Future of Applied Watershed Science at Regional Scales

The Internet-driven evolution in communication technologies coincides with a related evolution in environmental policy and natural resource management. Resource managers must increasingly deal with expanding spatial scales of land use directives (watersheds, landscapes, states, regions) involving multiple interacting agencies and stakeholders, many with similar objectives, similar questions, and similar data and analysis needs. These factors are motivating development of community supported, application-focused watershed database and analysis systems of common structure and function across large geographic areas.

We examine this issue in the context of resource use and conservation in the Pacific Northwest region (PNW) of the United States. Competing land uses involving hydropower, urbanization, logging, and agriculture, juxtaposed with ecological needs for sustainable watershed environments, have promulgated wide-ranging resource management programs. The Pacific Northwest Electric Power Planning and Conservation Act (1980) addresses impacts on fish and wildlife of hydroelectric dams on the Columbia River, a policy area of 500,000 km^2. Affected agencies and stakeholders include the state governments of Washington, Oregon, Idaho, Montana, and Native American Tribes, NOAA-Fisheries, and the U.S. Fish and Wildlife Service.

Overlapping this large geographic area are federal forest lands along the coastal PNW where concern over the effects of logging on salmon and other species (spotted owl) led to the Northwest Forest Plan (USDA-USDI 1994). The NWFP coordinates management of lands administered by the U.S. Forest Service and Bureau of Land Management to achieve both ecosystem protection and development of forest products over an area extending from western Washington to California encompassing about 100,000 km^2. Non-governmental organizations (NGOs), such as The Wild Salmon Center, Ecotrust, and The Nature Conservancy have developed conservation initiatives across the PNW (overlapping the aforementioned administrative areas) and extending internationally along the Pacific Rim to address habitat use of far ranging species such as the Pacific salmon.

L. Benda, D. Miller, Earth Systems Institute; S. Lanigan, USFS, Portland, OR; G. Reeves, USFS-PNW, Corvallis, OR

These efforts all involve several key features: 1) common land use and conservation objectives, 2) overlapping administrative programs of multiple agencies and organizations involving multiple species, 3) similar database and analysis tool requirements, and 4) very large administrative areas encompassing landscapes, states, and regions.

Watershed science is evolving in conjunction with these policy developments. A starting point is ‘watershed analysis’- style basin assessment (e.g., Reid and McCammon 1993, WFPB 1997, OWAM 1999) that provides information to guide resource management, conservation and restoration throughout the western U.S. This technology, however, cannot be applied practicably at the large spatial scales of today’s expanded land use and environmental programs because they can be expensive and time consuming and produce information that can be geographically spotty and inconsistent from one watershed to another. Available geographically extensive databases, such as the National Elevation Dataset (http://ned.usgs.gov) and National Hydrography Dataset (http://nhd.usgs.gov/applications.html), lack key attributes relevant to watershed management, such as habitat type and abundance, and they lack analysis capabilities to characterize processes such as wildfire, erosion and riparian functions. Moreover, the analysis tools and data to obtain these and other relevant attributes are often not widely available or user friendly.

The commonalities of large-scale environmental programs in conjunction with recent advances in science and technology pertinent to the watershed sciences (e.g., fast computers, watershed process models, and advanced GIS technology) are key components in the future of applied watershed science. One aspect of that future are community supported, web-based watershed data and analysis systems having the following characteristics:

1) Computer analyses of watershed attributes (hillslope morphology, stream morphology, road networks, vegetation, climate etc.) to create geographically extensive and uniform landscape databases of common structure that can: a) cross reference other digital databases (for example, the NHD), b) incorporate data from user-supplied analyses and field efforts, and c) provide data to user-supplied models and field studies.

2) Widely available, user-friendly analysis tools that utilize the landscape database in support of resource management, including applications in forestry, grazing, fisheries, restoration, monitoring, research, and conservation.
3) The coupled landscape database and analysis tool system is community based, in which the design, maintenance and distribution are shared by stakeholders.

The watershed science community has moved in the direction of large-scale digital watershed modeling and data systems. Examples include: U.S. Geological Survey's NHD and NED, Michigan State University's Digital Watershed tool (http://www.iwr.msu.edu/dw/), Northwest Forest Plan data repository (www.blm.gov/or/gis/data.php), Oregon Coastal Landscape Analysis and Modeling Study (http://www.fsl.orst.edu/clams/), Universities allied for water research - Hydrologic Information System (www.cuahsi.org/his.html), and the 'Community Hydrologic Modeling Platform' (CHyMP) (Famigleitti et al. 2008).

