Module 8. ROAD HYDROLOGY AND GEOMORPHOLOGY

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Effects of roads on routing of water, sediment, wood, and other materials, such as propagules of exotic plants, through landscapes have been the subjects of many studies in the Andrews Forest. These studies have taken a variety of perspectives, such as focus on processes of peak-flow generation and routing of sediment and disturbances through stream networks. From a landscape-ecology perspective we are interested in how road networks interact with stream networks in part because concepts of network properties are not well developed in this field, which has been dominated by terrestrial ecology studies in landscapes composed of vegetation patchworks. On a fundamental level, roads can be viewed as corridors facilitating movement along them, barriers to movement, sources of materials, such as landslides, or sinks for organisms or materials, such as roadkill reducing a population of organisms (Fig. 8.1). We therefore examine how road segments function in relation to their location in the landscape, such as proximity to ridges and patterns of intersection with stream networks. Beverley Wemple's work gives examples of many of these issues (Wemple et al., 1996, 2001; Wemple, 1998).

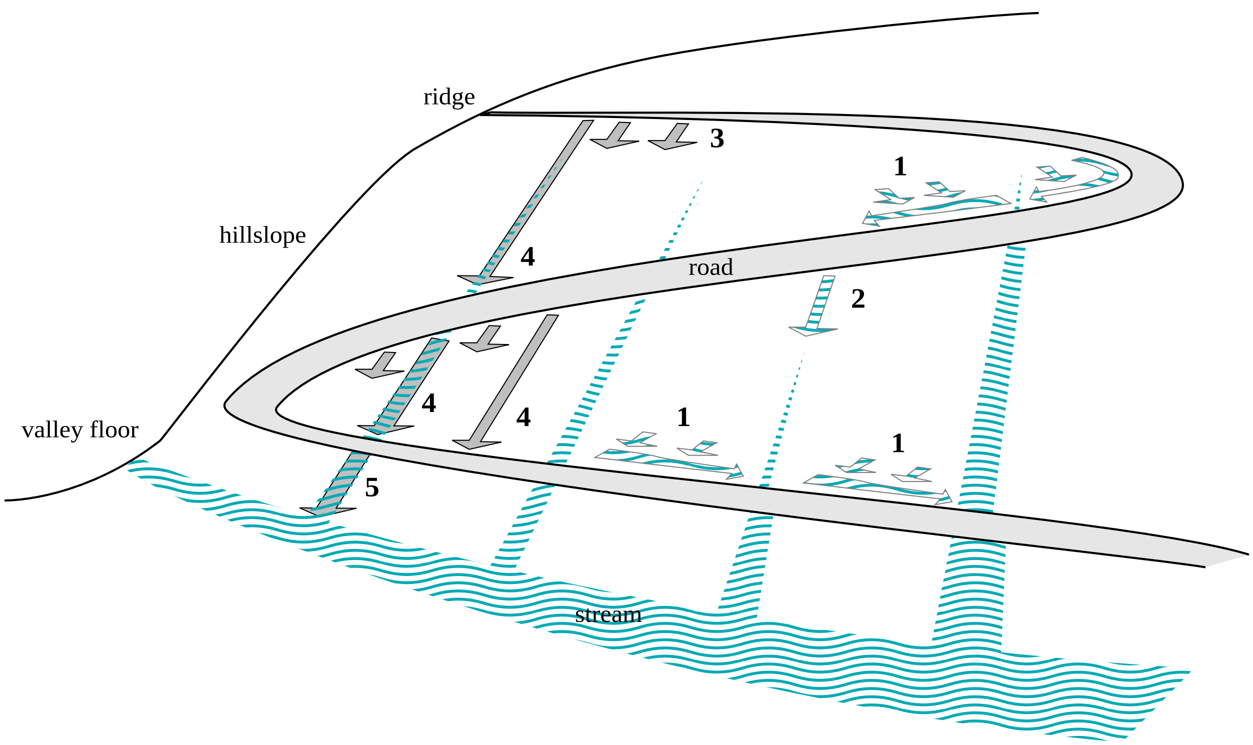

Figure 8.1. Interactions between road and stream networks. The road network consists of a valley floor road segment parallel to a large stream, hillslope road segments perpendicular to streams, and near-ridge roads without streams. Roads (1) intercept water in surface and subsurface flowpaths, (2) alter water flowpaths and extend the channel network, (3) initiate mass movements of sediment in unstable roadfills, (4) deposit sediment moved by mass movements on roads and (5) on valley floors. Overall, roads function to divert water and sediment from paths followed in roadless landscapes, and they initiate multiple new cascading flowpaths.

To test the hypothesis that roads may increase peak flows in Watershed 3 in the Andrews Forest (Jones and Grant, 1996), Wemple surveyed apparent extent of road ditches that carry channelized flow, similar to the stream network. Upper Blue River and Lookout Creek have drainage densities of about 3.0 km km^{-2} and road densities of 1.9. Wemple et al. (1996) found that about 60% of the road network seemed to route surface runoff and subsurface water caught in cutslopes down ditches and into the natural drainage network. Work to measure water routing associated with roads in upper Watershed 3 seems to confirm that such processes can contribute to increased peak flows from this 100 ha watershed (Wemple, 1998; Wemple and Jones, in review).

