Thinking about salmon, drinking water, forests and the future?

Think ....

When the Association brought watershed ecologist Rich Nawa to speak in Seaside, this past spring, he mentioned this article by Robert Ziemer as the best there is on steepland erosion. We hope you read it carefully in order to appreciate the importance of this issue. Robert Ziemer works for the Forest Service at the Pacific Southwest Forest & Range Experiment Station, Arcata, CA.

STEEPLAND EROSION

Steepland erosion is controlled most effectively, both in physical and economic terms, by preventive land-use practices rather than corrective action.

By Robert Ziemer

Steepland erosion is the result of complicated interactions between climate, soil, geology, topography, and vegetation. A change in any of these components may result in an adjustment of the driving or resisting forces and lead to increased or decreased erosion. process.

This paper describes how the interactions of climate, soil, geology, topography, and vegetation affect the management of steepland erosion. Three types of erosion are considered: surface, channel, and mass erosion.

In **surface erosion**, individual soil particles are removed by raindrops, thin film flow, and concentrated surface runoff in the form of sheet and rill erosion. Surface erosion is characterized by the lack of permanent channels. In undisturbed steepland forests, surface erosion is generally insignificant because infiltration rates usually exceed rainfall intensities.

Logging, road construction, wildfires, or mass erosion, however, can expose mineral soil where the naturally high porosity of forest soils may be severely reduced by raindrop impact and compaction by heavy equipment. Fire can also produce water repellency in steepland soils. If the resultant flow of water over these bare areas is not controlled, surface erosion may progress from sheet to rill to gully erosion as channels are formed.

Channel erosion is the detachment and movement of material from a gully or stream channel. The material may be individual particles derived from the channel skin, per se; or it may be sediment eroded by surface or mass erosion that was deposited in the channel, for example, when an undercut stream bank collapses into the channel

Land management activities influence channel erosion principally by placing erodible material in existing channels; by introducing large organic debris into small perennial channels; by increasing surface runoff from bare and compacted soils; by modifying the surface micro-drainage network by roads, tractor trails, and ditches; and by converting subsurface drainage to surface runoff (i.e., by intersecting subsurface flow with road cuts).

Creep is the slow downslope movement of the soil mantle where the long-term gravitational shear stress is large enough to produce permanent deformation, but too small to cause discrete failure. Creep is the most common and widespread mass erosion process in steeplands, but is the least understood and documented.

Although direct measurement of management-induced changes in creep rate may be nearly impossible, the quantity of material delivered to the numerous stream channels in the area can be large. For example, if timber cutting increased the average creep rate in a catchment from 3 to 10 mm/yr, the change would probably not be noticed even by detailed hillsope observation. But the quantity of soil added to stream channels would be trebled, and the change in sediment transport may be easily detected.

Earthflow can be considered accelerated creep where shear stress exceeds the strength of the soil mantle and results in discrete failures. The rate of movement of earthflows, as with creep, may be imperceptibly slow, but can exceed a metre per day.

Movement may be continuous, seasonal, or episodic. Like creep, deep-seated earthflows may be affected little by timber cutting or road building unless the distribution of mass or the water relationships within the slide changes substantially. The distribution of mass can be changed by excavations which undercut the toe of the earthflow, removing downslope support.

Road fill can add mass to the head of an earthflow, adding to the gravitational forces contributing to slope failure. Roads can also modify the water relations within the earthflow. Road cuts can intercept subsurface flow. If this water or surface road drainage is diverted away from the earthflow, the slide below the road may become more stable. If water is diverted onto the slide, dormant earthflows may be reactivated.

Timber cutting can also modify the internal water relations of the earthflow. Evapotranspiration by forests may deplete 50 to 75 cm of soil moisture per year.

There are interactions and feedback mechanisms between erosion types. In some cases, channel incision undercuts the toes of earthflows, upsetting the balance of forces on the hillslope. In other cases, aggradation with ac- companied increases in bank erosion undercut the toes of earthflows. In small steep streams, incision is more common than aggradation. while in large low-gradient streams the reverse is true. Accelerated earthflow erosion, in turn, can modify other types of erosion.

Debris avalanches are rapid, shallow hillslope failures generally found in shallow noncohesive soils on steep slopes where subsurface water becomes concentrated. Plant roots can reduce the frequency of these shallow failures. Roots can anchor through the soil mass into fractures in bedrock. They can also develop lateral support by crossing zones of weakness to more stable soil as well as providing long fibrous binders within a weak soil mass.

Although many studies have documented debris avalanche erosion following logging, **roads appear to increase the frequency of debris avalanche much more than does timber cutting**. In addition to profoundly affecting the soil water regime, road cuts can intersect and undercut the shallow failure surface, and road fills can add a substantial mass surcharge to the slope.

