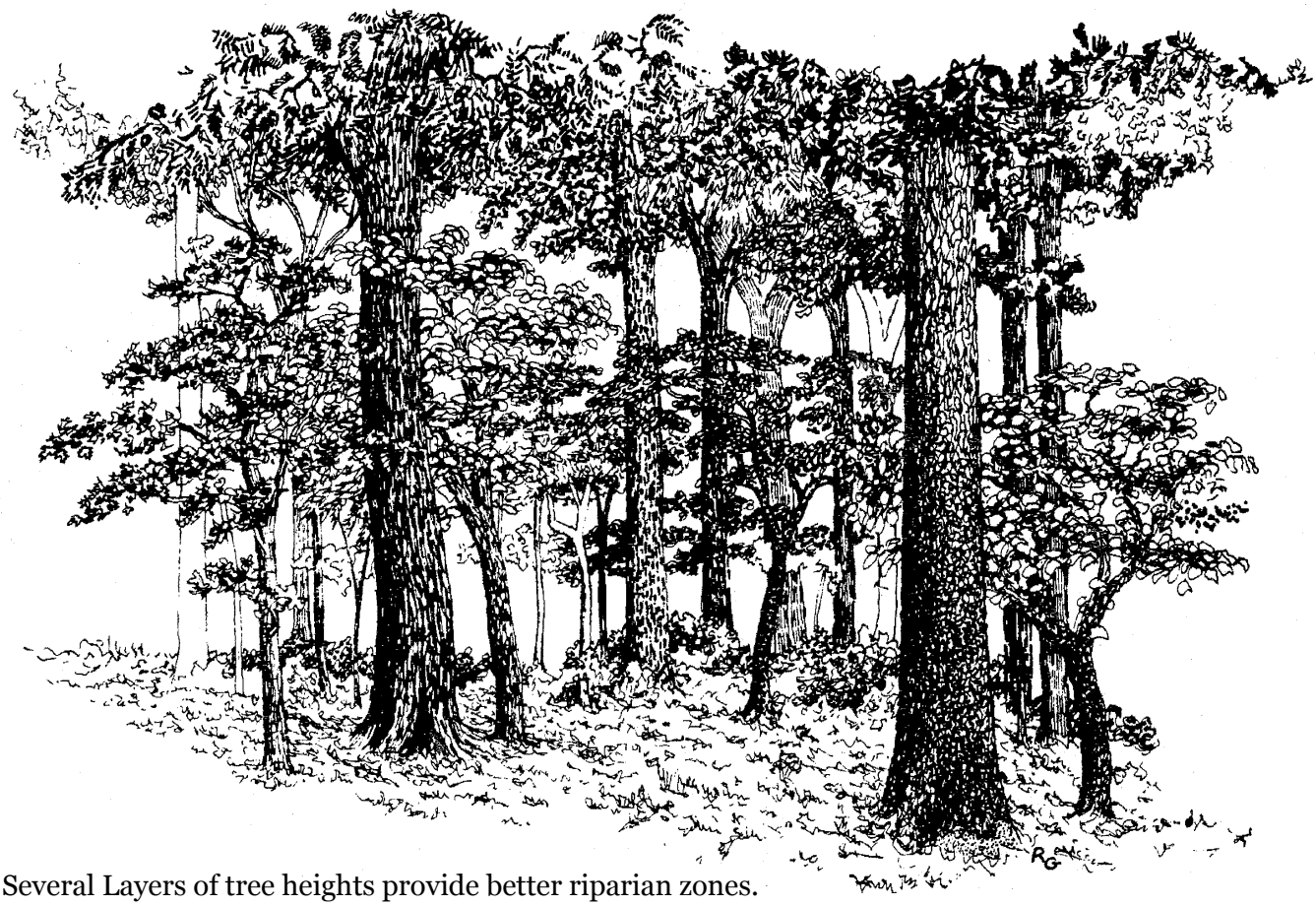
Missouri Woody Biomass Harvesting

Best Management Practices Manual

Missouri Department of Conservation



Several Layers of tree heights provide better riparian zones.

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Foreword

Woody biomass harvesting is a developing industry in its infancy. As world petroleum prices rise, alternative energy sources, such as biomass from our forests, will become more utilized. Harvesting woody biomass is similar to harvesting pulpwood. We expect new equipment and methods to be developed as demand grows, but in the beginning most harvesting will occur with equipment such as we now use. Currently we believe woody biomass harvesting to be economically feasible only when combined with sawtimber harvest.

This booklet has been prepared to inform forest owners, loggers, foresters and other interested persons about woody biomass harvesting best management practices (BMPs). These BMPs provide recommendations designed to protect the forest that the citizens of Missouri rely on for jobs, clean air and water, diverse wildlife habitat, scenic beauty, outdoor recreation and tourism.

Acknowledgments

The Forestry Division of the Missouri Department of Conservation expresses its appreciation to those individuals from the following agencies and organizations that contributed to the development of this publication:

- Big Springs Resource Conservation & Development
- BMPs for Woody Biomass Stakeholders Group
- Bootheel Resource Conservation & Development
- Clearwater Forestry Consultants, LLC
- Eastern Ozarks Forestry Council
- Missouri Department of Conservation
- Missouri Department of Natural Resources
- Missouri Forest Products Association
- Top-of-the-Ozarks Resource Conservation & Development
- University of Missouri, The School of Natural Resources
- USDA Forest Service – Mark Twain National Forest
- USDA Forest Service - Northern Research Station
- USDA Natural Resources Conservation Service

Doug Enyart, Clearwater Forest Consultants, LLC, conducted the technical meetings and developed this document. Dr. Francisco Aguilar and Dr. Bill Kurtz conducted stakeholder meetings and Dr. Kurtz edited the final draft. Rosanna Hernandez edited graphics and organized final format of manual and supplement.

The work upon which this publication is based was funded in whole or in part through a grant awarded by the Northeastern Area State and Private Forestry, USDA Forest Service, to the Top of the Ozarks Resource Conservation and Development, Inc.

Introduction

Missouri is one third forest covered and several counties are over 80 percent forested. In fact, Missouri ranks seventh of the 20 northeastern states in the amount of forest cover. The forests of the state contain some of the finest oak, walnut, pine and redcedar found anywhere.

Benefits from the state's forests are numerous. They provide many economic, environmental and social benefits. They protect the soil from erosion which keeps streams and rivers clean. They filter air, soften the extremes of the weather and add beauty to cities and towns. Much of Missouri's recreation and tourism industry is centered in the forested regions of the state. Forests are a diverse resource of plants, animals, birds, and other life forms.

Forest products are important to Missouri. Harvesting and processing trees into wood products provides more than 31,000 jobs and contributes over $5 billion each year to the state's economy.

Bioenergy from wood has been getting a lot of attention. There are several possible uses for woody biomass (examples of woody biomass are tree tops, small diameter trees, and cull logs). Electric and heat can be generated out of burning wood chips through different technologies to power generators and the use of steam for heat. Cellulosic ethanol can also be made out of wood.

This book provides best management practices (BMPs) to landowners, loggers, and foresters on harvesting woody biomass. Since all trees can be used for energy it is important to properly manage small diameter trees for future benefits and the sustainability of the forest. When in doubt of what management to implement in your forest there is still no substitute for a professional opinion from a forester, wildlife biologist or a private land conservationist.

A diverse group of stakeholders and professionals met several times to identify issues that are important to Missouri forests. All participants felt a strong need to manage Missouri's forest sustainably. These individuals developed the best management practices in this book.

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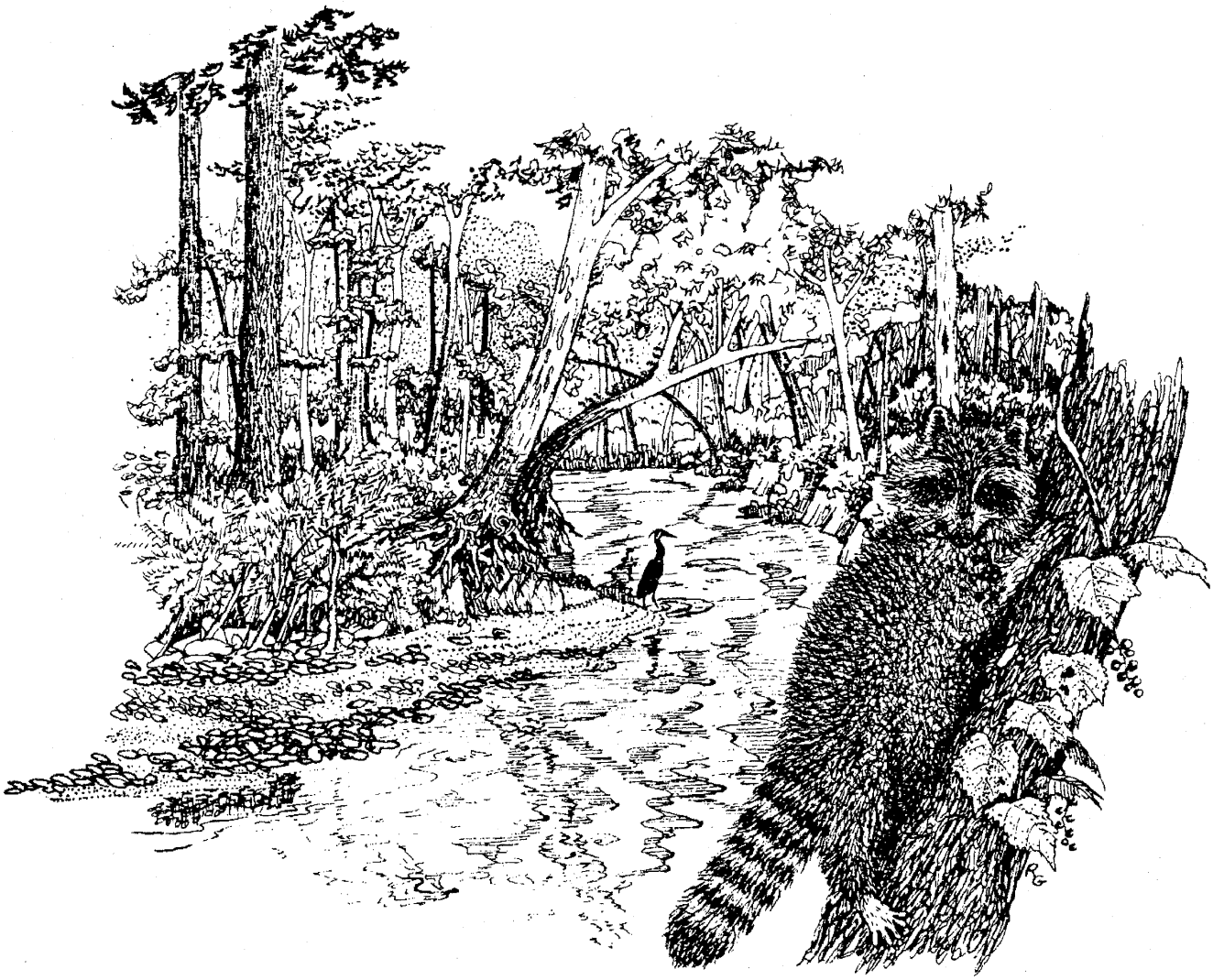


Section 1 - Forest, Wildlife, and Soil Management

Woody Biomass Harvesting – General Recommendations

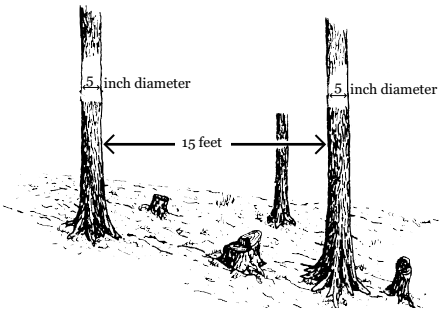
Dramatic increases in petroleum prices have resulted in greater emphasis on the need to develop alternative energy sources, including woody biomass. Woody biomass can be harvested to create many different products such as firewood, charcoal, bio-oil, ethanol, and even gasoline. As we move into this new era it is important to practice sustainable forest management during woody biomass harvesting. The Best management practices (BMPs) in this document are intended to help forest owners and loggers carry out woody biomass harvesting using sustainable management techniques that will protect our valuable natural resources.

