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Road Sediment Production and Delivery: Processes, Rates, and Possible Improvements

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Unpaved roads are increasingly recognized as one of the largest sources of anthropogenic sediment in forested areas. For nearly 20 years we have been studying road surface erosion and sediment delivery across widely varying environments in California, Colorado, and the Caribbean. The objectives of this paper are to: 1) compare road sediment production and delivery rates across different environments; 2) summarize the primary controls on road surface erosion and sediment delivery; 3) estimate the relative contribution of roads to watershed-scale sediment yields; and 4) suggest management practices to minimize road sediment production and delivery. In our studies segment-scale sediment production is measured with sediment fences, while detailed road surveys are used to assess road-stream connectivity and estimating the contribution of roads to watershed-scale sediment yields. Road-induced mass movements are not included here.

Our mean road sediment production rates range from 0.1 kg m^{-2} yr^{-1} in snow-dominated areas in California's Sierra Nevada to 3.5 kg m^{-2} yr^{-1} in Colorado and 7.4 kg m^{-2} yr^{-1} on St. John in the Caribbean. First-order controls on road sediment production are the amount and type of precipitation, road gradient, road surface area, and surface cover, although geology and soil type also can be important. Higher traffic levels can greatly increase road sediment production by reducing the amount of surface cover, increasing the supply of fine sediment, and increasing the propensity for rilling, particularly during wet weather. Applying gravel can reduce road sediment production by a factor of 2-8 times by largely eliminating rainsplash and reducing rilling. Grading will at least double road sediment production by increasing the supply of easily erodible fine particles.

The percent of road length connected to streams also varies widely. In California only 3% of the road length was connected in a snow-dominated area as opposed to 30% in a nearby rain-dominated area. Connectivity was less than 20% in permeable volcanics in California and coarse-textured soils in the Colorado Front Range. Road-stream crossings accounted for most of the connected segments, as in temperate forests drainage rills and sediment plumes rarely extend for more than 50 m. Few studies have quantified the effects of unpaved roads on watershed-scale sediment yields, but in northern California the estimated sediment yield was 1.4 Mg yr^{-1} per kilometer of road, while in Colorado the long-term, chronic sediment production from roads was estimated to be about 1 Mg km^{-2} yr^{-1}. On St. John roads were estimated to increase watershed-scale sediment production by 3-9 times, indicating that the road sediments are a critical stressor to near-shore coral reefs. Relatively simple management actions can greatly reduce sediment production and delivery from unpaved roads, but the necessary improvements are constrained by the lack of political will and funding.