NORTH DAKOTA Forestry Best Management Practices

July 1999

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OVERVIEW

Managing North Dakota's forestlands and resources can produce significant benefits. Careless activities in woodlands can, however, damage water resources, soils, wildlife habitat, aesthetic values, and even the ability to produce future benefits. The North Dakota Forest Service believes voluntary Best Management Practices BMPs), when carefully applied, will ensure productivity of our woodlots from tree planting, timber harvesting, thinning and other forest management activities.

BMPs are intended to serve as a basis for sound management decisions. Often BMPs can be applied directly by the landowner. Sometimes the landowner will want help from a forester or other natural resources professional to interpret field situations and determine on-the-ground activities. Flexibility and the ability to modify guidelines to suit local conditions are needed to effectively apply these practices.

The North Dakota Forest Service encourages landowners to prepare Forest Management Plans for their woodland and planting areas. Preparing a management plan is a good way to clarify goals, provide direction, and schedule planting and management activities. *North Dakota Forestry Best Management Practices* are described under the following categories: Resource Planning; Block Plantings and Windbreaks; Native Woodland Management; Forest Protection; Timber Harvesting and Site Preparation; Streamside Management; Stream Crossings; and Roads.

RESOURCE PLANNING

Landowner Objectives

Woodlands are a renewable resource, but they require many years to mature. Decisions made now about tree planting, stand improvement, timber harvesting or pest control can influence the character of your woodland for the next half century. Consequently, it is essential to plan for the long term, because whatever is done—or not done—will have long-term impacts. The following suggestions will help you set objectives for your property:

• Be specific about your objectives. Vague - improve land for wildlife. Specific - increase the number of grouse on the property.

• When there are multiple objectives, set priorities.

• Consider the following when determining your objectives:
  a. Riparian buffers - water quality; provide a buffer zone next to streams, lakes, wetlands to protect them from adjacent land uses. Stabilize banks and flood plains.

b. Windbreak establishment and renovation; protect buildings, animals and crops from wind and snow; provide shade for animals and buildings.
c. Wildlife food and habitat; encourage or discourage certain wildlife species.
d. Streambank protection; improve localized water chemistry parameters.
e. Forest products; lumber, fuel wood, berries, nuts, Christmas trees.
f. Living snow fence; protect roads and buildings from snow drifting.
g. Aesthetics; foliage, bark and berry colors, tree forms, stand arrangements.
h. Grazing; provide shade and protection from wind and snow.
i. Recreation; Establish camping, picnicking, fishing, hiking, winter activity areas.
j. Cultural; unique natural, historical or archeological areas that need protection or development.

Management Plans

A management plan will help a woodland manager implement personal objectives, manage efficiently, avoid costly errors, make knowledgeable decisions and evaluate progress.

• A number of natural resource professional can assist in developing a management plan. Agencies that can assist you include the North Dakota Forest Service, Soil Conservation Districts, Natural Resources Conservation Service, or the North Dakota Game and Fish. These services are provided through your state tax dollars with no additional cost to individual landowners.

• The following information should be included in a management plan:

a. Landowner management objectives.
b. Description and mapping of existing resources. Property boundaries, woodland boundaries, water sources, building locations, adjacent land uses.
c. Inventory of existing woodlands to assess tree species composition, stand age and density, grass stand composition and density erosion-resistant nature), condition, insect and disease problems, growth rates, and tree diameters, heights and quality.
d. Soils description as it relates to erodibility and suitability to support trees and shrubs.
e. The management practice s) that will help meet the objectives.
f. An activity schedule that assesses and reflects labor, equipment and financial resources. The activity schedule should cover at least five to ten years.

• When implementing practices, keep good records. Keeping accurate records of what has been done is important in updating plans and may also be needed when filing income tax reports and perhaps for settling an estate.

BLOCK PLANTINGS AND WINDBREAKS

Planting and Location

Tree planting is viewed as a positive activity and will rarely cause negative impacts if a few guidelines are kept in mind:

• Determine the objective s) of the planting.

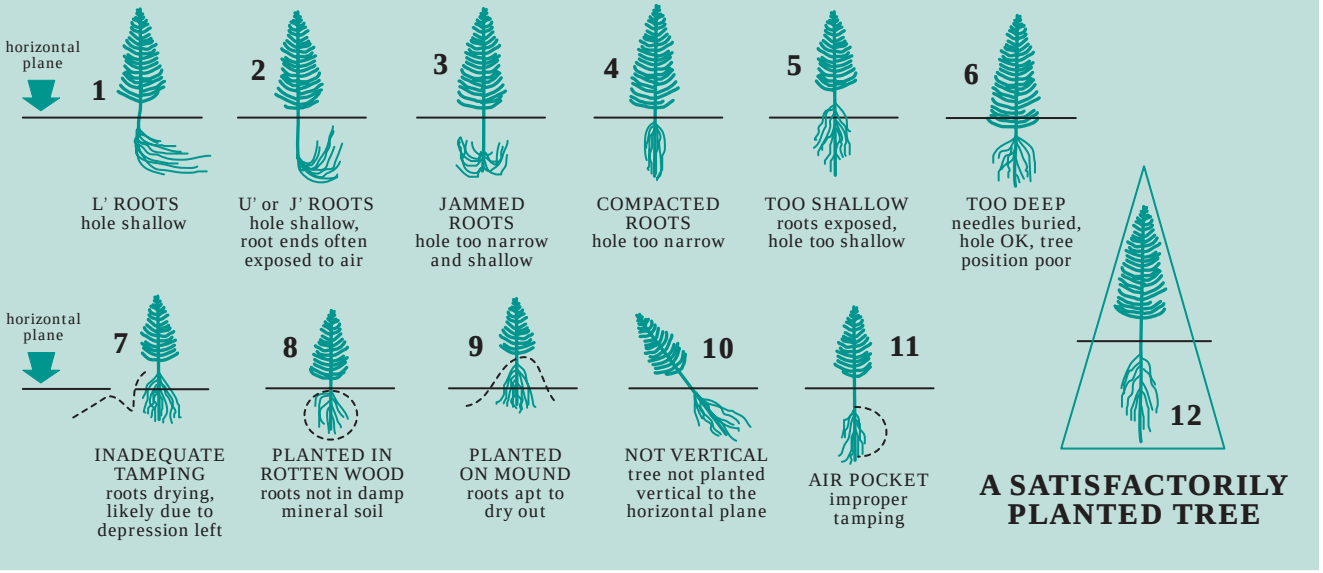
• Evaluate the site's ability to support the planting. Consider:
  a. Soils
  b. Topography.
  c. Erosion potential
  d. Depth of water table.
  e. Impacts to plants and animals present on the site.
  f. Impact of the planting during each season of the year.
  g. Competing vegetation and/or noxious weeds.
  h. Potential effects on water quality and beneficial water use.

• Choose species for the planting that meet the objective s) and are compatible with the site. Refer to the *Natural Resources Conservation Service (NRCS) Field Office Technical Guide.*

• Determine the method of planting, such as mechanical planting, hand planting or scalping. Scalping is planting in non-cultivated areas by plowing a trench into which the trees are planted. This practice is most effective on highly-erodible sites, such as land in the Conservation Reserve Program CRP).

• Complete a planting plan. Successful tree plantings are the result of careful design, good site preparation and follow-up maintenance, including weed control and replanting if needed. Make sure all these elements are included in the planting plan.

• Decide what kind of site preparation and follow-up weed control will be needed.



Site Preparation

Choose the preparation technique that meets your objectives:

• Existing grass and weed vegetation can be removed by disking, plowing, rototilling, scalping, or any other form of mechanical tillage.

• Chemicals can be an effective alternative for site preparation. Chemical application in the fall or summer prior to the planned tree planting may be necessary. *See Forest Protection: Hazardous Substances.*

• When trees and shrubs are located on the site to be planted, clearing with a tractor or dozer will be necessary. Perform clearing in the summer prior to planting. A temporary cover crop may be needed to prevent erosion.

• Extensive site preparation is not recommended for light or sandy soils, or within riparian areas. Consider using chemical site preparation in conjunction with scalp planting.

Weed Control

Follow-up weed control is an essential practice in regard to tree and shrub survival. The weed control method chosen should be based on the landowner's ability to perform the practice, the machinery they have available, weed pressure within the site, potential ground water pollution from chemicals, and potential pollution of surface water from sediment and/or chemicals. Limit cultivation to the minimum needed to control weeds. Excess cultivation makes the area susceptible to erosion and may damage trees and shrubs.

• When mechanical methods; disc, rototiller, weed badger or other farm equipment are used to cultivate near trees, be careful to prevent damage to the branches, stem, or roots of the tree.

• Cultivation equipment should be kept shallow, 2 inches to 4 inches, to minimize root system disturbance and damage.

• Chemical weed control should be planned prior to planting. The type of chemical used, method of application and potentially negative effects to the seedlings, surrounding vegetation, wildlife and water are factors that should be considered when comparing weed control methods.

• Artificial and natural mulches are an alternative to chemical and mechanical practices that provide effective weed control. Mulches offer the advantage of long-term weed control with one application. Organic mulches should be applied no more than 3 to 4 inches in depth and kept away from tree stems. Artificial mulches, such as weed barrier, must be secured along the edges and openings must be large enough to prevent fabric from rubbing the tree or shrub.

Maintenance and Renovation

Once a stand is established, it still requires maintenance throughout it's life to ensure a healthy and productive stand.

• As a tree planting matures, thinning practices should be used to remove dead and dying trees and those that are suppressed. Thinning will give trees more room to grow and develop.

• Promptly replace any trees or shrubs in which their removal or death has created a gap in the windbreak.

• When the trees and shrubs in two or more adjacent rows are scattered or a majority are dead or in poor condition, consider:

a. Interplanting - planting new rows between the existing rows.
b. Removal of some or all of the existing rows and replanting.

• Consider adding adjacent rows or plantings to a windbreak in order to:

a. Increase snow trapping ability.
b. Increase tree/shrub diversity for wildlife benefits.
c. Provide age diversity.
d. Provide fruit or nut trees for human use.
e. Increase wind protection.

• Replenish the life of a tree planting by managing the natural regeneration or seedlings that are produced by the existing trees. Select and maintain the naturally regenerated trees that will one day replace the existing trees. Naturally regenerated windbreaks and forestry plantings do not need to be in straight rows to provide effective wind protection or productive woodlands.

NATIVE WOODLAND MANAGEMENT

Left to herself, Mother Nature can produce valuable native forests. Man can assist nature by controlling the kinds of trees grown and enhancing the growth rate of selected trees through active management. This is done by implementing timber stand improvement practices over the life of the forest until the trees mature and are ready for harvest. At this time, the trees may be selected individually for harvest or an entire stand may be removed. These harvesting methods are used to regenerate the forest so they are also called reproduction cuttings.

