Criterion 4

Conservation and Maintenance of Soil and Water Resources

Criterion 4. Conservation and Maintenance of Soil and Water Resources

Soil Conservation

The emphasis in soil conservation is on maintaining site productivity and soil resource functions. Soil provides a reservoir of water for plants and streams between rainstorms, and is a storehouse of nutrients for plants and animals. It serves as an anchor for vegetation and is the seasonal or permanent home to a variety of burrowing animals, insects, and microscopic organisms. The organically enriched and biologically active portions of the soil reduce excess nutrients and transform pollutants, thus contributing to a healthy environment.

- **Soil erosion** occurs when the rate of soil loss from a site is greater than the rate of soil formation. Soil erosion from land clearing has had a significant impact in the Northern United States (Shands and Healy 1977).
- Timber harvest activities, road building, and lack of maintenance on roads and recreation trails are the most common contemporary sources of erosion in the Northern United States. Prescribed burns that create excessive ground temperatures and expose the root layer can also increase the potential for erosion. Management practices are widely available to minimize erosion from these activities.
- In the Northern United States, effects on soil organic matter content and nutrient stores are related to timber harvesting, land use history (i.e., fire, agriculture), acid deposition (acid precipitation and dry deposition), and soil erosion.
- Widespread reductions in productivity due to the cumulative effects of soil erosion, harvest, and acid deposition on nutrient cycles are not clearly demonstrated by empirical evidence to date (Hallett and Hornbeck 1997, Horsley and others 2000, Nuengsigkapian 1998). Localized effects on productivity are anticipated in the long term. For example, forest productivity may remain relatively unaffected on sites with large nutrient stores in the soil, while it may decrease on soils with inherently low nutrient stores.

Water Resources in the Northern United States

- Roughly 15 million acres in the Northern United States are water bodies and streams in permanent open water area (USDA NRCS 2001). There are approximately 960,000 acres of lakes and nearly 13,400 miles of fishable streams on national forests alone. Major river systems include the Mississippi, Hudson, Ohio, Illinois, Susquehanna, Delaware, Connecticut, and Missouri. The Great Lakes—Superior, Michigan, Huron, Erie, and Ontario—form much of the northern border of Northern United States. The Eastern States are bordered by Atlantic coastal bays and estuaries. Notable features include Chesapeake Bay, Delaware Bay, Long Island Sound, Massachusetts Bay, Casco Bay, and Penobscot Bay.
- In addition to surface waters, the region has extensive ground water resources. Bedrock aquifers are prevalent at varying depths throughout the Northern United States. Ancient sand lenses are a source of ground water in the Midwest and coastal plains. Aquifers in glacial deposits are common in the northern portions of the region.

Water Resource Quality

The challenge in protecting water resource quality in the Northern United States lies in targeting the actual causes of water quality degradation. Impacts on water resource quality may be the result of activities or natural disturbances that affect the land and vegetation of a watershed or aquifer recharge area. They may also be the result of activities, like point source pollution or over-fishing, that directly impact the physical or chemical nature of the water resource or the biota.

Water resource quality is often assessed on a watershed basis. Most watersheds encompass a mosaic of land uses, including forests. Many forests in the Northern United States are intermingled with farmland, pasture, and, increasingly, suburban development. Watersheds with a large proportion of forest land are generally associated with good water quality (Omernik and others 1981). Forests help sustain watershed functions (figure 18). Forty-one percent of the Northern United States is in forest cover (USDA Forest Service 1999a).

