WATER RESOURCES RESEARCH ON FOREST AND RANGELANDS IN ARIZONA

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ABSTRACT

A progressive and coordinated effort is underway to provide a sound technical basis for managing water resources on forest and rangelands in the Southwest. An in-house Forest Service (USDA) research program including pilot testing and economic evaluations of multiple-use alternatives provides information necessary for this purpose. Demands for other goods and services also are increasing on these lands in the face of a burgeoning population. Homeseekers, vacationers, and recreationists seek a variety of recreational experiences that require open space and a relatively undisturbed environment. Frequently these uses conflict, and the combined pressure from too many activities can damage the environment. A new research effort has been organized in the central and southern Rocky Mountain Region to cope with these problems. Nine Western universities including Northern Arizona University, Arizona State University, and University of Arizona have joined forces with the Rocky Mountain Forest and Range Experiment Station to form the Eisenhower Consortium for Western Environmental Forestry Research. Simply stated, the consortium seeks to better our understanding of the relationships between man and his open-space environment in order that its quality might be maintained.

INTRODUCTION

Water is a limited resource throughout most of the Southwest, and the bulk of the surface water available for man's use originates on mountain lands where precipitation substantially exceeds evaporation. This is particularly true in central Arizona where impoundments on the Salt, Verde, and Gila Rivers capture about 1.25 million acre-feet of water annually for downstream farms and rapidly growing cities (Harshbarger, et al. 1966). Most of this water comes from the central highlands where forest and range watersheds contribute up to 20 percent of the precipitation they receive. Past research has shown that water yield from these lands can be significantly increased by converting trees and shrubs to grass. However, some of the treatments required for major increases in water may adversely affect other forest values.

Timber, also, is a relatively scarce resource in the Southwest, and the needs of the area's wood products industries continue to expand. These industries, traditionally important in the regional economy, are especially critical to many rural communities where employment opportunities are limited. Ranching likewise is dependent on these forest and rangelands. Although no longer as important to the regional economy as they once were, livestock operations continue to bolster local communities. Unlike most other resources, forage production usually increases under management practices that increase water.

But to most residents and tourists, the forests and rangelands of the Southwest have their greatest value as a place to enjoy a wide variety of outdoor recreation. The natural beauty of landscapes and streams, and the occasional sighting of wildlife, are particularly important to many thousands of users of these public lands. Thus, a large segment of the general public seriously questions management practices that diminish landscape beauty, wildlife habitat or other amenity values to achieve increased yields of water, timber, domestic forage or other commodity products.

Principal Hydrologist, located at Tempe, Arizona in cooperation with Arizona State University: central headquarters are maintained at Fort Collins, in cooperation with Colorado State University.

Because it is not possible to maximize all products and amenities simultaneously from a given piece of land, managers and land-use planners must identify the best possible balance of these outputs. This "best" balance must be in terms of ecological, environmental, and socioeconomic consequences--both short- and long-range--as they affect local communities, the region, and the nation. This task requires complex analyses of alternatives which must be increasingly thorough as demands for all products and services expand. New and improved technology, methodology, and tools are needed to accomplish these goals.

Water-producing areas in central Arizona are mostly administered by the Forest Service (USDA), which assumes major responsibility for research done on them. Two research programs are outlined here. Each deals with specific problems relating to use and management of public (and private) lands. Neither program is concerned exclusively with water, although a large part of the first program is devoted to watershed studies in Arizona. The first of these is an in-house program of research conducted by the Rocky Mountain Forest and Range Experiment Station in cooperation with Region 3 and other federal, state, and private agencies. The second is a new and complementary research effort known as the Eisenhower Consortium to cope specifically with man-environment problems in the central and southern Rocky Mountain region.

ROCKY MOUNTAIN STATION RESEARCH PROGRAM

Background. Research in water resources on forest and related lands in Arizona has been conducted by the Rocky Mountain Forest and Range Experiment Station for many years. A growing demand for water combined with a declining water yield from central Arizona watersheds during the 1940's and early 50's provided the impetus for a concerted effort by watershed specialists to evaluate the feasibility of increasing the surface water supply. Their consensus was published as the Barr Report (Barr 1956), which led to establishment of the Arizona Watershed Program. As part of this program, a number of experimental watersheds were established on National Forest lands to test and evaluate effects of manipulating vegetation, primarily for improving water yield.

Other studies also were made by the U. S. Geological Survey, universities, and other agencies. This discussion deals primarily with water resources studies conducted by the Forest Service and its cooperators on forest and rangelands in Arizona.

