Sediment Movement from Forest Road Systems

Roads: a major contributor to erosion and stream sedimentation

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Nonpoint source pollution is a major concern related to natural resource management throughout the United States. Undisturbed forest lands typically have minimal erosion, less than 0.13 ton/acre (0.30 ton/hectare), due to the increased cover and surface roughness found in these areas. However, disturbances caused by forest management practices can result in accelerated erosion losses and stream sedimentation. Forest management activities were identified by the Clean Water Act (CWA) of 1977 as source activities for nonpoint source pollution. Soil erosion and sedimentation resulting from forest operations remain a concern in forest management. Activities with the potential to have detrimental impacts on water quality due to soil erosion and sediment delivery to stream systems are road activities, harvesting, site preparation, fertilization and fire management.

Research conducted in various geographical areas clearly presents roads as a major contributor to erosion and stream sedimentation on forested lands. Roads alone can increase erosion rates and turbidity three orders of magnitude greater than the undisturbed forest condition. Concentrated flow, reduced infiltration, increased slopes, removal of surface cover and interception of subsurface flow are just a few factors that contribute to the increased erosion potential of forest roads. Each of these factors can contribute to increasing runoff energy to detach and transport sediment by increasing the volume and/or the velocity of storm runoff. Soil eroded from the forest road prism can be delivered directly to forest stream systems causing adverse impacts on the nation's water quality. However, exact numbers on sediment delivery are lacking because of the complexity in assessing this parameter.

Impact of forest road BMPs

Planning is perhaps the most important way to decrease erosion and sedimentation from forest roads. Based on what we know about the accelerated erosion potential of roads, minimizing road construction should be a major consideration in forest management. The planning process should consider all possible alternatives to road construction. Environmentally sensitive road designs are designs that plan for water quality by considering removing runoff from the road surface at a non-erosive velocity. Accomplishing this goal requires reducing the volume of runoff and/or slowing runoff to reduce erosive energy. Currently, forest road best management practices (BMPs) recommend the minimum number of drainage features required based on road design and gradients to minimize soil movement. Inclusion of drainage structure spacing as recommended by BMPs minimizes soil erosion by reducing the contributing area, which reduces volume requirements for individual drainage structures.

In the late 1950s, the forest floor was introduced as a filter of sediment-laden runoff from land-disturbing activities on forestlands. Increased infiltration rates, infiltration capacity and surface roughness exhibited by the forest floor greatly reduce the erosive energy of storm runoff. The forest floor provides a buffer zone (filter strip) to minimize sediment delivery to stream systems by providing a space between disturbances and water courses. Filter strip widths required to minimize impacts vary depending primarily on downslope gradient, soil erosive hazard and obstructions. However, there is a gap in the understanding of how factors influence sediment travel distances downslope and, more importantly, the influence of time on sediment travel distances. The bulk of work investigating sediment travel distances and minimum filter strip widths only considers short-term effects. Consequently, BMPs have been defined and developed based on the assumption

Typical sediment plume development downslope of a forest road turn-out section.

that the forest floor efficacy in filtering road runoff never diminishes.

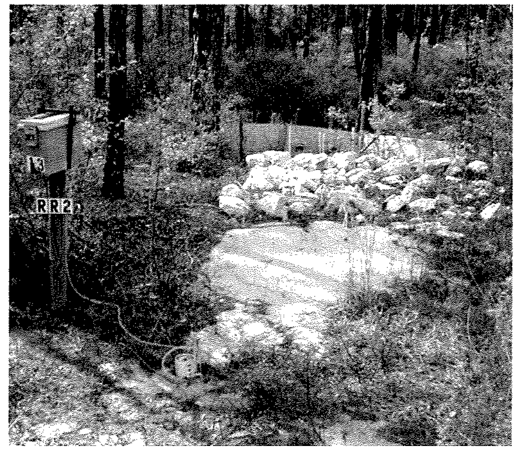
Forestry BMPs establish minimum filter strip widths to reduce soil erosion and sedimentation from roads. BMPs are effective in controlling soil erosion and non-point source pollution when properly implemented. However, most state forestry BMP programs recognize forest roads as perhaps the greatest threat to water quality on forested lands. In recent years, application of forest road BMPs to protect water quality has become a common forest management practice in response to the CWA. BMPs have the potential to reduce environmental impacts associated with forest roads, but it is a challenge to quantify the effect of BMPs on a watershed. Achieving the goal of maintaining or improving water quality flowing from forestlands requires additional information on how road BMPs aid in the cause. This information is required to make informed assessments on the adequacy of current forestry BMPs. In addition, controlling sediment export from the forest road prism and its eventual delivery to forest streams will likely require alternative BMPs to reduce the risk of environmental impacts.

Future directions

The filtering capacity of the forest floor likely decreases as increased sediment is deposited in the form of sediment plumes. Sediment plumes are deposition zones for road sediments and have greatly contrasting characteristics to those of the forest floor. Characteristics of sediment plumes are similar to those of the road system; consequently the energy reductions to storm runoff are greatly reduced from that of the undisturbed forest floor. Road runoff travels across sediment plumes farther into the forest stand before the forest floor can behave as a filter. In time, sediment plumes creep closer to the stream systems that filter strips protect, and sediment is delivered directly to the stream.

Perhaps the most effective manner to reduce the impact of road systems on water quality is increasing the detention time for road runoff, allowing soil particles time to drop out of suspension. The most commonly applied method to increase the detention time of runoff from forest roads is brush barriers. Brush barriers, consisting of wood debris removed during the construction process, can be strategically located in the flow path to slow runoff and reduce its erosive energy.

Alternative approaches to increase detention time of road runoff have shown effectiveness in reducing runoff concentrations. When utilized as primary control structures, alternative structures may likely trap road sediments before reaching the forest floor. Alternative structures, such as sediment basins, rock checks and vegetation buffers, may prove essential in extending the time required before sediments are delivered to streams. In a study conducted by the Southern Research Station Forest Operations Research unit in Auburn, Ala., sediment control structures have shown efficacy in reducing runoff concentrations of forest road runoff. Runoff concentration reductions from sediment basin, sediment fence, vegetation and rip-rap treatments ranged from 30 to 90 percent.



Example of sediment trapped by alternative sediment control technique (rip-rap) located in forest road turn-out section.

Sediment control structures have been utilized in urban stormwater systems and construction for many years. Detention ponds, for example, are common structures in most municipal stormwater systems and provide effective treatment of municipal runoff. Similarly, forest road designs could utilize sediment control structures on a smaller scale to provide cost effective treatment of forest road runoff, specifically in critical areas. Perhaps sediment control structures could be used as primary sediment control for road runoff in a manner consistent with that of urban systems and construction sites. The forest floor, established as an effective filter, could serve as emergency containment for road runoff in the event of a failure of sediment control structures.

Reducing the impact of forest road systems on soil erosion and water quality is a continuing process. Since the enactment of the CWA in 1977, road designs have evolved to consider environmental impacts as well as functionality. However, there is an extensive network of roads constructed prior to the enactment of the CWA in 1977. Many of these roads deliver or have the potential to deliver sediment directly to stream systems. With this in mind, two types of information are likely critical to further development of environmentally acceptable road systems: 1) factors influencing sediment travel distances downslope of forest roads and 2) determination of the portion of sediment leaving road systems actually delivered to downslope streams. Alternative approaches to control sediment transport, similar to those discussed in this article, perhaps hold the key to reducing the impact of forest road systems on downslope streams. R

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