The recommendations below are general. Please refer to specific sections related to your question or area of interest.

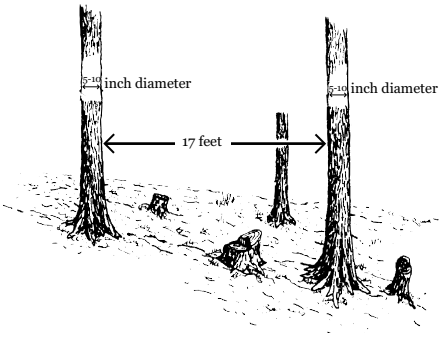
Recommended Best Management Practices:

- Before harvesting trees, **a written management plan** should be completed by a professional forester that addresses all of the natural features and the forest owner's objectives.
- Logging crews should always be required to **follow BMPs in a <u>written</u> sale contract.**
- All **harvesting should be done at a time** when soil is firm to minimize rutting, compacting, and erosion which damages the soil and reduces water quality.
- **Damage to crop/leave trees** left to grow should not exceed 10 percent by number. Excess damage may result in insect or disease infection leading to loss of volume, quality, and value.
- In thinning and commercial harvests <u>with a chainsaw</u>, **retain a minimum of 1/3 of the harvest residue** (tops, branches, etc.) on site, distributed throughout the harvest area. In thinning and commercial harvests <u>using a feller buncher or other mechanized harvester</u>, leave 1/3 of treetops from sawtimber harvest and 1/3 of the typical size small trees cut on the site, distributed throughout the harvest area.
    - Limited knowledge exists about nutrient recycling as it is related to woody biomass harvesting on Ultisol soils in Missouri; this BMP is subject to change as more research is carried out.
- **Woody biomass should be harvested** at the same time as sawlog timber to avoid re-entry. This is also the most economical approach.

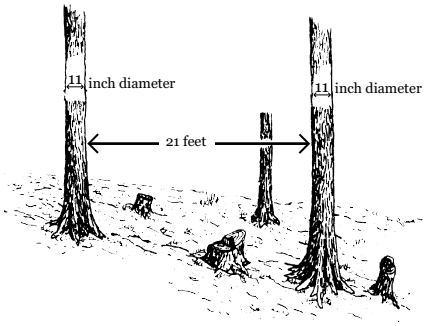
- When **harvesting woody biomass in sapling-size stands (5 inches DBH or less)**, identify a minimum of 200 crop trees (healthy trees that should be left) scattered uniformly per acre on a spacing of at least 15 feet by 15 feet.



- When **harvesting woody biomass from pole-size stands (5 to 10 inches DBH)**, identify and retain no fewer than 150 crop trees (healthy trees that should be left) distributed uniformly per acre on a spacing of at least 17 by 17 feet.



- Any **thinning operation in a sawtimber-sized stand (11 inches DBH or greater)** that produces woody biomass will ideally leave between 80-100 crop trees per acre scattered uniformly throughout the stand (tree spacing of approximately 21 feet by 21 feet).



- **Use of prescribed fire after a woody biomass harvest for site preparation** can cause erosion if not properly planned and conducted. Only professional foresters and wildlife biologists trained to use fire in critical habitats should attempt this practice.

Things To Avoid:

- **High grading harvests** that take the best trees and leave only defective, deformed trees and undesirable species (such as elm and hickory) to grow the next forest.
- **Clearcutting should be limited to only prescribed acres** in a written forest management plan.
- **Converting natural forests** into tree plantations, pasture or other non-forest use; natural forests are healthier, provide more wildlife food and habitat, and may sequester more carbon.
- **Allowing oil, hydraulic fluid, gas, or other chemicals to soak into soil or enter water bodies.** Maintaining equipment will prevent leaks and save money.

High Conservation Value Forests

High Conservation Value Forests (HCVF) are forests with an especially high ecological and/or social value that provide the conditions needed to support rare or uncommon species. They are more valuable for the number of different plant and animal species they support (biodiversity) and the ecological functions they provide than for just the timber that they can produce. Examples of HCVFs in Missouri include forested zones along streams protecting water quality, glades, sinkhole fens, and wetlands.

Groups of species, called natural communities, regularly occur together under specific conditions. The HCVF provides a wide array of different conditions and thus, the highest biodiversity. Ecological classification systems contain lists of plants and animals found in each natural community along with maps identifying where they are likely to occur. More information about natural communities, particularly those having high conservation value, can be provided by contacting a professional forester, a Missouri Department of Conservation (MDC) Private Land Conservationist, or a MDC Wildlife Biologist.

Recommended Best Management Practices:

- **Before harvesting, conduct an on-site survey and evaluation** to see if there are any natural features or unusual wildlife and plants that may need special care or protection during the harvest.

  Look for:
  - Unusual karst or geologic features.
  - Types of wildlife or plants you rarely see or have never seen before.
  - Large nests in the tops of trees, especially near water.
  - More than the normal amount of very old or large trees.

- Even if a **threatened or endangered species** is present, a well-designed and supervised harvest may be possible and may even be used to improve habitat for the species.
- To be certain about the presence or absence of **natural features of high conservation value**, consult a professional forester or wildlife biologist prior to harvest.

Things To Avoid:

- **Damaging special or unusual habitats** by careless logging.

Wildlife[1]

These guidelines focus primarily on wildlife that lives in forested natural communities. The word "wildlife" brings to mind animals or birds that people are familiar with, but it includes many other less well known species. Maintaining diversity promotes stability within the biological community, protecting wildlife from stresses like food shortage and disease, just as a diverse economy is more stable than a single industry economy.

Wildlife diversity begins with plant diversity. Trees are plants and all native trees benefit wildlife in some way. Oaks, hickories, persimmon, mulberry, hackberry, dogwood, serviceberry, pawpaw, black cherry and black gum are all common wildlife food trees in Missouri, but oaks are the most important.

Acorns are the most critical winter food supply for wildlife in forested areas. There are two groups of oaks in Missouri, the white oak group and the red oak group. Acorns in the white oak group ripen in one growing season while the red oak group ripens in two years. This reduces the chance of complete acorn failures, although it occasionally happens. Acorns are occasional food for many species of animals, even foxes and channel catfish.

Forest owners should consider the effects timber/woody biomass harvesting can have on all animals and plants that exist in the local forests. Harvesting woody biomass, while maintaining or improving the biodiversity of natural communities is a significant challenge. The advice of experienced resource professionals can help forest owners achieve these worthy goals.

1 NOTE: These recommendations may not match those in other sections and are intended for situations where wildlife is given higher priority.

Recommended Best Management Practices:

- **Contact a wildlife biologist or professional forester** to help decide which trees to leave and which trees to harvest to enhance wildlife habitat in a way that meets your personal goals and values.
- **Leave trees of various sizes and species** for mast production, especially oaks.
- Loggers should use **directional tree felling** to avoid damaging soft mast trees such as dogwood, cherry, mulberry, and persimmon.
- Create a **gradual transition** from areas that are to be heavily cut to areas that are to be lightly cut.
    - An abrupt change results in what is known as a "hard edge". This concentrates wildlife in a narrow strip, which favors predators. A "feathered" edge allows wildlife to nest and spread out naturally reducing losses to predation.
- Consider leaving **travel lanes for wildlife** in clear cuts if the harvest area is wider than 300 - 400 feet or is larger than 40 acres.
- **Smooth and seed logging decks, main skid trails, and haul roads** with green browse food plot crops. (see Table 3).

Things To Avoid:

- Harvesting without any consideration of **wildlife needs**.
- **Using invasive plants** such as Kudzu and Sericea lespedeza for cover crops after harvesting woody biomass. Native plants are more useful to native wildlife.
- **Cutting all soft mast trees** that produce wildlife food.

Den Trees and Snags

Den trees are standing hollow trees with a hole for wildlife entry. They provide homes and food for many species including squirrels, raccoons, owls, woodpeckers, and wood ducks. White oaks make the best den trees because they are long-lived and great food producers. If all den trees cannot be saved, at a minimum leave trees with holes high in the tree to benefit most den-dwelling wildlife species.

Recommended Best Management Practices:

- See Table 1 for specific **recommendations on the number of den trees and snags** to leave per acre based on habitat type.
- **If den trees are not present**, leave at least 1/5 acre of trees in a group surrounding at least one large tree that could become a den tree for every 5 acres harvested.

Things To Avoid:

- **Cutting or destroying all den trees and snags** which will degrade wildlife habitat.

Table 1. Snag and Den Tree Recommendations for Wildlife Management[1]

Remaining Trees (Per Acre)

	Heavily Forested		**Riparian Corrido**		**Bottomland Hardwoods**	
	Den	Snags	Den	Snags	Den	Snags
Minimum	3	3	25	12	12	3
Optimum	7	6	25	12	12	3

1 Snags and den trees 10 inches in diameter are preferred - the larger the better.

Coarse Woody Debris

Coarse woody debris (CWD) consists of stumps, downed trees, and treetops with limbs larger than 6 inches at the large end. It provides good habitat for a variety of insects, salamanders, snakes, and small animals that form the lower levels of the food chain. Many predators, ranging in size from shrews to black bears, rely on the food they find while searching in CWD.

Recommended Best Management Practices:

- **Coarse woody debris left near permanent or seasonal water sources** provides excellent wildlife benefits.
- **Debris from a variety of tree species and sizes** should be left. In general, bigger is better.
    - In thinning and commercial harvests with a chainsaw, **retain a minimum of 1/3 of the harvest residue** (tops, branches, etc.) on site. In thinning and commercial harvests using a feller buncher or other mechanized harvester, leave 1/3 of treetops from sawtimber harvest and 1/3 of the typical size small trees cut on the site.
- **Leave as many of the leaves and twigs** (fine woody debris-FWD) as possible on the harvesting site to encourage nutrient recycling and habitat for small animals.
- **Use long-term rotation ages** to provide mast for wildlife. Uneven-Aged Management (UAM) is a silvicultural management strategy for this.

Things To Avoid:

- **Removing all coarse woody debris.**
- **Leaving debris in places** where it is likely to be swept into logjams that would cause water to cut around, eroding the bank and reducing water quality.

Sustaining Soil Productivity

The productivity of a forest is based on the quality of the soil it grows in. Trees and plants need soil to provide a balance of nutrients, water, air, and physical support. The ability of the soil to provide these in balance, when needed in the life cycle, determines soil productivity. Across Missouri, nutrient levels vary widely. Soils developed in glacial till and alluvium have high nutrient levels, but most Ozark soils, where most of the forestland occurs, lack these high levels of natural fertility. Heavy or frequent woody biomass harvesting can reduce soil productivity.

Use of BMPs for timber/woody biomass harvesting is important to maintain soil productivity and protect water quality in all Missouri forestlands.

- **Information and assistance** is available from the USDA Natural Resources Conservation Service (NRCS), Missouri Department of Agriculture, Missouri Department of Natural Resources, or University Extension. Detailed maps of the soils on your property are available from the NRCS.
- **Identify sensitive areas with shallow soils** or very steep slopes which may be more subject to erosion.
- **Soil needs to be managed** based on site-specific characteristics.

- Long-term tree rotations are recommended to encourage natural fertility. Uneven-aged management is a silvicultural management strategy option that maintains natural fertility.
- In thinning and commercial harvests with a chainsaw, **retain a minimum of 1/3 of the harvest residue** (tops, branches, etc.) on site, distributed throughout the harvested area. In thinning and commercial harvests using a feller buncher or other mechanized harvester, leave 1/3 of treetops from sawtimber harvest and 1/3 of the typical size small trees cut on the site, distributed throughout the harvested area.
    - *Limited knowledge exists about nutrient recycling as it is related to woody biomass harvesting on Ultisol soils in Missouri; this BMP is subject to change as more research is completed.*

Things To Avoid:

- **Skidding on shallow soils** (0- 20 inches to bedrock) and on steep slopes (greater than 35%) while harvesting woody biomass should be avoided when possible.
- **Grazing areas after woody biomass harvesting**; the forest needs to regenerate and grazing will prevent natural tree regeneration.

