ARIZONA WATERSHED MANAGEMENT PROGRAM

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ABSTRACT

Formed in the early 1960s, the Arizona Watershed Program was a joint initiative of the State Land Department and the Arizona Water Resources Committee. The program worked with the USDA Forest Service and others to obtain and extrapolate research findings related to integrated watershed management practices designed to increase water yields by manipulating vegetative cover. Other program goals included measuring the positive and negative effects of the vegetative manipulations on all natural resources and economically evaluating the manipulations. The Forest Service, other governmental agencies, and their cooperators, implemented many research projects throughout the vegetative types in the Salt and Verde River Basins and elsewhere in Arizona to meet the program goals. The Arizona Watershed Program attempted to solve the age-old problem of rainfall conservation in an arid environment. The history of this milestone program is presented in this paper.

INTRODUCTION

Two events were the stimulus for the creation of the Arizona Watershed Program—a meeting of ranchers who were concerned about the conditions of Arizona's watersheds and a field trip to inspect the condition of the watersheds. In the summer of 1955, Dave Wingfield invited his longtime friend and neighbor Kel Fox, who was to become the leading light of the Arizona Watershed Program, to attend a meeting. The purpose of this meeting was to listen to a novel idea introduced by Wingfield, Jake West, an employee of the Salt River Project (a project that provides water to central Arizona for agricultural, municipal and industrial uses, and electricity) and Joe Arnold, a researcher with the USDA Forest Service. Their thought was that water and other products from and uses of Arizona's watershed lands could be increased if the watersheds were intensively managed.

Wingfield had noted entries in his diary that indicted forage production had decreased significantly over the previous 50 years. West had studied the record of rainfall and related runoff for the same 50 years that showed a steady decline in water yields. Meeting attendees decided that it was probable that the steady increase in trees and shrubs on the watersheds contributed to the decline in forage and water. Someone in the group suggested that they invite members of Congress and the State Legislature, representatives of the land management agencies, and the media on a field trip to investigate a representative site.

The field trip to the Long Valley area near Clint's Well in 1955, was a success. Among those that attended were Senators Carl Hayden and Barry Goldwater, Congressman John Rhodes, several members of the Arizona Legislature, upper managers of the Salt River Project, and representatives of the media. The field trip generated support for a study of the conditions on the Salt and Verde watersheds. The Salt River Project financed the study, the Arizona State Land Department provided the personnel, while the University of Arizona contributed George Barr, an agricultural economist, to provide the scientific leadership. Looking toward the future, Fox saw the need for additional funds to conduct the anticipated recommendations of Barr and his colleagues. Accordingly, he drafted a bill containing the necessary appropriations for submission to the State Land Department.

BARR'S STUDY

Barr and his team spent the summer of 1956 touring the Salt and Verde watersheds. By late summer, Barr handed Arnold and Fox his completed report, *Recovering Rainfall—More Water for Irrigation*, a massive document (Volume II) (Barr 1956a) plus a shorter summary (Volume I) (Barr 1956b). The report, commonly called the Barr Report, confirmed that Arizona's watersheds were in serious condition. The report provided the scientific impetus to test the group's belief that intensive management practices, especially vegetative modifications, could improve the condition of the watersheds.

Barr's team recognized the importance of the Salt and Verde watersheds for their ability to provide water, timber, grazing, wildlife, and outdoor recreation. They also thought that the greatest increase in water yields from vegetative manipulations would be obtained from those parts of the Salt and Verde watersheds that were at the highest elevation, where precipitation is the greatest. Therefore,

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emphasis was placed on the ponderosa pine and mixed-conifer forests growing at higher elevations. The team also recommended implementation of silvicultural treatments along stream channels and on poor timber-producing sites. Substituting grass and other drought-tolerant forage plants, that could generate additional water from the extensive pinyon-juniper woodlands, was also considered important.

