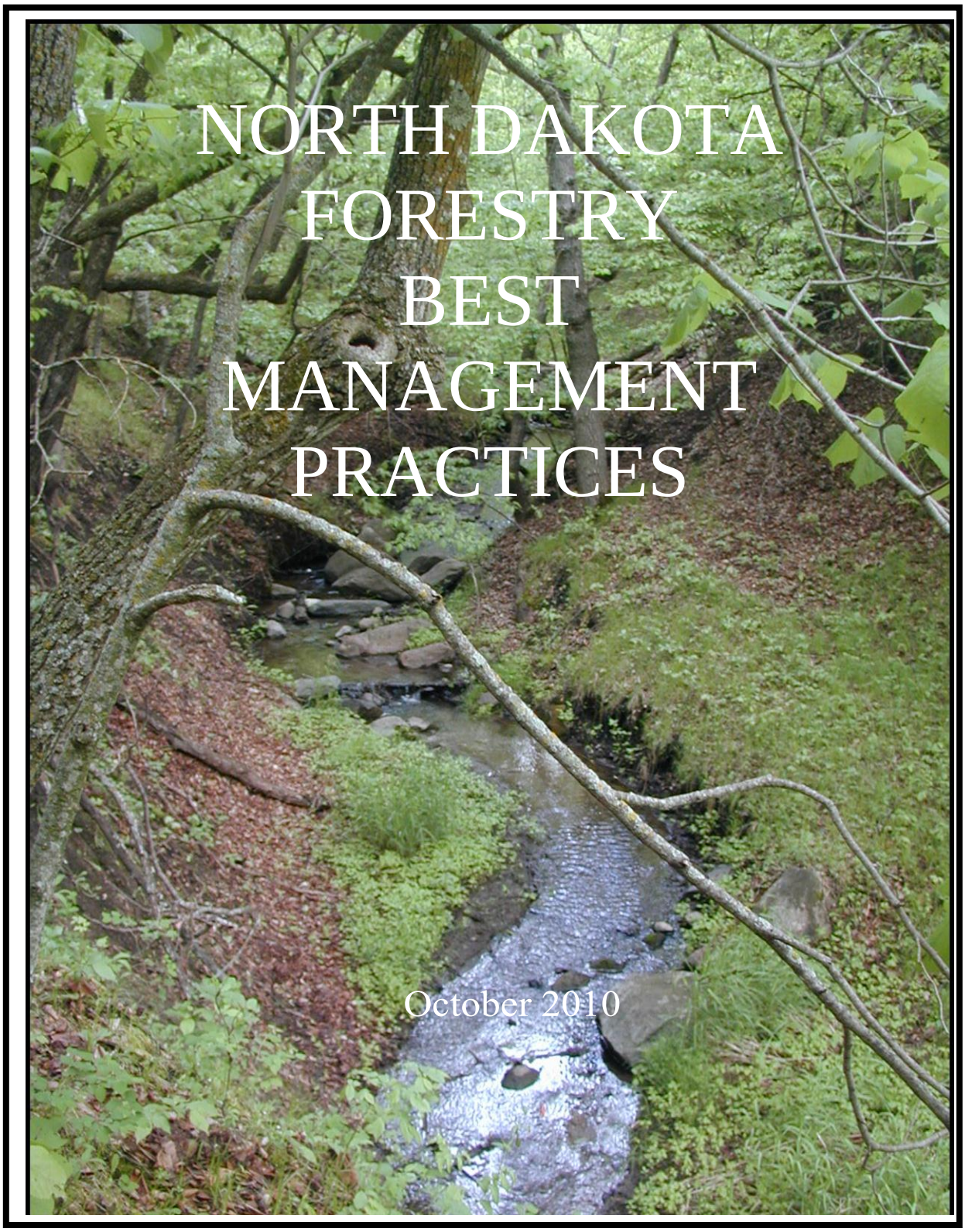
NORTH DAKOTA
FORESTRY
BEST
MANAGEMENT
PRACTICES
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OVERVIEW

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 ***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 resource 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 have a Forest Management Plan prepared for their woodland and planting areas. 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; Windbreaks; Native Woodland Management; Forest Protection; Timber Harvesting and Site Preparation; Streamside Management; Stream Crossings; and Roads.

RESOURCE PLANNING

Land Owner 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 the long term, because whatever is done—or not done—will have term impacts. 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:

- 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.

- Windbreak establishment and renovation; protect buildings, animals and crops from wind and snow; provide shade for animals and buildings.
- Wildlife food and habit; encourage or discourage certain wildlife species.
- Stream bank protection; improve localized water chemistry parameters.
- Forest products; lumber, fuel wood, berries, nuts, Christmas trees.
- Living snow fence; protect roads and buildings from snow drifting.
- Aesthetics; foliage, bark and berry colors, tree forms, stand arrangements.
- Grazing; provide shade and protection from wind and snow.
- Recreation; establish camping, picnicking fishing, hiking, winter activity area.
- 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 professionals 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.

The following information should be included in a management plan:

- Landowner management objectives.
- Description and mapping of existing resources. Property boundaries, woodland boundaries, water sources, building locations, adjacent land uses.
- 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.
- Soils description as it relates to erodibility and suitability to support trees and shrubs.
- The management practice(s) that will help meet the objective(s).
- An activity schedule that assesses and reflects labor, equipment and financial resources. The activity schedule should cover at least five to ten years.

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.

WINDBREAKS

Windbreaks or shelterbelts are an integral part of the rural landscape. They reduce soil erosion, reduce heating and cooling costs for a home, reduce heat and cold stress for livestock, and help manage snow. They can also provide some protection from wildfire around a rural home. In addition to providing protection, windbreaks can create wildlife habitat, beautify the landscape and enhance property values.

Kinds of Windbreaks

There are several different kinds of windbreaks based upon the primary use of the planting. Most plantings are simply modifications of two basic windbreak/shelterbelt designs.

1. Building site or livestock shelterbelts, which are designed to protect farmsteads, feedlots or other building sites.
2. Field windbreaks that are single- or multiple-row plantings designed to prevent erosion; protect crops and roads; to harvest snow; or to provide noise or visual screens.

Farmstead Windbreaks

A farmstead windbreak is a windbreak that is installed around a rural home to provide protection from the weather. Landowners who wish to attract wildlife, such as songbirds, can plant species that provide edible fruits as well as nesting sites. A farmstead windbreak can also provide a source of seasonally fresh fruits and beautify the landscape.

Field Windbreaks

A field windbreak is a tree planting that is designed to protect a crop field from the wind and increase the crop yield. Field windbreaks function in different ways throughout the year. During winter months, field windbreaks can aid in snow distribution. By selecting the proper species at the proper spacing, farmers can alter the distribution of snow across their fields. A dense windbreak will accumulate snow, while a less dense windbreak will distribute it evenly across a crop field. In early spring, windbreaks reduce soil blowing.

Feedlot Windbreaks

A feedlot windbreak is placed around a concentrated livestock feeding area to provide protection during the late fall through early spring periods. This reduces stress to livestock during critical periods. Installing a windbreak around feedlots can reduce the visual impact and also moderate the odor associated with these areas.

Vegetative Fuelbreaks

A vegetative fuelbreak is designed to provide a break in fuel types between a wildland area (i.e. CRP field, rangeland, and prairie) and a rural home or other structure. It has three special design considerations. The first is a short or mowed grass strip on the outside of the windbreak. The second is a tilled strip between the grass area and the tree planting. The third part is the tree planting using less flammable species outlined by Firewise North Dakota. These three zones are designed to: (1) reduce flame heights, (2) stop the spread of the fire, and (3) alter the wind environment to protect the rural home.

Living Snow Fences

A living snowfence is a specially designed windbreak to trap snow and keep it from accumulating where it is unwanted. Living snowfences are generally installed along travel routes such as Interstates, State Highways, county and township roads. These are typically multiple rows set at least 200 feet back from the area to be protected.

Establishment

Preparation

The success of any tree planting is dependent upon site preparation, stock quality, planting and handling techniques, and maintenance employed by the planner, vendor, planter, and landowner. This document illustrates a wide variety of methods that have proven successful for conservation tree and shrub plantings in North Dakota.

Refer to the Specific Windbreak Suitability Group assigned to the soil for each county to determine appropriate tree and shrub species. These can be found at http://efotg.nrcs.usda.gov/ in Section II, Windbreaks/Forest subfolder.

Site preparation may include the whole field, strips, or patches. Individual site preparation for each tree/shrub should provide a minimum 4-foot diameter circle, or a minimum 4-foot x 4-foot square, or a 4-foot wide strip at each planting spot (2 feet on each side of the planted stock). The planting area must be free of living sod and perennial weeds before planting. Fabric weed barrier (see photo) may also be applied.

Abandoned feedlots and farmsteads may hinder the success of a planting due to nutrient imbalances or subsurface toxic materials that can damage tree roots and shorten the lifespan of a tree planting. Livestock should also be fenced out of any new tree planting.

Another consideration in determining an appropriate planting site is the presence of overhead or underground utilities. Many underground utilities are buried deep enough to be out of the reach of tree planters or tree roots. However, these utilities should be located before planting to reduce any potential complications. Overhead power lines also need to be considered. Move the windbreak a few feet away from the lines or select a shorter species to mitigate these problems.

Diversity

A lack of diversity in existing tree plantings can be blamed for many of the tree problems that we see today. Dutch elm disease is a perfect example of relying too heavily on a single species. Diversifying a planting provides a certain level of insurance that if one species is removed due to a forest health problem there will be other trees to maintain the function of the planting.

In single row field windbreaks, landowners should at least alternate the species between windbreaks. In larger windbreaks, combining a whole variety of species can greatly improve the overall health of the windbreak and make it more resistant to damage from insects or disease. In addition, landowners can select trees that have differing life spans. For example, use a hybrid poplar to create a fast growing windbreak. Plant a hackberry next to the hybrid poplar that will provide protection when the short-lived poplars die. Finally, species like bur oak can give the windbreak a long-term life span. Mixing in shrubs and short trees can also add to diversity of the windbreak and provide for understory protection.

For more specific information on windbreak design and installation, please refer to the Natural Resources Conservation Service Design and Installation Guide which can be found at http://efotg.nrcs.usda.gov/ Section IV, Conservation Practices subfolder.

Renovation Options

When properly applied, windbreak renovation can:

- Restore the function of an existing windbreak.
- Modify the function of an existing windbreak.
- Increase the health and vigor of selected windbreak plants.
- Increase the longevity of a windbreak

Caution: several windbreak renovation methods involve substantial soil disturbance at depths below typical agricultural tillage. If the depth of disturbance will exceed 18 inches, notification of various utility companies via the North Dakota One Call System at 1-800-795-0555 is required. Several of the windbreak renovation methods are considered undertakings per

Section 106 of the Federal Historic Preservation Act and will need to be investigated and assessed accordingly.

Windbreak Renovation Methods

- Coppicing
- Gap planting
- Managing natural regeneration
- Pruning
- Root pruning
- Row removal and replacement
- Shearing
- Sod release and management
- Supplemental planting (intra-planting)
- Thinning

Row Removal and Replacement

Probably the easiest method of renovating a failing windbreak is to remove the existing trees and start again. Two of the most common tools for tree removal in North Dakota are bulldozers or a skid-steer loader mounted with a Marshall saw. A chainsaw is another important tool to have on hand. The biggest benefit of this method is it can be completed in a relatively short time period. Using a dozer can often push out many of the roots along with the tree removal. The ground should be re-cultivated with a disc or other heavy machinery to ensure that all roots have been removed from the planting site. Once the site is properly prepared, it can be replanted according to the specifications in the NRCS Design and Implementation Guide.

If using a Marshall saw, it should be noted that only the portion of the tree above the ground will be removed. Therefore, it is either necessary to cut the trees high enough to be able to pull the stumps later, or the new planting should go in between the existing rows. The roots of the previous tree rows will make standard machine planting difficult at best. Trees can be hand planted between stumps within the old row or between rows. Tools for hand-planting include a shovel or a 4-inch diameter auger that can be mounted on a three-point hitch to pre-drill holes.

Each individual tree site should be prepared by scraping (scalping) any existing vegetation on at least a 2 foot by 2 foot square prior to digging the hole. Vegetation could be treated chemically as well. The tree should be protected from weed competition by chemical or mechanical means or by placing a small square of weed barrier fabric around each tree.

Coppicing

This is the practice of removing the above ground portion of the tree and allowing the re-sprouting from the stump to provide the replacement trees. This works very well with many shrub species such as lilac, honeysuckle and caragana. Short-lived tree species, such as hybrid

poplar, willow and aspen can also be managed in this way. The existing root structure allows the plant to put all of its energy into above ground growth so the new trees and shrubs grow very quickly.

A pole-mounted chainsaw can be very helpful in this practice when working with shrubs to reduce the amount of bending required for cutting the stems. Whether working with shrubs or larger trees, the stems should be cut as close to the ground as possible to allow the sprouts to emerge low. The nearer to the ground they are, the stronger they will be as they get larger. With shrubs, all new shoots should be left to provide a dense row. If coppicing larger trees, all but the best 3-5 sprouts should be removed at the end of the first growing season. After 2-3 years the remaining sprouts should be removed leaving only the tallest, best formed, healthiest stem.

Following the removal of the above ground growth, the woody debris can either be piled or scattered through the site. If the debris is piled, it can either be burned or left for wildlife habitat. If the debris is scattered over the site, it will provide protection for the emerging shoots.

Thinning

There are essentially two objectives for this practice. One is to allow for more even snow distribution in a field where the planting season is delayed due to wet conditions. The other is to remove crowded, suppressed, diseased or dead trees to improve the health and vigor of the remaining trees. An easy solution for the first objective is to remove every other tree within a row. This can often be effective for the second objective as well, but flexibility should be maintained to allow for dead and diseased trees that don't follow the pattern established.

For multiple row windbreaks an easy solution for both objectives may include the removal of an entire row. Other patterns for thinning can be discussed with a professional forester to help determine what is most appropriate.

Underplanting

Often, hand planting can be an effective way to fill the gaps in a windbreak. The shade tolerance for a species must be taken into consideration when undertaking this practice. Species listed as shade tolerant include: redosier dogwood, amur honeysuckle, American linden (basswood), and eastern redcedar. Species listed as moderately shade tolerant include: Russian almond, caragana, black chokeberry, common chokecherry, cotoneaster, golden currant, forsythia, tatarian honeysuckle, Juneberry, American plum, Hansen hedge rose, snowberry, sumac, nannyberry, black ash, green ash, Siberian elm, hackberry, Russian olive, and Rocky Mountain juniper.

Reducing competition can be done through chemical or mechanical means, similar to those used for machine planting. A 3-4 foot area around the planting hole should be stripped of sod and other competing vegetation before planting the tree. Use of fabric weed barrier in 3-4 foot squares can also be a very effective way to enhance survival of hand plants.

Other factors to consider are water tolerance, snow or ice tolerance, root suckering, and regeneration potential. These can be determined by referring to the Tree and Shrub Characteristics table available at http://efotg.nrcs.usda.gov/ Section I, Windbreaks and Woodland subfolder.

Managing Natural Regeneration

Utilizing natural regeneration to fill gaps that exist within rows is a cost-effective means to increase overall efficiency of a windbreak. The natural regeneration found within a windbreak could provide extra protection to the farmstead or field, while adding structural diversity to the stand. Structural diversity is the variation in height, diameter and crown classes that exist in a natural setting. It is also seen as a critical component of good wildlife habitat. The management of natural regeneration is the most effective practice in achieving the landowner's desired wildlife improvement goals.

