

Rocky Mountain Research Station

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Road Scholars for the Western States: Protecting Natural Areas by Improving Road Management Research



A researcher checks the conditions of a decommissioned road on the Siuslaw National Forest in western Oregon (photo by USDA Forest Service).

In 2003, the American novelist and environmental activist Wendell Berry wrote about the differences between a path and road. “A path,” he said, “is little more than a habit that comes with knowledge of a place. It is a sort of ritual of familiarity. As a form, it is a form of contact with a known landscape. It is not destructive. It is the perfect adaptation, through experience and familiarity, of movement to place; it obeys the natural contours; such obstacles as it meets it goes around.”

Wendell Berry was much less complimentary when it came to roads, which he described in this way: “The road is a word, conceived elsewhere and laid across the country in the wound prepared for it: a word made concrete and thrust among us.”

It’s safe to say that few Americans are as critical of roads as Wendell Berry. By most estimates, the United States is home to the second largest passenger ve-

SUMMARY

A poorly placed or unsuitably designed road can result in landslides, flooding, gullies, stream damage, and wildlife habitat destruction. Particularly in natural areas, benefits of roads, such as accessibility and convenience, must be weighed against potential water quality degradation, scenic and wildlife habitat destruction, and hazardous driving conditions.

Scientists at the Rocky Mountain Research Station helped create two free tools—GRAIP (Geomorphic Road Analysis and Inventory Package) and GRAIP-Lite—to help land managers make better decisions about road management in environmentally sensitive areas. GRAIP helps land managers analyze and predict surface erosion, gully risk, landslide risk, stream crossing failure risks, and other hazards. GRAIP-Lite allows land managers to quickly compare roads and road lengths in terms of their potential impact on the environment.

Land managers in places like southwest Crown of the Continent in Montana and the Payette National Forest in Idaho are finding GRAIP and GRAIP-Lite to be useful tools for prioritizing road management projects, validating road management decisions, and building consensus among stakeholders. The tools have also been useful in context of the Legacy Roads and Trails program, Clean Water Act requirements, and the Collaborative Forest Landscape Restoration Program.



Culverts that concentrate surface water and discharge it onto steep, unstable hill slopes can contribute to landslides like this one near Verlot, Washington (photo by USDA Forest Service).

hicle market of any country in the world. If asked to consider the relationship between roads and nature, many Americans would likely think in terms of accessibility or of favorite scenic drives.

Yet there are places where roads have caused significant damage to the surrounding ecosystem. Landslides, flooding, gullies, and stream damage can all result from unsuitable road placement or design. Consequences can include water quality degradation, scenic and wildlife habitat destruction, and hazardous driving conditions. And it's important to recognize that not all roads are created equal. Rocky Mountain Research Station (RMRS) scientists estimate that less than 10% of all road lengths are responsible for more than 90% of road-related damage to the environment.

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Improving Wildland Ecosystems via Road Research

Thankfully, scientists such as Charlie Luce and Tom Black give roads and their environmental impact due consideration. As hydrologists for the Rocky Mountain Research Station Air, Water, and Aquatic Environments Program in Boise, Idaho, Luce and Black study roads and how they affect a wide range of environmental fac-

tors, including erosion, sedimentation, slope stability, and hydrology.

Luce and Black work with different teams across the western States, often in support of the Legacy Roads and Trails program, which was created by Congress in 2008 to fund USDA Forest Service projects to reduce the impacts of roads and trails on water and aquatic resources. The work of Luce, Black, and their collaborators is part of a broader effort for which RMRS has partnered with the Pacific Northwest, Intermountain, Northern, and Pacific Southwest Regions of the Forest Service along with the Bureau of Land Management to assess the effectiveness of road decommissioning and storage treatments at reducing runoff and erosion impacts of forest roads on streams.