The team felt that the hydrologic effects of controlling chaparral shrubs were speculative, because of the limited watershed research done in that vegetative type. Removal of the chaparral might reduce interception and transpiration losses and result in increases in water yields, but typically the low amount of rainfall would limit the amount realized. Although the team recognized that streamside losses that occur when water flows from the point of production to the reservoirs might be large, any reductions in these losses would mean substantial savings. They believed that replacing the deep-rooted trees and shrubs with shallow-rooted herbaceous cover would greatly reduce evapotranspiration losses in the riparian corridors.

Barr and his team recommended that an extensive, well-coordinated action program be initiated to increase the water yields from Arizona's watersheds (Barr 1956a). They knew that water was not an unchangeable and inexhaustible byproduct of a watershed devoted to timber and forage growth. A program was implemented first in areas where the greatest increase in water might be economically obtained, and where results of water-yield improvement treatments and costs could be adequately evaluated.

ARIZONA WATER RESOURCES COMMITTEE

Commissioner Ernst suggested the formation of a citizens committee to implement the programs recommended by Barr's team. Arnold and Fox organized a policymaking committee to work with the Watershed Management Division of the State Land Department. Over the next 20 years or so, the committee would help to raise more than $80 million (2002-2001 dollars) in federal, state, and private funds for watershed programs in Arizona. Immediately after it was organized, the committee had to decide whether to implement Barr's recommendations on improving water yields from watershed lands or to test the concepts before recommending their adoption. The latter approach was selected and Arizona Watershed Program was born (Fox et al. 2000).

ARIZONA WATERSHED PROGRAM

The Arizona Watershed Program was a joint initiative of the Arizona Water Resources Committee and the State Land Department. The focus of the program was to work with the USDA Forest Service, their cooperators, and others to obtain and extrapolate research findings on water-yield improvements designed to increase water yields by manipulating vegetative cover. Other objectives of the program included determining the costs of water-yield improvement treatments, encouraging the development of improved methods and techniques for multiple-use management practices on Arizona's watershed lands and conducting economic evaluations of these practices, and supporting watershed management research.

At one of their first meetings with the Committee, Fred Kennedy, Regional Forester, Southwestern Region, Forest Service, announced his decision to set aside 250,000-acres of the Coconino National Forest for the planned research. This area would later be known as the Beaver Creek Project (Worley 1965). Ray Price, Director, Rocky Mountain Forest and Range Experiment Station, Forest Service, supported the Beaver Creek Project, which was primarily in the ponderosa pine (*Pinus ponderosa*) forests and pinyon-juniper (*Pinus-Juniperus*) woodlands. Price also asked the Committee to endorse research efforts in the high-elevation mixed-conifer forests in eastern Arizona and the chaparral shrublands scattered on lower elevations throughout Arizona.

The partnership between Kennedy and Price, and the Arizona Water Resources Committee was to last for the next decade or so. However, the decision to work together toward a common goal needed more than a dedicated partnership. Funding was needed to conduct the research that Kennedy and Price envisioned. Senator Carl Hayden's belief in the goals of the program, and his commitment to Arizona, provided the financial resources needed to realize the vision.

CARL HAYDEN

Hayden, among the dignitaries who attended the first watershed field trip to Long Valley in 1955, understood the significance of the proposed research. When Kennedy and Price recommended Beaver Creek as the site for the initial watershed experiments, Hayden successfully obtained the first appropriation. The Committee added a second project in the chaparral shrublands to the list, and sent Hayden a letter asking for additional funding.

Again, the Senator procured the needed funds, as he did on many future occasions. Encouraged by Hayden's support, the Committee expanded its horizons, and other federal and state agencies and stakeholders began to participate and support the research effort.

WORKING WITH AMERICAN INDIANS

The Committee sponsored two large projects on the White Mountain Apache Reservation, one on Corduroy Ridge and another on the Cibecue watershed. The first project was a pinyon-juniper woodland-to-grass conversion treatment, while the second was a combination of pinyon-juniper woodland and chaparral shrub conversion. Senator Hayden was again instrumental in obtaining the needed funding, the Bureau of Indian Affairs furnished the equipment to implement the project, the Tribe provided the necessary labor, and the U.S. Geological Survey (USGS) monitored the runoff. Although all parties performed as agreed upon, the results of the conversion treatments were inconclusive.

