

Contributions of the College of Agriculture, University of Arizona, to Education, Research, and Technology Transfer in Watershed Management

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Abstract.—The College of Agriculture, University of Arizona, has been heavily involved in providing research, education, and outreach concerning the management of watersheds. The Barr Report of 1956, a cooperative effort of the Salt River Project, the State Land Department and the University of Arizona, was a significant beginning that addressed the productivity of watersheds in the state and a plan of action to enhance water flows. Out of this initial effort came the formation of the Arizona Watershed Program, a state program that began to focus on watershed management activities in Arizona. Realizing the need for the university's involvement in the Arizona Watershed Program, the Arizona Board of Regents established the Department of Watershed Management at the University of Arizona, and a forestry program at Arizona State College (now Northern Arizona University) in 1958. The Department of Watershed Management became part of the School of Renewable Natural Resources in 1974, and now offers BS, MS and PhD degree programs in watershed management that are internationally recognized.

Introduction

The College of Agriculture, University of Arizona, has a long history of contributions to education, research, and technology transfer in watershed management. These contributions started with providing a leadership role in the preparation of the report that led to formulation of the Arizona Watershed Program in the early 1960s and continue to the present by providing a diversity of educational opportunities, supporting needed research investigations, and fostering the transfer of watershed-related information. Much of this history is interwoven with the history of the Arizona Watershed Program and Arizona Water Resources Committee, a citizens group that was instrumental in moving the Arizona Watershed Program to fruition, presented in the publication that was included with the registration materials for this conference. I would like to extract and expand upon a few of the more notable contributions of the College of Agriculture, University of Arizona, reported upon in this publication, starting with the Barr Report of 40 years ago.

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Barr Report

A milestone study on the conditions of watershed lands in northern Arizona in the middle 1950s culminated in what became known as the Barr Report. This report was prepared in response to a call by the people of Arizona to explore potential productivities of these watersheds and outline a plan of action to improve on these conditions where necessary. The Salt River Project, responsible for storing and delivering water and producing and supplying hydropower to the people of central Arizona, financed the study; the Arizona State Land Department furnished much of support personnel and logistics; and the University of Arizona provided scientific leadership with Dr. George W. Barr, an agricultural economist and the founder of the University of Arizona's Department of Agricultural Economics. With the assistance of Bob Humphrey, a range management specialist in the College of Agriculture, other members of the University's faculty, and a group of watershed management experts within and outside of the region, Barr and his team began their study in the winter of 1955-56.

The products of this effort, a massive document (Volume II) and a shorter summary (Volume I), both going under the title of "Recovering Rainfall — More Water for Irrigation," confirmed that the "condition" of Arizona's watersheds could possibly be improved by more intensive management practices (Barr 1956a, 1956b). These two volumes, made public in the fall of 1956, represented the first formal announcement of what was to become known as the Arizona Watershed Program.

On October 26, 1956, in an address at the Westward Ho Hotel in Phoenix, George Barr stated "The day has passed when water can be considered a mere by-product of a watershed devoted chiefly to timber and forage. Water production is now the most important use of the land...."

In their report, Barr and his team recommended that an extensive, well-coordinated action program be initiated as quickly as possible to explore the possibilities of increasing the flow of water from these watersheds into downstream reservoirs. The team believed that the time had passed when water could be considered only a un-

changeable and inexhaustible by-product of watershed lands devoted chiefly to growth of timber and livestock forage. They suggested that the proposed action program be initiated in areas where the greatest increase in water might be economically obtained, and where results of water-yield improvement treatments and costs of these treatments could be adequately evaluated. The team concluded that watershed research closely linked to the action program should lead the way to improved methods of achieving this goal — thus, the beginning of the Arizona Watershed Program.

