Watershed Research and Development in the USDA Forest Service

Douglas F. Ryan

Abstract

The USDA Forest Service has a long history of watershed research and development intended to address issues facing land managers. Topics of study include development and testing of forest Best Management Practices to protect water quality, instream flow studies to evaluate effects of flow alterations on stream and riparian ecosystems, and effectiveness of measures to reduce risks to water resources after wildland fires. Forest Service research watersheds serve as sites for integrated ecosystem studies, including six that are formally part of the National Science Foundation's Long-Term Ecological Research (LTER) Network. Integration of watershed studies enables results to be applied to a variety of issues including protection and restoration of habitat for endangered fish and aquatic species, and impacts of air pollution in water quality. In the future, results of watershed studies will be synthesized more widely to address management and policy issues at larger scales of time and space.

Keywords: watershed, research, forest, management, ecosystem, network

Introduction

Among the mandates that Congress gave the USDA Forest Service in its "Organic Act of 1897" was insuring "favorable conditions of water flows" from the federal lands that the agency administers. To comply with this mandate, the Forest Service began studies of the effects of land management on water quantity and quality early in the 20th century. Although methods and techniques have evolved greatly in the intervening years, the agency's interest and research in this topic continues to the present.

The objective of the Forest Service watershed research and development program is to provide a scientific basis for decisions by land managers and policy makers in the Forest Service and other federal, state, and tribal agencies, and technical assistance to managers of private lands regarding the effects of land management on water resources.

Funding for Forest Service research and development on watershed processes was $16 million in fiscal year 2002. This program is substantially an in-house effort that is carried out in collaboration with other federal agency and university scientists. A related agency program of research on fish and aquatic habitats that was funded at $7.5 million in fiscal year 2002, but that program is not the primary focus of this paper.

Program Description

Consistent with the agency's water resources mandate, a long-running focus of research in the Forest Service has been the development and testing of Best Management Practices to protect water quality during land management including practices such as timber harvesting and road building and maintenance. These studies continue to be relevant as new management practices are devised in response to new technology, increased demands to protect the environment and changing resource conditions. For example, while construction of forest roads was a major focus of research in the 1980s, over the past decade a need has emerged for environmentally acceptable methods to

Ryan is a Staff Watershed Specialist, USDA Forest Service, Wildlife, Fish, Watershed and Air Research Program, Washington, DC 20250. E-mail: dryan01@fs.fed.us.

decommission roads as national forests have come under pressure to reduce the size of their road networks. The research emphasis on roads has shifted accordingly to include studies of practices to remove roads from service and reduce the impacts of existing roads. Studies of land use effects are often classic, paired-watershed experiments in which land use on one study watershed is deliberately manipulated while a similar watershed is maintained as an unaltered reference.

Many parts of the country are experiencing an increase in competing demands for scarce water resources. Some water users, such as urban, agricultural, and industrial activities, withdraw water from streams, while others, such as instream recreation, hydroelectric power generation, and protection of aquatic and riparian habitats for fish and wildlife, require flows within stream channels. Managers and policy makers in the Forest Service and other agencies often interact with states, tribes and other agencies in decisions on how to allocate water that flows across federal land among such competing uses. An important question for land managers involved in these decisions is how much water needs to remain within the stream for "in-stream" uses? The Forest Service has research devoted to developing a scientific basis for estimating maintenance flows to protect aquatic and riparian ecosystems in streams that have their flow regime altered by water withdrawals or dam operations. These studies examine how changing stream flow affects geomorphology, sediment transport, and aquatic and riparian habitats. Studies also include assessing the economic impacts of altered stream flows on instream recreation. The Forest Service has established a technology transfer team dedicated to making the results of these studies readily available to legal teams negotiating water rights adjudications, and agency participants in Federal Energy Regulatory Commission proceedings on hydropower relicensing involving streams and rivers on national forests.

Watershed research examines the effects on water quality and aquatic habitat of processes occurring on hill slopes, in streamside areas, and in channels. This work is coordinated with research on the habitat requirements of threatened and endangered fish, aquatic organisms and wildlife in streams and streamside zones. Studies include the relationships between hydrology and geomorphology and important ecological components such as streamside vegetation, landslides and debris flows, and large woody debris that are often critical to fish and wildlife habitat. Results of these studies have been incorporated into management and policy actions that are being taken to protect and restore fish and aquatic species at risk of extinction such as the native salmon species in the Pacific Northwest.

Forest Service scientists conduct research on the effects on water resources of wildland fire and the management actions to reduce the consequences of wildland fires. Severe wildland fires can consume surface litter, and some soils can become water-repellent after their surface has been burned. As a result of these and other changes after fires, severe erosion, floods and damaging mud flows may occur immediately downstream after wildland fires. Such extreme events can pose a risk to life and property for nearby communities even after the fires are out. A science synthesis found few studies of treatments to reduce the risk to downstream assets (Robichaud et al. 2000). As a result, agency scientists have initiated investigations of the effectiveness of post-fire treatments. Preliminary results show that existing treatment techniques, such as straw wattles and log erosion barriers, can reduce the risk of erosion for low intensity rain events, but not for high intensity events. Research is continuing to develop, test and monitor new techniques to protect the public from post-fire risks. Models has been developed that incorporate research results to permit managers to evaluate post fire erosion hazard and decide which actions best reduce the risk.