Debris torrents are the failure and rapid movement of water-saturated soil, rock, and organic debris in small, steep stream channels. Debris torrents might be considered a transitional link between debris avalanche mass erosion and channel erosion. They typically occur during periods of high rainfall and streamflow. They may be started by a debris avalanche which enters the channel or they may result from an initial failure of accumulated debris within the channel. Typically, as debris from the failure moves downslope, it traps large quantities of additional material obtained from the channel banks and bed. The resulting channel may be scoured to bedrock for a great distance.

Land management activites may increase the frequency of debris torrents by increasing the quantity of water delivered to a channel or by increasing the quantity of debris in a channel. Channel flow can be dramatically changed by roads intercepting subsurface flow, rerouting of small drainage networks, and the concentrating of surface runoff from compacted road or tractor trails. Material from accelerated hillslope erosion can increase the amount of debris accumulated in channels.

Road fills at stream crossings place a large mass of rock and soil in channels. It is common for road culverts in small steep stream channels to plug with soil and organic debris, resulting in saturation and failure of the road fill. Failure of road crossings is a principal cause of accelerated channel erosion and debris torrents in many forested steepland areas.

The key to successful management of erosion is the ability to:
1) **Identify** potentially erodible sites.
2) Correctly **assess** appropriate activities at those sites, and
3) Have a political/regulatory system that allows for the **exclusion** of hazardous sites from land treatment.

Where and how land management is conducted are the two primary considerations in efforts to reduce steepland erosion. The "how" consideration is often thought to be completed with planning. Although good planning is a major and necessary step in minimizing erosion, the carrying out of the plan is all too often underplayed. The on-the-ground operator is the key to success or failure of a plan. Commonly, little effort is expended to include operators in the planning process. In general, their skills have been developed through personal experience of what seems to work.

Unfortunately, what works best for dragging a log or constructing a stream crossing may not be best for managing erosion. An important part in managing steepland erosion is successful interactions between planners and operators. Success is often based as much on personalities as on technical abilities.

Many management rules approach prevention as though there was an equal probability of erosion occurring at any given location. It is becoming increasingly clear that most steepland erosion occurs in a limited number of areas and that most of the area produces only a small amount of erosion.

To effectively manage erosion in steeplands, it is more important to specify where land is to be treated than to be concerned with how much land is to be treated.

The key to successful management of erosion is the ability to 1) identify potentially erodible sites. 2) correctly assess appropriate activites on those sites, and 3) have a political/regulatory system that allows for the exclusion of hazardous sites from land treatment. In some cases, the most appropriate activity on a site may be no activity. The cost required to correct management-induced erosion is often far beyond the benefits obtained from the land management activity or the costs required to follow a more sensitive alternative plan.

Channel erosion and mass erosion are usually associated with rare storms. Guidelines tend to address the control of erosion on the basis of the "typical" event (storm). It is, however, normally the "unusual" event which produces the erosional characteristics that are generally considered to be "unacceptable". Efforts to control erosion from the typical runoff event could lead to more erosion during the large storm.

One common method to minimize road-related debris torrents is to install "oversized" culverts or to bridge the water-course. This method is often discounted because of its high initial expense. Construction costs are frequently viewed in the short term and fail to include subsequent costs of maintenance and replacement. If the accounting system included the total costs required during the design life of the project, many current construction practices would probably be changed.

Management activites can modify the stability of debris within the channel. The local gradient of a steepland channel, as well as its stability, is often controlled by bedrock. However, large woody debris, a natural component of forested steepland channels, can also control channel gradient. The residence time of large decay-resistant logs, such as large logs of Douglas-fir, may remain in a channel for several hundred years. When this organic debris decays, accumulated material is subject to channel erosion and, further, is available for rapid mobilization into a debris torrent.

If channel stability is controlled by the long-term supply of large organic debris, and large trees adjacent to channels are eliminated by continued forest management, active channel erosion may follow the decay of existing logs because new larger logs are no longer available for replacement. In **intermittent channels,** live roots from surrounding trees provide substantial strength and reinforcement to the channel bed. If these trees are cut, the strength of the debris composing the bed will progressively weaken as the roots decay. This condition may result in accelerated channel erosion or increased risk of a debris torrent.

Prudent management should identify the values at risk and direct erosion control activites toward processes most likely to affect those values. Steepland erosion is controlled most effectively, both in physical and economic terms, by preventive land-use practices rather than corrective action. Management of steepland erosion is merely the appropriate application of varying levels of care and caution when dealing with terrain of varying erosional sensitivity.

There is a great tendency to fix past mistakes. However, unless more effort is devoted to looking forward toward prevention rather than backward toward correction, we will continually be trying to catch up. The successful management of erosion is as much a philosophical and political problem as a technical one.