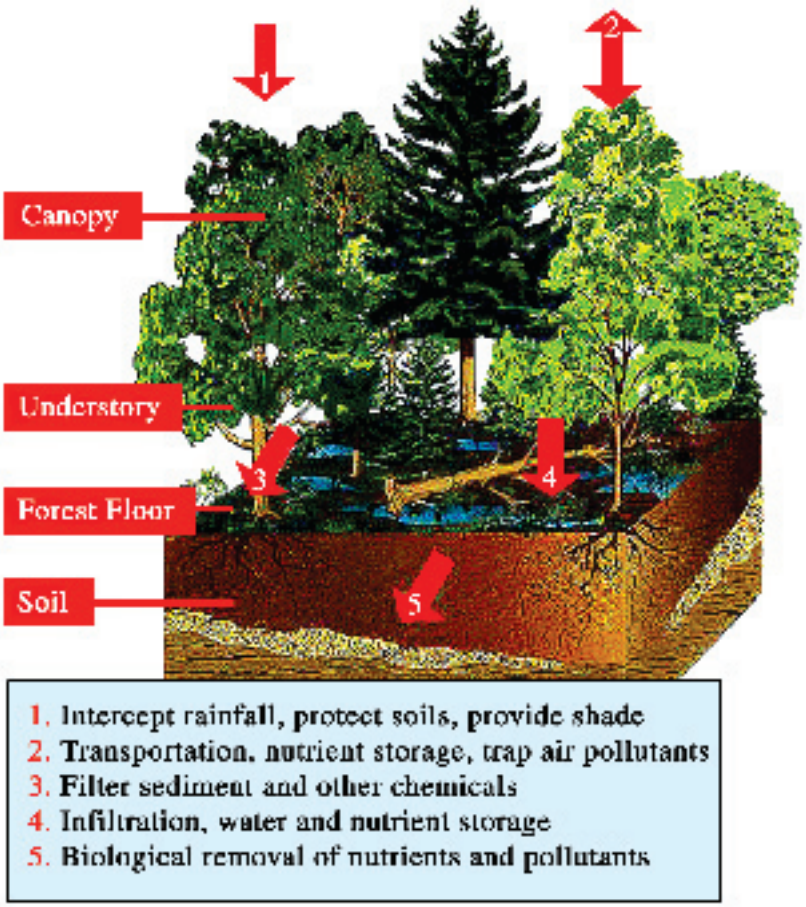

Figure 18. **Forest functions**. Physical, chemical, and biological processes in forests are key to sustaining water quality and supply, and watershed health.

- Preliminary data assembled by the U.S. Environmental Protection Agency indicate that surface waters supply nearly 4,000 water systems in the Northern United States, serving over 76 million people (table 9). Protection of surface and subsurface water quality for drinking water is an important benefit of forested watersheds.
- Sediment problems in many forest streams in the Northern United States do not reflect a response to current land use but are the result of erosion from land clearing and the use of rivers to transport logs a century or more ago (figure 19, Bassett 1987).
- Forest management operations have comparatively less impact on water quality than agriculture, urban development, and most other human land uses. A report by the Council

Table 9. **Surface water supply sources.** Forest land in the Northern United States helps protect surface water supplies for over 76 million people[1] (Source: U.S. Environmental Protection Agency).

Forest land ownership	Number of watersheds	Number of water systems	Population served
State and private	512	3,074	68,746,700
National Forests	86	925	7,750,000
Total	**598**	**3,999**	**76,496,700**

[1]Data include Virginia.

on Environmental Quality indicated that forest land accounted for only 5.2 percent of nonpoint source contributions of total suspended sediment nationwide in 1980 (figure 20).

Poorly planned forestry activities have the potential to degrade water resources, but impacts such as sedimentation from forest operations and increased water temperatures due to canopy removal can be eliminated or minimized with proper care.

- Agricultural runoff is a significant source of nonpoint source pollution that can be reduced by using streamside forests as buffers. Agricultural runoff includes herbicides, fungicides, insecticides, nitrate and phosphate components of fertilizer, and animal waste from agricultural land and operations. Ninety-five percent of the watersheds in the Northern United States show moderate to high levels of agricultural runoff.
- Since over three-quarters of the surface water supply systems in the Northern United States have the potential to be affected by State and private forest land stewardship, public and private forest landowners share the responsibility to protect drinking water. This is leading to some vital public-private partnerships.

Figure 19. Logging in New Hampshire's White Mountains in the early 1900's typifies the extensive harvesting that occurred across the Northern United States (USDA Forest Service photo).

- Over 350 private land trusts in the Northern United States have identified watershed and water quality protection as an objective of their efforts (Land Trust Alliance 1998). The USDA Forest Service's Forest Legacy Program enables States to purchase properties or conservation easements where forest lands provide high watershed values and are threatened by conversion to other land uses.

