# FOREST AND WATER SYSTEM PROBLEMS

**E. M. GOULD, JR.—Forest Economist at the Harvard Forest, Petersham, Mass.**

If my remarks today seem rash or irrelevant, it is because they are almost totally uninhibited by any knowledge of the technical problems of municipal water production. I rather enjoy this reversal of role—for years economists have complained that the streets are full of people who feel qualified to give advice on even the most abstruse aspects of economic policy. This feeling of expertise among people at large probably stems from the fact that economics has to do with the business of the world's work, and because everyone takes some part each feels qualified to speak of all parts. Whatever the reason, economists are plagued by a host of experts—and I suspect that the managers of municipal water systems suffer from the same plethora of advisors. If this is so, then my remarks today will merely add one more bit of free advice to a measure that is already "pressed down and running over." Like the others, my credentials are those of a consistent and frequent water user, and this will have to stand as my qualification to talk to the people who supply all this liquid refreshment.

However, because I am more than 20 miles from home I qualify as an expert and should never be at a loss for something to say. As a student of forest resource management it occurs to me that there are some remarkable similarities between this activity and water resource management. The problem of furnishing a constant flow of potable and process water to our burgeoning population sounds much like the task foresters originally set themselves with wood. It might be that we could learn much from looking at the remarkable success that you folks have generally enjoyed, and it may be that you can learn something from the difficulties that we have encountered.

Let's look first at a few of the problems foresters are struggling with, the origin of some of these troubles, and possible solutions. Then we might see whether any of this experience can be applied to water supply systems. Because you people are probably accustomed to dealing with systems we can start by outlining the one foresters have staked out as their particular domain.

## Original Forestry Concept

Using the "black box" scheme of notation that is so popular today, we can say that the original conception of forestry in this country was that of combining inputs of time, forest land, and capital through a management process relying heavily on inventory control and itensified silviculture to produce wood, water and grazing. At a later date recreation or amenity was also recognized as a valuable output.

You will notice that I have enclosed the several outputs in one box. In the early days, although these several values were recognized, the rather heroic assumption was made that these were all joint products. This was a mighty convenient simplifying assumption—because it implied that any system of management that was best for wood production, would automatically lead to the best production of the other values.

Thus we had a simple system that focused attention on the land to produce a constant flow of primary forest products, sold either on the stump or delivered at the roadside. In addition, as I have hinted, success was measured by how near the forester could push production toward the maximum sustained yield of wood. I have somewhat over-simplified the situation but the concept will do for our purposes today. The whole idea was admirable from the standpoint of being logical and easy to understand, it had readily measurable output, was eminently teachable, and easy to work—on paper.

Unfortunately, this vision of the forestry system had only a passing resemblance to the systems that existed in the real world and