Timber Stand Improvement

Timber stand improvement is defined as all cuttings that are not a part of a major harvest or made during the life of a forest stand for the general purpose of improving stand composition, condition or growth rate. Cuttings may be commercial or noncommercial, depending on the size of the trees during the removal.

• Evaluate the stand condition and determine the management objectives. Management objectives may include: increasing timber value; removal of insect/disease infested trees; removal of undesirable species; protecting and enhancing wildlife values and aesthetics.

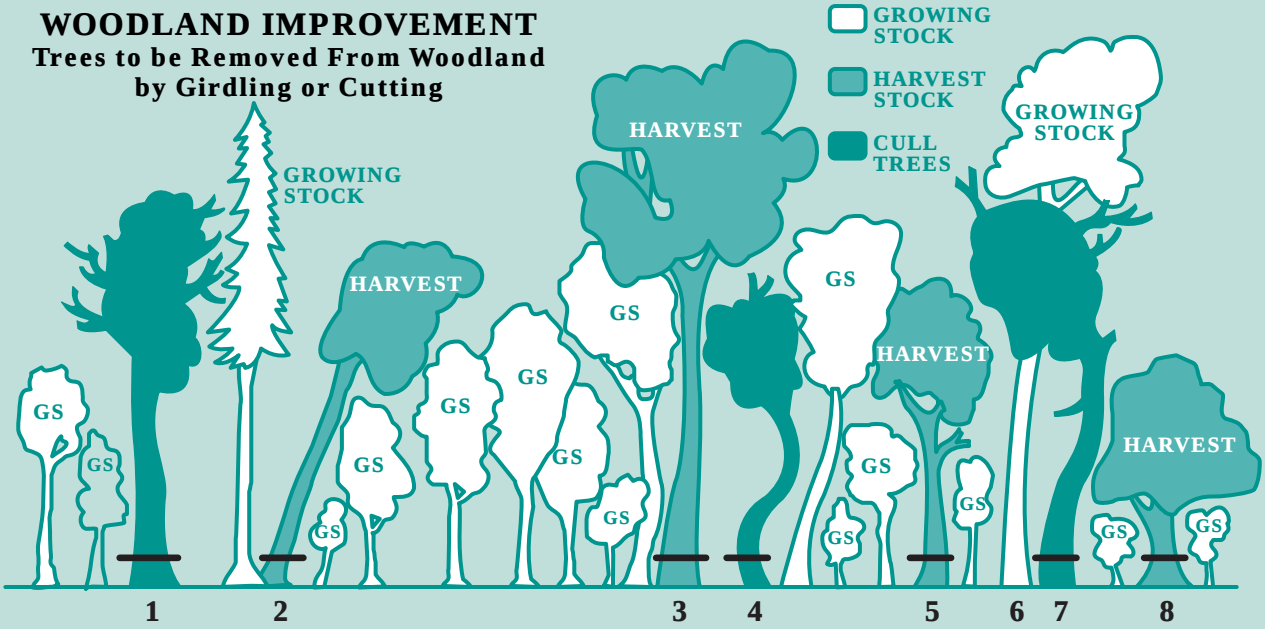
• Timber stand improvement can be accomplished by the following harvesting methods:

a. Cleaning or weeding: These are cuttings made in small size sapling stands, trees four inches or smaller in diameter, for the purpose of removing undesirable trees so that the remaining young trees have room to develop. Examples include trees with bad form or trees that overlap or injure young desirable trees.

b. Liberation: A liberation cutting is one in which young trees, saplings, are released from oppression by the removal of over-topping trees. This is the same as cleaning cuttings, only liberation cuttings are used with trees in older age classes. Examples include cull or wolf trees that are live trees of poor form that are preventing the development of younger trees.

c. Thinning: Thinnings are cuttings made in immature stands beyond the sapling stage for the purpose of increasing the growth rate of the residual trees. These may be made in natural stands or in forest plantations.

d. Improvement: These are cuttings made in a forest that have passed the sapling stage to remove trees of undesirable form, condition and species. These cuttings are like cleaning and liberation cuttings, but remove trees that often occupy a dominate position in the crown canopy.



1 Cull, badly damaged by fire.
2 Root-sprung harvest tree will produce 2 logs.
3 Harvest tree will produce 3 logs.
4 Deformed tree, cull.
5 Harvest tree will produce 1 1/2 logs.
6 Growing stock, tree needed for proper stocking level.
7 Diseased tree, numerous fruiting bodies, no merchantable value.
8 Wolf tree, over valuable young stock, will produce 1/2 log.

e. Salvage or Sanitation: Salvage cuttings are made for the removal of trees killed or injured by fire, insects, disease or other harmful factors. These are done to utilize the merchantable material and to control the spread of insects and disease.
f. Pruning: Pruning is removing selected live or dead branches from a standing tree that has been selected to remain in the stand. This includes the yield of knot-free, high grade lumber that can be obtained from the tree upon harvest.

Reproduction Cuttings - Harvesting

A reproduction cutting is one made for the purpose of assisting regeneration. This cutting is usually done to mature timber so that a new stand of young trees takes its place and continuous wood production is assured. These cuttings are classified into two main groups.

• Selection: A selection cut is a method in which single trees or small groups of trees are removed and reproduction is obtained under the remaining stand or in the openings. It is called a group selection method when groups of trees are removed. Selective cutting helps to develop a forest in which all-age classes are established. Shade tolerant species work best with the selection method, but shade intolerant species, like pine, can also effectively regenerate using the group selection method. The selection method works well when soil erosion and aesthetic considerations are important, and is a good method for wildlife habitat development.

• Clearcutting: Clearcutting is the removal of merchantable trees in a large area in a stand or over the entire stand. Regeneration occurs from the seeds from the remaining trees, seed in the litter layer of the soil, or by stump or root sprouting. This method works best with intolerant tree species such as pine, cottonwood and aspen. Environmental considerations such as soil erosion and aesthetics should be taken into account before using this harvest method. In practice, the clearcutting system, if applied to small areas on a grid format, may be carried out similar to the group-selection method. The result will be an all-aged woods containing small areas of even-aged stands or mosaic cuts. Mosaic cuts are used for aspen and wildlife habitat objectives.

Interplanting

Planting trees and shrubs within a native woodland may provide increased diversity for wildlife food and cover, increase the aesthetics of the stand and enhance water quality.

• When selecting species to interplant, consider: owner and stand objectives; site conditions; species shade tolerance; foliage and bark color; and wildlife cover and food production.

Grazing

Grazing within North Dakota hardwoods is damaging, even when low numbers of livestock are present. In addition to eating seedling trees and shrubs, livestock compact the soil, which can reduce tree growth and increase runoff rates, contributing to silt loading in streams and ponds. Continuous season-long grazing in woodlands along riparian areas, streams, lakes and wetlands, often removes important riparian vegetation and may cause streambank erosion and water quality degradation. The following suggestions provide valuable advice for managing grazed woodlands:

• Newly established plantings should be fenced to exclude livestock. At times, special fencing or other controls may be necessary to exclude deer, elk or moose from new plantings.

• Livestock should be excluded as necessary to achieve and maintain the intended management objectives for native woodlands.

• Determine if the feed and forage requirements are balanced with the production potential of the land. Work with Natural Resources Conservation Service or Department of Agriculture personnel skilled in developing grazing systems to determine the proper methods of managing grazing animals. Refer to the following example:

EXAMPLE: In this example, the land will produce enough hay to feed 3 horses for 6 months. However, there is not enough forage grazing) to meet the animal's needs. Overgrazing will occur if the animals are allowed to graze for 6 months.

	FEED hay) tons/month	**FORAGE** AUMs of grazing/month
1 cow	.4	1.2
1 horse	.5	1.25
1 sheep or goat	.1	.2

Feed Requirement:
3 horses x .5 tons/month x 6 months = 9 tons of hay

Feed Production
10 acres fertile, non-irrigated soil) x 1 ton/acre = 10 tons of hay

Forage Requirement:
3 horses x 1.25 AUM/month x 6 months = 22.5 AUMs

Forage Production:
10 acres fertile, non-irrigated soil) x 1 AUM.acre = 10 AUMs

• Locate corrals, watering sources and other livestock confinement areas away from woody draws and outside the Riparian Management Zone, 60 feet from a water course. Water course crossings and livestock watering should be located and sized to minimize the impact to buffer vegetation and function.

• Establish and maintain shrubs and grasses along streams and around animal confinement areas to trap and absorb pollution-laden runoff before it reaches streams and other riparian areas.

• Impairment of buffer or woodland function by livestock use; such as trampling, compaction, or consumption of tree seedlings, shrubs and other woody plants shall require immediate removal of livestock from the riparian or woodland area.

• Woodlands adjacent to feedlots can be detrimentally affected by animal wastes. Properly dispose of manure, feed and bedding wastes. Ensure that runoff from snow trapped behind windbreaks does not drain across feedlots, nor should feedlots drain into windbreaks or woodlands.

Insects and Diseases

Frequent inspection of woodlands is the best way to determine the condition of your trees. Low-level insect or disease occurrence is natural and usually does not require treatment. Individual trees may be damaged or killed, but the total woodland is not harmed. Exotic pests or very high levels of native organisms may require treatment.

• Stressed trees are more susceptible to insects and diseases. Avoid unnecessary stress to trees by preventing soil compaction by equipment operation, grazing, damage during logging, damage due to herbicides, and uncontrolled sod competition.

• Use of chemicals to prevent or combat insect and disease problems must be done in compliance with label instructions. *See Forest Protection: Hazardous Substances and Pesticides and Herbicides.*

Pesticides and Herbicides

Use an integrated approach to weed and pest control, including manual, biological, mechanical, preventive and chemical means.

• Control noxious weeds and unwanted plant material in planting and harvest sites and reclaimed roads.

• To prevent the entry of hazardous substances into surface water:
  a. Refer to chemical label instructions for additional guidance on use near water and required buffer zones.
  b. Chemical treatments within the Riparian Management Zone RMZ) should be by hand with proper equipment and safety precautions and shall be applied only to specific targets.
  c. Leave a 25-foot buffer along surface waters when chemicals are being applied through ground application with power equipment.
  d. For aerial application, leave at least a 50-foot buffer along surface water and do not spray in the RMZ.

• To enhance effectiveness and prevent water pollution, apply chemicals during appropriate weather conditions, generally calm and dry, and during the optimum time for control of the target pest or weed.

Hazardous Substances

Know and comply with regulations regarding the storage, handling, application and disposal of hazardous substances. Certain chemicals require applicator licensing. Contact the local Extension Agent for more information.