U.S. GEOLOGICAL SURVEY

Committee members were interested in determining how much water was transpired and lost to runoff in dense stands of cottonwoods (*Populus fremontii*) and other tree species that made up the higher-elevation riparian ecosystems, which were mentioned in the Barr Report as having a great potential for increased water yields. The area chosen for the cottonwood study was a 3-mile reach of Cottonwood Wash, a perennial stream in Mohave County near the Yavapai County line. The USGS built the gauging stations, treated the vegetation, and monitored the results as its contribution to the effort. The Salt River Project and the State Land Department assumed the costs. The study successfully produced benchmark estimates on transpiration losses from riparian plant communities. The Salt River Project used the results from this experiment as the basis for treating hundreds of acres of cottonwoods along the Verde River to reduce water consumption by riparian ecosystems.

Another USGS effort occurred on the Middle Gila Project on a reach above San Carlos Dam. This project involved measuring transpiration losses from saltcedar (*Tamarix ramosissima*), an introduced tree species that grows extensively within Arizona's riparian ecosystems. Results showed that substantial savings in water was possible by controlling saltcedar. However, the results of this research effort were not implemented due to opposition from sportsmen and wildlife advocates who were concerned that the clearing process would destroy wildlife habitats.

USDA FOREST SERVICE

The Forest Service was the most active supporter of the Arizona Watershed Program. The agency's interest manifested itself in research and action projects throughout the national forests of Arizona. The largest effort was the Beaver Creek Project located south of Flagstaff. Beginning in 1957 and continuing into the early 1970s, various vegetative manipulations were applied to watersheds in the pinyon-juniper woodlands and ponderosa pine forests on Beaver Creek. The treatments were monitored to evaluate their effect on water yields and other multiple-use values.

Beaver Creek Project

As predicted, the results from the treated pinyon-juniper woodland watersheds on Beaver Creek showed only a modest increase in water yields from this vegetation type. The only exception was on a watershed where an aerial application of herbicides had killed the overstory trees. However, since these chemicals were later withdrawn for use in land management due to concerns about their environmental effects, prospects for increasing water yields from the pinyon-juniper woodlands did not appear encouraging. Results from the treated ponderosa pine forest watersheds were more promising. Most of the treatment prescriptions —thinning, strip-cutting, clearing—that were applied to ponderosa pine forests showed increases in water yields in the years following treatment implementation. It also appeared that the treatments tested would be beneficial to other multiple-use values (Brown et al. 1974). However, the duration of these treatment effects on water yields and the other watershed resources were largely unknown.

Beaver Creek developed into a multiple-use evaluation effort in the early 1970s when planners and managers of timber, livestock forage, wildlife, and recreation, and other amenities expressed concern about the scarcity of water resources. The multiple-use, multidisciplinary orientations on Beaver Creek were in accord with a policy adopted by the Arizona Water Resources Committee, which was based on the Multiple Use and Sustained Yield Act of 1964.

Other Forest Service Research Efforts

Although the Committee was proud of the fame achieved by the Beaver Creek Project, members were also proud of the lesser known, but equally

important, collaborative efforts with the Rocky Mountain Forest and Range Experiment Station. Chaparral shrublands, largely ignored by Barr's team, were a focus of the Arizona Watershed Program. The first investment in chaparral research yielded greater dividends than those reported from the ponderosa pine forests. Unexpectedly high water yields were observed following the conversion of chaparral shrubs to a cover of herbaceous plants on the Three-Bar Experimental Watersheds, near Roosevelt Lake. The vegetative manipulations for water-yield improvement in the high-elevation mixed-conifer forests was another Committee interest addressed by the Rocky Mountain Forest and Range Experiment Station. Research in these forests, with their high precipitation, promised results as significant as those obtained on the chaparral shrublands. Silvicultural treatments in the mixed-conifer forests included single-tree and group selection methods and partial clearings to duplicate the forest management practices of the late 1960s and early 1970s. Water yields and other multiple-use values increased in the short-term from these treatments. The duration of these effects is unknown.

