22. Thirty-five years of road decommissioning in the US: Lessons learned

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Introduction

The US has been decommissioning (or deactivating) old forest roads for more than 30 years. Since the first road was decommissioned in Redwood National Park in the 1970s there has been a wealth of knowledge gained on methods and effectiveness of this restoration treatment. We give an overview of road decommissioning methods and research that has been conducted in the US, including research on sediment reduction and a new road inventory and monitoring tool called the Geomorphic Roads Analysis and inventory Package (GRAIP). GRAIP helps managers more effectively prioritize road mitigation and restoration. Finally, we'll present recent research on the ecological response of decommissioning roads.

This paper does not cover all aspects of road decommissioning including costs because they are highly variable and mostly based upon how many stream crossings there are present. Prioritization strategies for treating roads are not addressed, except for GRAIP, and we do not cover simply closing or ripping roads.

Road decommissioning

Roads are essential for forest management, and extensive road networks have been developed across large landscapes (e.g., Daigle 2010). But over the course of the last 30 years or so, the US has been closing and decommissioning roads at a landscape scale. And places like Redwood National Park (Figure 1), they have removed entire road systems – hundreds of kilometers – potentially restoring landscape-level ecosystem processes (Madej et al. 2013).

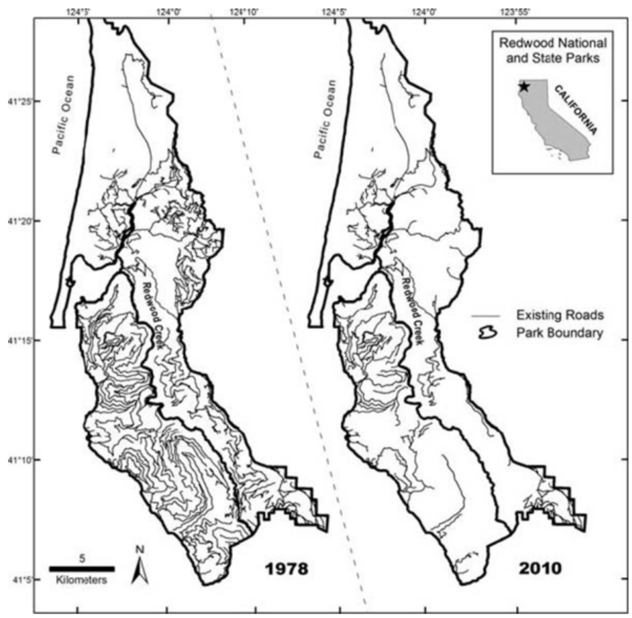

Figure 1. Presence of roads in Redwood National Park (California) in (a) 1978 and (b) 2010. About 425 km of roads were decommissioned during this time period (reprinted from Madej et al. 2013).

Road decommissioning is defined as "the physical treatment of a roadbed with a variety of methods to restore the integrity of associated hillslopes and flood plains and their related processes and properties" (Switalski et al. 2004). See Figure 2. Roads are being reclaimed at a large scale with about 3,000 km a year reclaimed on US Forest Service lands alone. In Canada, road decommissioning is commonly called road deactivation.

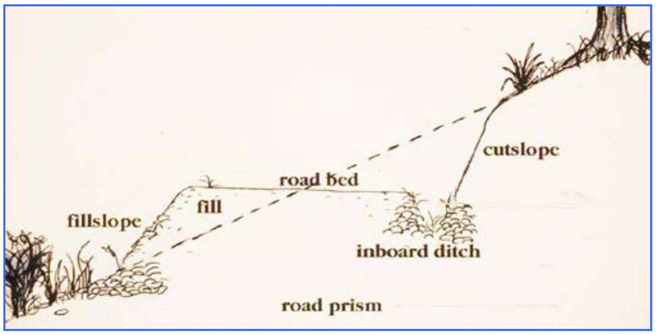

Figure 2. Components of a road and a recontoured road (reprinted from Switalski et al. 2004).

Redwood National Park (California)

Redwood National Park was the first place in the US where roads were decommissioned at a large scale. In 1978, the Park acquired 200 km^2 of mostly industrial timberlands in the headwaters of the park. The roads soon became a focus of a large restoration effort. They initially focused on just stream crossings, and spent a lot of time trying to engineer ways to reduce channel erosion after the treatment. They used hand tools in the very beginning; however, it soon became apparent that they needed to use the same heavy equipment that was used in the construction of the road. The redwoods are big trees, and big roads were built to transport them. Accordingly, large excavators and dozers were used to decommission them. Research followed, showing apparent declines in erosion on roadbeds and stream crossings following treatment (Figure 3). With this knowledge, National Forests and Parks around the US started decommissioning roads at an increasing pace.