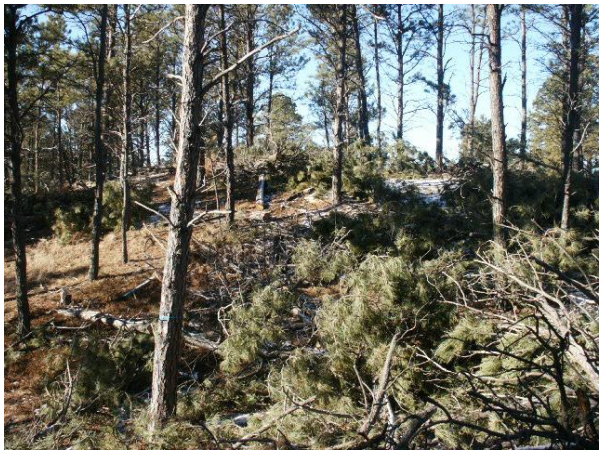
To encourage natural regeneration in areas where it is not occurring, the site may have to be prepared. In many windbreaks, sod and other dense grasses dominate the ground surface and prevent tree and shrub seeds from reaching mineral soil. Remove this dense mat of grasses using chemical or mechanical methods. Exposing the mineral soil will enhance the survival of seeds dropped from the overstory trees.

Where natural regeneration is already established, thinning the older, taller, decadent trees will release the regeneration from competition. This thinning of the older trees must be done carefully to avoid creating large gaps in the windbreak. Another benefit of opening small portions of the canopy is the establishment of a rotational cycle. This cycle of thinning small portions of the overstory over regeneration will extend the life span of a windbreak indefinitely.

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



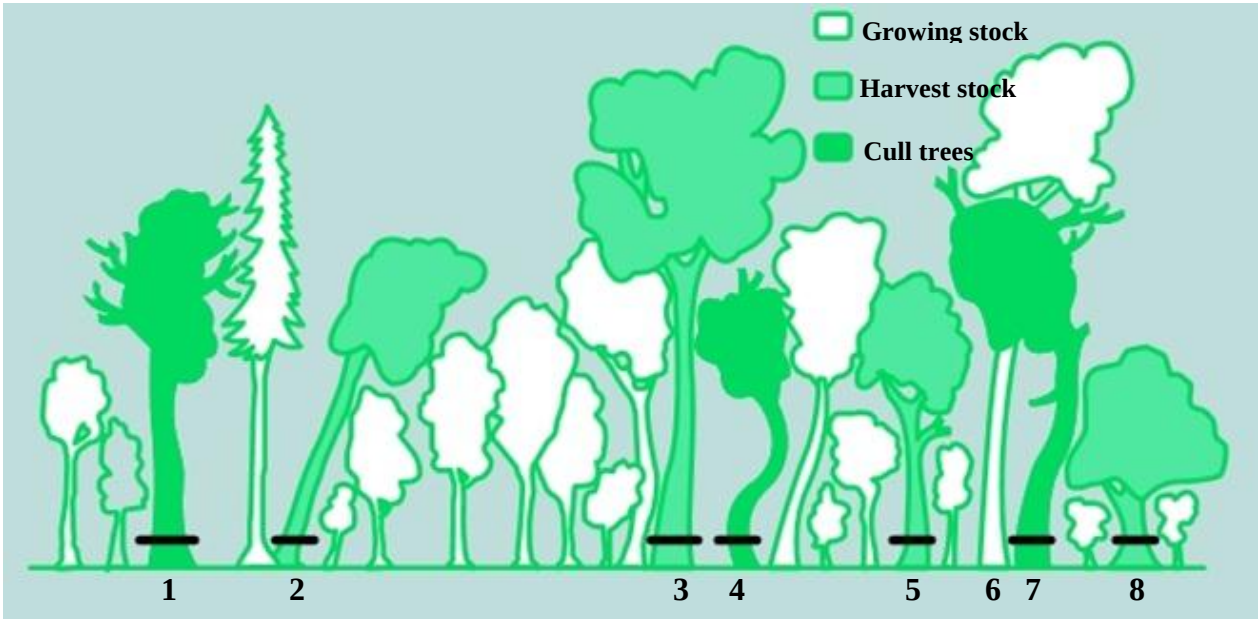
Timber stand improvement is defined as all cuttings that are not a part of a major harvest or made during the life of a forest stand for the general purpose of improving stand composition, condition or growth rate. Cuttings may be commercial or noncommercial, depending on the size of the trees during 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. Protecting a stand from the harmful effects of wildfire by thinning or removing ladder fuels and pruning lower branches may be another management alternative for conifer plantations or native forests. 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.

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. 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.

Woodland Improvement – trees to be removed from the woodland by girdling or cutting.



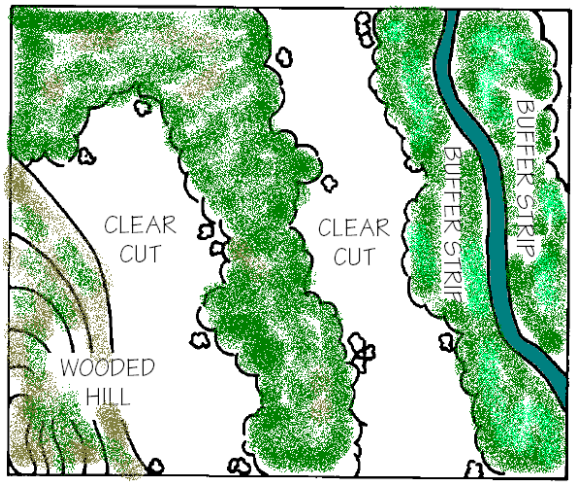
1. **Cull, badly damaged by fire.**
2. **Root-sprung harvest tree will produce 2 logs.**
3. **Harvest tree will produce 3 logs.**
4. **Deformed tree, cull.**
5. **Harvest tree will produce 1½ logs.**
6. **Growing stock tree needed for proper stocking level.**
7. **Diseased tree, numerous fruiting bodies, no merchantable value.**
8. **Wolf tree standing over valuable young stock, will produce ½ log.**

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 shade 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. 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 management and wildlife habitat objectives.

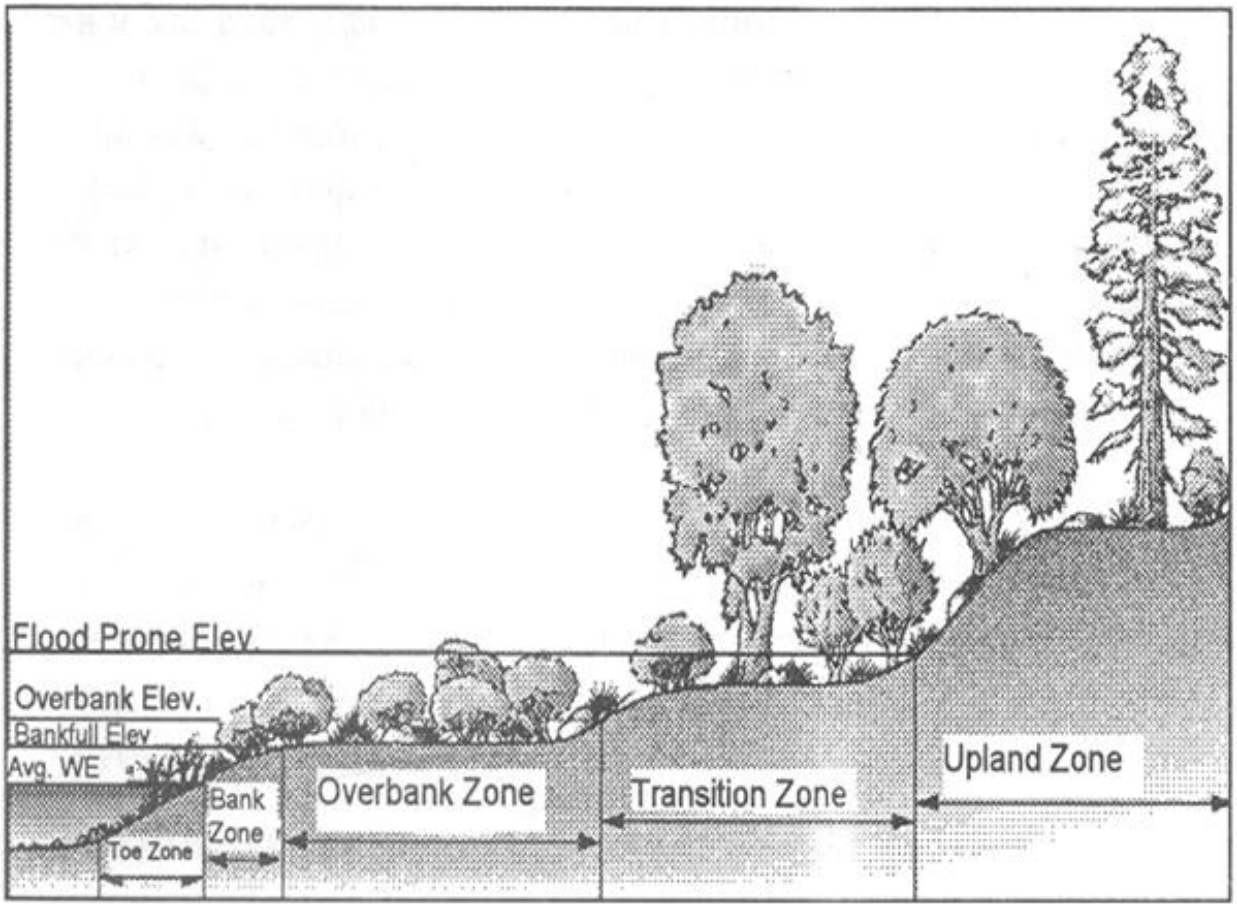


Interplanting

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; soils, species shade tolerance; foliage and bark color; and wildlife cover and food production.

FOREST PROTECTION

Riparian areas consist of a zone of vegetation influenced by water associated with streams, rivers or wetlands. This vegetation of grasses, shrubs and trees has the important functions of filtering pollutants, stabilizing banks along streams and wetlands, buffering flood flows and providing critical wildlife and fisheries habitat.



Riparian areas within North Dakota and Minnesota can be quite variable due to changes in weather conditions, geology, and land use patterns. Riparian areas in central and western ND are usually woody draws with scattered overstory trees, including American elm, native cottonwood, willow, green ash, boxelder and dominant understory shrubs including native plum, common chokecherry, gooseberry, wild and woods rose, buffaloberry, Juneberry, hawthorne and snowberry with a herbaceous understory. In western woody draws, management is often in conjunction with adjacent uplands utilized for grazing or hay production.

In eastern North Dakota and western Minnesota, the riparian areas are generally bottomland hardwood forests dominated by a well-developed overstory of trees including American elm,

native cottonwood, green ash, American basswood and boxelder. In eastern North Dakota, bottomland hardwood riparian areas are generally found in association with cropland and, therefore, usually fenced and grazed as individual units.

In eastern North Dakota, a large amount of grazing is close to or associated with riparian areas (areas which often times are too wet or inaccessible to farm. These areas usually include hills with low lying areas of sloughs, creeks or rivers. In the western part of the state, grazing is more widespread and not so concentrated in the riparian areas, however, places for drinking water are always a valuable and highly used area. These same riparian areas are also conducive to good tree growth as well. If managed properly, grazing in riparian areas can be done and still maintain the integrity of the riparian forest.

An assessment of the current condition of your riparian areas is important. Dead and downed large trees, bromegrass invasion, little or no regrowth of existing tree or shrub species in the understory, opening up of the forest canopy to more sunlight are all indications that the riparian forested areas may be under stress due to overgrazing. Although livestock get the majority of the blame for overgrazing, wildlife, too, can be detrimental if large numbers are concentrated in a small area over an extended period of time.

Grazing Management

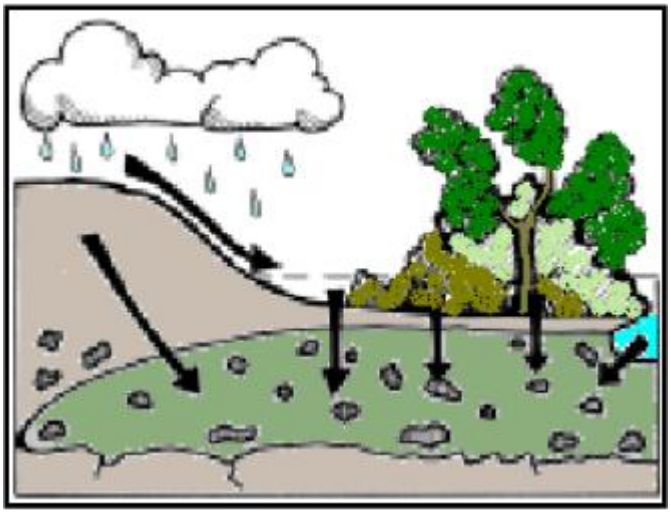
A first step in any riparian grazing strategy is to improve livestock distribution - to better balance out the grazing load over the landscape. Good distribution requires consultation with a range manager, imagination, trial and sometimes error. The most common option is to place attractants in the uplands away from the riparian areas. Things like salt, minerals, watering sites, oilers or rubbing posts will help draw animals away from riparian areas. “Animal placement” is where the stockman employs special herding techniques to “settle” livestock in more lightly-used upland areas. Portable electric fencing technology may allow you to build a temporary drift or barrier fence, at low cost, that prevents cattle from grazing stream banks during high risk periods, such as early spring.

Some advantages in grazing riparian areas include: getting rid of unwanted brush, noxious weed removal, protection for the livestock - wind and cold in winter, shade in summer, and can provide a source for quality drinking water and source for forage during drought times

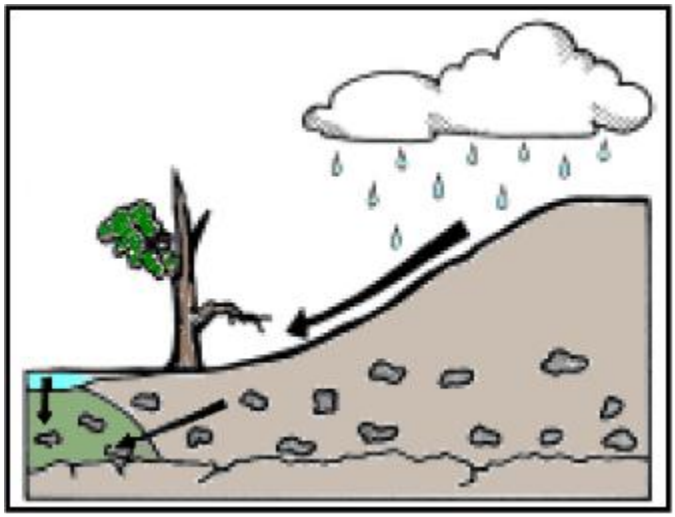
Some disadvantages for unmanaged grazing of riparian areas include: trampling and compaction of the forest floor, stream bank erosion, under story degradation and poor replacement seedling reproduction, invasion of unwanted plant species, livestock injury and health risks from downed and dead trees, contaminated and poor water quality from runoff, and reduced production of quality forage.

