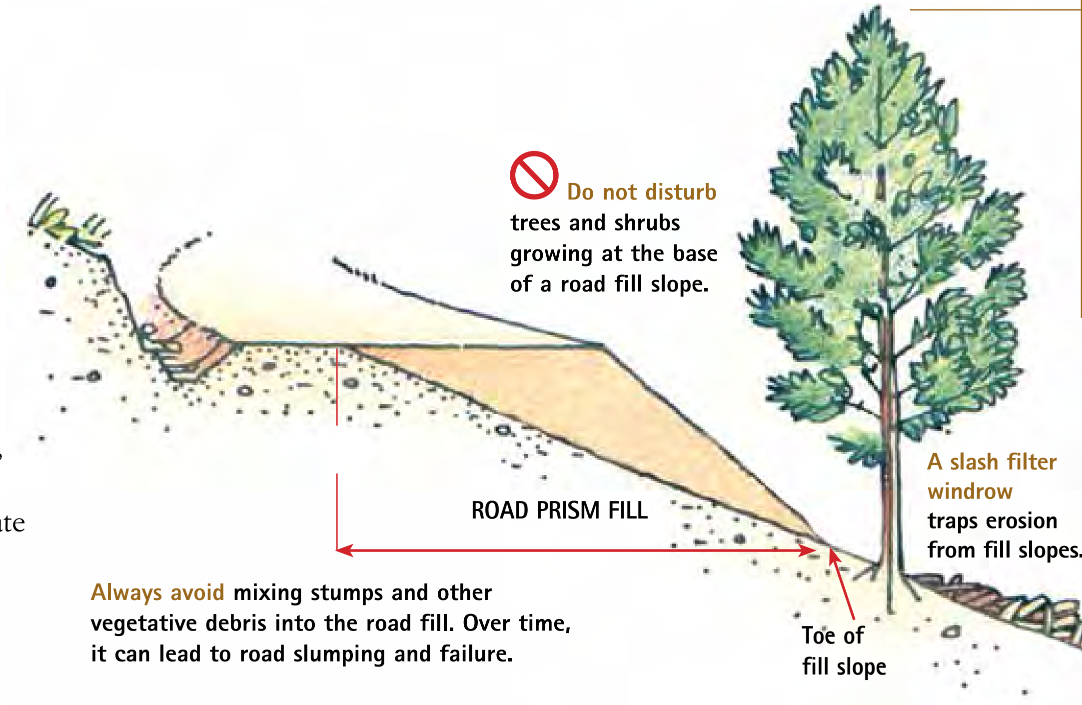
When constructing a full-bench road, the entire road surface is excavated into the hill. The excavated material is hauled to an area needing fill or to a disposal area. Full bench roads may not need a ditch.

BMP Place debris, overburden, and other waste materials associated with construction and maintenance activities in a location to avoid entry into streams. Include these waste areas in soil stabilization planning for the road.

When root wads, slash, and vegetative debris accumulated during road construction are not needed for construction of slash filter windrows, it is disposed of by piling for later burning. To prevent contamination, locate slash piles away from water sources. Alternatives to burning the slash may also be utilized for disposal.

You Need to Know

Most road erosion occurs in the first two or three years after construction before cut and fill slopes re-vegetate and stabilize. Stabilized slopes mean decreased erosion rates. After this initial period, and with proper maintenance, erosion in later years comes primarily from the road travelway. Without a rock surface, water erosion on a bare soil travelway may continue to generate sediment. Control techniques for travelway erosion are described beginning on page 26.



BMP Avoid incorporating potentially unstable woody debris in the fill portion of the road prism. Where possible, leave existing rooted trees or shrubs at the toe of the fill slope to stabilize the fill.

BMP Minimize earth-moving activities when soils appear excessively wet. Do not disturb roadside vegetation more than necessary to maintain slope stability and to serve traffic needs.

BMP Complete or stabilize road sections within the same operating season as they are constructed.

Slash Filter Windrows

BMP At the toe of potentially erodible fill slopes, particularly near stream channels, pile slash in a row parallel to the road to trap sediment. When done concurrently with road construction, this is one method that can effectively control sediment movement, and it can also provide an economical way of disposing of roadway slash. Limit the height, width, and length of "slash filter windrows" so wildlife movement is not impeded. Sediment fabric fences or other methods may be used if effective.

Spreading slash along the right-of-way is one way to cover bare soil and reduce erosion.

Slash-filter windrows are compacted logging slash, installed along the base of fill slopes during road construction. Built by excavators, these windrows are very effective at slowing surface runoff and keeping sediment from entering streams.

Sediment fences are another technique for reducing sediment movement. They slow surface water and trap sediment.

Geotextiles and Their Uses

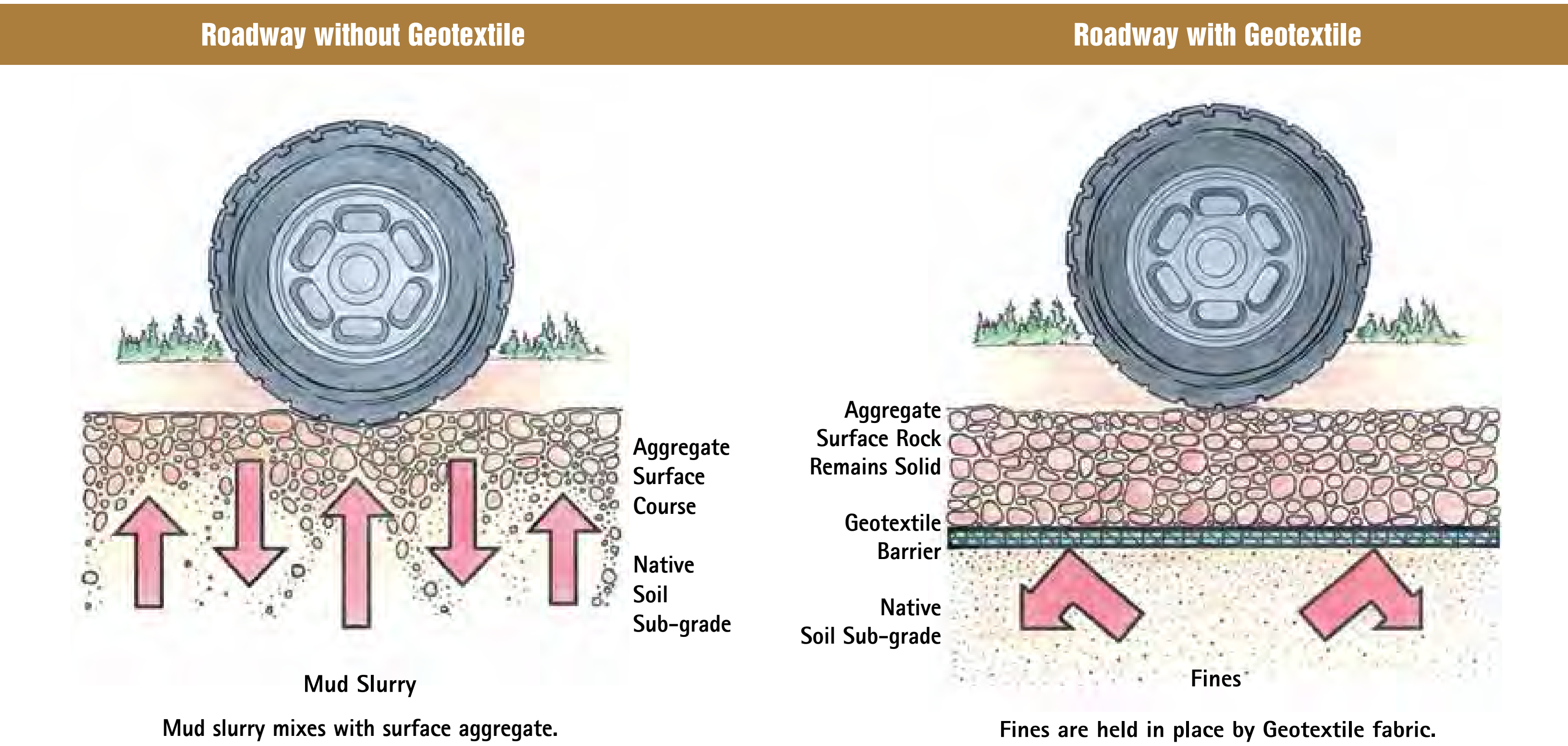
Geotextiles are synthetic permeable fabrics used to reduce rutting, stabilize the ground, and increase the load-carrying capacity of unpaved roads. They are used to separate rock surfacing materials from sub-grade soils while allowing for water passage.

Geotextiles can reduce the amount of rock surfacing needed and reduce road costs.

BMP Consider road surfacing to minimize erosion.

Geotextiles are used to reinforce sub-grades by spreading the load over a larger area. This reduces the chance of settling and failure. It also allows road construction over wet areas, reducing the need to remove unsuitable roadbed material.

Road surfacing can double the cost of a road. However, gravel roads can provide all-weather access, reduce road maintenance costs, and ensure water quality protection, because the soil is covered with a weather-resistant surface. Rock may be applied in two or more layers. The base layer can be 6-18 inches of larger rock, capable of supporting heavy loads. The running surface is a 2- to 4-inch layer of smaller rock. Use of a geotextile fabric can significantly reduce required thicknesses.



Geotextiles can keep weak sub-grade soils from moving into the road base rock layer, reducing its weight-carrying effectiveness.

Road Improvements

Over time, it is often necessary to add or replace culverts and other drainage structures for improved drainage. Anticipate the need to maintain or upgrade structures to avoid drainage problems.

Deep, wide road fills can be stabilized with log terraces. After installation, the entire road fill is seeded with grass cover.

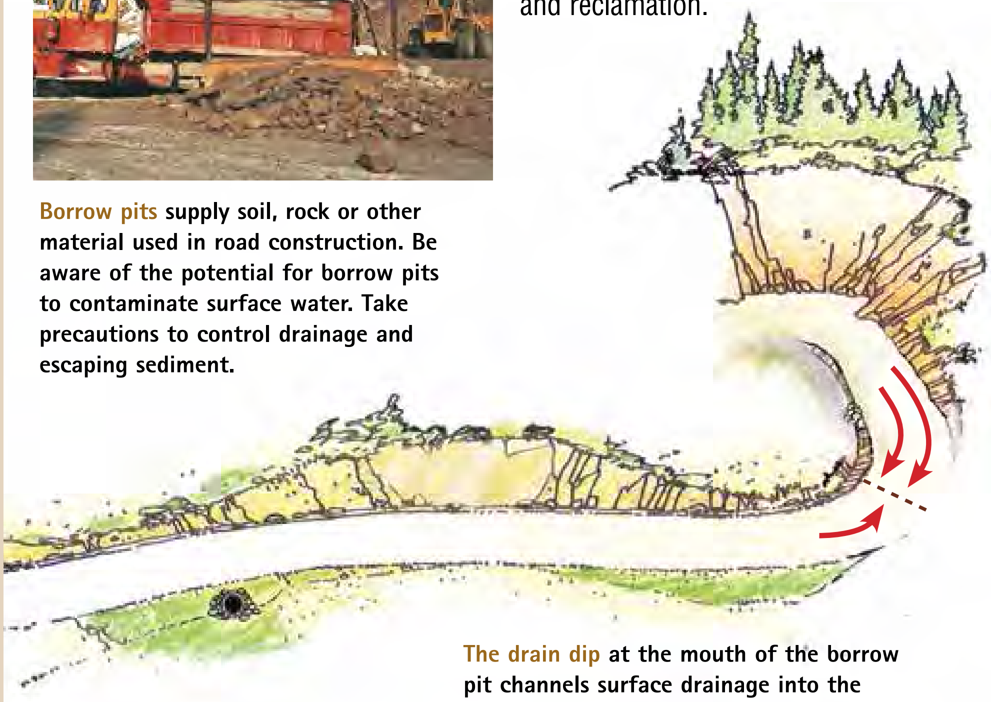
Road improvements such as laying back a road cut slope or removing vegetation crowding the roadway can improve vehicle safety and visibility.

Geotextile material can also be used to hold embankment soil in place, allowing vegetation to grow. It is applied at culvert inlets and outlets to protect slopes adjacent to flowing water. Note that geotextiles with small openings may impede native broad leafed vegetation from emerging through the fabric.

BMP Stabilize erodible, exposed soils by seeding, compacting, riprapping, benching, mulching or other suitable means prior to fall or spring runoff.

BMP Minimize sediment production from borrow pits and gravel sources through proper location, development, and reclamation.

Borrow pits supply soil, rock or other material used in road construction. Be aware of the potential for borrow pits to contaminate surface water. Take precautions to control drainage and escaping sediment.



The drain dip at the mouth of the borrow pit channels surface drainage into the road ditch and away to a safe location.

Reopening Existing Roads

Use existing roads if possible to reduce new construction. Sometimes existing roads are poorly designed, were built in a poor location, or have degraded to a point that they cannot or should not be re-used. This is especially true with roads built in an unstable or stream adjacent location.

Reopening a closed road can be a big job. In addition to removal of overgrown vegetation, culverts, ditches, and the original surface grade may need reconstruction. Carefully consider how road work can be completed to minimize sediment creation and transportation to water bodies.

BMP When using existing roads, reconstruct only to the extent necessary to provide adequate drainage and safety; avoid disturbing stable road surfaces. Prior to reconstruction of existing roads within the SMZ, refer to the SMZ law. Consider abandoning existing roads when their use would aggravate erosion.

CONTROLLING DRAINAGE FROM ROAD SURFACES

A primary factor influencing road erosion and sediment delivery to streams is adequate road drainage. Without properly installed drainage, water running down roads can cause rill or gully erosion. This erosion produces sediment that can negatively impact nearby streams. A primary road BMP is ensuring that roads are properly drained, and runoff is diverted onto vegetated areas where the sediment stays while the water flows on to streams. Maintaining adequate road drainage will reduce overall road maintenance costs making it beneficial for the landowner and the watershed.

Drainage Techniques that Work:

- Ditch grade
- Ditch relief culvert
- Open top pipe culvert
- Open top wood culvert
- Water bar
- Flappers
- Outsloping
- Rolling drain dip

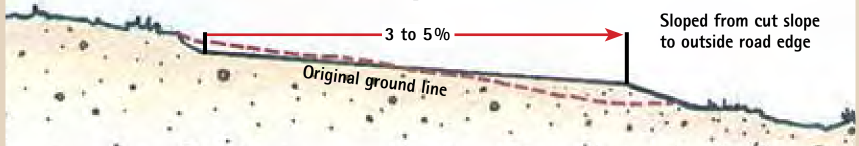
BMP Provide adequate drainage from the surface of all permanent and temporary roads. Use outsloped, insloped or crowned roads, and install proper drainage features.

BMP Outsloped roads provide means of dispersing water in a low-energy flow from the road surface. Outsloped roads are appropriate when fill slopes are stable, drainage will not flow directly into stream channels, and transportation safety can be met.

BMP For insloped roads, plan ditch gradients steep enough, generally greater than 2% but less than 8%.

Roadway surfaces are normally crowned or sloped to remove surface water. Well-designed forest roads have changing road grades, adequate ditches, and ditch relief culverts that control drainage and ensure water quality.

