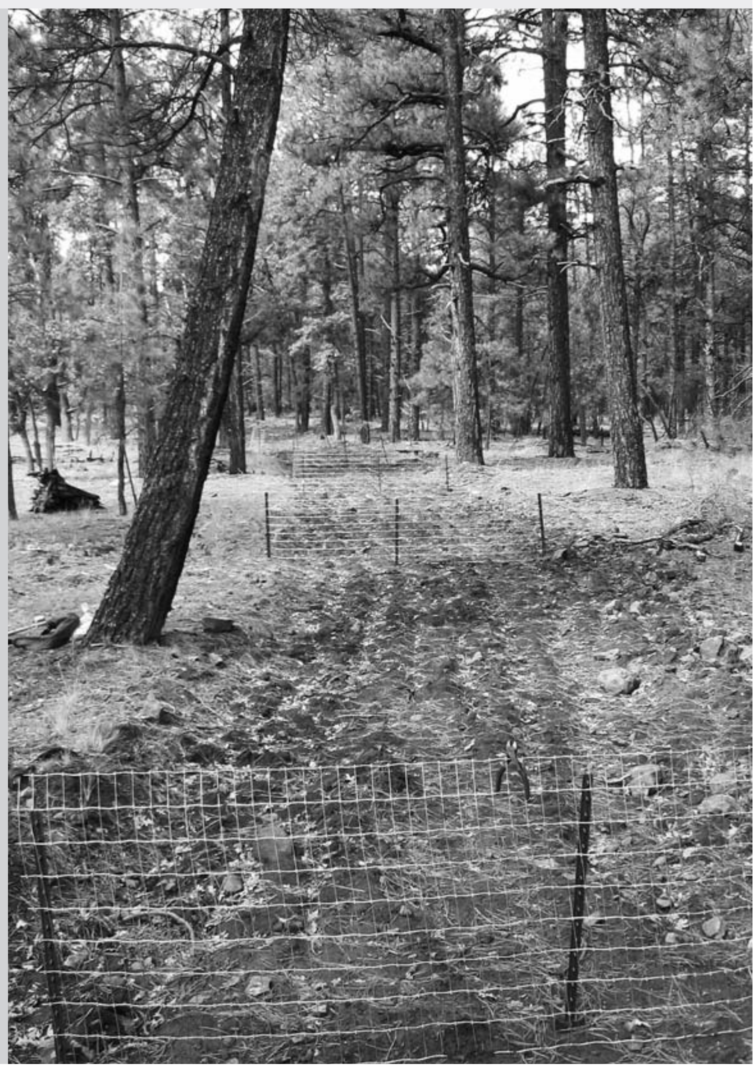
Working Papers in Southwestern Ponderosa Pine Forest Restoration

12

Restoring Forest Roads

June 2005



NORTHERN ARIZONA UNIVERSITY

Ecological Restoration Institute
P.O. Box 15017
Flagstaff, AZ 86011-5017
www.eri.nau.edu

Working Papers in Southwestern Ponderosa Pine Forest Restoration

Ecological restoration seeks to heal degraded ecosystems by reestablishing native species, structural characteristics, and ecological processes. The Society for Ecological Restoration International defines restoration as "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability. . . . Restoration attempts to return an ecosystem to its historic trajectory" (Society for Ecological Restoration International 2004).

In the southwestern United States, most ponderosa pine forests have been degraded during the last 150 years; many areas are now dominated by dense thickets of small trees and have lost their once diverse understory. Forests in this condition are highly susceptible to damaging, stand-replacing fires and increased insect and disease epidemics. Restoration of these forests centers on reintroducing frequent, low-intensity surface fires—often after first thinning dense stands—and reestablishing productive understory plant communities. The Ecological Restoration Institute at Northern Arizona University is a pioneer in researching, implementing, and monitoring ecological restoration of southwestern ponderosa pine forests. By allowing natural processes such as fire to resume self-sustaining patterns, we hope to reestablish healthy forests that provide ecosystem services, wildlife habitat, and recreational opportunities.