Arizona Watershed Program

The Arizona Watershed Program was a joint initiative of the State Land Department, the Arizona Water Resources Committee (a citizens group formed to obtain public support for the Arizona Watershed Program), the USDA Forest Service (the major land management agency in Arizona), the University of Arizona, and other cooperators. The purpose of the program was to obtain and then extrapolate needed research findings on water-yield improvement potentials to operational-scale watershed management practices designed to increase water yields by manipulating vegetative cover.

Other aspects of the Arizona Watershed Program included determining the costs of water-yield improvement treatments; encouraging the development of improved methods and techniques for multiple use management practices on the state's watersheds; measuring both positive and negative effects of planned vegetative manipulations on all natural resources; making economic and social evaluations of these practices in assessing the feasibility of operational applications; and supporting watershed management research. The Arizona Watershed Program, therefore, became a focus of watershed management activities in Arizona from its inception in the early 1960s.

Arizona Board of Regents Actions

Eager to have the state's institutions of higher education become an active player in the Arizona Watershed Program, the Arizona Board of Regents took two actions in 1958 to involve these institutions in the program. Establishment of a Department of Watershed Management at the University of Arizona, Tucson, and a forestry program at Arizona State College, later to become Northern Arizona University, Flagstaff, were approved.

Department of Watershed Management

The Board of Regents accepted a gift of \$120,549 from the Charles Lathrop Pack Foundation for the study of watershed management and authorized the University of Arizona, the state's land grant institution, to establish a Department of Watershed Management in the College of Agriculture. This gift helped the College tie into other proposed work in aridlands research that was contemplated through an earlier grant of \$201,800 from the Rockefeller Foundation.

This action by the Board of Regents confirmed program authority in watershed management to the University of Arizona, with options in forest-watershed management and watershed hydrology. An existing program in Range Management, taught in the College of Agriculture since the 1920s, was also incorporated into the instructional and research structure of the Department of Watershed Management. When the new department was formed in 1958, the USDA Plant Materials Center was affiliated with the department under a grant from the U.S. Soil Conservation Service (SCS). This continued until 1962 when the Center reverted to the SCS.

The Department of Watershed Management was created largely in response to the growing public interest in managing vegetation of all types on the state's watersheds to increase water yields. The University of Arizona was directed, from the date of approval for establishing the Department of Watershed Management, to conduct instructional programs and supporting research in forestry and forestry-related subjects, and range management and other renewable natural resources fields. The University was also directed to develop the necessary information and professional capabilities for managing watersheds. In 1973, the Water Hydrology Unit of the Department of Watershed Management held the first symposium ever given on the topic of surface-mining reclamation in the West. This stimulated the funding of a number of major projects in the West by several federal agencies and the coal and copper mining industries.

School of Renewable Natural Resources

Organization of the Department of Watershed Management into a broader School of Renewable Natural Resources at the University of Arizona was approved by the Board of Regents in 1974. The purpose of the School of Renewable Natural Resources was, and continues to be, the integration of teaching and research programs primarily related to land management and to land use products. Changes brought about by the creation of the School of Renewable Natural Resources also brought together closely allied academic and public service interests. It was antici-

pated that this interdisciplinary approach to the problems of land management should be more productive with this new arrangement.

Instructional programs in the newly formed School of Renewable Natural Resources were expanded from those programs available in the Department of Watershed Management to include wildlife ecology, fisheries management, natural resources recreation, and landscape architecture, which has since moved to the College of Architecture. The Board of Regents authorized the School of Renewable Natural Resources to offer interdisciplinary degree programs in a Renewable Natural Resources Studies program in 1984. This academic orientation and emphasis remains the basic framework of the School of Renewable Natural Resources to the present time.

Water Resources Research Center

Another important component to the state's watershed-related research program is the Water Resources Research Center (WRRRC). Currently housed in the Department of Soil, Water and Environmental Science Department of the College of Arizona, the Water Resources Research Center was established in 1964, as authorized by the federal Water Resources Research Act of 1964, to facilitate research at all three Arizona universities on water-related problems of critical importance to the state and region. The foundation for the WRRRC was provided earlier by the establishment of the Institute of Water Utilization in the College of Agriculture in 1953. The Water Resources Research Center administers the federal grant program authorized by the Water Resources Research Act of 1964. Related missions include the communication of water-related research needs from researcher users to researchers, and to report research findings to potential users of that information. The Water Resources Research Center also works with public and private organizations and individuals, and provides information and services through a publications program including two newsletters, conferences and symposia, and through outreach.

