

STREAMFLOW—Important Factor In Forest Management

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Streamflow in the southeastern coastal plain often follows an erratic pattern. For the last 10 years streamflow from the major portion of this land area has been bountiful, but prior to that a five- to seven-year drought stopped flow from all but the largest streams and rivers. An understanding of how streamflow behaves will enable us to prepare for periods of too much or too little water. This paper discusses how streamflow affects the management of foresters in the lower coastal plain and presents a summary of streamflow behavior from a forested watershed in that area.

The Importance Of Streamflow

Several factors related to the amount of streamflow leaving a watershed must be understood in order to manage wisely the forest resources in the coastal plain:

(1) *Drainage requirements* — Much of the forest land in the lower coastal plain receives more rainfall than the soil can store. Part of any excess rainfall quickly runs off the area after a rainstorm, while the remainder of the water lingers on the land. Some areas remain flooded for considerable lengths of time, and this extended flooding can adversely affect tree growth. Many woodland owners have turned to controlled drainage as a means to remove this undesirable surface and ground water. In planning the drainage system, the engineer needs to know what percentage of a rainfall will run off quickly and what percentage the drainage system will have to remove. A bad guess on natural runoff could seriously affect the utility of the prescribed drainage system. An over-extensive system is wasted money and may lower water tables excessively, while an inadequate system will not remove enough water and may require costly enlargement at a later date.

Inadequate rather than excess drainage has been the rule thus far

on forest land in the Southeast. Quite often this inadequacy has resulted from poorly developed outlets, while in other instances ditches which are too far apart or too shallow have failed to drain off the ground water at a fast enough rate. Too often trial and error has prevailed. As more information on the natural hydrology of wet woodlands becomes available, however, sounder water management engineering on forests should result.

(2) *Bridge and culvert openings* — Peak flows from coastal wetland forests are difficult to estimate. The necessity for such estimates has not been critical in the past, however, because the forest land affected by floods was virtually undeveloped. Formerly, special provisions were made at the time of logging in order to gain access to excessively wet areas. With the advent of more intensive forest management, however, permanent roads have been built in order to break large tracts into manageable units. These roads have required bridges and culverts at streams and branches to accommodate streamflow from the higher portions of the watersheds. Unfortunately, many of these openings were too narrow to handle even the rather

small floods that occur every few years, and costly wash-outs of the structures and roads have occurred (Figure 1). As roads are improved and bridges are built to handle larger storms, it is even more important that this construction be adequate in size.

The Southeast is quite vulnerable to large rainstorms that produce peak flows. Thunderstorms with one to two inches of rain occur frequently during the summer, and several successive days of such rain can produce extensive flooding. More spectacular are the hurricanes that deluge points along the coast from Cape Hatteras, N. C., to Brownsville, Texas, with 12 to 25 inches of rain once or twice every fall. The peak streamflows produced by these hurricanes cause extensive damage to accessways regardless of how large bridges are built. Rainstorms of a size between the frequent summer thunderstorms and fall hurricanes are also of great concern to road engineers. Damage to roads and bridges from these intermediate storms is more extensive than that from the usual summer thunderstorms. These intermediate rainstorms are usually produced by low-pressure frontal systems that can



FIGURE 1.—Forest roads over-topped and under-mined by flood waters from coastal forests.

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dump huge quantities of rainfall in a short period. Often these frontal systems stall at or near the coast, and light-to-heavy rain falls for days.

Accurate prediction of peak flows is the key in planning for adequate bridge and culvert openings on forest roads in the coastal plain. Because prediction methods are based on measured streamflow, an understanding of streamflow behavior is essential.

(3) *Water resource development*—Streamflow potential from lower coastal plain forests may influence significantly the future development of industry, agriculture, and municipalities in that area. Not only must water be available in sufficient quantity to meet man's needs, but it must also be distributed favorably in order to be available when needed. In addition, care must be exercised so that future utilization of water from coastal plain forests will not be the detriment of resources now dependent on it, such as wetland timber species, fish, waterfowl, and other wildlife.

An Example of Streamflow Behavior

The streamflow records dealt with here come primarily from a 400-acre watershed on the Santee Experimental Forest, 30 miles northwest of Charleston. This outdoor laboratory is forested with mature loblolly pine on the slopes and flats and with swamp hardwoods, mainly swamp tupelo, in the natural runs and lows. The soils range from well-drained to very poorly drained, with the majority in the somewhat poorly to very poorly drained category. Surface elevations range from about 20 to 30 feet above m.s.l. The amount

of surface water leaving the watershed is recorded at a stream-gaging station located at the natural outlet (Figure 2). Flow was first recorded in January 1964, and has been recorded continuously since then.