Grazing management ***Best Management Practices*** will sustain woody draws and bottomland hardwoods for riparian benefits of streambank protection, water quality, wildlife, and fisheries habitat. These techniques should provide for regeneration of trees and shrubs and maintenance

of herbaceous riparian plants necessary for riparian benefits important to ranchers while providing forage production for livestock grazing.



Healthy floodplains which are well vegetated slow the flow of water allowing it to spread and soak in effectively.

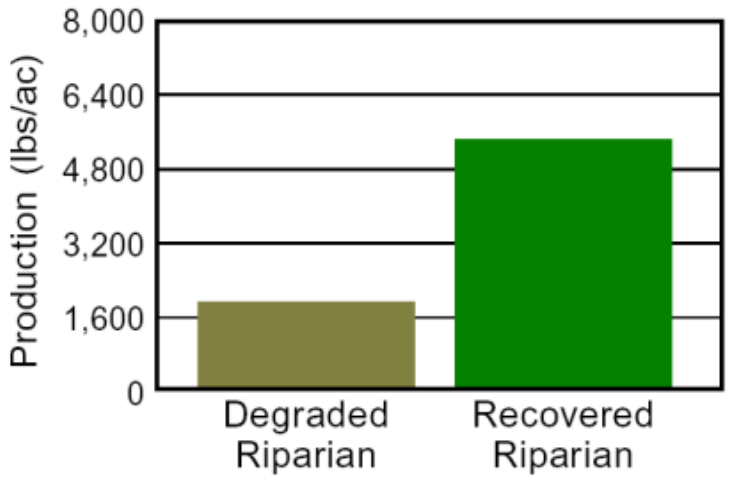


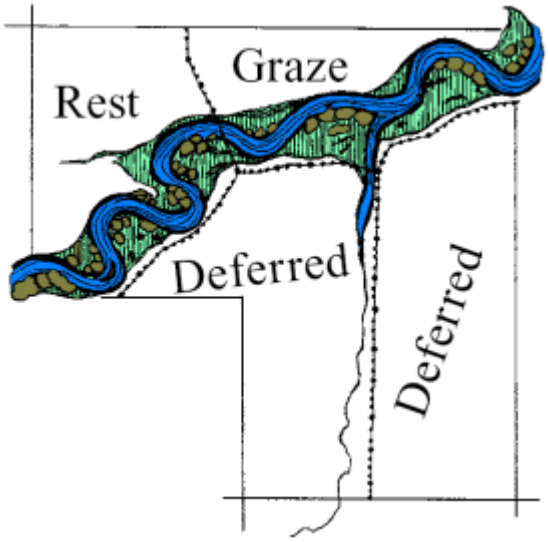
Water speeds over floodplains and overflow sites with poor vegetation health with channelized portions or cutoffs, and does not linger long enough to fill the ground water or recharge zone.

Riparian Grazing Management in Woody Draws (associated with adjacent upland pasture)

Livestock are attracted to riparian areas because they provide a source of water, forage that is generally greener longer into the grazing season, and seasonal protection from the elements (an example is shade). Also, livestock tend to loaf in these areas. To offset the attractiveness of these areas to livestock and reduce the amount of time livestock spend in there, the manager needs to:

1. Alter livestock distribution patterns through:
    a. Moving salt and minerals away from the riparian zone.
    b. Developing fresh stock water on the uplands.
    c. Installation of drift fence to alter cattle trailing.
    d. Animal placement or herding (low stress animal handling).
2. If a stream is to be used as a water source:
    a. Provide ease of access through graveling or hardened access points that livestock will prefer to use.
3. Control the timing of grazing when riparian areas are vulnerable.
    a. Avoiding soft stream banks in the spring of the year or after major rainfall events.
4. Install a rotational grazing system to:
    a. Enhance plant vigor, which allows for bank stability.
    b. Provide rest and deferment for riparian areas, allowing tree and shrub seedlings to grow and reach a more grazing resistant stage.
    c. Minimize the time livestock spend in the riparian area.





TIP: Off-stream water sources have been shown to reduce time livestock spent in streams by up to 89 percent and in stream areas by 51 percent. Cattle preferred drinking from a fresh water source up to 92 percent of the time compared to drinking from the stream. Stream bank erosion was reduced by up to 77 percent when off-stream water sources were utilized. *Source: Sheffield. 2003.*

5. Develop riparian pastures.
    a. Fencing the riparian area into a separate pasture, with separate management objectives and strategies.

A change to rotational grazing, from a season-long to continuous style, produced a significant response in forage production. Forage production went from pounds/acre to tons/acre.

6. Develop exclusion fencing.
    a. This prevents livestock access to high risk or chronic problem areas and allows for riparian restoration.

Riparian Grazing Management in Bottomland Hardwoods (not associated with adjacent upland pasture)

Managing grazing in bottomland hardwoods is difficult because it is hard to maintain and regenerate overstory trees in pasture. This is particularly true where there is not adjacent upland pasture typical of eastern landscapes. If the primary objective is to maximize forest health, vigor and production in bottomland hardwoods, season-long livestock grazing is not compatible. In addition, forage production in bottomland hardwoods is much more limiting than in woody draws or upland pastures. Bottomland hardwood pasture has the additional liability of livestock injury due to downed woody debris and uneven ground. Because forage production can be

highly variable, proper stocking rates should be determined on-site. Although management options are limited, impacts on bottomland hardwood riparian areas can be reduced.

1. Reduce livestock impacts on bank stability.
    a. Provide off stream watering points.
    b. Provide ease of access through graveling or hardened access points that livestock will prefer to use.

2. Develop rotational grazing system.
    a. Enhances plant vigor which allows for bank stability.
    b. Provides rest and deferment for riparian areas, allowing tree and shrub seedlings to grow and reach a more grazing resistant stage.

3. Develop forage capability in adjacent uplands.
    a. Convert adjacent marginal cropland into spring or summer pasture.
    b. Plant high production forage crops.

The following grazing systems can be utilized to minimize the impacts of livestock on riparian areas:

Rotational Grazing: Rotational grazing involves a planned sequence of grazing and rest periods. In eastern North Dakota, a minimum of 30 days of rest is usually recommended, In western North Dakota, a minimum of 45 days is usually required for best results. As plant growth slows, rest periods of 45 days for eastern North Dakota and 65 days for western North Dakota may be required for best results. Under drought conditions, longer rest periods may be needed to ensure grazed plants recover adequate leaf area prior to next grazing.

Deferred Grazing: Postponing grazing or resting grazing land for a prescribed period. Used in areas with bare ground or low percent ground cover to encourage less ground surface disturbance, improve soil bulk density characteristics, and infiltration rates. The objective is to encourage re-vegetation. With no animal waste there would be less chance for adverse runoff effects into surface or aquifer water.

Time-Controlled Grazing: Shortening the period of grazing use (sometimes referred to as flash grazing) particularly during the phase of most active plant growth.

Rest-Rotation Grazing: When it's necessary to restore woody vegetation in riparian areas, a more conservative grazing strategy like rest-rotation grazing may be necessary.

Riparian Pastures - a Landscape Approach: Means defining fields in a manner that reduces the variation within a given field, such as fencing uplands separately from the flood plain.

Holding Pastures: Holding pastures are those fields or lots where livestock are held or "parked" for prolonged periods such as for winter feeding or calving, and where supplemental feeding is normally provided.

Corridor/Exclusion Fencing: Involves eliminating livestock grazing on a narrow fringe of the riparian area. Certain delicate areas such as fens, marshes, and springs, may require the livestock to be excluded entirely year round. This will provide protection both for the land area as well as the livestock, which can sometimes become stuck or mired in the mud leading to injury or death.

By putting into practice the principles of good range management, you can achieve a number of key conditions in riparian areas. These conditions have a common thread that runs through all successful riparian grazing strategies.

Healthy vegetation

- Rest and regrowth produce vigorous, productive riparian plants.
- Energy stored in roots will sustain healthy riparian growth.
- Healthy plants build strong stream banks.
- Woody vegetation adds reinforcement.
- Plant species diversity adds forage and shelter values.

Enough vegetation during high water flows

- Dissipate stream horsepower.
- Trap sediments and build streambanks.
- Build ground water reserves.
- Maintain stream channel shape.

Protection during vulnerable stages

- Protect banks from trampling when fragile.
- Protect brush species during periods of dormancy.
- Maintain productive forage species.

Grazing Management

1. Alter livestock distribution through:
    a. Salt and mineral location.
    b. Stock water development.
    c. Drift or temporary fencing.
    d. Animal placement/herding.
    e. Alter species or class of livestock.

2. Animal access to water:
    a. Provide ease to access through graveled or hardened access points that livestock will prefer to use.
    b. Provide off-stream watering sites.

3. Control the timing of grazing when riparian areas are vulnerable:
    a. Avoid loft stream bands or times that may be stressful to key plants such as tree seedlings and shrubs in autumn or winter.

4. Add more rest to the grazing cycle:
    a. This enhances plant vigor, allows for bank building, and allows tree seedlings to grow and reach a more grazing resistant stage.

5. Control grazing intensity:
    a. Intensity is a function of number of animals times the duration of grazing.
    b. Lower intensity results in better plant vigor and species composition.
    c. Grazing intensity may also be regulated by providing supplemental feed.

6. Riparian pastures:
    a. Fence the riparian area into a separated pasture, with separate management objectives and strategies.
    b. Riparian pastures increase the landowner's control over the grazing process (animal numbers, season grazed, length of grazing and rest periods).

7. Grazing systems:
    a. A grazing system defines recurring periods and patterns of grazing and rest for two or more pastures. Grazing systems put range management principles and practices into effect.
    b. These systems are a management tool to enhance livestock production and maintain or improve the plant community.
    c. When properly designed, a grazing system provides adequate rest and deferment periods to offset the impact of cropping and trampling during the grazing period.
    d. Examples include deferred rotation, rest rotation, and time controlled systems.

8. Corridor or exclusion fencing:
    a. Although not a favored option, exclusion of livestock grazing may be the only option to deal with riparian grazing problems in high risk or chronic problem areas.

9. Monitoring grazing:
    a. Percent grazed with woody degradation guidelines - the harmful effects of overgrazing in woodland areas can result in health risks to the livestock (ex. oak leaf poisoning and abortion).

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.

1. Control noxious weeds and unwanted plants in tree planting, harvest sites and reclaimed roads.
2. 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.

3. 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

Prescribed fires under the right conditions can reduce the amount of woody debris in a woodland, which in turn helps reduce the hazard of catastrophic wildfires. Fire returns nutrients to the soil, which encourages 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.

1. 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 desired outcome?
    e. Weather conditions.
    f. Adjoining resources at risk, such as farmsteads, livestock, etc.

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

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

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

5. 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:

1. Work with a professional forester to set up a sale.
2. Select trees to harvest.
3. Determine timber value.
4. 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.
5. Advertise the timber sale.
6. Select a buyer and the sale price by a single offer - oral auction or sealed bids.
7. Develop a written timber sale contract with the buyer.
8. Inspect the harvest operation.
9. Aesthetics.

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, re-grading 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:

1. Soils and erosion hazard identification.
2. Season.
3. Silvicultural objectives.
4. Critical components (aspect, water courses, topography, etc.).
5. Forest types and potential for regeneration.
6. Potential effects on water quality and beneficial water uses.
7. Wildlife habitat.
8. Local markets and/or current timber value.

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 trail 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.

WATER BAR SPACING GUIDE

Grade	Distance Between Water Bars
2%	250 feet
5%	135 feet
10%	80 feet
15%	60 feet
25%+	40 feet

Landings, Decks and Portable Sawmill Locations

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

1. Avoid locating landings that require skidding across drainage bottoms.
2. 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.
3. 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.
4. Avoid decking logs within the ordinary high-water mark of any stream.
5. Responsibly dispose of containers, cartridges, filters, used oil and other refuse.

Winter Harvesting

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

1. Suspend operations when conditions change rapidly and the erosion hazard becomes high.
2. Consult with operators experienced in winter logging techniques.
3. 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.
4. Return the following spring and build erosion barriers on any trails that are steep enough to erode.

Photo courtesy of the University of Georgia

Slash Treatment

Rapid reforestation of harvested areas is encouraged to reestablish protective vegetation.

1. When piling slash, avoid incorporating soil into the pile. Care should be taken to preserve the surface soil horizon.
2. Minimize or eliminate elongated exposure of soils up and down the slope during mechanical scarification.
3. 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.
4. Carry out brush piling and scarification when soils are frozen or dry enough to minimize compaction and displacement.
5. Stabilize or reclaim landings and temporary roads on completion of use.
6. 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.

- **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 peak flow levels. Greater infiltration also replenishes groundwater that helps 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, as well as 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 provide food for algae and small aquatic organisms, which in turn become food for fish.

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 28, 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 characteristics. *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 on this page provides minimum RMZ widths for corresponding stream widths. As bank and upland slopes become steeper and/or soil erodibility 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

RMZ WIDTH IN RELATION TO STREAM WIDTH

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

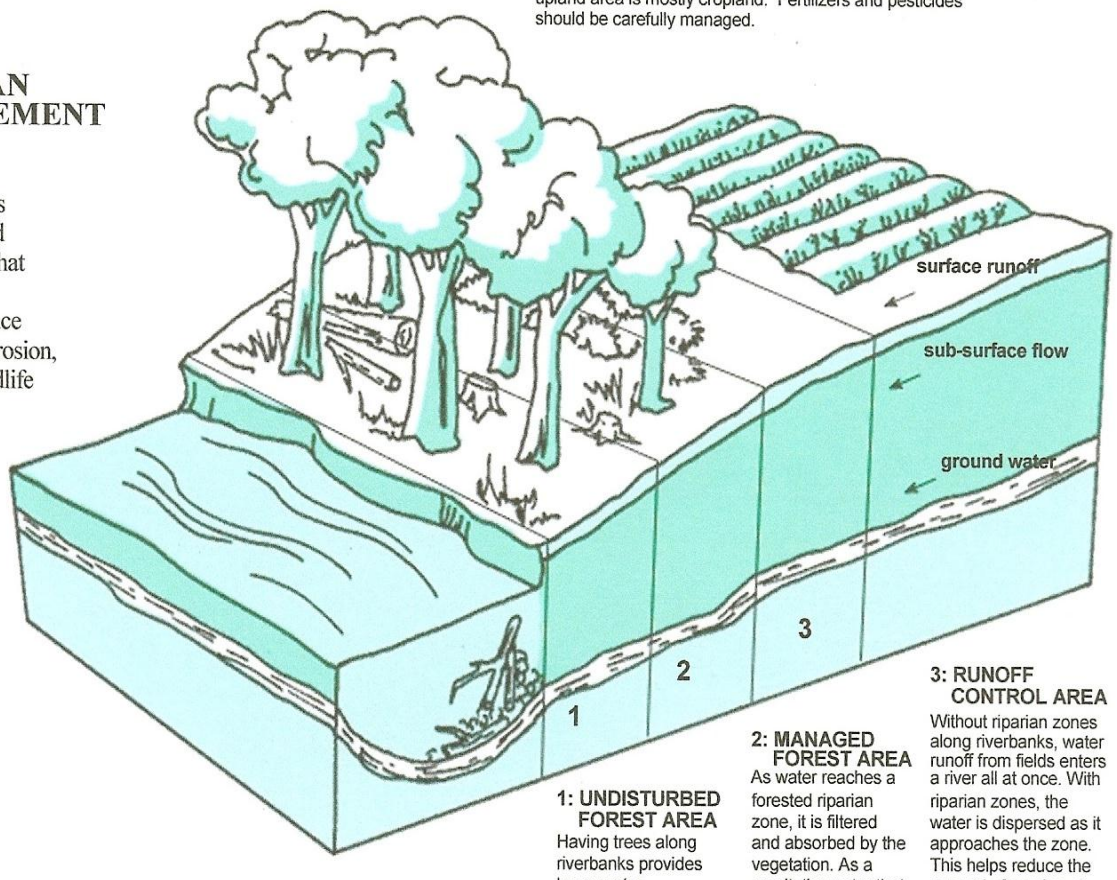
RMZ WIDTH IN RELATION TO LAND SLOPE

LAND SLOPE (Between upland and surface water)	RECOMMENDED RMZ WIDTH (Minimum)
0 – 10%	60 feet
11 – 20%	90 feet
21 – 40%	125 feet
41 – 70%	150 feet