Every restoration project needs to be site specific, but the detailed experience of field practitioners may help guide practitioners elsewhere. The Working Papers series presents findings and management recommendations from research and observations by the ERI and its partner organizations.

This publication would not have been possible without significant funding from the USDA Forest Service. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government.

1: Restoring the Uinkaret Mountains: Operational Lessons and Adaptive Management Practices

2: Understory Plant Community Restoration in the Uinkaret Mountains, Arizona

3: Protecting Old Trees from Prescribed Fire

4: Fuels Treatments and Forest Restoration: An Analysis of Benefits

5: Limiting Damage to Forest Soils During Restoration

6: Butterflies as Indicators of Restoration Progress

7: Establishing Reference Conditions for Southwestern Ponderosa Pine Forests

8: Controlling Invasive Species as Part of Restoration Treatments

9: Restoration of Ponderosa Pine Forests to Presettlement Conditions

10: The Stand Treatment Impacts on Forest Health (STIFH) Restoration Model

11: Collaboration as a Tool in Forest Restoration

Introduction

Restoring unused and abandoned forest roads is an important step in the rehabilitation of natural ecosystem processes. The Forest Service estimates that there are over 435,000 miles of road within the national forest system, 52,000 miles of which are unclassified and not maintained for vehicle use (USDA Forest Service 2004). Temporary forest roads can facilitate ecosystem restoration by providing access for equipment and by serving as firebreaks. But they have the potential to cause an array of ecological problems (Havlick 2002; Forman et al. 2003). Many agency land management plans call for closing and rehabilitating unneeded roads. This publication presents both an overview of the ecological problems forest roads can cause and a guide to traditional and novel methods that can be used in their restoration.

Major Considerations in Road Restoration

1. Have the appropriate NEPA guidelines been met (Coghlan and Sowa 1998)?
2. Has the road been adequately barricaded to discourage vehicle use?
3. How will the colonization of exotic plants be minimized? How will they be removed if they do colonize?
4. What strategies will be used to monitor the site after the project is complete?

How Is Ecosystem Functioning Affected by Forest Roads?

Many factors contribute to the overall influence roads have on an ecosystem. Length of operation, frequency of use, type of vehicles used, presence of plant and animal species, general health of the landscape, and location are important predictors of ecosystem impacts. Not all ecosystems are affected by roads in the exactly the same way; the following patterns of disturbance, however, are consistently observed.

Soils

The compaction of forest road soils is known to reduce aeration, porosity, infiltration rates, water movement, and biological activity in soils. Research indicates that soil bulk density, organic matter, moisture, and litter depths are much lower on roads than on nearby forest lands. Macropores, which provide soil drainage and infiltration, have been shown to significantly decrease in size as a result of road construction and use. Reduced infiltration and increased compaction promote soil erosion, especially during the seasonal southwestern monsoon rains (Elseroad 2001).

Plants

Physical disturbances caused by road construction and vehicle use create ideal conditions for colonization by invasive exotic plant species. The use of roads by vehicles, machinery, or humans often aids the spread of exotic plant seeds. Once established, they can have long-term impacts on surrounding ecosystems and can be difficult to remove. Read more about exotic plants in *Working Paper 8: Controlling Invasive Species as Part of Restoration Treatments.*

Wildlife

Roads are known to cause habitat fragmentation. Many create ecological "edges" with different plant species, light levels, and hiding cover, all of which may alter animal survival, reproductive success, and movement patterns. The introduction of exotic plants can disrupt the availability of native vegetation used by wildlife for food and shelter (Trombulak and Frissell 1999).

Hydrology

Forest roads often develop a water-repellent soil layer caused by lack of vegetative cover and changes in soil composition. This can substantially influence how runoff is processed. Erosion, the formation of water channels beside the road, and increased sediment loads in nearby streams are common results of this process (Baker 2003).

