

MANAGEMENT OF SEMI-ARID WATERSHEDS: TECHNOLOGY TRANSFER

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The Apache Maid Ranch lies nestled in the hills of central Arizona. Here, in the summer of 1955, a small group of ranchers met with a Forest Service researcher and a representative of the Salt River Project (an organization of water users in southern Arizona). The ranchers were concerned that too many trees were reducing the flow of streams and the supply of livestock forage in Arizona's National Forest.

Following this meeting, the University of Arizona was commissioned to investigate ways to improve stream flow from the state's forests and ranges. The university issued a study, "Recovering rainfall: More water for irrigation" (Barr 1956), also known as the Barr Report. The study suggested that surface water runoff from mountain watersheds might be increased by replacing high water use plants, such as trees and shrubs, with plants that use less water, such as grass.

In the 1950s and 1960s, the Arizona Water Research Program of the USDA Forest Service initiated research studies to evaluate the usefulness of watershed management techniques for increasing water yields and other multiple resource benefits within the Salt and Verde river basins of Arizona. Studies were installed at the Sierra Ancha Experimental Forest, in the White Mountain headwaters of the Salt and Black rivers, on the 3 Bar watersheds, on the Whitespar and Mingus Mountain watersheds, and on Beaver Creek, a tributary of the Verde River.

The objectives of the Beaver Creek Program were to provide land managers with facts about the effects of resource management in pinyon-juniper and ponderosa pine vegetation types and to assess land management options to develop better plans and programs. Some of the questions considered include the following: What areas should be preserved for scenic values and recreation? How should timber be harvested? Where and how much? Should livestock forage be im-

proved? Where? What will happen to water quality and quantity as a result of management actions? How will management programs affect fire hazards?

For example, various treatments applied to ponderosa pine forests included total clear-cutting, strip-cutting in uniform or irregular strips, thinning by group selection, using a combined shelterwood-seed tree silvicultural treatment, patch cutting to improve wildlife habitats, and grazing on a watershed converted to herbaceous plants.

The treatments were analyzed using the above questions. In reference to recreation, it was noted that reducing densities of ponderosa pine forests increased food while retaining protective cover for deer and elk. Total clear-cutting was detrimental to big game and Abert squirrel, although cottontail habitat can be enhanced when slash and Gambel oak thickets are retained. Reductions in the density of ponderosa pine forest overstories produced increases in the production of herbaceous plants. This may have an effect on available livestock and wildlife forage. In reference to water quantity, annual water yield increases of 1-2 inches were realized in the initial (up to 10 years) post-treatment periods. These increases in water yields diminished over time, approaching pre-treatment levels by the early 1980s. No meaningful, long-term changes in total sediment production or water quality occurred as a result of the treatments. However, the highest sediment concentrations occurred after clear-cutting, followed, in order of decreasing concentration, by strip-cutting, thinning by group selection, and the combined shelterwood-seed tree silvicultural treatment. The effects of fire can include thinning forest overstories from below, increasing seedling establishment, increasing production of herbaceous plants, and temporarily reducing fire hazard.

Research conducted during the Beaver Creek Project shows that changes in some types vegetative cover can produce changes in streamflow, at least in the short-term. Some vegetative modifications on upstream watersheds can be designed to

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increase water yields and still provide forage, wildlife, timber, and amenity values required by society. This finding is not necessarily surprising, however, as many of the management practices tested are common in principle and application to programs often employed to benefit other natural resources in a ecosystem-based, multiple-use management framework.

The land management models studied and tested at Beaver Creek were designed to be useful to land managers by meeting several criteria: First, managers can readily learn to use them with a minimum of complex data manipulation. Second, the models allow field personnel at remote locations to obtain reliable predictions, at a reasonable cost, using modest computer equipment. Third, the outputs from the models are easily displayed so that differences among management options (including economic costs and benefits) are readily identified. Finally, the models help scientists identify gaps in the knowledge of natural processes, and design research to fill those gaps.

Because of the research being conducted and the natural resource database being developed, the Beaver Creek Experimental Watershed received special recognition when it was incorporated into UNESCO's International Biosphere Reserve Program in 1978. Although the 1980s saw a decline in support for the total Arizona Water Research Program, the Forest Service continued to collect and assess data from Beaver Creek and has made this information available through various government reports. However, these reports are not widely known or readily accessible to other than a few watershed management professionals. Therefore, a project was developed to increase the accessibility of the information to a much broader audience.

This project uses a three-pronged approach to delivering information gained from the Beaver Creek Experimental Watershed. The major emphasis is to bring these resources to the public through the Internet's World Wide Web. Specifically, a Web site on the Sustainable Management of Semi-Arid Watersheds (<http://ag.arizona.edu/OALS/watershed/index.html>) is being developed that will feature the Beaver Creek data as real-life examples of what works and what does not work. The Web site is a cost-effective effort that provides integrative expertise that can be applied to other semi-arid regions in the world that might be facing similar problems.

