AN EXPLANATION AND ASSESSMENT OF ROAD REMOVAL IN VARIED HABITATS

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Abstract

There are three main ways to mitigate the impacts of roads: with mitigation structures; mitigation banking; and road prevention and removal. To date, most mitigation research, as well as mitigation on the ground, has employed the first two options -- building structures that allow wildlife to cross a road, or reserving land in one place to make up for degraded land elsewhere. Interest in road removal is increasing, but the research on the benefits of road removal is limited and it remains the least common, though potentially most effective, mitigation practice.

This paper briefly discusses the ecological impacts of roads on terrestrial and aquatic/hydrologic systems. It then explains the different types and methods of road removal as well as the relative advantages and disadvantages of each. It concludes with a short introduction to several ongoing road removal programs around the country.

Introduction

Road impacts on wildlife, terrestrial systems and hydrologic processes are dramatic, extreme and well-documented in thousands of scientific papers (see Noss 1995). Some ecological problems caused by roads, especially those to wildlife, can be mitigated through a variety of means. In most instances, road impacts to wildlife are mitigated through the construction of wildlife overpasses or underpasses, or by setting aside undamaged land elsewhere to make up for the immediate and adjacent impacts of roads. These two methods, however, provide only limited relief to the problems caused by roads for a number of reasons, including questionable design effectiveness and limited application on the ground. Mitigation for the aquatic and hydrologic impacts of roads is both more difficult and less frequently applied than these other types of mitigation. To address the impacts of roads on hydrologic processes and aquatic systems it is often necessary to remove the problematic road entirely, or at minimum, to remove the culverts and restore stream crossings.

Beginning with an explanation of the ecological impacts of roads, this paper then discusses the different types of road removal, from simple decommissioning to complete recontouring; the advantages and disadvantages of these types of road removal; the benefits and drawbacks of road removal on all types of wildland ecosystems and wildlife species; and a comparison of how different land management agencies are approaching road removal.

Road Impacts

Roads cause direct and indirect impacts to both terrestrial and aquatic systems. Below is a summary of the impacts of roads on terrestrial systems, and a more complete discussion of how roads impact watershed hydrology.

Terrestrial Impacts

Roads cause both direct and indirect terrestrial impacts. They increase habitat fragmentation, increase the spread of non-native plants, pests and pathogens, increase air pollution, cause direct killing of wildlife and increase human use that can result in increased fire ignitions, illegal poaching and illegal off-road vehicle use (e.g Evink 1996, 1998). Terrestrial road impacts can be mitigated by changing road use patterns, constructing crossing structures, closing roads or removing them.

Aquatic/Hydrologic Impacts

Perhaps the most significant, yet least discussed problem with roads is their impact on how water flows through an ecosystem or hydrologic system. For example, wetland hydrology is disrupted because roads:
-constrain and/or divert surface and subsurface water flow;
-concentrate and accelerate erosive surface runoff;
-intercept groundwater flows and reduce groundwater discharge;
-increase or decrease channel gradients and runoff velocities;
-increase sediment loading;
-reduce low flows and increase peak flows; and
-accelerate soil erosion and nutrient loss (Zeedyk 1996).

Roads can also act as dams, altering or blocking water flow from one side of a road to the other (Winter 1988), effectively changing vegetation from wetland to upland plants or vice versa on either side of the road. Even short-term alterations of flood cycles can have substantial and long-lasting effects on wetland vegetation (Thibodeau and Nickerson 1985). In addition, culverts installed below the water's surface can accelerate surface runoff, also changing vegetation patterns. As described in Figure 1 below, road impacts on wetlands are somewhat dependent on their location within or adjacent to wetlands (Zeedyk 1996).

Few studies focus specifically on the direct impacts of roads on wetland hydrology, partly because it is understood that introducing a solid structure into a fluid system will completely change the function of that system. The same is true, in effect, for roads in mountainous systems. Prior to reaching an established stream channel, water flows downslope primarily through the soil profile rather than on the ground surface. Roads are built across slopes, intercepting groundwater flow and bringing it to the surface, concentrating diverted surface water flow and increasing surface water volume. Many of these factors, in turn, lead to increased sedimentation of streams and higher peak streamflow discharges. Increased sedimentation degrades habitat for aquatic species. In addition to problems with sedimentation, improperly installed culverts can act as barriers to fish passage, either by being perched above the level of the stream, or by increasing stream velocity (e.g. USDA 1998, Yee and Roelofs 1980, Belford and Gould 1989).

