Management Recommendations for Forestry Practices on Wisconsin's Lake Superior Red Clay Plain

June 2007
PUB FR-387 2007

Acknowledgements

The development of this report was assisted by members of a voluntary steering committee. Jay Gallagher; DNR Forester, Nancy Larson; UW-Extension Basin Educator, Dennis Pratt; DNR Fisheries Biologist, Charly Ray; Living Forest Cooperative Forester, and Tom Fitz; Northland College Associate Professor of Geoscience are all thanked for their contributions. Information provided by these individuals from their various areas of expertise was critical in making this report as informative as possible.

Authors
Kristin Shy
Carmen Wagner
Department of Natural Resources, Division of Forestry
Cover photos: Carmen Wagner; DNR, Dennis Pratt; DNR, Albert Dickas; University of Wisconsin-Superior

PRINTED ON RECYCLED PAPER

Chapter 1 – Introduction

The red clay plain of Wisconsin's Lake Superior watershed has been the focus of research and debate for several decades. The high levels of erosion common to this area impact many aspects of life in the region, including the ability to sustainably manage forestland while protecting the water quality of Lake Superior and its tributaries. It is important to understand how forests in this area can be managed sustainably while preventing excessive runoff and erosion.

Forestry Best Management Practices (BMPs) for Water Quality are guidelines designed to protect lakes, rivers, and wetlands from nonpoint source pollution during forest management operations. These practices have proven to be very successful in protecting Wisconsin's waters from sediment and other pollutants that are generated from forest management activities. Forestry BMPs however, do not provide guidance specifically related to the highly erosive soils such as those in Lake Superior's red clay plain.

As people become more aware of the need to protect this landscape, it is important to recognize what steps can be taken to reduce excessive runoff and limit erosion and sedimentation during timber harvesting or other forest management activities. The information in this document is intended to provide *voluntary* guidelines for how to protect the red clay plain during forest management. Forestry BMPs are recommended to be used in addition to these practices.

Where Should These Management Recommendations Be Implemented?

The management recommendations within this document refer extensively to the "riparian area" and the "watershed". The recommendations are labeled to indicate whether they are intended to be implemented in the riparian area or the watershed.

The riparian area includes the water feature that transports water for at least a portion of the year and the area where the aquatic ecosystem transitions into the terrestrial ecosystem (1). The boundaries of a riparian area can be highly variable, but usually extend across part of the floodplain, up the slopes that drain the water, and along the water course at a variable width (1).

On a bigger scale, it is useful to consider the entire watershed. The riparian area is one component of the watershed, and it is important to understand that activities anywhere in the watershed can impact the riparian area.

A watershed can be described as an area of land, ranging from a few acres in size to hundreds of square miles, which is drained by a watercourse. A watershed is a network of surface streams, underground water flows, and other water bodies (Figure 1), that collect, store, and filter rain and snowmelt, recharge groundwater aquifers, and connect uplands and headwaters to riparian areas and wetlands. Headwater streams and ephemeral areas – areas that tend to be wet for only a portion of the year – exist at the top of a watershed and feed intermittent streams. Intermittent streams feed perennial streams and associated riparian areas farther down in the watershed (2).

The effect of management activities that occur in a watershed will be influenced by the size of that watershed, which as mentioned above, can vary from a few acres to hundreds of square miles. Not all management recommendations provided in this document will have the same impacts, depending on the size of a watershed, so it is important to keep the scale of your project and the size of the watershed in mind.