The first phase of the site development, loading of an annotated bibliography compiled by M. B.

Baker Jr. and P. F. Ffolliott, is complete. The bibliography provides access to 652 research articles, compiled from 40 years of investigations on Beaver Creek, and is essential to linking natural resource scientists worldwide. Dating from 1956 through 1996, these references cover a wide range of topics, including climate, erosion control, water yield improvement, and silviculture.

The home page of this Web site, "Watershed Management in the Southwest, With Information from the Beaver Creek Biosphere Reserve," includes introductory topics (watersheds, watershed management, public land management, etc.) as well as in-depth information on the Central Arizona Highlands in general, and the Beaver Creek Biosphere Reserve in particular. The site also includes frequently asked questions (FAQs), an interactive training package, a discussion of current issues in watershed management, hyper-text links to other related resources on the Web, and a search engine for the site allowing visitors to locate targeted information using keywords, authors, and titles. This Web site is linked to the U.S. Forest Service, Rocky Mountain Research Station site [<http://www.for.nau.edu/usfs/rms>], the International Arid Lands Consortium site [<http://www.ialc/>] and AgNIC [<http://ag.arizona.edu/OALS/agnic/home/html>], as well as others.

The universality, flexibility, and minimal usage costs that characterize the Internet and the Web make this delivery system an optimal choice. More than 40 million people across 168 countries were wired in 1995 and forecasts predict there will be 150 million Internet users by 1998 (Gartner Group Internet Strategies Section 1996). There were more than 6.8 million documents on the Web at the end of 1995 (Panos Institute 1995). This growing use of electronic technology by people all over the world to meet their information needs provides an unprecedented opportunity for students, teachers, scientists, and information professionals to work together to bring timely and pertinent data to a broad range of users.

However, Web-based information is only useful if the whole clientele has electronic access. Therefore, we are using two additional delivery methods. We are establishing a telephone system to provide recorded information on the sustainable management practices specifically for semi-arid watersheds. The 2-minute telephone messages will in large part duplicate the information available on the Web site as FAQs. "Dial Extension" is a program from the University of Arizona Cooperative Extension; it is currently in place in Maricopa

and Mohave counties. Residents call a dedicated telephone line to access recorded information on various subjects.

Establishing the phone system involves leasing a multiple-port telephone line and electronic equipment in the Prescott office of the Yavapai Cooperative Extension, writing and recording information on watershed issues, and updating the information as needed. The project includes funding for an 800 number to provide statewide access. At the end of 3 years, we will look for other sources of support for the 800 number, or turn it into a 900 number.

We will also host two field days on the Beaver Creek Biosphere Reserve to provide experiential and hands-on learning for teachers, students, and the interested public. The educational field days will introduce the Beaver Creek Biosphere Reserve Watershed to the general public as well as initiating future educational workshops. The program will focus on four general themes: forest management, wildlife habitat and management, rangeland management and monitoring, and watershed condition and function. Rather than hearing lectures, participants will experience hands-on demonstrations, conduct experiments, and perform watershed monitoring techniques. The interactive format should promote more interaction between presenters and tour participants. Teams will conduct experiments and other activities that will also increase dialogue among members. The materials prepared for and tested at the field days will be adapted for the Web site as part of an interactive training package.

The state and local delivery systems, via phone and experiential learning at field days, provide an inclusive method for access to information. Rural inhabitants often live long distances from urban population centers and have limited access to electronic technology, making it difficult for them to participate in the information flow. Opportunities for utilizing the data are increased by providing other avenues to access information.

This project provides a unique opportunity to combine the strengths of three units: the U.S. Forest Service as a major repository of watershed management information, the University of Arizona Cooperative Extension, with its commitment

to training and information dissemination, and the University of Arizona Arid Lands Information Center for the necessary Web site management expertise.

People who will benefit from the increased availability of the Beaver Creek data include both U.S. and international professional practitioners, consultants and industry, students and faculty in universities, college, and grades K through 16, citizens involved in community development and conservation, federal, state, and local agencies, and policy makers. The three delivery methods are targeted at an international audience through the World Wide Web, a statewide audience through the telephone system, and a local audience through field days. This three-level approach has been conceived to maximize the transfer of information on issues concerning watershed management in semi-arid lands.

By bringing practical and field-tested data on watershed management to the arid world on the World Wide Web, this project provides an invaluable service to the worldwide community of practitioners, educators, and policy makers. In addition, this project seeks to make science more useful, helping the general public make better and more informed decisions concerning the use of their own natural resources. The state and local delivery systems, via telephone services and experiential learning at field days, provide not only a test forum for how to package this information for the Web, but also a means for rural inhabitants to increase their skill and knowledge levels. In summary, these three delivery methods facilitate better access to management information and technology, ultimately contributing to the increased sustainability of semi-arid watersheds.

References

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