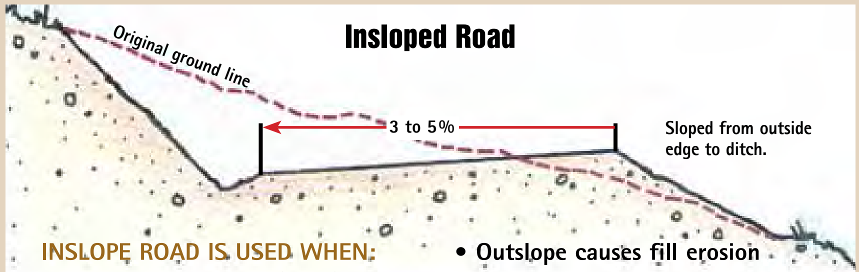
Outsloped Road



OUTSLOPE ROAD IS USED WHEN:

- Road grade is gentle or flat (< 7%)
- Ditch or cut slope is unstable
- Surface can be kept smooth
- Rocky soils, dry hillsides
- Road is closed
- Rutting can be controlled
- Road use is seasonal and traffic is light

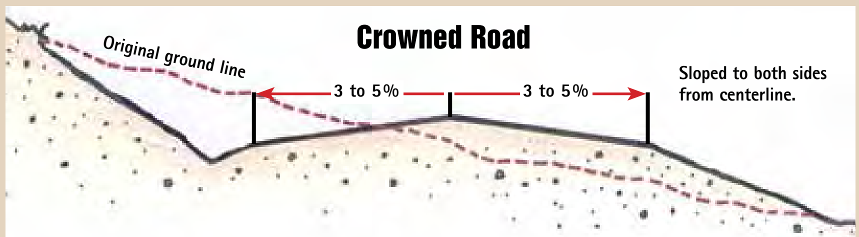
Insloped Road



INSLOPE ROAD IS USED WHEN:

- Road grade is steep (>8%)
- Surface drainage is carried to a ditch or surface drain
- Outslope causes fill erosion
- Outslope is ineffective due to ruts
- Slippery or icy road conditions are prevalent

Crowned Road

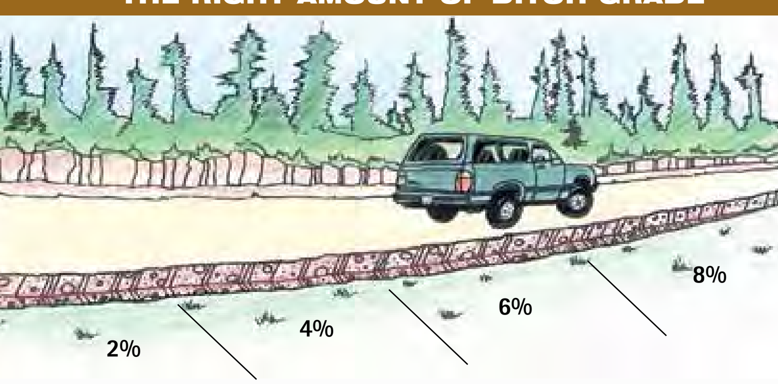


CROWN ROAD IS USED WHEN:

- Two traffic lanes are required
- Regular maintenance of ditches, crown, and cross-drains is possible
- Single lane road on steep grade
- Slippery or icy road conditions are prevalent
- Road grade is flat (crowned fill)

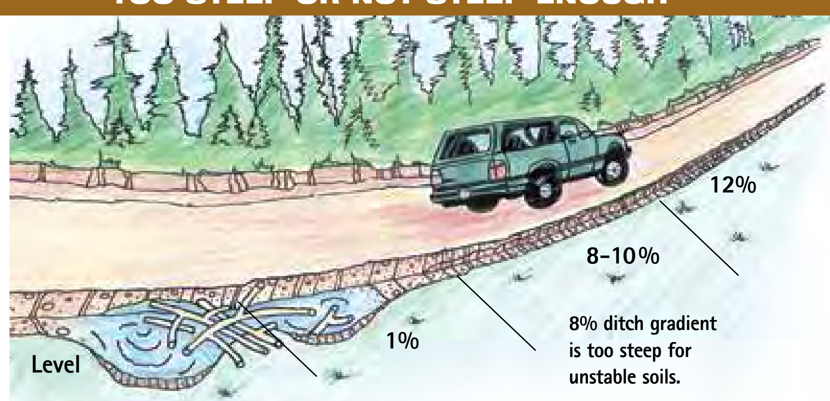
Ditch Grades

THE RIGHT AMOUNT OF DITCH GRADE



2-6% ditch gradients are steep enough to keep water moving to relief culverts without excessive sediment generation.

TOO STEEP OR NOT STEEP ENOUGH



Ditch gradients steeper than 8% can give water too much momentum and carry sediment and debris for great distances. Where the ditch levels off, debris drops, clogging ditches and carrying sediment into streams. Consider ditch relief options when grade breaks create minimal to no water movement.

Ditch Relief Culvert

- Ditch relief culverts transfer water from the ditch on the uphill side of the road, under the road, releasing it onto a stable area on the downhill side.
- They prevent water from crossing the road surface and softening the road bed.
- Ditched roads with ditch relief culverts are wider and more costly, but they also allow for faster speeds and greater safety.

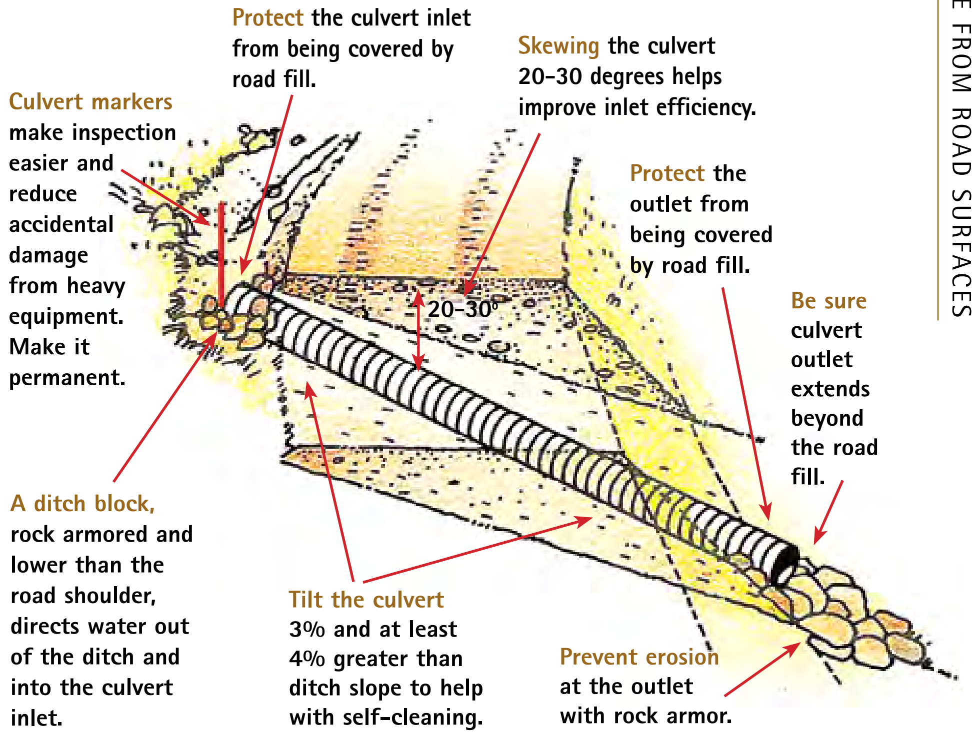
Rock-armored catch basins prevent water from eroding and undercutting the culvert inlet and flowing under the culvert.

BMP For ditch relief culverts, construct catch basins with stable side slopes. Protect the inflow end of cross-drain culverts from plugging and armor if in erodible soil. Skew ditch relief culverts 20 to 30 degrees toward the inflow from the ditch to help maintain proper function.

BMP Prevent downslope movement of sediment by using sediment catch basins, drop inlets, changes in road grade, headwalls or recessed cut slopes.

Mitered Relief Culvert Inlets can prevent plugging from soil or debris.

BMP Provide energy dissipators (rock piles, slash, log chunks, etc.) where necessary to reduce erosion at the outlet of drainage features. Cross-drains, culverts, water bars, dips, and other drainage structures should not discharge onto erodible soils or fill slopes without outfall protection.



BMP Design all relief culverts with adequate length and appropriate skew. Protect inflow end from erosion. Add catch basins where appropriate.

BMP Where possible, install culverts at the gradient of the original ground slope; otherwise, armor outlets with rock or anchor downspouts to carry water safely across the fill slope.

Ditch Relief Culvert Installation

Ensure proper slope of culvert. At least five inches in every ten feet.

Seat the culvert on the natural slope. Bedding material should be free of rock or debris that might puncture the pipe or carry water around the culvert.

Cover with soil, using at least one foot or one-third the culvert diameter, whichever is greater. Avoid punctures from large rocks.

Compact soil at least halfway to prevent water seepage around sides. Be sure outlet extends beyond any fill and empties onto an apron of rock, gravel, brush, or logs.

Rolling Drain Dip

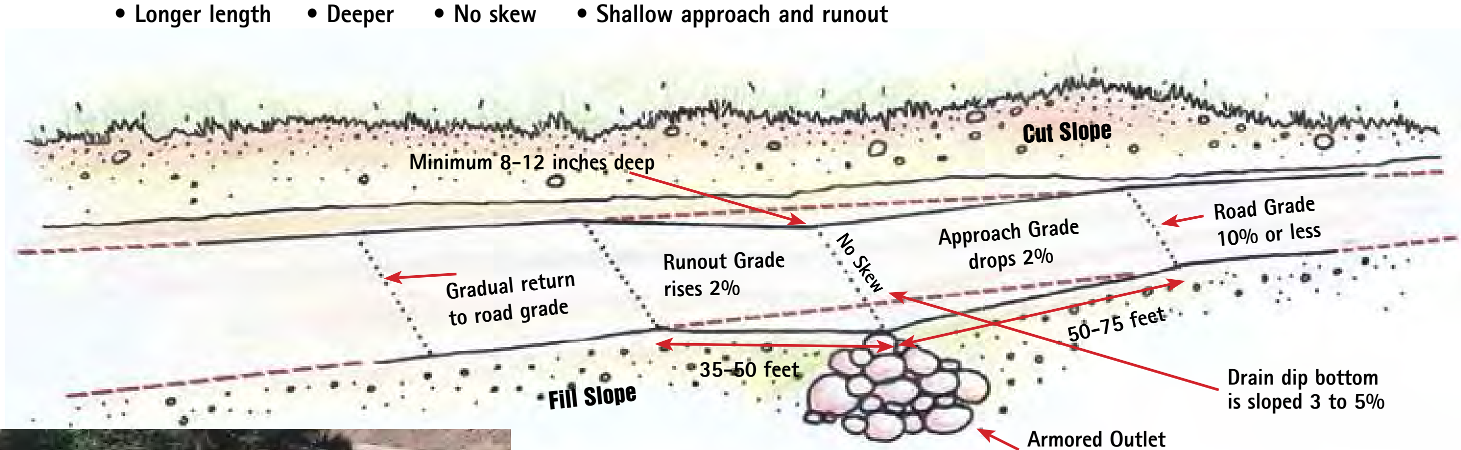
- Used on ditched or un-ditched active roads.
- Preferred alternative to the traffic obstruction of a water bar.
- It is a gentle roll in the road surface, sloped to carry water from inside to outside, onto natural ground.
- The approach, depth, and runout provide drainage without being a driving hazard.
- Effective on roads with grades up to 10%.
- Difficult to construct on steeper roads and difficult for log trucks to pass. For steeper road grades consider an open top pipe culvert or a rubber water diverter commonly called a "flapper" (see page 30).
- Must have a full reversal of grade into and out of dip to effectively get water off the roadway.

The drain dip bottom is sloped to carry water from the inside to the outside of a road surface and onto natural ground.

High Service Level Drain Dip

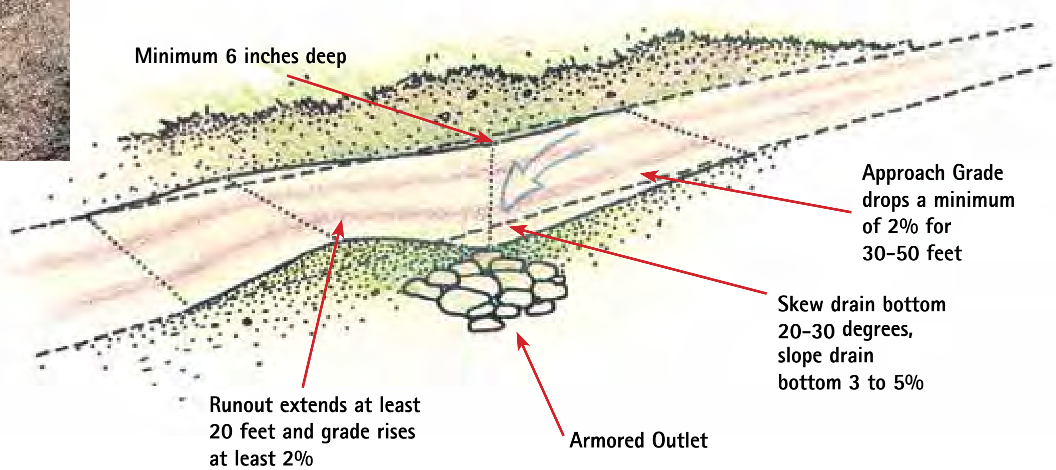
(Higher speed, lower clearance)

- Longer length
- Deeper
- No skew
- Shallow approach and runout



Use at least 50 feet for approach and runout. More on steeper road grades.

BMP Properly constructed drain dips can be an economical method of road surface drainage. Construct drain dips deep enough into the sub-grade so that traffic will not obliterate them.



Low Service Level Drain Dip

(Lower speed, higher clearance)

- Shorter length
- Skewed
- Less depth
- Steeper approach and runout

Open Top Pipe Culvert

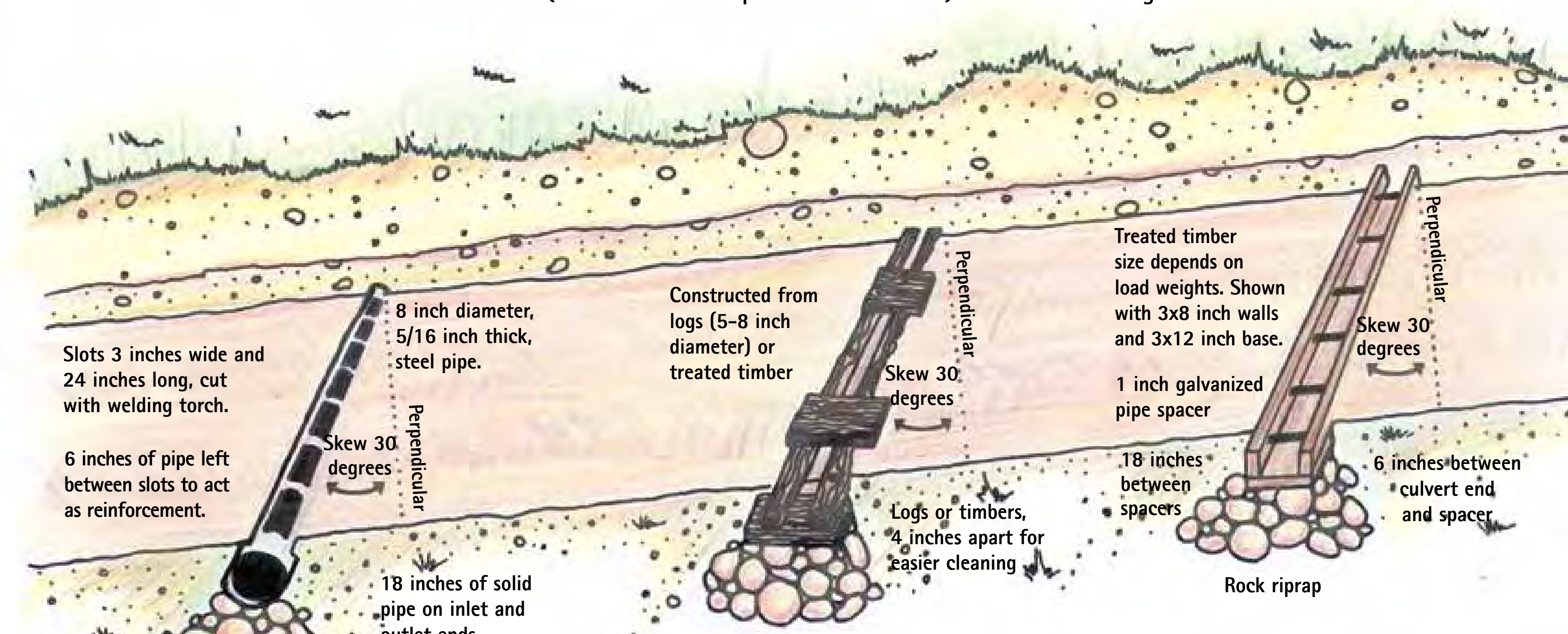
- Alternative to drain dip on road segments with greater than 10% grade.
- Used to control surface water on un-ditched roads.
- Water cannot run past them as long as they are maintained.
- Can be constructed from steel or wood (see below).
- Steel is more resistant to damage and relatively permanent.
- Road grader operators should lift blade when passing.
- Require periodic cleaning.