JOHN J. RHODES

When Senator Hayden retired from Congress, the Committee turned to another member of Congress from the Phoenix area, John Rhodes of Mesa. Rhodes was also among those who had visited Long Valley and, like Hayden, his specialty was securing appropriations. Hayden, a Democrat, had risen to the chair of the Appropriations Committee in the Senate. Rhodes, a Republican, was the ranking Minority member, which was a position of power and influence. The following incident illustrates how well Rhodes wielded that power.

Carl Wenger and Bill Hurst, who replaced Price and Kennedy as Rocky Mountain Forest and Range Experiment Station Director and Regional Forester, respectively, came to the Committee in the early 1970s with a sad story. Increasing inflation and the expanding work throughout the Arizona Watershed Program research locations, was depleting the coffers. Not wanting to curtail research, the Committee wrote to Rhodes requesting an increase of $400,000 in the annual appropriation. Believing in the value of the effort, Rhodes succeeded in procuring an increase of $600,000 plus the additional requested $178,000 for Forest Service administration.

ARIZONA WATER COMMISSION

As State Land Commissioner, Andrew Bettwy felt that the language in the earlier legislation did not justify the annual appropriations that were necessary to maintain the Watershed Management Division within his organization. He terminated the division, and its connection with the State Land Department. However, before the division closed its doors, the State Legislature decided to consider a bill to create a water commission in Arizona. The Committee voted to endorse a Arizona Water Commission bill, if it referenced the role of watershed management. In 1971, the State Legislature reorganized and expanded the Arizona Interstate Stream Committee, restructuring it as the Arizona Water Commission. The membership, powers, and duties of the Arizona Interstate Stream Commission were transferred en bloc to the new commission.

The Arizona Water Resources Committee ended its relationship with the State Land Department and began a relationship with the Arizona Water Commission. During the transition, the policymaking role of the Committee, and its quasi-public position, was modified. The Commission, rather than the Committee, now began officially to assume the state's role in watershed management programs (Fox et al. 2000).

A SETBACK

An agreement had been signed in 1964 between the Salt River Project and the Forest Service to rehabilitate the Salt and Verde watersheds. The first projects to convert pinyon-juniper woodlands and chaparral shrublands to herbaceous plant covers to improve forage production and increase water yields were initiated. As part of a rehabilitative program to reduce the densities of the chaparral stands in the foothills of the Pinal Mountains, a helicopter, hired by the Forest Service, sprayed herbicides on a stand of chaparral shrubs in June 1969. The routine operation used a chemical mixture dominated by the herbicide known as 2,4,5-T. Since 1965, similar operations had often been performed at locations on the Tonto National Forest.

On Sunday morning, June 8, 1969, a longtime Globe resident said she "stepped outside (her) bedroom door . . . and was covered with a spray mist from a helicopter flying over (her house) located at the foot of the Pinal Mountains." On that same day, a resident of nearby Kellner Canyon thought he saw a sudden gust of wind carry droplets of 2,4,5-T and the other chemicals into his yard, where they fell on his farm animals. A group of area residents subsequently endorsed a proposal, which they sent to the Salt River Project and the Forest Service, calling for the immediate cessation of all vegetative spraying on the Pinal Mountains. A lawsuit alleging that the herbicides sprayed in the Pinal Mountains caused malformations in farm animals in the Globe vicinity was filed a year after the spraying incident. Resi-

dents filed suit against Dow Chemical, the manufacturer of the herbicide, the Salt River Project, and Arizona Helicopters, Inc., claiming negligence, and these entities, along with the Forest Service, were named as defendants. Due to the lawsuit and adverse publicity, the Forest Service stopped all planned conversion projects, which were intended to be the first operational water-yield improvement projects of the Arizona Watershed Program.