Restoring Roads

Though there may be myriad local reasons to remove and restore roads, the essential goals of such projects are:

- Reduce soil erosion
- Reestablish vegetation
- Promote hillside stability
- Protect plant and wildlife species
- Restore aquatic and terrestrial habitats
- Preserve and enhance natural drainage patterns
- Restrict access to remote or sensitive forest sites

All of these factors contribute to the larger goal of forest restoration—that is, the reestablishment of natural and self-sustaining ecosystem functions.

Standard Road Removal Methods

Several strategies have proven successful in restoring roads to a more natural and sustainable condition (Table 1). Traditional methods such as road ripping, reshaping, and revegetation are commonly used in all forest types. The ecosystem response to these activities is varied and depends on the initial condition of the road and the process by which the method was implemented. A successful road restoration project will likely need to incorporate most, if not all, of the following strategies.

Barricades

This method is commonly used for road decommissioning. It involves blocking the road from vehicle use. Barricades must be appropriate for their setting in order to be effective. When implemented alone, barricades are not considered to constitute road restoration; however, barricading is an important first step in the restoration process if used in conjunction with other methods such as those listed below.

Reshaping

Physical reshaping of the roadbed may be necessary to prevent erosion on steep slopes, or if one management goal is to bring the landscape back to the pre-road contour. It is an expensive procedure that must be linked with other strategies to achieve full restoration.

Ripping

The main purpose of ripping a road is to loosen the soil. Soils compacted by mechanized equipment may remain compacted for decades without rehabilitation. Soil productivity and physical characteristics are crucial to an ecosystem's overall functioning (Selmants et al. 2003). Ripping a road reduces soil density while increasing soil porosity, infiltration, moisture, and seedbed potential (Luce 1997). Adding organic amendments to the soil after ripping may expedite the recovery of hydrological and vegetative processes. Bringing in mulch or topsoil adds organic matter. Mulch and soil should come from nearby locations, as native soils often contain plant fragments and seeds specific to that location, along with the propagules of mycorrhizal fungi (Bagley 1998; Elseroad 2001; Korb et al. 2004). The best soil to add is that removed when a temporary road is built; it can be collected and replaced after the road has been ripped. Some research indicates that the positive effects of road ripping, when performed in isolation, are not long-lived. Although ripping loosens the soil, it does little to improve soil structure. Without seeding the newly ripped soil, the soil's crust can become hardened and block the infiltration of water (Elseroad 2001).

Revegetation

After ripping, some plants may sprout from the soil seed bank or when seeds enter the road area from elsewhere, but seeding can speed up the process of reestablishing herbaceous cover, reducing erosion, and stabilizing the soil. A weed-free mix of native seeds is most appropriate for restoration. Only on severely disturbed sites at grave risk of erosion should managers consider nonnative annual species for soil stabilization; if possible, they should be sterile varieties (Robichaud et al. 2000). Immediate seeding after ripping makes it more difficult for exotic species to colonize a newly disturbed road (Switalski et al. 2004). Some research indicates that adding topsoil and then mulch, in conjunction with seeding, can help protect seeds, reduce erosion, contain moisture, increase organic matter, and regulate soil temperature (Elseroad et al. 2003). Materials commonly used as mulch at road restoration sites include straw and wood chips (Bagley 1998).

Novel Restoration Approaches

The symbiotic relationship between plants and mycorrhizal fungi—which generally live in soils—has been proven to enhance plant diversity and productivity (Amaranthus 1999; Hartnett and Wilson 1999). Populations of these fungi can promote the recovery of the herbaceous understory, and appear to be increased by some forest restoration activities (Korb et al. 2001, 2003). The growth of mycorrhizal fungi can be enhanced in several ways, most easily and effectively by applying soil from the site to a road under restoration.