A backhoe is the best choice for open top pipe culvert installation.

Pipe bed must have a grade of 8% to keep pipe working.

Skew pipe 30-45 degrees for self-cleaning. (15 foot roadbed requires 20 foot culvert)

Slots are wide enough for cleaning but do not damage tires.



Because water is discharged above the road fill, protect fill with rock riprap.

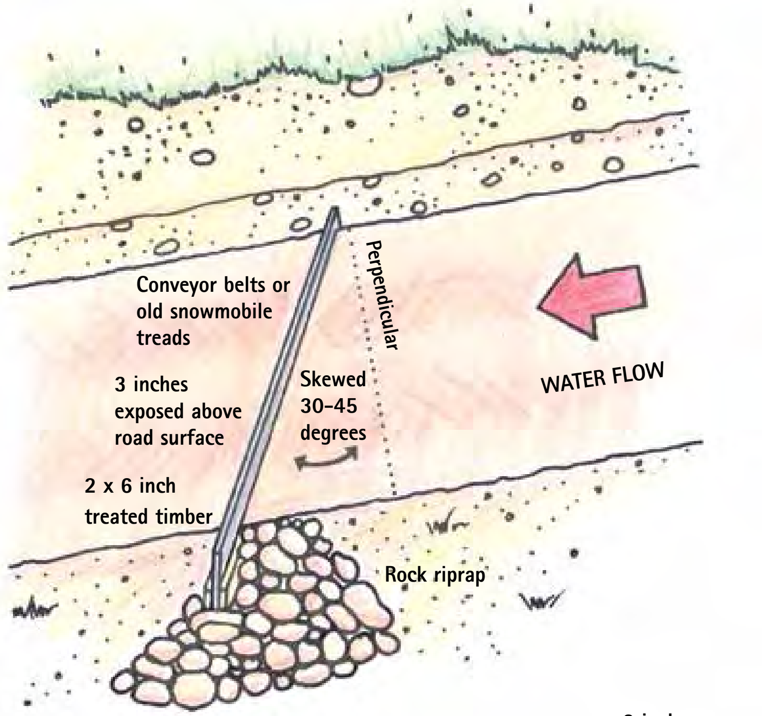
Open Top Wood Culvert

- Used on steep, lower standard, un-ditched roads.
- Less expensive and work well if maintained.
- Require frequent cleaning to remain effective.
- Easily damaged by logging equipment, road graders, and snow plows

Open Top Wood Culvert

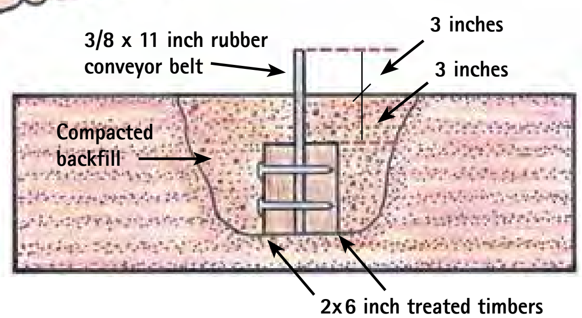
Storm Runoff

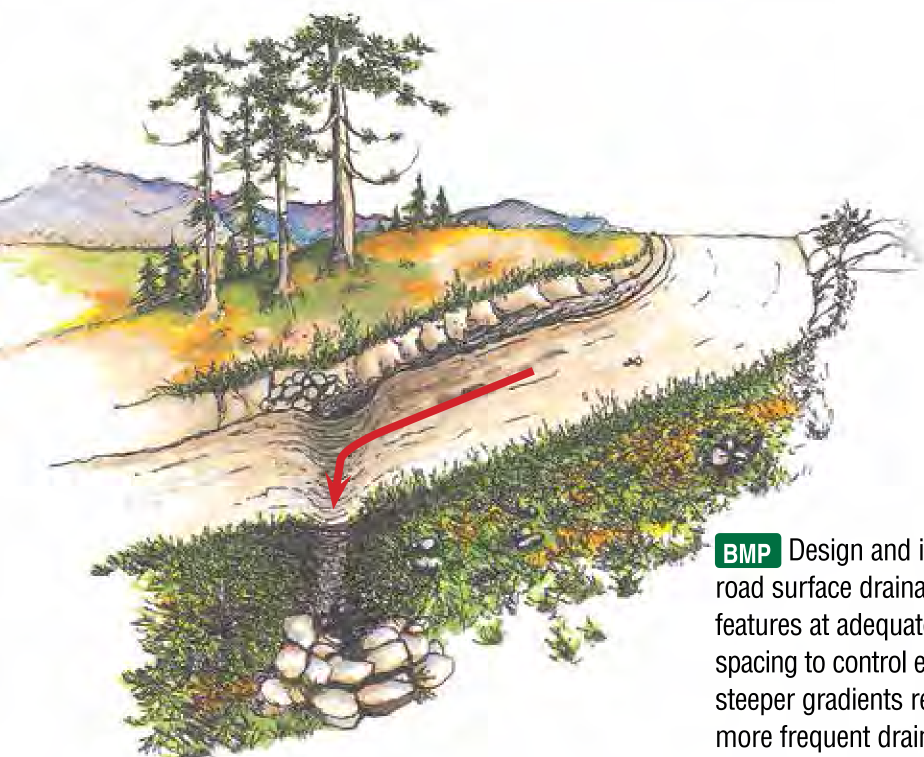
The impacts of wildfire-altered landscapes as well as 10-year, 50-year, and 100-year floods should be assessed for each site-specific road situation. Whereas BMP guidelines are for application under what might be considered "normal" climatic events, identifying areas where past flood events impacted soils, slopes, and drainages will help avoid future road failures.



Rubber Water Diverter or Flapper

- Another surface water control alternative.
- For steep, un-ditched roads.
- Rubber belt fastened between timbers and buried in the road.
- Easily damaged by track machines, road graders, and snowplows.
- Expect frequent replacement on regular traffic roads.

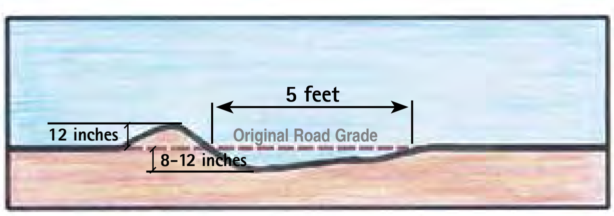




Water Bar

- Small earth dam or hump built into the road surface.
- Used to divert road surface water to where it will not cause erosion.
- Used on inactive roads and skid trails.
- Can be constructed with a shovel, but mechanical equipment is most common.
- Spacing recommendations should be based on soil type, topography, road dimensions, road aspect, and climate.

BMP Design and install road surface drainage features at adequate spacing to control erosion; steeper gradients require more frequent drainage features.



Suggested Water Bar Intervals for Different Soils *(Intervals in feet)*

ROADS AND LANDINGS			
SLOPE	GRANITIC OR SANDY	CLAY OR LOAM	SHALE OR GRAVEL
2-5%	400'	500'	600'
6-12%	200'	250'	300'
SKID TRAILS			
SLOPE	GRANITIC OR SANDY	CLAY OR LOAM	SHALE OR GRAVEL
5-10%	250'	300'	400'
11-12%	150'	200'	300'
over 25%	75'	100'	150'

ROAD GRADING

Roads are one of the most important and costly features constructed on forest land. Maintenance is required to ensure road usefulness and reliability, in addition to environmental performance. Ignoring or delaying maintenance often leads to damage that is more costly to repair than the original road construction cost.

Road Maintenance Activities

- Road grading
- Culvert and ditch cleaning
- Cut and fill slope inspection
- Dust control
- Snow removal

Road Grading

- Purpose is to maintain a functioning road surface.
- Maintain road surface cross-drain structures.
- Corrects road surface damage resulting from vehicle traffic and freeze-thaw cycles that reduce drainage effectiveness.
- Timely road grading and road use restrictions during wet periods can protect drainage on unimproved roads.

BMP Grade road surfaces only as often as necessary to maintain a stable running surface and adequate surface drainage.

Road grading precautions:

- Grading should be done when roads are neither dusty nor muddy. Damp surface roads are more easily shaped and compacted.
- Watch for steep sections or curves as added wear and rutting in these locations may need additional work to bring the road back to standard.

BMP Avoid cutting the toe of cut slopes when grading roads, pulling ditches or plowing snow.

Roads receive heavy use during logging. Be aware of early signs of damage. Serious damage to road surfaces starts with excess water. Standing water is a sure sign of road-drainage problems. Ruts indicate that road strength is deteriorating. Get water off of the road into filtration zone before it gets into the stream.

Road grading repairs the drainage by smoothing surface ruts and potholes.

Avoid grading sections of road that do not need it. This only creates an unnecessary sediment source from the disturbed surface. Raise the blade where grading is not needed!

Grader damage to inside ditch toe slopes exposes an easily erodible surface, destabilizes cut slopes, and is a source of sediment.

Slow, controlled grader operation is key to reducing culvert inlet and outlet damage. Reduce damage by keeping graders on the road running surface. Never sidecast gravel over culvert inlets or outlets.

If grading produces excess material, feather it out or haul it away. Sidecasting material into streams is illegal under SMZ Law. Avoid leaving a berm that channels water down the road unless it is routed into an effective vegetation filter zone (page 37) which spreads it out and removes sediment.

ROAD MAINTENANCE

Culvert and Ditch Cleaning

• More culverts fail from inlet debris than from any other cause.

• Debris reduces flow velocity at the culvert inlet, causing sediment to drop and making the culvert non-functional.

• Culvert inlet debris can cause water to overtop the embankment, in turn causing embankment erosion and/or flooding of land upstream from the culvert.

This undersized cross-drain culvert resulted in a breached ditch block and sediment flowing directly into the stream. With proper cross-drains, water cannot soak into the road, causing surface softening and rutting.

Hand, shovel, and chainsaw work are usually all that culvert maintenance requires. But don't delay! Delay in cleaning a blocked culvert or ditch can result in a damaged road that requires costly reconstruction.

An armored culvert.

An unusually high flow event contributed to this blown out ditch which resulted in a relief culvert too high to drain under the road surface. A rock armored catch basin at the inlet could have reduced impacts on this site.

BMP Maintain erosion-control features through periodic inspection and maintenance, including cleaning dips and cross-drains, repairing ditches, marking culvert inlets to aid in location, and clearing debris from culverts.

Watch for damaged culverts that need replacement. Repair work should be completed during dry weather.

Dust Control

- Road dust is a driving hazard and a source of sediment to water bodies.
- Road surfaces can be protected with the use of water or chemicals.
- Dust abatement chemicals can decrease rutting.
- Abatement chemicals can be pollutants, and caution should be used in their application near streams or drainages.
- Grading roads during excessively dry conditions can increase dust impacts to water and air resources.

Snow Removal

BMP When plowing snow, provide breaks in the snow berm to allow road drainage.

Snow berm breaks allow for spring drainage without damaging the road surface. They also serve as escape corridors for wildlife.

Poor road surface drainage caused this fill slope erosion by concentrating too much water in this location.

Soil sloughing off a road cut.

Cut and Fill Slopes

- In steep terrain, ditch walls, cut slopes, and fill slopes can slump.
- Debris collects in ditches, and vegetation may block water flow.
- Ditch inspection should be conducted during or immediately after storm events when drainage problems are most obvious. Watch for blockage and overflow problems.
- Clean promptly. Move soil and debris to a location where they will not create additional erosion problems.
- Vegetating or covering cut slopes and fill slopes with organic debris will reduce erosion.
- Ditchline erosion may indicate a need for more frequent ditch relief using cross-drains or other relief structures or ditch stabilization through compaction or armoring (see ditch gradients page 26).
- On dry roads, grading creates dust which may travel as airborne silt to streams.

BMP Haul all excess material removed by maintenance operations to safe disposal sites and stabilize these sites to prevent erosion.

CLOSING ROADS TO PROTECT WATER QUALITY

Forest roads remain part of the landscape long after harvest operations, site preparation, and reforestation are completed. If access is no longer needed, steps should be taken to temporarily close, permanently close, or obliterate roads.

Temporary road closure is easiest. Permanent closure, or storing a road for future use, involves specific actions described on page 35. In contrast, road obliteration, used in some situations, is described below.

Alternatives to gates include large berms or trenches, logs, stumps or rock boulders.

It may be necessary to physically block road access. Gates provide temporary closure along with quick access if needed. To prevent vandalism, gates and other barriers need to be well anchored.

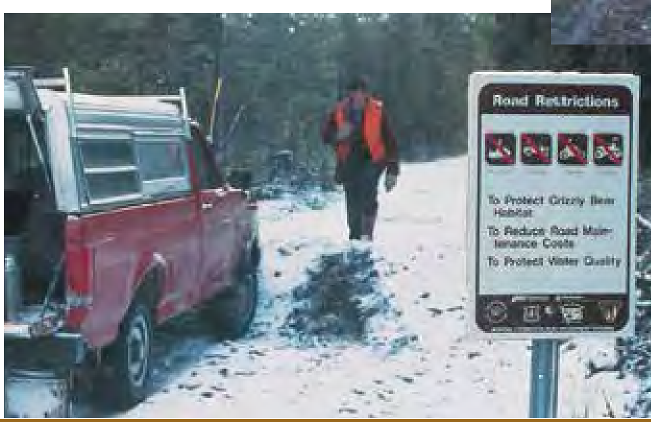
BMP Consider gates, barricades or signs to limit use of roads during spring break up or other wet periods.

Traffic control is 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 road open but restricted to only light use. Whatever traffic control option is selected, all require regular maintenance inspections.

Temporary Road Closure

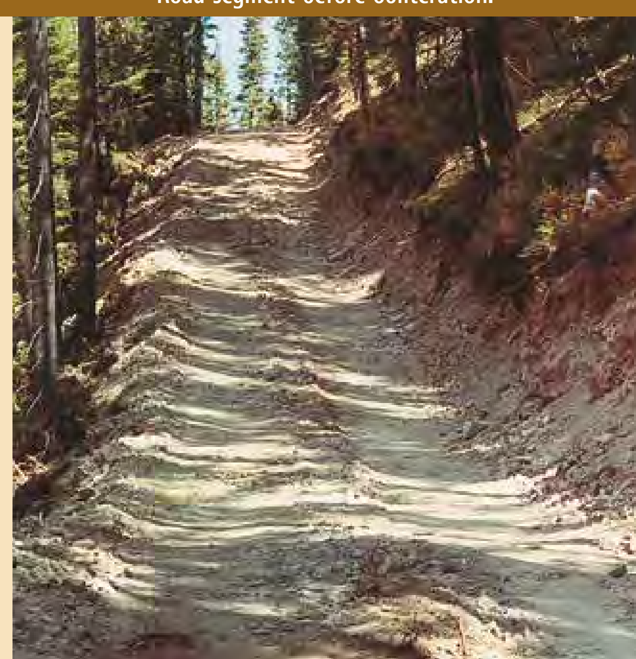
BMP Avoid using roads during wet periods if such use would likely damage the road drainage features.

BMP Upon completion of seasonal operations, ensure that drainage features are fully functional. The road surface should be crowned, outsloped, insloped, or water-barred. Remove berms from the outside edge where runoff is channeled.



Do not let closed roadways become streams. When roads become channels for drainage, major sediment pollution can result. Outslope the surface of closed roads or build frequent water bars and periodically inspect to avoid this problem.

Road Obliteration



Road segment before obliteration.

When should obliteration be considered?

- When the road no longer serves a useful purpose.
- When there is a need to eliminate or discourage access.
- To reduce watershed peak flows that are the result of roads.
- To reduce erosion and sedimentation.
- When a road is channelizing a stream.

Fully recontouring roads has been done where there is no future need for the road and overall stability of the site will be improved. Decompaction of the road bed before side cast material is excavated and used to recontour the road is necessary to ensure as little effect to natural subsurface water movement as possible. Spreading organic debris over the recontoured surface can reduce the risk of erosion and improve micro climate for vegetation re-growth.