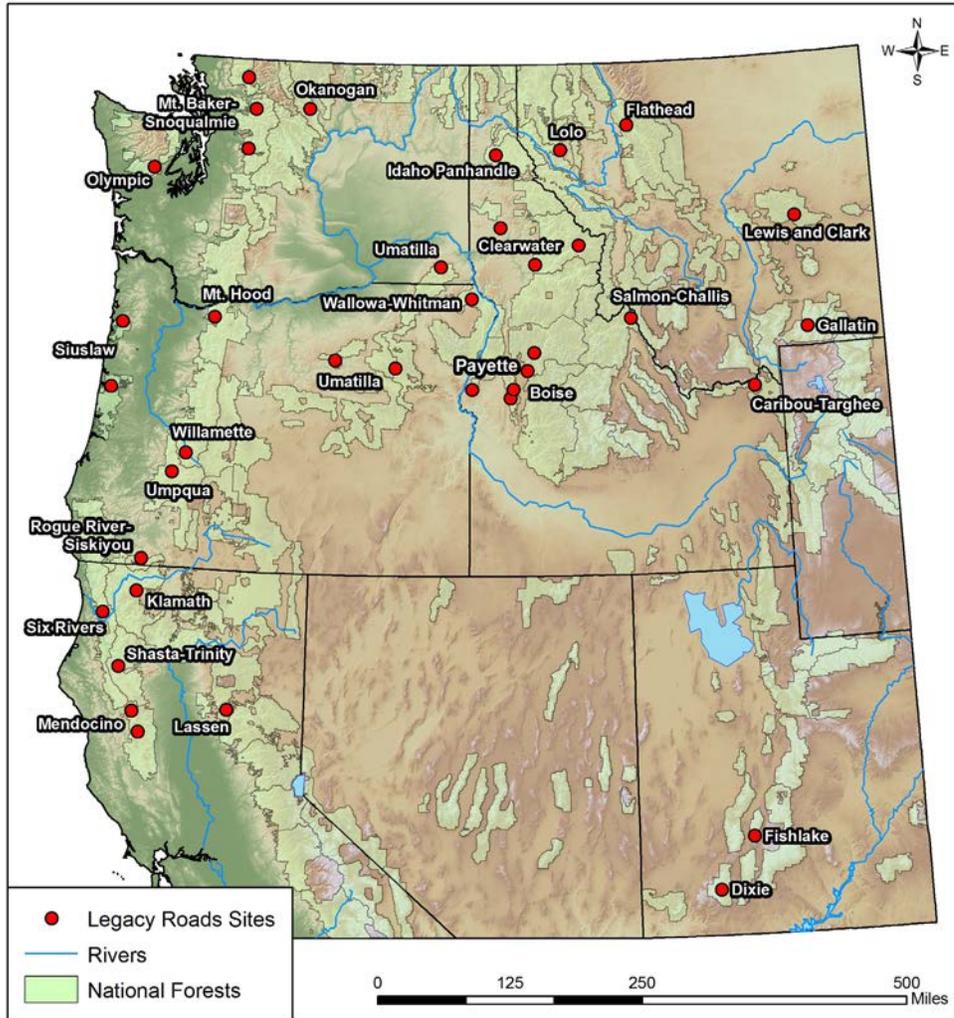
A Brief Look: Rocky Mountain Research Station's Air, Water, and Aquatic Environment Research Program

The Rocky Mountain Research Station has eight science program areas, one of which is the Air, Water, and Aquatic Environment (AWAE) Program. The expertise of AWAE scientists spans atmospheric sciences, soils, forest engineering, biogeochemistry, hydrology, plant physiology, aquatic ecology and limnology, conservation biology, and fisheries. Priorities of AWAE scientists include the development of core knowledge, methods, and technologies to help land managers provide for clean air and water, sustain biodiversity, and maintain healthy watershed conditions across the West.

In the words of Dr. Frank McCormick, AWAE Program Manager, "Natural disturbances, land management, and human expansion affect water quality and quantity and the aquatic resources. Our research explores the complex relationships among the physical, chemical, and biological properties of watersheds, the ecosystem processes that sustain biodiversity, and resource conservation and restoration."

