PHYSICAL AND SOCIAL PROBLEMS IN WATERSHED MANAGEMENT

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Water problems are certainly fast becoming a number one topic of conversation if one takes as an indication the numerous conferences like this series in New Mexico, and the increasing number of books and publications on the subject. Nonetheless, there are many people, particularly in the eastern part of the country, who do not know there are water problems and most of us, I suspect, can only guess at the form of the ultimate solutions to these problems. On a recent flight across New Mexico a man, apparently a farmer from eastern United States, crossed the isle in front of me and from 12,000 feet looked down at the desert, remarking to his wife "My, Martha, look at all the empty land down there. Just think how many farmers could settle there, one every half mile."

Each year our water problems become more acute. This is so because as each year passes the per capita use of water increases and the number of water users also increases. In the eleven western states the per capita water use in 1955 was 4,112 gallons per day. In contrast, in eleven eastern states where there is little irrigation agriculture, use was 872 gallons per day. In the past ten years the population of the United States has increased by 30,000,000 and at the present rate of growth it will increase by another 80,000,000 by 1980. In the West existing demands are pressing hard on total supplies and in some areas use exceeds renewable supplies and ground water is being mined. None of this is new to you.

The basic problem we look forward to is how to get enough water to keep ahead of demand. The oceans represent an inexhaustible supply and if the economics of desalinization and inland transport could be solved, a major source of worry would cease to exist. For coastal areas desalinization may become economic sooner than we think. For inland areas, however, use of such water seems rather remote so we must look elsewhere for possible solutions.

Dr. Kassander has just spoken about increasing precipitation through weather modification and speeding up the cycle of evaporation and precipitation. Other solutions center around making our existing supplies go further by reducing transmission losses and increasing the efficiency of use, especially in agriculture. Still another possibility, as Dr. Reynolds has shown, centers around increased yields from our watersheds. My remarks are related mainly to the latter possibility and some of the problems involved.

Watershed management is based on the concept that land, that is the plant cover, the soil and the rock mantle, is a reservoir that receives, stores and discharges water and also supplies water for on-site use by plant and animal life which in itself performs useful services and provides valued products. The reservoir is subject to change and regulation by treatment or land use.

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Good watershed management has several goals. First, it must develop and maintain the watershed conditions which produce and put to beneficial use the maximum amount of water. Second, it must do this in a manner to assure satisfactory control of runoff and erosion. Third, these objectives must be integrated with the program providing for the optimum production and utilization of all resources of the watershed.

In considering watershed management problems two points stands out. The first is that water yield is a very complex phenomenon controlled by a considerable number of individually important factors. These factors may act together in increasing or decreasing water yields and regulating stream regimen or they may oppose each other. The relative importance of the controlling factors may vary very significantly from one watershed to another. Therefore, it is very important to know each watershed in detail and to recognize that uniform treatment and management of dissimilar watersheds will give dissimilar results. Secondly, on any one watershed there is a number of alternative solutions to the management problems which arise. These alternatives are based in part on physical and in part on social considerations. The solution to individual watershed management problems is difficult because (1) we do not have sufficient information regarding the way a variety of factors affect the physical processes going on in the watershed, (2) we are unable to accurately measure and predict the desires of people regarding alternative uses of the watersheds, and (3) there are real conflicts among watershed users, both within localities and between localities and regions as to what should be the dominant use or uses.

Some current problems about which there is much talk and some considerable research in progress concern the manipulation of plant cover on watersheds to increase water yielded as streamflow. Almost all of the existing research suggests that yields of water can be increased by either (1) decreasing the density and changing the composition of the vegetative cover or (2) decreasing the depth to which roots penetrate the soil and absorb water from it. Vegetation intercepts precipitation and causes part of it to be evaporated back into the air. Vegetation absorbs water from the soil and transpires it. Vegetation also shelters the soil and reduces direct evaporation of soil moisture and tends to increase infiltration rates and deep percolation. In general, when the density of the vegetative cover is decreased interception and transpiration are decreased more than soil moisture evaporation is increased and a net water yield increase is effected.