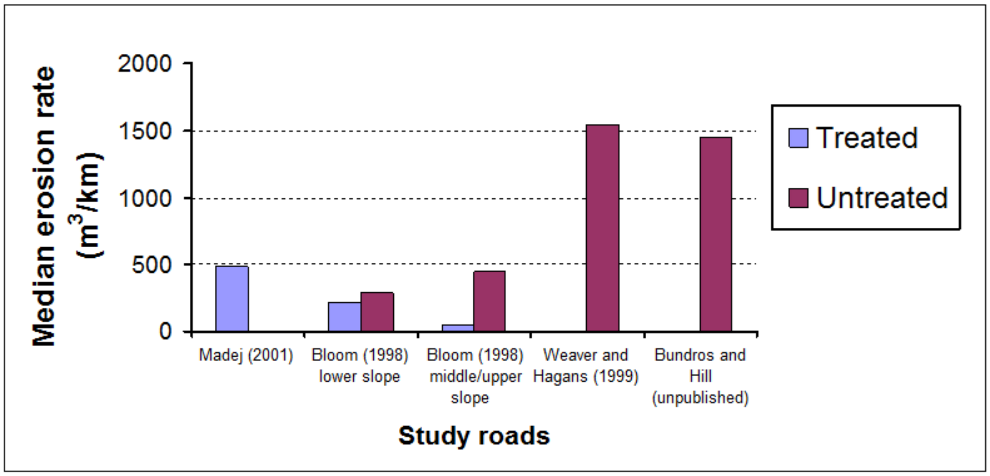

Figure 3. Sediment loss on treated and untreated roads in northern California. Values from Bloom do not include sediment loss from stream crossings on these roads, whereas the other studies include stream crossing erosion as part of the sediment loss (reprinted from Switalski et al. 2004).

Road decommissioning methods

Road decommissioning basically involves reversing the process of road building. First, any trees growing on the road are removed and staged along the road. Starting at the end of the road segment, an excavator first decompacts the inboard side of the road. The excavator then removes the fill side-cast during construction, and places the material on the cutslope - thus recontouring the roadbed to its original slope. After recontouring, staged trees are placed on the slope, and duff is pulled down from the hillside (Figures 4 and 5).

Figure 4. Example of a decommissioned road on the Gallatin National Forest, MT.

When stream crossings are encountered, culverts and fill are carefully removed. If fill was hauled in to build the crossing, it may need to be hauled off of site. In large stream crossings, a dozer may be useful for moving fill. The first step in stream crossing restoration is often to temporarily divert the creek. The fill around the culvert is excavated and the culvert removed. The excavator continues to remove fill until signs of the original channel such as darker soil or rockier substrate are detected. Then the adjacent slopes are recontoured to the original slope.

It is essential to remove all of the fill and contour the slopes correctly. Not excavating enough fill is the most common mistake that leads to post-treatment erosion (Pacific Watershed Associates 2004). After excavation, channel stabilization structures are often placed in the channel to reduce channel erosion. The slopes are vegetated through a combination of the excavator placing clump plantings (which are very successful at stream crossings) and laying woody material and duff. Hand crews may follow laying straw and revegetating with seeding, sprigging, and/or additional hand plantings.

Figure 5. Decommissioned road ten years later on the Clearwater National Forest, ID.

Research on sediment transport

As road decommissioning efforts spread around the western US, so did research - especially on the impact on reducing road-associated sediment. Studies on recontouring roadbeds found significant reductions in sediment loss and road-triggered landslides (Harr and Nichols 1993; Cloyd and Musser 1997; McClelland et al. 1997; Bloom 1998; Hickenbottom 2000; Madej 2001; Pacific Watershed Associates 2004; Nelson et al. 2012; Black et al. 2013). Short-term sediment loss was reported, but mitigated by incorporating woody debris and organics (such as duff), as well as quick revegetation.