Photo by Rosanna Hernandez

Section 2 - Water and Special Features

Stream Identification

Identifying the type of stream is important to determine the level of protection needed. Forest owners will usually be familiar enough with a stream's flow patterns to identify the stream. If the forest owner is uncertain which type of stream they have, they should consult a professional forester or other qualified natural resource professional.

Figure 1. Stream Type Identification
(photo provided by South Carolina's Best Management Practices booklet)

Perennial, intermittent, and ephemeral streams are common in forested watersheds. Rain and snowmelt funnel through a network of stream channels called watersheds (see Glossary of Terms).

- **Perennial Streams** flow year-round and have well-defined banks and natural channels.
- **Intermittent Streams** only flow during wet seasons, but still have well-defined banks and natural channels.
- **Ephemeral Streams**, or stormwater courses, only flow with runoff from rain or snowmelt and do not have well-defined banks or channels.

Ephemeral streams mostly flow in the upper parts of a watershed following rain or snowmelt. They rarely carry enough runoff to erode soil. However, they may still wash away the litter on top of the soil and deposit it directly into perennial and intermittent streams.

Streamside Management Zones

Streamside Management Zones (SMZs) or Riparian Management Zones (RMZs) are areas along intermittent and permanent streams and rivers that are important in maintaining water quality. Trees and other plants in SMZs are the "last line of defense", slowing floodwater, filtering and trapping sediment to clean the water and create rich bottomland soil. Streamside Management Zones require special treatment when harvesting timber/woody biomass and conducting other forest management activities to protect streambanks from erosion and provide shade to cool stream temperature. The deep, moist soils of many streamside forests provide excellent growing sites where high quality trees and bottomland tree species can grow. Caves, springs, sinkholes, and lakes are other special areas treated like SMZs.

SMZs are composed of two parts. The *primary* filter strip starts at the top of the well-defined bank and runs 25 feet out on both sides of the stream. A *secondary* filter strip varies in width depending on the steepness of the land. It is found by multiplying times 2 the slope, measured by percent, of the land immediately beyond the first 25-foot strip. The resulting number is added to the 25-foot strip for the total width of SMZ to be protected. **Note:** the widthof an SMZ should always be **at least 50-feet**. To determine SMZ widths wider than 50-feet use the rule stated in this paragraph.

Example:

Percent slope is the rise ÷ run x 100. A rise in elevation of 5 feet over a distance of 25 feet is 5 ÷ 25 = 0.2, 0.2 x 100 = 20% slope. If the slope of the land beyond the first 25-foot strip is 20%, multiply 20 x 2 = 40 feet. The total SMZ is 25 feet + 40 feet = 65 feet on each side of the stream.

Figure 2 shows an SMZ. *Table 2* lists the total width of filter strips for different slopes. These are the recommended widths to reduce the amount of sediment reaching streams from areas disturbed by logging or other activities.

Note: the exception to the SMZ rule stated previously is around large streams and rivers with wide, flat flood plains. These areas should have a minimum of 100-foot SMZs on each side of the stream.

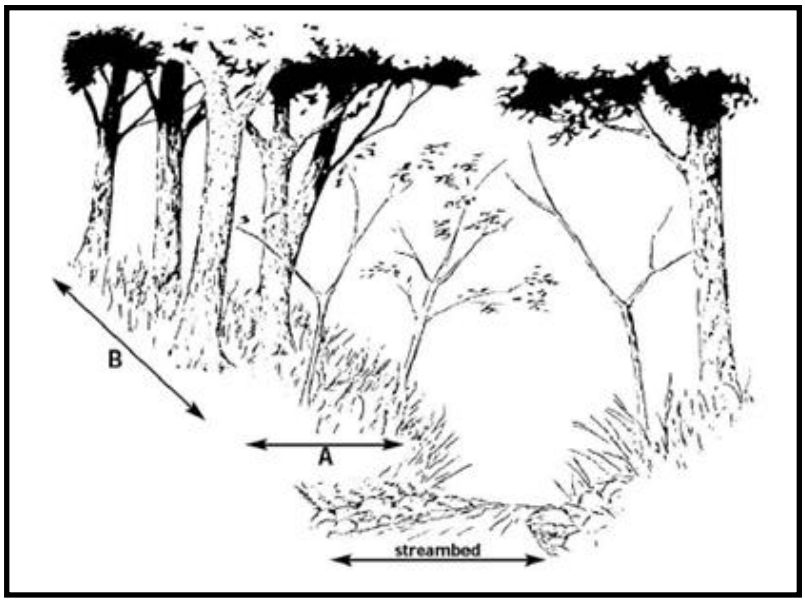


Figure 2. Streamside Management Zones

Where should an SMZ/RMZ be applied? Streamside Management Zones or Riparian Management Zones should be used on all perennial streams, intermittent streams, and around sinkholes.

Recommended Best Management Practices:

- For specific **recommendations on harvesting practices in SMZs/RMZs,** please refer to recommendations under Skid Trails, Log Landings,and Forest Roads.
- **Always leave at least 1/3 of the typical size trees in the SMZ** – 40 basal area (BA) or greater – in a fully stocked stand of trees during a woody biomass harvest, but ½ to 2/3 is recommended in most cases. Logs and woody biomass should be cabled out of the primary zone (first 25 feet) of the SMZ.
- **Use of heavy equipment**, like log skidders and bulldozers, is permissible in SMZs, but special care is needed (see previous recommendation for an example).
- A **harvest plan** should be completed before the harvest. It should include specific recommendations on which trees to leave and which may be removed.
- **Leave most trees on stream banks** to protect the soil and water quality. Trees on south and west banks are especially critical for cooling water temperature. A closed canopy should always be maintained in SMZs.
- Always use **Missouri Forest Products Association professionally trained loggers.**
- Use of the *Best Management Practices for Harvesting Woody Biomass and the Missouri Watershed Protection Practice* booklet should be **required in all written harvest contracts.**
- Try to **leave a variety of tree species and sizes in SMZs/RMZs**. Special exceptions may be needed in shade intolerant tree species to regenerate the riparian forest; contact a professional forester for assistance.
- Use of **prescribed fire after a woody biomass harvest for site preparation** can cause erosion if not planned and conducted properly. Only professional foresters and wildlife biologists trained to use fire in critical habitats should attempt this.

Things To Avoid:

- **Selling woody biomass without a written contrac**t that includes protection for SMZs/RMZs.
- **Leaving trees tops from harvesting activities in water.** Naturally occurring trees and tops in water provide enough habitat.
- Permitting **wildfire to burn through SMZs and other critical areas.** Use of prescribed fire for specific management objectives in SMZs should only be conducted by resource management professionals such as professional foresters and wildlife biologists.
- **Exposing mineral soil during site preparation** for seeding or planting a stand of trees in an SMZ when heavy rain or snowmelt is likely to cause erosion and sedimentation.
- Placing **portable sawmills or log landings** in SMZs/RMZs.
- **Leveling of gullies** unless immediately seeded and mulched.

Table 2. SMZ Width by Slope

Use of a Streamside Zone as a Filter Strip

Slope of Land between Road and Stream (Percent)	Width of Filter Strip for Common Logging Areas (Feet)
0*	50*
10*	50*
20	65
30	85
40	105
50	125
60	145

* Minimum width of an SMZ is 50 feet. Slopes 12% or less should have the 50-feet minimum SMZ rule applied when determining SMZ width.

Stream Management Zones & Forest Roads

Please refer to section on Stream Crossing under the Forest Roads section.

Sinkholes, Caves, and Springs (karst features)

Sinkholes are natural depressions or holes that occur where the underlying carbonate bedrock, such as limestone or dolomite, dissolves. They can vary in size and depth, and may be bowl or chasm shaped. Forming gradually, underground sinkholes suddenly collapse, creating a direct connection between the surface and groundwater. They often are associated with an underlying cave and provide a source of food for creatures that never leave the cave.

Harvesting woody biomass near sinkholes is permissible, but it poses a significant risk to cave systems, the creatures that live in them, and water quality. Leaky harvesting equipment is very common and may contaminate sinkholes if the harvesting operation is not properly supervised.

A **cave** is a natural opening extending beyond the zone of light, and home to some of the least common wildlife. This natural feature, and the plants and animals that live there, can be harmed by careless harvesting activities. Caves should always be located and protected when harvesting timber/woody biomass. Forested buffers around cave entrances provide valuable protection for this unique and sensitive habitat.

A **spring** is a point where water flows out of the ground, where the aquifer meets the surface. It may run year round or only during certain times depending upon the amount of rain or snowmelt received.

Recommended Best Management Practices:

- For specific **recommendations on harvesting practices near sinkholes, caves, and springs,** please refer to recommendations under Skid Trails, Log Landings, & Forest Roads.
- **Locate and flag all sinkholes, caves, and springs** prior to the start of harvesting.
- **All sinkholes, regardless of size, require protection** with <u>at least</u> a 100-foot buffer zone completely surrounding them. Limited harvesting within the buffer zone is permissible,but always leave in the zone <u>at least</u> $^1/_3$ of the typical size trees (40 BA or greater) in a fully stocked stand of trees during a woody biomass harvest, although ½ to $^2/_3$ is recommended in most cases. Logs and woody biomass should be cabled out of all buffer zones.
    - The intent is not to buffer every depression; features that identify a sinkhole from other areas include recent slumping (soil movement), a rock rim, and/or a steep drop in elevation in the sinkhole.

- Be sure your **timber sale contract** contains language to protect resources from leaky harvesting equipment, and follow through with frequent inspections of the harvesting activities.
- Protect **unique sinkholes** - flag a buffer around them to protect them from harm.
    - *Unique sinkholes* must have one of the following: significant changes in elevation (30% slopes or greater), caves, permanent standing water, exposed rim rock, or different vegetation than the surrounding forest. These unique sinkholes should be buffered by at least 200 feet and no logging should take place.
    - If harvesting is needed in unique sinkholes, contact a professional forester or biologist for advice.
    - Maintain a buffer zone between harvesting and the edge of unique sinkholes. A buffer zone should be at least 200 feet in width starting from the rim of the sinkhole.
- **Divert runoff** from haul roads, skid trails, and log landings so it does not drain directly into sinkholes, caves, or springs.
- **Establish staging areas for equipment**, fuel and oil, chemicals and other hazardous materials no closer than 200 feet to a sinkhole, cave, or spring.
- Leave a **buffer zone between harvest areas and the cave opening** – buffer zones should extend around the cave entrance and be 200 feet in width.
- **Stockpile any excavated material** well away from a cave opening so that the material cannot wash back into the opening.
- Leave a wide **natural vegetated buffer area around any spring**; the buffer should be a minimum of 200 feet in width.
- **Utilize standard BMPs** for SMZs when harvesting near streams and below springs.
- **Limit harvesting in concave** (bowl shaped) areas that receive water from the surrounding landscape; the area should be harvested when the ground is dry to prevent rutting.

Things To Avoid:

- **Disturbing soils in sinkholes** with open swallets (*see Glossary of Terms*).
- **Pushing soil, logging debris**, or other waste materials into the bottom of any sinkhole, into any sinkhole opening or in any drainage that ends in a sinkhole.
- **Draining equipment fluids onto the ground** or parking logging equipment in the bottom of sinkholes.
- **Blocking or modifying cave entrances**, or making loud noises near the entrance to caves.

Wetlands

Wetlands are areas where the soil is saturated, often covered with water for varying periods of time during the year. Wetlands support many natural communities with unique features and some endangered and rare species of wildlife and plants. Plants and animals in wetlands are adapted for life in saturated soils.

Recommended Best Management Practices:

- For specific **recommendations on harvesting practices in wetlands** please refer to recommendations under *Skid Trails, Log Landings, & Forest Roads*, section *Forested Wetland Road Construction*.
- A **professional forester or wetland specialist can provide** important information before harvesting begins. They can locate, flag, and map the boundaries of wetlands to limit damage from harvesting equipment.
- **Extend Stream Management Zones (SMZs) to include** all adjoining wetlands. Always leave in the SMZ at least $^1/_3$ of the typical size trees (40 BA or greater) in a fully stocked stand of trees during a woody biomass harvest, but ½ to $^2/_3$ is recommended in most cases. Logs and woody biomass should be cabled out of all primary zones in SMZs and wetland buffers.
- Write a **sediment and erosion control plan** using Best management practices during nearby road construction (see special section on road construction in wetlands).