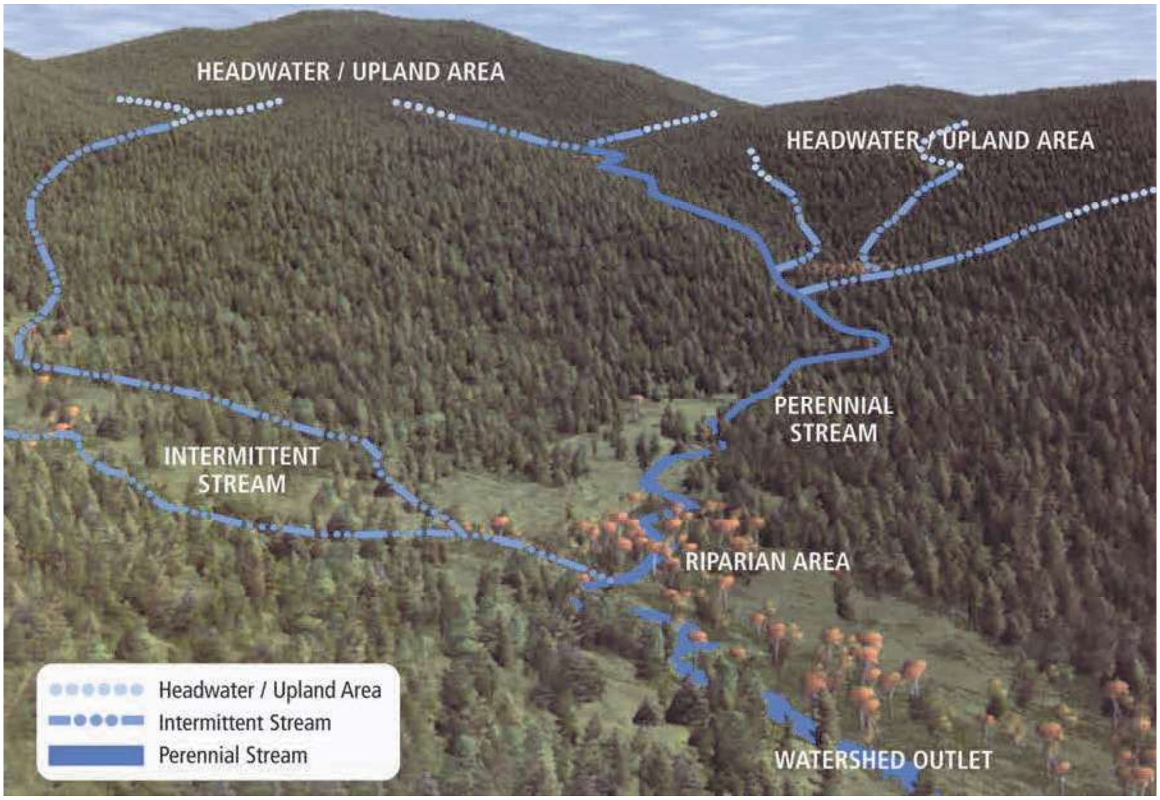

Figure 1. A watershed and its parts. Credit: Montana State University Extension Service (2).

It is important to realize that activities at the top of the watershed can generate problems that only get exacerbated as they move downstream and down the watershed. For example, sediment that enters a small headwater stream in the upland area of a watershed can be transported down the watershed and into perennial streams with one heavy rainstorm or during spring snowmelt. In other words, although forest management activities in the upland area of a watershed may seem disconnected and far away from a particular stream, those activities may have cumulative effects on the water quality of a stream much farther down in the watershed.

The riparian area, or the area adjacent to a particular stream, can be thought of as the last line of defense in protecting water quality. It can be extremely difficult to manage land on scales as large as entire watersheds, but it is important to understand that activities in a watershed can have far-reaching effects. The riparian area, if managed properly, may prevent runoff from reaching the stream and having detrimental impacts. In some cases, the volume and/or velocity of runoff may be too great, for example if channelization has occurred. If that occurs, the riparian area will only provide minimal protection to a particular stream. Most erosion and sedimentation occurs when high-powered runoff reaches the stream, and erodes the streambanks, delivering sediment directly to the stream channel.

Background on the Red Clay Plain of Wisconsin's Lake Superior Watershed

The red clay plain of Ashland, Bayfield, Douglas, and Iron counties comprises approximately 890,000 acres, or slightly less than half, of the 1,975,640 acres of Wisconsin's Lake Superior Basin (Figure 2) (3). Red clays, intermixed with sandy deposits are the predominant soils of this area (3, 4).