Hydrologic changes lead to vegetative changes, which impact available wildlife habitat in addition to affecting aquatic species. Standard terrestrial mitigation techniques (such as well-designed wildlife overpasses/underpasses or road closures) may improve habitat connectivity for wildlife species, but these same techniques may have little or no impact on the hydrologic problems caused by roads. Mitigation techniques for restoring hydrologic function should be considered equally to other mitigation efforts in all ecosystems.

Mitigation through Road Removal

Road removal can be the simplest and most effective method for mitigating terrestrial and aquatic/hydrologic impacts of roads. But there are many different levels of road removal, from abandoning or gating a road to completely obliterating a road and recontouring the slope. Below is an explanation of the advantages and disadvantages of the four main types of Aroad removal,@ followed by an explanation of the physical procedures used in road decommissioning and obliteration. (Much of this review is adapted from *The Road-Ripper=s Guide to Wildland Road Removal* Bagley 1998).

Closure

Roads may be closed with gates, berms, or deep ditches (tank traps) to mitigate their impacts on wildlife. In some instances, the first quarter mile or the immediately visible part of a road is recontoured and revegetated to camouflage the road and therefore discourage vehicular travel. Road closures, when effective, can help mitigate road impacts on road-averse species such as grizzly bears and elk. Road closures are often ineffective , however, resulting in continued vehicular use (whether authorized or unauthorized), and therefore continued wildlife impacts. Independent field surveys of Forest Service roads in the Northern Rockies, for example, have found that only 35% of road closure devices effectively stop all motorized use (Roads Scholar Project 1996). For this reason, camouflaging the road entry, or removing the stream crossings and culverts are more effective.

Abandonment

Public land management agencies and other land owners/managers frequently abandon roads. If a road is abandoned, the responsible party stops maintaining it, but they don=t physically treat the road to make it undriveable or to reduce the road=s impacts on terrestrial and aquatic systems. In some instances these roads remain driveable, and in many instances they continue to fragment habitat and contribute sediment to nearby streams. Even more critical, however, is the impact abandoned roads can have on aquatic systems (note: sediment/aquatic impact mentioned in previous sentence). If a road is abandoned, the culverts remain in place, where they may fail when plugged by debris or if they are insufficiently sized to convey peak stream discharges. In addition, the road will continue to bring subsurface water to the surface, inboard ditches will continue to alter peak flows, and culverts can continue to act as a barriers to fish passage.

Decommissioning

In many places, land managers are now decommissioning roads to mitigate sediment problems. In decommissioning, a road is Astored@ or Aput to bed@ for future use. Culverts are removed, water bars and cross-road drains are installed and problem fill areas are stabilized. In some instances, inboard ditches are removed and the road is mildly outsloped. The road prism itself is left intact so the road can be easily reconstructed in the future. Decommissioning accomplishes three important mitigation goals: it stabilizes most unstable fill; it allows streams to run unimpeded; and it disperses concentrated water, returning exposed, concentrated, and hence erosive, subsurface water to the ground. Decommissioning can be particularly helpful to anadramous species such as salmon. Because culverts often act as barriers to fish passage - in many instances preventing fish from reaching their spawning grounds - removing culverts can open up entire drainages for recolonization. In addition, by stabilizing fill material, the likelihood of road failures and resultant sedimentation is reduced.

Obliteration

Obliteration can be the most effective treatment for both aquatic and terrestrial species. In full obliteration, culverts are removed, road surfaces are ripped and slopes are recontoured (see below for explanations of these treatments). In simple decommissioning, sites (such as stream crossings) are treated, but the segments (such as the roadbed between two stream crossings, or between water bars) are left intact. In obliteration, all sites and segments are treated. Subsurface water flow is no longer interrupted, allowing water to flow normally throughout the system and therefore aiding with vegetative recovery and reconnecting fragmented habitat. Recovering the original topsoil may also aid in revegetative success and limit the spread of non-native species on the site. Road obliteration, therefore, addresses both the aquatic/hydrologic and terrestrial problems caused by roads.

Road Removal Treatment Methods

Mitigating the effects of roads can be accomplished, to some degree, through all of the methods described above. The relative advantages and disadvantages are summarized in Table 1. The specific treatments described below are used to mitigate particular problems or as the components for completely removing roads.