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 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 under-ground also is absorbed by ro

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 an evaluation of the forest health. The following management suggestions target RMZs with stable soil conditions and a healthy forest canopy:

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

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

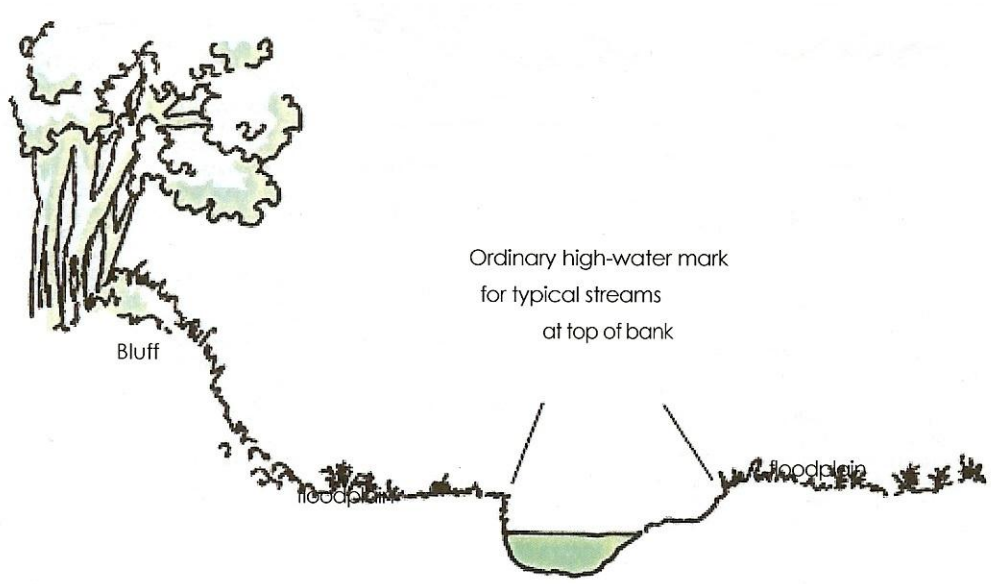
    a. Limit harvesting within 15 feet of the ordinary high-water mark, targeting only problem trees. Retain some snags in the upland to provide cover for wildlife. In addition, leave appropriately located naturally occurring snags and woody debris in streams to provide habitat for fish and the microinvertebrates 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 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.
    g. 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.

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 areas affect 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. The 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 on 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.

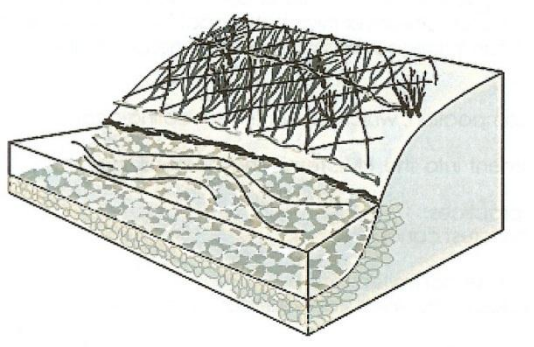
The following show techniques that can be used to stabilize the early stages of bank failure:

Brush Mattresses

Combination of live stakes, live fascines, and branch cuttings installed to cover and physically protect streambanks from high water 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.



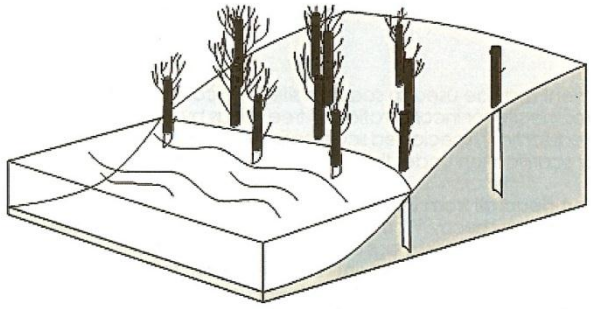
- Rapidly restores riparian vegetation and streamside habitat.
- Enhances conditions for colonization of native vegetation.
- Limited to the slope above base flow levels.
- Toe protection is required where toe scour is anticipated.
- Appropriate where exposed streambanks are threatened by high flows 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, especially 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.

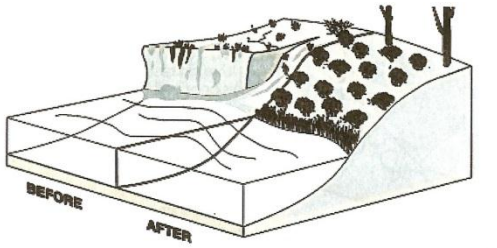


- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure a regenerative source of streamside vegetation.
- Unlike smaller cuttings, post harvesting can be very destructive to the donor stand, therefore, they should be gathered as salvage' from sites designated for clearing, or thinned from dense stands.

Bank Shaping and 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

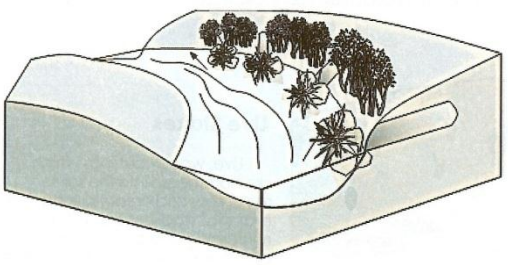


- Most successful on streambanks where moderate erosion and channel migration are anticipated.
- Reinforcement at the toe of the embankment is often needed.
- Enhances conditions for colonization of native species.
- Used in conjunction with other protective practices where flow velocities exceed the 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



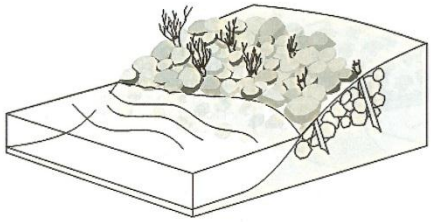
- Will tolerate high boundary shear stress if logs and rootwads are well anchored in trenches and backfilled.
- Suited to streams where fish habitat deficiencies exist.
- Should, where appropriate, be used with soil bioengineering systems and vegetative plantings to stabilize the upper bank and ensure 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

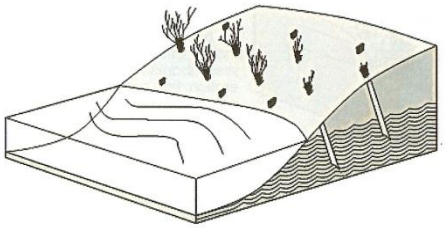


- Appropriate where there is a lack of desired vegetative cover on the face of existing or required rock riprap.
- Root systems provide a mat upon which the rock riprap rests and prevents loss of fines from the underlying soil base.
- Root systems also improve drainage in the soil base.
- Will quickly 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



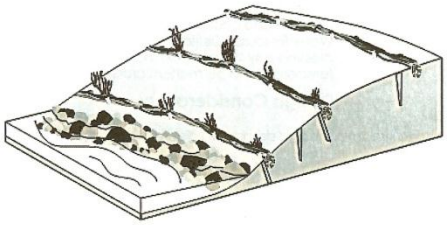
- Effective where site conditions are uncomplicated, construction time is limited, and an inexpensive method is needed.
- Appropriate for repair of small earth slips and slumps that are frequently wet.
- Can be used to stake down surface erosion control materials.
- Stabilize intervening areas between 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

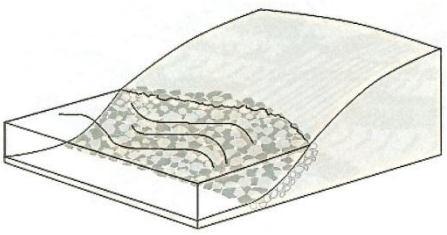


- Can trap and hold soil on streambank by creating small dam-like structures and reducing the slope length into a series of shorter slopes.
- Facilitate drainage when installed at an angle on the slope.
- Enhance conditions for colonization of native vegetation.
- Should, where appropriate, be used with 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-size 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

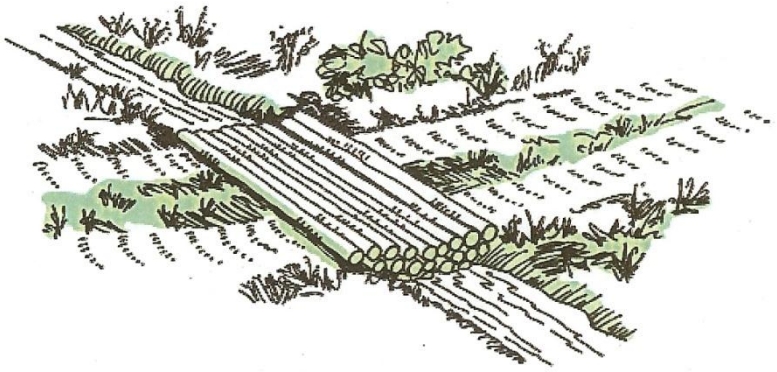
Design stream crossings to minimize streambank and streambed disturbance.

- 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.

Installation of Stream Crossings

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.



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

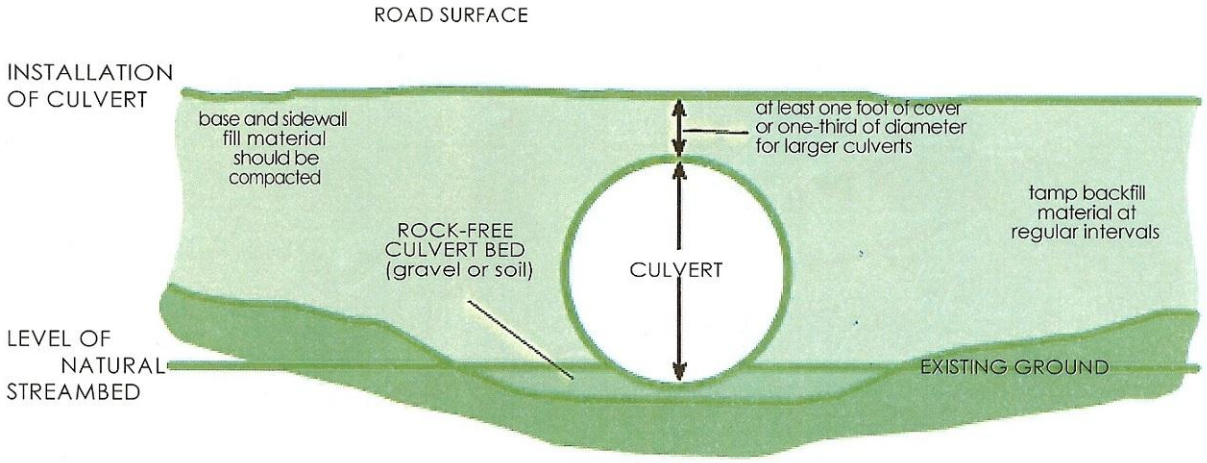
to avoid culvert outfall barriers. Do not alter stream channels upstream from culverts, unless necessary to protect fill or to prevent culvert blockage.

- 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.



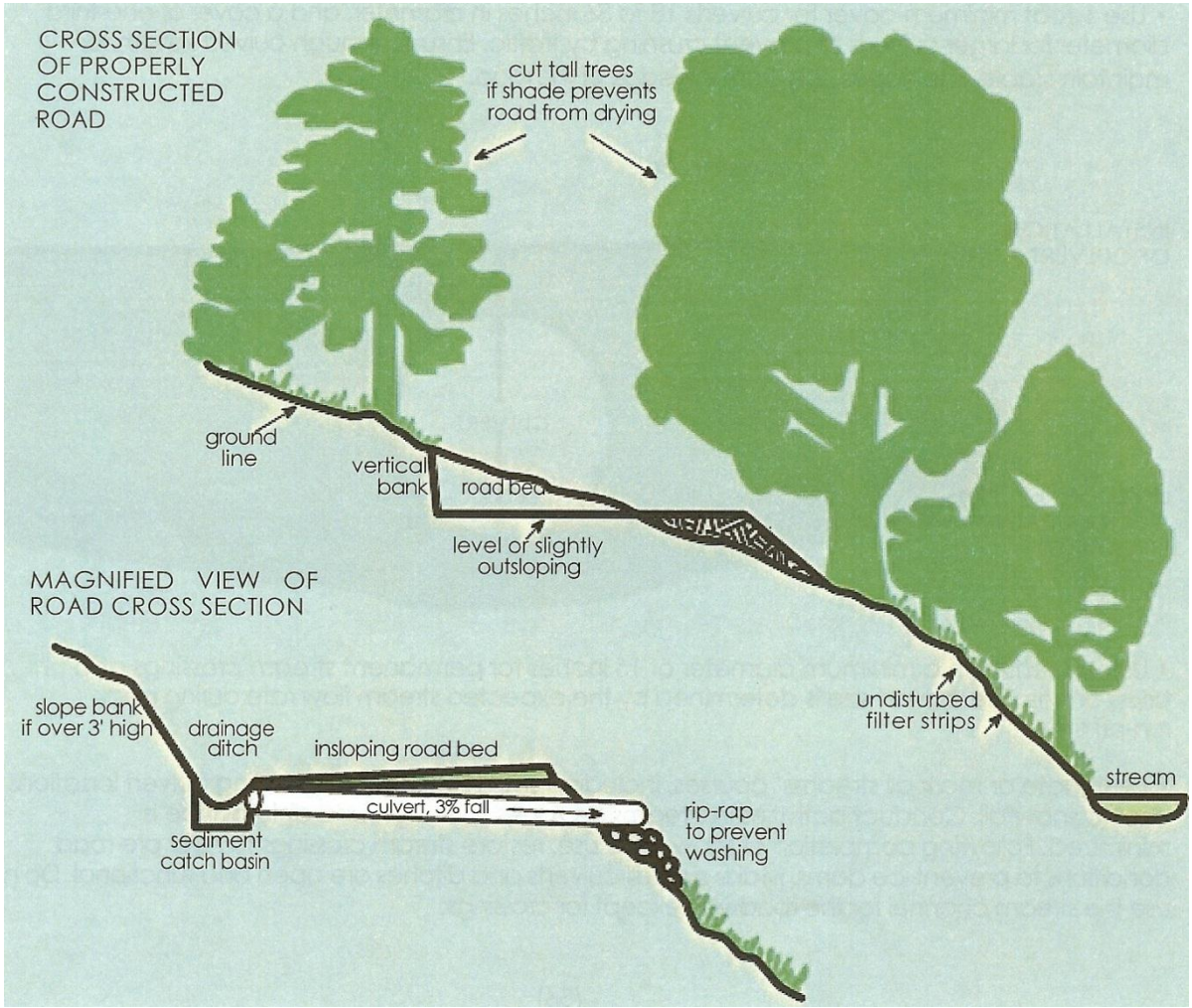
- Use culverts with a minimum diameter of 15 inches for permanent stream crossings and cross drains. The culvert size is determined by the expected stream flow rate during peak run-off time.
- Designate or mark all streams' courses, including small streams, and existing culvert locations prior to snowfall. 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.