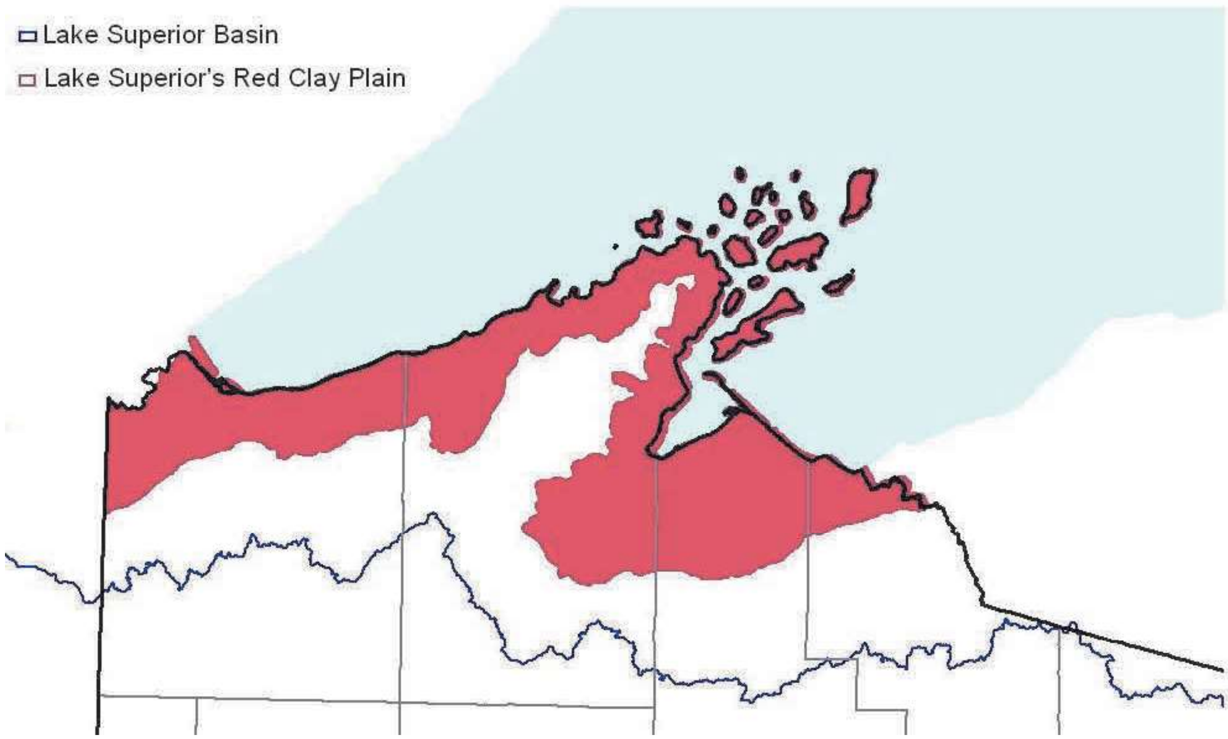

Figure 2. The red clay plain of Wisconsin's Lake Superior watershed.

The red clays have an extremely low infiltration rate (0.25 cm/hr) when compared to sandy soils (19 cm/hr) (4). The low infiltration rate, combined with the natural features and the human activities of this area, create a scenario where higher volumes and velocities of surface water flow overland. In addition, the mixture of the red clay layered with sand creates an unstable soil which may erode very easily, especially in the gullies and steep river valleys that are characteristic of the Lake Superior south shore area (3, 5).

It is important to keep in mind that some of the erosion occurring in this area is natural and not necessarily caused by human activities. This area has had glacial activity in recent geologic time and is therefore considered a young landscape. High levels of erosion are natural because this area is so young geologically (6). For example, eroding bluffs are natural features of this landscape, especially along the shoreline of Lake Superior (7). In that respect, it is important to understand that not all aspects of erosion can be controlled.

Vegetation plays a critical role in controlling runoff and stabilizing the soil, especially on steep slopes (3, 5). Although a portion of the erosion occurring in this area is natural, human activities, including agriculture and forestry practices, have increased the rates of runoff, erosion, and the resulting sedimentation. Because forestry operations can impact the vegetation composition greatly, it is important to recognize how different forestry practices affect the potential for runoff and erosion.

Historic Impacts to Streams in Wisconsin's Lake Superior Watershed

Logging during the late 1800s and early 1900s was very devastating to the landscape and to the streams of northern Wisconsin. Farming and the construction of extensive road networks also played a role in the degradation of streams. Understanding the impacts that these activities had on streams can provide insight as to what impacts current practices may have and what practices should be avoided in order to prevent erosion and protect water quality in northern Wisconsin streams.

Clearing of forests during the late 1800s and early 1900s, including the harvesting of stream-side forests, removed many of the benefits that those forests were providing to the landscape and to streams. Forests were no longer able to provide and regulate many of the factors critical to creating healthy aquatic ecosystems. One of the most detrimental effects of land clearing was that the loss of forest caused an increase in the volume and velocity of water running over the land. The increased surface water runoff caused extreme erosion, sedimentation, and peak flows, all of which had extremely negative impacts on streams.

Impacts to streams were exacerbated by the log drives that were used to transport the harvested wood. The logs themselves scoured stream banks and the channel bottom. Furthermore, splash dams were created which held water behind them to be released so that the flushing flows would carry the logs to the desired destination. The excessive volume of water increased channel width and depth and wiped out most of the in-stream habitat. Logs that existed naturally in the stream were removed to facilitate the log drives, which further increased water velocity and eliminated the habitat and spawning substrates fish, such as trout, need to survive (summarized from 8).

