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CASE STUDIES AND CATALOG OF WATERSHED PROJECTS IN WESTERN PROVINCES AND STATES

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Technology Transfer

Use of the program for technical and educational purposes was a planned element. Information gathered would be used to improve hatchery operation, harvest management, operation of the Central Valley Project, and land use practices in adjacent watersheds. Program information is currently being used in developing goals, objectives and plans for the Klamath Fishery Management Council and the Klamath River Basin Fisheries Restoration Task Force. Public education was implied in the initial plan but not included as a specific action item. The TCC has added education and library projects to the program. Involved entities also put out information in the form of videos, brochures and news releases. There is a need to educate students and the general public about goals and progress of the program to maintain a high level of support and preserve benefits that are achieved.

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Walnut Gulch Experimental Watershed

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Introduction

Work on the Walnut Gulch Experimental Watershed, an ephemeral tributary of the San Pedro River in southeastern Arizona, began in 1954 as a project of USDA Soil Conservation Service (SCS) Research Division. Functions and staff of the Research Division were transferred in 1954 to a new organization in USDA, the Agricultural Research Service (ARS) and headquartered in Tucson, Arizona.

Research on the Walnut Gulch watershed greatly accelerated when the Southwest Watershed Research Center was funded as one of the facilities recommended in Senate Document 59 in Fiscal Year 1961. At that time, a multidisciplinary staff was developed and research objectives expanded to a broader-based range resource assessment. Passage of the Clean Water Acts during the 1970s led to major changes to incorporate water quality problems in the research program. Other changes in the research program associated with legislation such as the USDA 1977 Resource Conservation Act and the 1985 Farm Bill have resulted in further emphasis on water quality. Finally, in 1985, the Aridland Ecosystems Improvement Unit merged with the Watershed Hydrology and Watershed Erosion Units to become the Aridland Watershed Management Research Unit, thereby providing expertise in most aspects of rangeland resources. Since 1954, the research program has remained under ARS.

In the early 1950s, SCS had problems implementing upstream conservation programs affecting downstream water yield because of prior laws affecting appropriation of water which existed in most western states. The Research Division was asked to select experimental areas where the role of watershed treatments on downstream water yield could be studied. A team of four specialists representing the disciplines of soil, vegetation, geology and engineering selected two areas, one typical of the blue grama grasslands of southern Colorado and northern New Mexico, the other typical of the black grama grass-brush areas of southern New Mexico and Arizona. Based on ranking criteria, the upper Alamogordo Creek Experimental Watershed (a 67 sq mi area) near Santa Rosa, New Mexico and the Walnut Gulch Experimental Watershed (a 57.7 sq mi area) near Tombstone, Arizona were selected. These watersheds were partially instrumented with runoff-measuring stations and precipitation gages in 1954.

Problems

The concrete runoff-measuring devices constructed in 1954 on Walnut Gulch and Alamogordo Creek were inadequate. By the end of 1955, four of the five devices on Walnut Gulch had failed, and the station on Alamogordo Creek was severely damaged. The failures resulted from inadequate hydrologic and hydraulic information concerning thunderstorm-dominated environments.

Hydraulic model work was needed to develop a device to measure the flash floods in the broad sandy channels with heavy debris loads. Design criteria tests were begun by ARS engineers at the Outdoor Hydraulic Laboratory in Stillwater, Oklahoma to develop a new measuring device. In 1958, the first prototype of the new super-critical measuring flume was installed on the Walnut Gulch Experimental Watershed. In the ensuing years, nine additional devices of this design were constructed to complete the instrumentation network. On Alamogordo Creek, one additional measuring device was constructed on a large tributary before the project location was terminated in 1977 because of limitations on funds and staff.

The original precipitation gaging network was expanded from the 1954 sparse networks until there were 100 recording gages on Walnut Gulch and 67 recording gages on Alamogordo Creek. Precipitation which was found to average about 12-14 inches has varied widely with the annual maximum to minimum ratio being consistently more than 1.5.

In addition to the larger watersheds, numerous small homogeneous response units were instrumented to study process-based hydrology on units where vegetation and soil are relatively homogeneous and the areas are small enough to receive relatively uniform rainfall across the area during individual thunderstorm events.