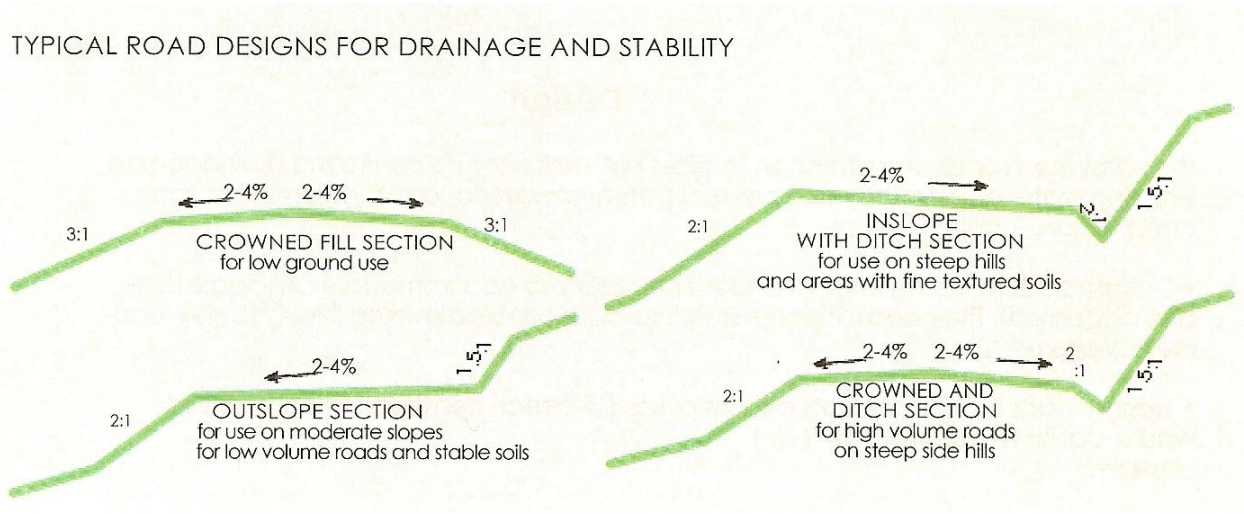
Drainage from Road Surface

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 cross drains. Space road drainage features to adequately handle runoff during peak flow conditions.
    - Out-sloped roads provide a means of dispersing water in a low energy flow from 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.
    - 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.
    - Properly constructed drain dips can be an economical method of channeling surface flow off the road. Construct drain dips deep enough into the subgrade to that traffic will not destroy them.

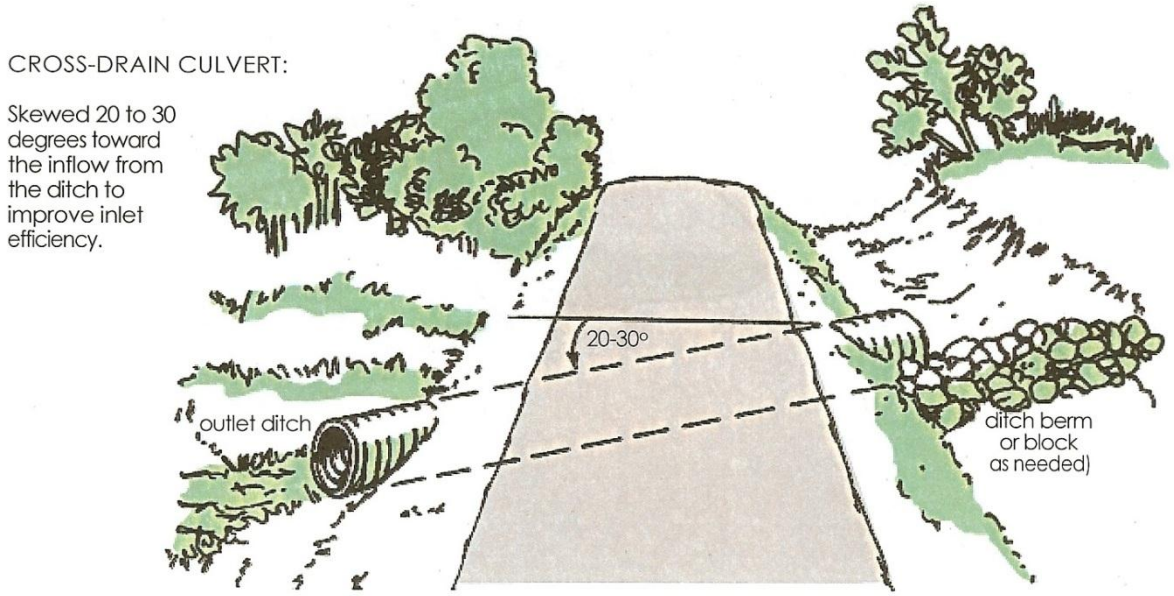
DRAIN DIP SPACING GUIDE

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

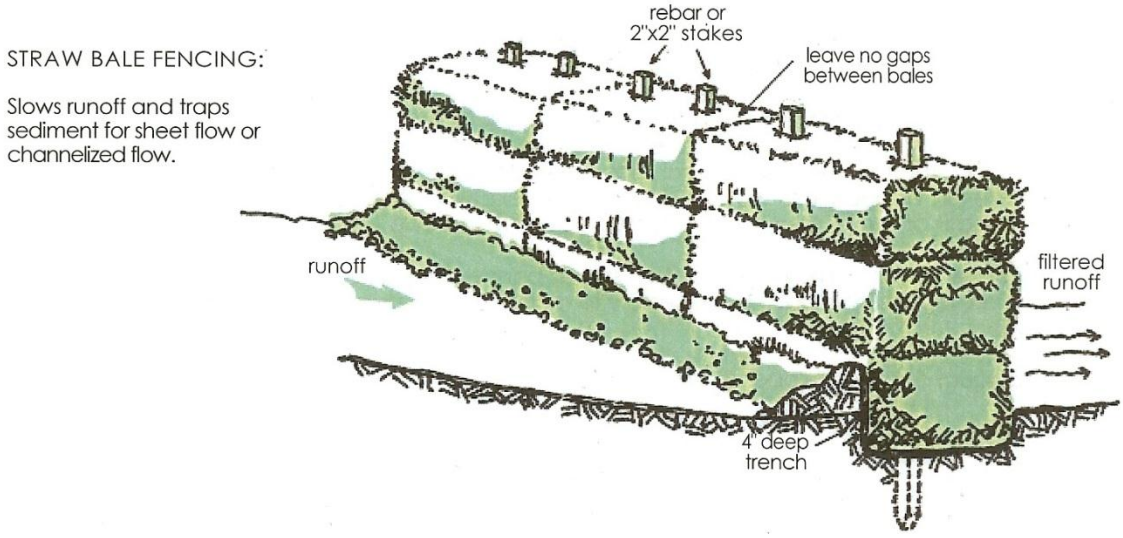


- Skew ditch relief culverts 20 to 30 degrees toward the inflow from the ditch to improve inlet efficiency. Protect the upstream end of cross-drain culverts from plugging.

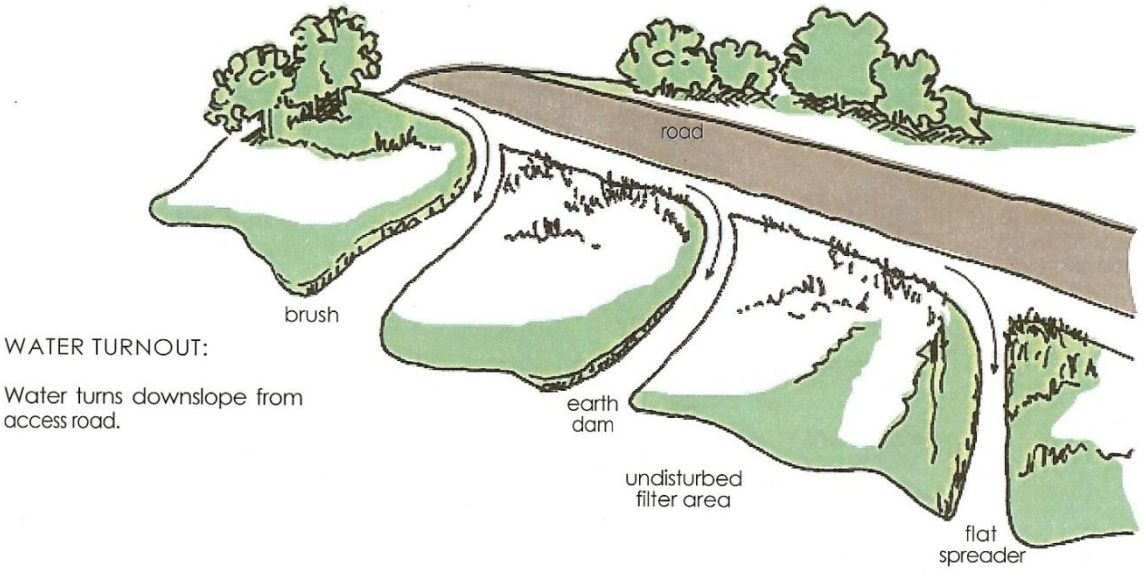
- Where possible, install ditch relief culverts at the gradient of the original ground slope; otherwise armor outlets with rock or anchor down spouts to carry water safely across the fill slope.
- Provide energy dissipators rock piles, logs, etc., where necessary at the downstream end of ditch relief culverts to reduce the erosion energy of the emerging water. Cross drains, culverts, water bars, dips, and other drainage structures should not discharge onto erodible soils or fill slopes without rock or vegetative protection.



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



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



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.

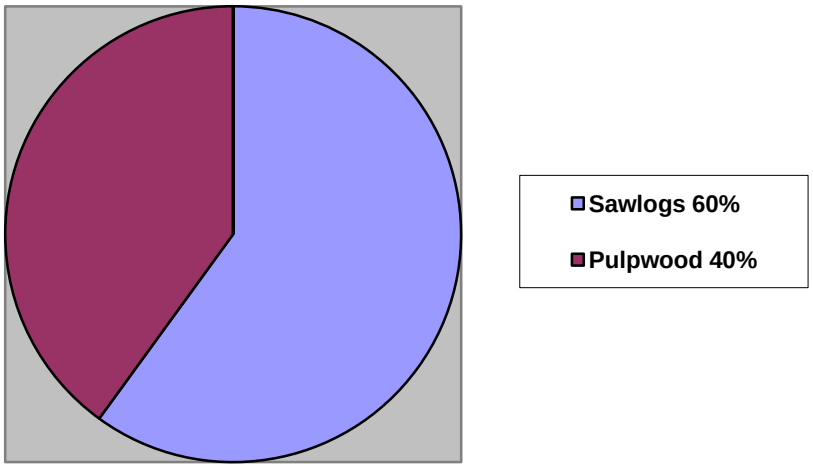
APPENDIX A

NATIVE FORESTS OF NORTH DAKOTA

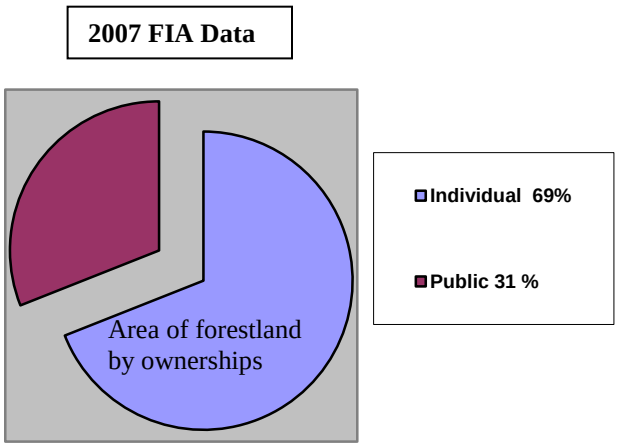
North Dakota is a Great Plains state, but native forests can still be found here. In 2007, North Dakota had 700,200 acres of forest (USDA Forest Service FIA data), which was very close to the amount of forestland at the time of European settlement in the mid-1800s. Native forests make up only about 1.6 percent of the total land area, but their scarcity makes them even more valuable to the people and the environment. These forests provide wildlife habitat, forest products and beautiful settings for many recreational activities and eco-tourism. The location of these forests also makes them valuable as thousands of these acres are within 200 feet of a waterway which can help improve water quality and stabilize stream banks.

The largest concentrated forested areas are in the Turtle Mountains near Bottineau, the Pembina Hills near Walhalla, and in the Devils Lake region. In addition, many thousands of acres of bottomland and upland hardwood forests are found along river corridors statewide. North Dakota is also unique in that it has both hardwood and coniferous forests, as native pines and junipers can be found out in the western badlands area.

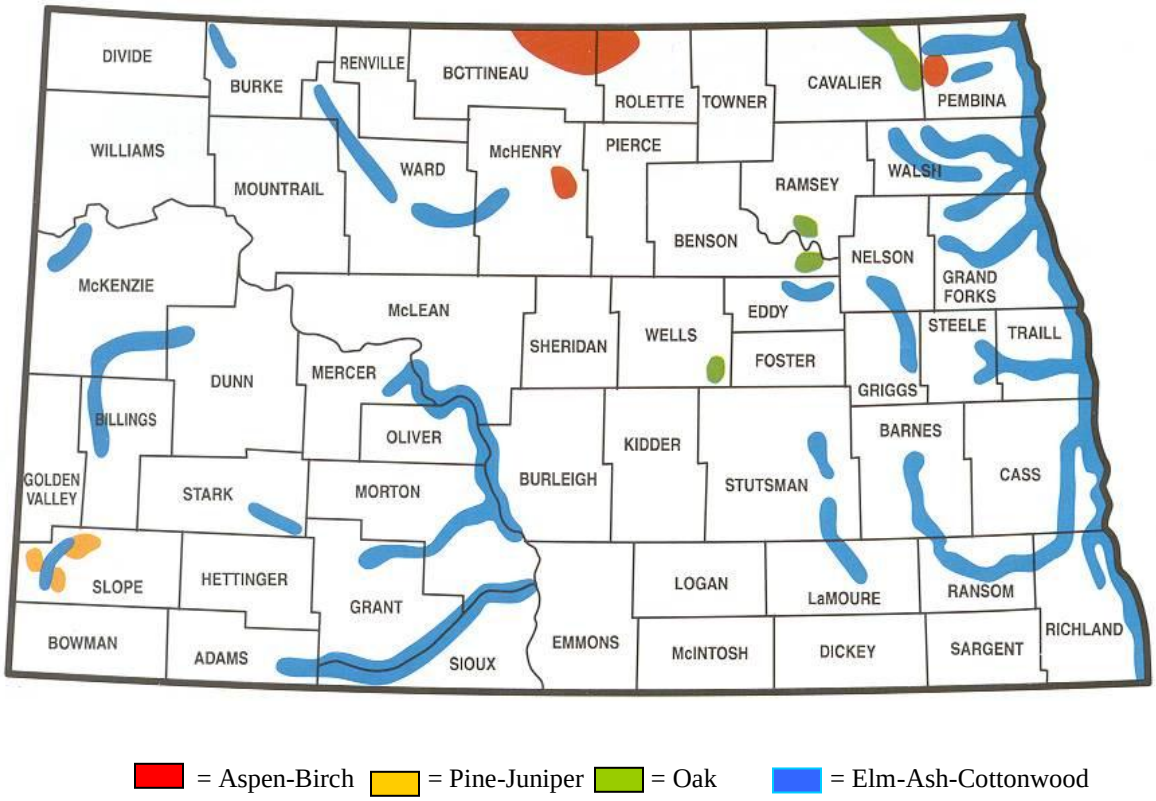
Of the 700,200 acres of forestland, 500,200 acres were classified as forestland which is land that is capable of producing industrial wood crops. In 2003, sawlogs accounted for 60 percent of industrial roundwood harvested from North Dakota forestlands, but the following years experienced an increase in the harvest of pole size aspen for pulp and OSB (oriented strand board). There are typically about 9-12 sawmills in the State that operate mostly on a part-time basis producing lumber, pallet lumber and cabin logs. In addition, companies from out-of-state occasionally come in when certain markets become "hot".