The New York City Department of Environmental Protection is implementing an aggressive effort to purchase forest lands and conservation easements in key areas to safeguard the drinking water supply to 9 million residents in the metropolitan area. It is working with the USDA Forest Service, State forestry agencies, other Federal, State, and county agencies, and private organizations to promote voluntary programs to protect water quality without compromising the economic viability of farming and forestry in the watersheds. The cost of this protection strategy is far less than the nearly $7 billion needed to construct filtration plants (National Research Council 2000).

Riparian Areas

Riparian ecosystems include soil, surface structure (woody debris, rocks, depressions), and plant and animal communities along lakes, streams, and wetlands. Because of their position in the landscape, riparian ecosystems interact with the flow of surface and ground water from upland areas and play an important role in filtering runoff, reducing excess nutrients, and transforming pollutants. They also provide food and cover for aquatic and terrestrial species. Species abundance and richness tend to be greater in riparian ecosystems than in adjacent uplands (Odum 1979).

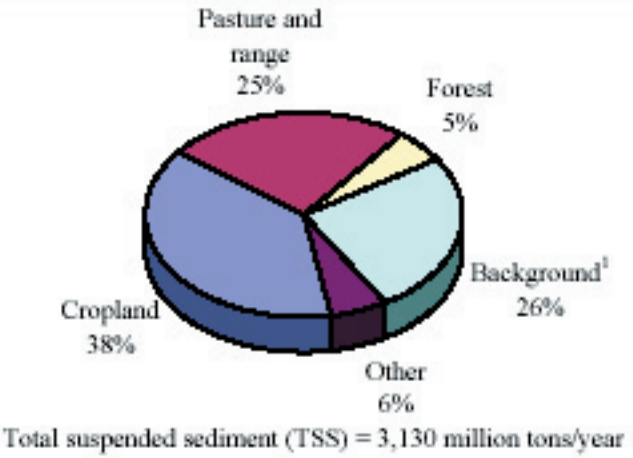

Figure 20. **Sources of suspended sediment.** Nationally, forest land contributed about 5 percent of the total suspended sediment from nonpoint sources in 1980 (Welsch 1991).

[1]Naturally occurring sediment in undisturbed landscapes.

- In the past, streamside forests in the Northern United States lined most rivers and streams, but deforestation associated with agricultural and urban expansion has drastically reduced their extent. In agricultural areas, many floodplain forests have been reduced to isolated fragments no longer capable of supplying rivers with essential woody debris or an adequate organic food supply for healthy fisheries.
- The loss of trees along streams in the Northern United States has resulted in increases in water temperature and decreases in in-stream woody debris critical to the successful maintenance of cold-water fish such as trout. The linkage between streamside forests and the health of fish stocks may stretch to ocean fisheries as well, where the natural process of delivering large quantities of wood from the watershed to the sea has essentially been severed (Maser and Sedell 1994).
- The presence or absence of trees adjacent to a stream channel may be the single most important factor affecting stream insects, an essential part of the food chain in aquatic systems. In the Northern United States, almost half of the watersheds have more than 56 percent of their stream miles in forested cover, while nearly a fifth have more than 89 percent (Jones and others 1997).

Restoring streamside and lakeside forests can help remove pollutants in runoff or reduce their effects, and can increase the biological diversity and productivity of aquatic communities by improving habitat and adding to the organic food base.

- The Federal Wild and Scenic Rivers and the American Heritage Rivers Programs offer opportunities to protect streamside forests and riparian functions. The Northern United States is home to 39 Wild and Scenic River segments covering 1,803 miles, and 9 nationally designated American Heritage Rivers (USDI National Park Service 2001, U.S. Environmental Protection Agency 2002).

Stream Hydrology

Forested watersheds are important for storing water, providing for its long-term release, and recharging ground water. They are the source of approximately 66 percent of the total national water yield. Land use and cover ultimately affect the hydrology of streams, lakes, and wetlands in a watershed. Forest land tends to have a moderating influence on peak flows compared to agricultural or developed land. Pavement and other impervious surfaces in developed areas cause rainfall to run off into streams and other water bodies more rapidly than under natural conditions (figure 21). In forested systems, rainfall is stored in surface depressions and infiltrates into the ground.