Things To Avoid:

- **Restricting the natural surface and subsurface flow** of water under haul roads in wetlands (provide adequate cross-road drainage).

Section 3 - Skid Trails, Log Landings, & Forest Roads

Skidding Logs & Woody Biomass

Nearly 90 percent of all erosion from timber/woody biomass harvesting comes from unplanned, poorly constructed skid trails, landings, and roads. Poor log skidding also damages trees by knocking off bark and often compacting the soil, causing root damage and poor growth. The important message here is to plan ahead and be able to adapt to changing conditions that go with outdoor work.

During dry conditions, rutting is limited to moist areas or primary skid trails where repeated use compacts the soil. Most rutting is unintentional and usually is not a significant concern. But, if harvesting when soil is wet, deep rutting can become a serious problem. Rutting reduces forest health and has a very visible impact most people find offensive. Special care should be taken in the planning and implementation of harvesting to minimize the amount of rutting.

Recommended Best Management Practices:

- **Flag the location of main skid trails** before work begins. Minimize the number needed to log the site efficiently and limit soil compaction. Use old skid trails if they are suitable.
- The total amount of **area occupied by roads and skid trails** should be limited to no more than 10 percent of the area.
- **Protect crop trees** during woody biomass harvesting. While flagging skid trails, mark trees for removal that will obviously be damaged during harvest. Use other marked or low value trees, such as elm and hickory, and defective trees as bumpers.
- **Harvest areas furthest from landings first** so slash can be used to cover skid trails on the way out to slow water flow and protect the soil. Concentrate skid trails to minimize soil compaction and rutting.
- Logs and woody biomass should be **cabled out of the first 25 feet of the SMZ** and wetlands to avoid rutting by skidder tires.
- **Minimize rutting** by skidding woody biomass only when the soil is firm. Harvesting should be temporarily stopped when the soil is saturated to decrease the likelihood of erosion, rutting, and compaction. Logging can be moved to more stable areas, limited to felling trees only, or time can be focused on equipment maintenance until conditions have improved.
- **In SMZs** and other special areas, pull fewer logs/woody biomass behind the skidder to minimize rutting. Cut trees so they fall away from wetlands, and other special features.

- **Minimize the number of stream crossings**, locate them at narrow points, and cross directly at 90 degree angle. Logging impact on streams must be minimized. Before crossing a stream, make a turnout or waterbar that will shed water off the skid trail.
- **Prevent runoff from skid trails** from entering streams and wetlands by using waterbars, side and wing ditches, broad-based dips, rolling dips, out-sloping, grade breaks, and other erosion control methods.
- During **heavy rain events or during extended periods of inactivity** of harvesting, install temporary erosion control structures on skid trails.
- Where a s**teep skid road** is absolutely necessary, it should be at less than a 15 percent grade and not exceed 330 feet in length. Waterbars should be installed as soon as possible (*see Installing Waterbars*).
- Take advantage of natural turns and bends to **shed water naturally** and keep it from gathering speed, picking up and moving more soil.
- **Repair, smooth, seed, and install waterbars** when skid trails are no longer needed.
- Always **service equipment and store fuel and oil at least 200 feet away from** SMZs, sinkholes, caves, springs, wetlands, and other water bodies.

Things To Avoid:

- **Removing skidder from harvest site** before water bars and other protection practices requiring use of equipment have been completed.
- **Driving a skidder** through a wetland.
- **Operating skidders in SMZs and buffer areas** around sinkholes, caves, and springs.
- **Allowing skidders to cut ruts** 6 inches or greater into the soil for a distance greater than twice the length of a skidder (approximately 50 feet). Ruts disrupt the natural flow of water across the surface and into the soil.
- **Using soil for fill**, either alone or in combination with slash, for stream crossings.

Log & Woody Biomass Landings

Landings are areas where logs or woody biomass are skidded for loading onto trucks. They are very visible and usually the largest areas affected by concentrated equipment use, resulting in a high degree of soil compaction and rutting. Landings, skid trails, and roads are the main sources of erosion and sedimentation in streams and other water bodies. The challenge is to control the volume and velocity of water that flows from these sites.

Recommended Best Management Practices:

- Always use **old existing landings** if possible. Between harvests, landings can be used as wildlife food plots.
- **Construct new landings** at least 200 feet from SMZs, sinkholes, caves, springs, wetlands, and other water bodies. Always pile debris from clearing new landings on the downhill side.
- Try to **place landings out of sight or leave screens** to limit visibility.
- **Landings should be kept small**, yet with enough room for equipment operation, product sorting, and removal. Small decks are easier to clean up, do less damage, and are less visible.
- **Locate log/woody biomass landings** uphill on dry sites with good drainage but on a fairly level site.
- **Stabilize landings by seeding and mulching** as soon as possible. Use only non-invasive plants such as wheat or annual rye grass for this cover crop (see Table 3).
- During **expected heavy rain events or during extend periods of inactivity** of harvesting, install temporary erosion control structures on landings.

Things To Avoid:

- **Locating log decks in low areas**, poorly drained sites, or on wet soils.
- **Skid trails and haul roads that drain water** onto landing sites.

Forest Roads

Forest roads, over time, become compacted which creates a hard surface where water from rain and snowmelt run off instead of soaking in. Surface runoff washes away thousands of tons of soil over time, and eroded soil takes a very long time to replace through natural weathering.

Sediment can be deposited in streams, reducing water quality. Areas with steep slopes, erodible soils, and wet soils are the highest risk. Most of this erosion can be prevented by using Best management practices to properly plan, construct, and maintain forest roads. If surface runoff water is controlled, soil remains in place, keeping our streams clear and our forests growing.

Types of Roads

- Temporary roads
    - Temporary roads are only intended to be used short-term when the soil is firm.
    - Usually these roads are made using a skidder blade with no advance planning or design.

- Permanent seasonal roads
    - Are part of the permanent road system but should only be used when firm.
- Permanent all-season forest roads
    - Permanent all-season roads will have gravel surfaces, side and wing ditches, and culverts. They are designed for year-round use. Even these roads can become too wet to use, especially for heavily loaded log trucks.

Road Construction

(NOTE: see special section on Road Construction in Forested Wetlands)

Recommended Best Management Practices:

- Always **have a plan and a design before you build**. Unplanned road construction will result in higher maintenance and reconstruction costs, as well as reduced water quality. A professional forester with experience in designing and laying out forest roads and supervising construction can provide valuable advice.
    - Decide what type of road will fit the need. How much traffic will use it? What kind of vehicles will it need to support? Will it be used year around or only seasonally?
- **Minimize the number of new roads** by using old roads if they are well placed and in good condition.
- **Locate property lines** to avoid building roads on someone else's property.
- **Walk the route** and hang flagging once you determine the best location for the road. Your contractor may suggest changes prior to construction based on experience.
- **Locate roads on well-drained soil** or soil with rocky surfaces away from streams, seeps, and other wet areas. If surface material is needed, use crushed rock instead of creek gravel. It works better and does not create other environmental problems associated with creek gravel.
- **Construct roads during dry periods** when moisture and soil conditions are not likely to cause erosion and sedimentation.
- **Minimize soil disturbance** and removal of trees. Pile cleared debris on the lower sides of the road and cut banks.
- Construct road approaches to SMZs, springs, sinkholes, caves, and wetlands to minimize **surface runoff**.
- When road construction is necessary in special areas, **minimize the number, length, and width**.
- **Road grades should be kept at less than 8 percent** except where terrain requires short length and steep grades.
- **Forest roads should be designed to shed water**. Water control methods include crowning the road, using the natural slope, side ditches, culverts, water turnouts (also known as wing ditches), broad-based dips and water bars (*see Figure 3*).
- If the road you build enters a public road, you will need to contact the authority in charge to obrain proper permits. If it is a state road, you must contact the **Missouri Department of Transportation** (1-888-275-6636).
- A **seed mix appropriate for the season should be applied** to disturbed areas immediately following road construction to promote re-establishment of plant growth to reduce erosion (see Table 3).

Things To Avoid:

- **Burying wood debris in the road base**. Eventually the wood will rot, requiring repair and reconstruction.
- **Using invasive and exotic plants** when seeding areas that were disturbed during road construction.

Stream Crossings

Road building and vehicle travel across streams should be avoided whenever possible because it increases sediment in the water, reducing water quality. Planning in advance will reduce the number of stream crossings necessary or eliminate them altogether. The following recommendations are specific to stream crossings to be used in addition to the general road construction recommendations above.

Recommended Best Management Practices:

- **Designate the location and type** of stream crossings.
- **Cross streams only as needed** at narrow points and at 90 degree angles. Locate crossings where stream banks are low, rocky, and level.
- **Locate fords where** stream banks are low with level, rocky bottoms.
- **Use bridges or culverts to minimize erosion** and to maintain normal stream flow. Use temporary portable bridges when possible – they have less impact on the environment and are easily removed. Be sure to use a culvert big enough to handle storm flows.
- The **County Soil and Water Conservation District technicians can advise you** on temporary or permanent bridge construction, and on proper size, construction, and maintenance of culverts. If the culvert is too small, the road may wash out.
    - *Note: Stream crossings that have uses other than forestry or agriculture applications may require special permits (404 permits); these permits can be applied for at the US Army Corp of Engineers' office. Special BMPS are required in forestry and agriculture to be exempt from the permit process (see Forest Wetland Road Construction)*
- **Soil around culverts, bridges, and crossings** should be stabilized with coarse rock or large stones.
- **Protect and stabilize approaches to fords** with crushed rock extending at least 50 feet from both sides of the stream bank.
- **Use turnouts so runoff water does not enter the stream** directly from the road ditches; allow a sufficient width for a filter strip.
- **Exposed soil should be stabilized** using seed and mulch, hay bales, rock, and silt fences.
- **Do not remove culverts** from stream channels following logging if the crossing may be used again within 10 years.

Things To Avoid:

- **Crossing streams more than necessary** to get the woody biomass to the landing.
- Changing the **natural flow of water.**
- **Building temporary crossings** with logs and brush topped with soil.
- **Draining water carrying sediment and pollutants directly into streams** or intermittent drainages. Diverting it off into the surrounding vegetation will filter out sediment and allow it to soak into the soil.
- **Locating roads in streambeds**.
- **Constructing roads inside SMZs**. Roads can be constructed in SMZs only where necessary to cross streams.