• Do not transport, handle, store, load, apply or dispose of any hazardous substance or fertilizer in such a manner as to pollute water supplies or waterways, or cause damage or injury to land, humans, plants or animals.

• Do not store, mix, or rinse hazardous substances or fertilizers below the high-water mark or where they might enter surface water.

• Develop a contingency plan for hazardous substance spills, including cleanup procedures and notification of the State Department of Health.

• Responsibly dispose of containers, cartridges, filters, used oil and other refuse. Leave a positive image after any forest activity; leave your woodlands trash-free.

Fire

Fires burning under the right conditions can reduce the amount of flammable woody debris in a woodland, which in turn helps reduce the hazard of catastrophic fires. Fire returns nutrients to the soil which encourage the growth of desirable plants; holds insects and diseases in check; and encourages a healthy ecosystem. On the other hand, wildfires can destroy valuable trees and cause a significant loss of other woodland values.

• When implementing a prescribed burn aimed at reducing woody debris, a burn plan should be prepared with these considerations:

a. Objective of the burn.
b. Tree species and fire tolerance.
c. Amount of fuel, slash and grasses, on ground.
d. Time of year. Will the prescribed fire encourage or discourage the desirable outcome?
e. Weather conditions.
f. Adjoining resources at risk such as farmsteads, livestock, etc.

• Always provide adequate man power and equipment to keep the fire under control.

• Be sure to locate and maintain fire breaks to protect woodlands against known hazards such as railroads or other wildfire sources.

• Within any woodland situation, it is important to provide and maintain access roads to allow fire fighters to reach wildfires at an early stage.

• Contact your local Fire Department for permits as needed and to let them know when you burn.

TIMBER HARVESTING AND SITE PREPARATION

Marketing

Harvesting is an important management tool to improve the health and vigor of a stand, promote natural regeneration, control stand density, develop wildlife habitat, alter species composition, establish planting areas and provide income.

• Follow these steps when marketing timber:

a. Work with a professional forester to set up a sale.
b. Select trees to harvest.
c. Determine timber worth.
d. Determine how the timber will be sold: lump sum— receive a single payment for the harvested trees; or sale-by-scale— paid a certain amount for each unit thousand board feet, cord, post, ton, etc.) of timber harvested.
e. Advertise the timber sale.
f. Select a buyer and the sale price by a single offer - oral auction or sealed bids.
g. Develop a written timber sale contract with the buyer.
h. Inspect the harvest operation.

• Prepare a signed, written contract with the buyer to reduce the possibility of misunderstandings and disagreements and to provide each party with legal assurance that the other will abide by the terms of the sale. The contract should address the exact description of the area to be logged, price, method of payment, when the harvest must be completed, performance bond requirements, slash treatment, road construction requirements, regrading and revegetation after the sale, and any other factors related to the harvest. Contact the North Dakota Forest Service for a sample of a timber sale contract.

Harvest Design

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

• Plan timber harvest to meet your management objectives and in consideration of the following factors:

a. Soils and erosion hazard identification.
b. Season.
c. Silvicultural objectives.
d. Critical components aspect, water courses, topography, etc.).
e. Forest types and potential for regeneration.
f. Potential effects on water quality and beneficial water uses.
g. Wildlife habitat.
h. Local markets and/or current timber value.

WATER BAR SPACING GUIDE

GRADE	DISTANCE BETWEEN WATER BARS
2%	250 feet
5%	135 feet
10%	80 feet
15%	60 feet
25%+	40 feet

• Design and locate skid trails and skidding operations to minimize soil disturbance. Limiting the number of skid trails is one means of minimizing site disturbance and soil compaction.

• Locate skid trails to avoid concentrating runoff and so they are away from natural drainage systems. Provide breaks in grade and divert runoff to stable areas. Use mitigating measures, such as water bars and grass seeding to reduce erosion on skid trails and prevent sediment from entering streams.

• Skid trails on geologically unstable, highly erosive, or easily compacted soils should not exceed 30 percent slopes.

• Install necessary water bars on skid trails at the completion of harvest. Appropriate spacing between bars is determined by the soil type and slope of the skid trails.

Landings, Decks, and Portable Sawmill Locations

Minimize the size and number of landings and decks to accommodate safe and economical operation.

• Avoid locating landings that require skidding across drainage bottoms.

• Locate landings and residue piles, slash, sawdust, slabs, chips, etc., away from natural drainage systems and divert runoff to stable areas. Provide and maintain a drainage system, such as water bars or seeding, to control the dispersal of water and to prevent sediment from entering streams.

• Locate sites for decks and portable mill locations in advance of road construction and at least 50 feet from the edge of the Riparian Management Zone.

• Avoid decking logs within the ordinary high-water mark of any stream.

• Responsibly dispose of containers, cartridges, filters, used oil and other refuse.

Winter Logging

Conduct winter logging operations when the ground is frozen or snow cover is adequate, generally more than one foot, to minimize site disturbance.

• Suspend operations when conditions change rapidly and the erosion hazard becomes high.

• Consult with operators experienced in winter logging techniques.

• Prior to felling in wet unfrozen soil areas, use tractors or skidders to compact the snow for skid trail locations. Avoid

steeper areas where frozen skid trails may be subject to erosion the next spring.

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

Slash Treatment

Rapid reforestation of harvested areas is encouraged to re-establish protective vegetation.

• When piling slash, avoid incorporating soil into the pile. Care should be taken to preserve the surface soil horizon.

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

• Scarify the soil only to the extent necessary to meet the reforestation objective of the site. Low slash and small brush should be left to slow surface runoff, return soil nutrients, and provide shade for seedlings.

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

• Stabilize or reclaim landings and temporary roads on completion of use.

• Remove all logging machinery debris to a proper disposal site.

RIPARIAN MANAGEMENT ZONES

Riparian zones are an integral part of the landscape, providing essential ecological, social, and economic benefits to a watershed. These areas play an important role in sustaining the biological integrity of a watershed, act as sources of species dispersal to disturbed areas and corridors for migrating wildlife, and regulate the transfer of nutrients, organic matter, and pollutants between the adjacent upland and surface waters. In the eastern and central regions of North Dakota, healthy riparian areas contain a diversity of trees, shrubs, forest plants, and some grasses and sedges. In the drier, western regions of the state, healthy riparian areas may be dominated by grasses, sedges, and other wet prairie vegetation, with few trees. There are generally two types of streams:

• **Perennial streams** flow throughout most of the year and have a well defined channel; and

• **Intermittent streams** usually flow only in the spring or after a rainfall and are dry most of the year. Intermittent streams are important to protect because they channel runoff to perennial streams, rivers and lakes.

Benefits of Healthy Riparian Zones

Filter sediment, nutrients, and pesticides from runoff. Runoff from snowmelt or rainfall passing through the riparian zone is slowed by plants, tree roots, and forest litter leaves, twigs, and decaying matter) allowing sediment carried by the runoff to settle out. The slowed runoff also infiltrates into the ground where nutrients can be used by plants and trees. Both of these processes reduce the amount of nonpoint source pollution flowing into lakes and rivers.

Increase infiltration and groundwater recharge. Plants, trees, and litter in the riparian zone slow surface runoff, allowing the water to soak into the soil. Less surface runoff reaches the stream channels, thereby decreasing peakflow levels. Greater infiltration also replenishes groundwater that helps to maintain lake levels and stream flows during drier periods.

Provide bank-stabilization and shade streams. Tree and plant roots hold the bank soil in place and armor the banks against waves, currents, and runoff. Plants also protect the otherwise bare soil from the impact of raindrops. The canopy of trees and overhanging grasses close to a stream shade the water, keeping it from becoming too warm for some types of aquatic life.

Enhance wildlife habitat. Riparian zones provide excellent habitat for all types of wildlife because of the diversity of plants and trees, as well as the proximity to water. Snags, woody debris logs, branches, and twigs), and overhanging vegetation also provide habitat for fish and aquatic invertebrates in streams and lakes. Forest litter and other organic debris that falls into the water provides food for algae and small aquatic organisms, which in turn become food for fish.

RMZ WIDTH IN RELATION TO STREAM WIDTH

STREAM WIDTH	RECOMMENDED RMZ WIDTH (min.)
< 20 feet	60 feet per side
20 to 40	75 feet per side
> 40 feet	150 feet per side

RMZ WIDTH IN RELATION TO LAND SLOPE

LAND SLOPE (bet. upland and surface water)	RECOMMENDED RMZ WIDTH (min.)
0 - 10%	60 feet
11 - 20%	90 feet
21 - 40%	125 feet
41 - 70%	150 feet

Establishing Riparian Management Zones RMZ)

RMZs are an integral part of effective forest management and should be designated adjacent to lakes, streams and rivers. The RMZ encompasses a strip at least 60 feet wide on each side of a stream, measured from the ordinary high-water mark or definable bank. The ordinary high-water mark, as shown in the diagram on page 16, is defined as the point on the bank or shore up to which the presence and action of the water is so continuous as to leave a distinct mark, either by erosion, destruction of terrestrial land) vegetation, or other easily recognized characteristic Wisconsin Department of Natural Resources, 1995).