When a forest area is clearcut the increase in water yield would be expected to be directly related to the size of the area cleared. In the humid southeastern United States clearcutting all vegetation has resulted in a 50 percent increase in water yields. In the humid, high-elevation lodgepole pine and spruce-fir forests of Colorado a 25 percent increase has followed clearcutting of 50 to 60 percent of the land area. Where forests are selectively cut or thinned the water yield would not be expected to increase uniformly with decreasing stand density. A number of considerations suggest that between 50 and 100 percent of maximum forest density there would be only very small water yield increases and that below 50 percent density increases might be nearly proportional to decreased density.

In considering the desirability of making vegetation changes and the degree of such changes it is important to consider a number of relationships. First of all, if the region is a forested one it is not possible to practice timber growing on a sustained yield basis if much of the area is kept clear of vegetation. If it takes 100 years to mature a crop of trees the maximum area that can be cleared in any one year is 1/100 of the total. Hence, the expected water yield increase accompanying clearcutting with sustained yield forest management would be only a fraction of that obtained from small clearcut plots or watersheds even though young small trees use less water than old large ones. The larger part of the increase would come from the smaller part of the area represented by valley bottoms and lower slopes.

If the forest were clearcut and reseeded to grasses rooting more shallowly than trees a water yield increase could be expected from those areas having soils thicker than the depth of root penetration, in those localities where there is enough water to wet the entire soil profile. In many mountain areas there are no large areas of such deep soils.

If forests are thinned very heavily and water yield increased it is important to consider how much the timber yield is decreased as water yield is increased, or in other words, what is the value of the extra water consumed by trees in terms of the added growth produced. Unfortunately, we have none of this information at the present time. It generally has been assumed in the Southwest that the value of the water on-site is greater than the value of the timber growth that could be produced with that water. We need to know if this assumption is correct and if so whether a consideration of stream transmission losses would change the picture.

Still other points that need to be considered concern the effect of the vegetation manipulation on the character and timing of the runoff, on the percentage of surface runoff, on water quality, on soil changes relating to water infiltration and movement and on timber and forage production, and on erosion and silting of stream channels and reservoirs. Lastly, there is the question of the costs of changing vegetation and maintaining a different kind of cover.

The vegetation does consume water. Are the products and services it performs worth the cost in terms of water? What is the safe or desirable level of change? We do not have sufficient information as yet to confidently answer these questions.

A second problem area conserns the best place or places in a watershed to use the water that falls on the area. Mr. Dorrah of the Soil Conservation Service has estimated that on the San Simon drainage of southeastern Arizona and adjacent New Mexico only 20 percent of the water measured on-site up-stream reached possible irrigated areas near the stream mouth. On Rillito Creek near Tucson 75 percent of the water from the Catalina Mountains disappears into the stream bed in a distance of 10 miles or less. Some of this water replenishes the ground water supply and some is evaporated from the soil and transpired by uneconomic phreatophytes. We do not know how large each part is. Some of the evapotranspiration loss could be avoided by removal of phreatophytes or by conversion to less deeply rooted plants like, for example, some of the grasses.

Transmission losses increase with increasing distance the water moves. To reduce or stop these losses would require piping water from the upper, higher-elevation parts of the watershed where it is produced to lower areas where it is presently used, or to eradicate and control the phreatophytes.

What is the cost of these operations in terms of the "extra" water obtained? Would it be better to capture and use this water on the upper watershed where it might be spread on the better land for crop production or to increase range forage yields. Would it be better used for recreational purposes or for industrialization and urbanization of the presently smaller communities around a state. From the long-run social and national defense points of view, would it be better to disperse our population than to concentrate it in a few large centers like Albuquerque, Tucson and Phoenix. These are particularly important questions in view of the ever increasing percentage of our population in urban areas, the ever increasing industrialization and the problems of air and water pollution and the greatly increased demands for recreation. They suggest possible changes in water-use priorities.