For stream crossings, road decommissioning was found to reduce chronic sediment as well, and eliminate the risk of debris torrents (Klein 1987; Bloom 1998; Madej 2001; Pacific Watershed Associates 2004; Foltz et al. 2008; Nelson et al. 2012). Again there can be short-term sediment loss especially if all the fill is not removed which can result in channel incision, surface erosion, and slumping. This erosion can be mitigated, however, by removing appropriate amount of fill, using sediment traps or check dams, and ensuring quick revegetation.

Geomorphic Roads Analysis and Inventory Package (GRAIP)

Inventorying roads is an essential first step in managing any road system. A new approach to measuring road erosion and hydrologic hazards has been developed by the US Forest Service called GRAIP (Cissel et al. 2012; Black et al. 2012; Prasad 2007). The GRAIP approach combines a road inventory with a powerful GIS analysis tool set to predict sediment production and delivery, hydrologic connectivity, landslide and gully risk, and stream-crossing failure risk. GRAIP can help professionals determine the overall infrastructure condition with identified erosion points. The method is rapidly being adopted by forests around the western US (e.g., Cissel et al. 2011; Fly et al. 2010; Nelson et al. 2010).

Local calibration is very important for the model. So a representative sample of road-derived sediment is collected using a settling tank. The methods for collecting road sediment calibration data as well as road runoff and suspended sediment information are documented in Black et al. (2013). In an example from western Montana (Figure 6), a lightly-traveled road generated much more sediment than a gated road (notice the logarithmic scale). In this example, summer thunderstorms drove most of the sediment transport results.

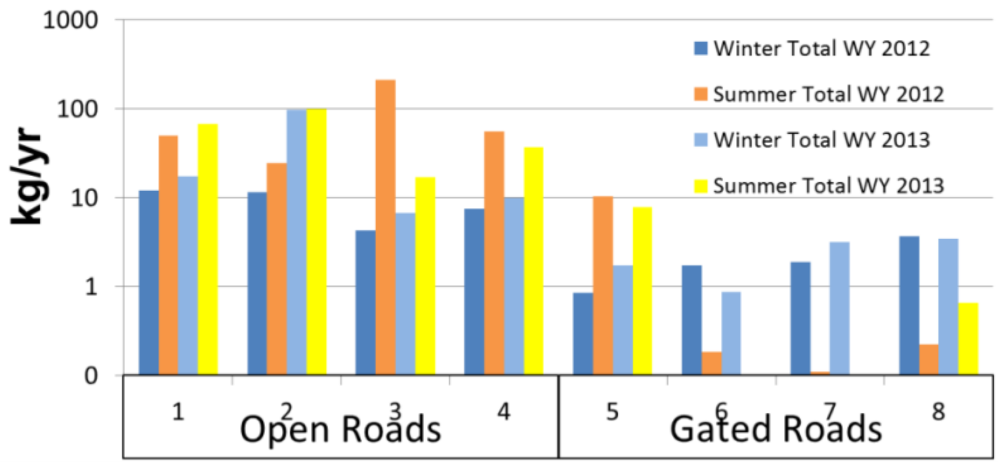

Figure 6. Road-derived sediment on open and gated roads over four seasons in western Montana.

There are two general scales at which to apply the GRAIP method.

The first way (the principal method) is to inventory all of the roads in a watershed, with the goals of determining where problems are located, so that they can be fixed, and quantifying the sediment risks and mass wasting risks that are associated with the road network in that watershed (e.g. Nelson et al. 2010, Fly et al. 2010). In addition to identifying the individual road segments and drainage features that are large sources of chronic fine sediment delivery (Figure 7), GRAIP also accumulates the delivered road sediment in channel segments in a downstream direction (Figure 8). To determine which channel segments or sub-watersheds are likely receiving the highest fine sediment impacts, a sediment per unit area value called specific sediment delivery is provided. When specific sediment impacts are added to the mass wasting and other risk metrics in GRAIP, it provides a simple GIS method for assessing the risks to water quality and aquatic resources.

