# THE POSSIBILITY OF INCREASING WATER YIELD THROUGH MANAGEMENT

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## INTRODUCTION

Demands for water in the arid Southwest far exceed the supply. The problem will worsen and become increasingly critical as the population increases and we continue to over-pump underground water supplies. In the Southwest we are always short of water. Some years we are shorter than others.

The primary sources of our water supplies are the higher mountain watershed lands, most of which are within the National Forests. Protecting watershed lands from fire and exploitation was a primary consideration when the National Forests were reserved from the public domain 60 years ago.

During the early years of National Forest administration, emphasis was placed on watershed protection, and the primary aim in watershed management was maintenance of water quality. The fundamental principle involved utilization of a cover of trees, grass, and brush to hold the soil and to facilitate water percolation and water storage within the soil.

## WATERSHED MANAGEMENT POLICY FOR NATIONAL FORESTS

Significant events have occurred in recent years which are changing and reshaping watershed management policy and management direction for the National Forests in the Southwestern United States. This change reflects a response to the demands of people who are dependent on these lands for resources.

In 1957, the Chief of the Forest Service amended the policy for watershed management in the Southwest. He recognized that the Southwestern National Forests are moving into a much more intensive phase of resource management; that in some areas water is perhaps the most valuable resource from these lands; and that the more intensive phase of watershed management must not only continue to consider protective functions of the watershed, but also give important weight to other practices affecting the quantity or amount of water yield. This change in policy was significant. He directed attention to management practices that would not only protect watershed lands, but would also be designed to increase water yields where practical.

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## MULTIPLE USE SUSTAINED YIELD ACT

In 1961, Congress passed the Multiple Use Sustained Yield Act. This Act emphasized that the renewable resources of the National Forests will be managed so that they are utilized in the combination that will best meet the needs of the American people. No resource would have automatic priority. In management decisions all resources would be considered. In water-short areas, water yields would receive major consideration. Modification of management practices to improve water yields would be undertaken when proven practical by research and trial application.

## A DEVELOPMENT PROGRAM FOR NATIONAL FORESTS

In 1961, another significant event for the Forest Service was when the President of the United States sent to Congress "A Development Program for the National Forests." This was a ten year program to accelerate resource management and development work needed on the National Forests and National Grasslands to assure that the resources from these public lands will meet their full share of present and future public needs.

The development program was favorably received by Congress and has been partially implemented with funds. It has allowed for substantial increases in watershed management activities and development programs on the National Forests in New Mexico and Arizona.

The accelerated program will allow for more professional attention to all aspects of the watershed management job. We, in the Forest Service, accept the challenge with a lot of enthusiasm. One of the big jobs ahead for watershed management technicians in the National Forests is to prescribe the type of co-ordinated management practices which will increase water yields and at the same time minimize impacts or enhance other important resource values.

## WATERSHED MANAGEMENT RESEARCH

To guide us in preparing proper prescriptions or management practices we have a lot of data and facts from watershed management research on which to draw. I would like to briefly review with you a few of these basic principles and significant research findings.

Studies by Forest Service research scientists in watersheds throughout the United States have established certain principles of watershed management to increase water yields. Among these are the following: deep-rooted plants create greater soil-moisture deficits than plants with shallower root systems; these deficits must be replenished before water will percolate through the soil to recharge groundwater and maintain streamflow; thinning dense coniferous stands on north slopes in areas of heavy snowfall will allow more snow to reach the ground and thereby increase water available to

Figure 1. Fool Creek Watershed has been treated to improve water yields. Fraser Experimental Forest, Fraser, Colorado.

Figure 2. North Fork of Workman Creek, Serra Ancha Experimental Forest, Central Arizona. One-third of a 240-acre watershed was cleared of timber and converted to grass.

streamflow; on deep soils conversion from deep-rooted to shallow-rooted vegetation will result in more water available to streamflow if conditions for infiltration are satisfactory and precipitation is sufficient to wet down through the root zone.

At Fraser, Colorado, watershed scientists, Love and Goodall, found that by harvesting commercial timber on a 714-acre watershed by clear-cutting in alternate strips that water available for streamflow was increased by 31 percent.

In this system, clearcut strips alternate with uncut strips to form a checkerboard pattern. The trees on the uncut strips are not logged until new tree growth is established on the strips first cut. This perpetuates the checkerboard arrangement. Streamflow had been measured for this and a neighboring watershed for several years. The flow from the two areas was so closely comparable that one could be used as a control to determine the effect of timber harvest on the other.

Cutting on the test area was completed between 1954 and 1956. Widths of cut and uncut strips ranged from 30 to 400 feet (from one-half tree height to seven times tree height). No trees were cut within 90 feet of the stream. All live trees larger than four inches in diameter on cut strips were made into logs, poles, mine props, and pulpwood. Slash was looped and scattered. There were 550 acres of merchantable forest on the watershed, of which 55 percent was lodgepole pine and the remainder was spruce-fir. The trees cut on the strips and in the clearing for roads amounted to half of the total timber volume.