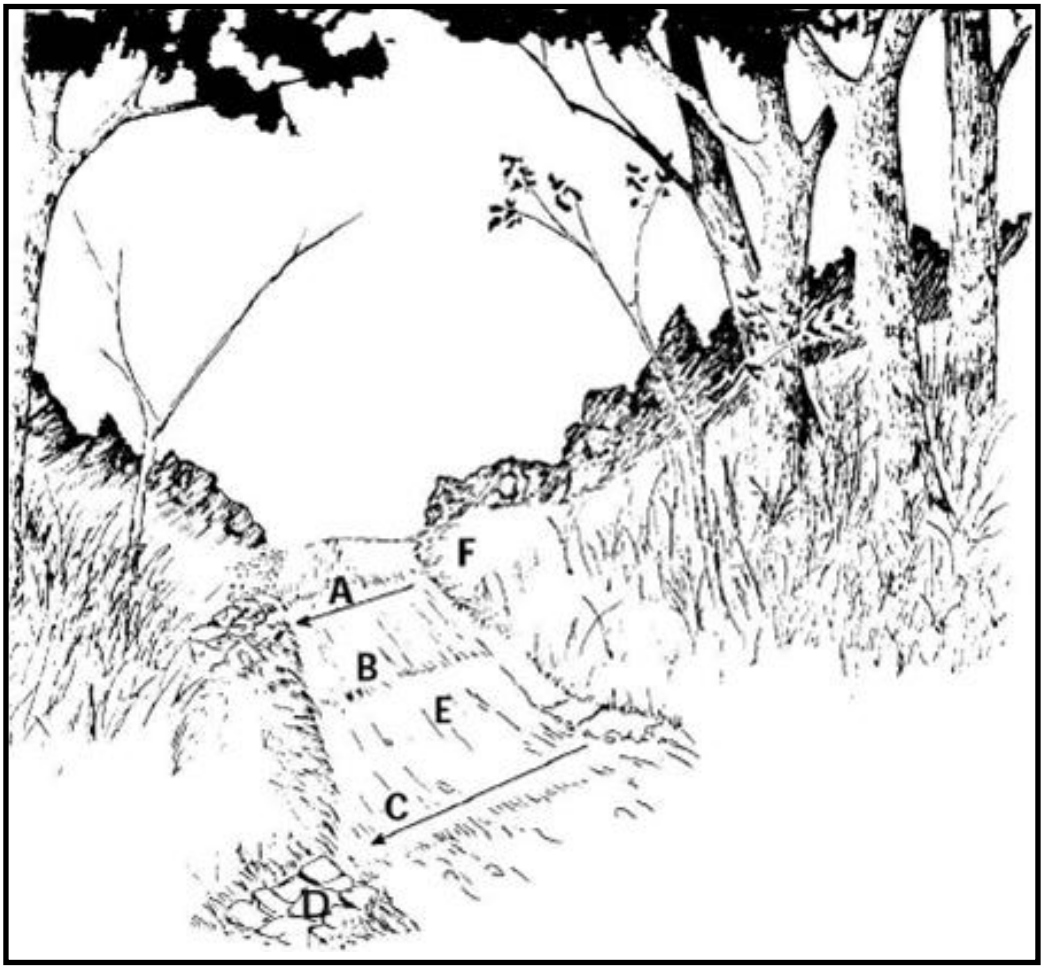
Road Use & Maintenance

Recommended Best Management Practices:

- Inspect stream crossings, culverts, ditches, and bridges regularly to **remove debris and to prevent blockage**. Clogged water control structures create a serious erosion hazard, causing the water to cut around or through the structure.
- **Install waterbars, broad-based dips**, and other water control structures to moderate the flow of water on the road.
- **Install temporary erosion control structures** on roads during expected heavy rain events or during extended periods of harvesting inactivity.
- **Forest roads and skid trails** that are no longer useful should be closed.
    - Clear away stream crossings, restore original stream contours, and stabilize approaches and stream banks.
    - All exposed soil should be seeded and mulched with the appropriate seed mix (see Seeding and Mulching, and Table 3).

Things To Avoid:

- **Using forest roads when they are wet**, soft, and easily damaged.



Legend:
A – Waterbar at the top of the grade.
A, B, C – Waterbars spaced properly at the recommended distances.
C – Waterbars located at a 30 degree angle downslope.
D – Stone riprap at diversion outlets.
E – Road is out-sloped and follows the contour.
F – Cut banks are seeded as necessary.

Seeding and Mulching

Seeding forest roads, landings, and other exposed soil provides vegetation that reduces the impact of raindrops and forms roots to bind the soil and hold it in place. Seeding is also a way to improve the absorbency of forest soils. Make sure seed comes in contact with the soil.

Mulching with straw, woodchips, bark, or synthetic netting also helps retain soil and moisture for the growth of grasses and other plants. Hay mulch may contain its own seeds, but it may also contain the seeds of invasive noxious weeds – be sure of the source before spreading. Mulch can be used without seeding if only natural vegetation is desired. In these cases, wood chips or bark mulch can help protect the soil for weeks or months after logging is completed.

Recommended Best Management Practices:

- **Inspect completed harvest areas** to look for exposed erosion-prone soils. Mark areas where seeding and/or mulching is needed with flagging. Areas that usually need treatment include:
  - Landings and approaches to landings
  - Main skid trails
  - Temporary roads and roads that will no longer be used
  - Stream crossings
- **Seeding and mulching should be done** as soon as equipment moves out.
- **Seeding can attract wildlife**, serving double duty as food plots.
- A **professional forester** can visit the site and help identify areas that should be seeded.
- If the site has been harvested in the winter, **apply a layer of mulch** to provide some protection to the soil until seed can germinate.
- **Chose a good seed mixture** (*see Table 3*). Seeds should consist of native or non-invasive plants. The mixture should have fast-germinating seeds for quick protection and slower-germinating seeds that will take over and stabilize the site for years to come.
- **Consult with the County Soil and Water Conservation District** for information on conservation seeding and special hydro-seeding equipment they may have available for loan.

Things To Avoid:

- **Spreading invasive noxious weeds** such as Sericea lespedeza, Kudzu, and Crown Vetch when seeding and mulching exposed soil.

Table 3. Seeding Rates (pounds pure live seed per acre [PLS/ac] - single species) and Species Suitability for Skid Trails, Landings and Road Seeding

Species	Conservation Cover (PLS/ac)	Erosion Control (PLS/ac)	Wildlife Habitat 3 (PLS/ac)	Seeding Dates Spring (PLS/ac)	Seeding Dates Fall (PLS/ac)
Cool Season Legumes:					
Ladino Clover	3.0	6.0	2.25	Mar 01-May 31	Aug 01- Oct 15
Red Clover	6.1	12.2	4.6	Mar 01-May 31	Aug 01- Oct 15
Alfalfa	7.5	15.0	5.6	Mar 01-May 31	Aug 01- Oct 15
Warm Season Legumes:					
Common Lespedeza 1	7.5	15.0	5.6	Mar 01-Jun 30	N/A
Illinois Bundleflower	14.5	29.0	10.9	Mar 01-Jun 30	N/A
Partridge Pea 2	26.8	53.6	20.1	Mar 01-Jun 30	N/A
Roundhead Bushclover	6.3	12.6	4.7	Mar 01-Jun 30	N/A
Showy Ticktrefoil	10.0	20.0	7.5	Mar 01-Jun 30	N/A

Species	Conservation Cover (PLS/ac)	Erosion Control (PLS/ac)	Wildlife Habitat 3 (PLS/ac)	Seeding Dates Spring (PLS/ac)	Seeding Dates Fall (PLS/ac)
Cool Season Grasses:					
Canada Wildrye	15.3	30.6	11.5	Mar 01-May 31	Aug 01- Oct 15
Virginia Wildrye 2	15.0	30.0	11.2	Mar 01-May 31	Aug 01- Oct 15
Kentucky Bluegrass	2.2	4.4	1.7	Mar 01-May 31	Aug 01- Oct 15
Orchardgrass	4.2	8.4	3.2	Mar 01-May 31	Aug 01- Oct 15
Redtop	1.7	3.4	1.3	Mar 01-May 31	Aug 01- Oct 15
Timothy	3.1	6.2	2.3	Mar 01-May 31	Aug 01- Oct 15
Warm Season Grasses:					
Big Bluestem 2	8.0	16.0	6.0	Mar 01-Jun 30	N/A
Composite Dropseed	2.3	4.6	1.7	Mar 01-Jun 30	N/A
Eastern Gamagrass 2	8.0	16.0	6.0	Mar 01-Jun 30	N/A
Indiangrass 2	7.8	15.6	5.9	Mar 01-Jun 30	N/A
Little Bluestem 2	6.4	12.8	4.8	Mar 01-Jun 30	N/A
Sideoats Grama 2	7.5	15.0	5.6	Mar 01-Jun 30	N/A
Switchgrass 2	4.7	9.4	3.5	Mar 01-Jun 30	N/A
Warm Season Forbs:					
Grayhead Coneflower	3.6	7.2	2.7	Mar 01-Jun 30	N/A
Pale Purple Coneflower	16.4	32.8	12.3	Mar 01-Jun 30	N/A
Ox-eye Falsesunflower	11.3	22.6	8.5	Mar 01-Jun 30	N/A
Wild Berganot	1.4	2.8	1.0	Mar 01-Jun 30	N/A

[1] Annual species - plant early in the growing season to allow seed-set to occur.
[2] Use locally adapted cultivars or ecotypes of these native species where possible.
[3] Use these rates on non-erosive sites.

For mixtures: Use the single species seeding rates from *Table 3* for the appropriate site use multiplied by the desired seeding mixture percentages to determine the seeding rate per species. Final seeding rate for the mixture will equal each adjusted seeding rate added together. For seeding Canada wildrye and Timothy as a conservation cover with each species making up 50 percent of the mix, the formula would be:

Example:

15.3 PLS pounds/acre X 50% = 7.6 pounds/acre seeding rate (Canada wildrye)
3.1 PLS pounds/acre X 50% = 1.5 pounds/acre seeding rate (Timothy)
Total PLS for seeding mixture = 7.6 lbs Canada wildrye+ 1.5 lbs timothy = 8.1 lbs/acre total seeding rate.

Installing Waterbars

Waterbars are a combination of a mound and trench angling across skid trails and roads. The purpose is to intercept, divert, and disperse water off exposed soil onto the forest floor where it will be filtered and soak into the soil without causing erosion and sedimentation. Waterbars form a significant, almost impassible bump and should be used only where machinery will no longer travel. Continued use will ruin waterbars. If the forest owner wishes to continue use of the road for recreation or cutting firewood, broad-based dips can be substituted for waterbars.

Recommended Best Management Practices:

- Waterbars are generally **built at a 30 degree angle** (*see Figure 4*). The distance between waterbars will vary from every 250 feet on gently sloping trails to every 40 feet (or less) on steep trails (*see Table 4*).

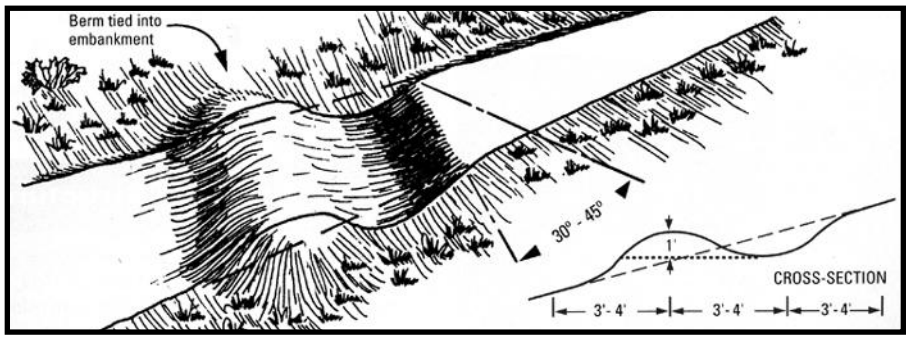


Figure 4. Waterbar Design
(from Wisconsin's Forestry Best Management Practices for Water Quality, 1995)

Table 4. Spacing Between Water Bars

Road Grade (% slope)	Approximate Distance Needed Between Water Bars (Feet)
1	400
2	245
5	125
10	78
15	58
20	47
25	40
30	35
35	32
40	29

- The **height of waterbars** will vary from 8 to 30 inches; lower on gentle slopes, higher on steeper slopes.
- The **bottom edge of a waterbar** should be open to allow water to freely flow out into the leaf layer on the forest floor where it will be filtered and soak into the soil.

Things To Avoid:

- **Building waterbars without placing them on a 30 degree angle.** Water will dam up and cut through waterbars that don't drain out a lower end.
- **Driving vehicles or equipment over** waterbars once they have been built.
- **Building waterbars with blockages** (such as stumps or logging debris) that prevent drainage.

Forested Wetland Road Construction (A Special Case)

Roads built for forest management in land described as 'Wetland' under federal rules of Section 404 of the Clean Water Act are a special case. If the intended use is only for forest management, the construction and use are exempt from the permit requirements. To qualify, construction must comply with the following recommended best management practices.

Recommended Best Management Practices:

Federally Required BMPs

1. Roads and skid trails in waters of the United States must be the minimum number possible. The width and length must match with the forest management need and local conditions.
2. All roads must be located far enough from streams or water (except where water <u>must</u> be crossed) to minimize the amount of material put into the waters.
3. The road must be designed to prevent the restriction of normal flows.
4. The fill must be stabilized and maintained to prevent erosion during and after construction.
5. Use of trucks, tractors, and other heavy equipment in water and adjoining wetlands must be minimized.
6. Disturbance of natural plant life in water and wetlands must be minimized.
7. The construction and maintenance of the road must not prevent natural movement of aquatic wildlife living in the water or wetland, especially migration.
8. Borrow material must be taken from upland sources whenever possible.
9. Road construction and maintenance must not harm any threatened or endangered species listed under the Endangered Species Act, including destruction or damage to critical habitat for listed species.
10. Fill material in breeding and nesting areas for migratory waterfowl, fish spawning areas, and wetlands must be avoided if any practical choice exists.