Beaver Creek. In the late 1950's the Beaver Creek pilot project was established on the Coconino National Forest south of Flagstaff to conduct multiple-use evaluations of watershed treatments on lands covered with ponderosa pine and juniper (Worley 1965). Pilot treatments are being tested on 18 small watersheds ranging from 66 to over 2,000 acres. Combinations of treatments found to be effective on the small watersheds will be pilot tested on one or two larger watersheds of 10,000 acres or larger. Objectives here are to test predictability of treatment results on a large area under operational conditions, and to provide a large-scale demonstration of watershed management (Brown 1971). Only when responses of all the land products are viewed together can the manager have an adequate basis for choice of a management practice. Depending on his objectives, he then can choose a practice that will give the greatest overall multiple-use value, or he can choose a practice that will optimize the particular product or products that are most important to his particular situation. Economic models are being developed concurrently with the watershed treatment program to provide a framework for correlating and interpreting the physical and economic data.

Results from the small watershed tests at Beaver Creek indicate modest gains in livestock forage after trees were eliminated in alligator and Utah juniper types, but these gains were offset by a complete loss of wood products. Water and sediment appear to be unchanged, and effects on wildlife are uncertain. In the ponderosa pine type, clearcutting resulted in substantial gains in water and in forage for livestock and game, but there was a total loss of wood production, a loss in esthetic value, and an increase in sediment yield. In more refined treatments in which watersheds were strip-cut or thinned, water yields and forage were found to vary with the degree of forest removal. Some losses occurred in wood production and esthetic value, and sediment yields increased slightly.

Other studies in pine and mixed conifer. Watershed studies also are located in the White Mountains in eastern Arizona and in the Sierra Ancha Mountains near Lake Roosevelt. Various management and treatment practices are being tested in ponderosa pine, mixed conifer, and high elevation grasslands (Rich 1965, 1972). The Forest Hydrology Laboratory located on Arizona State University Campus in Tempe is headquarters for these studies and others pertaining to forest and rangelands. Complementing the Beaver Creek studies, these treatments are showing substantial increases in water yield from timber harvest practices that materially reduce the forest cover, while little or no change in water production results from light thinning practices. Accelerated soil erosion followed some treatments, especially where roads were constructed near streams and where fire was involved. In others, however, sediment production did not increase, which demonstrates that forest treatment practices to improve water yield do not necessarily cause erosion problems.

In order for timber harvest practices to materially increase water yield, the forest stand must be cleared or substantially reduced. Wildlife habitat may be improved or damaged depending on methods and degree of timber harvest, and the type of replacement vegetation. Scenic values usually suffer under practices where heavy stand reduction occurs. However, judicious thinning and patch cutting may actually "enhance" the esthetics of some stands. Regeneration of productive timber stands after treatment is proving difficult under some conditions. The feasibility of establishing evergreen tree species in high elevation grasslands to induce snow drifting for improving water yield is being studied.

Chaparral. Tempe is also headquarters for chaparral conversion studies for improving water and forage production. The chaparral is intermediate in water production between the high water yielding forests above and the low yielding desert areas below. The chaparral is considered noncommercial because little timber and wood products are produced. However, it is important habitat for several big game species, including mule and white-tailed deer, and black bear. Forage for domestic livestock is fair in open chaparral but becomes scarce in dense stands of brush. In general, as density of the shrubs increases, forage and water production decline, fire hazard and cost of control increase to high levels, and accessibility is severely restricted. Because of these features, the chaparral is somewhat unique in that most management practices that reduce stand density (a prerequisite for increasing water yield) also tend to improve productivity and accessibility, and reduce fire hazard.

Substantial increases in streamflow have been demonstrated where deep-rooted shrubs have been replaced with shallow-rooted grasses and forbs that use less water (Hibbert and Ingebo 1971). On experimental catchments of less than 100 acres, flow is now perennial in channels that once were ephemeral. These gains in water yield can be maintained as long as the grass cover is kept essentially free of shrubs. Conversion is difficult and costly, however, and unless herbicides can be used to help in conversion and maintenance, it is questionable whether fire and grazing alone can adequately control shrub recovery. Erosion probably will increase for a time following most conversion practices. Over the long run, however, conversion should reduce erosion by reducing or eliminating the heavy erosion cycle set off by periodic wildfires. If treatment areas are kept small and interspersed with patches of brush, protective cover and browse for game animals will always be available nearby, and the edge effect created by the openings will improve the overall wildlife environment.

Economic evaluations. At Tucson, a team of scientists is evaluating the economics of watershed management programs in the Southwest. Both market and nonmarket values of products and services resulting from land management practices must be determined before large-scale treatment programs are launched. Benefits must exceed costs for a treatment program to be economically sound, and negative entities such as erosion and loss of esthetic values must be recognized in the evaluation procedure even if dollar values cannot be placed on them. However, some dollar significance can be attached to intangibles when one considers the value of tangible products (wood, grass, water, game, etc.) given up to provide for intangible values (scenery, solitude, wildlife habitat, etc.). Procedures being developed do not explicitly tell managers what desirable intangible benefits are worth, but they do indicate best alternative approaches based on those resource changes that can be measured monetarily. Dollar evaluations can then be tempered with good judgment in assessing intangible resource values.

