The Effectiveness of Surface Rehabilitation Treatments for Unpaved Forest Roads

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Abstract. Up to $1 million per year is being spent to reduce sediment production and delivery from unpaved roads on the Lassen National Forest in northeastern California. The purpose is to protect the remaining Chinook salmon habitat, but little is known about the effectiveness of the various treatments. In this study we measured the volumes of erosion features and assessed road-stream connectivity for 10 road surface treatments on 44 km of roads. The following treatments were considered in order of increasing cost and disturbance: 1) road closure, 2) installation of additional dips, 3) installation of additional cross drains, 4) rocking, 5) rocking and installation of additional dips, 6) rocking and installation of additional cross drains, 7) out-sloping, 8) rocking and out-sloping, 9) paving, and 10) road decommissioning. The measured erosion features included incised ditches, road surface rills, fill-slope rills, and drainage rills. Each drainage feature was followed to assess connectivity to the nearest stream. Erosion volumes and road sediment delivery were normalized by length to facilitate comparisons among treatments, but the data are inherently biased because of the tendency to implement the most intensive treatments on the worst roads with the highest road-stream connectivity.

The treatments with the greatest mean erosion volumes were 52 $m^3 km^{-1}$ for rocking and additional dip installation, 42 $m^3 km^{-1}$ for rocking and additional cross drain installation, and 35 $m^3 km^{-1}$ for additional cross drain installation. Decommissioned roads had estimated road erosion volumes of 20 $m^3 km^{-1}$, while the mean erosion volumes were progressively lower for roads with additional dips (14 $m^3 km^{-1}$), rocking and out-sloping (13 $m^3 km^{-1}$), rocking (8.0 $m^3 km^{-1}$), and closed roads (6.5 $m^3 km^{-1}$). Out-sloped and paved roads had no significant surface or drainage erosion features.

Decommissioned, paved and rocked roads had the highest road-stream connectivity with about 30% of the surveyed length connected to a channel. The high connectivity can be attributed to the tendency to implement these treatments on roads adjacent to streams. The combination of these data showed that rocked roads with additional cross drains had the highest estimated sediment delivery of 42 $m^3 km^{-1}$, followed by 14 $m^3 km^{-1}$ for roads with additional dips, and 9.6 $m^3 km^{-1}$ for roads with additional cross drains. The estimated sediment delivery for the other treatments was less than 7.0 $m^3 km^{-1}$. These results indicate that road design, particularly insloping, and road location are the two most important controls on estimated road sediment delivery. The highly skewed distributions of erosion and delivery volumes mean that most of the road-related sediment is coming from a few "bad" road sections or segments. Detailed road surveys are critical for identifying which roads should be treated, and which roads may need additional work to adequately protect fish habitat.