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Watershed Management Research in the Southeast

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RESEARCH to determine the effects of forest vegetation and land management practices on the components of the water cycle are carried out by the Southeastern Forest Experiment Station primarily at two locations. Most of the work has been clone at the Coweeta Hydrologic Laboratory, located in the mountains of North Carolina in the region of maximum rainfall in the eastern United States. At the Union Research Center, in the piedmont of South Carolina, studies have been oriented toward the problems of rehabilitation of depleted watershed lands. Also, rather intensive studies of soil moisture have been made at this location.

The development of the research program at Coweeta reflects to some extent the evolution of forest hydrology in general. Large-scale field treatments to determine the effects of vegetation management on streamflow were begun in an era of great concern over our natural resources. The use of entire watersheds, carefully gaged for several years before treatment, to demonstrate the influence of the forest 011 components of the water cycle has led to newer ways of looking at land management problems.

The original rain- and stream-gage system on the 5,600-acre tract of mountain land at Coweeta was constructed during the years 1934 to 1940. There had been much speculation about the influence of vegetation on streamflow. following the Wagon Wheel Gap experiment in 1911, but few worthwhile records had been collected to document the theory that forests consume much water while providing protection to watershed lands. Consequently, a primary objective in the beginning was to observe the seasonal behavior of streams from forested watersheds. During the early years annual hydrographs were compiled, seasonal comparisons were made among watersheds during normal and storm periods, and the water balance of the forest was calculated. Gradually, the annual patterns of water supply, consumption, and delivery were outlined in this area of deep soils, high rainfall, and dense forest cover.

By 1940 the backlog of information on local stream behavior was large enough to begin studies of forest influence on streamflow. A series of cover-type changes, ranging from complete clearcutting to removal of only portions of the forest vegetation, were planned and executed during the next decade. Prom the first records, the treatments indicated that it was possible to alter streamflow significantly in humid climates by drastic changes of the vegetative cover. The results of these studies have become part of the background of watershed management research, and are too well-known to dwell on here.

At the same time, treatments of a more practical nature were being tested on another series of watersheds. In line with the concern over the destruction of forest soil and the sedimentation of mountain streams by abusive forest and agricultural practices, efforts were made to demonstrate the deterioration of watershed values under planned abuse. Mountain farming, grazing, running cattle in the woods, and poorly managed logging were clearly shown to be destructive on watersheds of the Appalachian Mountains unless done with more care than is usually employed nowadays.

These demonstrations led to studies during the last decade of the recovery of depleted watersheds under protection and proper management. Vegetative measures for reducing storm runoff and erosion have proved very successful in these continuing studies. During this period, watershed stabilization research was extended to the Union Research Center in the piedmont of South Carolina, where the rehabilitation of eroded land in a troublesome area of poorer soils and lower rainfall has been studied on several small watersheds.

Throughout these years, techniques were being developed for conducting studies in forest hydrology. The usefulness of different types of weirs and rain gage installations, various methods for treating and comparing watersheds, and the application of hydrograph analysis to small streams were among the many contributions of Coweeta to the field of forest hydrology.

Basic records of rainfall, streamflow, and other factors pertinent to the study of the water cycle on unit watersheds continue to accumulate in the Coweeta files. The value of such long-term records, when dealing with weather factors, cannot be seriously questioned. Portions of Coweeta data have been

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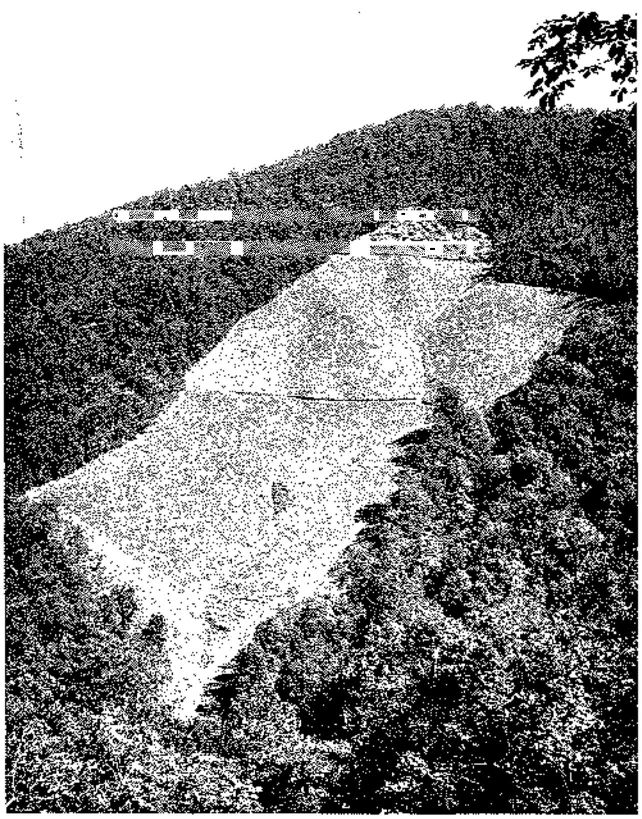
used in many ways: to check theories of forest water consumption, to illustrate facets of forest ecology, to provide runoff estimates for neighboring areas, and to suggest practical systems for management of municipal watersheds. The files constitute what is perhaps the longest and most thorough hydrologic record on small mountain watersheds now available. To make these records more usable, means are being employed for simplifying the compilation and summarization of the data. A portion of the stream records have been put on IBM cards for electronic computation, and similar treatment of additional data is planned.