Thorud-Ffolliott Report

Representatives of the Arizona Water Resources Committee approached the (then) Department of Watershed

Management in 1973 to discuss a project of vital importance to the Committee. About 15 years had passed since George Barr had completed the historic report that had made his name a byword in the annals of the Arizona Watershed Program. Since that time, millions of dollars had been spent on watershed education and research in the state. Thousands of hours had gone into the collection of extensive, and often unique, data sets depicting hydrologic conditions throughout Arizona. The Committee felt that it was time to assemble, collate, refine, and analyze all the information obtained by watershed researchers over the decade-and-a-half that the Committee and the Arizona Watershed Program had been in business, and present this collated information and its interpretation to the public. The Department of Watershed Management was asked to do the job. Thus, what became known as the Thorud-Ffolliott Report, more formally titled, "Vegetation Modification for Increased Water Yields in Arizona," was initiated.

It took Thorud, Ffolliott, and their collaborators about 18 months to prepare the report, a massive document exceeding 1,000 pages (Ffolliott and Thorud 1975). A shorter version of the report, published by the Arizona Agricultural Experiment Station, College of Agriculture, had been made available to the public earlier (Ffolliott and Thorud 1974). The report contained a detailed summary of the status-of-knowledge obtained from the Arizona Watershed Program to that time and a statement of a "theoretical maximum" water-yield improvement potential that might be obtained through implementation of hypothetical vegetation management practices. This latter statement became part of the Thorud-Ffolliott Report at the request of the Arizona Water Resources Committee, who felt such an estimate might be helpful in placing the water-yield improvement potentials of the state's watersheds into perspective.

Arizona Water Resources Committee

The College of Agriculture remains proud of its close, long-standing relationships with the Arizona Water Resources Committee throughout the existence of the latter. These mutually beneficial collaborations helped the Committee to establish working relationships with important interest groups and governmental entities in the state, region, and nation. These relationships afforded the Committee opportunities to broaden its political base and secure endorsements from decision-making influential individuals in the community.

College of Agriculture faculty members also assumed responsible roles with the Committee. The Director of the School of Renewable Natural Resources served as an Associate Member of the Committee throughout the 1970s, participating in the Committee's regularly scheduled monthly meetings. Other faculty members were also frequent guests of the Committee at these meetings, where they presented invited inputs to the Committee's agenda. The Director of the Office of Arid Lands Studies, College of Agriculture, was Vice President at the time that the Committee voluntarily terminated its existence in 1992.

Several Committee members held public office at one time or another. All of its members were civic and professional leaders in the state. Several members received national, state, professional, or academic honors and awards. One noteworthy award was the presentation of an honorary degree of Doctor of Science to Kel Fox, a founding leader of both the Arizona Watershed Program and the Arizona Water Resources Committee, by the University of Arizona. Fox, whose contributions to the Arizona Watershed Program are well chronicled (Ffolliott et al. 1998), was nominated for this honor by the School of Renewable Natural Resources, formerly the Department of Watershed Management which, in 1958, he and the Committee were instrumental in forming.

In presenting this honorary degree at the University of Arizona's commencement ceremony on May 19, 1973, Harold Myers, the (then) Dean of the College of Agriculture, remarked that Fox had "rendered outstanding service to the people of Arizona in advancing research, policies, and practices for the wise use and conservation of the state's natural resources." Furthermore, as a lawmaker, Fox helped pass legislation that promoted soil and water conservation and improved the management of Arizona's wildlife resources.