They also report that least snow is found under dense groups of trees, and the deepest snow is near the center of the largest openings. Also, that reducing the number of trees per acre by thinning increased the snow accumulation by 23 percent. This increase comes from reduced interception and transpiration.

At the Workman Creek watersheds in Central Arizona, water yield has increased 55 percent following replacement of 80 acres of forest with perennial grass. The 80 acres were approximately one-third of a 240-acre Douglas fir-white-fir forested watershed at 6,500 feet elevation and 32 inches average precipitation. Only the moist-site timber closest to the stream channel was cut.

It was interesting to know that the increases in water yield from this experiment closely approximated the results from other studies in aspen plots in Central Utah that were converted to perennial herbaceous vegetation.

The increase in water yield was attributed to the removal of deep-rooted plants and the replacement of shallow-rooted plants that did not extract or use as much water through the evapotranspiration process. Thus leaving more water available for streamflow.

Figure 3. A chaparral watershed near Roosevelt Lake, Arizona, which has been converted to grass following a wild fire in 1959.

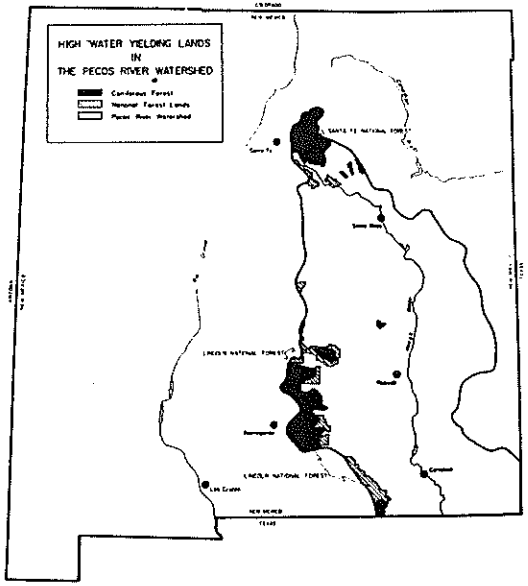


Figure 4. Pecos River Watershed, New Mexico. National Forests comprise 10 percent of the area and produce 78 percent of the water yield.

A. R. Croft, at the Intermountain Research Station, found a four inch saving of water by removing aspen trees and converting the site to a herbaceous cover. The reason water is saved by removal of aspen is found in the distribution of its roots with respect to roots of herbaceous plants. The tree roots penetrate the soil to a depth of six feet or more. This is two or three feet deeper than herbaceous roots extend. Thus, three or four inches more water was available to aspen roots than to herbaceous roots. Changing the cover from deep-rooted plants to shallow-rooted plants resulted in a water saving of about two inches per foot of soil depth. The two inches varies with soil texture.

Other studies in Arizona showed that Bermuda grass, because of shallower rooting, consumed much less water than salt cedar.

Blaney estimated that a saving of 50 percent, or about 32,600 acre feet of water per year, could be obtained by replacing salt cedar with Bermuda grass in the Pecos River channel between Artesia and Carlsbad, New Mexico, a distance of 36 miles. I understand a program is now underway for removal of salt cedar in the Pecos Valley.

At the 3-Bar Experimental Watersheds north of Roosevelt Lake, three experimental watersheds were burned by wild fire in 1959. Regrowth of chaparral species on one of these watersheds has been held in check by spraying shrubs with chemicals. Water and sediment yields increased on all watersheds after the fire. The watershed on which the chaparral species have been held in check has maintained a small but continuous flow of water, with negligible soil movement.

During the last two years, water yield on the treated watershed had doubled the water yield from the control watershed where sprouting and regrowth of the shrubs has now reached a 40 percent canopy cover. Water yield has amounted to 27 percent of precipitation for the converted watershed and less than 11 percent for the control or resprouted watersheds.

Current watershed management research throughout the west shows promise of increasing water yield by manipulating or changing the vegetation.

PILOT STUDIES

Before starting a large scale action program, research results and principles must be pilot tested on a large scale to determine the quantitative effects under local conditions, impacts on other resources, and costs and benefits of such treatments. The Forest Service is moving ahead with a program of pilot testing of watershed management practices to increase water yield. This is being done in the Beaver Creek Watershed, a 275,000-acre tributary of the Salt

River Basin. Practices now being tested are conversion of the juniper and sparse pine types to grass and thinning of pine on commercial timberlands. Measurements are being made to determine the effects of these treatments on soil stability and yields of forage, timber, wildlife, and water. Research and pilot-scale tests are being expanded to additional areas representative of other vegetative types and various methods of treatment.

At the Burro Creek Watersheds on the Apache National Forest, the Forest Service has harvested timber under various methods of clear-cutting in patches which vary in size from three to 23 acres. Different methods of slash disposal and post-treatments were applied.