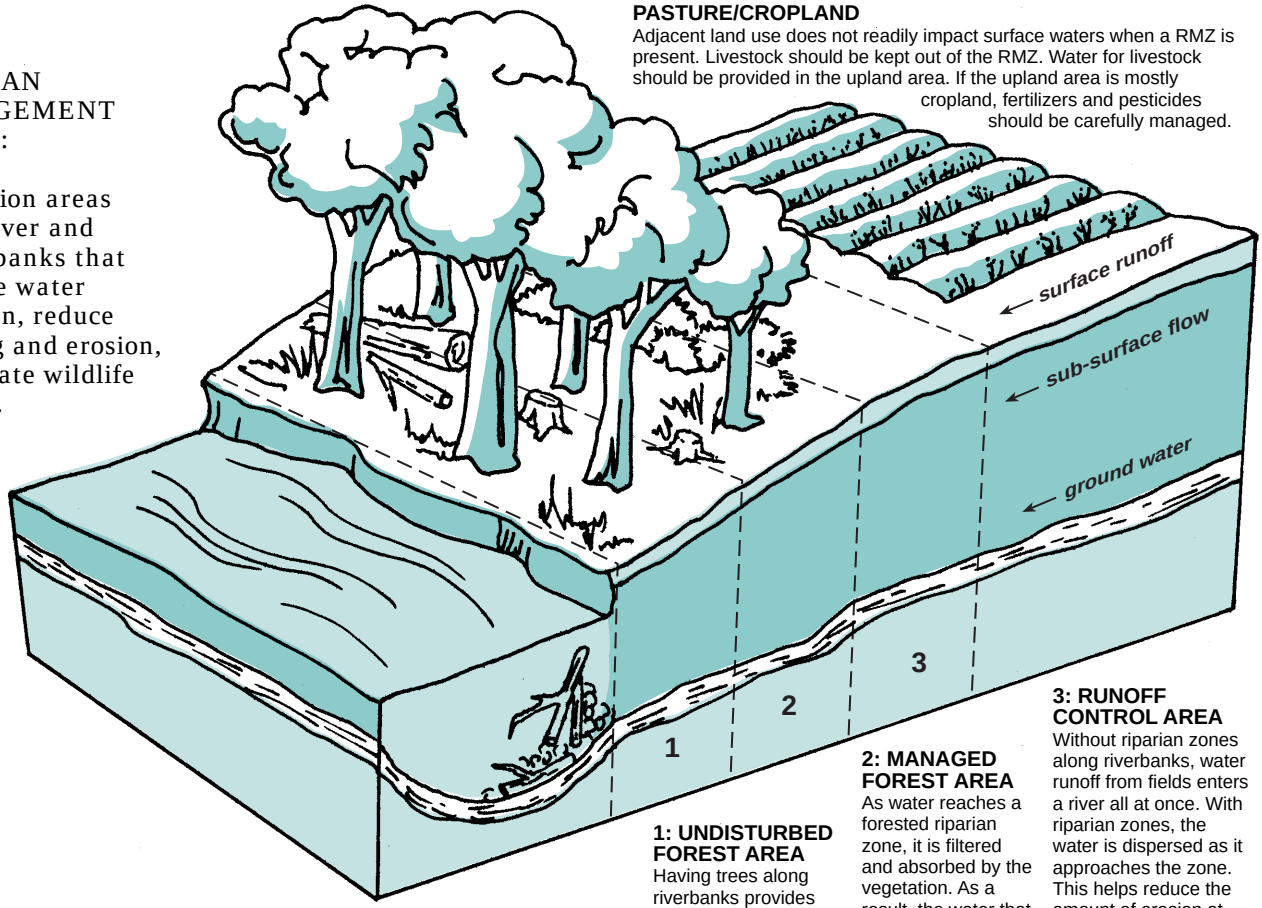
The width of the RMZ will vary with the width of the river, slope of the banks, and the adjacent land use. RMZs should always include associated wetlands. The first table in the left column of this page provides minimum RMZ widths for corresponding stream widths. As bank and upland slopes become steeper and/or soil errodibility more severe, a landowner or manager should extend the RMZ further into the upland. The second table provides recommended minimum RMZ widths according to the corresponding slope of the land between the body of water and the

adjacent land use. If clearing land for alternative land uses, such as grazing, farming, or development, maintaining a 150-foot minimum buffer strip to protect the lake or stream from increased sedimentation and nutrient loading is highly recommended. Do not allow livestock to graze in forested RMZs. Contact the local USDA Natural Resources Conservation Service to establish a grazing plan.)

Riparian zones in eastern and central North Dakota can be divided into three management areas. Grassland streams in the western portions of North Dakota may not be able to be managed following this plan. The first area 1) is closest to the stream or other surface water and should remain undisturbed from agriculture, development, grazing or other human activity. This zone should be at least 15 feet wide. The managed forest area 2) provides protection to the adjacent surface water, filters sediment and nutrients, and enhances wildlife habitat. Periodic harvesting of trees in this area, following sustainable timber harvesting practices, can improve the health of the riparian zone. The third area 3) is a runoff control buffer strip to filter sediment and nutrients, and slow runoff from the adjacent agricultural or developed lands.

RIPARIAN MANAGEMENT ZONES:

Vegetation areas along river and streambanks that promote water filtration, reduce flooding and erosion, and create wildlife habitat.



PASTURE/CROPLAND
Adjacent land use does not readily impact surface waters when a RMZ is present. Livestock should be kept out of the RMZ. Water for livestock should be provided in the upland area. If the upland area is mostly cropland, fertilizers and pesticides should be carefully managed.

STREAM CHANNEL
The stream channel is a habitat for fish, mammals, and aquatic invertebrates. A healthy RMZ keeps sediments and nutrients from entering the channel and provides shade to stabilize water temperatures for the stream inhabitants. Trees and plants in the RMZ also deposit detritus and woody debris into the channel, which is essential food and habitat for fish and other stream dwellers.

1: UNDISTURBED FOREST AREA
Having trees along riverbanks provides lower water temperatures vital to fish habitat. Also, mature trees drop branches and twigs into the river, providing cover and shade for fish.

2: MANAGED FOREST AREA
As water reaches a forested riparian zone, it is filtered and absorbed by the vegetation. As a result, the water that enters the zone reaches the river more slowly. Also, the forested area provides natural habitat for animals. Water traveling to the river underground also is absorbed by roots.

3: RUNOFF CONTROL AREA
Without riparian zones along riverbanks, water runoff from fields enters a river all at once. With riparian zones, the water is dispersed as it approaches the zone. This helps reduce the amount of erosion at riverbanks.

RIPARIAN MANAGEMENT TREATMENTS

The condition of the Riparian Management Zone will determine the level of treatment needed at any given time. Protecting healthy functioning riparian areas from becoming degraded is the first step in effective riparian management. North Dakota Forest Service personnel can be contacted to provide a evaluation of the forest health.

The following management suggestions target RMZs with stable soil conditions and a healthy forest canopy:

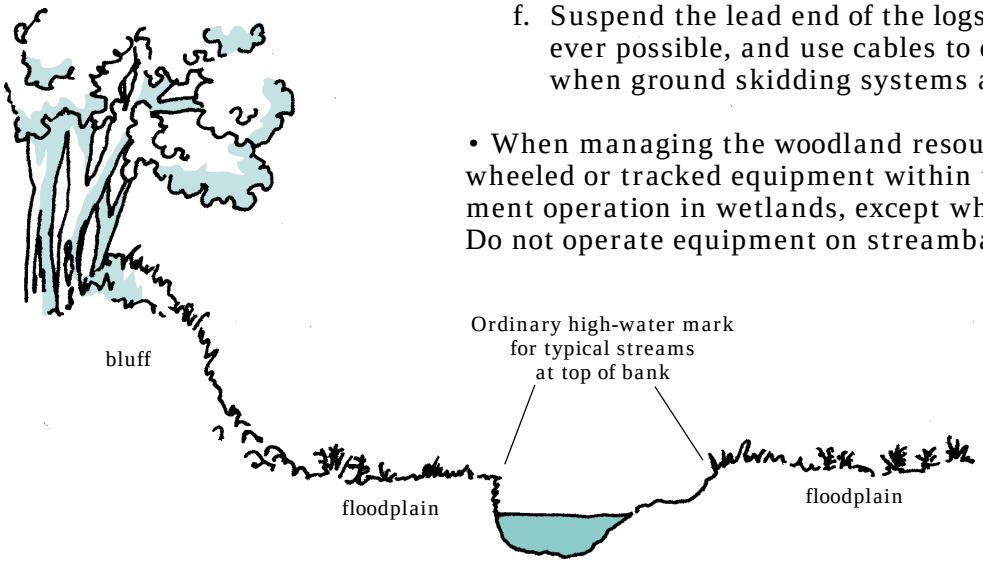
• Maintain a healthy stand within the RMZ. Employ the appropriate timber stand improvement techniques to ensure that trees remain healthy. *See Native Woodland Management.*

• Consider the following practices when harvesting timber in the Riparian Management Zone:

a. Limit harvesting within 15 feet of the ordinary high-water mark, targeting only problem trees. Retain some snags in the upland to provide cover for wildlife. In addition, leave appropriately located naturally occurring snags and woody debris in streams to provide habitat for fish and the microinvertebrates on which they feed.
b. Retain trees necessary for bank stabilization.
c. Do not remove all trees from the riparian area. In some soils and drainage patterns, clear cutting can cause marked increases in the water table, cold-air ponding, and grass/shrub competition. These factors can inhibit hardwood regeneration. To ensure hardwood reestablishment, some mature trees need to be left on site. In addition, scarification, hand planting, or other techniques may be necessary to reforest the site.
d. Maintain groundcover or groundcover to trap sediment and prevent soil erosion.
e. Use directional felling for harvest operations in the RMZ and wetlands. Avoid felling trees or leaving slash in streams or other surface waters. Whole-tree or tree-length yarding can reduce the need for slash disposal in the RMZ.
f. Suspend the lead end of the logs during skidding whenever possible, and use cables to drag logs out of wetlands when ground skidding systems are employed.

• When managing the woodland resource, minimize operation of wheeled or tracked equipment within the RMZ, and avoid equipment operation in wetlands, except when the ground is frozen. Do not operate equipment on streambanks.

ORDINARY HIGH-WATER MARK FOR STREAMS AND RIVERS



If not managed properly, riparian areas degrade and no longer function effectively to filter nutrients and sediment, stabilize banks, promote infiltration and groundwater recharge, or benefit

wildlife. Sections of degraded riparian area effect not only the adjacent stream or river, but impact the entire watershed. Some of the natural and human factors that can influence the stability and general condition of riparian areas and RMZs include:

• Livestock grazing and its subsequent soil compaction, which prevents tree rooting and leads to unstable soil conditions.
• Encroachment of agriculture or development into the RMZ removing all stabilizing vegetation.
• Inappropriate or untimely tree harvesting practices.
• Insect and disease infestations removing the forest canopy

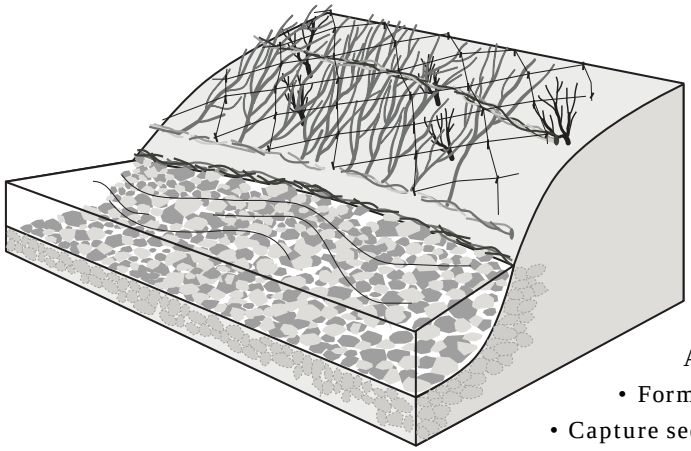
Some impacts of these factors can include but are not limited to:
• Lack of appropriate vegetation and associated roots, which stabilize streambanks and prevent soil erosion from the uplands.
• Steambank slumping, sliding, and excessive cutting, causing loss of land area in the RMZ, and the increased introduction of sediment into the watershed.
• Excessive channel erosion and channelization of the stream.