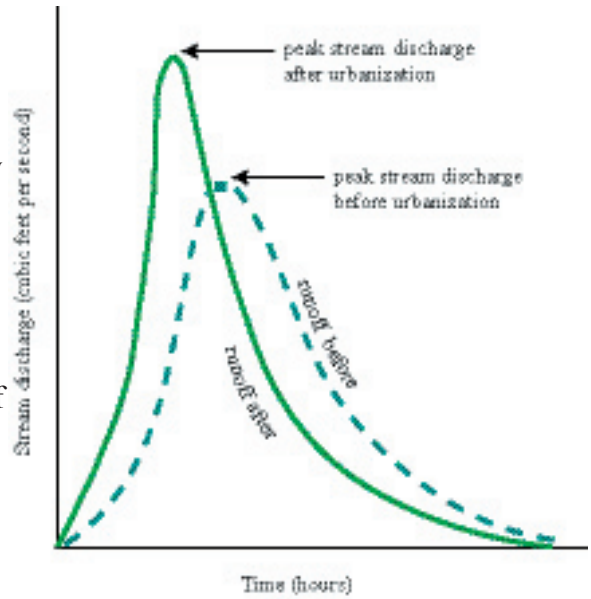

Figure 21. **Stream flow before and after urbanization.** Runoff enters a stream faster following urbanization, leading to higher peak stream discharge than in a natural system (Source: adapted from Federal Interagency Stream Restoration Working Group 1998).

- The natural hydrology and biological integrity of streams begins to degrade when just 10 percent of the watershed is covered by impervious surfaces (figure 22). Increases in surfaces such as roads, sidewalks, roofs, and compacted soils can increase runoff volume and rate, and decrease a stream's capacity to handle floods.

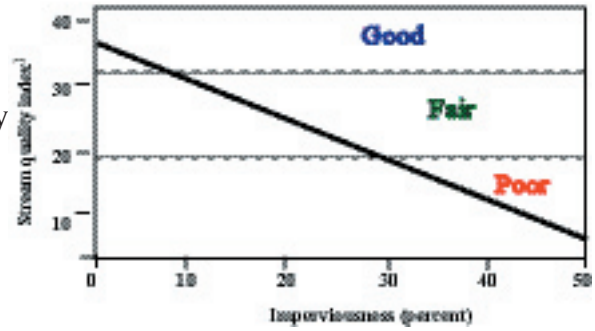

Figure 22. **Effects of imperviousness on stream quality index.** Streams show signs of degradation of natural hydrology and biotic integrity when watershed imperviousness reaches 10 percent (Schueler and Galli 1992).

[1]Values are based on a ratio of selected stream invertebrates reflecting different levels of water quality.

Wetlands

Wetlands provide a multitude of ecological, economic, and social benefits. They provide habitat for fish, wildlife, and a variety of plants.

They serve as nurseries for many saltwater and freshwater fish and shellfish of commercial and recreational importance. Wetlands are an important landscape feature because they hold and slowly release floodwater and snow melt, recharge ground water, act as filters to cleanse water of impurities, recycle nutrients, and provide wildlife viewing and recreation opportunities for millions of people. Conversely, because of their position in the landscape, pollution, drainage, urban development, and other activities that may not necessarily occur in wetlands can impair wetland functions.

- The Northern United States had an estimated 41 million acres of wetlands on non-Federal land and water areas in 1997, roughly half of that present in the late 1700's (Dahl 1990, USDA NRCS 2001). Forested wetlands comprise the largest segment of wetlands in the Northern United States (figure 23).
- Gross losses of palustrine (including forested) and estuarine wetland types in the Northern United States between 1992 and 1997 totaled 131,800 acres. Losses were reported for changes in land use to agriculture (33 percent), silviculture (18 percent), development (46 percent), and other (3 percent) (USDA NRCS 2001). Most silvicultural treatments of forested wetland types in the Northern United States do not result in long-term changes in a site's underlying hydrology. In these situations forests will usually regenerate after harvest and the wetlands character is retained.

