The Eastern Forester and His Watersheds

Charles R. Hursh

As foresters, we profess to be the guardians of water resources. The author asks how well is the average forester able to live up to this responsibility. Some helpful reference points and concepts regarding water resources are presented.

N their formal education, foresters are considered to be trained in the management of the basic natural resources of the forest—water, timber, wildlife, and recreation. Because water is the least understood of all, the average student receives less formal training in this field than in any other phases of forest land management. Nevertheless, today the forester encounters an increasing number of problems that call for a knowledge of water. There are active programs of watershed improvement for flood control, of better land use planning, of municipal and industrial watershed management. Water enters into all the everyday problems of multiple use of land. Because of our lack of understanding, we have too often treated water resource management as only incidental to timber management rather than as a major responsibility of forest management.

A lack of knowledge of water resources has frequently been a handicap to a practicing forester, as illustrated by the following incident. Before a recent civic club meeting a forester gave a good account of the wildlife and timber resources on his forest. Also he stated that there were some fine streams much sought after for domestic and industrial uses. This encouraged a business man representing the pulp and paper industry to inquire what was the minimum dependable flow of a certain stream from this forest. At first inarticulate, the forester finally said he knew nothing about the yield of water from the streams on his forest, and that he was not familiar with any of the units in which water was measured and discussed. Thus not only did he create a poor impression as a land manager, but he missed a good chance to sell his profession to the public. The answer was easily accessible in published stream flow records of the region. It was simply that the stream had never fallen below 0.4 cubic feet per second per square mile for the past thirty years, with exception of the year 1925—when for a period of 20 days in August the discharge was as low as 0.1 cubic feet per second per square mile.

One way of finding out what the forester needs to know about water is to answer the question—what should a local forester know about timber resources? In other words, one can establish the minimum of what he can reasonably expect of himself or of another forester in the field of timber management, and then use this pattern for an analogous set of standards in the field of water management.

How Do You RESPOND TO TREES?

When a trained forester looks about him in the woods, he first automatically appraises certain individual trees. Because of his training, he takes cognizance of individual trees in terms of diameter, species, form factor, height, site, and possible defect. Thus he arrives at an approximate volume and probable growth in terms of board feet. Then he observes not only individual trees but also the probable number of trees per acre, and satisfies himself as to the approximate volume of the stand per acre and its probable annual growth in terms of board feet or cords. But he doesn’t stop here. His next thought is one of logging possibilities—accessibility, and probable stumpage value on the present market. Is the growth rate good? Should the stand be cut now? If so, how should it be cut to insure maximum returns and future productivity from its timber values? Thus there are certain logical mental steps that are the result of technical training, of experience, and of knowledge of local timber values. Back of it all there must be a certain logic and judgment that comes from both training and from experience.

How Do You RESPOND TO WATER?

Following this same line of reasoning, we can draw an analogy of what a trained forester can demand of himself in regard to water resources. Suppose in his routine activities he crosses a small stream. What are the mental processes that
are analogous to those about timber resources? Instead of diameter and form class, he automatically thinks in terms of width of the flow section of the stream, its depth, cross section, and velocity. For example, he notes that a stream is about 20 feet wide and will average about 6 inches deep, thus having a cross section of 10 square feet. Then he tosses a twig into the stream and watches as it moves with the current, thus estimating the velocity of the stream in terms of feet per second. For the present problem, suppose he counts out four seconds—one thousand one, one thousand two, one thousand three, one thousand four—and the twig has moved about 8 feet down stream. Eight feet in four seconds, so the stream has a velocity of 2 feet per second and a cross section of 10 square feet—thus it is discharging water past a certain point at a rate of about 20 cubic feet per second.

But so far, he has arrived at only a single fact—that the stream is flowing at a rate approximately of 20 cubic feet per second. This tells him very little in itself, about as much as arriving at the volume of a single tree in a timber stand. He looks at his map and sees that the drainage area about the point on the stream where he stands is about 10 square miles. So now he has a unit of expressing water flow that will be universally understood. Ten square miles are producing a flow of 20 cubic feet per second, or as it is usually stated, the stream is flowing at a rate of 2 cubic feet per second per square mile, which is written as 2 c.s.m.

THE UNITS BY WHICH WATER IS MEASURED

His next mental process would be that 1 cubic foot flow per second is equal to 448.83 gallons per minute, or 646,323 gallons per day. This same flow is also equal to 86,400 cubic feet per day, and will cover one acre to a depth of 1.9835 feet. A flow of one gallon per minute is equal to 1,440 gallons per day or 192.5 cubic feet. This is equal to 0.00442 acre feet per day. A flow of 1 cubic foot per second per square mile (c.s.m.) is the same as 0.7013 gallons per minute from one acre. A flow of one gallon per minute per acre is equal to 1.4259 cubic feet per second per square mile. In terms of volume, one cubic foot is equal to 7.48 gallons. One acre covered with one foot of water is equal to a volume of 325,851 gallons or 43,560 cubic feet.