Objectives

Scientists associated with the project conduct research on technology to enhance conservation and optimize resource utilization in arid and semiarid regions. Research involves understanding fundamental principles of the plant-soil-water-animal relationships and developing tools for transferring technology to areas having little or no research data. Emphasis is on understanding processes and developing:

- point and areal precipitation characteristics and their relationships to plant growth and runoff and erosion processes

- models of plant-soil-water-air-animal interactions of the rangeland biotic components under conditions of limited moisture and nutrients
- technology for manipulation of vegetation on rangelands and abandoned farmlands for conservation of soil and water resources
- models to describe the hydraulics of runoff from complex watersheds for predicting flood and water yield characteristics including models for erosion prediction technology
- principles describing sediment, chemical, and nutrient transport, channel morphology, and spatially varied flow in alluvial channels and sediment yield from arid and semiarid watersheds
- models to assist research planning, to quantify responses from management systems, and to transfer data and ideas to other areas.

Information from the studies is used, for example, to: establish soil, water, and land management systems; increase and stabilize plant cover; determine present and future water resource potential of arid and semiarid regions; provide design concepts and criteria for controlling flash floods and sediment movement; and manage yield and quality of water for competing local and downstream users.

Planning

Initial planning associated with selection of the Walnut Gulch Experimental Watershed was completed by the SCS Soil and Water Conservation Division, but program planning since 1954 has been done by ARS in cooperation with SCS, the Agricultural Experiment Station at the University of Arizona, and local ranchers, upon whose ranches the research is conducted. The research program is tailored to address the Research Needs Reports of the SCS and research needs identified by professional societies such as the American Society of Agricultural Engineers, American Society of Civil Engineers, Society for Range Management, and the Soil and Water Conservation Society.

Planning and research program reviews have continued to respond to legislative changes, and to direct and define program emphasis.

Implementation

Research began in 1954 with the installation of a small networks of installations to measure precipitation and runoff. Early analyses revealed that variability of annual precipitation is greater in southeastern Arizona than at any other location in the contiguous USA. Precipitation measurements made 16 km (10 miles)apart also showed wide aerial variability in the same year (Osborn *et al.* 1979).

Many factors have contributed to decreases in rangeland productivity and associated deterioration of soil and water resources. These factors are conversion of land to agronomic crops (although not on Walnut Gulch), invasion of brush species, grazing practices, reduced incidence of fire, channelization, and soil erosion. It is difficult to quantify the magnitude and interaction of each factor in the overall assessment. Perhaps the greatest threat of all to southwestern rangeland is not included among these factors. The impending megalopolis being created by millions of people moving to the "sun belt" to work and to retire may in the end decide the fate of grazing lands of the southwest.

Following early failures of devices to measure runoff and completion of hydraulic design experiments, flumes were replaced, and flumes were constructed at additional sites during the period 1958 to 1968 to complete the experimental design.

Treatments of various tributary watersheds have been sporadic because USDA does not control the land areas involved. Most treatments have been restricted to small areas, and others involved use of rainfall simulators.

Day-to-day operation of the project involves a research leader and several lead scientists capable of providing expertise in areas of hydrology, erosion-sedimentation, and plant-soil-water relationships. The project has also had frequent visiting scientists as well as sending staff members on assignments to other locations. A mix of senior and younger scientists has also been used successfully in the research. The research program has involved parallel field, laboratory, and analytical experiments.

Evaluation

Evaluations of the research work have been an integral part of the program since work began. Result have been documented in more than 700 publications in various USDA reports, symposia proceedings, and refereed journals. Each scientist's program is evaluated on the basis of the quantity and quality of resulting publications.

Major technological advances have resulted from the program.