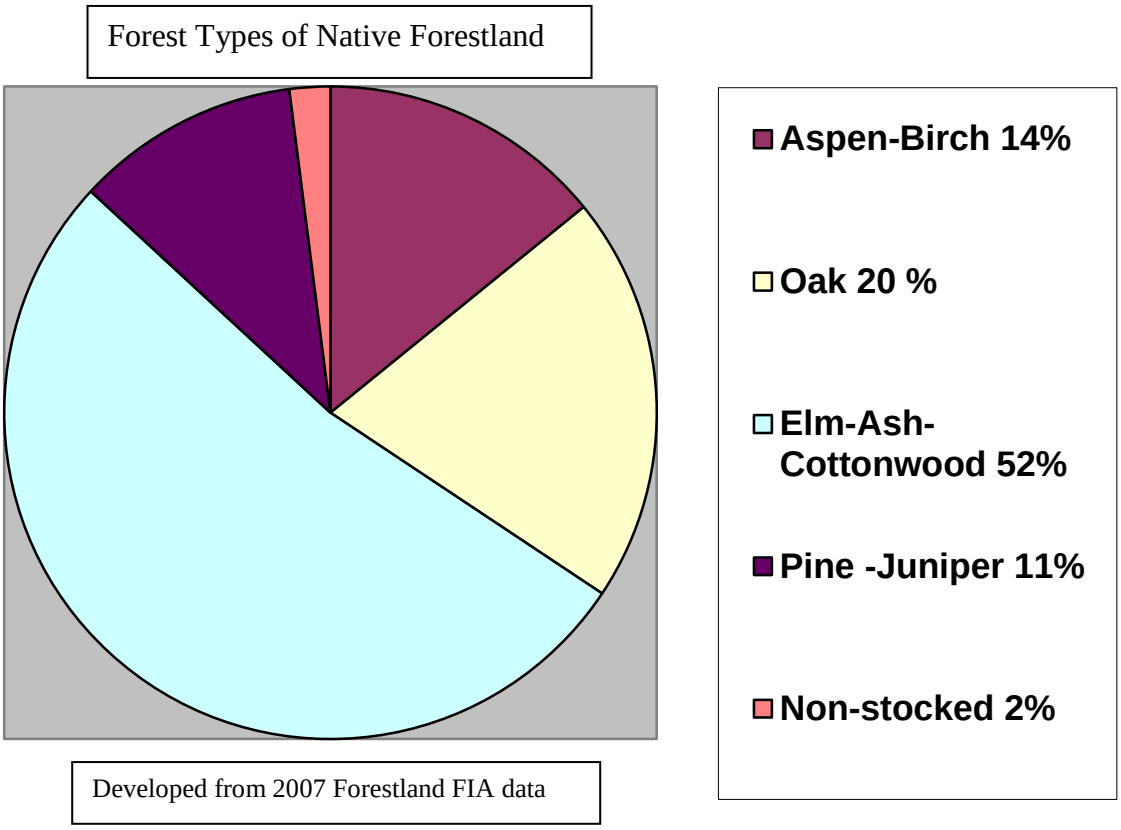
As expected, much of this forestland is in private ownership as nearly 70 percent are owned by farmers, ranchers and a wide assortment of other private landowners. Farmers make up the largest number with Pembina and Cavalier Counties containing the largest amount of privately owned forestland in the State.



North Dakota forests can be broadly classified into four major forest types: Aspen-Birch, Elm-Ash-Cottonwood, Oak and Pine-Juniper.



Using data from the 2007 FIA survey, the forest types in that report (which are named more for the dominant species in the type) can be grouped into the very broad classifications above yielding the following chart:

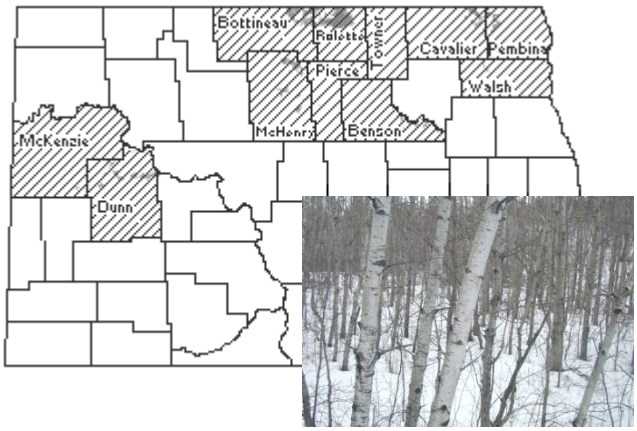

Forest Types of Native Forestland
Aspen-Birch 14%
Oak 20 %
Elm-Ash-Cottonwood 52%
Pine -Juniper 11%
Non-stocked 2%
Developed from 2007 Forestland FIA data

ASPEN-BIRCH

Description

Quaking aspen makes up most of this timber type and is found on drier upland sites, such as the Turtle Mountains and Pembina Hills. White birch is less common and is found more on moist, north-facing slopes and in protected ravines. Birch can be found in pure stands or as scattered trees in the aspen forest. This type is so classified when these two species (alone or together) dominate and cover over 50% of the stand. Smaller areas of this type can be found scattered in the Killdeer Mountains, Missouri river breaks, and in the sandhills near the Sheyenne and Souris Rivers. Shrubs that are associated with this forest type include beaked hazel, highbush cranberry, silverberry, Juneberry and Virginia creeper. This type covers about 27 percent of the forestland in the State.

Primary counties containing aspen-birch forests



Management

Historically, aspen-birch forests relied on catastrophic events such as wildfire to regenerate a forest. These events would kill a large acreage of trees without destroying their root structure. The roots then would root sprout creating a new and vigorously growing forest. With the introduction of wildfire control measures due to the introduction of communities within these forests, this natural process has been virtually eliminated. Consequently, active forest managers must mimic this disturbance. The main technique recommended for the aspen-birch forest management is to clearcut the forest. Aspen and birch are shade intolerant species whose seed will not germinate without direct contact to mineral soil and sunlight. Furthermore, the production of root suckers is reduced without abundant sunlight. Under this system, trees are removed in 5-10 acre patches as they reach maturity (usually 40-50 years), resulting in a mosaic pattern with all age classes present. This variability in age classes benefits many species of wildlife. For instance, moose, elk and deer utilize newly harvested areas for forage. Deer utilize 5-10 year old forests as bedding areas, and ruffed grouse utilize every age class throughout their life cycle. Small pockets of oak can also be left in these clearcut areas for acorn production that will further benefit wildlife. It is best to clearcut these stands before they become too old as suckering ability diminishes with age and overmature aspen may not be suitable for many forest products. Aspen should also be harvested in the winter to allow the root sprouts to utilize the stored nutrients from

the previous growing season. Root sprouting is significantly reduced when the cutting is done after leaf development in the spring.

Forest Health

Aspen forests of North Dakota are subjected to numerous insects and pathogens that may conflict with landowner objectives. Three commonly encountered tree pests of aspen include: aspen trunk rot (*Phellinus tremulae*), Hypoxylon canker (*Hypoxylon mammatum*), and the forest tent caterpillar (*Malacosoma disstria*).

Aspen trunk rot is caused by a wood-decaying fungus and reduces the structural strength of the tree and increases the probability of stem breakage. In addition, stem rot significantly reduces the amount of useable wood with a stand. Infection occurs through wounds and branch scars. Once the fungus is established within the tree, it will continue to decay wood and eventually produce a spore-bearing conk (also known as a fruiting body). Often infected trees will have several of these hoof-shaped conks along the trunk). Aspen trunk rot tends to increase as stands age and begin to decline in vigor. As aspen stands exceed an age of 50 years, the incidence and severity of aspen trunk rot increases significantly. It is important to harvest aspen prior to substantial decay. This will increase the volume of useable wood and encourage aspen regeneration.

Another problematic pathogen of aspen is Hypoxlon canker caused by the fungus *Hypoxylon mammatum*. This fungus forms a canker on the bole that eventually girdles the tree. Infection typically occurs through mechanical wounds or those caused by wood-boring insects. Once established, the pathogen grows beneath the bark, disrupts the flows of nutrients, and eventually girdles the tree. Hypoxlon canker tends to cause more damage in poorly stocked stands of low site index. As a result, maintaining properly stocking levels and enhancing stand vigor is the most effective means to manage this canker.

A commonly encountered insect pest of aspen is a native moth known as the forest tent caterpillar. The female moth lays her eggs on the branches of deciduous trees in the fall. Caterpillars hatch from these eggs in the following spring and begin feeding on leaves, sometimes completely defoliating the tree. Defoliation, although unappealing to the human eye, rarely threatens the survival of the tree unless the tree is defoliated for several successive years. Often, defoliated trees will produce a second flush of leaves once the caterpillar stops feeding. Although the masses of larvae in early summer can be unappealing, the duration of caterpillar presence is short lived, lasting approximately 5 to 6 weeks. When the caterpillars are fully grown, they spin cocoons, and eventually emerge as full-grown moths in late summer.

Defoliation can result in growth reduction and tree stress, however, it is typically not detrimental to the stand. The forest tent caterpillar can be best managed by promoting healthy stands that are more resilient to defoliation. Chemical treatments are not warranted to control this pest because control is short lived and expensive.

Representative Wildlife

Ruffed Grouse

Ruffed grouse rely on aspen throughout the year, especially in winter months when buds of aspen and birch are about the only thing available for food. Actually, the grouse depend on the different successional stages of the trees in the aspen forest as the grouse must have both young and older aspen trees to survive and reproduce.

Stands of 1-10 years old provide a high protein diet of insects for young grouse chicks and the leaves protect the chicks from predators like owls. As they get a little older, they feed on leaves and fruits. Good breeding sites are best found in aspen stands of between 10-20 years of age. Male grouse stand on logs in the spring and "drum" out a mating call. These stands typically have a thick brush forest floor. Stands of 20-30 years of age provide the grouse with good nesting sites. These stands have a more open forest floor so the hen can better watch out for predators from where she builds her nest, which may be at the base of a tree or against a fallen log. And finally, aspen trees 25 –40 years of age provide buds for food and have an understory that provides additional food sources from species like nannyberry, wolfberry, rose and highbush cranberry.

Moose

An adult moose, averaging 1,000 pounds and standing 6 feet at the shoulder, is the largest wild animal in North America. Moose have keen senses of smell and hearing, but they're also near-sighted. Their front legs are longer than their hind legs, allowing them to jump over fallen trees, slash, and other debris. Moose, like deer, lack a set of upper incisors; they strip off browse and bark rather than snipping it neatly.

Only bulls grow antlers. Antler growth begins in March or April and is completed by August or September when the velvet is shed. Antlers are dropped starting in December; young bulls may retain their antlers into early spring. The bell the flap of skin and long hair that hangs from the throat, is more pronounced in adult bulls than in cows or immature bulls. During fall and winter, moose consume large quantities of willow, birch, and aspen twigs. In some areas, moose actually establish a "hedge" or browse line 6 to 8 feet above the ground by clipping most of the terminal shoots of favored food species. Spring is the time of grazing as well as browsing. Moose eat a variety of foods, particularly sedges, pond weeds, and grasses. During the summer, moose feed on vegetation in shallow ponds, forbs, and the leaves of birch, willow, and aspen.

ELM-ASH-COTTONWOOD

Description

This forest type is found statewide along rivers, lakes and streams and in upland areas without the cottonwood component. Coulees and slope bases that have deep alluvial soils with thick layers of organic matter characterize the stands found in lowland areas. Species such as green ash (*Fraxinus pennsylvannica*), box elder (*Acer negundo*), and basswood (*Tilia americana*) may dominate along the eastern rivers, whereas, cottonwood (*Populus deltoids*) and green ash may be more common to the west. Other lowland associated species include American elm, hackberry, bur oak and willow. Shrub species found in bottomland forests include redosier dogwood, high bush cranberry, chokecherry, gooseberry, snowberry and wolfberry.

The species composition of these forests has changed dramatically over the past several decades. Eastern bottomland forests have been severely impacted by Dutch elm disease. This disease has eliminated many of the once abundant American elms that naturally occurred in these forests and has shifted the species composition toward green ash and box elder. Conversely, decline of cottonwood forests in the western portion of the state can be attributed to over-maturity and lack of flooding to promote cottonwood regeneration. Flood control measures along the Missouri River have restricted the formation of moist sandbars that are critical for cottonwood regeneration. The lack of cottonwood regeneration coupled with gradual senescence and decline of old cottonwood trees has shifted the species composition toward green ash and box elder. In addition, encroachment of species such as Russian olive (*Elaeagnus angustifolia*), buckthorn (*Rhammus* sp.) and brome grass (*Bromus* sp.) inhibits management strategies and may conflict with landowner objectives.

The elm-ash forest type is also found on upland areas, particularly in the eastern and northern parts of the state. Topography and how a slope is oriented to the sun are the most influential factors in determining the types of species found on the upper slopes and elevations. As with the lowland areas, much of the elm has died off due to Dutch elm disease. In addition to green ash, common associated species on upland sites include bur oak, aspen, and birch. Shrubs such as chokecherry, Juneberry, buffaloberry, gooseberry, nannyberry, currant and beaked hazel can be found on the upland sites.

Management

Proper forest management can result in a healthy, sustainable forest that provides a multitude of benefits. Forest management techniques will depend on species composition, stand age and the objectives of the landowner. Useful harvesting techniques of elm-ash-cottonwood forests include single tree, group selection, and clearcut harvest methods.

For stands that are composed of shade tolerant species such as ash, boxelder and basswood, a selective or group selective cut can be employed to maintain an all-aged stand of proper stocking level. The trees are removed individually or in small groups (patches less than ¼ acre) as they reach maturity (usually 60-80 years), resulting in a gradual succession of young trees growing up to replace the mature ones that have been cut. Undesirable species or trees exhibiting poor form or disease should be selected for removal. Conversely, the landowner may leave a few older decadent trees within the stand to serve as wildlife nest sites.

In addition to tree removal, landowners must consider what species will regenerate within their stand. Stump sprouting and site scarification are two methods to encourage regeneration.

Winter harvesting tends to encourage stump sprouting as well as minimizing site damage. Basswood sprouts readily from stumps and can be adequately regenerated from a group selection method. Typically, many new shoots will emerge from each stump. Landowners should consider removing many of these shoots so that there is only 1 to 3 per stump.