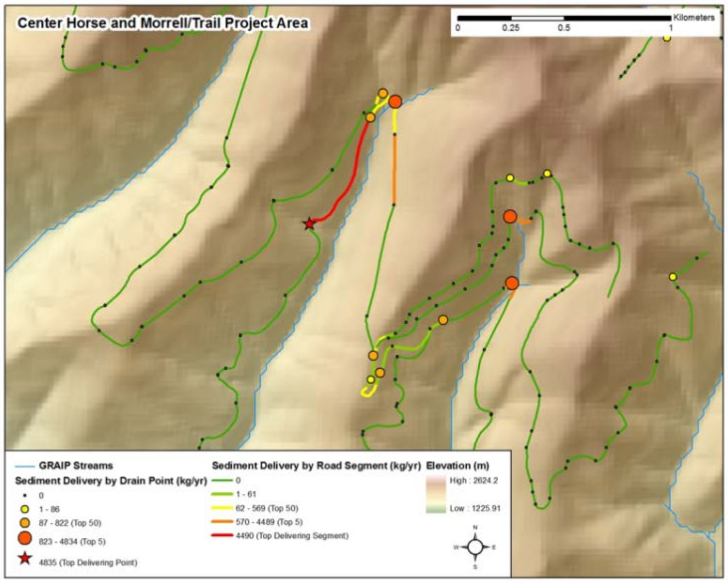

Figure 7: Example of GRAIP output in western Montana. Sediment delivery by drain point (circles), and road segment (lines) with red having high delivery rate and green little or none. GRAIP predicted that most of the road system was not connected to the channel network, however, several long road segments did route sediment to stream crossings. The highest delivery location was predicted to deliver 4,835 kg/yr.

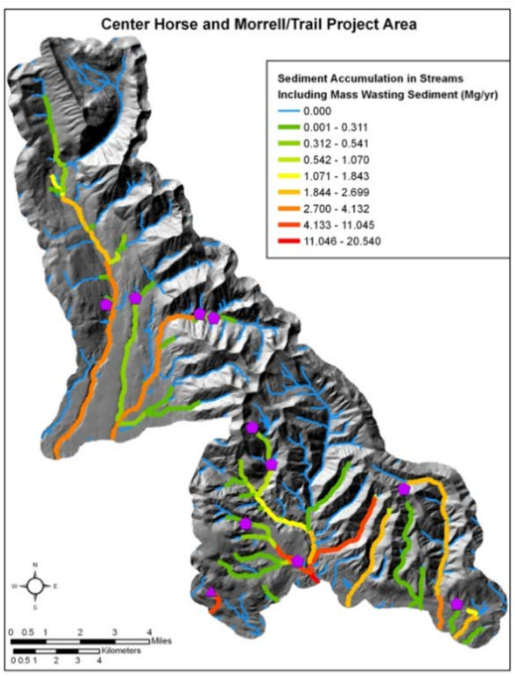

Figure 8: Example of GRAIP predicted sediment delivery rate to streams. Red is higher predicted stream sedimentation, and green and blue less. GRAIP can estimate the how much each sediment delivery feature contributed to the stream sediment. One of the more compelling outputs of GRAIP is that a small percentage of the road system delivers most of the sediment in a watershed (Figure 9). In these 4 watersheds from the western US, only between 2 and 10 percent of observed drain points deliver 90% of the sediment. So managers with this knowledge can target just a small percent of the road system for mitigation or restoration.

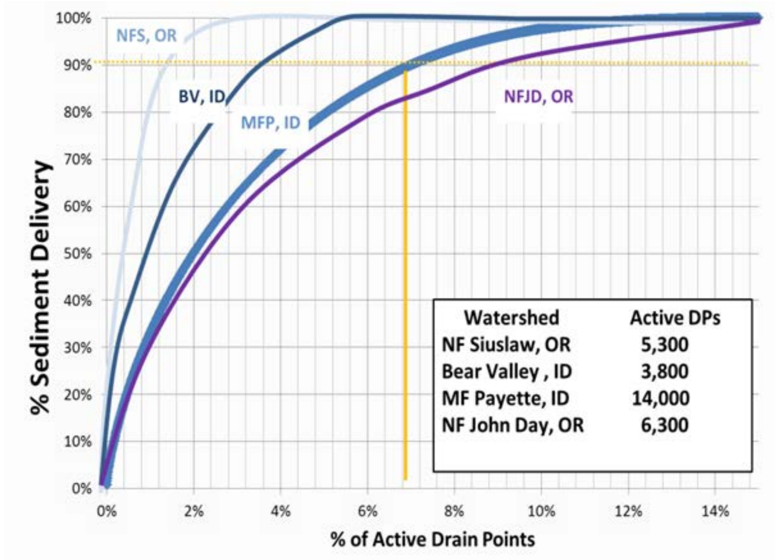

Figure 9. In these 4 watersheds from the western US, between 2 and 10 percent of observed drain points deliver 90% of the sediment.