1. Development of hydrologic measurement devices. Perhaps foremost has been the development of super-critical measuring devices to measure runoff in ephemeral streams. These devices have now been mimicked throughout the world. Also developed was sediment sampling equipment to obtain unattended aliquots of the mixture of water and sediment from the entire depth and width of flow in small streams.
2. Precipitation characterization such as those that dominate the hydrologic process in air-mass thunderstorm areas. The depth-area-duration characteristics of thunderstorm-dominated areas now provide routinely the design for many water resource project designs and evaluations.
3. Transmission losses, due to infiltration in alluvial streambeds, dominate the hydrologic response of ephemeral streams to rainfall events. The technology developed on Walnut Gulch provides a model for engineering handbooks.
4. Water harvesting systems developed on Walnut Gulch have created an awareness of a technology which although having a long history of use has been systematized in design so their use is now widespread and economical.
5. A hydrologic data base has been developed that will be invaluable for future hypothesis testing. The data base attracts much interest because of its uniqueness and completeness in a form that permits ready access via computers.
6. Walnut Gulch has provided a focus on desert hydrology, its uniqueness when compared to that in humid climates. A steady stream of visitors from developing countries with similar climates attests to the interest.
7. Development of analytical models to address water balance, precipitation description, rainfall-runoff relationships, erosion-sedimentation and water quality problems are but a few examples. The staff have provided input to many analytical models used to support conservation and environmental problems in action agencies of U. S. Departments of Agriculture and Interior.

Technology Transfer

The research program has had a long history of development of educational material. For example, classes from the University of Arizona participate in training at Walnut Gulch. The facility is a regular stop for visiting scientists and engineers from arid and semiarid areas around the world. Furthermore, numerous theses have been developed in connection with the work. The research has also resulted in many handbooks which are an integral part of USDA programs (see references). ARS has conducted workshops on special topics, and the staff actively participates in many professional societies.

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Catalog of Watershed Projects

Information provided by the correspondent for each watershed management project is presented in this section. Most of the information provided here has been reviewed, edited, and corrected by the correspondent. Anyone desiring additional information about a project should contact the person(s) named in the entries entitled **Report by** or **Contacts**.

This catalog is organized primarily according to political boundaries. Canadian provinces are followed by western states, both in alphabetical order. The secondary arrangement is by the name of the watershed, stream, river, or lake, again in alphabetical order. This secondary arrangement disregards names of branches and forks and such designations as "upper" or "lower". Thus, the reader should expect to find the East Branch of the North Fork of the Feather River under the river's name, and the same is true for the Upper Stillaguamish River

The discerning reader will sometimes note that one or more fields seem to have been omitted for a project. This is because no information was provided . For example, if data on costs were not provided for a project, then that field was deleted. In other cases only part of the requested information may have been provided, for example, on stream gradient. but not on stream order, or on topography, but not on aspect. If "none" was reported in the field for publications, then it was so recorded; however, if that field was left blank, then it was deleted (even though reports or publications may exist).

Canada

Alberta

Watershed Name: Cache Percotte & Whiskeyjack Watersheds

Report by: Peter J. Murphy, Professor and Associate Dean, Faculty of Agriculture and Forestry, University of Alberta, Edmonton, Alberta T6G 2P5, Canada, (403) 492-4931

Location: Nearest Town, Hinton, Alberta

Township and Range: 53°26'N, 117°32'W

Problem Statement and Study Objectives: establish as an adjunct to operation of the Forestry Technology School to illustrate techniques in forest hydrology and watershed management; objective was to determine streamflow characteristics and water balance before, during, and after forest harvesting

Treatments: installation of H-type and trapezoidal flumes, central weather station and 15 rain gages, 1964; streamflow measurement, spring 1965; V-notch wiers on tributaries; groundwater wells and piezometer clusters

Expected or Final Results of Treatments: monitoring of changes during forest management cycle

Cost Estimate: less than $100,000 (Canadian), plus major contributions

Watershed area and size of treated area: Cache Percotte, 679 ha; Whiskeyjack, 301 ha

Stream gradient and order: first and second order

Geology and soils: western flank of Alberta Syncline; two major bedrocks, Brazeau formation (late Cretaceous), and

Treatments: records, 1959-1983; herbicide treatment on 40 percent of area, 1965; remaining shrubs treated, 1968; herbicides treatments on 100 percent of area, 1960-1969

Expected or Final Results of Treatments: 1.3 inch increase in annual water yield from removal of 40 percent of chaparral; from herbicide treatment of 100 percent of area in 1960, 5.8 inches, in 1969, 2.7 inches

Cost Estimate: $1,740,700 includes admin., data processing ($15,000 and $60,000/yr), and treatments ($75/ac) totalling $15,700

Watershed area and size of treated area: 0.07, 0.15 square miles; treated; 0.12 square miles control

Stream gradient and order: first order

Geology and soils: coarse-grained granite; gravelly loams

Topography, aspect, and elevation: steep slopes, northerly; 3,300 ft. to 3,680 ft. at weirs