Aquatic Biodiversity

The historical emphasis in water resource conservation has been to maintain the chemical characteristics in surface and ground water in order to meet specific human demands such as water for drinking, industrial cooling, irrigation, and recreational activities such as swimming. More recently, emphasis has been placed on the need to maintain the physical, chemical, and biological integrity of the Nation's waters. This emphasis includes maintaining both the resilience of aquatic ecosystems in the face of disturbance or stress and the stability of streambeds and streambanks.

- Of 642 watersheds across the Northern United States, a quarter of them had 5 or more known species at risk, almost half had between 2 and 5 species at risk, and a fifth had at least 1 species at risk. The status of 10 percent of the watersheds is currently unknown (U.S. Environmental Protection Agency 1997).
- Aquatic biodiversity is affected by factors such as pollution, the introduction of exotic and invasive species, changes in water temperature, bank erosion, sedimentation, and loss of woody debris or natural carbon and nutrient inputs from streamside vegetation.
- Exotic species can harm aquatic resources and their use. Exotic plants that threaten aquatic habitats include European frog-bit, hydrilla, fragmites, flowering rush, purple loosestrife, and water chestnut. Eurasian watermilfoil reduces populations of invertebrates and fish such as bluegill and largemouth bass. Exotic fish include popular species such as bass, brown trout, and rainbow trout, as well as carp, round goby, rudd, Eurasian ruffe, white perch, and sea lamprey. Hybridization of introduced fish species with native species has reduced genetic diversity. Exotic crustaceans include the rusty crayfish and the zebra mussel. Mute swans destroy wetland habitat and displace native wetland bird species.

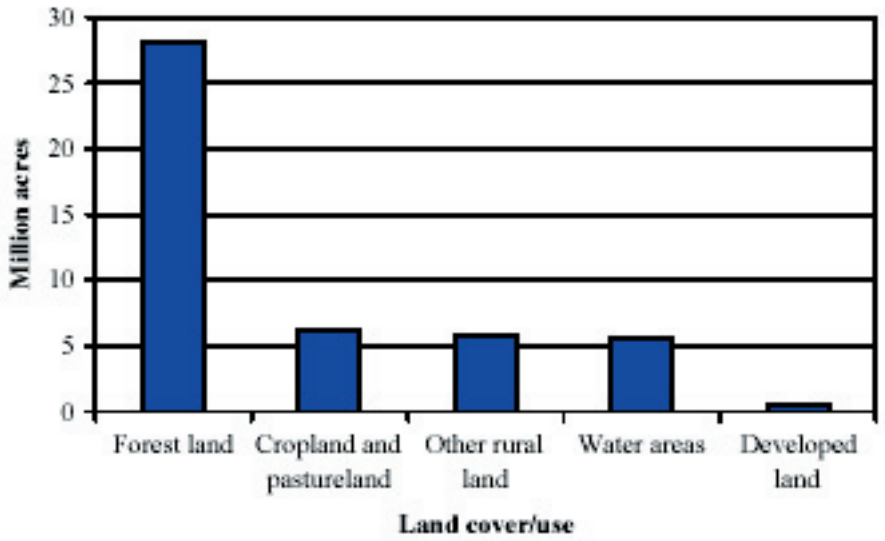

Figure 23. **Palustrine[1] and estuarine[2] wetlands on water areas and non-Federal land by land cover/use in the Northern United States, 1997**. Forested wetlands comprise the largest percentage of wetlands in the Northern United States (USDA NRCS 2001).

[1]Palustrine wetlands include all nontidal wetlands dominated by trees, shrubs, persistent emergent plants, or emergent mosses or lichens, as well as small, shallow open water ponds or potholes. They are often called swamps, marshes, potholes, bogs, or fens (Cowardin and others 1979).

[2]Estuarine wetlands are tidal wetlands that are usually semi-enclosed land but have open, partly obstructed or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land (Cowardin and others 1979).

Sustainable forest management can contribute to healthy aquatic ecosystems. Management actions include managing riparian vegetation adjacent to lakes and streams to ensure a continual source of large wood debris, restoring streamside forest diversity and health, managing riparian vegetation to discourage beaver habitation along important cold-water streams, managing roads to minimize sedimentation, reducing sediment input through stabilization and sediment traps, managing recreation pressure on aquatic systems, and restoring habitat.