A long term interest of Forest Service research has been effects of land management on water quality. An enduring focus has been the linkage between land disturbance and erosion, sediment production and deposition. Steam chemistry has been studied in relation to processes such as biogeochemistry and effects of atmospheric deposition. One of the earliest studies on effects of acid deposition, for example, was conducted at Hubbard Brook Experimental Forest that contains Forest Service study watersheds. Recent Forest Service work in Southern California has found impacts on soils and water chemistry from atmospheric deposition of pollution-derived nitrogen compounds. Responding to the Safe Drinking Water Act's requirements for states to conduct Source Water Assessments, the Forest Service published a synthesis of effects of forest management on drinking water quality (Dissmeyer 2000). This study pointed out that little information was available on the relationship between dispersed recreation and the presence of human pathogens in surface waters. To

fill this gap, Forest Service scientists formed a collaboration with the USDA Agricultural Research Service to investigate better means of detecting and studying pathogens in streams.

Forest Service experimental watersheds often serve as the sites for long-term, integrated, ecosystem studies. The Forest Service manages six Long Term Ecological Research (LTER) sites in collaboration with National Science Foundation, and numerous agency and university cooperators. These sites are Hubbard Brook Experimental Forest in New Hampshire, Coweeta Hydrologic Laboratory in North Carolina, H. J. Andrews Experimental Forest in Oregon, Luquillo Experimental Forest in Puerto Rico, Bonanza Creek Experimental Forest in Alaska, and the Baltimore Ecosystem Study in Maryland. Data from these intensively-studied sites are often used to develop and validate models of ecological processes because measurements of many interrelated environmental variables have been done over long time periods at these sites. Most of these sites were host to ecosystem-level investigations even before the NSF formally established the LTER Network in 1980. An exception is the Baltimore Ecosystem Study that was started in 1997 to investigate how a city functions as an ecosystem. Although the Forest Service does not manage the land in this urban area in the same sense that it does at most of its forested research sites, watersheds still comprise the basic unit of this urban study in ways the are similar in many respects to investigations that were traditionally conducted in forests.

Future Directions

Although an historic strength of Forest Service Research has been its focus on intensively studied watersheds, a goal for the future is to develop better ways of linking studies into networks that permit research results to be synthesized to apply at larger spatial and temporal scales. A joint effort is underway between the Forest Service's H. J. Andrews Experimental Forest and the NSF's LTER Network to develop a web-based network to provide public access to long-term hydrology data from Forest Service research watersheds and LTER sites. A search engine has been developed that permits users to find and download long-term data and metadata on steam discharge and meteorology. Twenty-three Forest Service-related experimental watersheds and additional LTER sites are in the process of linking their long-term stream flow and meteorological data and metadata to this search engine. This new resource, called "HydroDB," can be visited on the web at: http://www.fsl.orst.edu/climhy/hydrodb/index.htm. Graphical and statistical tools to display and analyze these data are being developed. Future plans include adding the capability for practical uses of these data for applications such as improving road culvert design for fish passage. Addition of other types of data such as sediment transport and stream and precipitation chemistry is also anticipated. This approach has the potential serve as a model that could be applied to many types of interrelated environmental observations. Developing this tool has been an interagency enterprise from its inception, and we welcome participation in this effort by other agencies and institutions with long-term studies. This new tool is a first step toward drawing upon the agency's investment in intensive, long-term studies to make their results more widely available for synthesis and application to larger-scale problems in the future.

Summary

Forest Service watershed research and development has long been part of the agency's response to its original Congressional mandate to protect water resources as an integral part of managing national forests. The agency has a long-running history of watershed studies designed to investigate the effects of land use practices on water quantity and quality. Over many decades these studies have evolved as public values with respect to land use have changed. An early emphasis on developing and testing Best Management Practices for timber operations continues but has refocused on new and emerging management practices. Instream flow studies seek to provide tools to help managers to evaluate flows needed to maintain viable stream and riparian ecosystems where water withdrawals and flow modifications occur on federal land. Studies of effects of wildland fire focus on estimating the effectiveness of practices to reduce post-fire flood risk and sediment flows and other post-fire remediation. Watershed studies have been incorporated into investigations of factors that are critical for protecting and restoring habitat for fish, aquatic and riparian species in danger of extinction. Forest Service watersheds have become sites of integrated ecosystem studies with six formally participating in the LTER Network. In the future Forest Service watershed research will focus on developing better ways to synthesize the agency's

long-term watershed studies to address emerging problems for decisions makers at larger temporal and spatial scales.

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