In addition to stump sprouting, site scarification may be used to encourage regeneration of the stand. This may be accomplished during the logging operation where the mineral soil is exposed by the use of skidding equipment, such as a crawler tractor or during a cleanup operation with a dozer equipped with a brush rake. Site disturbance may also be accomplished by the use of herbicides such as Roundup, especially in more open areas that have a heavy grass cover. Be sure to follow all labels when applying herbicides.

Livestock grazing in riparian areas can have negative impacts on the forest, particularly to young stands. Most damage to tree seedlings occurs from trampling when soils are excessively wet and unstable and when the new succulent growth is browsed. Damage to tree seedlings can be minimized if grazing rotations can avoid these areas until trees are of sufficient size and if livestock can be excluded during wet periods to reduce soil compaction. For additional assistance, work with your local NRCS to set up a grazing plan.

For stands that are composed mainly of shade intolerant species like cottonwood, a clearcut method of harvesting should be employed to produce an even-aged stand. Proper regeneration of cottonwood is most easily attained from stump sprouting, particularly in stands younger than 50 years of age. As previously mentioned, harvesting in the winter months will assure better sprouting. As cottonwood trees continue to age and decline, stump sprouting decreases and ensuring adequate regeneration becomes problematic. In the absence of sprouting, cottonwood must regenerate from seeds. A favorable seedbed of moist, exposed mineral soil in addition to a local seed source is required for seed regeneration. Full sunlight, freedom from competition of weeds and grass, and abundant moisture are essential for seedling development. Unless this can be duplicated at the harvested site (perhaps by dozing or controlled burning the site after harvest), the best method may be planting stem cuttings that may or may not be rooted. Direct seeding of dried cottonwood seed may also have promise. Work with your local forester for assistance with all of these management systems.

Natural Competition

Many shrub species, such as nannyberry and beaked hazel, are very aggressive competitors within a forest. Consequently, in addition to tree removal, landowners must consider what species will regenerate within their stand. If a forest has had a very open canopy where trees do not shade the shrubs under them, there is a good chance that these shrubs will provide natural competition to any young trees that the landowner is trying to establish. Site scarification is an excellent method to encourage regeneration. It can be accomplished during the logging operation where the mineral soil is exposed by the use of skidding equipment such as a crawler tractor. Site disturbance may also be accomplished by the use of herbicides such as Roundup, especially in more open areas that have a heavy grass cover. Be sure to follow all labels when applying herbicides. Harvesting on steep slopes should be avoided unless precautions like cable yarding are taken to prevent soil erosion.

Forest Health

Insects and diseases are an important component of forest ecosystems, influencing species composition and driving forest succession over time. Despite this, insects and pathogens can become problematic when the damage they cause conflicts with desired management objectives. Successful management of these damaging agents requires an understanding of the health or vigor of the stand, the potential long-term pest problems that may persist, and the physical environment that will influence the health of the stand and the pest population. Generally, stressed trees are more susceptible to insect and disease problems. Stress occurs within a stand as trees age, stand density increases, and trees compete for a limited amount of resources essential for growth and development (such as water, light, and nutrients). Silvicultural techniques that create adequate growing conditions often reduce tree stress and future insect and disease problems. Other stressors include periodic flooding, drought, hail damage, and frost. Although these things cannot be controlled, managing for forest health will make the stand more resilient and minimize the damage caused by these stressors, which in turn will reduce future insect and disease problems.

Elm-ash-cottonwood forests are subject to numerous insects, diseases, and environmental stresses. Exotic pests (non-native insects and pathogens) are of great concern in forested communities. The most damaging exotic disease in North Dakota has been Dutch elm disease. This disease has decimated the elm population on both lowland and upland sites. The loss of elm in these forests has resulted in a shift in the species composition of these forested communities. Despite the devastation caused by Dutch elm disease, native insects and pathogens can be managed effectively. Proper stand management will reduce the impact of many of these damaging agents and allow landowners to meet their desired management objectives.

The following sections describe some of the more common insect and disease problems found in North Dakota's riparian forests.

Ash Stem Rot (Ash Fomes)

Ash fomes (*Perenniporia fraxinophila*) is a common stem rot of green ash in native woodlands. The fungus typically enters through branch wounds, grows down the branch into the heartwood, and initiates decay. After several years, the fungus will produce a white conk from which spores are dispersed to infect new trees. Although the internal decay rarely kills the tree, the rot reduces the amount of useable wood from the tree and increases its probability of major stem breakage. Minimizing mechanical damage to the stand can prevent the fungus from becoming established, because the fungus requires branch wounds for infection to occur.

Ash Bark Beetles

Ash bark beetles (*Hylesinus* sp.) commonly attack and breed in weakened, storm-damaged, and recently felled ash trees. Typically, tree mortality caused by the beetle is restricted to weakened and dying trees. However, healthy trees are killed on occasion when the beetle population is high. Adult beetles bore into the tree during the spring and construct horizontal grooves where they lay eggs (known as egg galleries). These galleries restrict the flow of nutrients within the tree and result in dieback above the girdled region. Larvae hatch from these eggs, feed within the inner bark, and develop into pupa. The following spring the pupa will develop into adults, emerge from the tree, and seek new breeding material (a susceptible ash tree). To prevent the beetle population from reaching a high enough level to kill healthy ash, a landowner must reduce the amount of suitable breeding material within the stand. The most effective way to accomplish this includes: maintaining appropriate stand density to

promote tree vigor; selectively removing weakened, suppressed ash trees of poor vigor; and removal of ash logging slash. These techniques will reduce the amount of suitable breeding material for the beetle and keep its population at a low level that will not threaten healthy ash trees.

Forest Tent Caterpillar

The forest tent caterpillar (*Malacosoma disstria*) is a defoliating moth whose larvae feed on the leaves of nearly all native hardwoods found in North Dakota. Adult moths lay eggs on the upper branches of trees in late summer. The following spring, larvae emerge from the eggs and begin feeding on the leaves. When populations are high, entire trees and stands can be defoliated. Typically, outbreaks last for three years, depending on environmental conditions and the establishment of natural predators that will cause the caterpillar population to collapse. One year of defoliation rarely affects the health of the tree, however, several successive years of defoliation may lead to tree stress and increase the stands susceptibility to wood-boring insects and stem cankers. In forested stands, direct control is typically inefficient and expensive. Preventative measures, such as maintaining or improving stand health, will result in a greater resilience to forest tent caterpillar defoliation.

Note: As of the date this report was written, the emerald ash borer (EAB) has not yet been found in North Dakota. Management strategies will have to be implemented to control the spread of this very invasive pest.

Representative Wildlife

Beaver

These large rodents are found in riparian areas throughout North Dakota but are more common in areas with cottonwood, poplar, willow, birch and aspen. The bark, twigs and leaves of these woody species are their preferred food, but they will move on to other species like oak, basswood and ash when their preferred food diminishes. Beavers can consume up to a ton of bark in a single season and are active year-round. They typically build lodges out of mud and sticks with an underwater entrance.

Beaver activity often negatively impacts the efforts of land managers, but in the right location, the positive benefits of beavers to riparian areas far outnumber the negative. For example, beaver activity benefits a number of animal species. The dams**,** which beaver construct in smaller streams and coulees, usually hold water all summer long, creating a water source for other animals. The deep pools provide the calm, cool water that many waterfowl and some fish

species prefer. Also, when beavers thin the forest canopy, they can actually stimulate natural regeneration. Beaver activity can rejuvenate a stand of aspen or willow by removing the older decadent trees and stimulating shoot development. Also, as river water is slowed by the beaver dams, excess sediment in the water is able to settle out, thereby, helping to promote water quality.

The natural behavior of beavers is often a nuisance for landowners. Beaver prefer eating tender, young seedlings and saplings rather than eating older, less palatable trees and shrubs. This can be a problem for new tree plantings. Often a woven wire fence installed around the planting will discourage beaver from undoing your work, and will encourage them to simply find another place to have lunch. Old fencing can also work as long as it is close to the ground hindering the movement of the beaver. Beaver can be controlled, if necessary, through hunting and trapping during established seasons. Landowners are encouraged to consult the North Dakota Game and Fish Department (NDG&F) rules and regulations for small game and furbearers before hunting or trapping. In areas where a large tree planting is threatened, landowners should contact the NDG&F or the animal damage control officer for the USDA Wildlife Service Program.

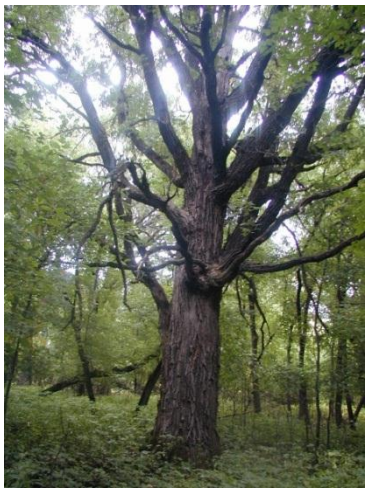
White-Tailed Deer

Upland and lowland hardwoods provide some excellent food and cover for North Dakota's most hunted big game animal – the white-tailed deer. Deer are mainly classified as browsers (feeding on woody vegetation), but this is not entirely true. For most of the spring and summer, deer graze on grasses and forbs which are actually their preferred food. They will also browse during this time on the leaves of trees, especially aspen if they can reach them. They become browsers of twigs and buds only when these high protein grasses and forbs (and leaves) are no longer available and they are forced to eat the less nutritious twigs of shrubs and trees. Woodlands that are in a brushy, reproductive stage will be able to sustain larger deer herds over a period of time. Deer use thick stands of timber for bedding down and hiding, but not extensively for feeding. Small open areas in the forest that have an abundance of grasses, forbs and shrubs are often preferred feeding sites. When deer are hungry they will eat almost anything, but some of the upland tree and shrub species that they prefer as browse are apple, birch, bur oak, chokecherry, cotoneaster, dogwood, green ash, hackberry, maple, sandcherry, serviceberry , Siberian crab and Viburnum. Species that have berries with low appeal during the fall but persist long into the winter are very attractive to deer and other wildlife during the winter months. Some of these would include hawthorn, hackberry, Russian olive, Siberian crab, sumac and snowberry.

Due to windbreak plantings, row crop production, and lack of predator mortality, these woodland creatures have expanded their population statewide. The size of the deer herd must be a compromise between the minimum number of deer desired for public enjoyment and the maximum number the land can support without damage to crops and tree reproduction. If there is a primary underlying theme to preventing depredation problems from deer it is this: keep it close and keep an eye on it. It is much easier to deal with a depredation problem caused by five or ten animals than with fifty or a hundred. For remote areas, consideration should be given to allowing hunter access to keep the deer in check. Contact your local North Dakota State Game & Fish Department for more information on managing deer and wildlife management considerations.

OAK

Description



The oak has been named the national tree by the Arbor Day Foundation and North Dakota is blessed by having bur oak (*Quercus macrocarpa*) found statewide. The oak forest type in North Dakota is dominated by bur oak and is often associated with other hardwoods. The bur oak has the largest acorns of all the native oaks and is very drought tolerant. The acorns are an important food source for wildlife and it grows on a variety of sites from dry uplands to moist bottomlands. Some of the larger concentrations of oak forests can be found in the Pembina Hills and the Devils Lake basin. Other areas include the savannas of the Sheyenne sandhills in the east and upland coulees in the west where it is a pioneer species invading prairie grasslands. The large taproot and very thick bark make it able to withstand the effects of drought, wind and fire.

Because of the tolerance of oak to a wide variety of soil and moisture conditions, bur oak is an associate of many other trees and shrubs depending on site location. Some of the more common tree associates include green ash, basswood and quaking aspen. Associated shrubs include smooth sumac, beaked hazelnut, snowberry, and chokecherry. Sedges are found in the bottomland areas.

Bur oak is a good timber tree and the wood has many uses. The wood is commercially valuable and is marketed as white oak. High quality logs (often on lowland sites) can be sawn into dimension lumber for use as fine furniture and paneling. Other uses include railroad ties, decking, stakes, fence posts, barrel staves and firewood.

Management

Oaks are relatively long-lived trees. When properly managed they can live more than 300 years. The slow growth and weak competitive ability of oak seedlings mean that managing for oak regeneration is very challenging. Planning to regenerate a mature oak stand can take several decades, but if successful demonstrates the landowner's ability to manage their landscape.

Conversion of a mature oak stand to a seedling/sapling stand or to a mixed oak, shrub, grass stand is best accomplished by reducing the overstory canopy by 40 to 50 percent or reducing the total basal area to 40-60 square feet per acre. Basal area per acre is simply the cross – sectional area (in square feet) of all of the trees measured at 4-1/2 ft. above the ground. Remove all undesirable tree and shrub species and those oaks that contribute least to the productivity of the stand.

Following the initial removals, a new understory of oak reproduction will be generated though acorn growth and stump sprouts. Non-oak reproduction, except those species highly desired by the landowner, should be systematically removed at five and ten years after the initial cut has been made. This second and third entry will accelerate the growth of the young oak. This second regenerated stand should be allowed to fill in the canopy. After about 25 to 50 years, the original trees remaining on the stand can be removed and the entire stand can be thinned again to 40 to 50 percent canopy.

Performing this practice of thinning, undesirable tree control and seed tree harvest, the landowner will ensure that oak will remain on the site in perpetuity.

Forest Health

Oak is a hardy, resilient tree native to North Dakota, tolerant of climatic extremes, soil conditions and damaging pests. Despite the resiliency of oak, forest pests can become problematic when oaks are stressed by drought, root injury, or soil compaction. Forest pests of oak woodlands include: cankerworms, wood boring insects, oak anthracnose, and oak leaf blister. A commonly encountered pest of oak following a period of drought is the two-lined chestnut borer.

The two-lined chestnut borer belongs to a family of beetles generally known as flathead borers. In contrast to its name, this borer's principle host is oak. Oaks damaged by drought, defoliation, root injury, or soil compaction are most susceptible to this insect. Like many wood boring beetles, the female lays her eggs in small clusters in bark cracks from which the larvae hatch and burrow beneath the bark. The larvae construct meandering galleries as they feed beneath the bark, restricting the movement of food and water within the tree and causing the area above the gallery to die. Initial symptoms of attack appear as scattered branches in the upper crowns of trees. Repeated attack results in increasing crown dieback and eventual tree death. Typically, trees die over a 2 – 3 year period.

The two-lined chestnut borer, like many other woodborers, is often referred to as secondary tree pests because they are most damaging to weakened and dying trees. Only on rare occasions are healthy oaks killed by the two-lined chestnut borer. Little can be done to save an oak that has been colonized by the beetle because the larval galleries have already damaged the tree. Reducing the trees susceptibility to the beetle is the most effective means of control. Thinning overstocked stands, removing weakened trees, and planting oaks on appropriate sites will increase the overall health of the stand and minimize potential two-lined chestnut borer damage. In doing so, potential damage from other pests may be avoided also.

Representative Wildlife

Wild Turkey

The wild turkey is the largest game bird in North America and was almost named our national symbol. In North Dakota, wild turkey populations have been on the rise in recent years, often making a nuisance of themselves in communities and farmsteads. Since one of the best population controls is harvesting, the North Dakota Game and Fish Department has both a spring and fall hunting season, which has become quite popular.

These creatures are adaptable to a number of different habitats, but prefer mature hardwood forests, especially oak, that are interspersed with openings of variable sizes. Important habitat requirements include roosting and nesting cover, food sources and brood-rearing habitat.