THORUD-FFOLLIOTT REPORT

Some months later, members of the Arizona Water Resources Committee met with Dave Thorud, Head of the Department of Watershed Management, University of Arizona, to discuss a project of vital importance. The Committee felt that it was time to assemble and analyze all the information gleaned by watershed researchers over the decade-and-a-half that the Committee and the Arizona Watershed Program had been collaborating. The Committee also felt that it was time to change the focus of the Arizona Water Program from research to application. The Department of Watershed Management was asked to help, and Thorud agreed that a working relationship was needed. The association between the Committee and the Department was the seed that would bear the fruit *Vegetation Modification for Increased Water Yields in Arizona*, a publication informally known as the Thoroud-Ffolliott Report (Ffolliott and Thorud 1974, 1975).

Thorud, Ffolliott, and their associates worked for about a year preparing a report, which was a massive document that came off the press in 1975. A shorter summary, *More Water for Arizona*, prepared by the Committee and the Arizona Water Commission, was also available to the public. Bill Hurst, the Southwestern Regional Forester, commented that the report "constitutes an excellent summary of the knowledge available on water-yield possibilities from the major vegetative types in Arizona." He continued, "this information will be extremely helpful to land managers in developing management objectives for specific areas of land during the planning process" (Fox et al. 2000).

BATTLE FLAT

The need to test and refine chaparral ecosystem management for shrubland-grassland mosaics to increase multi-resource outputs became a critical issue by the mid-1970s. Earlier research on the Three-Bar Experimental Watersheds had shown that improvements in water yields were possible through conversion of chaparral shrublands into less water-consuming herbaceous plant cover. Consequently, what became known as the Battle Flat Pilot Application Program was initiated as a prototype chaparral management project in 1977. The Battle Flat study site, an area of about 3,800 acres near Prescott, Arizona, contained a dense chaparral cover on a mixture of volcanic, granite, and alluvial soils. The site was grazed by livestock, provided habitat for a variety of wildlife species, and was used for hunting, hiking, and horseback riding. Battle Flat is not as steep as most chaparral shrubland in Arizona, although its terrain was suitable for testing the proposed conversion treatments and then demonstrating the results of these treatments to the public.

Forest Service researchers, and their cooperators, developed the baseline data sets and predictive models for future treatment evaluations during the pretreatment calibration period. Researchers planned to treat smaller watersheds, whose treatment responses had been predicted by the models, and to conduct a large-scale treatment involving an optimal shrubland-grassland mosaic pattern placed on the ground. Although inventories and studies were undertaken as prescribed, the mosaic treatment of the entire watershed on Battle Flat Creek was not implemented, largely because of the controversy about using herbicides to treat watersheds. On the smaller watershed that was treated, prescribed burning only temporarily reduced the shrub-cover. The researchers determined that prescribed burning was not a feasible alternative to the use of herbicides in converting chaparral shrublands because of the subsequent need to control the post-fire sprouting and the study ended.

CURRENT SITUATION

In the early 1980s, the Rocky Mountain Forest and Range Experiment Station examined the status and resulting benefits of the existing experimental watershed studies in relation to their contributions to watershed-related research in Arizona. As a result of this review, the station decided to consolidate its watershed-related research in Arizona into a research project in its Tempe, Arizona, office. The tasks of this project included studying the effects of fire on soil nutrients in the pinyon-juniper woodlands and chaparral shrublands of Arizona, examining erosional processes and rates in these ecosystems, and investigating the effects on water quantity and water quality in areas of high precipitation when high-density chaparral shrublands are manipulated. The project's personnel continued to evaluate the effects of vegetative manipulations on water yields from Arizona's watersheds.

