Inventory and Modeling the Impacts of Forest Roads in the Middle Fork of the Payette River, Idaho and the North Fork of the Siuslaw River, Oregon

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Forest roads have been shown to cause water quality impairment in many environments. The main impacts to water quality result from increases in fine sediment delivery increased mass wasting risk, stream channel diversions and changes in local hydrology. We used the Geomorphic Road Analysis and Inventory Package (GRAIP) to inventory and analyze forest roads in landscapes with different ranges of these risks. These studies illustrate different interactions of climate, geology and road management practices and show some of the risks and behavior posed by existing forest roads within watersheds listed as water quality impaired.

The Boise National Forest and Rocky Mountain Research Station were funded by the EPA to inventory the roads on public land within the Middle Fork of the Payette River over the course of three summers. Field data was collection on 583 miles of road in the 12 sixth field sub-watersheds. These sub-watersheds are located in managed coniferous forestland between 900 and 2,650 meters elevation within the erodible Idaho batholith.

Road sediment was monitored at 5 plots for two seasons to calibrate the road sediment production function. The total amount of fine sediment from mapped roads delivered to the Middle Fork Payette River and its tributaries was 1691 Mg/yr, or 20% of total production. The average GRAIP predicted sediment delivery rate from roads of 2 Mg/km^2 (5.5 ton/mi^2) although the values for sub-watershed range from zero to 5.3 Mg (0-15.0 ton/mi^2). The sediment delivery was modeled to be 10% of the natural background stream sediment mass as predicted by BOISED (Reinig et al. 1991), with a range from 0 to 22%. Road-stream hydrologic connectivity was calculated to be 113 miles (19% of all road length surveyed).

The public lands in the North Fork of the Siuslaw River of Oregon were inventoried in 2011 and found to contain 167 miles of mostly ridge top roads. This steep and wet coastal coniferous watershed has been managed for timber harvest with intensive harvest beginning in the 1960s.

Hydrologic connectivity was found to be a relatively low 4.7% of all road length at 12 km out of 266 km (8 mi out of 165 mi). The GRAIP model predicted 11.5 Mg/yr of delivered sediment to stream channels, which is 3% of the 456 Mg generated annually. This sediment was delivered through 203 of 5346 (3.8%) drain points. It was found that road surfaces that have been rilled and/or eroded are most likely to deliver sediment to streams. Specific sediment in some small catchments were as high as 1.5 Mg/km^2/yr, but ranged from 0.002 Mg/km^2/yr to 0.20 Mg/km^2/yr in 303(d) listed streams. There were 121 landslides observed by field crews in the course of the inventory, with a total volume of 19,030 m^3 (28,890 yd^3). Of those, 109 were road related. Calibrated stability index modeling with SINMAP showed that 16 km^2 (10 mi^2), or 7.8%, of the watershed area had a high risk of shallow landslide initiation by road drainage.

Watershed road inventory data can provide some useful insights into the complex interactions between road segments, drainpoints, hillslopes and streams that result in sediment delivery and non-point pollution. One of the most significant results from these extensive watershed surveys is the ability to examine the landscape drivers that underlie the impacts that roads present to water quality. We examine a suite of standard metrics available from GIS that may help produce predictive models of road risks to watersheds, while minimizing the need for extensive local calibration. In the 12 MF Payette sixth field sub-watersheds at the drainpoint scale the distance from ridge top, hillslope position, upslope contributing area, local hillslope under road, and a wetness index were the most promising predictors of fractional sediment delivery.