Restoration Treatments

Many activities and their negative impacts on the watershed can be managed. If an area has been degraded, the first step is to cease activities causing the stresses and allow the riparian zone to rest and naturally regenerate. A RMZ management plan should include regular evaluations of forest health by North Dakota Forest Service personnel to monitor the progress of regeneration. In certain cases, the RMZ may require additional action to improve the deteriorated conditions, which may include poor tree and native plant regeneration and bank failure. Some of these practices include:

• **Scarification.** Harvesting equipment may be used to scarify a site to encourage natural regeneration. Scarification prepares the site for incorporation of tree seeds by exposing mineral soil. In addition to logging equipment, specialized scarification equipment is available. NRCS has guidelines for scarification under their forest stand improvement practice.
• **Removal of excessive snags and deadfall from upland sites.** Snags have many wildlife habitat benefits and build forest soils as they decay. Woody debris can also reduce depredation of tree seedlings or grazing impacts. However, excessive snags and deadfall can limit access to forest stands for viewing, tree planting, or other improvement practices. When removing snags leave at least three snags per acre for cavity nesting birds and other wildlife.
• **Replanting native trees and riparian vegetation.** Planting native trees, shrubs and plants in degraded RMZs can quickly stabilize soils and reestablish sediment and nutrient filtering capabilities. Because of Dutch Elm Disease and other impacts mentioned above replanting is often recommended to supplement natural regeneration. Planting also allows the opportunity to add diversity of trees and shrubs.

The following pages show techniques that can be used to stabilize the early stages of bank failure:

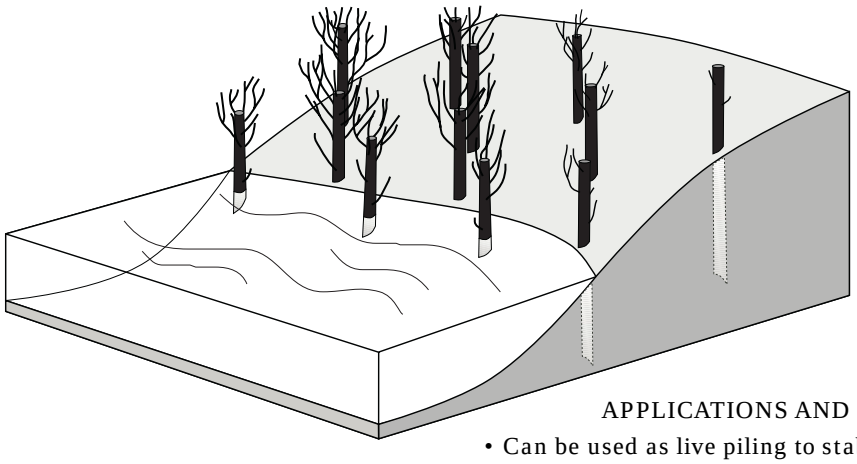


Brush Mattresses

Combination of live stakes, live facines, and branch cuttings installed to cover and physically protect streambanks from highwater erosion; eventually to sprout and establish numerous individual plants whose roots stabilize soils.

APPLICATIONS AND EFFECTIVENESS

- Form an immediate protective cover over the streambank.
- Capture sediment during flood flows.
- Provide opportunities for rooting of the cuttings over the streambank.
- Rapidly restores riparian vegetation and streamside habitat.
- Enhances conditions for colonization of native vegetation.
- Limited to the slope above base flow levels.
- Toe protection is required where toe scour is anticipated.
- Appropriate where exposed streambanks are threatened by high flows prior to vegetation establishment.
- Should not be used on slopes which are experiencing mass movement or other slope instability.

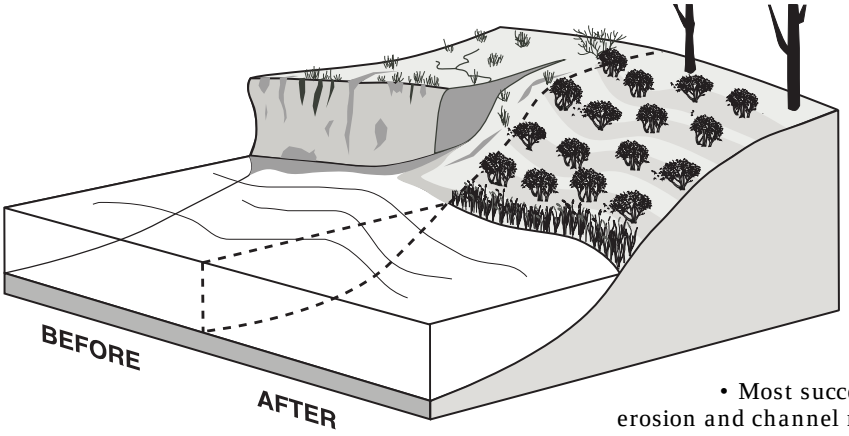


Dormant Post Plantings

Plantings of cottonwood, willow, poplar, or other species embedded vertically into streambanks. Plants sprout and their roots stabilize soils to increase channel roughness, reduce flow velocities near the slope face, and trap sediment.

APPLICATIONS AND EFFECTIVENESS

- Can be used as live piling to stabilize rotational failures on streambanks where minor bank sloughing is occurring.
- Useful for quickly establishing riparian vegetation, expecially in arid regions where water tables are deep.
- Will reduce near bank stream velocities and cause sediment deposition in treated areas.
- Reduce streambank erosion by decreasing the near-bank flow velocities.
- Generally self-repairing and will restem if attacked by beaver or livestock; however, provisions should be made to exclude such herbivores where possible.
- Best suited to non-gravelly streams where ice damage is not a problem.
- Will enhance conditions for colonization of native species.
- Are less likely to be removed by erosion than live stakes or smaller cuttings.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streamside vegetation.
- Unlike smaller cuttings, post harvesting can be very destructive to the donor stand, therefore, they should be gathered as 'salvage' from sites designated for clearing, or thinned from dense stands.

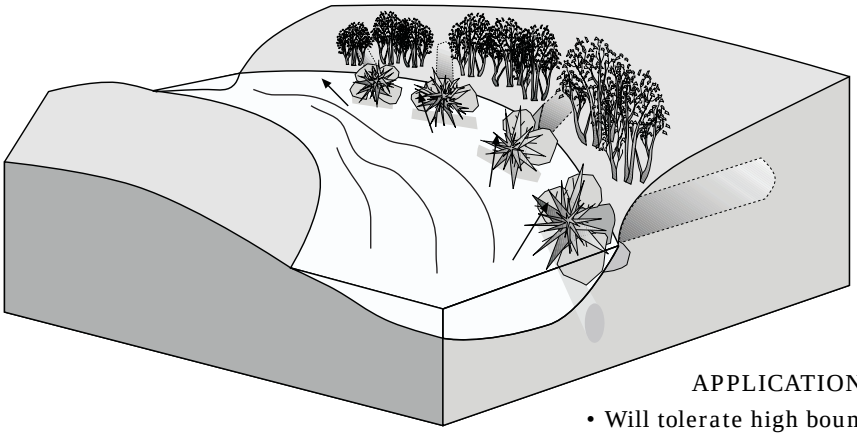


Bank Shaping & Planting

Reshaping streambanks to a stable slope, placing topsoil and other materials needed for sustaining plant growth, and selecting, installing, establishing appropriate plant species.

APPLICATIONS AND EFFECTIVENESS

- Most successful on streambanks where moderate erosion and channel migration are anticipated.
- Reinforcement at the toe of the embankment is often needed.
- Enhances conditions for colonization of native species.
- Used in conjunction with other protective practices where flow velocities exceed the tolerance range for available plants, and where erosion occurs below base flows.
- Streambank soil materials, probable groundwater fluctuations, and bank loading conditions are factors for determining appropriate slope conditions.
- Slope stability analyses are recommended.

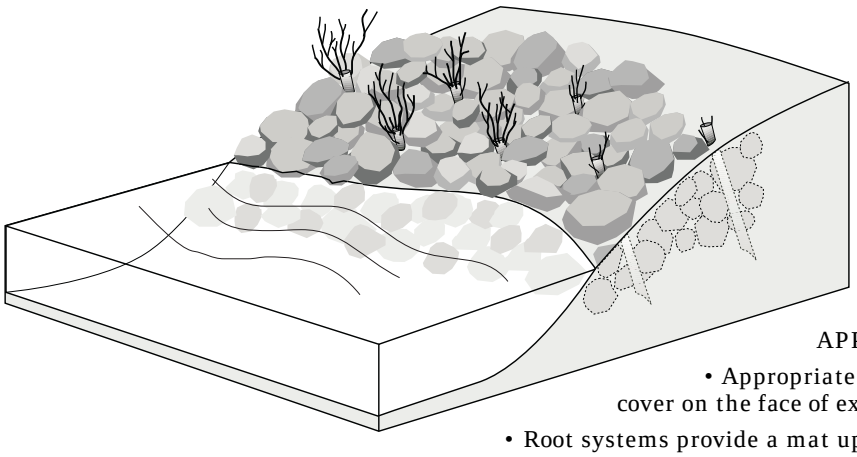


Log, Rootwad, and Boulder Revetments

Boulders and logs with root masses attached placed in and on streambanks to provide streambank erosion, trap sediment, and improve habitat diversity.

APPLICATIONS AND EFFECTIVENESS

- Will tolerate high boundary shear stress if logs and rootwads are well anchored in trenches and backfilled.
- Suited to streams where fish habitat deficiencies exist.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Will enhance diversity in riparian areas when used with soil bioengineering systems.
- Will have limited life depending on climate and tree species used. Some species, such as cottonwood or willow, often sprout and accelerate colonization.
- Might need eventual replacement if colonization does not take place or soil bioengineering systems are not used.
- Use of native materials can sequester sediment and woody debris, restore streambanks in high velocity streams, and improve fish rearing and spawning habitat.
- Site must be accessible to heavy equipment.
- Materials might not be readily available at some locations.
- Can create local scour and erosion.
- Can be expensive.