A related problem concerns the relation of stream channel transmission losses to water yield increases resulting from vegetation manipulation and management. In the case of San Simon Creek, if we assume that a 10 percent water yield increase would follow a reduction in grass and forage plant density on the watershed, then if the downstream water yield was 20 percent of the on-site yield the increase in water yield downstream would be 20 percent of 10 percent or 2 percent. The question that then arises is what are the economics of using the "extra" water on the upper parts of the watershed for increased yields of grass and livestock as compared to (1) using one-fifth as much water downstream on perhaps more fertile level soil for crop production or (2) transporting the extra water downstream without evapotranspiration losses. These are particularly important questions in view of the more rapid normal erosion in arid versus humid climates and the accelerated erosion that probably would accompany a decrease in vegetation density effective in increasing water yields. Again, is the increased on-site production of economic plants and the service rendered by the plants through maintenance of soil fertility and reduction of erosion and silting worth the cost of the water involved and if not so, how far do we want to go with vegetation changes to increase water yields?

Still another problem relates to the question of how to allocate water for various uses, and to changing water-use priorities. In the Southwest there have been very large gains in urban populations in recent years. In many areas, the normal working of economics has resulted in priority shifts as housing developments and industrial plants have been placed on formerly irrigated agricultural land. In areas where water is being mined adjustments inevitably must be made. The large increase in industrialization and urbanization in the Southwest has resulted in the need for greatly expanded recreational opportunities. Much recreation centers around water in streams, lakes and reservoirs, or the plant and animal life the water produces, and providing recreation opportunity is a part of watershed management. Can recreational demands compete with agriculture and industry? If so, what water developments are needed and where should they be? A recent study by the University of Arizona Bureau of Business Research suggests that the income to Arizona from all kinds of recreation exceeds the income from agriculture, mining or industry alone. I suspect the same may be true of New Mexico

How to get people to work together in planning watershed developments is another important problem, especially where there is a wide variety of opinion among land users as to desirable goals. This is a sociological problem and outside my specialty. Much needs to be done, however, to assure optimum development and use of all watershed resources and this requires a recognition of problems, decision-making based on good information and the ability of people representing private citizens and public officials and land administrators to understand each other and to work closely together. As an illustration, since coming to Arizona 18 months ago I have been trying to assess the importance of erosion problems on the watersheds. My own impression is that there has been rather serious accelerated erosion on a considerable part of the arid lands, particularly the more fertile and better watered part, that soil productivity has been reduced, that stream discharge patterns may have changed materially, and that these conditions still persist on important areas. Somewhat to my surprise, I found some vocalized opinion to the contrary. Admittedly, it is difficult to assess what may have happened 50 to 80 years ago, and in a land of great annual climatic variability, what is happening today. Do we not know what the situation is? Or has communication among different segments of the population been inadequate. What can be done here to get closer to the truth of the matter, to communicate the facts to more people and to stimulate the collective action needed to better deal with the related problems?

Lastly, there is the very basic problem of the balance between population and resources. Our land base is fixed. Water other than that in the ocean has finite limits as do most of our other natural resources. As population increases the per capita quota of these resources decreases. For example, in 1940 there were 2.7 acres of arable land for each person in this country. In 1960 this figure had dropped to 1.9 acres and in the year 2000 it is estimated to be between 0.6 and 1.0 acre. As the per capita natural resource base decreases the pressures on all resources will increase, a pressure which in other countries has resulted in depletion and occasionally the destruction of the resource. There is a question of whether we will be able to continue to increase our standard of living or even to maintain our present standard if predicted population increases occur. If we can, it means more efficient production and use of resources. For watershed management this means reducing water use by uneconomic plants, minimizing soil moisture evaporation losses, providing the conditions for the most efficient use of water by plants both on and off the watershed and making the same water serve several uses. James N. Land, Senior Vice-president of the Mellon National Bank and Trust in Pittsburgh recently said "Because our population is expanding rapidly, we must drill deeper oil wells and exploit less productive veins of coal and other minerals and less accessible and poorer quality forest areas and go further afield for the water supplies of our cities, all of which adds to unit costs and is a drag on prosperity." Our watershed problems increase and their solution becomes more difficult and costly as population pressures increase. The margin for managerial error in resource management will become less as population increases, the probable result of which will be more regulation by public agencies and a reduction in the freedom of action to which we in this country have become accustomed. The solution to water and watershed management problems is as much a problem of dealing with population increase as with increasing our scientific knowledge and technology. We can get more water for beneficial use by various water and watershed management techniques but the probable gains appear smaller than the increased demand arising from increasing populations. Inevitably a balance, good or bad, must be achieved.