A meeting was convened in Tempe in November 1983 to discuss the future of watershed research in the state, particularly the status of the experimental watersheds. Attending were members of the

Arizona Water Resources Committee, researchers from the Rocky Mountain Forest and Range Experiment Station, and representatives from the Salt River Project and the State's universities. At the meeting, it was decided that the USGS would monitor Watershed 13 in the ponderosa pine forests on Beaver Creek because the watershed was being considered for congressional designation as a Research Natural Area. However, except for the two large watersheds, Woods and Bar M Canyons, which had been set aside for pilot applications, research on the remaining Beaver Creek watersheds was stopped. The USGS continued streamflow and precipitation measurements on Watershed 13 through October 1992, when all measurements were terminated. The area never became a Research Natural Area. Northern Arizona University continues to measure streamflow and precipitation on the watersheds on Woods and Bar M Canyons.

The decisions reached at the Tempe meeting also affected research efforts on other watersheds in Arizona. The Three-Bar Experimental Watersheds were immediately canceled. Streamflow and precipitation measurements continued on the Whitespar Watersheds, in the chaparral shrublands near Prescott until October 1988, when they also ended. The Workman Creek watersheds in the mixed-conifer forests on the Sierra Ancha Experimental Forest were cancelled. However, the Forest Service reactivated the monitoring work on the Workman Creek Watersheds in July 2001 to evaluate the effects of wildland fire on streamflow regimes. The Rocky Mountain Forest and Range Experiment Station continued taking precipitation and other meteorological measurements at the Sierra Ancha Headquarters until the middle of the 1990s, when Arizona State University assumed the task. Streamflow and precipitation measurements on the Castle Creek Watersheds, in the ponderosa pine forests of the White Mountains, continue to be taken by the Apache-Sitgreaves National Forest. The watersheds were then released as experimental areas to the Apache-Sitgreaves National Forest, who incorporated them into their forest planning process.

FINAL THOUGHTS

A significant amount of the application envisioned by the Arizona Watershed Program were not conducted as intended. Changing societal values limited the adoption of the management practices proposed in 1956. However, the Arizona Watershed Program established a research-base to build upon the proposed management program offered by Barr's team of experts, although hydrologic limitations and multiple-use concerns constrain the operational implementation of these finding. Other limitations, such as those on timber harvesting and livestock grazing, continue to constrain management activities on Arizona's watershed. The early goal of the Arizona Watershed Program to increase water yields from watershed lands through intensive management practices, especially vegetative manipulation, has been tempered by the passage of time and placed into a current perspective.

AUTHORS' NOTE

A more comprehensive history of the Arizona Watershed Program is in *More Water for Arizona: A History of the Arizona Watershed Program and the Arizona Water Resources Committee*, by Kel M. Fox, Peter F. Ffolliott, Malchus B. Baker, Jr., and Leonard F. DeBano, published in 2000.

LITERATURE CITED

Barr, G. W. 1956a. *Recovering rainfall: More water for Arizona. Part II.* Department of Agricultural Economics, University of Arizona, Tucson.

Barr, G. W. 1956b. *Recovering rainfall: More water for Arizona. Part I.* Department of Agricultural Economics, University of Arizona, Tucson.

Brown, H. E., M. B. Baker, Jr., J. J. Rogers, W. P. Clary, J. L. Kovner, F. R. Larson,, C. C. Avery, and R. E. Campbell. 1974. *Opportunities for increasing water yield and other multiple use values on ponderosa pine forest lands.* USDA Forest Service, Research Paper RM-129.

Ffolliott, P. F., and D. B. Thorud. 1974. *Vegetation management for increased water yield in Arizona.* Arizona Agricultural Experiment Station, University of Arizona, Tucson, Technical Bulletin 215.

Ffolliott, P. F., and D. B. Thorud. 1975. *Water yield improvement by vegetation management: Focus on Arizona.* U.S. Department of Commerce, National Technical Information Service, PB246 055/AS.

Fox, K. M., P. F. Ffolliott, M. B. Baker, Jr., and L. F. DeBano. 2000. *More water for Arizona: A history of the Arizona watershed program and the Arizona Water Resources Committee.* Primer Publishers, Phoenix, AZ.

Worley, D. P. 1965. *The Beaver Creek watershed for evaluating multiple use effects of watershed treatments.* USDA Forest Service, Research Paper RM-13.