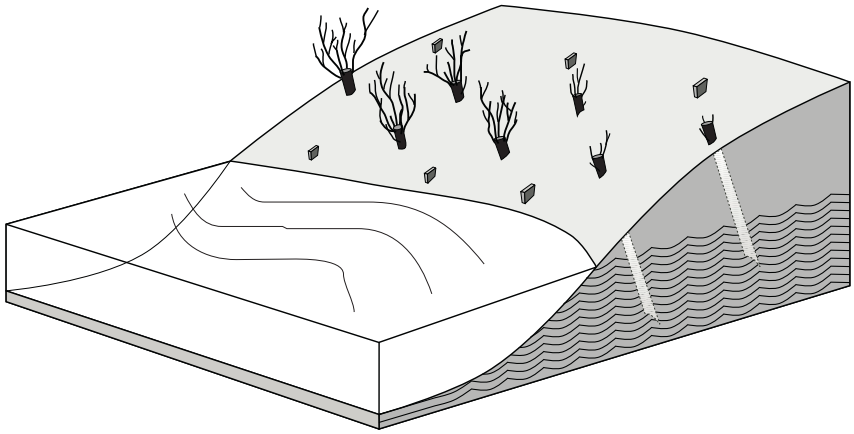


Joint Plantings

Live stakes hammered into joints or openings between rock which have previously been installed on a slope or while rock is being placed on the slope face.

APPLICATIONS AND EFFECTIVENESS

- Appropriate where there is a lack of desired vegetative cover on the face of existing or required rock riprap.
- Root systems provide a mat upon which the rock riprap rests and prevents loss of fines from the underlying soil base.
- Root systems also improve drainage in the soil base.
- Will quickly establish riparian vegetation.
- Should, where appropriate, be used with other soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streambank vegetation.
- Have few limitations and can be installed from base flow levels to top of slope, if live stakes are installed to reach ground water.
- Survival rates can be low due to damage to the cambium or lack of soil/stake interface.
- Thick rock riprap layers may require special tools for establishing pilot holes.

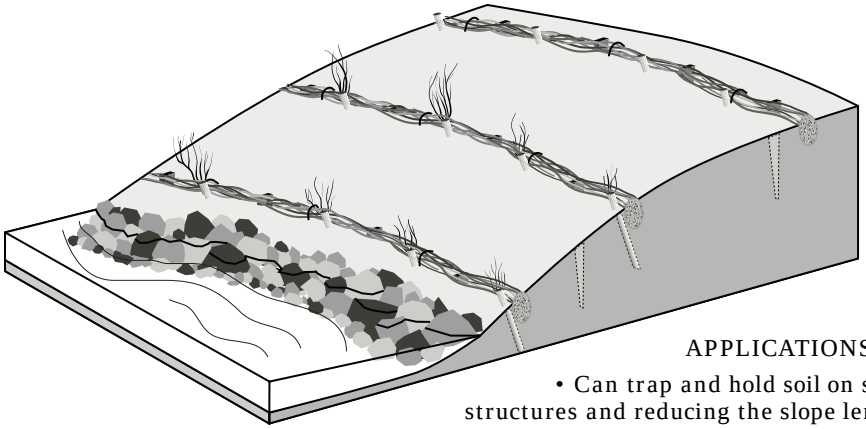


Live Stakes

Live, woody cuttings which are hammered into the soil to root, grow and create a living root mat that stabilizes the soil by reinforcing and binding soil particles together, and by extracting excess soil moisture.

APPLICATIONS AND EFFECTIVENESS

- Effective where site conditions are uncomplicated, construction time is limited, and an inexpensive method is needed.
- Appropriate for repair of small earth slips and slumps that are frequently wet.
- Can be used to stake down surface erosion control materials.
- Stabilize intervening areas between other soil bioengineering techniques.
- Rapidly restores riparian vegetation and streamside habitat.
- Should, where appropriate, be used with other soil bioengineering systems and vegetative plantings.
- Enhance conditions for colonization of vegetation from the surrounding plant community.
- Requires toe protection where toe scour is anticipated.

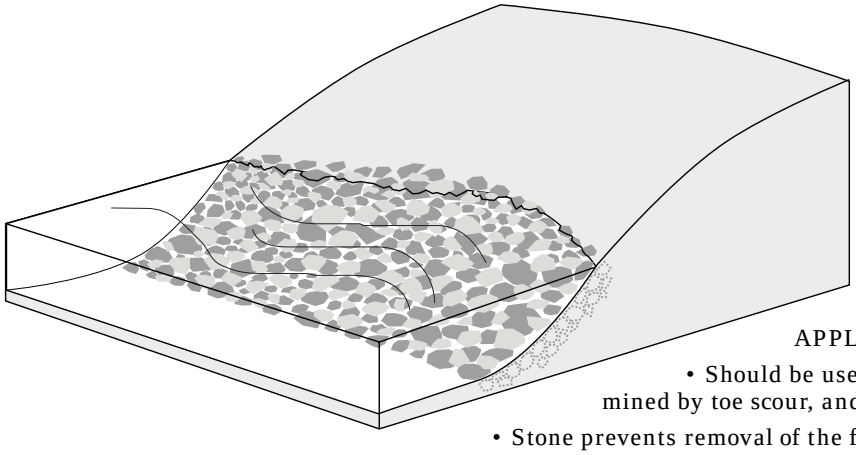


Live Fascines

Dormant branch cuttings bound together into long sausage-like, cylindrical bundles and placed in shallow trenches on slopes to reduce erosion and shallow sliding.

APPLICATIONS AND EFFECTIVENESS

- Can trap and hold soil on streambank by creating small dam-like structures and reducing the slope length into a series of shorter slopes.
- Facilitate drainage when installed at an angle on the slope.
- Enhance conditions for colonization of native vegetation.
- Should, where appropriate, be used with other soil bioengineering systems and vegetative plantings.
- Requires toe protection where toe scour is anticipated.
- Effective stabilization technique for streambanks, requiring a minimum amount of site disturbance.
- Not appropriate for treatment of slopes undergoing mass movement.



Stone Toe Protection

A ridge of quarry-sized rocks or stream cobble placed at the toe of the streambank as an armor to deflect flow from the bank, stabilize the slope and promote sediment deposition.

APPLICATIONS AND EFFECTIVENESS

- Should be used on streams where banks are being undermined by toe scour, and where vegetation cannot be used.
- Stone prevents removal of the failed streambank material that collects at the toe, allows revegetation and stabilizes the streambank.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerated source of streamside vegetation.
- Can be placed with little disturbance to existing slope, habitat, and vegetation.

Streambank failure, slumping, and rapid bank cutting typically cannot be corrected with the techniques described above. At many locations, the source of the problem is on-site and correctional steps can be taken. Techniques include log, rootwad, and boulder revetments; vegetated gabions; and live cribwalls. These techniques require heavy equipment and engineering of the streambank slope and are typically used to protect homes, roads, bridges, and valuable agricultural land. However, the cause of some problems may be upstream from the site or of such a nature that stabilization techniques will not likely be successful. For assistance in evaluating and stabilizing severe stream bank failures contact the local Natural Resources Conservation Service office, ND Forest Service, ND Game and Fish Department, ND Department of Health, county water board, or Resource Conservation and Development Council.

STREAM CROSSINGS

Contact and coordinate with your local Water Resource District if you plan on crossing any streams. This includes both temporary and permanent crossings.

Design Considerations

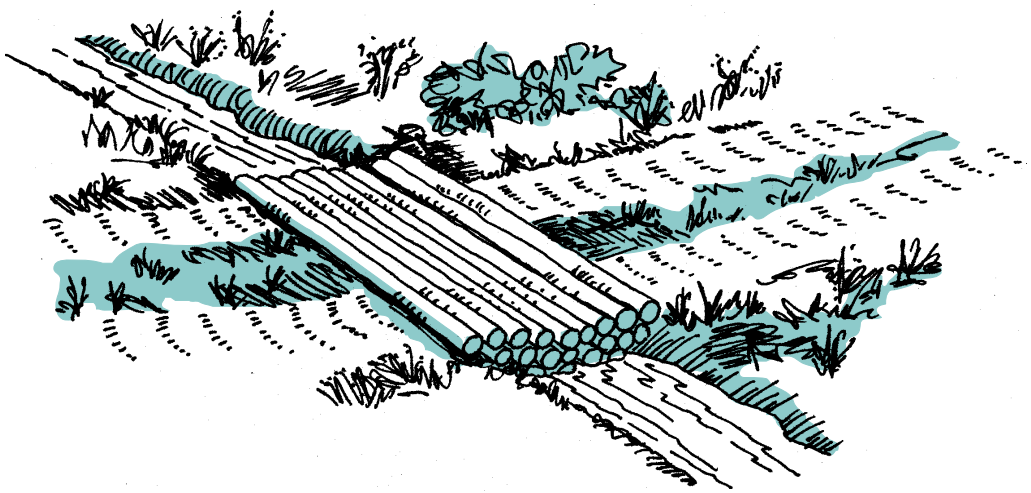
Design stream crossings to minimize streambank and streambed disturbance.

• Cross streams at right angles to the main channel, if practical. Adjust the road grade to reduce the concentration of water carried through the drainage system to stream crossings. Direct drainage through an RMZ and away from the stream crossing site.

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

POLE FORD FOR SMALL STREAM CROSSINGS:

Pole fords must be removed immediately after use or before the upstream end becomes clogged with debris and impedes streamflow.



Installation of Stream Crossings

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.

• When using culverts to cross small streams, install those culverts to conform to the natural streambed and slope on all perennial streams and on intermittent streams that support fish or that provide seasonal fish passage. Use appropriately sized culverts or multi-culvert systems to stage flows. 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.

• Install culverts to prevent erosion of fill. Compact the fill material to prevent seepage and failure. Armor the inlet and/or outlet with rock or other suitable material where needed.

CULVERT WITH RIPRAP AT THE INLET:

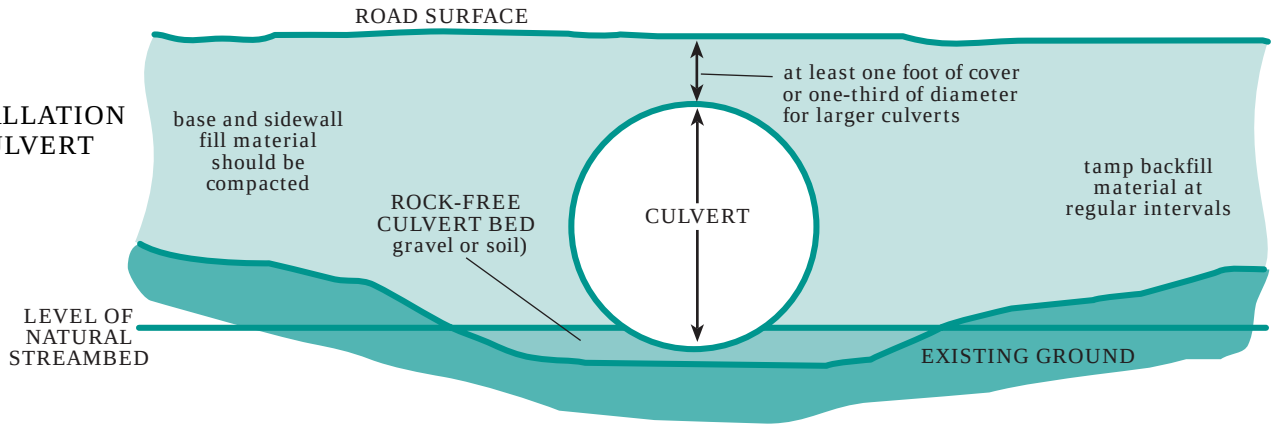
Prevents water from eroding and undercutting.