Continuing Involvement in Watershed Management

Nearly 40 years have passed since George Barr and his team of experts recommended the testing and implementation of improved methods and techniques for multiple-use management practices on Arizona's watershed lands. One result of this action has been to provide today's managers with a better, more holistic, and perhaps more realistic basis for management of the state's water and other watershed-based natural resources. In this regard, the School of Renewable Natural Resources and other faculties in the College of Agriculture continue to play an active, often catalytic role in offering and fostering water-

shed-related educational, research, and technology transfer programs to the benefit of people in Arizona and elsewhere.

Educational Programs

The School of Renewable Natural Resources continues to offer educational programs in watershed management and, more generally, integrated natural resources management. These programs have gained regional, national, and international recognition through the years (Tejwani 1985, Ffolliott et al. 1990). Degree programs are available at the BS, MS, and PhD levels in the School of Renewable Natural Resources.

The BS program curricula present basic knowledge of principles and techniques for a wide range of watershed-related subjects. BS programs also outline approaches to integrating these "building blocks" into technically-sound packages for practical applications of watershed management. MS programs present, in greater depth, available knowledge of principles, methodologies, and techniques in a watershed management field of interest. Additionally, students acquire conceptual and technical skills to develop new technologies in watershed management. PhD programs, consisting largely of research orientations, aim at finding solutions to fundamental problems. Basic knowledge that permits development of "path-breaking" techniques in watershed management is also expanded through these programs.

The School of Renewable Natural Resources, together with other faculties in the College of Agriculture and faculties from other universities, has also offered short-term technical training courses focusing on watershed management to targeted professionals regionally, nationally, and globally. These training courses are structured more toward imparting technical knowledge and "here's how" information. A body of proven and locally adapted methods and techniques for integrated land management systems involving hydrology, forestry and rangeland management, and agriculture is presented in these courses.

The capability of the School of Renewable Natural Resources to offer a breadth of training and education in watershed-related areas was very much enhanced during the period from 1969 to 1976, when the Department of Watershed Management, and then the School, received an annual 211d institutional grant from the U.S. Agency for International Development to strengthen university watershed management competency.

Such institutional building provided the underpinning for a six-week technical training course that the School of Renewable Natural Resources conducted for nearly 15 years that was titled "Resource Development of Watershed Lands," offered in cooperation with the Office of

International Cooperation and Development, U.S. Department of Agriculture to mid- and upper-level professionals from largely developing countries throughout the world. A theme of this course was "training of trainers," a concept that resulted in a cadre of nearly 300 professionals who subsequently trained people in watershed management in home-country settings.

Shorter, largely *ad hoc* training courses on a variety of watershed-related topics have also been, and continue to be, offered by faculty of the School of Renewable Natural Resources to professionals in the United States and internationally, with the assistance of faculties in the College of Agriculture and other universities in many instances. Titles of these training courses, structured largely to meet in-country needs include "Watershed Management and Environmental Monitoring," "Integrated Watershed Management," "Watershed Instrumentation and Measurements," and "Forest Hydrology Modeling." In addition to offerings on campus, venues for the courses have included the Philippines, Thailand, Indonesia, India, China, Mexico, Honduras, Panama, Zimbabwe, Jordan, and Israel. Among collaborating sponsors have been the U.S. Agency for International Development, CARE International, the Farmer-to-Farmer Program, Partners of the Americans, and other non-governmental agencies; UNESCO's Man and the Biosphere Program, the Food and Agriculture Organization (FAO) of the United Nations, the United Nations Development Programme, and the World and Asian Development Bank; and numerous regional and national governmental agencies in this country and abroad. These training courses are often offered for continuing-education credit from in-country educational institutions.

Research Programs

One of the more valuable outcomes of the watershed research programs in the state has been the opportunities for long-term monitoring and continuing evaluations of the resulting databases describing vegetative manipulations on watershed lands. A more responsive, more holistic management-framework for conservation and the sustainable use of natural resources on the state's watersheds has often evolved from these evaluations. These databases are unique in their "multi-resource character" by describing the dynamics of the diverse ecosystems studied. Information of this kind has, and continues to, become increasingly important in attaining a better understanding of how ecosystems on the state's watersheds function through time — information that today is at a "high premium" in planning to accommodate people's demands for better long-term ecosystem management.