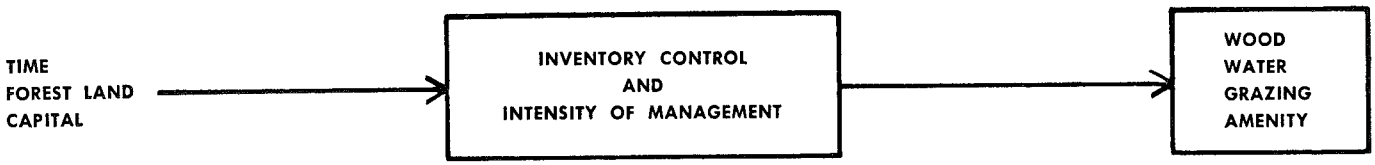


FIGURE: 1. THE FORESTRY SYSTEM

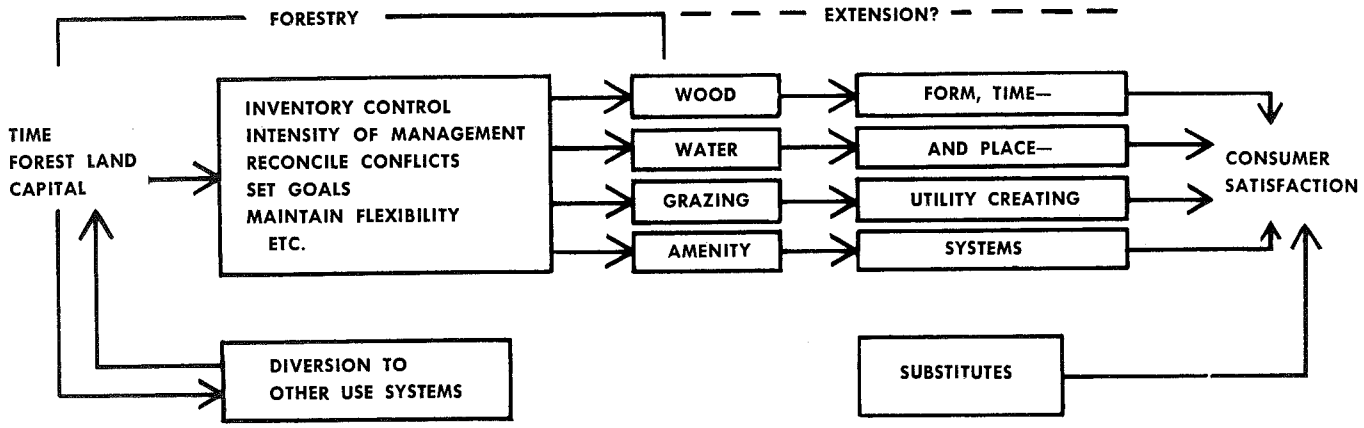


FIGURE 2. THE EXPANDED FORESTRY SYSTEM

actually controlled the use and development of forest land. The difference between the world of forest theory and the world where foresters worked was too marked to escape notice, and reconciling these differences led to considerable professional schizophrenia.

Without going into too much detail, there seem to be two major sources of trouble. First of all, it appears that the several values that can be realized from the forest are not really joint products—recent research suggests that at some intensities of management they are joint, while at other intensities they compete with each other for either land or capital or both. Thus it is unsafe to assume that management keyed to one product will automatically satisfy all other needs most effectively. Developing analytical schemes to set divergent goals and meet them by allocating scarce land and capital among the several uses is now a major objective in forestry.

The second source of difficulty is perhaps more basic and lies in defining the breadth of the system that foresters should rationally concern themselves with.

Even if the production of each of the several products is treated as a separate problem there are rather elaborate engineering, economic, and social systems that take over the primary pro-

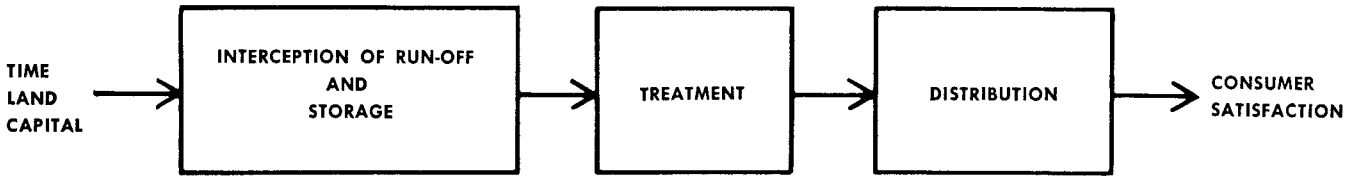


FIGURE 3. WATER SUPPLY SYSTEM (RESERVOIR TYPE)