Removing stream crossings

Stream crossing removal is a fundamental treatment for mitigating the impacts of roads on aquatic systems. When done correctly, stream crossings are removed by excavating all fill materials and restoring the original channel and valley shape. Simply removing culverts is not sufficient, because any remaining fill from the crossing can erode into the channel. Materials excavated from stream crossings can be used to recontour road segments to their natural slope, essentially returning fill to the location from which it was cut. Endhauling is necessary when the amount of fill removed is greater than that needed for recontouring. Any road removal project that does not remove stream crossings (or does not remove *all* fill materials from stream crossings) is not effective and may cause more ecological damage by causing additional sedimentation .

Cross road drains

Cross road drains are deep ditches excavated across road surfaces (similar to waterbars, but more substantial) to facilitate drainage on closed roads. They are too deep and steep to be cleared by motor vehicles. Unless spaced frequently enough to disperse concentrated water, cross road drains may cause erosion downslope. They must be constructed more frequently on roads with steep grades, but are not necessary if roads are fully recontoured or outsloped steeply.

Ripping

Ripping involves decompacting road surfaces and fill sites to a depth of two to three feet. The goal is to enhance subsurface water flow by reducing soil density and increasing porosity, infiltration, and percolation. Ripping relatively impermeable fill sites reduces the chance of fill saturation and failure. Some soil settling occurs since organic matter is limited in near sterile road soils. Therefore, adding organic matter to the ripped soil can greatly accelerate the recovery of hydrologic function, including both infiltration and percolation (Luce 1997). Ripping also increases revegetation success.

Outsloping

Outsloping involves filling inboard ditches with sidecast fill material and sloping the road surface to disperse water to the downhill side of the road. Some sidecast fill materials remain, but saturation and potential failure is reduced because water cannot concentrate in inboard ditches or on the road surface. The remaining fill slope materials may still cause stability problems, especially on steep slopes (see Figure 2).

Recontouring

Recontouring involves placing all fill materials back into locations where fill was removed during road construction. Recontouring restores the original slope as much as possible, dispersing concentrated water and greatly enhancing slope stability. Full recontouring is sometimes impossible, especially on very steep slopes, since the sidecast material may have slid downhill out of reach. In some cases, cutslopes will be so high and road cuts so narrow, that replaced fill material will not blend with the original undisturbed slope. Even so, slope recontouring to the extent possible generally results in the most stable landform shape, restores natural surface runoff patterns and deters motorized access (see Figure 2).

Road Removal in Action

Road removal is occurring on all public lands to some degree and on private lands to a lesser degree. The Forest Service has begun actively removing roads to mitigate their impact on species such as grizzly bear, elk, trout and salmon. Entire road networks have been removed in Redwood National Park, while other National Parks have removed particularly problematic or unnecessary roads. The Bureau of Land Management (BLM) has also removed roads in some critical areas. Road removal, however, is still happening on a very small scale as compared to the entire number of roads on National Park, Forest Service or BLM lands. While none of these agencies has a coordinated agency-wide program for road removal, the Forest Service is in the midst of a national planning process to determine what to do with their crumbling road system. Their plans are likely to include a significant amount of road removal to restore and mitigate the damage from former and existing roads.

As a tool for mitigation, road removal provides the opportunity to improve habitat connectivity and aquatic health at the landscape level if done effectively. To be effective at this level, however, it is important that the roads to be removed, or the sites along roads to be treated, are prioritized appropriately. While road removal can benefit a single species, if managers consider other species that will be impacted, it may change the design of the project. For example, in the Flathead National Forest in Montana, the Forest Service has a legal obligation under the Endangered Species Act (ESA) to remove roads to improve grizzly bear habitat. In the midst of the 10 year road removal program to comply with grizzly bear needs, an aquatic species, the bull trout, was also listed under the ESA. Road removal is now a concern for both grizzly bears and bull trout, potentially resulting in a significantly modified road removal program on this forest. In this instance, in particular, there is significant discussion about the hydrologic and aquatic benefits of road removal as compared to the terrestrial benefits to grizzly bears. It is also interesting to note that road removal was mandated by the courts after field surveys showed that road closures were ineffective in mitigating the impacts of roads on grizzlies.