The objectives of these clear-cutting tests are to appraise the fire hazard,. determine costs of slash disposal, determine rate of natural regeneration, test methods of tree planting, measure losses from windfall, and determine benefits to range forage and wildlife habitat.

Other pilot studies are underway in New Mexico. Stream gages have been installed on the Tesuque Watersheds, northeast of Santa Fe. This is a cooperative program between the State Engineer, Interstate Stream Commission, U. S. Geological Survey, and the Forest Service. The work thus far has been the installation of eight stream gages to measure water yield from the different vegetation and elevation zones.

Each year of water yield data collection brings us closer to watershed calibration. That is, a time when we have determined the relationship at one watershed to one or several other watersheds. Once this relationship is known we can then accurately predict what one watershed will yield by looking at the performance of another. In this way the effects of change within a watershed on water yield are measured. When the Tesuque watershed calibration is complete watershed treatments will be designed to test various practices of timber harvest on recreation values, water yield, and wildlife habitat.

Studies are also underway on the Santa Fe River watershed to appraise the opportunities for management of the Alpine snowfield to improve water yield.

Last year watershed management studies were started on five small pinyon-juniper watersheds on the Carson, Santa Fe, and Cibola National Forests in Northern New Mexico. While we know the pinyon-juniper type is not found in a high water yielding zone, we need to know more about the hydrologic functioning and condition of this vegetative type. We must appraise what opportunities do exist for intensive water management.

## WATER YIELD

In the New Mexico portion of the Rio Grande Basin, the spruce-fir and ponderosa pine zones make up 30 percent of the land area and provide 72 percent of the streamflow. Most of these timberland lands are in the National Forests. It is within these higher water producing areas that the opportunities exist for improving water yields.

Let's take a closer look at the headwaters of the Pecos River within the Santa Fe National Forest.

Long time records of annual water yield at the gaging station near Pecos, New Mexico, shows an average annual water yield of 74,065 acre feet from 189 square miles drainage. In acre inches this amounts to 7.35 inches annually, with 26 inches as average annual precipitation this would amount to a recovery of 28 percent of rainfall.

This compares very favorably with the rest of the high mountain watersheds in the Rockies.

In comparison, the average annual water production for the entire Pecos River Basin is four percent of precipitation. At Colonias the water yield amounts to one area inch. Most of the rainfall at the lower elevations is used to maintain the plant cover so vital to soil stability. Little is available for streamflow.

Most of the watershed lands in the National Forests are covered with spruce-fir, ponderosa pine, and aspen, with pinyon-juniper on the lower slopes. There are some natural openings, but they would be a relatively small percent of the watershed.

It was interesting to learn that the annual water yield from the Pecos River above the town of Pecos closely approximates the water yield, on an area basis, from the Santa Fe River watershed, 7.35 inches at Pecos and 6.5 inches at Santa Fe. Both watersheds are located on the southern end of the Rocky Mountains which extend into New Mexico.

## ACTION PROGRAMS

These watersheds can be considered as good water producers for the amount of precipitation they receive.

No doubt there are opportunities to make them better water producers by more intensive management.

Let's look at the headwaters of the Pecos River which are located above the town of Pecos and within the Santa Fe National Forest. This is the area that produces the 7.35 area inches of water annually.

We find about 100,000 acres of commercial forest land, 72,000 acres within the Pecos Wilderness Area, and about 70,000 acres of woodland, brush and grass. These are the higher water yielding lands where more intensive management could improve water yield.

It would be premature to make any meaningful predictions at this stage of the program. However, the Forest Supervisor is currently developing a timber harvest program in the mixed conifer type which will be designed to use a system of strip or block cutting. This should favor increased water yield. Hydrologic studies will be made to furnish the basic data needed for correlating the timber harvest with water yield.

In other areas a program of maintaining the openings from scrub tree invasion is being carried out. The program is modest, but every little bit helps. At least we have an action program started.

Southwestern National Forests are moving into a much more intensive phase of resource management. The watershed management that has been practiced up to now has been directed primarily toward protection, with attendant soil stability and good quality of waterflow. The more intensive phase of watershed management which the Forest Service is now developing must not only continue to consider protective functions of the watershed, but also give important weight to other practices affecting the quantity of water yields. Responsible stewardship of National Forests requires this kind of intensive management to meet the increasing water needs of a growing population, industry, and agriculture.

SUMMARY

Water is recognized as one of the very important resources from National Forest lands. In some places and situations it may well be the most important resource.

Water yield can be increased by replacing deep-rooted plants with shallow-rooted plants.

The harvesting of timber by clear-cutting in strips or patches will make more precipitation available for streamflow.

Sound principles, based on watershed management research, have been established for increasing water yield. Pilot tests are underway to determine costs, impacts on other resources, and methodology. Modest action programs are underway.

In my judgment, the Forest Service is rapidly moving from the custodial era of watershed management to intensive multiple use management. This transition will be based on the demands of people for more products and services from the National Forests. It will be carried out under sound principles of multiple use and sustained yield management.