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Dynamics of Road-stream Connectivity: Key Controls, the Role of Wildfires, and Management Options

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Unpaved roads are often the largest anthropogenic sediment source in forested watersheds given their annual erosion rates of about 1 to as much as 10 kg m-2 yr-1. Most of the eroded sediment is sand-sized or smaller and easily transported, and the delivery of this material can adversely affect streams, coral reefs, other aquatic resources, and reservoir sedimentation. In general, the most cost-effective means to reduce these impacts is to decrease road-stream connectivity rather than trying to reduce road surface erosion. The objectives of this paper are to: 1) summarize the key controls on road-stream connectivity; 2) present a case study on how and why wildfires can greatly increase road-stream connectivity; and 3) discuss different management options for reducing road-stream connectivity.

The percent of road lengths or road segments directly connected to streams is strongly related to mean annual precipitation, as this affects both the stream density and the amount of road surface runoff. In forested areas unpaved roads are rarely connected when they are more than about 30 m from a stream, as the intervening buffers typically have a high infiltration capacity to capture the road runoff and a high roughness to slow the overland flow and trap sediment. In hilly areas burned at high or moderate severity the unpaved roads collect the surface runoff from upslope, which increases the amount of rilling, and the accumulated runoff is typically discharged at a single location. The discharge of this concentrated runoff at the road segment outlet causes downslope rilling or gullying, with little potential for the water and sediment to infiltrate or be captured given the greatly reduced downslope infiltration rate of less than 10 mm hr-1 and the near complete loss of surface roughness. Hence nearly all of the road segments were connected to a stream after burning, regardless of the distance to a stream

In unburned areas road-stream connectivity can be most efficiently reduced by draining the road surface runoff immediately before a stream crossing. Increasing the number of drainage points also will help as this reduces the amount of runoff from any given point and hence the downslope travel distance. In a relatively dry montane area we found that road decommissioning (ripping, or ripping and mulching) reduced road-stream connectivity from about 13% to just 3% as the ripping increased road surface infiltration and the furrows captured nearly all of the eroded sediment. Road-stream connectivity also can be reduced by outsloping the road to facilitate constant drainage as opposed to insloped or crowned roads with ditches and cross-drains. The problem is that outsloping is only effective when the road is correctly graded and wet weather traffic is excluded to prevent road surface rutting and the resultant preferential flow of water down the wheel tracks.