Permanent Road Closure - Abandonment

Closed roads that will not be regularly maintained should be left in a self-maintaining condition. This may mean adding additional drain dips, water bars or other drainage structures. Culverts left in place can be flood proofed by installing a dip across the road beside the culvert which allows flow over the road should the culvert inlet plug with sediment or debris. In some cases when the road will not be needed in the foreseeable future the culverts can be pulled and stockpiled for reinstallation at a later date. Where roads are unneeded, obliteration and recontouring of the hillslope can be done.

BMP Leave abandoned roads in a condition that provides adequate drainage without further maintenance. Close these roads to traffic; reseed and/or scarify; and, if necessary, recontour and provide water bars or drain dips.

Removing culverts can prevent erosion problems, and water bars may be a solution. Space water bars more closely in areas likely to erode. Cut and fill slopes may need to be extended to a more natural grade.

It may be necessary to rip or decompact both the road subgrade and its surfacing material before seeding can be successful. Attaching a sub-soiler can improve decompaction results.

It is necessary to restore all drainage features to approximate their original condition. This includes reseeding both the road surface and cut and fill slopes.

Bridges present special road closure problems. Unless there are regular inspections of bridge abutments and other structural components, it may be best to remove the bridge structures.

Excavator dismantling the road corridor.

Obliterated road segment with large wood in place before reseeding the surface with grass.

CHOOSING AND DESIGNING A STREAM CROSSING

Stream crossing structures include culverts, arches, bridges, and fords. Each is designed to maintain natural water flow and provide a safe vehicle crossing. Choosing the wrong stream crossing structure can result in damage to both the immediate site and downstream water uses.

Your Choice of Stream Crossing Depends On:

- **Stream size.** Bridges are best for streams more than 10 feet wide and those with high-gradients.
- **Is it a fish-bearing stream?** Arches and bridges protect the natural streambed with less impact on fish.
- **Construction and maintenance costs.** Crossing structures ranked in order of increasing cost are: ford, round culvert, squash culvert, bottomless arch, and bridge.
- **Future years of use.** Culverts provide a smoother ride and better access than fords.
- **Soil foundation conditions.** Bedrock crossings may require a bottomless arch, bridge or ford.
- **Available equipment and materials.** Culverts require a backhoe, crane, or excavator, portable compactor, bedding gravel, armoring material, and sediment filter.
Bridges may require additional equipment depending on the complexity of the installation.
Fords require armoring of approaches and stream bottom and possibly geotextile and excavation equipment.
- **Fords vs. culverts/bridges.** For low use roads, fords may be a practical and economical choice in streams that may or may not have fish and that have a hard bottom which can support vehicles or allow armoring to protect it.

Design Considerations

BMP Design stream crossings for adequate passage of fish (if present) with minimum impact on water quality. When using culverts to cross small streams, install those culverts to conform to the natural stream bed and slope on all perennial streams and on intermittent streams that support fish or that provide seasonal fish passage. Ensure fish movement is not impeded. Place culverts slightly below normal stream grade to avoid outfall barriers.

Planning for a stream crossing must include flood calculations. When ignored, the potential for water-quality damage is enormous. The costs of this culvert repair will far exceed the costs of a properly planned installation.

BMP Minimize the number of stream crossings and choose stable crossing sites.

Legal Requirements

BMP Under the Montana Natural Streambed and Land Preservation Act of 1975 (the “310 Law”), any activity that would result in physical alteration or modification of a perennial stream, its bed or immediate banks must be approved in advance by the supervisors of the local Conservation District. Installation or removal of permanent or temporary stream-crossing structures, culverts, fords, riprapping, or other bank stabilization measures on perennial streams are some of the forestry-related projects subject to 310 permits.

BMP Before beginning such a project, the operator must submit a permit application to the Conservation District indicating the location, description, and project plans. The evaluation generally includes on-site review, and the permitting process may take up to 60 days.

BMP Stream-crossing projects initiated by federal, state or local agencies are subject to approval under the “124 permit” process (administered by the Department of Fish, Wildlife and Parks) rather than the 310 permit.

Other Permits

Other permits may be required. These permits may be local in origin (city, county, special protection zone, etc.). It is your responsibility to acquire all necessary permits before work begins.

Appropriate Road Drainage and Vegetation Filter Zones

Intact duff layers and larger woody debris (over 3" diameter) that has good soil surface contact slows water movement and also allows for better soil water absorption and retention.

BMP Leaving appropriate amounts of logging debris on a landscape can slow surface water runoff and help mitigate flood events.

BMP Cross streams at right angles to the main channel if practical. Adjust the road grade to avoid the concentration of road drainage to stream crossings.

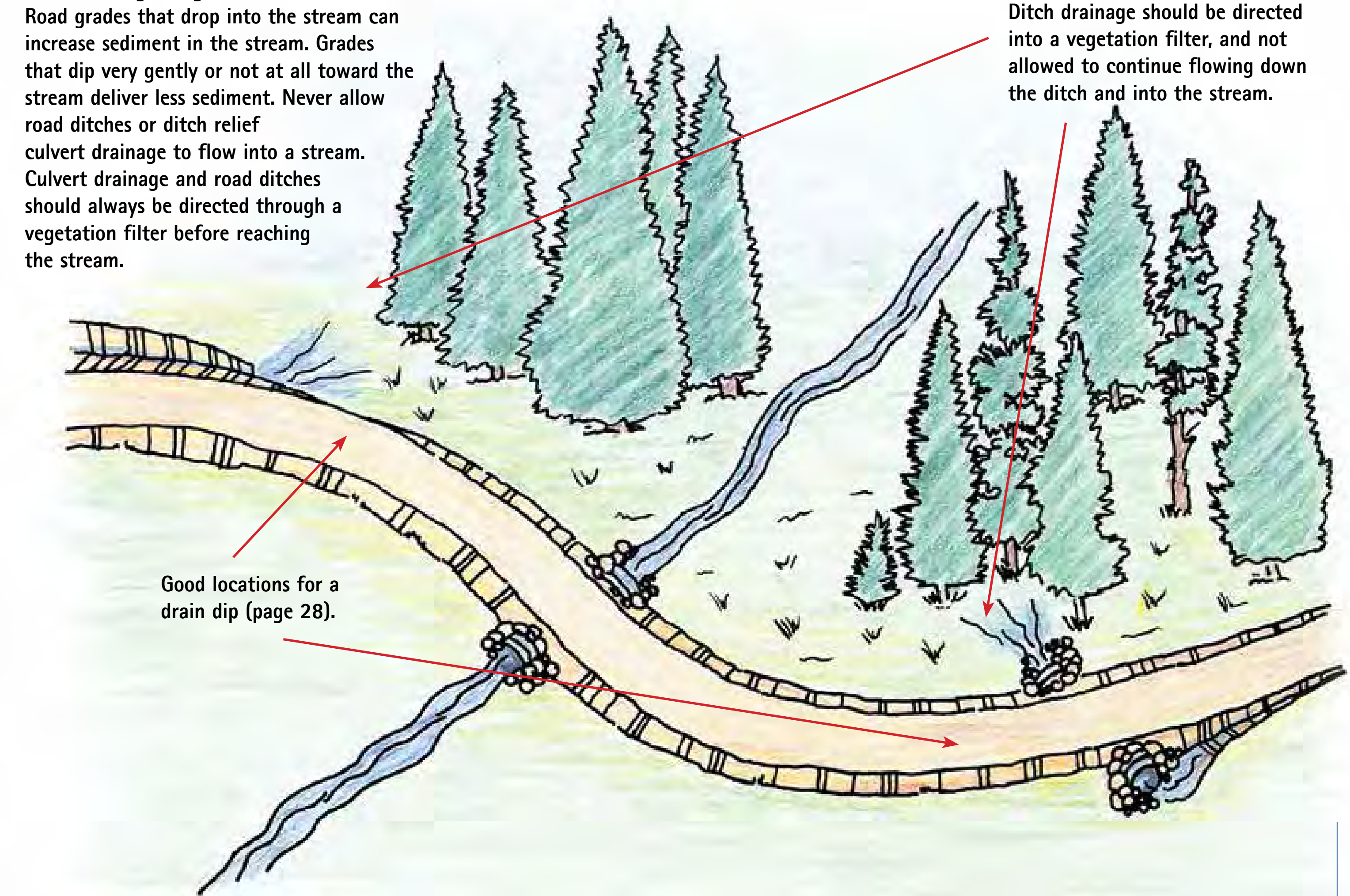
BMP Direct road drainage away from stream crossing site.

The Problem: Here we see the old practice of allowing ditch drainage to flow directly into a stream. At one time, this was common practice. Current practices and BMPs require diversions and protection of the stream. Never let ditch water flow directly into a stream.

The Solution: Always route ditch drainage through a filter of undisturbed vegetation so sediment can be removed before water reaches the stream.

Roads should be located so they cross streams at right angles to the main channel. Road grades that drop into the stream can increase sediment in the stream. Grades that dip very gently or not at all toward the stream deliver less sediment. Never allow road ditches or ditch relief culvert drainage to flow into a stream. Culvert drainage and road ditches should always be directed through a vegetation filter before reaching the stream.

Ditch drainage should be directed into a vegetation filter, and not allowed to continue flowing down the ditch and into the stream.



Good locations for a drain dip (page 28).

STREAM CULVERT INSTALLATION

Remember: a 310 permit is required for any perennial stream crossing (see page 36).

BMP Minimize stream-channel disturbances and related sediment problems during construction of road and installation of stream-crossing structures. Do not place erodible material into stream channels. Remove stockpiled material from high-water zones. Locate temporary construction bypass roads in locations where the stream course will have minimal disturbance. Time construction activities to protect fisheries and water quality.

BMP 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 feasible.

BMP Consider dewatering stream-crossing sites during culvert installation.

Fish Passage

BMP When using culverts to cross small streams, install those culverts to conform to the natural stream bed and slope on all perennial streams and on intermittent streams that support fish or that provide seasonal fish passage. Ensure fish movement is not impeded. Place culverts slightly below normal stream grade to avoid culvert outfall barriers. Do not alter stream channels upstream from culverts, unless necessary to protect fill or to prevent culvert blockage.

1

Construction of culvert stream crossings has the greatest potential to cause immediate sediment pollution. Installing culverts is more than just placing a pipe in a stream. Complete the work promptly, at a time when the least damage will occur.

2

The temporary channel in the foreground carries stream water. The dewatered stream channel is being cleared for culvert installation. The channel foundation and trench walls must be free of logs, stumps, limbs, or rocks that could damage the pipe.

5

Once the ends are secured by backfill, the center of the culvert is covered.

9

After checking to be sure the new culvert is working, close the dewatering channel.

10

The road approach to the new culvert is the next phase of construction.

3

The culvert bed must conform with the natural streambed. The bed should be either rock-free soil or gravel. Bedding should provide even distribution of the load over the length of the pipe. Countersink the culvert to allow stream gravel to deposit in culvert bottom (see detailed diagram, page 40).

4

Secure each end of the culvert with backfill. Pour backfill material over the top of the pipe. This allows finer soil particles to flow around and under the culvert sides. Larger particles roll to the outside. Fine soil particles, close to the culvert, compact more easily.

6

Tamping fill material throughout the entire backfill process is important. The base and sidewall material should be compacted first. This reduces any chance of water seepage into the fill.

7

Armor the culvert inlet and outlet. Rocks, logs or grass seeding can be used to protect these locations against erosion. Check the area upstream and downstream from the culvert. Clear upstream area of woody debris that might plug the culvert.

8

After the new culvert is opened to water, watch for the need for more rock armor. Be sure that a minimum of one foot of compacted soil covers the top of the culvert. For larger culverts, the compacted fill material should be 1/3 the culvert diameter, at a minimum.

11

Layers of fill are pushed into place and carefully compacted to build up and maintain a consistent road grade.

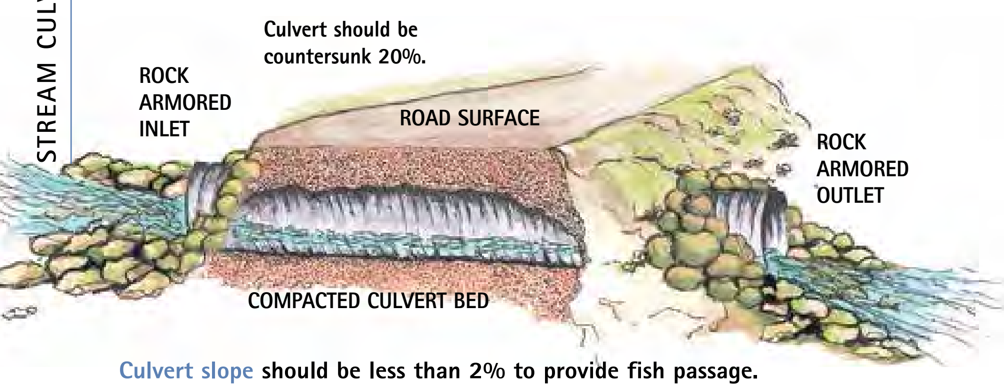
12

Additional measures that severely limit sediment entering the stream are rock armoring and the placement of a slash-filter windrow (see page 23) to both limit sediment flow and provide stability to the fill slope.

Stream Culvert Installation Details

BMP Use culverts with a minimum diameter of 15 inches for permanent stream crossings and cross-drains.

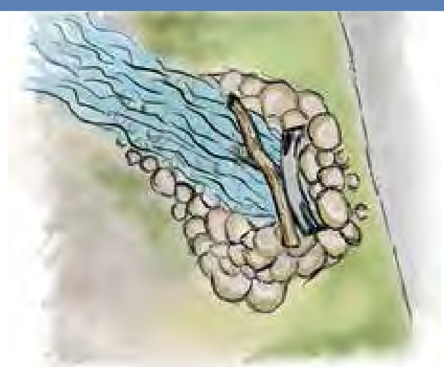
BMP Maintain a 1-foot minimum cover for culverts 15 to 36 inches in diameter, and a cover of one-third diameter for larger culverts to prevent crushing by traffic.



Culvert slope should be less than 2% to provide fish passage.

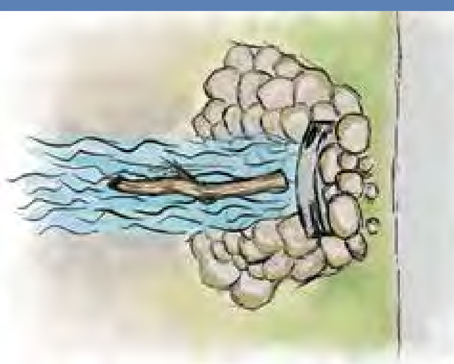
At least 20% of the culvert should be countersunk. This partial burial of the culvert into the streambed reduces water velocity in the culvert and allows gravel to deposit in the bottom.

Incorrect Culvert Alignment



Incorrect alignment of culvert with stream results in accumulation of floating debris and eventual inlet plugging.

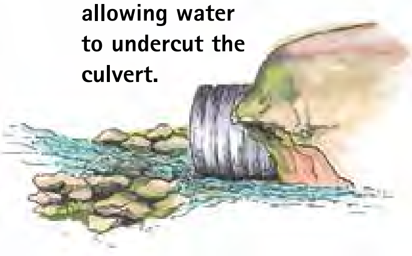
Correct Culvert Alignment



Common Culvert Installation Problems

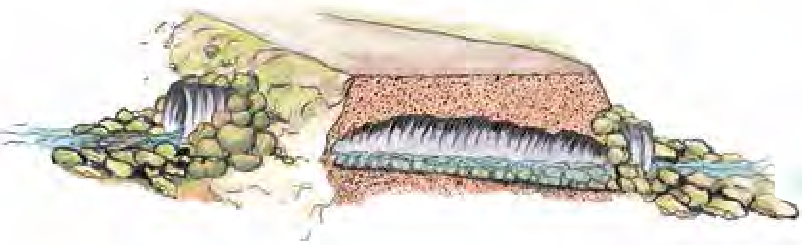
Culvert alignment is critical for proper culvert function. Culverts set at an angle to the channel can cause bank erosion. Skewed culverts can develop debris problems. Culvert alignment must fit the natural stream channel. Place culverts slightly below the natural streambed so water can drop slightly as it enters.