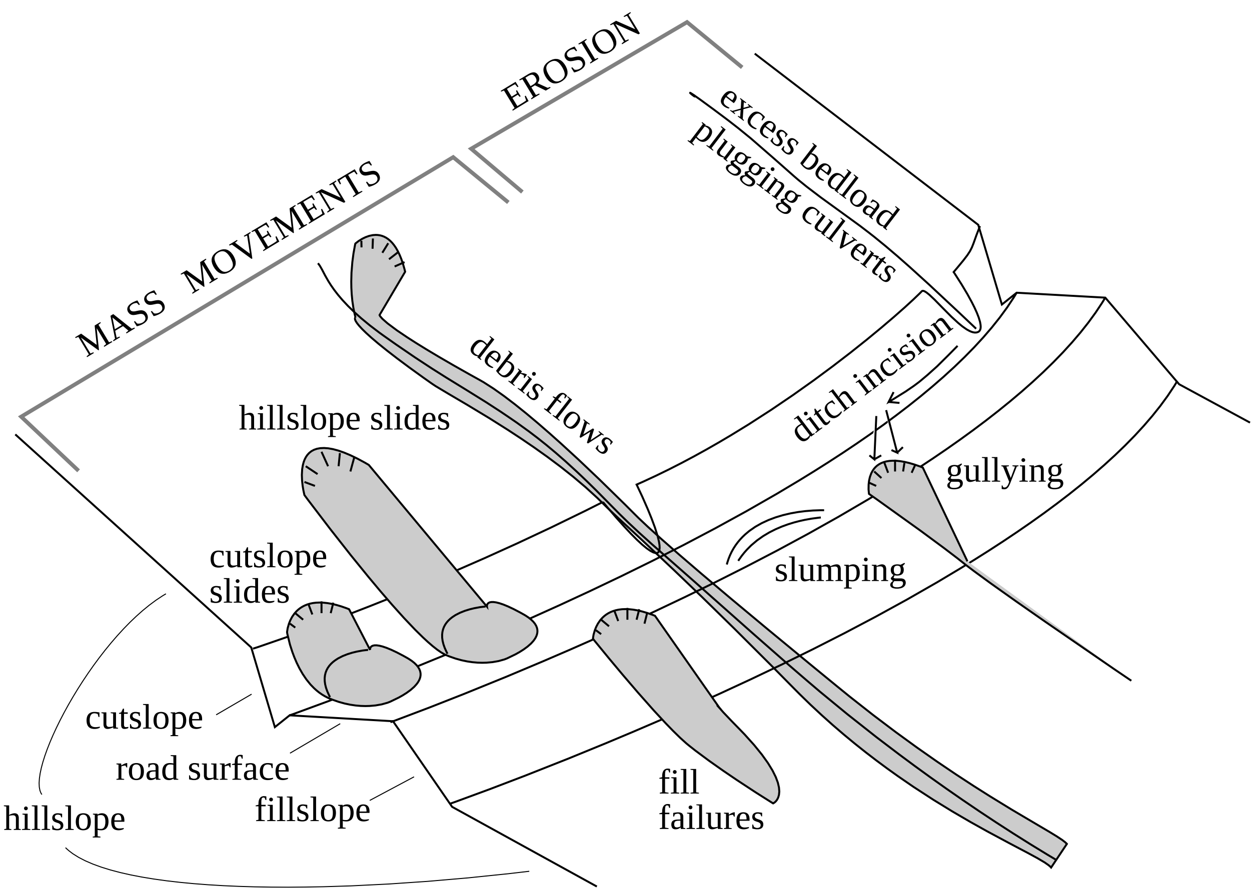

Figure 8.2. Eight types of road failures inventoried in the Lookout Creek and Blue River watershed (from Wemple et al., 2001).

The February 1996 flood triggered varied types of erosion and deposition events (Fig. 8.2) associated with roads in the upper Blue River and Lookout Creek area.

Wemple et al. (2001) inventoried these events and stratified their occurrence on the upper slope (within 100 m of ridge), mid-slope (below the upper slope zone), and valley floor (floodplain, terrace, alluvial fan landforms). Frequency of these features increased downslope (Table 8.1). Roads caused cascades of events involving transformations from one type of sediment-transport process to another. For example, excess bedload plugged culverts, diverting flow down a ditch, which was gullied, until water flowed over the road, saturating a fill, leading to a fillslope slide (Fig. 8.3). Upper-slope roads were net sources of sediment (0 m^3 reached the road from upslope and 5450 m^3 moved downslope from roads). Mid-slope roads were net sources of sediment to downslope areas (12,500 m^3 reached roads, 27,100 m^3 moved downslope). Valley floor roads were net sinks for sediment (13,200 m^3 reached roads, 6,100 m^3 moved downslope).

Table 8.1. Distribution and frequency (numbers per kilometer of road length) of mass movement and fluvial features associated with roads, according to hillslope position and function of the road in intercepting or producing sediment (from Wemple et al., 2001).

Slope position / function	Road length (km)	Number		Frequency (no./km)	
		Mass Movement	Fluvial Feature	Mass Movement	Fluvial Feature
Upper slope					
Intercepted by roads		0	0	0	0
Produced on roads		5	0	0.05	0
Total	102	5	0	0.05	0
Midslope					
Intercepted by roads		11	9	0.05	0.04
Produced on roads		41	5	0.20	0.02
Total	205	52	14	0.25	0.07
Valley floor					
Intercepted by roads		10	4	0.24	0.10
Produced on roads		10	8	0.24	0.20
Total	41	20	12	0.49	0.29