This community philosophy could also be applied in an application oriented and geographically focused way that targets specific stakeholders and particular purposes. For instance, a community analysis and database system could be developed specifically for natural-resource management and associated environmental applications in the PNW region where stakeholders are connected by common land-use objectives, overlapping administrative programs, and similar database and tool requirements. User groups may include practitioners in forestry, wildfire prevention, grazing, urban planning, water supply planning, and environmental protection. Analysis tools and databases would emphasize watershed attributes pertaining to erosion, flooding, water quality, stream temperature, organic flux into streams, aquatic habitats, wildfire impacts, and watershed restoration over a range of spatial scales. The focus would be on community development of applied tools and watershed attribute databases with a specific structure and set of attributes necessary for addressing a finite set of critical issues.

Existing examples illustrate aspects of geographically focused systems. The Information Center for the Environment at the University of California, Davis (http://ice.ucdavis.edu/) provides resources for projects throughout California. Two authors of this paper (Benda and Miller) have been involved in development of NetMap (www.netmaptools.org), a coupled watershed database and analysis system designed to support resource management, restoration and conservation in the Pacific Northwest (Benda et al. 2007). Application oriented systems require the ability to communicate with larger national efforts (e.g., CUAHSI, CHyMP, NHD). This could be accomplished by utilizing universal languages, such as CUAHSI's WaterML, or by incorporating the ability to transfer data across diverse GIS systems and data layers.

Access to a uniform and geographically extensive landscape-attribute database would allow users in different places and with different questions to quickly access similar types of information in a consistent format. Use of a uniform database and set of analysis tools that analyze dissimilar watersheds in similar ways can promote common methodologies, vocabularies, and problem-solving techniques. A regional database and analysis system could support existing analysis and regulatory programs, including watershed analysis -style basin studies, EPA's TMDL programs, and state-wide habitat restoration activities.

When contributing to the development of a geographically extensive database, agencies and groups can pool their resources, thereby greatly reducing the cost of assessing watershed conditions. The increasing availability and accuracy of digital data in conjunction with computer based analyses can contribute to economic efficiency by creating prioritization strategies involving habitat restoration, road maintenance and abandonment, and pre- and post wildfire management planning over geographically extensive areas (state and national forests, landscapes, states etc.). A community-supported system of watershed data catalogues and analysis tools should also promote evolution in tool design based on needs of users.

The tools and data required for developing regional-scale watershed data and analysis platforms exist today and efforts are underway. Local projects can contribute to a community database and analysis system if data acquisition (and metadata requirements) are managed in a central (web-based) location, consistent methods are used to synthesize the data into forms usable by universal tools, and protocols for data storage and distribution are established. Initially, the system could be desktop and client based, but overtime it could evolve to a web-server based system.

Benda, L., D. J. Miller, K. Andras, P. Bigelow, G. Reeves, and D. Michael. 2007. NetMap: A new tool in support of watershed science and resource management. Forest Science. 52:206-219.

Famigietti, J.,Murdoch, L., Lakshmi, V., Hopper, R. 2008. Community modeling in hydrologic science. EOS. V. 89, 32, p. 292.

Pacific Northwest Electric Power Planning and Conservation Act. 1980. 16 United States Code Chapter 12H (1994 & Supp. I 1995). Act of Dec. 5, 1980, 94 Stat. 2697. Public Law No. 96-501, S. 885.

Reid, L.M and B.P. McCammon. 1993. A procedure for watershed analysis. Review draft prepared for the Forest Ecosystem Management Assessment Team, 14 July 1993. USDA Forest Service Region 6, Portland, OR.

Oregon Watershed Assessment Manual. 1999. Prepared for the Governor's Watershed Enhancement Board, Salem, Oregon. Watershed Professionals Network.

U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management [USDA and USDI]. 1994. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents in the range of the northern spotted owl and standards and guidelines for management of habitat for late-successional and old growth forest related species in the range of the northern spotted owl. [Place of publication unknown]. 74 p.

Washington Forest Practices Board (WFPB). 1997. Board Manual: Standard Methodology for Conducting Watershed Analysis. Washington Department of Natural Resources., Olympia, Washington.