• Consider dewatering stream crossing sites during culvert installation.

• Prevent plunge pool and downstream erosion from high velocity discharges.

• Use 1-foot minimum cover for culverts 18 to 36 inches in diameter, and a cover of one-third diameter for larger culverts to prevent crushing by traffic. Ensure enough culvert length to maintain stable side slopes, 2:1), from the edge of the road.

INSTALLATION OF CULVERT



• Use culverts with a minimum diameter of 15 inches for permanent stream crossings and cross drains. The culvert size is determined by the expected stream flow rate during peak run-off time.

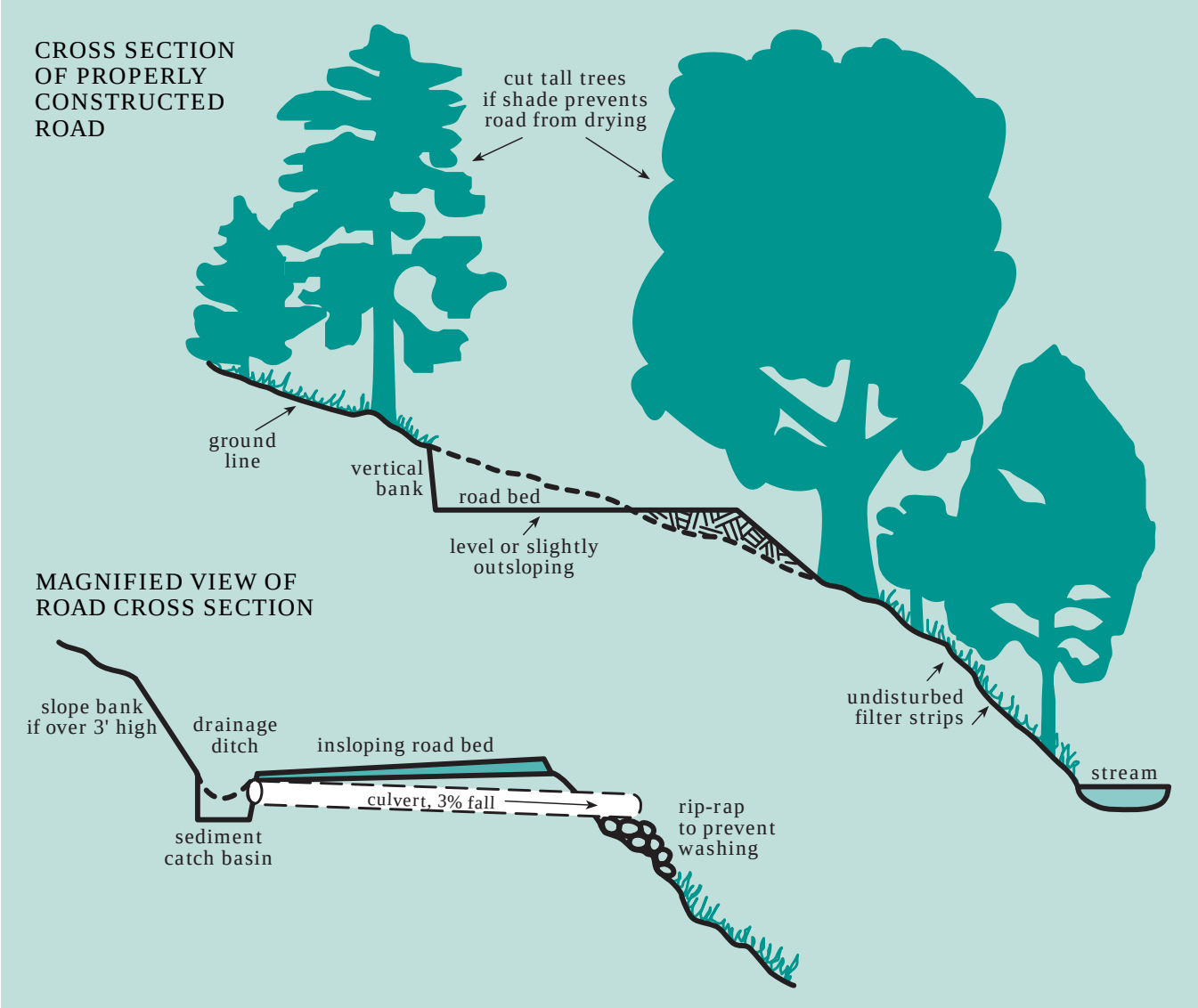
• Designate or mark all streams' courses, including small streams, and existing culvert locations prior to snowfall. Conduct activities in streamside zones so the ground disturbance is minimized. Following completion of snow road use, restore stream crossings to near pre-road conditions to prevent ice dams. Make sure all culverts and ditches are open and functional. Do not use the stream channel for the roadway except for crossings.

ROADS

Planning and Location

Roads produce 90 percent of all sediment from forest activities. That's why planning, design and location of roads is so critical. Contact and coordinate with your local Water Resource District and the local Natural Resources Conservation Service office for any proposed road building. This includes both temporary and permanent roads needed to access a stand of timber. Adherence to USDA and Army Corps of Engineer wetland and water course requirements should be thoroughly investigated before construction begins.

• Minimize the number of roads constructed 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.



• Review available information and consult with professionals as necessary to help identify erodible soils and unstable areas, and to locate appropriate road surface materials.

• Fit the road to the topography by locating roads on natural benches and following natural contours. Avoid long, steep road grades and narrow gullies, draws or coulees.

• 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, swamps, wet meadows, and natural drainage channels.

• Consider snow-road construction and winter harvesting for logging sites that are characterized by wet meadows, high-water tables, sensitive riparian conditions or other potentially significant soil erosion and compaction hazards.

• Locate roads a safe distance from streams when roads are running parallel to stream channels. Provide an adequate Riparian Management Zone RMZ) to trap sediment and prevent its entry into the stream.

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

• Locate roads to provide access to relatively flat and well-drained log landing areas to reduce soil disturbance.

Design

Well-designed roads and drainage facilities are important for controlling drainage and ensuring water quality. They also prevent potential water quality problems from road construction.

• Design roads to the minimum standard necessary to accommodate anticipated use and equipment. The need for higher standard roads can be alleviated through better road-use management.

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

• Design roads for minimal disruption of drainage patterns. Vary road grades to reduce concentrated flow in road drainage ditches, culverts, and on fill slopes and road surfaces.

• Design stream crossings for adequate passage of fish, minimum impact on water quality, and at a minimum, the 25-year frequency runoff. *See Stream Crossings.*

Drainage from Road Surface

Runoff water from roads must be controlled to prevent road surface erosion and increased stream sedimentation.

• Provide adequate drainage from the surface of all permanent and temporary roads by using out-sloped or crowned roads, drain dips, or in-sloped roads with ditches and crossdrains. Space road drainage features to adequately handle runoff during peak flow conditions.

DRAIN DIP SPACING GUIDE

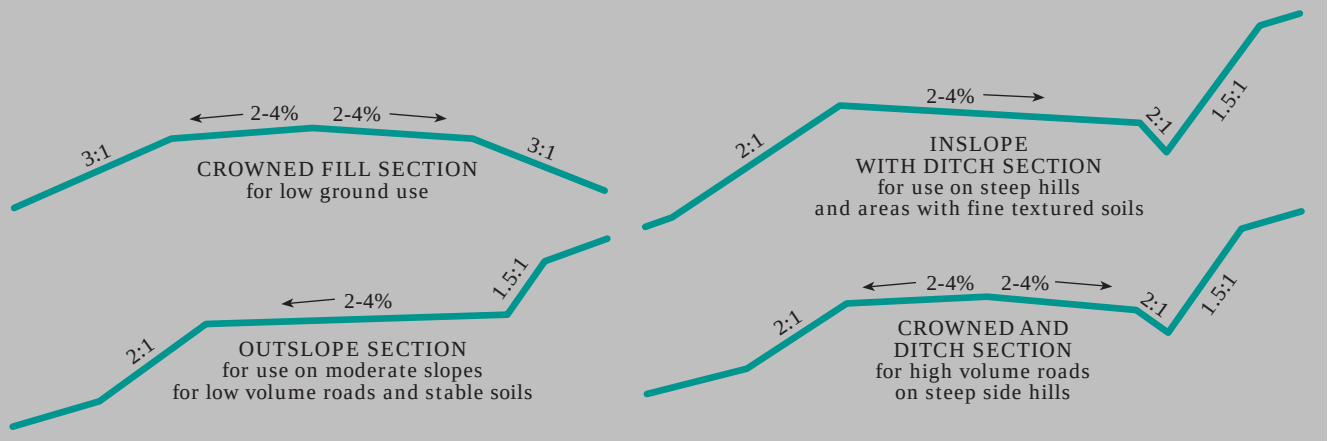
ROAD GRADE	SPACING BETWEEN DRAIN DIPS
0 - 2%	500 feet
3 - 4%	300 feet
5 - 7%	180 feet
8 - 10%	150 feet
11 - 15%	130 feet
16%+	110 feet

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

b. For in-sloped roads, plan ditch gradients steep enough, generally greater than 2 percent, but less than 8 percent, to prevent sediment deposition and ditch erosion. The higher gradients may be suitable for more stable soils; use the lower gradients for less stable soils.

c. Properly constructed drain dips can be an economical method of channeling surface flow off the road. Construct drain dips deep enough into the subgrade so that traffic will not destroy them.