Additional information on AWAE and its research efforts can be found at http://www.fs.fed.us/rm/boise/awae_home.shtml.





GRAIP Legacy Roads monitoring sites span national forests in California, Washington, Oregon, Idaho, Montana, and Utah (image source: USDA Forest Service).

Graip Modeling Tools for Land Managers

To help land managers evaluate the impacts of roads on their local environments, Luce and Black worked with civil engineers at Utah State University to develop a modeling tool called the Geomorphic Road Analysis and Inventory Package, or GRAIP. David Tarboton, a professor of civil and environmental engineering at Utah State University, led the development of GRAIP. According to Tarboton, “It’s a very simple model but there’s an elegance to it in that it captures

the knowledge that field surveyors find from the roads. And people keep coming back for the upgrades.”

GRAIP combines on-the-ground road inventories with a powerful GIS tool set to predict surface erosion, sediment production and delivery, mass wasting risk from gullies and landslides, stream crossing failure risks, and other hazards. GRAIP factors in various road attributes and characteristics, including road design and slope, surface material, traffic level, rainfall, soil type, local geology, and above-

and below-ground water flows. “GRAIP is useful in many places, but it provides a tremendous amount of value in places like the Pacific Northwest where there’s a lot of steep, wet country,” Black says. “It also helps reduce liability by helping to demonstrate that you’ve done your due diligence.”

The team also developed GRAIP-Lite, a geographic information system (GIS)-based tool that evaluates and compares sediment delivery from different roads. GRAIP-Lite is a less detailed, more “big-picture” approach than GRAIP, with the purpose of helping land managers prioritize road restoration projects that minimize risk and environmental damage.



Hydrologist Richard Cissel weighs sediment as part of GRAIP research in Montana (photo by USDA Forest Service).



Cost, Transportation, and Environmental Benefits

Whether a project calls for GRAIP or GRAIP-Lite, Luce says, the tools are highly cost-effective relative to the alternatives. “If you’re looking at treating a section of road in advance of an erosion event you may be looking at spending tens of thousands of dollars per mile. The cost of fixing a landslide or a washout can easily hit \$100,000 per mile or more, or you just close the road and write it off,” Luce explains. And according to Brian Staab, a hydrologist for the Pacific Northwest Region of the Forest Service, “There’s not enough money for us to treat the entire road system, so it’s crucial to know where to focus our efforts. GRAIP has also been useful as a before-and-after monitoring tool to check the effectiveness of road treatment.”

GRAIP or GRAIP-Lite are available at no cost from the Rocky Mountain Research Station. GRAIP road inventorying might take a full summer and have associated costs running to hundreds of dollars per mile. Road inventorying for GRAIP-Lite usually takes about a month and costs around \$1 per mile of road.

Both tools have helped land managers determine the locations where restoration efforts will yield the greatest benefits while meeting travel management objectives. Travel management directives require all national forests or ranger districts to designate roads, trails, and areas open to motor vehicles based on accessibility and environmental considerations. “Having a suite of tools that includes GRAIP and GRAIP-Lite can help land managers make smarter decisions and avoid making unnecessary mistakes in

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road management,” Black says. “It’s a more rigorous approach than the default methodology out there, which we like to call ‘mental GIS.’ That’s when someone just knows where all the problem areas are, and it all goes into a big binder that was started around 1950. That information can be lost or become irrelevant. By having things spatially based using GRAIP or GRAIP-Lite, it’s easier to update, share, and control the data.”

GRAIP and GRAIP-Lite also help land managers comply with the Clean Water Act’s requirements to identify impaired water sources and calculate their Total Maximum Daily Load (TMDL), which is the maximum amount of a pollutant that a water body can receive and still meet water quality standards. In a study of 52 road treatment projects where roads



Road crews use a crane to weigh sediment as part of GRAIP roadside research (photo by USDA Forest Service).