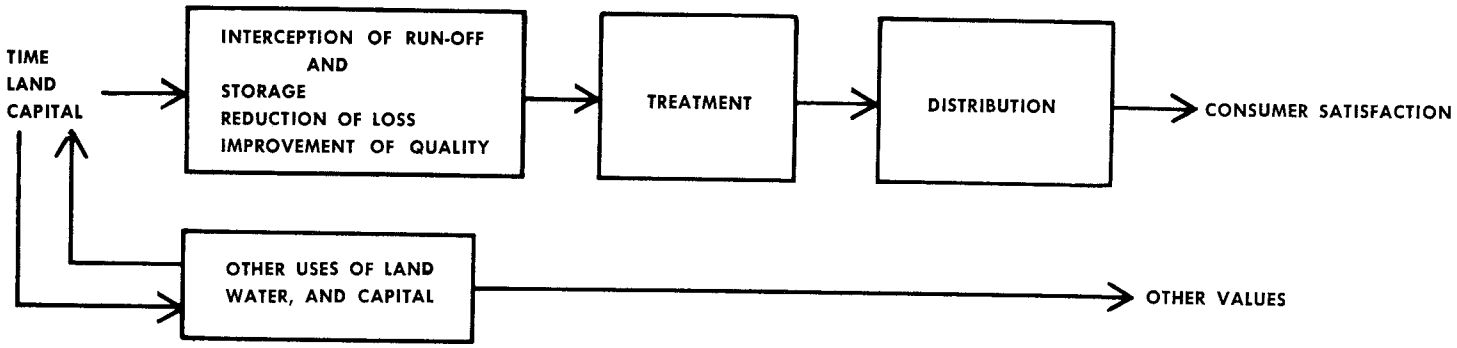


FIGURE 4. EXPANDED WATER SYSTEM

ducts at the edge of the forest, change their form, move the resulting item to a place where it is needed, and get it there at a time when it is required to satisfy consumer demand. Thus wood passes through a sequence of markets, factories, and transportation facilities that turn a log in the forest into this table, here in this room, for me to talk from today. In one way or another these sub-systems are essential links connecting the land and consumers. Additional completely unrelated systems are busily coming up with substitutes like plastic and steel for forest produced values. We have also become painfully aware that still other forces are competing for the land and capital inputs that foresters plan on using.

All in all, this concept of the forces actually at work gets to be a very complex one of interacting biological, engineering, and social subsystems; and the problem of carving out some workable portion to call "forestry" is rather difficult. However, the real world is complex, and there isn't much to be gained by bemoaning the fact or by pretending it is all very simple—foresters should know, they have tried both approaches! At the moment, we are starting to sort out some methods that will help us define the areas most relevant to forestry and also help us analyze plans for coping with the complexity and uncertainty that will be inherent in the resulting system.

## Water Managing Problems

What relevance can all this have to the problems faced by water systems managers? I said earlier that you people seem to have been generally more successful with your operations than foresters. Perhaps this stems from the fact that your concept of a system is more useful than the one foresters visualized. I suspect that this is because you started with a strongly felt need on the part of consumers for ample, high quality water delivered at the point of consumption. Rather than starting with the land and working part way toward the consumer as we did, you started with people's needs at the moment of consumption and built a complete system to satisfy this need all the way back to the land.

To an outsider, a municipal water supply system appears to use the same inputs that foresters start with—time, land, and large increments of capital for engineering works. If this is a reasonable approximation, it has the outstanding virtue of being a working model of the real world. In order to get water of a quality desired, to the place where it is needed, and at the right time, you have drawn heavily on engineering to arrest part of the hydrological cycle and prevent runoff. At the same time you store the water until needed; not, of course, without some waste through percolation and evaporation. Pollution is reduced by controlled use of the watershed and by supplementary treatment if it is needed. You have created social institutions to do all this, along with distribution to the point of consumption. Thus water supply systems are not only mental constructs but also very real assemblies of working natural and social sub-systems.

I think that many water people have also done a better job than foresters in looking ahead to recognize the growing demands likely to be met before they constructed their supply systems. This was, of course, encouraged by the need for massive doses of capital to cure already existing or imminent shortages. Few things induce planners to exercise their full powers of anticipation more than the "carrot and stick" provided by an irate public and the chance to spend a few million dollars.