TYPICAL ROAD DESIGNS FOR DRAINAGE AND STABILITY



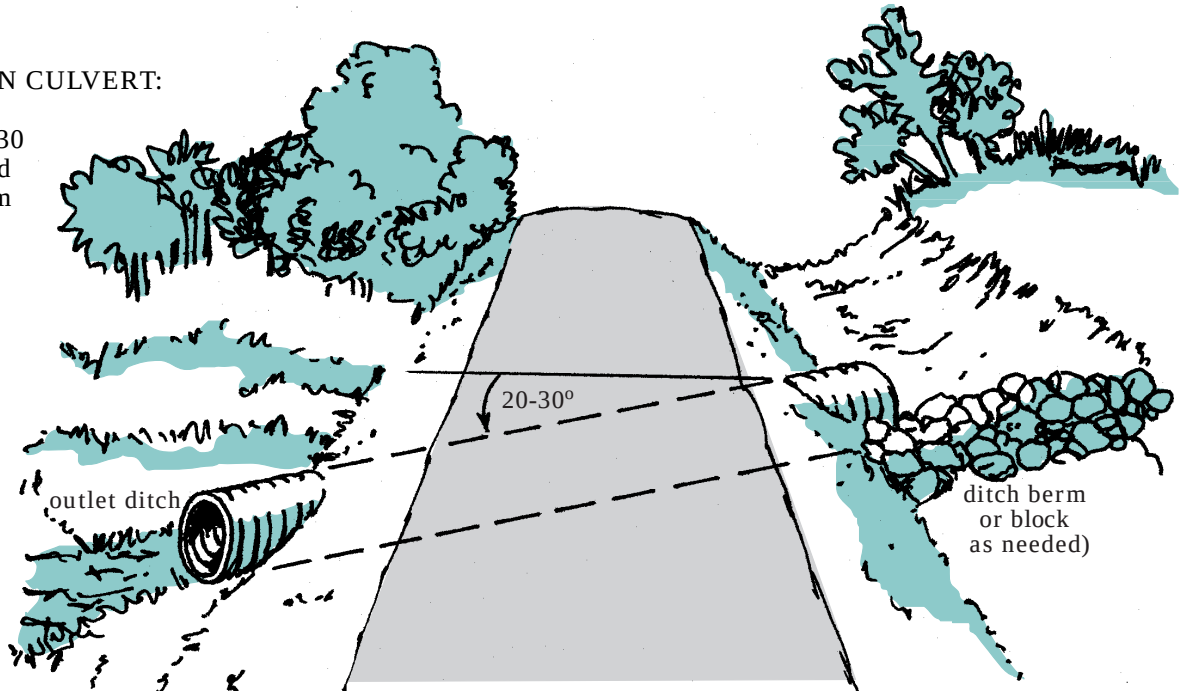
• Skew ditch relief culverts 20 to 30 degrees toward the inflow from the ditch to improve inlet efficiency. Protect the upstream end of cross-drain culverts from plugging.

• Where possible, install ditch relief culverts at the gradient of the original ground slope; otherwise armor outlets with rock or anchor down spouts to carry water safely across the fill slope.

• Provide energy dissipators rock piles, logs, etc.) where necessary at the downstream end of ditch relief culverts to reduce the erosion energy of the emerging water. Crossdrains, culverts, water bars, dips, and other drainage structures should not discharge onto erodible soils or fill slopes without rock or vegetative protection.

CROSS-DRAIN CULVERT:

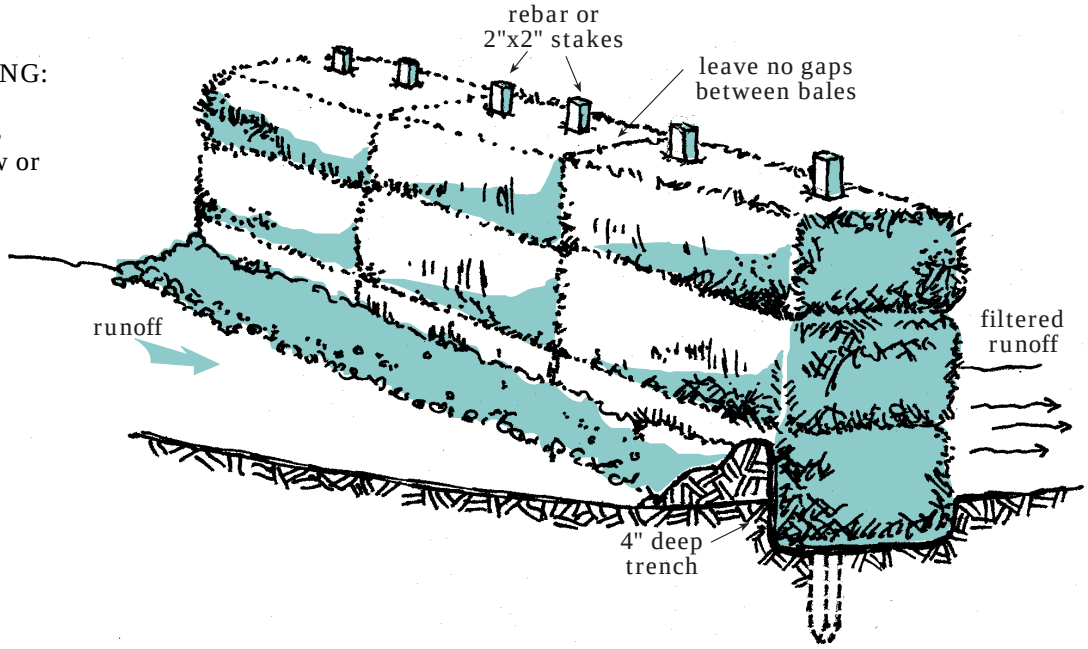
Skewed 20 to 30 degrees toward the inflow from the ditch to improve inlet efficiency.



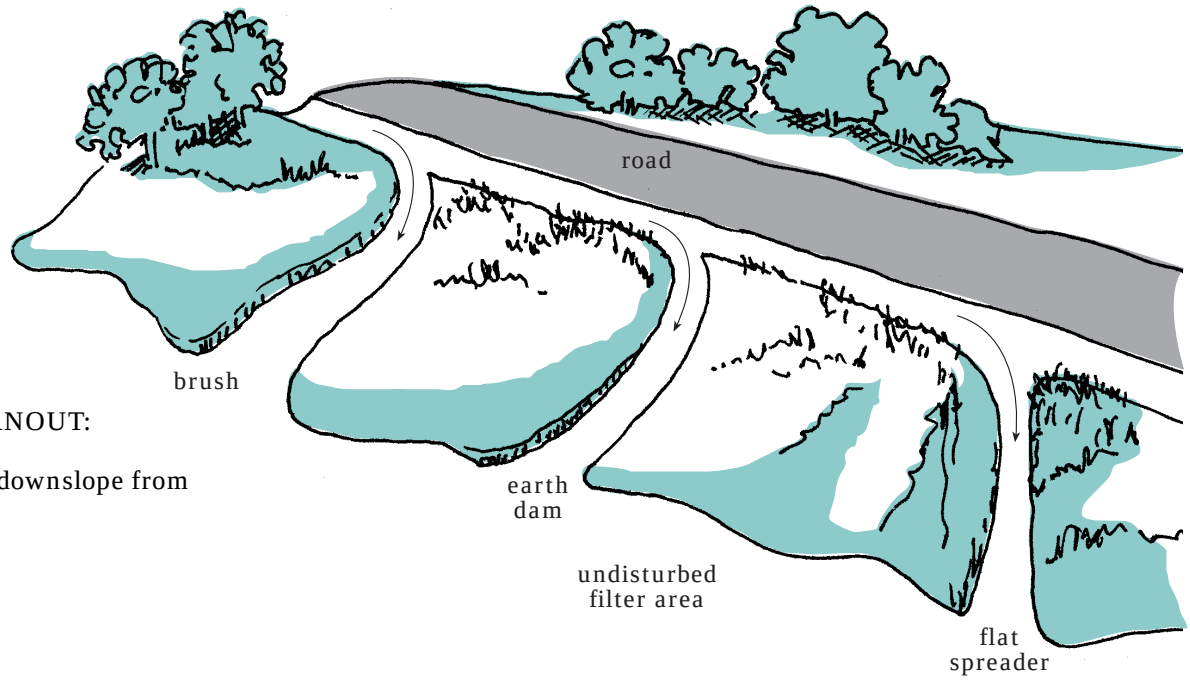
• Prevent downslope movement of sediment by making changes in road grade and/or installing straw bales, rock piles, filter fence, etc.

STRAW BALE FENCING:

Slows runoff and traps sediment for sheet flow or channelized flow.



• Route road drainage through a vegetative filter zone or other sediment settling structures. Make sure road drainage features are installed above stream crossings.



WATER TURNOUT:

Water turns downslope from access road.

Construction

Keep slope stabilization, erosion and sediment control work as current as possible with road construction.

• Install drainage features as part of the construction process. Complete or stabilize road sections within the same operating season, ensuring that drainage structures are fully functional prior to spring or fall runoff and that major road sections are not left in an unstable condition over winter.

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

• 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 practice can effectively control sediment movement and can provide an economical way of disposing of roadway slash. Limit the height, width and length of these slash filter windrows" so not to impede wildlife movement.

• 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.

• Construct cut and fill slopes at stable angles.

• 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.

• Consider gravel surfacing to minimize erosion.

• Place debris, overburden, and other waste materials associated with construction and maintenance activities in a location to avoid entry into streams.

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

• When using existing roads, reconstruct only to the extent necessary to provide adequate drainage and safety; avoid disturbing stable road surfaces.

Maintenance

Grade road surfaces only as often as necessary to maintain a stable road surface and to retain the original surface drainage.

• Maintain erosion control features through periodic inspection and maintenance. Clean dips and crossdrains, repair ditches, mark culvert inlets to aid in locations, and clear debris from culverts.

• Avoid cutting the toe of cut slopes when grading roads or cleaning ditches.

• During cold weather, plow any snow cover off of the roadway to facilitate deep freezing of the road grade.

• When plowing snow for winter timber harvest, provide breaks in snow berm to allow road drainage.

• Haul all excess material removed by maintenance operations to safe disposal sites and stabilize these sites to prevent erosion. Avoid plowing or grading material into streams or locations where erosion will carry materials into a stream.

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

• Upon completion of seasonal operations, the road surface should be crowned, out-sloped, in-sloped, or water barred. Remove plowed or graded material from the outside edge where runoff is channeled.

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

ACKNOWLEDGMENTS

The North Dakota Forest Service is very grateful to the agencies, organizations, and professional people who assisted in the development of the *North Dakota Forestry Best Management Practices*. It provides a foundation for implementing sound forestry practices on private and public land. May our efforts continue to produce a strong commitment to stewardship of our natural resources.

Energy and Environmental Research Center
Grand Forks Herald
Grand Forks Park District
Natural Resources Conservation Service
Nelson County Water Board
ND Department of Health
ND Fish & Wildlife Service
ND Game & Fish Department
ND Soil Conservation Districts
ND State Water Commission
NDSU Extension Service
Red River Regional Council
Red River Resource Conservation & Development
UND Geology Department
U.S. Army Corps of Engineers
U.S. Fish & Wildlife Service

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