“GRAIP and GRAIP-Lite have been fabulous tools in helping land managers set priorities and reduce sediment to meet state water quality standards.” - Leigh Woodruff, Environmental Protection Agency

had been contributing to water quality issues, scientists found that road removal reduced sediment production by about 80% while road improvements reduced sediment by about 60% on average, as measured after a significant storm. According to Leigh Woodruff, Idaho TDML Program Manager for the Environmental Protection Agency, “Sediment is a big problem in the northwestern states and a lot of that sediment comes from roads. GRAIP and GRAIP-Lite have been fabulous tools in helping land managers set priorities and reduce sediment to meet state water quality standards.”

Researching Roads in Crown of the Continent

One place where GRAIP has been especially useful is the Crown of the Continent ecosystem in northwest Montana. Three times the size of Connecticut, Crown of the Continent spans 28,000 square miles of protected land, including Glacier National Park and the Lolo, Helena, and Flathead National Forests. Crown of the Continent’s biologically rich environment supports more than 1,000 native plants, 70 mammals, and 260 species of birds. From its high peaks to glaciated valleys, windswept prairies, and

Road Analysis and Inventory with GRAIP and GRAIP-Lite

The Geomorphic Road Analysis and Inventory Package (GRAIP) is a process and a set of tools for analyzing the impacts of roads on forested watersheds. GRAIP couples on-the-ground road inventories with a powerful GIS tool set to predict sediment production and delivery, risk of mass wasting from gullies and landslides, stream diversion potential, and other road impacts. GRAIP inventory and analysis methods can be locally calibrated and implemented with minimal effort, making it a powerful tool to support decision-making under a variety of environmental conditions.

GRAIP-Lite is a “big-picture,” less detailed approach to road analysis that evaluates and compares sediment delivery from different roads. GRAIP-Lite can help land managers prioritize road restoration projects that minimize environmental damage.

GRAIP and GRAIP-Lite software, frequently asked questions, publications, and other supporting information are available at <http://www.fs.fed.us/GRAIP/>.

rushing rivers, Crown of the Continent is important to naturalists, tourists, and residents alike.

Crown of the Continent contains many of the largest remaining blocks of roadless lands in the contiguous United States, but it also includes thousands of acres of

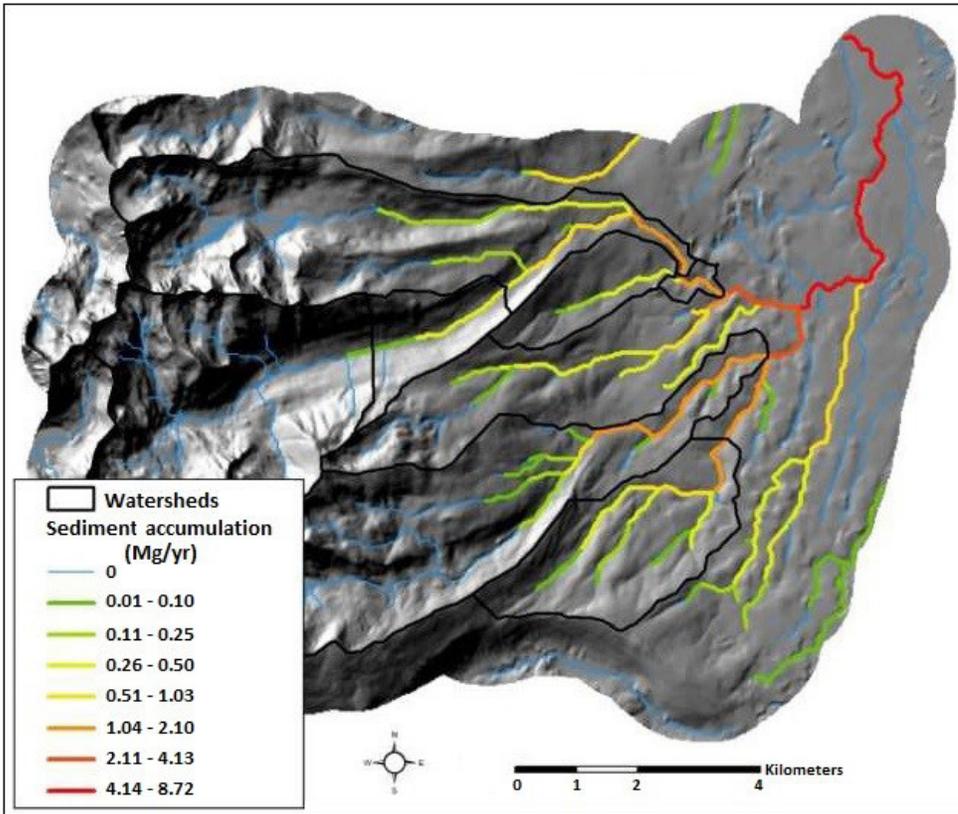
forest lands that have been heavily logged and densely roaded. Many of these areas need ecological restoration. According to Shane Hendrickson, a fisheries biologist for the Lolo National Forest in western Montana, “The southwest Crown of the Continent is considered one of the ecological hubs for the greater Continental Divide area. It also has very dynamic topography and climate, and it’s important to consider the area’s roads as part of that context.”