The second way is to apply GRAIP on a small scale, as a project monitoring tool (e.g. Cissel et al. 2011; Black et al. 2009). A road or set of roads is inventoried before and after a road treatment (such as decommissioning or water-bar installation) in order to determine the effectiveness of that treatment. In this second method, untreated control roads that have similar properties to the treatment roads are also inventoried so that the effectiveness of the treatments can be gauged by reinventorying all of the roads after a large storm event.

GRAIP_lite

The US Forest Service has developed a more broad-scale GIS prioritization tool designed called GRAIP_lite (N. Nelson et al., in press). This tool uses existing road map data, a Digital Elevation Model (DEM) and a small amount of calibration to locate areas at high risk of road sediment delivery. GRAIP_lite is ideally suited to look across a forest (or landscape scale) and pick the few sub-watersheds where you would want more detailed information, whereas GRAIP is well suited to pick out the biggest sediment producing roads and drain points in a few sub-watersheds.

Ecological response to road decommissioning

In addition to sediment production and delivery research and monitoring, there have been a number of recent studies and publications that focused on ecological processes. A recent study looking at soil development on decommissioned roads found that recontouring roads restored both the above-ground and below-ground ecosystem processes (Lloyd et al. 2013). This included orders of magnitude greater root growth, and orders of magnitude greater soil carbon and nitrogen.

For revegetation research, Kolka and Smidt (2004) found significantly greater growth and diameter on yellow-poplar, and greater diameter on white pine on reclaimed roads than control in the upper Midwest. In Montana and Idaho, Grant et al. (2010) found that using native seed mixes resulted in increase overall cover and cover of native species. There was also a decrease in the cover of non-natives compared to control sites. Also, they report that less seed was needed than commonly prescribed addressing a concern by many managers that native seeds are too expensive to use on a broad scale. However, addressing weeds in any disturbance activity continues to be a concern of managers and focus of researchers.

While research is limited on fish, Wegner (1999) found 8% decline in fine sediment, 16% increase in bull trout redds following road decommissioning on the Kootenai National Forest, MT. McCaffery et al. (2007) studied bull trout habitat in the adjacent Flathead National Forest, MT. Streams with roads in use had the highest percent of fine substrate, with decommissioned streams and wilderness streams similar. This effect was highly correlated with the level of regrowth on the former roadbed.

Few wildlife studies exist on decommissioned roads. However, using remotely-triggered cameras, Switalski and Nelson (2011) found that bears were using recontoured roads at a significantly higher rate than on other treatments on the Clearwater National Forest, ID. This was correlated with the amount of fruiting shrubs that recolonized recontoured roads. This study has been expanded region wide on six national forests looking at a suite of animals and using a before-after/control-impact (BACI) study design. Preliminary results show again that black bears are recolonizing roads, but only after two years of the decommissioning treatments. As shown in Figure 10, grizzly bears, while not detected before treatment, have since been detected on two post-treatment sites as well, suggesting benefits to this threatened species as well (A. Switalski, in prep).

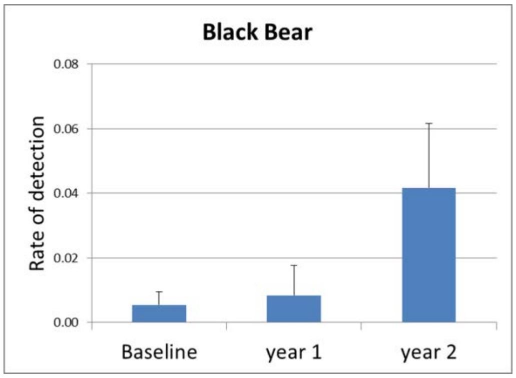

Figure 10: Rate of detection of black bears, before, 1 year, and 2 years after road decommissioning (A. Switalski, in prep.).

Conclusions

Road reclamation has been used extensively in the US and research/monitoring has demonstrated great reductions in erosion following road decommissioning. Recent advances have made inventory and monitoring this effort more effective. For example, GRAIP and GRAIP_lite allow road managers to inventory erosion and sediment delivery into streams and prioritize mitigation and restoration efforts at a range of spatial scales. Studies have found benefits to fish and wildlife habitat; however, more research is needed to measure ecosystem processes and landscape-scale effects over time.

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