As logging continued, the number of rail and road grades increased as new methods for transporting goods, including timber. The railroad grades and road networks contributed to the degradation of streams because they simplified drainages and watersheds, further accelerating the speed of surface runoff. Fires also contributed to the problem. Much of the logging debris was burned which led to extensive fires that ravaged the landscape. These fires instantly removed the duff layer, the layer of fallen leaves and branches on the forest floor. The duff layer slows water, allows it to infiltrate, and protects the soil from erosion. Fires caused these benefits to be lost (summarized from 8).

After the cut-over period, many parcels of land were converted to agriculture. Agriculture prolonged the period that soils went without tree cover, which exacerbated the problems already caused by the destructive logging practices. Furthermore, agricultural land use exposed soil to rainstorms and snowmelt, increasing erosion and subsequent sedimentation to streams (9).

Overall, the clearing of the land through logging and farming, and the simplification of drainages from road and rail grades, increased the speed at which surface water moved across the landscape. This meant that with every large precipitation event or during snowmelt, a greater volume of water was reaching streams in much shorter amounts of time (8). The runoff moved faster because there was less vegetation and structure to intercept and resist the flow of water over the forest floor (10). As a result, streams had to carry much larger volumes of water traveling at much faster speeds. With the increased volume and velocity of water moving through the channel, streambanks eroded to accommodate the extra water. The sediment from those eroding streambanks buried or washed away gravel spawning sites, filled in deep refuge areas, and washed out large logs which were providing protection and cover for fish.

The health of streams in this area has improved since the time of intensive logging, farming, and road building in the early 1900s. There is an opportunity to build on those improvements and protect these valuable resources. Understanding the impacts that past activities had on streams provides insight about the impacts that may result from current land management practices. It is important that forest management activities today minimize harmful impacts and also work to restore previously degraded streams.

Considerations for Current Timber Harvesting Practices

Research done in the lake states suggests that timber harvesting can significantly increase streamflows because it reduces the amount of precipitation that is intercepted by trees, reduces evapotranspiration (use of soil water by trees), and accelerates the rate at which snow melts (6).

It is critical to consider scale when interpreting the degree of impacts that timber harvesting can have on streamflow. Studies have found that the overall impacts to streamflow were usually minimal because only a small percentage of the total watershed was typically harvested at any one time (11).

Research documented in the report "Erosion and Sedimentation in the Nemadji River Basin" suggests that timber harvesting should be managed so that no more than 40% of a watershed is in trees 0-15 years old. Areas with young forests, in general, tend to generate more runoff during rainstorms and melt faster during the spring snowmelt period than areas with mature forests. By following the 40% recommendation, peak flows from runoff and snowmelt should not be significantly higher than those from a mature forest (summarized from 6).

It can be quite difficult for a landowner or forester to accurately estimate how much timber harvesting is occurring over an entire watershed such as the Nemadji River Basin. It may be easier to consider hydrologic units or sub-watersheds. These are smaller components of the larger watershed and can be thought of as "areas of land draining to a common outlet". Following the 40% recommendation on a sub-watershed level makes it easier to implement and will also prevent impacts at a local level (summarized from 6).

Conclusion

The red clay plain of Wisconsin's Lake Superior watershed is a very unique and important area of Wisconsin. Forest management is an important component of life in this area. Forestry activities in the red clay plain can have major impacts on runoff, erosion, sedimentation, and ultimately the water quality of many streams tributary to Lake Superior. The management guidelines in this publication are intended to provide information on how to protect the landscape of the red clay plain and to protect water quality during timber harvesting operations. They are suggestions that can be taken into consideration when planning forest management activities in this area in order to minimize impacts to soils and water quality. These voluntary guidelines should be used in addition to Forestry BMPs for Water Quality to be as effective as possible.

Chapter 2 – Status of Water Quality in the Lake Superior Watershed

High rates of runoff, erosion, and sedimentation occurring in the red clay plain of the Lake Superior watershed are major water quality concerns. The south shore area contains more than 180 streams which flow north into Lake Superior. Many of these streams are cold water trout streams. The sediment entering these streams, which may eventually reach Lake Superior, has numerous detrimental effects, including:

- reduction of water quality,
- reduction of water clarity,
- reduction of storage capacity of reservoirs,
- destruction of fish spawning areas,
- trapping and storing of organic wastes, toxic materials, and nutrients,
- increase in water treatment costs for municipalities and industries, and
- reduction of recreational value (summarized from 3).