Inlet is not deep enough, allowing water to undercut the culvert.

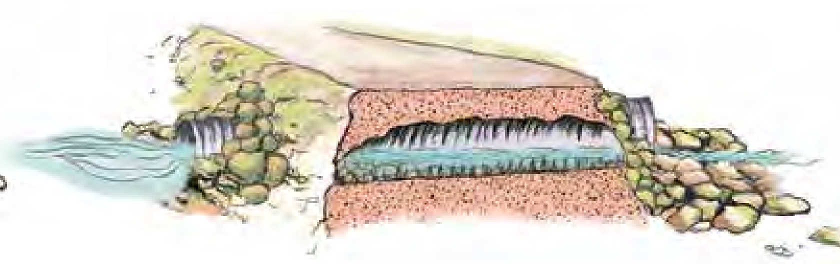


Outlet set too high and water undercuts the road fill and streambed.

Culverts installed at greater than stream grade result in the outlet becoming buried, and flow is restricted.



Culverts installed at less than stream grade result in the inlet becoming buried, flow is restricted, ponding occurs at inlet, and raised outlet results in scoured streambed.



STREAM CROSSINGS AND FISH

The Problem of Culverts and Fish

• Culverts can be a problem when used on fish-bearing streams.

• Fish move upstream to spawn, search for favorable water temperatures, and find food during aquatic insect hatches.

• A fish moving upstream through a culvert is like a person trying to climb an escalator moving in the opposite direction.

Make It Easier for Fish

• Do not force fish to jump to enter or pass through a culvert.

• Keep culvert openings free of debris.

• Be sure there is no change in channel slope at the culvert site.

• Minimize culvert length.

• Locate culverts on a straight part of the stream.

• Set culverts below stream grade so streambed gravels can naturally accumulate inside.

• Corrugated culverts help fish by providing a low flow zone next to the wall where passage is easier.

• Provide resting pools.

Fish may not be able to swim fast enough to overcome culvert water velocity that develops in round culverts with low cross-sectional flow area. Rule of thumb: water moving through a culvert faster than a brisk walking pace is potentially a fish passage barrier.

Water may be too shallow for fish to swim. This is sometimes a problem created by squash pipes that are used when road clearance over the pipe is limited. Shallow water leaves fish partially submerged and unable to get maximum thrust from tail and body movements.

There is no pool below the inlet for fish to rest in or jump from.

BMP Ensure fish movement is not impeded.

Hanging culverts can create a fall too high to jump.

Step pools at culvert outlets can sometimes correct the problem of hanging culverts by allowing fish to rest before attempting passage.

What's Best for Fish Passage?

Ranked from most optimum.

1. Bridges
2. Bottomless arches
3. Countersunk corrugated pipe
4. Corrugated pipe with a slope less than 0.5%.
5. Corrugated pipe, with baffles or sills, on grades between 0.5 and 5.0%. Sills are v-shaped, miniature dams that increase flow depth during low flows and decrease water velocity through the culvert.

Bottomless arches leave the streambed intact, making it easier for fish to pass. Natural streambed roughness creates pockets of low water velocity where fish can move comfortably. Bedrock or concrete footings are required.

BRIDGE CROSSINGS

Tips when Considering Permanent Bridges

• Size bridges to accommodate stream channel width plus minimum 25-year flood risk.

• Bridges and bridge approaches should be constructed to minimize soil or other material from reaching the stream.

• Whenever possible, retain existing vegetation and organic material around stream crossings. It is the most effective erosion control.

• Abutments and wingwalls should prevent material from spilling into the stream.

Bridges are best for large streams and those plagued with floatable debris problems. Bridges and arches have the least impact on fish.

Keep road drainage under control. Sediment is being carried around this bridge abutment and draining directly into the stream.

Advantages of Portable Bridges

• Handy for stream crossings on temporary low-standard roads.

• Useful when short-term access to forest land is cut off by a stream.

• Quick, economical, and can be installed with minimal impact.

• The crossing can be restored to its original condition.

A portable bridge provides access across streams less than 10 feet wide with minimal disturbance to streambanks or bed (310 permit required). Select locations with firm soil banks, level grade, and minimal vegetation clearing.

Along with its portability, this bridge is strong enough for all harvesting activities.

This 20-foot portable bridge was hauled into place on a flatbed truck, stretched across the stream, and set into place in one day. The bridge cribbing is 10-foot timbers laid on the ground four feet from the bank.

A small tractor built the road approaches to the bridge. Over a three-week period, the bridge carried approximately 25 truckloads of logs.

When harvest was completed, the temporary bridge was removed. Remember, whether temporary or permanent, any stream crossing on a perennial stream requires a 310 permit.

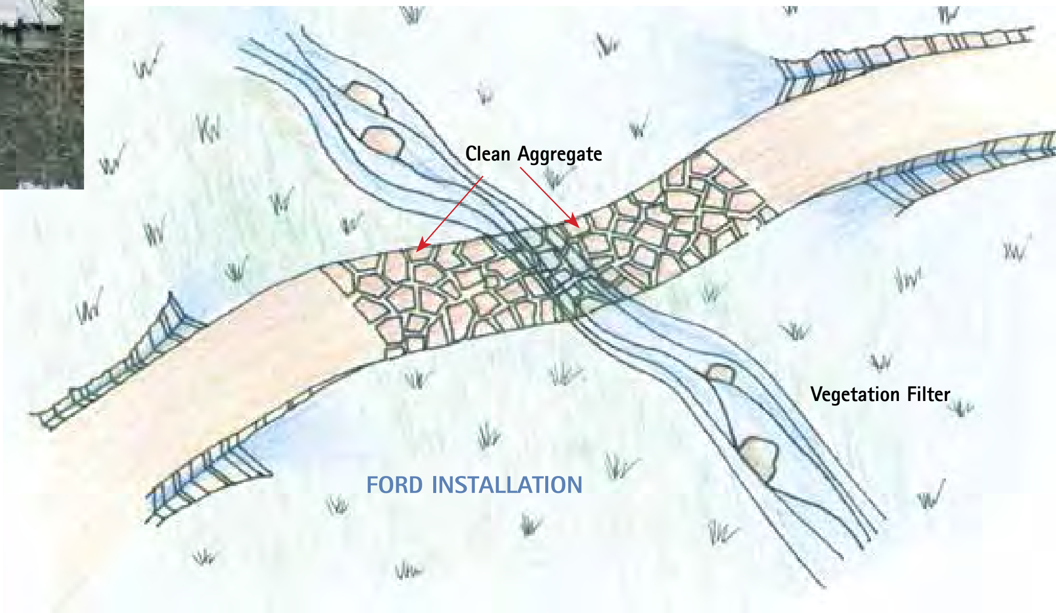
FORD CROSSINGS

What is a Ford?

A ford is a stream crossing option for low service level roads that are private, gated, and have infrequent use. Fords are low cost and maintenance is fairly minimal. Access control is important to avoid damage to the ford approaches during high water. Fords seldom have year-round access.

Limited traffic on this improved ford crossing has both minimal impact on the streambed and on sediment production.

Fords are the least desirable stream crossing because of the continued disturbance to the streambed. However if used infrequently, at low flows, it may be the least impact option.



FORD INSTALLATION

Where should a Ford be Located?

A bedrock stream bottom is ideal for a ford location. Otherwise, the bottom should be armored with suitable rock or concrete planks.

The size and shape of in-stream rock can indicate the minimum size of armor rock required to resist downstream movement. It should be larger than what you see in your stream bottom. Angular rock is preferred, because it resists movement by interlocking. When constructing a ford, keep water depth in mind. You should not restrict fish passage any more than normal fluctuations in stream flow.

Gently sloping, stable streambank approaches are preferred. Approaches should be rocked when necessary to minimize erosion when driving in and out of the ford. Where practical, approaches should be at right angles to the stream to leave a minimal footprint and minimize erosion. Approaches should dip into and out of the stream, creating a concave shape that ensures the stream cannot be diverted out of its natural channel and down the road.

When crossing a perennial stream a 310 permit is required for private lands. This permit is granted by the local county Conservation District, and they will approve the site prior to installation and the granting of the permit.

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

Concrete planks, fastened together and stretched across the streambed, provide an "improved" ford crossing.

FOREST SOIL

How does it function?

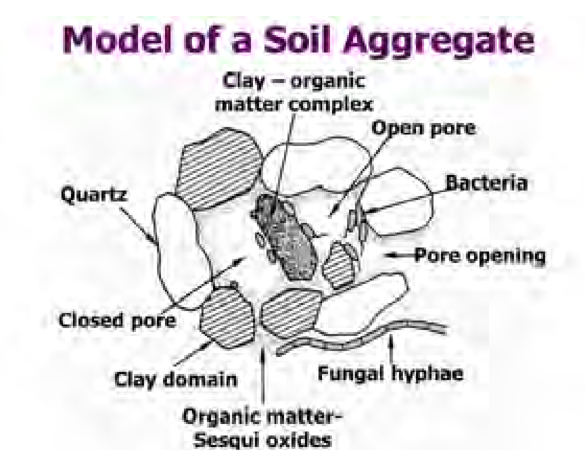
Forest soils are comprised of the original geologic mineral substrate that has been deposited across the topography of the landscape, acted upon by various biotic organisms, and over time weathered by the climate conditions of the region. The most biologically active portion of any soil is near the surface, where the levels of oxygen and water are most conducive for plant root growth and microorganism activity. For this reason approximately 90% of all forest tree roots occur within the upper 6 inches of soil. The uppermost soil layer is most heavily influenced by the incorporation of organic matter – mostly from grass, forb, and shrub fine root turnover and decomposition, but also the deposition of woody debris on the soil surface.

Soils on steep slopes and mid-to high elevation tend to be thin and poorly developed. 95% of the roots in this stand are within the upper 6 inches of soil and thus easily damaged by logging equipment.

Relatively young soils showing different layers within the soil as a result of surface organic matter, fine plant roots, leaching from water and time. Tree roots utilize each layer differently to capture optimal water and soil nutrients.

The Soil Profile

- The organic (O) horizon consists of detritus, leaf litter, and other organic material on the surface of the soil. This layer is dark because of decomposition. This horizon does not exist in all soils.
- The A horizon, or topsoil, is usually darker than lower soil layers, and it is loose and crumbly with varying amounts of organic matter. This horizon is usually the most productive layer of the soil.
- The E horizon, not shown here, is the zone of maximum eluviation (maximum transport of minerals downward to the B horizon). It is light in color with decreased pH. There are few roots in this zone.
- The B horizon, or subsoil, is usually lighter in color, dense, and low in organic matter content. Most of the materials leached from the A horizon stop in this zone. Because of this leaching, the B horizon has a higher clay content than the A horizon.
- The C horizon is the transition area between the soil and the parent material. This is the area in which parent material has only just begun to develop into soil. At some point, the C horizon will lead to the final horizon: bedrock or parent material.



Structure

Well developed and productive soils develop aggregates called "colloids" that combine to form a blocky matrix within the soil. These blocky structures are comprised of mineral particles that are glued together by organic mater as well as decomposed and chemically altered minerals naturally found within the geologic parent material.

Soil structure is important for multiple reasons, first because the larger cracks between colloids allow for rapid water infiltration, oxygen exchange and fine root penetration. The colloids hold onto water as well as important macronutrients such as nitrogen, phosphorus, potassium, sulfur, and calcium, and micronutrients including boron, zinc, manganese, iron, copper, chloride, and manganese. Finally, a well developed soil structure also helps give a soil strength and resistance to disturbances such as erosion and compaction from surface traffic.

FOREST HARVESTING IMPACTS

Compaction

Harvesting requires moving heavy logs, and this action has significant potential to cause soil compaction, whether it is through traditional means such draft horses, small tractors, or purpose-built equipment. Most modern logging equipment has been specifically designed to have low compaction potential through the use of multiple high floatation tires or specially designed tracked machines – actually much less than the compaction potential of a farm tractor.

Timing activities with periods of either frozen ground, deeper snow (> 1 ft), or dry soil is optimal for reducing compaction potential. Also using efficiently spaced designated skid trails (that cover less than 15% of the total soil surface area) can limit the impacts of these trails on tree growth to less than 2%. Alternatively using dispersed equipment travel, where the same site is not driven over more than once can also work, though this requires a greater sensitivity to soil conditions where only dry of frozen soils are driven on.

Every soil has a different potential for compaction and erosion, which is why soils have been mapped and analyzed for their potential uses. These maps, created by the Natural Resources Conservation Service (NRCS) can be easily accessed at: http://websoilsurvey.nrcs.usda.gov.

Wet soils are more prone to soil compaction from the pressure and vibration of heavy machinery than dry soils. However, by using only well spaced designated trails, long term impacts on overall forest growth can be reduced to 2% or less.

Machinery such as this forwarder operates on low pressure tires to move logs from stumps to truck loading sites. Well placed trails minimize impacts to soils and forests.

Soil compaction occurs when pressure and vibration is applied to a soil surface that results in compression of soil air spaces called "macropores." Without these pores soils are limited in their ability to absorb water and air, and root growth is stunted. Ultimately compacted soils limit water infiltration, which in turn promotes surface water runoff and erosion, and a loss of long term soil productivity. Compacted soil can be identified by its resistance to penetration by a steel rod, platy horizontal soil cracking (that leaves a structure resembling the pages of a book), and severe resistance to water infiltration (water runs off or pools on the surface rather than soaking in).

Soil moisture is a key to tree and forb growth, but can also enhance equipment impacts on soils. One pass of heavy equipment over wet soil can cause significant compaction, whereas dry soils can be extremely resistant to the same effect. Soil texture is also a key component. Sandy soils have poor strength and are easily displaced, but are difficult to compact. Clayey soils can have great strength and resistance to compaction when dry, but are severely compactable and structurally weak when wet.

HARVEST SYSTEMS

Designing a Harvest

"Timber harvest" is defined as the removal of any wood fiber from the forest for commercial purposes, and includes saw timber, pulp, and biomass materials such as slash, tops, branches, needles, and leaves.

BMP Plan timber harvest in consideration of your management objectives and the following:

1. Soil and erosion hazard identification, compaction potential, long term site productivity, organic material retention
2. Rainfall
3. Topography
4. Silvicultural objectives
5. Road location and transportation plan
6. Critical components (aspect, water courses, landform, etc.)
7. Habitat types
8. Potential effects on water quality and beneficial water uses
9. Watershed condition and cumulative effects of multiple timber management activities on water yield and sediment production
10. Wildlife habitat, biodiversity, and native species
11. The best time to harvest in relation to all of the above

Which of the Harvesting Systems Should You Use?

1. Whole-tree harvesting
2. Cut-to-length harvesting
3. Conventional harvesting
4. Cable yarding harvesting
5. Helicopter harvesting

Harvest site terrain influences the choice of a logging system. On gentle terrain, harvesters and forwarders, tractors and skidders, and even horses can be a logical choice. On steep terrain, cable or helicopter harvesting equipment is used. Each logging system is described in the following pages. You may also want to consider what equipment is suitable for removing biomass.

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

BMP Use the economically feasible yarding system that will minimize road densities.

Thinning

Light thinning, such as on open slopes, equal fewer trees removed – leaving the best and the healthiest.

Moderate thinning mostly in even-aged stands where competition is high.

Moderate to heavy thinning where multi-storied stands exist that create heavy fuels and a very dense and potentially stagnant forest. Here opened up in a scattered and clumpy pattern to favor wildlife and a more scenic look.

Questions for the Plan

A timber harvest plan must consider the long-term effects of harvesting on all forest resources. Before any timber harvest, ask the following questions:

When combined with other harvests and road construction in the watershed, will there be an effect on water yield and sediment?

Are there soils present with a high potential for compaction and/or erosion?

Do I understand the topography – slopes, drainages, streams, and other physical features?

Are there riparian and wetland plants indicating areas that require special attention? (See page 9)

How will the harvest affect wildlife habitat for large and small animals and birds? Are nesting snags being left? Will the alteration of elk habitat displace elk use due to a lack of grazing or good hiding cover?

Is there a forest management plan in place? Does it address all of your questions and concerns? Is it being implemented as the guide for your harvest project?