The fact that the stream is flowing 2 c.s.m. leads to still other mental activities. In terms of water yield, is it good or is it bad? What does it indicate regarding present watershed conditions? This is a more difficult test than just the computation of the unit yield. In other words, many of us can estimate stand volume without being able to determine whether the current annual increase is above or below the average for the locality. It implies a breadth of experience and knowledge, and an established standard of performance by which we think of tree growth. Stream flow changes with the seasons, and with the time of the day. Suppose it is a late afternoon in August and that there has been no rainfall of more than 0.5 inches for any single storm during the past month. Also suppose that the location is in the Southern Appalachian mountains and there has been no rain at all for more than three days. Under these conditions one knows that 2 c.s.m. is a remarkably high yield. Even 1 c.s.m. would be a very good yield. A flow of 0.5 c.s.m. would be about average. A yield of 0.2 c.s.m. would be approaching drought conditions.

WATER QUALITY

The requirements for a forester who manages land on which water resources are of first priority must be still more exacting. For water-
sheds supplying municipalities and water-using industries, water quality also enters into the picture as well as water yield. Certain manufacturing processes can succeed only with water of certain characteristics. Bleacheries, laundries, canneries, bakeries, rayon and high-grade paper plants are particularly strict about the water that enters into their processes. Certain kinds can clog up steam pipes and ruin expensive machinery. Water quality considers not only mineral content, but also organic material present, turbidity, including sediment in suspension, and bacterial count. It cannot be expected that every forester should be a specialist in water quality, but he should know what water quality is, and how it can be influenced through land management.

When water is used for domestic consumption—quality is defined as the degree of potability of the water. A potable water is one that is safe to drink, pleasant tasting, and usable for domestic purposes. A contaminated water is one that contains disease-causing bacteria.

A polluted water is one that contains undesirable substances that may make the water unfit for drinking or domestic use. A contaminated water is polluted but the reverse is not necessarily true since the pollution may be caused by some chemical industrial waste. A water polluted with sewerage is contaminated. In order to actually determine the quality of a water to be used for domestic consumption, a sanitary analysis is made. This analysis is divided into three parts: physical, chemical, and bacteriological. The U. S. Public Health Service has set up certain standards as the criteria of water quality for domestic purpose. These are known as the Treasury Department Drinking Water Standards. When water is used for other purposes such as irrigation, boiler feed-water, or the manufacture of steel or paper, other standards of quality may apply.

A general increase in sediment carried by a stream follows road construction, careless logging practices, clearing and cultivation for agriculture, excessive grazing and trampling, and other marked changes in the surface soil. This sediment can alter stream bottom conditions and be detrimental to fish food. It can smother the fish eggs during incubation. It can be a cause for increased costs in water treatment plants and make it necessary to install treatment plants not already present.

Basic Concepts

A well-informed watershed manager should know something of three geophysical sciences. The first treats of the origin and distribution of water on the earth's surface and is known as hydrology. The second, climatology, deals with climate; and the third is the science of the development and properties of soil. It is in this field of soils that the forester is most concerned in water resource management.

Soil is developed as a result of climate operating on parent rock material over a period of time and under the influence of vegetation. We cannot change the climate or the geology of any locality, but we can alter the vegetation. It is the only basic approach we have to soil management and thus to watershed management. Any land use practice that produces a marked change in the vegetation has an appreciable effect upon the soil. We control infiltration and storage of water in the soil through our management of the forest cover.

As a hypothesis we can say that for undisturbed forest conditions there has evolved over the centuries a natural balance between rainfall and the sum of runoff, evaporation, transpiration, and water stored on the surface or in the ground. This statement is commonly written: Precipitation = runoff + evaporation + transpiration ± water storage, or: P = RO + E + T ± Storage. All of these components of the water cycle can be measured either directly or indirectly. Hence the circulating water capital for any watershed can be estimated and carried forward at any time as a water invoice.

From this invoice we can write the water economy formula for any watershed. We can use this formula also for a basis of determining the effects of different land-use practices by using an experimental watershed as the study unit.

Soil Structure Important

Even more important is the use of present day concepts of the soil profile as a physical system in understanding what happens to water when it falls on the land. Movement and storage of water in the soil profile are controlled by the volume, size, shape, and continuity of the soil pore spaces. Hence the structure of the soil which determines porosity is the basis for understanding soil hydrology, or we can say land-use hydrology. To maintain a favorable soil-
structure is one of the main objectives of watershed management.

We often deceive ourselves by thinking that because water is associated with climate, and because we can’t do very much about the climate, then we can’t do much about water. This is fallacious. Through watershed management we do not aim at creating more water capital, but rather to control the circulation and distribution of such precipitation as does occur. We control and direct the distribution of this water to our own best interests.

A progressive forester should be as well informed on water as on any other forest resource. This may call for some special effort for many of us. As water comes more into the picture, we who teach and we who practice will be expected to master the subject as we have mastered other new problems that have arisen in the past. Some older foresters may not have time to learn new terms and new concepts, but to the next generation of foresters a knowledge of water will be just a part of their regular technical equipment.