11. The fill must not be located near a public water supply intake.
12. The fill must not occur in areas of high shellfish (native clams) habitat.
13. The fill must not occur in any part of the National Wild and Scenic River System.
14. Fill material must be suitable and free from poisons.
15. All temporary fills must be removed entirely and the area restored to its original elevation.

Below are interpretations of the 15 federally required BMPs above.

Forest Wetlands BMPs (interpretations)

- The height of roads on high ground should be less than 2 feet above the surrounding ground.
- Where a road crosses a stream, slough, swamp, or other wetland the fill should not be higher than the road at either end. Normally the road should be 2-3 feet above the ground, but it may be higher in low areas.
- Main roads at streams should be bridged or built with culverts large enough and numerous enough with permanent structures of a size and frequency to carry the expected flow of water. Where fords are used instead of bridges or culverts, they must have good rock bases to protect the stream bed.
- Soil must be stabilized around each structure where main roads cross seasonal or permanent streams with an average annual flow of 5 cubic feet per second or more. Structure stabilization is also required where rainwater runoff from the road can cause erosion and sedimentation.
- Where light-use roads cross seasonal or permanent streams, temporary bridges or culverts able to minimize interference with the flow of water should be used. When forest management use is completed, temporary bridges and culverts should be removed and the roads cross-ditched where needed to allow normal water flow.
- Get roadbed material from upland borrow pits whenever possible. The base of roads that cross sloughs or swamps may be logs, sand, or clay. Logs are preferred because they reduce the amount of fill required. Roads with only a sand or clay base gradually settle and must be built higher initially.
- Roads in swamps and river bottom areas may be constructed with fill from a ditch along the upper side of the road, and then capped with fill from an upland area.
- Continuous side ditches are preferred. They reduce the pooling of water on the upper side of the road if there are enough culverts to drain to the lower side.
- Ditch bottoms should follow surface contours and culverts should be located in the lower areas.
- Ditches should not be required to carry water for more than ¼ mile. They must also be separated from navigable water by vegetated filter strips.

Things To Avoid:

- **Using ditches to convert wetlands** into uplands.

Section 4 - Natural Disasters & Aesthetics

Natural Disasters

Natural disasters such as ice storms, floods, tornados, wildfires, or insects and disease create extreme conditions for which BMPs are not normally designed. Dead timber, especially pine, loses value very fast and salvage operations may need to be conducted quickly. Early response to these types of disasters is critical, but there is a tendency to overreact. Also, there are a few timber buyers who will take advantage of unknowing forest owners; consult a professional forester if in doubt. The responsibility of adjusting BMPs may rest on either the forest owner or the operator depending upon contract terms.

Casualty losses due to natural disasters can only be used for tax purposes if the original cost basis had been determined before the damage occurred. If the basis has been established, reasonable effort to salvage is required and the final lost value may be used for tax purposes. For detailed information on casualty losses and timber taxation, consult a professional forester and your accountant.

Recommended Best Management Practices:

- **Damaged wood should be salvaged** if at all possible. This may or may not fit with current management goals and strategies, and may require modifications to long term management plans.
- **Water quality protection measures** by use of Best management practices should still be followed.
- Forest owners are encouraged to **consult a professional forester or wildlife biologist** when natural disaster damages their forest. These resource professionals have the knowledge and experience to help with salvage and restoration efforts.
    - Many loggers do not carry insurance. Forest owners should protect themselves from liability with **clauses in a written Timber Sale Contract**, and get a written waiver signed by the logging crew supervisor.

Things To Avoid:

- **Cutting trees damaged from natural disasters** that are under stress (they can be very dangerous). Only trained professional loggers should attempt to cut damaged trees.

Aesthetics & Recreation Best Management Practices[1]

Introduction

The scenic and recreation features of our forests are often more valued than timber/woody biomass harvesting. Timber harvesting is unsightly to some and can be in conflict with other uses and values associated with our forests. However, harvesting is necessary to support the everyday items we use and take for granted. With thoughtful planning and careful conduct, the negative visual impact can be reduced. The practices and activities below can help protect the beauty and recreation values of Missouri's forests.

When considering a harvest, think about how it may impact the other values, such as lease hunting income, recreation, or selling the property. A property with every marketable tree cut is obviously less valuable to a potential lessee or buyer. Even if you have no intention to lease or sell, the view and your own uses of the land can be compromised by an unplanned harvest. It is important that you consider not just what occurs on your land, but what has happened or may happen on land nearby.

Other considerations include nearby homes, cultural resources, rare species of plants and animals, wetlands, or environmentally sensitive areas and areas of special scenic value. Aesthetics are subjective values and failure to recognize the concerns of others can result in hard feelings, even litigation. Scenic values should be considered when harvesting near parks and recreation areas, recreational trails, lakes, rivers and streams. Highways leading to scenic and recreational hotspots are highly visible to the public and a thoughtless harvest is likely to cause disatisfaction.

Harvesting can also improve scenes by opening up views of lakes, rock outcrops, and mountains in the distance. This can be done with normal harvest activities and minimal additional effort. When opening up views on large rivers and lakes, consider the view of people looking back from the water.

The goal is to buffer the visual impact of harvesting and other forest management activities, not hide it. In resource management, trade-offs must be evaluated. Not all values can be given highest priority. A successful harvest will accomplish most of the forest management goals while reducing the impact on scenery and recreation.

1 NOTE: Recommendations in this section may not match those in other sections. Recommendations here focus primarily on aesthetics and recreation, and in other sections the focus is most often water quality and soil conservation.

Recommended Best Management Practices:

Aesthetics should always be included in harvest plans. Listed below are some general harvest-planning practices that will help protect or improve the views and recreation values.

- In some cases it may be desirable to **open up panoramic views** to scenic attractions, like lakes and rivers, by removing trees or by pruning lower branches. In other cases it may be desirable to leave trees for a screen.
- In areas near roads and other places where harvesting may be visible to the public, **slash tops within 100 feet of the public roads** or visually sensitive areas so debris is within 3 feet or less from ground level.
- Try to **locate landings out of sight of the public**. Leave a forested buffer strip between the landing and public roads.
- Look for **colorful species and large trees** to leave for variation.
- Use terrain to **create a natural appearance** (*Figure 5*).
- **Shape cutting areas** to shorten line of sight, and minimize the area that can be seen from one viewpoint. Use group selection harvesting rather than regeneration cutting (clear cutting).
- **Leave scattered groups of trees** and clumps of woody vegetation in large cut areas.
- **Create visual screens** along roads and streams with irregular-shaped borders, uncut or partially cut buffer strips, and feathered forest edges (*Figure 6*).

Things To Avoid:

- **Creating abrupt changes** from harvested areas to forests.
- **Leaving safety hazards** near recreational use areas (snags, large dead limbs, etc.).

Figure 5. Design Cuts to Blend with the Terrain
(from the Woodland Owners' Guide to Oak Management, University of Minnesota Extension)

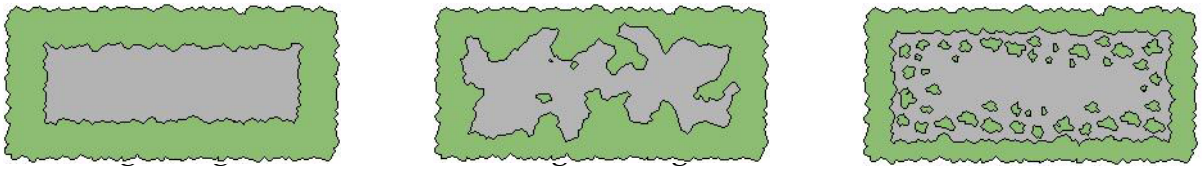


Figure 6. Irregular & Feathered Edges vs. Straight Edges
(from the Woodland Owners' Guide to Oak Management, University of Minnesota Extension)

Irregular or feathered edges are better than the straight edges of regeneration cuts (clear cuts). Harvesting should be done in a way that reduces erosion and protects the view. People object to piled slash, snapped trees, wasted logs, rutted roads, and exposed eroding soil. Well-planned and conducted harvesting will keep the landscape looking good.

Recommended Best Management Practices:

Screening:

- If the view from the road is not screened by a hill, high bank or other landform, maintain a 100-foot wide buffer strip.
- Cut lightly within the buffer strip. Maintain at least 1 of every 5 residual trees, including big ones. A distribution of sizes keeps a forest-like appearance along the road.

Cutting operations:

- Pick up oil cans, lunch wrappers, broken cable, other junk and litter. Keep the work area neat and clean.
- Use most of the merchantable wood from harvested trees.
- Pull down hung-up trees. Cut bent and broken trees so they are down and out of sight.
- Slash all tops within 100 feet of public roads so debris is 3 feet or less off the ground.
- No tops should be left in ditches, on road right-of-ways, or in streams or lakes.
- Cut stumps less than 12 inches high.

Equipment:

- Skidding should be done in a careful manner to protect residual trees.
- Try to use low-impact equipment and avoid erodible soils or steep areas, if possible.
- Excessively large equipment that will cause more damage should not be used in scenic areas.
- Summer harvesting is acceptable on well-drained soils but it may need to be temporarily halted during wet weather. Logging when soil is frozen will also minimize the risk of compaction.

Landings:

- Try to keep landings out of sight. Use landform and set them back in the woods as far as possible to block the view. A setback of 200 feet or more is usually enough distance.
- Dress up landings and access roads after you are done. Back-blade landings and haul roads so they are smooth, free of ruts, and mud holes. They look better and the exposed soil will quickly grow a green cover if reseeded properly.

Roads & Skid Trails:

- Logging road entrances to public roads can be built in ways to shield the harvest activity from public view. The exit approach can run at an angle until the last few feet where the road turns to exit straight for the big trucks (*Figure 7*).
- Entrances should be cleaned of debris, stumps, and logging slash during construction.
- Curve haul roads when possible; curved roads look better than a straight ones.
- Utilize butt offs and cull logs to avoid unpleasant aesthetics.
- Crown roads so water does not run down the road causing erosion. Use wing ditches to empty side ditches (*for wing ditch spacing see guidelines on waterbar spacing*).

- Re-grade and clean ditches along the roadside as needed.
- Cut trees so the tops land away from the road. This puts the slash further out of sight and reduces the need for lopping.
- Where needed, seed access roads, landings and ditches, especially where they come close to the highway.
- Skid trails should be well-spaced on contour, if possible, and lead away from highly visible areas.
- Close temporary roads.

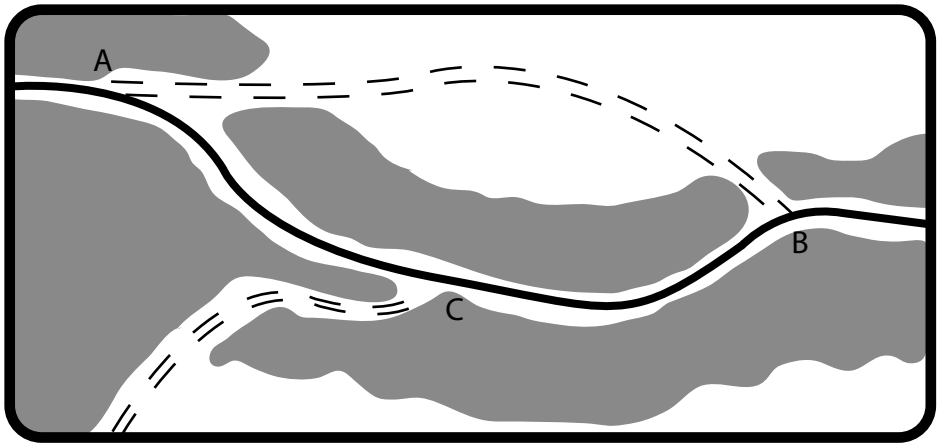


Figure 7. Logging Road Entrances
(Silviculture and Forest Aesthetics Handbook, Wisconsin DNR)

Legend:
A, B - The logging road entrances at "A" and "B" provide a direct view into the harvest area from the public road. They also present a safety hazard by joining the main road on curves.
C - The road entrance at "C" meets the main road at a 90-degree angle in a safe area but shields the view from the public road.