What kind of slash treatment and site preparation will be necessary? (See pages 54-55)

Forest Management Planning

Harvesting timber may be part of any forest management planning activity regardless of ownership. Federal lands must comply with many rigorous reviews under the National Environmental Policy Act (NEPA) and state lands under the Montana Environmental Policy Act (MEPA). Harvesting practices on federal or state lands will typically be highly specified by contract, though on the ground BMPs may not be individually described. Montana BMPs should be followed regardless of ownership and contract authority because water crosses all ownership boundaries.

Private lands may use a variety of forest management planning sources. Plans can be written by consultants, service foresters or by landowners themselves through workshops such as the Montana Forest Stewardship Program. An example of the criteria that should be considered and addressed for a forest management plan before harvesting takes place that is based on national and international standards of sustainable forestry can be downloaded from the Montana State University Extension Forestry web page at: www.msuextension.org/forestry/downloads.htm "Forest Stewardship Plan."

To ensure proper resource protection as part of a management plan it should incorporate the use of BMPs. BMPs are logging practices that can be applied when logging a managed property no matter the ownership.

WHOLE TREE HARVESTING

A feller-buncher cuts and piles small bundles of trees. A tractor drags the tree bundles to the landing with limbs and tops attached to the stem.

Attributes

• Slash - tops, branches, needles, and leaves - is brought to the landing or roadside where it can be sorted and processed for biomass markets, returned to the forest, or piled and burned.

Topography Considerations

• Can be used on slopes up to 50%.

• Haul roads are usually on flatter ground.

Soil Considerations

• Potentially more soil scarification than cut-to-length harvesting.

• A greater portion of the area is covered by machines as they cut, stack, gather, and drag whole trees to the landing or roadside.

• Skid trails may become rutted and compacted from repeated use.

• Potential for less nutrients and organic matter retained on site if slash is not returned/distributed.

Forest Stand Considerations

• Most efficient and effective method for harvesting logs and biomass off of a given site.

Equipment Used

• Feller buncher
• Skidder with grapple
• Log loader
• Mechanical processor

Slash Treatment

• Slash piles burned or ground at a later time.

• Sometimes slash is returned to the forest and distributed (see page 55 and 59).

Reforestation Considerations

• Dragging tree bundles can leave scarified soils for natural seeding.

• Care must be taken not to introduce noxious weeds onto harvest sites.

Economic Considerations

• Operating on steeper ground raises the harvest cost due to increased complexity.

• Longer skid distances increase costs.

• Bunching trees reduces costs for handling biomass (small diameter trees, limbs, tops).

A feller buncher severs trees and lays them in bunches with limbs and tops attached. Bunches are oriented with tree trunks facing downhill.

A crawler tractor or skidder with a grapple picks up bunched trees and drags them to a landing or roadside. Some grapples can swing 180 degrees, making it easier to operate in tight spaces.

The stroke-boom delimber operates at the landing or roadside, removing tree limbs and top, cutting the stem into logs, and stacking them.

In addition to loading log trucks, the loader is used to pile tops, branches, and log chunks for treatment or burning.

BMP Locate skid trails to avoid concentrating runoff and provide breaks in grade. Locate skid trails and landings away from natural drainage systems and divert runoff to stable areas.

BMP Limit the grade of constructed skid trails on geologically unstable, saturated, highly erosive or easily compacted soils to a maximum of 30%. Use mitigating measures, such as water bars and grass seeding, to reduce erosion on skid trails.

BMP Tractor skid when compaction, displacement and erosion will be minimized. Avoid tractor or wheeled skidding on unstable, wet or easily compacted soils and on slopes that exceed 40% unless operation can be conducted without causing excessive erosion. Avoid skidding with the blade lowered. Suspend leading ends of logs during skidding whenever possible.

BMP Ensure adequate drainage on skid trails to prevent erosion. On gentle slopes with slight disturbance, a light ground cover of slash, mulch or seed may be sufficient. Appropriate spacing between water bars is dependent on the soil type and slope of the skid trails. Timely implementation is important.

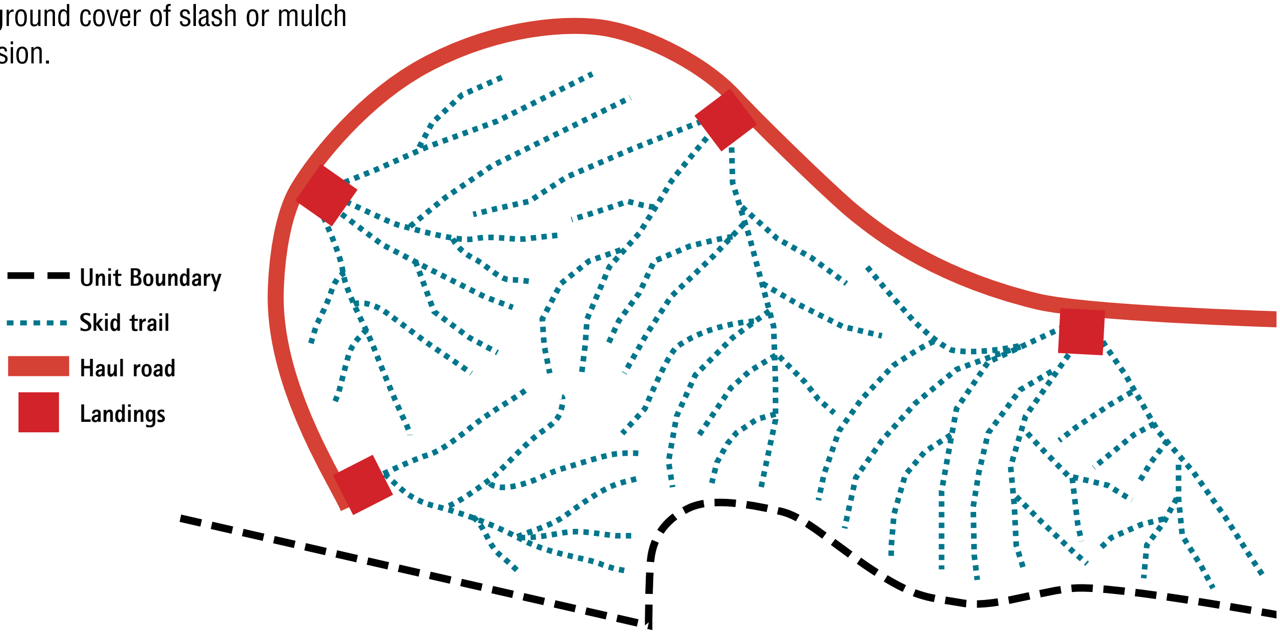
BMP When existing vegetation is inadequate to prevent accelerated erosion before the next growing season, apply seed or construct water bars on skid trails, landings, and fire trails. A light ground cover of slash or mulch will retard erosion.

As much as 40% of an area may be covered with skid trails if they are not planned and marked in advance. Heavy soil disturbance on multiple trails or poorly located trails can create erosion problems and reduce forest regeneration. Avoid multiple heavy-use trails; focus instead on a skidding plan that minimizes impacts.

Unnecessarily dense skid trails or trails on steep erodible slopes.

Typical Harvest Layout

The feller buncher and grapple skidder travel over most of the unit. There is an effort to confine multiple trips to primary skid trails.



CUT-TO-LENGTH HARVESTING

The processor cuts, delimbs, and bucks logs to lengths that are sorted and stacked in the forest. The forwarder picks up the logs in the forest and transports them to the roadside.

Attributes
- Distributes slash (tree branches and tops) and leaves on the forest floor.
- Minimizes the need for access roads and log landings.

Topography Considerations
- Limited to terrain with less than 40% slopes.

Soil Considerations
- Generally less soil disturbance.
- Minimizes soil disturbance by confining machines to designated trails.
- Compressed mat of slash stays in the forest and acts as fertilizer.
- Additional treatment may be required for reforestation.

Forest Stand Considerations
- Efficient method for commercial thinning.
- Moves short logs out of the forest rather than long logs.
- Useful for reducing wildfire hazard.

Equipment Used
- Harvester
- Forwarder

Slash Treatment
- Usually complies with Slash Hazard Law requirements without additional treatment.
- Can reduce the cost of required slash treatments.

Reforestation Considerations
- Preferred in stands where additional tree seedlings are not wanted.

Economic Considerations
- Fewer roads may reduce overall harvest costs.
- This machinery is expensive and availability may be limited.
- Collection of slash, tops, branches, needles, and leaves for biomass utilization is more expensive.

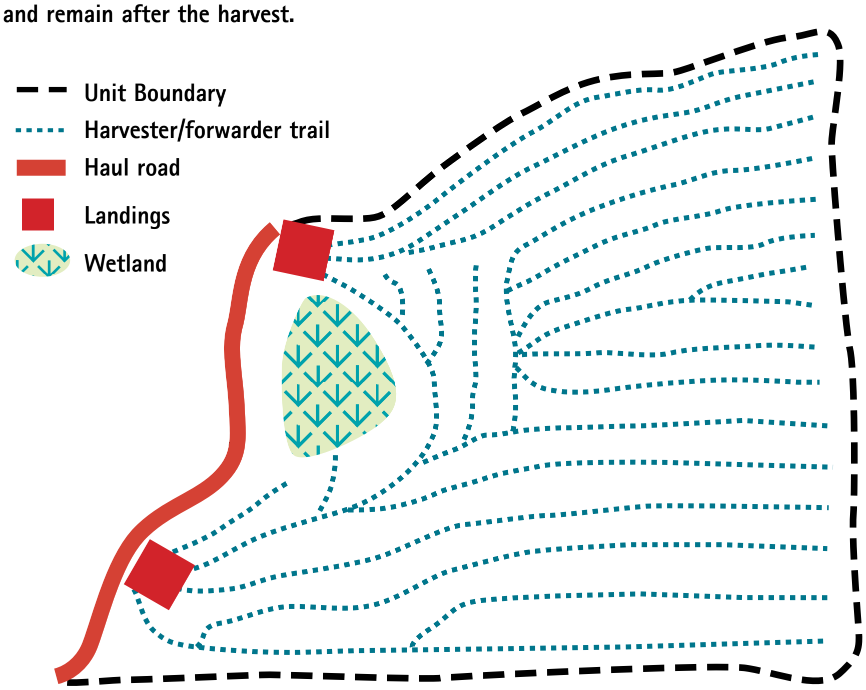
Harvesters reach out 30-40 feet, cut a tree, strip the limbs, cut the stem into computer-programmed lengths, and lay the logs on the ground, all in less than one minute. These machines travel on the carpet of tree tops and limbs they leave.

Forwarders follow behind the harvester, using the same slash carpet, picking up logs, and delivering them to the landing. They can travel long distances, reducing the need for haul roads.

Logs are offloaded from the forwarder directly to log trucks or road-side decks.

Typical Harvest Layout

Designated harvester/forwarder trails are generally at least 75 feet apart and often follow a parallel pattern across the harvest unit. Slash should be compacted on trails and remain after the harvest.



CONVENTIONAL HARVESTING

Attributes
• Adaptable to smaller harvest locations.
• Techniques are highly variable.
• Generally applicable to smaller acreages or high value trees.

Topography Considerations
• Can be used on slopes up to 50%.
• Haul roads are usually on flatter ground.

Soil Considerations
• Designated skid trails or existing roads confine machines to predesignated locations and reduce soil disturbance.
• Multiple trips on the same skid trail may result in rutting.
• Soil disturbance can be minimized by widely spaced skid trails.
• Lop and scattered slash may be retained to provide nutrients and organic material.

Forest Stand Considerations
• Gives maximum flexibility to a variety of stand management goals.
• Using designated skid trails allows for repeated entries over time.

Equipment Used
• Chainsaw
• Log loader
• Log skidder or farm tractor
• Processor

Slash Treatment
• Allows for lop and scatter of slash.
• Treatment involves piling and burning of numerous in-woods piles or large landing pile or chipping/grinding.

Reforestation Considerations
• Degree of ground scarification can vary by treatment or management prescription.

Economic Considerations
• Often more labor intensive.
• Generally, more roads are necessary.

BMP Design and locate skid trails and skidding operations to minimize soil disturbance. This limits site disturbance and soil compaction.

BMP Use existing skid trails where practical, located appropriately, and consistent with other management objectives.

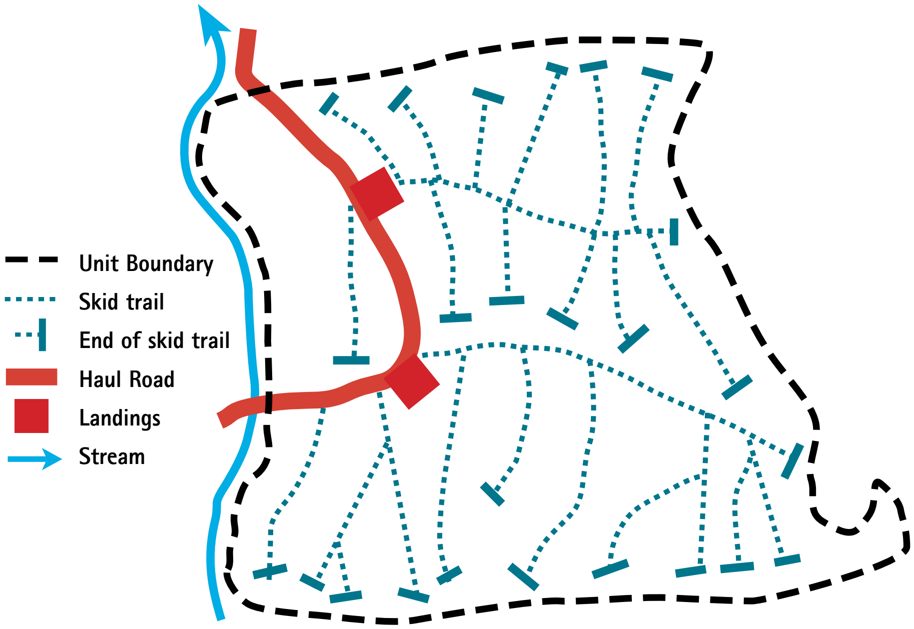
Tree felling, limbing, and bucking are done with chainsaws.

BMP Consider the potential for erosion and possible alternative yarding systems prior to planning tractor skidding on steep or unstable slopes.

Logs are dragged by a skidder from the forest to a log landing. Rubber tired skidders or crawler tractors remain on the skid trail and winch line and chokers pull the logs to the machine. Limbing and bucking are done with chainsaws.

Once at the landing, a log loader moves logs onto trucks for delivery to the mill.

Typical Harvest Layout



Skid trails should be planned and marked in advance. They often follow a parallel branching pattern as shown. By winching logs from greater distance, skid trails can be farther apart, reducing the number of designated skid trails and minimizing the soil impact by equipment.

CABLE YARDING HARVESTING

This system pulls logs to a landing or road using a steel cable.

Attributes
- Allows harvesting to occur on steep ground.
- Eliminates the need for skid trails.
- Haul roads are usually at the top of the logging unit.

Topography Considerations
- Usually 45% slopes and greater.
- Concave slopes allow more cable deflection and greater system efficiency

Soil Considerations
- Significantly reduces soil compaction and disturbance.
- All equipment is generally confined to roads and landings.

Forest Stand Considerations
- Used in partial cuts and clearcuts.
- Difficult for commercial thinning that is based on specific criteria such as species, tree health, or spacing where cable corridors may not be appropriate.