Using GRAIP to Support Collaboration

Managers and stakeholders of the Crown of the Continent have benefited from the Forest Service’s Collaborative Forest Landscape Restoration Program (CFLRP). Established in 2010, the CFLRP’s goal is to encourage collaborative, science-based ecosystem restoration of priority forest landscapes. According to Luce, “CFLRP helps bring a map to the table to help target funds and road testing planning.” GRAIP and GRAIP-Lite are naturally up to the task.



A GRAIP field crewmember enters survey data for a road in the Crown of the Continent ecosystem (photo by USDA Forest Service).



Sediment accumulation from road surfaces in the Cold Creek area based on a GRAIP-analysis for the Flathead National Forest in western Montana (source: Cissel and others 2014).

tion of the second largest Wilderness Area outside of Alaska. It also has an extensive timber management history. This dual heritage has resulted in highly conflicting views about management priorities. According to Rick Tholen of the Payette Forest Coalition, “One of the sticky issues, since our focus is watershed management as well as vegetation management, is that we’re trying to decommission roads—either block access or eradicate them completely. Getting agreement has been difficult, especially in small rural communities. The GRAIP model has allowed us to move forward because it demonstrates that the Forest Service is actually putting some research into its recommendations. It’s helped reestablish trust in the Forest Service.”

Jake Strohmeyer, a forest engineer for the Payette National Forest, agrees that

Goals of the Southwestern Crown of the Continent CFLRP are to restore forest and aquatic ecosystem function, to improve landscape-level biodiversity, resiliency, and adaptability, to enhance recreational experiences, and to reduce risks for those living in the wildland-urban interface. Forest Service managers and their partners are achieving these goals by reducing wildfire risk, restoring overall forest health, and reducing sedimentation from forest roads into lakes and streams. This project, which will take an estimated 10 years to complete, will include restoration efforts on nearly 200,000 acres of National Forest System land. Specific treatments include exotic species removal, planting in riverside areas, stream channel restoration, bridge and culvert upgrades and replacement, and road removal.

Hendrickson cites GRAIP and GRAIP-Lite as key parts of this effort in Crown of the Continent. “GRAIP provides boots-on-the-ground, empirical data that quantitatively validated what roads we thought were a concern and which were less of a concern,” Hendrickson said, adding, “GRAIP-Lite is more of a cursory model. It’s going to be a very useful planning tool that helps identify likely problem road segments across a large landscape.”

Creating Consensus in Payette National Forest

Payette National Forest is another area where GRAIP and GRAIP-Lite are helping land managers assess and manage forests roads. Located in western Idaho, Payette National Forest contains a significant por-



A sediment trap measures road sediment and runoff as part of the Weiser-Little Salmon Headwaters Collaborative Forest Landscape Restoration Program on the Payette National Forest in western Idaho (photo by USDA Forest Service).