Things To Avoid:

- **Skidding to public roadsides** and utility lines.
- **Causing ruts** on roads and skid trails. Soil compaction can reduce site productivity for many years after logging, particularly on clay or silt soils. Moist soils are more prone to compaction than dry soils.

In order to reduce the "tunnel appearance" when using roadside screening corridors, the density of trees can be gradually reduced as you approach the road entrance. This will give a "feathered" appearance. Trees in this area will grow in diameter faster for the "big tree view". Irregular shaped screening borders will create the same effect. The sight distance will be increased and the "closed-in" feeling will be reduced (*see Figures 8 – 11*).

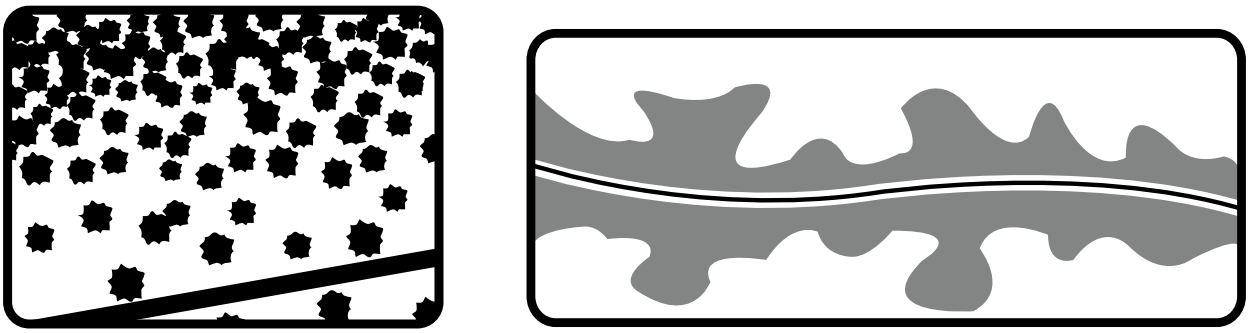


Figure 8. Visual Appearance Near Roads
(Silviculture and Forest Aesthetics Handbook, Wisconsin DNR)

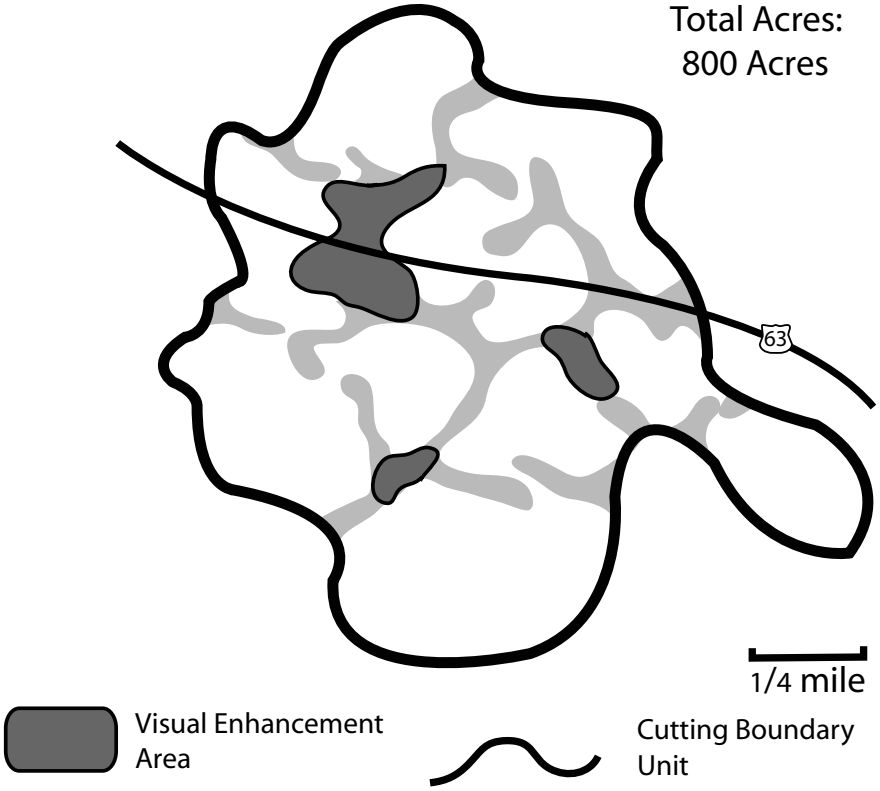


Figure 9. Screening Use Near Roads
(Silviculture and Forest Aesthetics Handbook, Wisconsin DNR)

An example of using screening to minimize sight lines into harvested areas.

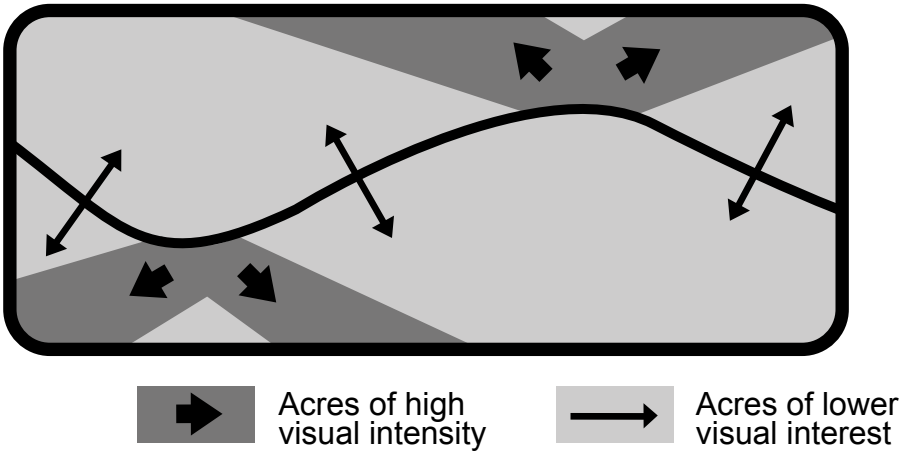


Figure 10. Visual Angles on Straight vs. Curved Road Sections
(Silviculture and Forest Aesthetics Handbook, Wisconsin DNR)

As a vehicle travels down a road, the driver tends to view objects off the end of a curve longer, and with greater intensity, than objects directly to the side.

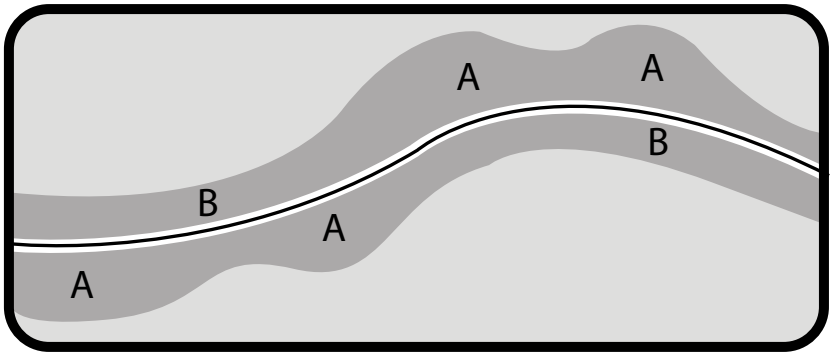


Figure 11. Varying Uncut Strip Width by Road View Angles
(Silviculture and Forest Aesthetics Handbook, Wisconsin DNR)

When leaving uncut strips along roads, additional width is needed in areas receiving the longest, most direct viewing (A) with less width needed in other areas (B) to have the same effect.

Logger's Field Guide

This guide is a summary of the most important parts of this manual for logging crew supervisors to take to the woods.

Starting the Job

A successful timber harvest begins with planning. Advanced planning will result in satisfied landowners, foresters, and the public. Do not just show up and start working - plan ahead!

Landings - Locate all the **landings** *before* starting the job.

- Use old existing landings when possible.
- Always try to avoid putting landings in view of public areas and residences.
- Use landings as hubs to lay out the main skid trails and link them together with haul roads.
- Locate landings at least 200 feet from Streamside Management Zones (SMZs), sinkholes, caves, springs, and wetlands.
- More small landings are better than a few large ones.

Skid Trails - Layout the **main skid trails** with flagging before cutting the first tree.

- Use marked trees or trees you know will be harvested for bumper trees. Other trees that make good bumper trees are trees that are deformed or defective, and species that are not as commercially important as oaks, such as elm, gum, and hickory.
- Point out problem trees that are not marked to the forester or owner before damaging them.
- Avoid crossing streams.
    - If crossing a stream is unavoidable, try to cross at narrow points where the bed is level and rocky.

Haul Roads - Once a road has ruts, you will have problems with it for the rest of the season. Shut down hauling for a day or two until things dry out - you can continue cutting and skidding to keep crews productive.

- Prepare the haul roads to drain water before starting the job. A road that drains well will keep you working more days.
- Access roads may be the first image a neighbor or the public sees associated with logging. People do not like to see root wads of trees pushed out of the ground or a lot of exposed dirt. Expose as little dirt as possible.
- If new roads need to be built, it is even more important to make sure they drain because they have not had traffic over the years to pack the soil.
- Cross streams only as needed at narrow points and at a 90 degree angle. Locate crossings where stream banks are low, rocky and level.
- Drain water carrying sediment off roads and into leaves where it will be filtered and soak into the soil, protecting water quality.

- Do not use soil for fill, either alone or in combination with slash, for stream crossings.
- Avoid road construction inside SMZs except where unavoidable to cross streams.
- Never locate a road in a streambed.

During the Harvest

What to Cut / What to Leave

- Leave a minimum of $^1/_3$ of the harvest residue (tops, branches, etc.) and $^1/_3$ of the typical size small trees cut on the site, distributed throughout the harvest area.
- Leave at least $^1/_3$ of the typical size trees in the SMZ in a fully stocked stand; ½ to $^2/_3$ is better.

Felling

- Always use directional felling to avoid trees that have been designated to be left for a future crop, dens, or just for looks. Directional felling is also necessary near fences, power lines, and other improvements.
- Fell trees to work with the skidder. Directional felling in a "herring bone" pattern will help the skidder operator avoid damaging leave trees.

Skidding

- Start skidding from the furthest point away from the landing first. This will allow you to build waterbars on the way out and place slash in between the waterbars.
- Cable logs out in the 25 feet of SMZs closest to the stream.
- Establish staging areas for equipment, fuel and oil at least 200 feet from SMZs, sinkholes, caves, or springs.
- Never allow oil, hydraulic fluid, gas, or other chemicals to soak into soil or enter water bodies. Maintaining equipment will prevent leaks and save money.
- Skidders should not cut ruts deeper than 6 inches into the soil, under normal circumstances, for a distance longer than twice the length the skidder. Ruts disrupt the natural flow of water across the surface and into the soil.
- Do not skid through wetlands.

Special Features (SMZs, Sinkholes, Caves, Springs, Wetlands) - Special Features such as SMZs, sinkholes, caves, springs, and wetlands all require buffer zones.

- All sinkholes require at least a 100-foot buffer zone around them, regardless of size.
    - *Unique Sinkholes* (see main manual) require at least a 200-foot buffer zone.
- Locate portable sawmills at least 200 feet from special features.
- Construct new landings at least 200 feet from SMZs, the rim of sinkholes, caves, springs, wetlands, and other water bodies. Always pile debris from clearing new landings on the downhill side.
- Stock pile any excavated material well away from Special Features.

- Divert runoff from haul roads, skid trails, and log landings so it does not drain directly into sinkholes, caves, or other special features. Utilize standard BMPs for SMZs when harvesting near streams and below springs.
- Never push soil, logging debris, or other waste material into a sinkhole or cave.