Discussion

Road removal is an important, yet underused tool for mitigating the impacts of roads. It is a relatively new field, leaving land managers with a lot to learn about how to use road removal to lessen or even reverse the severe impacts roads have caused to aquatic and terrestrial systems and the wildlife habitat they contain. Few comprehensive monitoring programs have been developed to test the overall effectiveness of different types of road removal, leaving significant research opportunities in this area. When discussing road removal, it is wise to consider that preventing new road construction in the first place will enable land managers to avoid having to deal with mitigation at all. In effect, prevention is the best mitigation, economically, ecologically. Many of the most ecologically damaging roads are built for primary uses such as resource extraction. In the event that the primary use of a road has been completed, and the road is causing significant ecological disturbance, road removal should be considered as a viable and effective mitigative option.

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Appendix A: Performing Inventories

(reprinted in part from Bagley 1998)

Overall road information

By completing this section, you will gain a general understanding of the road prior to performing a more in-depth field inventory. Road type and access will tell you about the potential and real impacts associated with a road. Knowing the year of construction will hep you determine, for example, whether organic materials were incorporated into a road's fill (initiating failure as it decomposes). Knowing maintenance history will help you determine the perennial problems associated with a road. For example, there may be sections of a road that have washed out on a regular basis, soaking up large amounts of maintenance money. Some roads may have surface drainage problems, requiring grading on a regular basis to stop rills from developing into gullies. Ask agency staff in order to find general information about a road.

Determine a road's hillslope position either by looking at the contour lines on a topographic map, or by estimating it in the field based on your sense of the surroundings.

Sites

Determine the type of drainage structure, if one exists. Note culvert sizes for additional information. Determine the condition of culverts, the ground around the culvert inlet, the ground below culverts, and fill materials by observing them up close.

Segments

Surface shape refers to the direction water will flow from a road's surface. Insloped road segments concentrate water in an inboard ditch (allowing water to become more erosive than if it was dispersed). The condition of the road surface, road fill, inboard ditch, and cutslope should be obvious by observing each portion of the road prism.

Understanding diversion potential

Diversion potential refers to the likelihood that backed up water behind a plugged culvert will be diverted down the inboard ditch or road surface, or onto the adjacent natural slope, rather than back into the stream channel. You can determine whether a stream crossing has diversion potential by standing or kneeling near the stream on the uphill side of the road or on the fillslope. Stand or kneel so that the road surface is at your eye level, then determine where backed up water will flow if it reaches the elevation of the road surface. If the road grade slopes to either side of the stream crossing, there is potential for diversion. If there is a broad dip in the surface of the crossing, the backed up water will flow back into the stream on the downhill side of the raod. Hence a stream crossing with a dip in the road surface has no diversion potential.

Figure 1
(Reprinted from Bagley 1998)