Vegetative cover type and density: interior chaparral; 60-75 percent crown cover

Climate and precipitation: warm, semi-arid; 25 inches; bimodal rainfall

Land ownership: 100 percent USDA Forest Service

Access restrictions due to weather or owner: occasionally in the winter

Contacts: Malchus B. Baker, Jr./Leonard F. DeBano, Rocky Mountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Arizona State University, Tempe, AZ 85287-1304, (602) 379-4365

Sponsors: USDA Forest Service

Descriptive publications and reports: 1974 Res. Pap. RM-126

Watershed Name: Walnut Gulch

Report by: Kenneth G. Renard, USDA Agricultural Research Service, Aridland Watershed Management, 2000 E. Allen Road, Tucson, AZ 85719, (602) 670-6381, 6881

Location: Nearest Town, Tombstone, AZ

County or Region: Cochise

Township and Range: T19S, R22E

Problem Statement and Study Objectives: scientists conduct research on technology to enhance conservation and optimize resource utilization in arid and semiarid regions; research involves developing fundamental principles of plant-soil-water-animal relationships and tools for transferring technology to areas having little or no research data

Expected or Final Results of Treatments: establish soil, water, and land management systems; increase and stabilize plant cover; determine present and future water resource potential of arid and semiarid regions; provide design concepts and criteria for flash flood and sediment control; manage yield and quality of water for competing local and downstream users; improve techniques for barley establishment and breeding

Cost Estimate: more than $1,000,000 per year current

Watershed area and size of treated area: 57.66 square miles

Stream gradient and order: from 1 percent upward; seventh order

Geology and soils: complex

Topography, aspect, and elevation: rolling topography, all aspects; elevation from 4,500 ft. m.s.l. to over 6,000

Vegetative cover type and density: mixed grass-brush with all densities generally less than 10 percent basal area

Climate and precipitation: semi-arid warm season dominated precipitation; precipitation averages about 13" near watershed center

Land ownership: 10 percent private; 30 percent federal; 60 percent state

Access restrictions due to weather or owner: all areas restricted by owners

Contacts: Kenneth G. Renard, USDA Agricultural Research Service, Aridland Watershed Management, 2000 E. Allen Road, Tucson, AZ 85719, (602) 670-6381, 6881; Howard D. Larsen, Box 213, Tombstone, AZ 85638, (602) 457-3321

Sponsors: USDA Agricultural Research Service; Aridland Watershed Management Research

Descriptive publications and reports: more than 700 publications from the research program

Watershed Name: Whitespar Watersheds A and B

Report by: Malchus B. Baker, Jr., Rocky Mountain Forest and Range Experiment Station, Forestry Sciences Laboratory, Arizona State University, Tempe, AZ 85287-1304, (602) 379-4365

Location: Nearest Town, Prescott, AZ (7 miles southwest)

County or Region: Yavapai

Township and Range: T13N, R3E, Sec. 25 & 36

Problem Statement and Study Objectives: evaluate effects of converting chaparral to grass on water yield

Treatments: records, 1958-1986; herbicide treatment in mosaic pattern, 1981; channel-sides treated with herbicides, 1967; upper slopes treated with herbicides, 1973

Expected or Final Results of Treatments: 2.7 inch increase in annual water yield (4.9 inches from area actually treated); treatment of channel-sides and upper-slopes increased in annual water yield by 66 percent or 0.5 inch (3.5 inches from area actually treated)

Cost Estimate: $1,420,000 includes admin., data processing ($10,000 and $40,000/yr) and treatment ($75/ac) totalling $20,200

Watershed area and size of treated area: 0.47 square miles, treated 55 percent; 0.38 square miles, treated 90 percent

Stream gradient and order: first

Geology and soils: fine-grained granite; gravelly loam

Topography, aspect, and elevation: steep slopes; southeast aspect; 5,800 ft. at weirs

Vegetative cover type and density: interior chaparral; 51 percent crown cover

Climate and precipitation: warm semi-arid; bimodal rainfall; 24 inches

Land ownership: 100 percent USDA Forest Service

Access restrictions due to weather or owner: none

Contacts: Leonard F. DeBano/Malchus B. Baker, Jr., Rocky Mountain Forest and Range Experiment Station,