The installation at the Santee Experimental Forest is a pilot laboratory for South Carolina and adjacent states. The data collected there can not be correlated as yet with streamflow behavior on the many thousands of acres of similar land in the area. Thus, only broad generalizations about streamflow can be made. Nevertheless, records gathered at the Santee have indicated several interesting characteristics of streamflow that should be of general interest to woodland managers.

Flow is influenced quite strongly by the moisture storage capacity of the soil prior to rainfall. During several of the larger storms on the Santee as much as 70 per cent of the rainfall ran off quickly as stormflow, and run-off values between 50 per cent and 70 per cent of rainfall were not unusual. These streamflows occurred when the water table was near the soil surface. One example of excessive run-off occurred during July 1964 when 17.3 inches of rainfall fell between the 9th and the 31st. The watershed was continuously saturated, and 8.25 inches of water (90 million gallons) ran off as stormflow. The peak stormflow during this period was 45,000 gallons per minute. This example certainly points out the tremendous flood potential from forest land in the coastal plain. Fortunately, these extremes do not occur often, and a medium-to-high water storage potential prevails for the watershed during periods of average and

below-average rainfall. Rainstorms as large as two inches have produced no stormflow on the watershed when the water storage potential of the soil was high prior to rainfall. The wide variance in the amount of potential stormflow from a given rainstorm makes it difficult, therefore, to arrive at accurate prediction methods of streamflow from these coastal areas. Care should be exercised when using a prediction method or formula that does not include water storage potential.

Records of average streamflow reflect the tendency of the watershed on the Santee to release rainfall more quickly than do other forested areas in the Southeast. Three years of measurements show that this watershed, on the average, yielded 20 per cent of its rainfall as stormflow. In contrast, small forested watersheds in the mountains and the Piedmont in the East and Southeast yielded only 10 per cent of their rainfall as stormflow.

The total amount of stormflow was also twice as great in the coastal plain as in the mountains and the Piedmont. The greater amount of stormflow in the coastal plain may come as a surprise to many people. Although the greater slope in the uplands does tend to cause water to drain off quickly, the deep soils in that area hold water and are seldom saturated to the surface. This retention of water prevents quick overland flow.

Base-flow or delayed flow may be of as much interest to the water resource manager as is stormflow. Delayed flow from the watershed on the Santee has been constant from year to year, averaging about 16 per cent of annual rainfall. This flow represents 105,200,000 gallons annually, truly an impressive volume from 400 acres. The yield of water has not been continuous, however, and seasonal droughts have occurred each year since the laboratory was set up in 1964. The three longest periods of no flow lasted 26, 40, and 66 days, respectively.

If these small woodland watersheds are to serve as sources of water, it will be necessary to construct reservoirs so that water will be available during dry periods. This construction, as well as the preservation and development of all natural resources of the forests in the coastal plain, will depend to a great extent upon an understanding of how streamflow operates in that area.

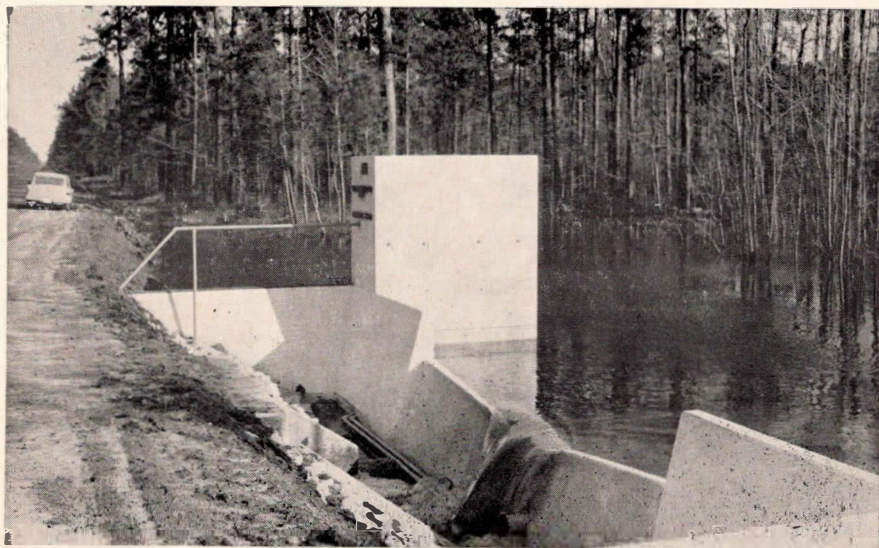


FIGURE 2.—Stream-gaging station for the 400-acre, forested watershed laboratory in the lower coastal plain of South Carolina.