In addition, fine sediment is considered to be one of the most widespread pollutants to streams (12). Excess sediment in a stream constricts the natural flow of the channel. Over time this will lead to increased bank erosion as the stream tries to cut back to the original channel. The excess sediment may also increase the chances of flooding beyond the normal range (13).

As cited in the Bayfield Peninsula Stream Assessment,

> *"Past clearing of watersheds has left behind young forests with insufficient density of … detritus and a low density of upland, floodplain, and in-channel roughness elements. Current upland and riparian landuse practices, coupled with this lack of roughness, has led to increased stream power, incision of the channel bed, and subsequent lateral erosion" (p.2-3, 10).*

The Bayfield Peninsula Stream Assessment found that all watersheds studied were impacted by "excessive stream power" during "high flow events" (10). This high stream power in Bayfield peninsula streams is considered to be the result of "past and current land clearing and the young age of forests" (10).

The 2004 Lake Superior Lakewide Management Plan (LaMP) identified the St. Louis River (northeastern Minnesota/northwest Wisconsin) as an Area of Concern (AOC). One of the primary contaminants identified was suspended sediment. Stressors to the river include turbidity and sedimentation (14).

When examining erosion and sedimentation problems in the red clay plain of the Lake Superior Basin, sand and red clay are the two primary culprits. The cause and resulting impact varies with each sediment type.

Sand

In most areas of the red clay plain, the red clay overlies a layer of sand and glacial till. The sources of sand input in Lake Superior tributaries include bank erosion, poorly maintained roads and rill erosion (10). Sand can become a problem as gullies and ephemeral streams suffer head-cutting. Head-cutting occurs when the streambed and banks are undercut, collapse, and then wash downstream. With these head-cuts, the streambed and bank act as sources for sand downstream.

When sand is deposited in a stream, it reduces aquatic habitat by covering gravel spawning beds and filling deep holes. After large storm events, large “pulses” of sand can be observed moving slowly downstream, covering everything in its path.

Red Clay

The red clays contain approximately 2% extractable iron oxide which gives the clay its namesake color (5). A primary source of red clay sediment in Lake Superior streams is mass wasting along valley walls. Mass wasting occurs where streams meander against valley walls, eroding the stream bank and undermining toes of slopes. Groundwater discharge from seeps and springs in the valleys can also encourage mass wasting. Lenses of beach sand are intermixed with the red clay, which create subsurface flow patterns and slippage plains that further encourage slope failure or mass wasting. Lastly, the natural shrink/swell tendency of the red clay soil creates deep cracks during dry periods that allow rapid infiltration of runoff during rain events, leading to slope wall failure (15).

The turbidity caused by red clays seems to have little impact on aquatic life in streams. Oxygen levels in streams are not significantly affected by red clay and the number and diversity of macroinvertebrates in streams is not significantly affected by clay turbidity (10).

Sixteen communities along Lake Superior draw their drinking water from Lake Superior. In May 2001, the Ashland Water Utility issued a warning to residents instructing them to boil their water. The warning was associated with high turbidity levels. The turbidity was caused by red clays moving into Chequamegon Bay after heavy rains (16).

Photo credit: Albert Dickas, courtesy University of Wisconsin-Superior

Conclusion

The soils of the red clay plain are a mix of sand and clay. This combination of soil makes it susceptible to erosion, especially in the stream valleys where mass wasting may occur. The sand primarily affects aquatic habitat by simplifying the habitat within streams. The red clays cause streams to be very turbid, but with little impact on aquatic habitat. The clays can cause problems, however, for those communities that draw their drinking water from Lake Superior.

Whether one is focusing on aquatic habitat or drinking water, one of the primary concerns is to slow runoff. Both the increased velocity and volume of runoff, whether it results from road construction, agriculture or vegetation changes, exacerbate erosion in Lake Superior's red clay plain.

Chapter 3 - Forests Reduce Runoff and Sedimentation

Vegetation plays a critical role in stabilizing the soil and slowing runoff, especially on steep slopes (3, 5). Although a portion of the erosion in the Lake Superior south shore area is naturally occurring, the rates of runoff and erosion have increased due to human activities such as agriculture and forestry practices. One way forested areas in the red clay plain minimize erosion is by stabilizing the soil with their extensive root systems (5). When forests are harvested improperly or vast areas of land are cleared or in young forest, the soil is no longer stabilized and erosion and sedimentation can be greatly increased.