Many of the databases are available today for additional analyses because of efforts made by researchers to protect the original maps and aerial photos, inventory sheets, and file copies of summaries. Faculty and students in the School of Renewable Natural Resources have helped to computerize many of these databases, making them easier to store, retrieve, and analyze as a basis for future studies of hydrologic processes and land management on watershed lands.

Research sites comprising the framework for the Arizona Watershed Program continue to be "outdoor laboratories" for faculty and students in the School of Renewable Natural Resources and elsewhere in the College of Agriculture to further investigate how land management practices impact forage, wildlife, water, and wood resources, and amenity values such as the scenic beauty of the state's landscapes. As the mixture of these benefits and values changes through time, the emphasis placed on the newly formulated studies can also change.

The College of Agriculture has recently added the V Bar V Ranch, located in north-central Arizona within the Beaver Creek watershed drainage, to the list of outdoor laboratories for education, research, and extension activities. Studies focusing on water and range restoration, riparian ecology, soil-vegetation relationships, livestock grazing practices, and wildlife habitat improvement are found on the V Bar V Ranch, a working ranch typical of those operating in north-central Arizona. The USDA Forest Service is responsible for managing the land, while users in the private sector share the responsibility for keeping the land healthy.

Technology Transfer Activities

One of the more lasting contributions of the Arizona Watershed Program is the large number of technical publications that resulted from the research efforts and following action programs; many of these publications have been authored or jointly authored by faculty and students in the College of Agriculture. An annotated bibliography of research on the Beaver Creek watersheds, compiled by a USDA Forest Service researcher and a member of the School of Renewable Natural Resources faculty, represents one example of the lasting value of the Arizona Watershed Program (Baker and Ffolliott 1998). This bibliography, consisting of nearly 670 citations of publications processed between 1956 and 1996, furnishes a valuable informational-base for the formulation of future research projects by faculty and students in the School of Renewable Natural Resources, College of Agriculture, and elsewhere.

Another major technology transfer effort was initiated by the College of Agriculture and USDA Forest Service in 1997 to deliver information generated by the Arizona Watershed Program, and more specifically the Beaver Creek Project, to a broader audience than previously possible (Young and Baker 1998). One phase of this project consists of bringing this information to the public through the World Wide Web. A Web site entitled the "Sustainable Management of Semi-Arid Watersheds" features the Beaver Creek references included in the recently compiled bibliography as real-life examples of what works and what does not work. The home page, titled "Watershed Management in the Southwest," includes topics on watershed management practices; order forms to obtain technical references on watershed management practices; and an interactive learning package on watershed management practices. Other technology transfer mechanisms with ties to the Web site are also available. A telephone system provides students, teachers, and others with recorded two-minute messages on sustainable management practices for watershed lands in arid and semi-arid environments. Field days to watershed sites are also scheduled to introduce the general public, including students and teachers, to forest management, wildlife habitat management, rangeland management and monitoring, and watershed condition and function, and to initiate future educational workshops.

This three-pronged technology transfer project provides a unique opportunity to combine the strengths of three units — the University of Arizona Cooperative Extension with its commitment to information dissemination and training; the USDA Forest Service as a major repository of watershed management information; and the University of Arizona Arid Lands Information Center for the necessary Web site management and expertise.

A Final Comment

Water is the lifeblood of Arizona. The appropriate management of watersheds is imperative to our future for water management and for important ecological and environmental concerns that contribute to the quality of life in our state. The University of Arizona, as the state's land-grant university, has been heavily involved in watershed management via its School of Renewable Natural Resources. The school's tripartite mission of education, research, and outreach has served the state well in the past. We look forward to continuing to better understand and manage Arizona's watershed in the future.

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