Equipment Used
- Cable yarder
- Log loader
- Chainsaw
- Processor
- Excaliner

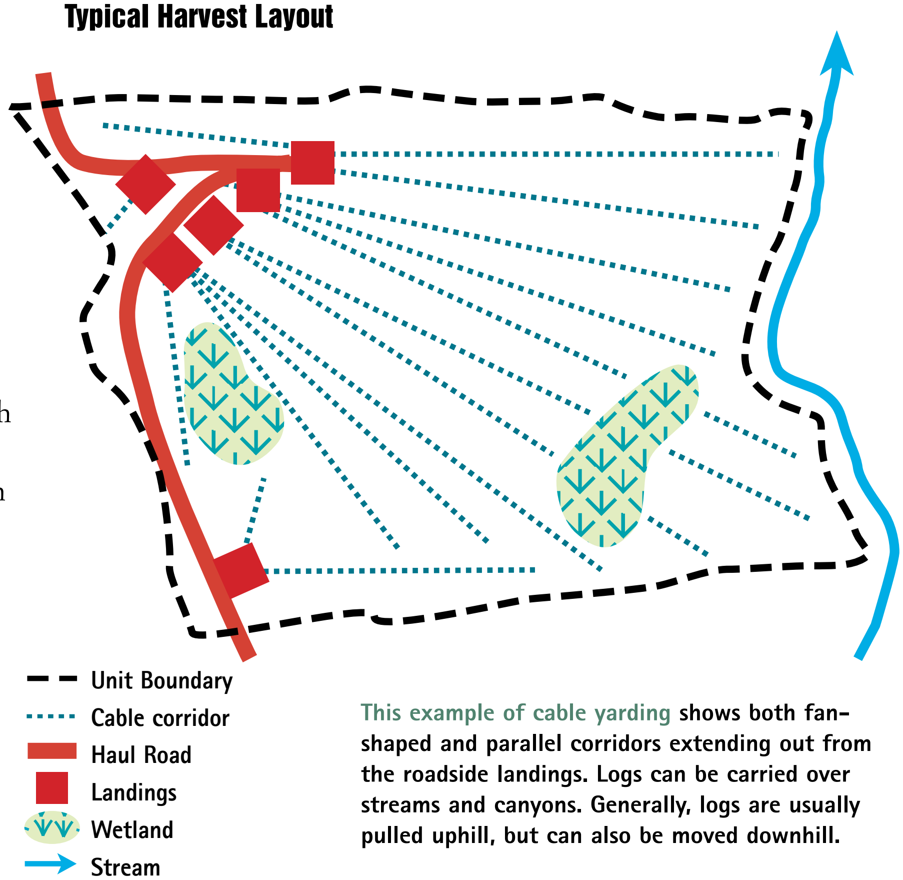
Slash Treatment
- Slash piles along roads and landings.
- If clearcut, may require broadcast burning (see page 55).
- May use whole tree yarding to address slash removal and facilitate biomass harvesting.
- Some steeper slopes may benefit from slash retention to reduce natural erosion.

Reforestation Considerations
- Can vary tremendously based on site.

Economic Considerations
- More expensive than ground-based harvest systems.
- Higher equipment costs and more labor intensive.

Trees are generally hand felled and bucked. A cable is stretched from the yarder to another point on the ground (stump, tractor, etc). The cable carries the logs over the terrain, with either one end or the entire log suspended, from where the tree is felled to the roadside or log landing. From there, logs are processed and loaded on trucks. Yarders can reach out 1,000 to 2,500 feet.

Typical Harvest Layout



This example of cable yarding shows both fan-shaped and parallel corridors extending out from the roadside landings. Logs can be carried over streams and canyons. Generally, logs are usually pulled uphill, but can also be moved downhill.

HELICOPTER HARVESTING

A harvest system once used exclusively for large, high value timber, helicopter harvesting has now become more common for smaller logs.

Attributes

- Ability to harvest sensitive, inaccessible areas or areas that cannot be harvested with other systems. Areas with high recreational use, special wildlife habitat, riparian/wetlands, and geologic hazard locations are common.
- Usually road construction is not needed.

Topography Considerations

- It can be used on any type of terrain.
- Landings are typically located downhill from harvest unit.

Soil Considerations

- Preferred where slopes are steep and soils are susceptible to compaction or erosion.
- Minimizes soil disturbance because logs are fully suspended.
- Larger landings are required.

Forest Stand Considerations

- Efficient, but costly, method of logging.
- Works where roads are not available or not desired and where management of high value stands is desired.

Equipment Used

- Logging helicopter
- Log loader
- Bulk fuel handling equipment
- Maintenance support equipment
- Chainsaw

Slash Treatment

- Typically, lop and scatter is used. Additional methods may be necessary and will be costly due to no road access.
- Biomass harvesting opportunities are limited due to cost and weight restrictions when flying.

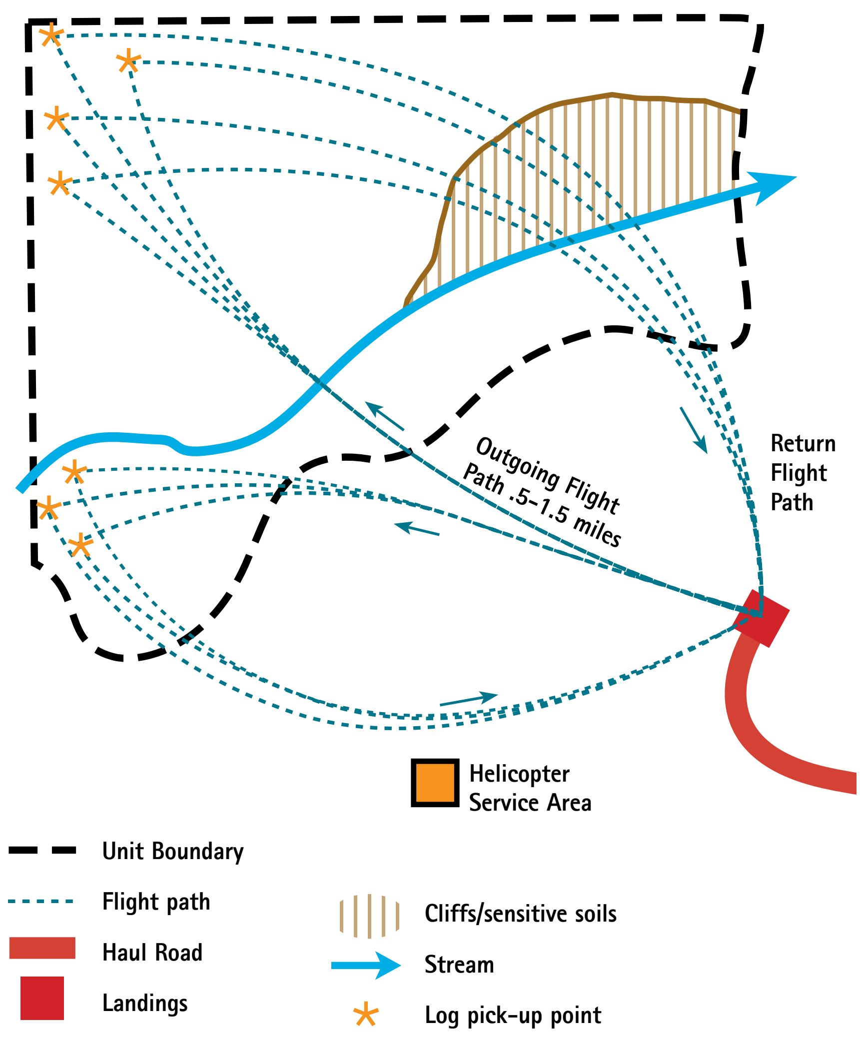
Reforestation Considerations

- Ground scarification may not be adequate for successful regeneration.

This KMAX Heavy Lift helicopter has a payload capacity of 6,000 pounds. Flight distances are typically kept to less than a mile. Longer distances are more costly. Optimum payload of each load makes the operation economic.

BMP Minimize the size and number of landings to accommodate safe, economical operation. Avoid locating landings that require skidding across drainage bottoms. Helicopter landings are large, and may require additional planning, especially if smaller logs and biomass are being harvested as well as saw logs.

Typical Harvest Layout



Economic Considerations

- Fewer roads are needed.
- Sophisticated machinery used and larger crew size typically results in costs that are 3 to 4 times more than ground-based systems.
- Used when the high harvesting cost is less than the combined cost of road construction and harvesting with a different system.

SLASH TREATMENT AND SITE PREPARATION

BMP Rapid reforestation of harvested areas is encouraged to re-establish protective vegetation. There can be significant variability in treatments depending on management goals.

Why treat slash and prepare the site?

- To reduce the wildfire hazard from logging debris.
- To prepare the harvest area for a new forest.
- To leave enough organic matter for the next forest.

Potential problems of slash treatment and site preparation

- Soil can be exposed to erosion, especially on steeper slopes.
- Soil can be compacted, displaced and/or rutted (see page 45).
- There can be a loss of organic matter needed for the next forest.
- Too much slash cleanup. When the forest is swept clean, soil erosion, compaction, soil displacement, and nutrient loss may interfere with a successful next forest.

What's Required

Montana's Slash Hazard Reduction Law requires the reduction and management of slash to reduce the risk of wildfire. However, the foliage and branches left after a harvest are a source of organic matter and nutrients needed for the next forest. Slash also protects soil from erosion. A balance is required between the need to reduce fire hazard and the need for organic matter and soil protection. Slash left in the woods should be scattered, not clumped, to keep flame lengths under the legal maximum of 4 feet.

Starting a new forest requires patches of exposed mineral soil on the forest floor. Seed from nearby trees germinates best in bare mineral soil. Mechanical slash treatment and site preparation must create some bare soil while minimizing erosion. Slash treatment, piling, or hauling to the landing, can also be done concurrent with the timber harvest.

Slash Treatment/Site Preparation

How to achieve the balance between the need for mineral soil and organic matter while minimizing erosion and reducing fire hazard.

Method 1: Machine Pile and Burn Slash

After logs are removed, excavators, skidders, or dozers equipped with a brush blade are used to pile slash. Machine piling reduces the fire hazard and creates a seedbed for the new forest. But this method can be expensive, and is not recommended on compactible soils. Multiple small piles in key locations can be an effective site preparation tool.

BMP Minimize or eliminate elongated exposure of soils up and down the slope during mechanical scarification.

Burn piles during Spring or Fall burning season when weather allows safe and effective burning.

BMP Carry out brush piling and scarification when soils are frozen or dry enough to minimize compaction and displacement.

What to Avoid When Machine Piling

Work around small trees, low brush, and large logs. Soft, loose soils may compact and inhibit new growth.

Green piles from ponderosa pine may act as breeding grounds for Ips beetles.

Stay clear of wet areas where compaction, soil rutting, and erosion can result.

BMP When piling slash, care should be taken to preserve the surface soil horizon by using appropriate techniques and equipment. Avoid use of dozers with angle blades.

BMP Scarify the soil only to the extent necessary to meet the resource management objectives. Some slash and small brush should be left to slow surface runoff, return soil nutrients, and provide shade for seedlings.

BMP Carry out scarification on steep slopes in a manner that minimizes erosion. Broadcast burning and/or herbicide application is the preferred means for site preparation, especially on slopes greater than 40%.

BMP Limit water-quality impacts of prescribed fire by constructing water bars in firelines, not placing slash in drainage features, and avoiding intense fires unless needed to meet silvicultural goals. Avoid slash piles in the SMZ when using existing roads for landings.

Method 2: Whole Tree Harvesting

Whole tree harvesting brings the entire tree, branches and top, to the landing. There, the branches and tops are removed, sorted, and processed for markets or piled and treated. Most slash is brought to a landing or central location and efficiently disposed of, leaving a clean forest floor. Where organic matter is removed, the disturbed forest floor may be susceptible to erosion, nutrient loss, and reduced productivity. Leaving some slash in the woods promotes nutrient recycling, retains organic materials, and provides habitat for a variety of species.

Method 3: Whole Tree Harvest but Return Slash

The same machines that bring whole trees to the landing can carry a portion of the slash back and scatter it on the forest floor. This method makes slash fertilizer available to the next forest and keeps soils protected from erosion, especially on skid trails. The fire danger is minimal because the slash is crushed and close to the ground. Some landowners object to the appearance.

Method 4: Lop and Scatter

Tree branches and tops are left at the stump. To meet hazard reduction standards, this material must be cut or lopped, generally by hand, so it lays close to the ground for rapid decay. This method protects and nourishes forest soils, but some landowners object to the appearance, while others claim it inhibits livestock and wildlife movement. However, while this is an inexpensive slash treatment for light harvests, it can leave a fire hazard in heavy harvest areas. Lop and scatter, combined with machine trampling, may be a remedy for heavy slash areas.

Method 5: Broadcast Burning

On steep slopes, broadcast burning can be an effective site preparation technique, eliminating the problem of soil disturbance, and controlling heavy fuels. By carefully monitoring moisture conditions, a fire can be set that consumes only part of the slash, leaving large material in place. Afterwards, the site is either planted or allowed to regenerate naturally. Whole tree harvesting (see page 48) and air quality requirements are making broadcast burning more rare.

Wildfire Impacts

Wildfires can have severe effects on vegetation and hydrologic cycles that occur immediately but can also persist for decades. Fine wood ash can immediately plug soil pore spaces which magnifies the loss of organic soil debris, allowing for, sometimes substantially, greater surface water flow and potential erosion that impacts road water diversion structures, stream channels, and water quality.

Salvage logging should, where feasible, take into consideration measures such as placement of woody debris on burned soil areas and maintenance of road drainage for increased water runoff and sediment capture. Larger culverts or other drainage structures may be needed to prevent road flooding and damage.

See: Post-Wildfire Effects page 60.

Winter freeze-up is an opportunity for low-impact logging. With proper precautions, work in sensitive areas can be done without affecting water quality.

WINTER LOGGING PRECAUTIONS

Winter logging on frozen ground avoids soil, watershed and riparian, and wetland area damage. It is a great season to accomplish harvest objectives with minimal impacts. However, there are a few issues to keep in mind.

1. Always mark riparian and wetland areas prior to snowfall to prevent damage from operating unknowingly in these areas.

2. Consider installing adequate erosion control prior to spring runoff.

BMP Conduct winter logging operations when the ground is frozen or snow cover is adequate (generally more than one foot) to prevent rutting or displacement of soil. Be prepared to suspend operations if conditions change rapidly and when the erosion hazard becomes high.

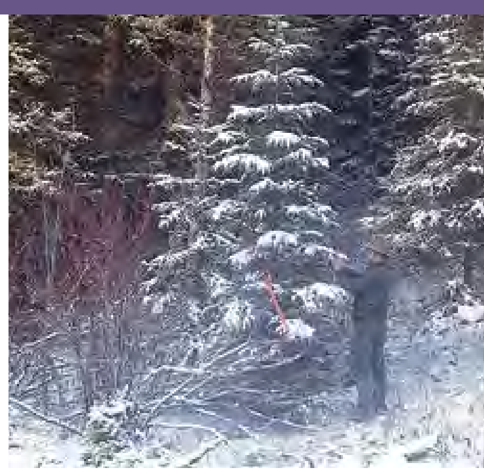
BMP Consult with operators experienced in winter logging techniques.

BMP Consider snow-road construction and winter harvesting in isolated wetlands and other areas with high water tables or soil erosion and compaction hazards.

BMP In wet unfrozen soil areas, use tractors or skidders to compact the snow for skid road locations only when adequate snow depth exists. Avoid steeper areas where frozen skid trails may be subject to erosion the next spring.

Winter Logging Tips

Consider compacting skid trail snow before skidding logs. It can prevent damage to soils that are wet, sensitive, or not completely frozen.



SMZs can be totally obscured by heavy snow. Avoid confusion by marking boundaries ahead of the first snow.

Winter thaws can happen. Don't take chances with soil compaction, rutting, and erosion. Expect to shut down temporarily. Start up should not begin until ground is solidly re-frozen or snow depth will protect soils.

Water bar all skid trails prior to spring runoff. If prohibited by frozen ground, install water bars during dry summer months. Slash on skid trails can act as temporary erosion control until water bars are installed.

To provide a winter road grade capable of heavy hauling, always remove snow cover. Deep-frozen road surfaces have tremendous strength. Do not let snow cover insulate and weaken the road—plow during cold weather.

WINTER ROAD AND DRAINAGE CONSIDERATIONS

BMP For road systems across areas of poor bearing capacity, consider hauling 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.

BMP Before logging, mark existing culvert locations. During and after logging, make sure that all culverts and ditches are open and functional.

BMP Use compacted snow for roadbeds in un-roaded, wet or sensitive sites. Construct snow roads for single-entry harvests or for temporary roads.

BMP Return the following summer and build erosion barriers on any trails that are steep enough to erode.

BMP Be prepared to suspend operations if conditions change rapidly and when the erosion hazard becomes high.