Some researchers and practitioners have used artificial inoculation of fungi to encourage the growth of native plants, bind soil particles together, and recycle nutrients, while inhibiting the growth of exotic species (Marler et al. 1999). Two methods have been tried. The first involves mixing a fungus-laden powder with plant seeds before they are distributed in the soil (Amaranthus and Steinfeld 2003). The second way to inoculate the soil is to place dowels of wood covered with fungi throughout the soil and/or mulch at a restoration site (unpublished data, J. Trudeau, Ecological Restoration Institute). Check the resources in the references section for more information.

Monitoring

An important component of any restoration project is monitoring the ecosystem response after on-the-ground restoration activities are complete. All restoration projects ought to begin with a set of clearly defined and measurable goals. The purpose of monitoring is to see if the ecosystem responds to the restoration efforts as expected. Monitoring the landscape at specific time intervals for several years can provide valuable feedback and help predict what the final outcome of future restoration projects may be.

There are several strategies for monitoring the ecological effects of a restoration project (see **www.eri.nau.edu/implementation/**). One valuable and easy tool for monitoring the ecosystem response to forest road restoration is taking photographs of the site to document change over time. This is usually started by selecting a handful of permanent photo points. Photographs are then taken at each of the points at set time intervals over the course of one to five years. The photos are usually stored in a binder so the progress of the landscape can be easily witnessed.

To maximize the benefits of this monitoring technique, select photo points that will provide the most useful information. For example, choose sites that will readily show whether erosion is taking place, and how herbaceous cover changes over time (Bagley 1998).

References

Amaranthus, M. 1999. Mycorrhizal management: A look beneath the surface at plant establishment and growth. **www.fungi.com/mycogrow/amaranthus.html**.

Amaranthus, M., and D. Steinfeld. 2003. A symbiotic relationship. *Erosion Control* (September/October). **www.forester.net/ecm_0309_symbiotic.html**.

Bagley, S. 1998. *The ripper's guide to wildland road removal*. Wildland Center for Preventing Roads. **www.wildlandscpr.org/WCPRpdfs/roadremovalguide.pdf**.

Table 1. Advantages and Disadvantages of Road Restoration Methods

Method	Advantages	Disadvantages
Barricades	• Inexpensive and easy	• Do not promote natural ecosystem function • Road can still be traveled by ATVs and by foot
Ripping	• Loosens soil • Increases soil infiltration • Reduces erosion • Prepares soil for revegetation • Equipment readily available	• Successes observed during short-term evaluation often disappear over time • Must plan to seed with native plants immediately following ripping to minimize the invasion of exotics
Revegetation	• Reduces erosion • Minimizes colonization of exotic plants • Roots reduce soil bulk density • Decaying plant material enhances quality and quantity of soil organic matter	• Seeds will likely not take root unless the soil has been disturbed before planting • Road must be well blocked to successfully eliminate all vehicle traffic
Reshaping	• Reduces the risk of landslides • Can bring the landscape back to pre-road appearance and functionality	• Expensive and often logistically infeasible • Does little to promote ecosystem function unless other methods of restoration are also implemented
Introduction of mycorrhizal fungi	• Forms a beneficial relationship with plants; promotes vegetation growth • Supports biodiversity • Binds soil particles and recycles nutrients	• Little research has been done in southwestern forests, though preliminary results are promising • Fungi may be eaten by wildlife or consumed by native molds

Sources: Elseroad 2001; Hunt and Wall 2002; Korb et al. 2003; Switalski et al. 2004.

Baker, M. B. 2003. Hydrology. Pp. 161-174 in *Ecological restoration of southwestern ponderosa pine forests*, ed. P. Friederici. Washington, D.C.: Island Press.

Coghlan, G., and R. Sowa. 1998. *National Forest road system and use.* Washington, D.C.: USDA Forest Service. **www.fs.fed.us/eng/road_mgt/roadsummary.pdf**.

Elseroad, A. 2001. Forest roads in northern Arizona: Recovery after closure and revegetation techniques. Master's thesis, Northern Arizona University, Flagstaff.