The growth of Boston's water supply from a few wooden pipes and a tank to its present dimensions that sprawl half-way across the state, is one of the best examples in the region of effective long-term planning. Once the move was started west to Long Pond, each additional expansion seems to have been influenced by an even longer look ahead to the most likely place to go thereafter. The move to the Nashua in 1898 was conditioned by the fact that Quabbin could be created from the Swift River, even though about 30 years elapsed before that step was taken. Quabbin, in turn, opened up the chance to tap the Millers and Deerfield rivers, which seems likely to be needed after a lapse of about 40 years.

This brings up two problems that I suspect water supply people have in common with foresters—while your systems are admirably engineered to provide water; meeting demand by continued expansion of the old pattern will use more and more resources that can be put to other uses—uses that are steadily rising on the human scale of urban values. Also some of the facilities you have created such as Quabbin Reservoir have unique capacities to satisfy needs in addition to water. Both of these questions raise difficult problems concerning the best planning strategy for the future.

Figure 4 suggests that, just as with foresters, there is a rising demand for the use of land and water resources to live in, travel over, and generally to enhance the quality of our urban environment. It seems to me that anything like the doubling of our population that is anticipated in the next couple of decades will increase these conflicts of interest to an intolerable level. Now is the time to investigate how these competing uses can be accommodated into the water supply manager's system.

I suspect that we need better information about the technical aspects of potable water production and the interactions likely to arise between other land and water activities before we can be sure which uses are joint or compatible and which are competing or incompatible. It is likely that the same situation exists with water as with forest resources—the degree of competition depends on the intensity of use and on the management practiced.

As one interested in planning the use and development of renewable resources four general areas of possible adjustment in water systems seem to me promising enough to warrant intensified research. We might describe these areas of knowledge as "water farming," "dual purpose systems," "recycling," and "strategy."

1. Under the heading of "water farming" I

would fit all of the possible ways that rainfall can be more efficiently captured. Essentially, this is a search for management practices that further alter the Hydrologic Cycle.

a. You have already heard a good deal about the possibilities of cover control to reduce the interception and evapo-transpiration of precipitation. At one time water supply managers accepted the planting of trees as good management, now it is apparent that forests are excellent interceptors of rainfall and very efficient pumps that can return about a quarter inch of water to the air each hot summer day. All this can reduce run-off, and the search for less water consumptive vegetation is being pursued along with study of the water impact of reduced densities of tree cover and changed patterns of the leafy canopy. It is of more than passing interest that changes in watershed cover will no doubt also have a joint impact on the production of game food and cover which may increase pressures to open closed areas for hunting; and a definite effect on the appearance of the landscape that may increase or destroy some of its amenity value. In addition, if chemicals are used extensively to cheapen cover control they may have a distinct deleterious impact on wildlife and water quality.

b. Another bundle of practices is designed to cut down evaporation from stored water bodies. Under this heading come such things as the shaping of storage reservoirs to reduce evaporating surface area. In some areas covered cisterns may be appropriate, or a similar effect may be achieved through the use of monomolecular films. The storage of water in underground aquifers is possible in some places. This raises the twin problems of efficient land forms to increase recharge, and effective schemes for recovering the stored water. In favorable areas the use of aquifers might release surface reservoirs for other much needed uses with a minimum of conflict.

2. Under the heading of "dual-purpose systems" I would include all methods of handling the problems of water supply and waste disposal as a single process. Our present network of streams is being used for both these essential activities anyway, and we might make more rational decisions if we viewed both these activities as part of the same broad system.

a. Because our urban society is vastly increasing its demand for potable and process water concurrently with its need for expanded waste disposal there are limits to the increase of one service at the expense of the other. It would make a good deal of sense to view the water in the whole state as part of one great system. Then we might be able to rationalize the uses of parts of it for supply and parts for waste more effectively. We could also more readily assign the costs of each use to the real beneficiary. Given the proper institutional organization it might be possible to sell the use of a river to the organization that needed it for a sewer—and the price would reflect the cost of making the water fit for the next user.

b. Whether the state or the region is the best planning area for this kind of a water system would also need more study.