See Road Maintenance, page 32 for tips on snow berm breaks for drainage.

Road surfaces deteriorate rapidly under heavy hauling and thawing temperatures. This road surface is starting to break up. Hauling should be suspended or limited to colder portions of the day. Standard practice is to begin hauling early, around 3-4am, and stop when the sun softens the road.

Trying to rely on memory can be expensive when it comes to culvert maintenance. Mark them before the snow falls to avoid logging machinery damage.

HAZARDOUS SUBSTANCES

BMP "Hazardous or toxic material" means substances which by their nature are dangerous to handle or dispose of, or a potential environmental contaminant, and includes petroleum products, pesticides, herbicides, chemicals, and biological wastes.

BMP Know and comply with regulations governing the storage, handling, application (including licensing of applicators), and disposal of hazardous substances. Follow all label instructions. Do not discard empty oil jugs, hydraulic fluid containers, filters carelessly. Dispose of such materials properly.

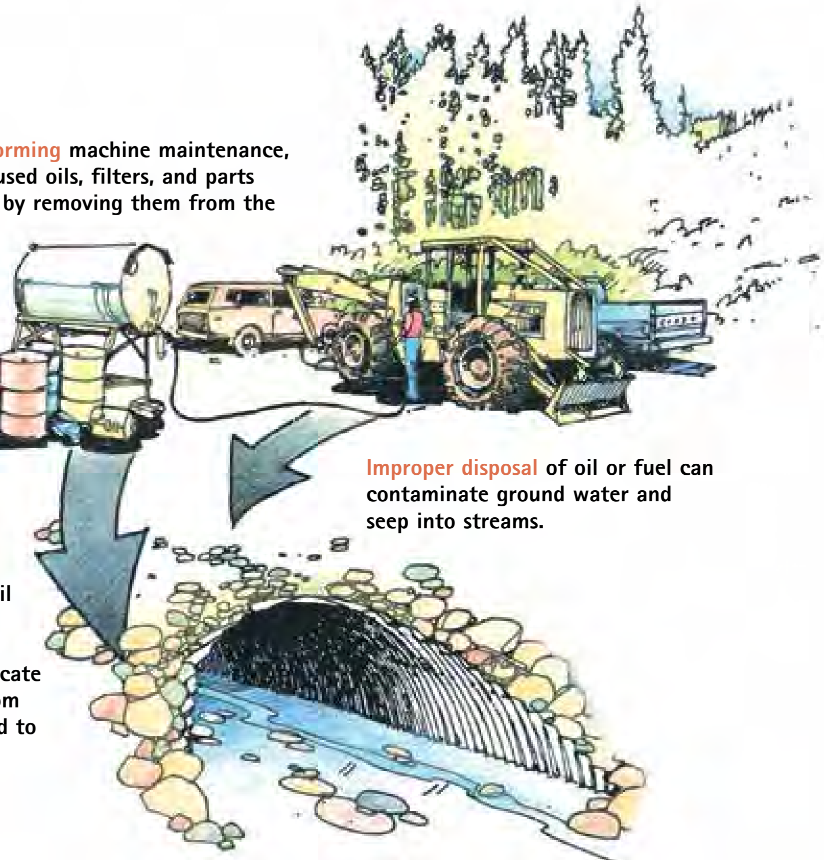
BMP Develop a contingency plan for hazardous substance spills, including cleanup procedures and notification of the state Department of Environmental Quality (DEQ) at 406-444-0379 or the Disaster and Emergency Services Duty Officer at 406-841-3911.

In Helicopter service areas, operators are required to provide fuel truck containment in case of accidental spills. Portable water tanks and pumps are ready for fire emergencies.

Pesticides/Herbicides

BMP Use an integrated approach to weed and pest control, including manual, biological, mechanical, preventive, and chemical means. Stay current with all Montana DEQ pesticide regulations and permitting requirements.

When performing machine maintenance, dispose of used oils, filters, and parts responsibly by removing them from the forest.

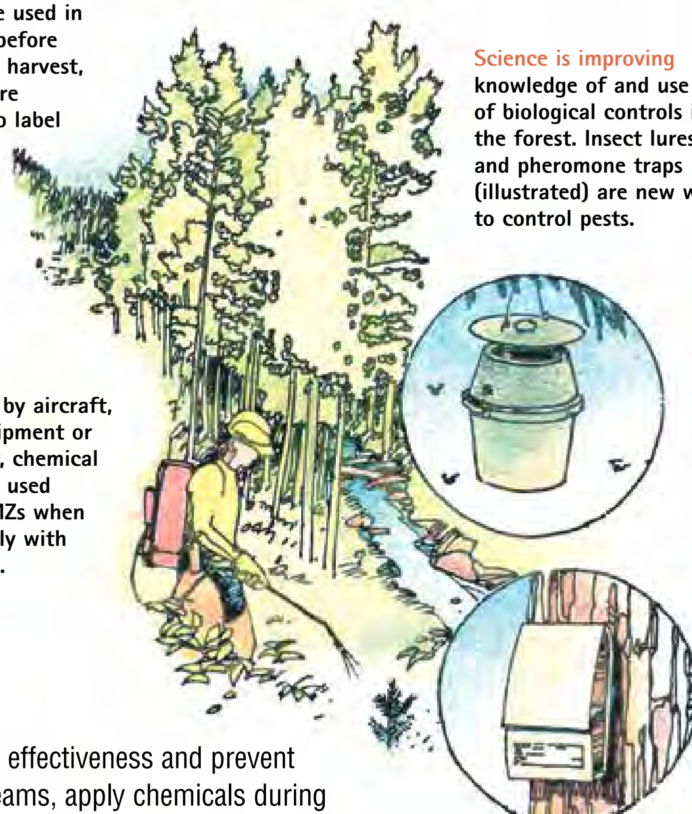


Improper disposal of oil or fuel can contaminate ground water and seep into streams.

Improper storage and handling of oil products and fuel can be a water-quality hazard. Locate facilities away from SMZs. Be prepared to clean up spills.

BMP Remove all logging machinery debris to proper disposal site (tires, chains, chokers, cable, and miscellaneous discarded parts).

Herbicides can be used in the SMZ, either before or after a timber harvest, as long as they are used according to label requirements.



Science is improving knowledge of and use of biological controls in the forest. Insect lures and pheromone traps (illustrated) are new ways to control pests.

Whether applied by aircraft, power-spray equipment or backpack sprayer, chemical pesticides can be used safely around SMZs when applicators comply with strict regulations.

BMP To enhance effectiveness and prevent transport into streams, apply chemicals during appropriate weather conditions (generally calm and dry), during the optimum time for control of the target pest or weed, and according to the product label.

THE ROLE OF WOODY DEBRIS

Any forest management activity that generates woody residuals (slash) in the forests of Montana is subject to a Fire Hazard Reduction Agreement (HRA) that requires slash, generated by commercial logging activity or Right-of-way clearing, be reduced to acceptable state standards. This generally requires that fuels do not allow for the fires flame lengths to exceed 4-ft in height during a "standard bad day." More information on this can be found at: http://dnrc.mt.gov/forestry/Assistance/Stewardship/slashred.asp. Contact your local DNRC office to obtain an HRA.

The Right Level is Beneficial

Certain amounts of woody debris left on site can have beneficial effects to forest ecosystems for nutrient cycling, microhabitats, and water quality purposes.

For best impacts from residual woody debris, also known as logging slash, materials should be in close contact with the soil, but not completely covering the soil surface. Needles and fine twigs contain the majority of the nutrients that cycle within the forest, and lose about 90% of these the first year to leaching and microbial activity. Good soil contact ensures that woody debris slows soil surface water flow, reducing erosion and increasing soil infiltration. Decomposition of these materials is also enhanced by close soil contact. Mixing with soil is not preferred as this can lead to erosion and poor water infiltration.

Micro Habitat

Wood itself does not contain much nutrient value, but does provide microsite habitat for a variety of smaller plants, seeds, wildlife as well as important soil fungi. A combination of fine and larger debris offers more microhabitat diversity than only fine or coarse materials. Bare soil is an important component of a recently disturbed forest as bare mineral soil offers the best germination site for tree seeds and a variety of other plant species that are important site colonizers that add to biodiversity. Depending on land manager objectives a range of 30 to 55% bare soil is appropriate – preferably in a dispersed pattern seen in photo depicting the "Minimum."

CAUTION: If noxious weeds are on site, soil scarification may allow them to spread.

Ensuring the right amount of woody debris is left on site provides benefits while reducing the potential fire fuel.

POST-WILDFIRE EFFECTS

Wildfires are a phenomenon that have been part Montana forests for the past several thousand years. They can also have significant effects on a forest's ability to absorb and provide water.

Typically, severe wildfires result in a large movement of surface ash and soils into streams, which, depending on the time of year and watershed, can have major short-term impacts on water quality and quantity. Such erosion events may also have long term impacts on soil and landscape productivity.

Restoration

Restoration practices seek to slow surface water, preventing soil erosion and promoting water infiltration into the soil which in turn can moderate downslope flooding events.

One of the most effective practices is to add soil surface roughness and organic matter that holds and slows water. Contour felling and straw mulch are two proven practices, but what about salvage logging? Much controversy remains about this process as any event that loosens soil, such as equipment travel over burned soils, has the potential to increase erosion. Alternatively, anything that increases soil surface stability, such as the matrix of fine and larger woody debris left by conventional logging practices can help stabilize heat-impacted soils and fine erodible ash. Extreme care must be taken to prevent or amend ruts created by logging and skidding practices and orient logging debris across slope contours versus up and down them.

Salvage

Salvage logging immediately after a wildfire that leaves a reasonable amount of logging debris in close contact with fire-affected soils can help stabilize soils, minimizing erosion and retaining moisture on site. All post-fire activities should be careful to avoid bringing exotic weedy species onto fire affected soils.

After the Fire BMP Implementation

Non-salvage Site Examples

Derby Fire: Site immediately after the fire.

Black Cat Fire: Two years after burn showing recovery can be slow.

Ash and organic soils erode off of site (above) with first rain and soils can lose their most productive layers (right).

Salvage Site Example

The site was salvage logged immediately after wildfire with good woody debris deposited on afflicted soils (left), showing no detectable soil loss, good water retention, and good vegetation recovery the first year following the fire (below). Vegetative recovery typically only occurs after spring run-off.

Fridley Fire: Salvage complete. The landscape in the spring after the fire.

Fridley Fire: Four months later.

Climate variability, natural disturbance, and Best Management Practices

The current expanse of forested watersheds across Montana landscapes have been shaped by the climatic period known as the Holocene Climatic Optimum. This relatively stable, warm period of approximately the past 10,000 years has experienced some significant variability, although much less than previous ice ages.

Shown on the graph below is the average temperature variation for the northern Pacific Ocean over the past 1,000 years. This temperature index, known as the Pacific Decadal Oscillation, shows a strong correlation to the climatic variability that shaped the forests and watersheds of western Montana. Warm periods correlate with high frequencies of wildfires and drought and cooler periods correlate with periods of ample rain and snow. These cooler periods are thought to have been the driver for expansion of tree species and forests across drier portions of our state.

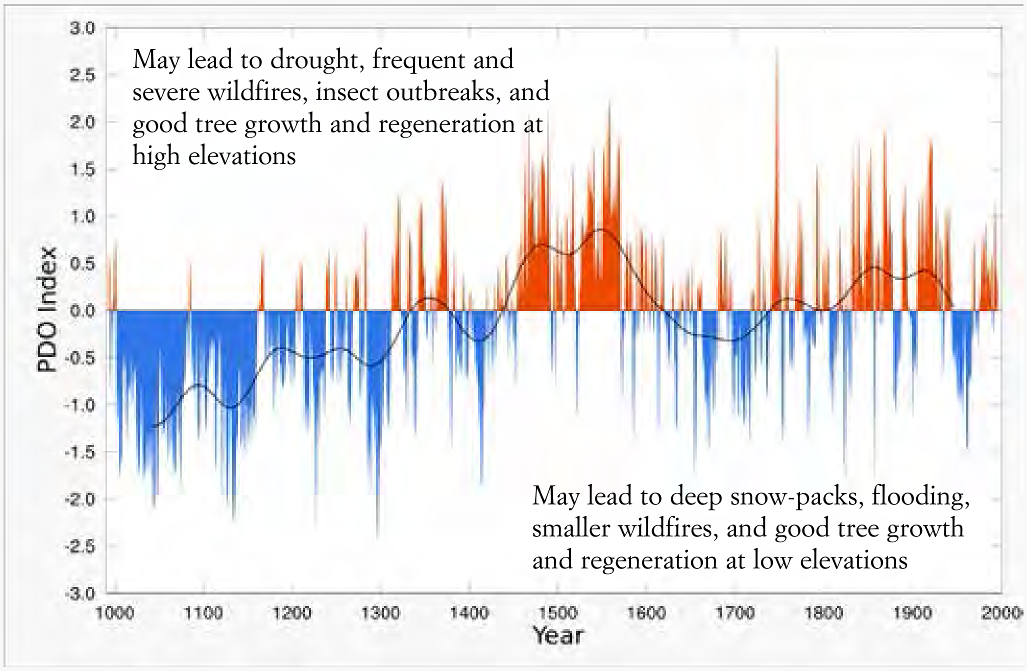
Recent studies of lake sediments across Montana have shown that although many forest species have been present over the past 3,000-5,000 years, their distribution and the wildfire occurrence and severity rate is a recent trend, having likely developed over the past 1,000 years. Even under the relatively stable conditions of the past millennia, natural variability in snowpack, rainfall, wildfire occurrence and severity, forest pests and pathogens, and events such as landslides and floods have had considerable influence on forest and watershed function.

These Forestry BMPs are designed to minimize undesirable human-caused impacts on water quantity and quality that may originate from managed forested landscapes. Following BMPs will assure that management actions meet their desired outcomes, typically within the historic range of variability. However, variability is often largely influenced by climate. Some fluctuations may be desirable to us such as increased water supply and healthy, resilient, and robustly growing trees, while others such as floods, insect and disease outbreaks, and severe wildfires are not.

Our state's environment and landscape has a history of change but proper BMP implementation, while not changing your world, will allow you to manage your forest lands with the knowledge that you are doing your work based on the most accurate science and that may prevent or mitigate what might be considered harmful impacts of both human and natural origin. Thank you for your commitment to the wise use of Montana's Natural Resources.

North Pacific Ocean Temperature Impacts

The graph illustrates the past 1,000 years of reconstructed climatic variability determined through North Pacific Ocean temperatures that strongly influence NW United States climate and ecosystem function.



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Forestry Assistance Bureau - contact us for a variety of publications, on-site visits, and consultation regarding the management of your forest.

Montana Logging Association
PO Box 1716
Kalispell, MT 59903-1716
(406) 752-3168
Toll free: 1-877-MLA-LOGS

Publications and Workshops
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Guide To Forest Work Contractors
Guide To Information and Services for Montana Forest Owners
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Workshops
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Forest Stewardship for Logging Professionals
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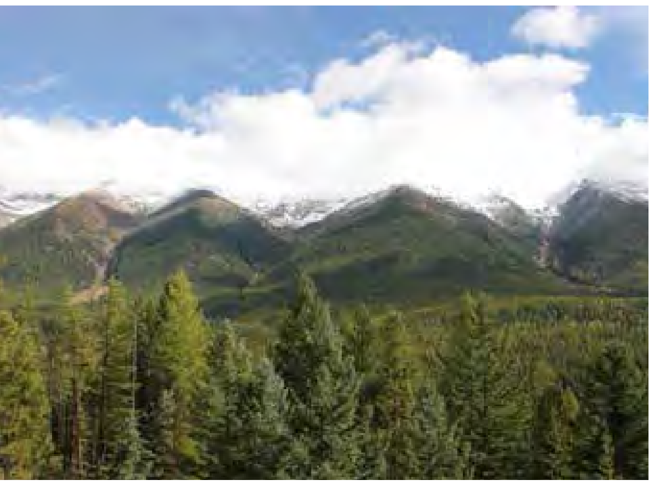
http://www.msuextension.org/forestry/

FORESTRY BEST MANAGEMENT PRACTICES



PROTECTING WATER QUALITY AND WATERSHEDS