Most of the Coweeta data has come from what is referred to as the "unit watershed approach," implying the calibration and subsequent treatment of the entire drainage area above a gaging station. The great advantage of the method is that streamflow is the net effect of many complicating factors in operation on the watershed. Unfortunately this is also a disadvantage; costly experiments constitute only single observations of the result, which may be different if the treatment is carried out at another time or on another watershed. The method has proved valuable, nevertheless, in setting goals for management and research and continues to be used at Coweeta and elsewhere.

A current series of watershed treatments at Coweeta is designed to determine the gross effects on water yield and regimen of four widely-differing types of vegetation, in an effort to provide some answers to long-standing questions about the comparative value of various possible types of watershed cover. In this test, not to be completed for another 10 or 15 years, native hardwood cover will be compared independently with a purely coniferous cover (white pine), grass cover, and shrub cover with the overstory removed. Two watersheds, one facing north and one south, have been planted to white pine, and another is substantially converted to grass (Fig. 1). In addition to this work, studies are underway at Union to determine the use of soil moisture by several densities of pine stands.

As experience with unit watersheds has accumulated from various parts of the country, appreciation for the complexity of watershed behavior has grown. Variations in results have led to the conviction that a clear picture of forest influence on streamflow will emerge only with better understanding of the basic processes involved in the water cycle. Unit watershed treatments must now be supplemented *by* greater knowledge of the mechanics of water supply, storage, evaporation, and runoff. The current program at, Coweeta and Union is aimed at more fundamental understanding of the behavior of water within the watershed.

Coweeta watersheds, because of their small size, steepness, and sharply defined boundaries, have always proved useful for conveying visual impressions of the nature of watershed processes. These processes cannot easily be divided into separate problems; however, four overlapping fields of study have gradually emerged. They may be roughly equated with the behavior of water in the soil, the



Left

FIG. 1.—A 22-acre watershed undergoing conversion from hardwood forest to grass. Changes in streamflow will be measured by a weir at the bottom of the clearing.

Below

FIG. 2.—The neutron-scattering apparatus for measuring soil moisture. It is shown being used in the South Carolina piedmont to measure soil moisture to a depth of 16 feet.

plant, the atmosphere, and the stream channels. Research is now organized along these lines.

Soil investigations have long been a part of hydrologic research at both Coweeta and Union. Most early work centered around gravimetric soil moisture sampling, as well as bulk density, pore space, and percolation determination for evaluation and comparison of soil hydrologic properties. In addition to this work, more recently developed methods for soil moisture measurements are now being applied to the problem of soil moisture movement and distribution in the profile. Still one of the most puzzling components of the water cycle, soil moisture comprises the bulk of stored water in mountain watersheds. Studies of sub-surface drainage on slopes, involving the use of large soil models as well as field observations, are promising to throw some light on soil moisture as a source of base flow in streams. Other studies, located chiefly at Union, are aimed at determining quantities and variability of moisture in different types of soil, with the ultimate purpose of developing improved techniques for measuring evapotranspiration and drainage losses from soils. Recently developed neutron-scattering devices for measuring soil moisture are proving useful in these studies (Fig. 2).

In recent years the role of vegetation in water losses from land areas has been eclipsed by energy balance considerations, in which plants are regarded as passive agents in the evaporation of water from their tissues. However, there is still much evidence that plants, through structural as well as physiological peculiarities, have considerable influence over rates of transpiration. One neglected area of research in forest hydrology has been the study of the water economy of forest trees and shrubs. An effort is being made at Coweeta to relate the moisture content of leaf tissue to site and water consumption potential of different trees.

Solar radiation measurements have recently been added to the customary records of air, soil and water temperature, relative humidity, wind speed, and evaporation at Coweeta. These records are part of an effort to evaluate the application of energy balance theories to calculation of evaporation from forest land. Present indications are that the energy balance in mountain forests is far from a simple surface phenomenon, as is sometime postulated for level crop lands. Calculations of relative percentage of radiation received by opposing slopes are providing some basis for further research on the influence of aspect and slope on water losses to the atmosphere.

On the average, 128 storms of all sizes occur each year on the watersheds at Coweeta. The storm hydrographs of many storms consist primarily of channel interception; in no storms have significant amounts of surface runoff been observed. The make-up of the average storm hydrograph has been under study since the early 1940's, when the theories of the unit hydrograph were first applied to small watersheds. A thorough understanding of the source of the various components of the storm hydrograph will be basic to future efforts to control stormflow by vegetative means. Further work along these lines is planned using the accumulated records from Coweeta streams.

Since we cannot, at least so far, have much control over precipitation, the principal job of watershed research is to learn how to utilize the water that falls to the ground to the fullest advantage. As more information accumulates about principles of watershed behavior, it will be put to practical tests on watershed lands of the Southeast. Logging studies on pilot areas in the mountains have already provided examples of how watershed lands can be better managed in terms of multiple use objectives. And rehabilitation methods worked out by research in the piedmont are finding many applications on depleted lands of the region. Continued research and application of research findings is a must if we are to make optimum use of our water resource—one of the most important resources we get from forested lands.