Forest canopies intercept precipitation and reduce the amount of water that reaches the forest floor, limiting surface runoff (8). Forest canopies also reduce the amount of snow that accumulates on the ground. Not only does the forest canopy hold snow, some of which evaporates before it even reaches the ground, the canopy also shades the ground causing the accumulated snow to melt more slowly. The reduced snow pack and the prolonged melting period help to delay the timing of snowmelt and reduce the peak flows of spring meltwater (8).

The duff layer, or the layer of fallen leaves and branches on the forest floor, also helps to reduce runoff (8). The duff layer protects the forest soil so that when raindrops fall, their impact is lessened and the soil is not moved by the force of the raindrop. In addition, the duff layer increases the biological activity on top of and within the top layers of soil, keeping the soil more porous (8). This allows for more water to percolate down into the ground as opposed to running overland (8).

Fallen trees and branches on the forest floor reduce runoff by creating a more variable surface. The presence of trees and branches increases the length of the path that runoff needs to take to reach a stream. This reduces the speed and quantity of runoff (8). In general, the vegetation, large woody debris (LWD), and duff layer that exist in the understory and on the forest floor create a variable surface which slows runoff and helps it to infiltrate into the soil as opposed to running overland. Fallen trees and branches that reach the stream also improve the physical structure of streams and create a more stable in-stream environment.

Forests in the red clay plain have changed significantly since the time of European settlement. For example, the Bayfield Peninsula coastline was once dominated by extensive forests of white pine and hemlock (10). The Nemadji River basin had several prominent forest types prior to European settlement: white pine with balsam fir, spruce, white cedar understories on the red clay soils; sugar maple-tamarack-yellow birch-white pine on non-red clay soils; and aspen-birch on disturbed sites (6).

Forests still dominate the clay plain, but the composition of those forests is much different today than it was prior to European settlement. Many forests now consist of young, even-aged stands due to clearcutting and the continued regeneration of aspen. One study concluded that restoring hydrologic regimes, reducing high flows, and controlling excessive stream power will depend on returning significant portions of riparian areas in the Lake Superior south shore area to forests similar to that of pre-European times (summarized from 10).

Chapter 5 – Protection of Headwater Streams

In any particular watershed, there are an extensive number of small streams and only a few large streams. The significant number of small streams represents the "maximum interface between terrestrial and aquatic systems" (12). In other words, the numerous small streams dotted across a watershed are associated with extensive amounts of land. These small headwater or ephemeral streams tend to be found in the upland area of a watershed, and are usually intermittent drainages, meaning they tend to be dry most of the year and only carry water after rainstorms or during spring snowmelt (13). Because these small streams are dry most of the year, they sometimes go unnoticed or unprotected during timber harvesting activities.

Most of the sediment that enters a stream system is brought to that stream from smaller streams that flow during rain events (12). Mismanagement of the riparian areas near headwater streams may cause sediment to enter those dry streambeds and during the next rain event, that sediment may be washed into the main stream channel. Hence, forest management guidelines must protect headwater streams so that they do not simply act as sediment transporters to the larger stream system.

Management Recommendations to Protect Headwater Streams

- Timber harvesting on land drained by small headwater streams must protect the integrity and function of these streams (12, 22).
- Timber harvesting practices on small headwater streams should follow management recommendations outlined in Chapter 4.
- To identify these streams, consider the following:
  - These streams often do not appear on 1:24,000 topographic maps, but must be protected to ensure their continued function when they do contain water (22).
  - This should include upland areas surrounding ephemeral headwater channels and terrace slope transition areas (10). Transition areas can be defined as areas where there is a gradual shift from deep-water offshore clay to shallow water beach deposits. These areas contain varying thicknesses of sandy or loamy deposits over heavier clayey or dense loamy till (6).
  - The best time to identify these water features is in spring after snowmelt, or after heavy rains (23).
  - Tree species such as black ash and black spruce or wetland plant species are indicators of these water features (24).
  - Once identified, mark these streams by flagging or painting nearby trees. Be sure that the forester or logger is aware of them before any harvesting takes place, so that proper measures can be taken to protect the streams (23).
- Manage the riparian area of headwater streams to promote the growth of native, large, older successional trees, if appropriate. This will create the opportunity for the natural accrual of large woody debris (12). Large woody debris on the forest floor will slow runoff in the upland area and prevent impacts further down the watershed.
  - Leave dead and down trees in the riparian area to avoid damaging the integrity of the streambank (25).