3. Things that could be done under the rubric of "recycling" are closely related to the ideas mentioned above. Water is already used and reused several times on its passage to the sea, but we generally recondition the water on a group basis to gain economies of scale. However, it may be feasible to do this on a dispersed house-to-house or industry basis with self-contained water supply-sewage disposal-purification systems. Such an approach might radically reduce the need for potable or process water and could relieve one of the restraints on new settlement patterns. We already have something very like this in areas like my town where everyone has his own well and septic tank, but a new approach to combine functions could be less land consumptive and less dependent on favorable soils.

4. Under the heading of the "strategy" of planning we could fit any number of things; I would like to mention briefly only two. Both of these points assume that the pressure for multiple uses of land and water will continue to rise and that retreat from single purpose use will be necessary. Of course, a great deal will depend on the answers found to "water farming," "dual-purpose systems," and "recycling." But if more use is to be made of present water systems to

produce other values the critical question is which uses to add first and which last.

a. Part of the answer to scheduling will depend on how well we can anticipate the health hazards likely to result from each kind of use. I am sure that we can agree that scenic highways around reservoirs are less of a threat than swimming—but what is the exact nature of the deleterious side effects and what capacity do we have to correct them? Can we successfully assess the import of virus invasion of drinking water and do we know how to remove them? How about the cumulative results of prolonged ingestion of certain chemicals at very low concentration levels? Certainly our knowledge in many important areas is far from perfect—but we should be able to at least rank new uses on the basis of our assessment of the uncertainty about health hazards associated with each.

b. Another problem is ranking the added costs associated with each new use introduced into a water system. Prudence would suggest opening the gates first to those uses with the lowest added cost and the least uncertainty about health hazards. But if your experience is like that of foresters, the costs of new uses mount rapidly so the question of having those who benefit pay for the values they realize becomes very important. There seems to be no rational reason why water consumers should foot the bill for recreationists, for example. I believe we are gradually moving in the direction where special users will pay for the added costs of the services they require. If we face the problem of connecting costs and beneficiaries squarely, it may have a decided impact on the rate at which new uses are introduced.

## Conclusions

To draw this discussion to a close—it would seem that water supply managers and foresters have many common problems. I have suggested that progress toward new solutions may come from a common source—first by broadening our concepts of the system we are managing and secondly by improving our knowledge of the techniques for designing each component part.

In reading over these remarks I notice that I have given you remarkably few of the "Guidelines" promised in the program. Perhaps one thought worth leaving with you is that resource managers are inevitably enmeshed in controlling the rate of innovation in an uncertain world. In this kind of situation the strategy of decision-making is most important and there is never enough time to consider all the questions that require an answer. A central need is some scheme for deciding which problem will get your full attention and which will not.

Glenn Johnson has suggested that classifying questions according to your estimate of the importance and uncertainty of each decision will help establish priorities.

A. **Act as if certain.** Most decisions fall in this class, where although you recognize there is some uncertainty about the outcome the amount of variation expected is too small to worry about. You take action quickly because you are willing to act as though your knowledge was perfect?

B. **Uncertain but act anyway.** Here there is real uncertainty about the outcome of your decision. But the gains of quick action outweigh your estimate of the pains of delay and the chances of learning enough more to improve the decision.

C. **Postpone.** Questions in this category are the reverse of the above. You feel your knowledge is too skimpy to justify action but the penalties of a mistake justify the delay needed to learn enough more to improve your decision. Most basic policy issues fall in this category, and on these administrators lavish much of their time and energy.

D. **Forced Action.** This is the situation that got out of hand. Although you are very uncertain, the premium on quick action overwhelms any possible gain from delay. There is really no choice left.

I suspect that the real art of management is to get questions into the right category so the weighty and important decisions, where real uncertainty exists, get the most attention. Perhaps we can say that a successful manager practices artful postponement without falling into the trap of the forced decision.