An economic analysis has recently been made of chaparral conversion on National Forest lands in the Salt-Verde Basin (Brown, et al. 1974). Of some 850,000 acres classified as chaparral on National Forest land, only 178,000 acres or about 20 percent would actually be treatable according to the criteria used in the study. Chaparral not considered treatable included (1) wilderness areas and a buffer zone around these areas, (2) shrub cover less than 30 percent, (3) slopes greater than 60 percent, and (4) 40 percent of otherwise treatable acreage left to provide cover and browse for wildlife. The treatable acreage was delineated into 140 potentially manageable units. Treatment and maintenance costs were estimated for two conversion alternatives based on Forest Service experience. Costs and benefits were compared in a benefit-cost ratio which was found to be greater than 1 for 90 of the 140 units under Alternative I, and 67 of the 140 units under Alternative II which had greater conversion costs.

Related studies dealing with problems in range management, timber stand regeneration, silvicultural treatments needed for various multiple-use objectives, effects of various treatments on wildlife habitat and populations, and use of fire as a management tool to convert and maintain alternate cover types are being pursued by Forest Service research projects at Tucson, Tempe, and Flagstaff. Where expertise, manpower, or facilities are not available within the Forest Service, contractual arrangements are made with the universities and occasionally other agencies to do research on pertinent problems. Several of these cooperative studies financed by the Forest Service are currently underway at University of Arizona, Arizona State University, and Northern Arizona University.

EISENHOWER CONSORTIUM

A new program of research has been organized in the central and southern Rocky Mountain region to cope with the increasing pressure on our wildlands from homeseekers, vacationers, recreationists, and associated commercial interests. Nine western universities, including Northern Arizona University, Arizona State University, and University of Arizona have joined forces with the Rocky Mountain Forest and Range Experiment Station to form the Eisenhower Consortium for Western Environmental Forestry Research. Simply stated, the consortium seeks to better our understanding of the relationships between man and his open-space environment in order that its quality might be maintained in the face of burgeoning demands on the land.

The consortium selects problems, solicits research proposals, establishes priorities, formulates research programs, and channels Forest Service and other research funds to member universities to solve the identified problems. Findings are then made available to resource planners and managers--the people who guide resource allocation and use, and make on-the-ground decisions.

While the consortium deals with many kinds of problems, much of its attention is focused directly or indirectly on the supply, quality, and conservation of water on forest and related lands.

Following are examples of studies started in 1973 in Arizona under this program:

NAU: Potential environmental impact of future surface mining or quarrying operations on the Coconino National Forest.

UofA: Impact of recreation use on water quality in the White Mountains of Arizona.

ASU: Effect of second homes and related vacation developments on the quality of Arizona streams and ground water.

The consortium currently supports 37 research studies at the nine member universities: 17 of these studies are in Arizona. Approximately 20 additional proposals will be funded by June 1974. Principal funding of the consortium is through the Forest Service as permitted by Congress; additional funds are provided by member institutions and other agencies.

President of the Consortium for 1974 is Dr. Charles O. Minor, Dean, School of Forestry, Northern Arizona University. President Elect is Dr. H. William Welch, Assistant Dean, College of Engineering Sciences, Arizona State University. Vice President for Research is Dr. Loren Potter, Head, Department of Biology, University of New Mexico. Each member institution, including the Rocky Mountain Forest and Range

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Experiment Station, is represented by an official delegate (and usually an alternate) through which all research proposals must be submitted. The proposals are screened by a committee composed of member delegates who select and recommend to the Forest Service for funding those proposals best suited to solve the particular problems at hand. In Arizona these delegates are:

NAU: Charles O. Minor, School of Forestry (no alternate designated).

ASU: H. William Welch, College of Engineering Sciences. Duncan T. Patten (alternate), Botany and Microbiology.

UofA: Gerald R. Stairs, College of Agriculture
Richard K. Frevert (alternate), Director, Agriculture Experiment Station.

Research proposals may also be submitted to the Forest Service delegate:

David E. Herrick, Associate Director, Rocky Mountain Forest and Range Experiment Station, 240 West Prospect Street, Fort Collins, Colorado 80521.

CONCLUSIONS

Immediate objectives of Forest Service research and administration are to develop sound, effective, and safe prescriptions for managing critical water-producing lands within Arizona and the Southwest. While water production remains vitally important to the well-being of area residents, industries, and farms, other uses of the land and environmental considerations must also be recognized and placed in proper perspective. The Eisenhower Consortium represents a serious effort to place environmental concerns on a basis equal to economic development of natural resources. This allows land managers and planners to truly recognize the environmental tradeoffs in water resource planning.