Good roosting habitat includes large trees with large horizontal limbs such as provided by bur oaks. Ideal nesting cover is moderately dense understories that cover the nest, but allow the hen to watch for predators. Deep grass, or fallen tree tops that conceal the nests are also used. Ideal brood – rearing habitat consists of grassland and agricultural fields, as well as oak savannas that provide an abundant source of insects for the young to feed on. Burned areas work especially well as it makes it easier to move about and watch out for predators.

Winter habitat quality is one of the biggest factors affecting turkey abundance in North Dakota. Open oak woodlands that have acorn mast are critical for good turkey habitat. In severe weather, turkey will even eat tree buds like grouse. Other desirable habitats include areas with south facing slopes that have less snow cover and areas with natural springs. Standing corn, unplowed corn stubble, and spread manure are also attractive to turkeys in the winter. Native prairies and fallow fields can produce forbs which are an important seed source if mast production is low.

For information on managing wild turkey populations, contact the North Dakota Game and Fish Department.

PINE-JUNIPER

Description

Ponderosa pine (*Pinus ponderosa*), limber pine (*Pinus flexillis*) and Rocky Mountain juniper (*Juniperus scopulorum*) are the only softwoods native to North Dakota. Ponderosa pine occupies almost several thousand acres in western North Dakota and can be found in stands on slopes and ridges of scoria rock or sandstone within 3-4 miles of the Little Missouri River. They have an open, park-like appearance as they often have an understory of mixed prairie grass such as little bluestem and Indian millet. Other associated species include buckbrush, chokecherry, creeping cedar, Rocky Mountain juniper and skunk bush.

Limber pine is much less common with only slightly over 200 acres in western Slope County. This single, isolated stand occupies a dry, windy site on coarse scoria rock (elevation 2,850 ft.) along the south drainage of Cannonball Creek west of the Little Missouri River. Associated species include skunk bush, creeping cedar, Rocky Mountain juniper and buckbrush. Native prairie grasses such as little bluestem can also be found.

Much more common than these pine species is Rocky Mountain juniper, which occupies thousands of acres in western North Dakota. Juniper stands are found on a variety of sites mainly within the Little Missouri and Missouri River system drainages. It is found in the ravines and along creeks of the badlands and is often mixed with green ash, boxelder and chokecherry. Pure stands of juniper can also be found on north facing slopes. Some of the associated understory species include western snowberry, skunk bush and creeping cedar. Little rice grass is also a common species in these habitats.

Management

As with other forest types, proper forest management can result in a healthy, sustainable forest that provides a multitude of benefits. However, because the locations of many of these trees are on highly sensitive areas, great care must be exercised before undertaking any management scheme. Pine is a shade intolerant species that needs sunlight to reproduce. As with other shade intolerant species, the best harvest system is one that involves clearcutting patches of pine so that natural regeneration of the seed from adjacent trees can occur. These patches can vary in size depending on terrain and landowner objectives. Clearcutting on steep slopes should be avoided

because of erosion concerns. Check with your local forester or natural resource person before cutting.

There are also certain timber stand improvement practices that can be applied. Thinning can be applied to stands that are younger than 70 years of age. Many of the ponderosa pine are found in "dog ear" stands, which are trees of small diameter spaced very close together. Another technique that could be applied to these pine stands includes prescribed burning. Historically, pine relied on natural fires to reproduce and maintain pure stands. Pine regenerates well after a fire (seeding from nearby stands) and this technique could be used but only if professional help is utilized. Any technique that breaks up the soil (scarification) so natural seeding could occur could also be used.

For juniper stands, similar concerns also need to be addressed before any management is undertaken. Again, many of these trees are on steep slopes where severe erosion could occur if clearcutting takes place. Juniper, however, is more of a shade tolerant species during seedling and sapling stages, but it later becomes more intolerant with age. Silvicultural guidelines for juniper have not been developed, but probably the best harvest technique would be the three-step shelter wood system. The best trees are left standing to shelter the remaining trees while the poorer trees are removed. Prescribed fire has only been used with mixed results (juniper is very susceptible to fire damage).

Livestock grazing in these areas can have negative impacts on the forest, particularly to young stands. Softwoods are not as sensitive as hardwoods, but pine needles do cause cattle to abort. Most damage to tree seedlings occurs from trampling when soils are excessively wet and unstable, and when the new succulent growth is browsed. Damage to tree seedlings can be minimized if grazing rotations can avoid these areas until the trees are of sufficient size and if livestock can be excluded during wet periods to reduce soil compaction. For additional assistance, work with your local NRCS to set up a grazing plan.

Forest Health

Despite the drought-prone climate, ponderosa pine and Rocky Mountain juniper are well adapted to these sites and are some of the most drought-tolerant species in North America. Similarly, these species are resilient to damage imposed by native pests found in these areas. Sporadic top-kill caused by pine engraver beetles (*Ips* sp.) and basal attacks by turpentine beetle (*Dendroctonus valens*) may kill old senescent ponderosa pines, but present no immediate threats to the sustainability of these forests.

Perhaps the greatest threat to these stands is wildfire. Years of past fire suppression and overstocked stands create conditions that may intensify fire behavior. Compounding this problem are periodic drought cycles that dru out downed woody fuels on these sites. Thinning

and prescribed burning may restore these pine stands to a healthier, more natural condition, thereby, minimizing the potential impacts of wildfire and native pests.

Representative Wildlife

Porcupine

Porcupines are often found in the pine forests of western North Dakota and are members of the rodent family. These naturally secretive creatures with nocturnal habits are normally seen in early morning and evening hours traveling between feeding and den sites. Feeding is confined primarily to the night when they can be found foraging on leaves, bark and fruits of many kinds of plants. Their barbed quills protect them from their enemies and they will lash out with their tail impaling attackers.

Most damage to trees takes place from late fall to early spring when there is a lack of other suitable food sources. The porcupines normally climb to the upper trunk and feed on the thin bark and cambium. Inadvertently, the branches or upper trunk is often killed due to girdling. Although the entire tree is seldom killed, the form is affected as upper lateral branches begin to curve and grow straight upward. The result is double, triple and quadruple tops, which destroys the aesthetic value of the trees. The trees are also weaker as a result of multiple tops and often split during ice storms or heavy wet snowfalls.

Control by baiting and poisoning has been used in the past although poisons are more carefully regulated today. In addition, poison is indiscriminant, resulting in the death of beneficial wildlife which inadvertently are attracted to the "bait". The most certain form of control involves patrolling the forest in late fall in early morning or evening hours. At this time, porcupines are most easily caught on the ground and removed. When patrolling, be sure to scan the individual trees looking for climbing or descending animals or those still feeding in the upper crown. Prior to actively hunting porcupines, please reference the North Dakota Game & Fish Hunting Regulations to familiarize yourself with the rules governing this species.

Mule Deer

Mule deer have large ears that move constantly and independently, from whence they get their name, "mule" or "burro deer." They do not run as other deer, but have a peculiar and distinctive bounding leap (stotting) over distances up to 8 yards, with all four feet coming down together. In this fashion, they can reach a speed of 45 mph for short periods. This stocky deer with sturdy legs is 4 to 6-1/2 feet in length and 3 to 3-1/2 feet high at the shoulder. During the summer, the coat on its upper body is yellow- or reddish-brown, while in winter more gray. The throat patch, rump patch, inside ears and inside legs are white with lower portions running cream to tan. A dark V-shaped mark, extending from a point between the eyes upward and laterally is characteristic of all mule deer,

but is more conspicuous in males. Males are larger than females. The bucks' antlers, which start growth in spring and are shed around December each year, are high and branch forward, forking equally into two tines with a spread up to 4 feet. Food of the mule deer is quite varied. In spring and summer, it feeds on green leaves, herbs, weeds and grasses more than on browse species. The reverse is true in fall and winter.

Seasonal movements involving migrations from higher elevations (summer ranges) to lower winter ranges are associated, in part, with decreasing temperatures, severe snowstorms, and snow depths that reduce mobility and food supply. Deep snows ultimately limit useable range to a fraction of the total. Mule deer in the arid southwest may migrate in response to rainfall patterns.

APPENDIX B

GLOSSARY

Acre - An area of land containing 43,560 square feet, roughly the size of a football field.

Afforestation - Establishing a forest on an area which currently has no trees growing on it.

Alkaline Soil - Any soil that is above pH 7.0.

All-aged Forest - A forest stand in which trees of all ages and usually all sizes are present.

Basal Area - Of a tree: the cross-sectional area (in square feet) of the trunk at breast height (4-1/2 feet above the ground). For example, the basal area of a tree 14 inches in diameter is approximately 1 square foot. Of an acre: the sum of basal areas of the individual trees on the acre. For example, a well-stocked northern hardwood stand might contain 80 to 100 square feet of basal area per acre.

Board Foot - A unit measuring wood volumes equaling 144 cubic inches which is commonly used to measure and express the amount of wood in a tree, sawlog, veneer log, or individual piece of lumber. For example, a piece of wood 1 foot x 1 foot x 1 inch contains 1 board foot of wood.

Bole - The main trunk of a tree.

Browse - Portions of woody plants including twigs, shoots, and leaves used as food by herbivores, such as deer.

Conifer - A tree belonging to the order Coniferales, which is usually evergreen, cone-bearing, and with needle-like leaves such as pine, spruce and fir.

Consulting Forester - A self-employed professional forester.

Cord - A pile of wood containing 128 cubic feet of wood, bark, and air. Usual dimensions are 4' x 4' x 8'.

Diameter at Breast Height (DBH) - The diameter of a tree in inches at 4-1/2 feet above the ground level.

Debark - The action of removing bark from trees or sections of trees.

Deciduous Tree - A tree which loses all of its leaves during the winter season.

Den Tree - A hollow tree used as a home or nesting site by a mammal or bird.

Dominant Trees - Those trees within a forest stand which extend their crowns above surrounding trees and capture sunlight from above and around the crown.

Edge - The boundary between open land and woodland or two other ecological communities. This transition area between environments provides valuable wildlife habitat.

Epicormic Branching - Branches which grow out of the mainstem of a tree, arising from buds under the bark. These branches often grow as a result of stress or added sunlight.

Even-aged Forest - A forest in which all of the trees present are essentially the same age (within 10 to 20 years).

Firebreak – A natural or constructed barrier utilized to stop or check fires.

Forest - A plant community that is comprised primarily of trees and other woody shrubs.

Forest Management - Providing the forest with the proper treatments so that it remains healthy and vigorous, and provides the products and amenities the landowner desires.

Forestry - The scientific management of forests for the continuous production of goods and services.

Hardwood - A term used to describe broadleaf, usually deciduous trees, such as oaks, maples, ash, or elms, but does not necessarily refer to the hardness of the wood.

Harvest - A generic term for the removal of trees, usually associated with sustainable production of firewood or sawlogs.

Herbaceous Vegetation - The low-growing, non-woody plants in a forest understory, including wildflowers, forbs, grasses, and ferns.

Leader - A terminal leader is the uppermost branch or vertical tip of the tree. It eventually becomes the tree stem or trunk.

Logging Debris - The unwanted, unutilized, and generally unmarketable accumulation of woody material in the forest such as limbs, tops, cull logs, and stumps, that remain as forest residue after harvesting.

Management Plan - A written plan outlining the options for a forest property based on forestry principles and oriented around the landowner objectives. It usually provides inventory data and prescribes measures designed to provide for multiple use of forest resources.

Mast - Nutlike fruits of trees or shrubs, such as acorns and hazelnuts, which are valuable as a food source for many wildlife species.

Multiple Use - Using and managing a forested area to provide more than one benefit simultaneously. Common uses may include wildlife, timber, recreation, wind protection, soil conservation, and water quality.

Non-industrial Private Forestland (NIPF) - Forestland owned by a private individual, group association, corporation, Native American tribe, or other private legal entity. It includes rural lands with existing tree cover, or suitable for growing trees.

Overmature Forest - A forest in which a majority of the trees have passed physiological maturity.

Plantation - A forested area established by planting or direct seeding.

Pruning - The removal of live or dead branches from trees.

Raptor - The birds of prey, primarily falcons, hawks, owls, eagles, and ospreys.

Riprap - A layer of rocks or rock fragments placed on soil to protect it from the erosive forces of flowing water.

Roots - That portion of the tree which is generally underground and which functions in water and nutrient absorption, anchorage, and storage of food and waste products.

Salvage Cut - A harvest performed to remove trees killed or damaged by fire, insects, disease, pathogens, or other harmful agents, to utilize available wood before further deterioration occurs.

Sanitation Cut - A harvest made to remove trees killed or injured by fire, insects, disease, pathogens, flood, or other harmful agents, for the purpose of preventing the spread of insects or disease.

Sawlog - A log large enough to produce lumber or other products that can be sawed. Minimum dimensions and quality vary with the utilization practices of the region.

Shrub - A low-growing, perennial plant with persistent woody stems and low branching habit.

Site - An area evaluated relative to its capacity to produce a particular forest or other vegetation based on the combination of biological, climatic, and soil factors present.

Site Preparation - Treatment of a site by mechanical clearing, burning, or herbicides to prepare it for planting.

Slash - Debris left after logging, pruning, thinning, or brush cutting; also, large accumulation of debris after wind or fire. It includes logs, chunks, bark, branches, stumps, and broken understory trees or brush.

Sprout - A tree that grows from the stump or sucker root of a parent tree: it is not of seed origin. Basswood is frequently of sprout origin.

Stand - A part of the forest that, due to its age, species composition, and other factors, is identifiably different from its surroundings. A forest is often comprised of many stands.

Stem - The portion of a tree that supports the branches isalso referred to as the bole.

Succession - The gradual, natural replacement of one plant community by another.

Thinning - Removal of trees in an overstocked stand to give the remaining trees increased room for growth.

Timber Stand Improvement (TSI) - A practice in which the quality of a forest stand is improved by removing less desirable trees, vines, and large shrubs to achieve the desired density of the best quality trees.

Tree - A woody plant having a well-defined stem, more or less definitely formed crown and usually attaining a height of at least 10 feet.

Underplant - To plant young trees or seeds beneath an existing stand.

Understory - The shrubs, seedlings, saplings, and small trees within a forest stand which form a layer between the overstory and the herbaceous plants of the forest floor.

Uneven-aged Stand - A group of trees of a variety of ages and sizes growing together on a uniform site, also called "all-aged."

Water Bar - A ditch and/or hump across a trail or road used to direct water runoff into a dispersion area to lessen the chance of soil movement and erosion.

Wildlife Habitat - The native environment of an animal, ideally providing all elements required for life and growth: food, water, cover, and space.

Windbreak - A wind barrier of living trees and shrubs maintained for the purpose of protecting a home, buildings, garden, feedlots, and fields, also referred to as a shelterbelt.

APPENDIX C

ACKNOWLEDGEMENTS

The North Dakota Forest Service is very grateful to the following 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.

Grand Forks Herald

Grand Forks Park District

Natural Resources Conservation Service

Nelson County Water Board

ND Department of Health

ND Game & Fish Department

ND State Water Commission

North Dakota State University - Extension Service

Soil Conservation Districts of North Dakota

Red River Regional Council

Red River Resource Conservation & Development

University of North Dakota - Energy and Environmental Research Center

University of North Dakota - Geology Department

US Army Corps of Engineers

US Fish & Wildlife Service

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Rocky mountain juniper in the badlands of western North Dakota.