Elseroad, A. C., P. Z. Fulé, and W. W. Covington. 2003. Forest road revegetation: Effects of seeding and soil amendments. *Ecological Restoration* 21(3):180-185.

Forman, R. T. T., D. Sperling, J. A. Bissonette, A. P. Clevenger, C. D. Cutshall, V. H. Dale, L. Fahrig, R. France, C. R. Goldman, K. Heanue, J. A. Jones, F. J. Swanson, T. Turrentine, and T. C. Winter. 2003. *Road ecology: Science and solutions.* Washington, D.C.: Island Press.

Hartnett, D., and G. W. T. Wilson. 1999. Mycorrhizae influence plant community structure and diversity in tallgrass prairie. *Ecology* 80(4):1187-99.

Havlick, D. G. 2002. *No place distant: Roads and motorized recreation on America's public lands.* Washington, D.C.: Island Press.

Hunt, H. W., and D. H. Wall. 2002. Modeling the effects of loss of soil biodiversity on ecosystem function. *Global Change Biology* 1(8):35-51.

Korb, J. E., N. C. Johnson, and W. W. Covington. 2001. Effect of restoration thinning on mycorrhizal fungal propagules in a northern Arizona ponderosa pine forest: Preliminary results. Pp. 74-79 in *Ponderosa pine ecosystems restoration and conservation: Steps toward stewardship*, comp. G. K. Vance et al. Proceedings RMRS-22. Ogden, Utah: USDA Forest Service.

Korb, J. E., N. C. Johnson, and W. W. Covington. 2003. Arbuscular mycorrhizal propagule densities respond rapidly to ponderosa pine restoration treatments. *Journal of Applied Ecology* 40:101-110.

Korb, J. E., N. C. Johnson, and W. W. Covington. 2004. Slash pile burning effects on soil biotic and chemical properties and plant establishment: Recommendations for amelioration. *Restoration Ecology* 12(1):52-62.

Luce, C. H. 1997. Effectiveness of road ripping in restoring infiltration capacity of forest roads. *Restoration Ecology* 5(3):265-270.

Marler, M. J., C. A. Zabinski, and R. M. Callaway. 1999. Mycorrhizae indirectly enhance competitive effects on an invasive forb on a native bunchgrass. *Ecology* 80(4):1180-87.

Robichaud, P. R., J. L. Beyers, and D. G. Neary. 2000. *Evaluating the effectiveness of postfire rehabilitation treatments.* General technical report RMRS-63. Fort Collins, Colo.: USDA Forest Service.

Selmants, P. C., A. Elseroad, and S. C. Hart. 2003. Soils and nutrients. Pp. 144-160 in *Ecological restoration of southwestern ponderosa pine forests*, ed. P. Friederici. Washington, D.C.: Island Press.

Society for Ecological Restoration International. 2004. *The SER International primer on ecological restoration.* **www.ser.org/pdf/primer3.pdf**.

Switalski, T. A., J. A. Bissonette, T. H. Deluca, C. H. Luce, and M. A. Madej. 2004. Benefits and impacts of road removal. *Frontiers in Ecology and the Environment* 2(1):21-28.

Trombulak, S., and C. Frissell. 1999. Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology* 14(1):18-30.

USDA Forest Service. 2004. National Forest system fact sheet. **www.fs.fed.us/eng/road_mgt/factsheet.shtml**.

For More Information

For more information about forest restoration, contact the ERI at 928-523-7182 or **www.eri.nau.edu**.

Written by Kimberly Lowe

Reviewed by Jesse Abrams, John Bedell, Adrien C. Elseroad, Julie E. Korb, Judith D. Springer,
Joseph Trudeau, and Diane Vosick

Cover photograph by Joseph Trudeau

Series Editor Peter Friederici

NAU Printing Services/G57276/2500/06-05

NORTHERN ARIZONA UNIVERSITY

Ecological Restoration Institute
PO Box 15017
Flagstaff, AZ 86011-5017

2ERI35AE