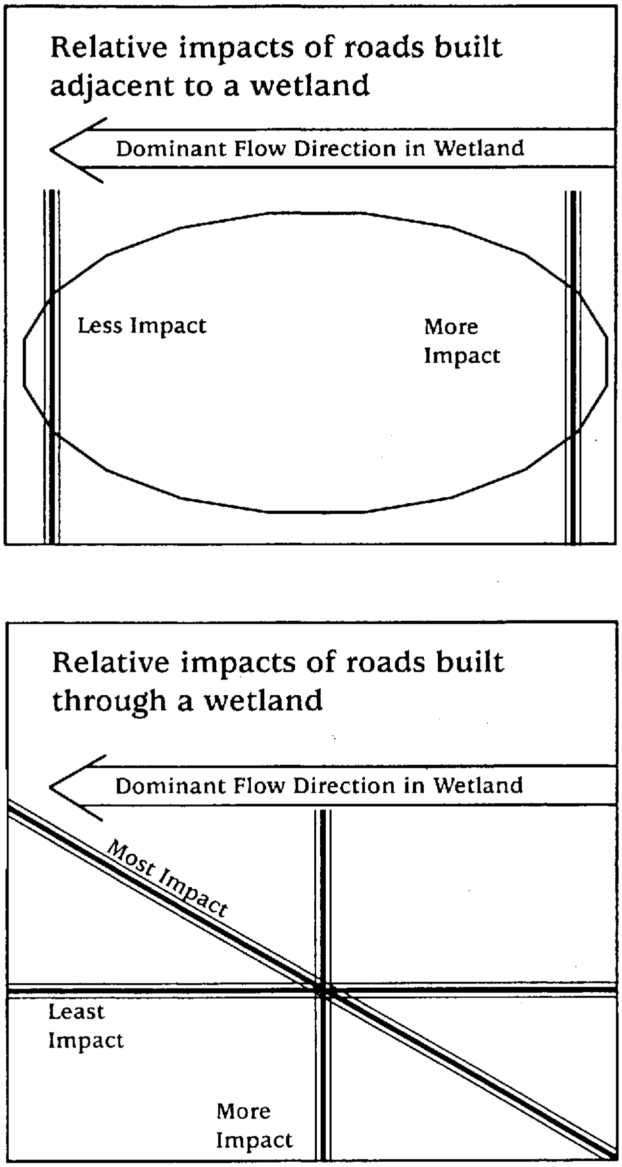
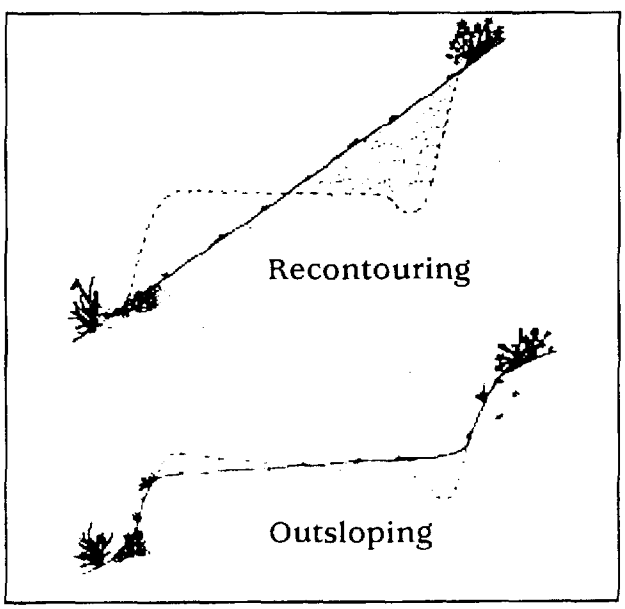


Table 1
(Reprinted from Bagley 1998)

Road impact considerations	How different approaches to removing roads address road impact considerations					
	Close	Abandon	Reclassify as trail	Decommission	Convert to trail	Obliterate
Is wildlife security improved?	Yes* (short - term)	Yes (long - term)	Depends on extent of trail use	Yes* (short - term)	Depends on extent of trail use	Yes* (long - term)
Are fill stability problems fixed?	No	No	No	Yes* (short - term)	Yes*	Yes*
Is surface erosion controlled?	No	No	No	Yes* (short - term)	No* (much reduced)	Yes*
Will the road be reopened or reconstructed?	Yes	No	No	Yes	No	No
Is motorized use accommodated?**	Yes	Yes (unless overgrown)	Yes	No*	Yes	No*
Will continued maintenance and repair funding be necessary?	Yes	No	Yes	No* (until reconstructed)	Yes	No*

* if implemented effectively
** *decommissioned and obliterated roads may continue to accommodate winter use by snowmobiles*

Figure 2
(Reprinted from Bagley 1998)



Road Inventory Form

Overall road information

Road name/number	
Date	
Location	
Agency	
Road type (service, haul, spur, etc.)	
Access (car, 4wd, ORV, walk only) Will portions of the road need to be reconstructed (due to previous failures)?	
Road history (year of construction, maintenance history)	
Hillslope position (valley bottom, low/mid/high slope, ridgetop)	
Comments	

Sites

Site number	
Type of site (stream crossing, swale crossing, seep, ditch relief culvert)	
Drainage structure (culvert, log crossing, bridge, ford, fill only)	
Culvert condition (good, plugged, inlet/outlet rusted, inlet/outlet crushed, inside rusted)	
Ground condition around culvert inlet (eroded, good/armored)	
Ground condition below culvert (gully, good/water reinfiltrates)	
Fill condition (rilling, cracking, slumping, sagging, holes)	
Crossing history (now diverted, past diversion, no diversion, washed out)	
Diversion potential? (Y/N)	
Comments	

Segments

Segment number	
Surface shape (outsloped, insloped, crowned, flat)	
Surface condition (rilling, gullying, ponded water, holes)	
Fill condition (rilling, cracking, slumping, sagging, holes)	
Cutslope condition (rilling, slumping)	
Inboard ditch condition (good, converted to gully, blocked by debris)	
Does inboard ditch discharge directly into a stream? (Y/N)	
Comments	

(Reprinted from Bagley 1998)