“The GRAIP model has allowed us to move forward because it demonstrates that the Forest Service is actually putting some research into its recommendations. It’s helped reestablish trust in the Forest Service.” - Rick Tholen, Payette Forest Coalition

GRAIP has helped build consensus. “GRAIP has helped us with travel management in sensitive watershed areas,” Strohmeyer says. “Everyone likes having the data—both the motorized folks and the conservation folks: It puts them all on an equal playing field.” Payette National Forest hydrologist Melanie Vining adds, “We were able to use GRAIP to validate the treatments we had already suggested. It helped people overcome the perception that road elimination decisions were somewhat subjective. It also helped us prioritize funding for roads that needed to stay open.”

Roads into the Future

Luce and Black offer a 2-week training session in Boise, Idaho, every May, and webinars and manuals for GRAIP and GRAIP-Lite are also available. Basic GIS skills are helpful, but GRAIP and GRAIP-Lite inventories can be done by novices. Additional information on GRAIP and

MANAGEMENT IMPLICATIONS

- Roads in natural lands are an important part of the wildland-urban interface, but poorly placed or unsuitably designed roads can degrade water quality, reduce scenic values, destroy wildlife habitat, and create hazardous driving conditions.
- Not all roads are created equal. According to Rocky Mountain Research Station scientists, less than 10% of all road lengths are responsible for more than 90% of road-related damage to the environment.
- GRAIP (Geomorphic Road Analysis and Inventory Package) and GRAIP-Lite combine on-the-ground road inventories with a powerful GIS tool set to help analyze impacts and hazards associated with forest roads.
- Analyses from GRAIP and GRAIP-Lite can provide a scientific basis for road management decisions and help build consensus among stakeholder groups, especially when prioritizing road decommissioning and balancing ecosystem concerns with travel management and accessibility requirements.

GRAIP-Lite can be obtained by going to www.fs.fed.us/GRAIP.

Luce and Black agree that the goal for road testing in natural areas is to find a balance between safety, access, and the environment. After considering Wendell Barry’s description of roads and paths, Luce says,

“Roads need to be safe, more than anything else, but it’s important to consider their environmental impact. It’s actually an achievable vision to make our roads more like paths in that they have nearly no impact on the environment. That’s what we set out to achieve with these tools.”



A GRAIP crewmember inventories a failed stream crossing culvert on a closed road in southwestern Idaho (photo by USDA Forest Service).



FURTHER READING

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WRITER'S PROFILE



Brian Cooke is a science writer for the Rocky Mountain Research Station in Fort Collins, Colorado. He received a bachelor's degree in journalism-science writing with a minor in geology from Lehigh University. Brian's work has included articles for the National Park Service, website writing for various environmental services companies, and editorial assignments for a Bureau of Land Management contractor. Brian's science and environmental writing is frequently colored by his National Park Service interpretive training and experience as a volunteer docent for Alcatraz Island and San Francisco Maritime National Historical Park.

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The following scientists were instrumental in the creation of this Bulletin.



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TOM BLACK is a hydrologist for Rocky Mountain Research Station's Air, Water, and Aquatic Environments Program in Boise, Idaho. He holds bachelor's and master's degrees in geography from the University of California, Berkeley and the University of Colorado, respectively. His research interests include the effects of disturbance on erosion and slope stability, hillslope and watershed hydrology, forest road sediment and water issues, soil genesis, and climatic and environmental change. He has been an affiliate member of the American Geophysical Union since 1995.



DAVID TARBOTON is a professor of Civil and Environmental Engineering with the Utah Water Research Laboratory, Utah State University. He received his doctor of science and master's degrees in Civil Engineering from the Massachusetts Institute of Technology. David's research focuses on advancing hydrologic prediction by developing models that incorporate new information and technology. His group has developed a number of computer models and software packages including GRAIP, the TauDEM hydrologic terrain analysis and channel network extraction package, and the Utah energy balance snowmelt model. David is lead on the National Science Foundation HydroShare project for the development of a collaborative environment for sharing hydrologic data and models.

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