Bad Weather - Bad weather is going to happen. Planning and preparing ahead of time will keep you working more days, protect water quality, and improve the public image of logging.

- Prepare access roads to drain before getting started. The key idea is to get the water off the road as fast as possible. Crowned roads with side and wing ditches will dry a lot quicker than roads that are just pushed in flat in a hurry. 'Daylight' main haul roads to get more sunshine and wind on them.
- When bad weather comes, shut down the hauling first. If you haul rock on roads always use crushed rock instead of creek gravel. The points and edges on crushed rock make it work better. Creek gravel acts like marbles because it is round; dredging out of creeks also damages water quality along with fish habitat.

Closing Down

- Do not move the skidder from the harvest site until all the waterbars and other work requiring its use has been completed.
- Remove all trash.
- Use seed appropriate for the season on main skid trails, landings, and roads that will be closed.
- For jobs finished in the winter, use hay, straw, or bark mulch on areas most likely to erode.
- Waterbars are generally built at a 30 degree angle. The distance between waterbars will vary from every 250 feet on gently sloping trails to every 40 feet (or less) on steep trails.
    - The height of waterbars will also vary from 8 to 30 inches; lower on gentle slopes, higher on steeper slopes.
- Do not drive vehicles or equipment over waterbars once they have been built.
- Do not build waterbars with blockages, such as stumps or logging debris, that prevent drainage. Make sure the bottom edge is open to allow free flow into the leaves where it will be filtered and soak into the soil.
- In areas where harvesting may be visible to the public, slash tops within 100 feet of roads or visually sensitive areas to 3 feet or less of the ground. Most people will look over the slash rather than at it. This should be included in the bid specification and in the harvest/sale contract.

Glossary of Terms

Alluvium – Clay, silt, sand, and gravel deposited by a river or other running water. It is relatively young sediment—freshly eroded rock from hillsides that is carried by streams, continually pounded, and ground smaller as it moves downstream.

Basal Area – The measure, in square feet, of area occupied by wood in standing trees at a point four and one-half (4½) feet above the ground, expressed per acre, on any given forest stand. Basal area is used by professional foresters to gauge the stocking levels within forest stands (over-stocked, under-stocked, under-stocked with good growing trees, over-stocked with dying and declining trees, etc.).

Broad-Based Dip – A drainage structure designed to drain water off a dirt road while in use for vehicles maintaining normal haul speeds. Also called a rolling dip.

Buffer Strip – A barrier of permanent vegetation established or left undisturbed downslope from disturbed forest areas to filter out sediment from runoff before it reaches a watercourse. Buffer strips help stabilize streambanks, protect flood plains from flood damage and provide important fish and wildlife habitat.

Bumper Trees – Trees along skid trails that are used by the skidder driver to help guide a drag of logs up the hill toward the landing. These trees will be severely damaged. Trees used as bumper trees should be trees designated for harvest or inferior trees not intended or desired for future growth.

Contour – An imaginary line on the surface of the earth connecting points of the same elevation. A line drawn on a map connecting points of the same elevation.

Coarse Woody Debris – Tree tops, stumps, fallen trunks or limbs more than six-inches (6 inches) in diameter at the large end.

Crop Tree – A tree having a dominant or co-dominant crown and stem having good form and with little to no defects that would prevent the tree from reaching biological maturity. Crop trees are selected for special treatment due to certain virtues, usually with a future product in mind. Virtues include species, form, growth rate, potential future products, match to site growing conditions, etc.

Culvert – Either a metal or concrete pipe, or constructed box-type conduit, through which water is carried under roads.

DBH – The diameter of the stem of a tree measured at breast height (4.5 ft or 1.37 m) from the ground.

Ephemeral Stream – Water flows only during or immediately after rain. Channel not well defined.

Erosion – The process by which soil particles are detached and transported by water, wind, and gravity to some downslope or downstream point.

Evenage Management System (EAM) – A forest management strategy that results in stands of trees all nearly the same age.

Felling – The act of cutting down standing trees.

Fen – A peat-accumulating wetland that has received some drainage from surrounding mineral soils and usually supports marsh-like vegetation including sedges, rushes, shrubs and trees. NOTE: Fens are less acidic than bogs, and derive most of their water from groundwater rich in calcium and magnesium.

Fine Woody Debris – Leaves, twigs, tops, limbs and other woody debris less than six-inches in diameter at the large end.

Fords/Stream Crossings – A place in a stream or river that is shallow enough to be crossed by wading, on horseback, or in a wheeled vehicle.

Forester – 1) In Missouri, "… any individual who holds a Bachelor of Science degree in Forestry from a regionally accredited college or university with a minimum of two years of professional forest management experience …" as defined in Senate Bill 931, 2008. 2) In general, a professional engaged in practicing the science and art of forestry. Foresters may be credentialed by states or other certifying bodies, and may be licensed, certified, or registered. An example is the Society of American Foresters Certified Forester credential. The requirements for each credentialing program differ but usually include at least a baccalaureate degree in forestry and passing a comprehensive examination.

Forest Road – An access route for vehicles into forestland.

Glacial Till – A mixture of clay, silt, sand, mud, gravel, and boulders deposited by a glacier.

Harvesting – The felling, skidding, loading, and transporting of forest products such as sawlogs, stave logs, veneer, pulpwood, pine poles, posts, etc.

High Grading – The removal of the most commercially valuable trees (high-grade trees), often leaving a residual stand composed of trees of poor condition or species composition – NOTE: High grading may have both genetic implications and long-term economic or stand health implications.

Intermittent Stream – A watercourse when water flows in a well-defined channel non-periodically. Same as a wet-weather stream.

Invasive Exotic – Any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem; and whose introduction does or is likely to cause economic or environmental harm or harm to human health (from www.invasive.org). Examples of invasive exotics are kudzu, emerald ash borer, Japanese honeysuckle, euonymus, Asian long-horned beetle, tree-of-heaven, gypsy moth, Japanese beetle, garlic mustard, tall fescue, and zebra mussel.

Karst – Topography with sinkholes, caves, and underground drainage that is formed by dissolution of a layer or layers of soluble bedrock, usually limestone, dolomite, or gypsum.

Log/Woody Biomass Landing – Also called log deck, log yard, or bunching area. A place where logs or tree-length materials are assembled for loading and transport.

Logging Debris – The unused and generally unmarketable woody material such as large limbs, tops, cull logs and stumps, that remains after timber harvesting.

Landform – Literally the 'lay of the land' (i.e. terrain features such as hills, plains, bottomland).

Lopping – Cutting large branches on tree tops to reduce their visibility near roads and other areas where the public may find the view offensive.

Low Soil Fertility – Soils that are poor in nutrients, limiting the growth of trees.

Mast – Fruit, seeds, and nuts from trees that provide food for wildlife. Mast is further defined into soft mast, such as persimmon, and hard mast, such as acorns.

Mineral Soil – The portion of soil originating from rock that has eroded and broken down into small particles.

Mulch – Any loose soil covering of organic residues, such as grass, straw, or wood fibers that helps to check erosion and stabilize exposed soil.

NRCS – Natural Resources Conservation Service. Formerly known as the Soil Conservation Service. A federal agency in the United States Department of Agriculture.

Perennial Stream – A watercourse that flows throughout the year in a well-defined channel. Same as a live stream.

Pesticides – Chemicals that are used for the control of undesirable insects, disease, vegetation, animals, or other forms of life.

Regeneration – 1) The young tree crop replacing older trees removed by harvest or natural disaster. 2) The process of replacing old trees with young trees.

Regeneration Cutting – Any removal of trees intended to assist regeneration already present or to make regeneration possible.

Retirement Of Road – Preparing a road for a long period of non-use. Methods include mulching, seeding, rehabbing or installing waterbars, etc.

Riparian Management Zone – An area along the banks of streams and bodies of open water where extra precaution is necessary in carrying out forest practices to protect the streambank and water quality.

Rotation (Period) – The period of time required to establish a forest stand from seed or planted seedling, grow the trees to financial or biological maturity, harvest the crop, and prepare for the next stand.

Sawtimber (Tree) –Logs cut from trees with minimum diameter and length and with stem quality suitable for conversion to lumber. Hardwoods must be at least 11 inches DBH or larger to be considered sawtimber.

Silviculture – The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis.

Sinkhole – A sinkhole is a surface depression resulting from the solution of underlying carbonate bedrock and possibly the collapse into an underground cavern. Sinkholes shall have delineated protection zones when the sinkhole contains vegetation, natural communities, and/ or geological features distinguished from the surrounding area. (Definition from US Forest Service Mark Twain Forest Plan Implementation Guide)

Site Preparation – A forest activity to remove unwanted vegetation and other material, and to cultivate or prepare the soil for reforestation. Includes bulldozing, brush hogging and use of herbicides.

Skid – Moving logs or felled trees along the surface of the ground from the stump to the log landing.

Skidder – A large tractor like machine used to pull logs from the place where they were cut to the log landing/deck. Skidders have very large rubber tires with 4-wheel drive. They have a blade in the front used to push dirt and small trees out of the way. There are cable skidders and grapple skidders. Cable skidders require the driver to stop, get off the skidder, and set the cable around each log. Grapple skidders allow the driver to back up to each log and grab it. Good work can be done by both types of skidder if the driver is skilled, but grapple skidders generally do more damage.

Skid Trail – A temporary, heavily used pathway to drag felled trees or logs to a log landing.

Slash – Tree tops, branches, leaves and other tree parts left after a timber harvest.

Slope Percent – The grade of a hill expressed in terms of percent. A vertical rise of 10 feet and a horizontal distance of 100 feet equals a 10 percent slope.

Snag – 1) A standing dead tree from which the leaves and most of the branches have fallen. NOTE: For wildlife habitat purposes, a snag is sometimes regarded as being at least 10 inches in diameter at breast height and at least 6 feet tall; a hard snag is composed primarily of sound wood, generally merchantable; a soft snag is composed primarily of wood in advanced stages of decay and deterioration. 2) A standing section of the stem of a tree, broken off usually below the crown. 3) A sunken log or submerged stump or tree. 4) The projecting base of a broken or cut branch on a tree stem.

Streamside/Riparian Management Zone (SMZ) – An area along the banks of streams and bodies of open water where extra precaution is necessary in carrying out forest practices to protect the streambank and water quality.

Swallet – A place where water disappears underground in a karst region. Swallet is commonly used to describe the loss of water in a streambed.

Timber Stand Improvement (TSI) – A thinning made in immature stands to improve the composition, structure, condition, health and growth of remaining trees.

Ulitisol – The dominant 'red clay' soils in the southern US, often having a pH less than 5. The high acidity and low amounts of major nutrients, such as calcium and potassium, make them poorly suited for agriculture without the aid of fertilizer and lime. They can be easily exhausted, and require careful management, but can support productive forests.

Uneven-Age Management System (UAM) – A planned sequence of treatments designed to maintain and regenerate a stand with three or more age classes.

Waterbar – A hump or small dike-like drainage structure used to divert water in closing skid trails, retired roads, and fire lines.

Watershed – An area of land that drains rain and snowmelt into a stream or river. Size is relative to the use of the information. Size may range from a single creek draining only a few acres to a large river where water comes from many states, like the Mississippi River.

Water Turnout – The extension of an access road's drainage ditch into a vegetated area to provide for the dispersion and filtration of storm water runoff. Also called a wing ditch.

Wetland – 1) A transitional area between aquatic and terrestrial ecosystems that is inundated or saturated for periods long enough to produce hydric soils and support hydrophytic vegetation. 2) A seasonally flooded basin or flat. NOTE: The period of inundation is such that the land can usually be used for agricultural purposes.

Woody Biomass – "...small-diameter trees, branches, and the like (brush, tree tops) —that is generated as a result of timber-related activities in forests..." (United States Government Accountability Office).

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This information published to the web on May 23, 2001.
Toso Bozic
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Alberta Agriculture and Food

Timber Harvesting Guidelines New York State Department of Environmental Conservation, the New York Society of American Foresters, and the College of Environmental Science and Forestry.
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101 S. Webster Street . PO Box 7921 . Madison, Wisconsin 53707-7921
Wisconsin Department of Natural Resources
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