WATERSHED MANAGEMENT TO INCREASE WATER YIELD

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A potential opportunity exists for increasing the water supply in the Western United States by the management of the upland watersheds to reduce consumptive use by the native vegetation and thereby to improve the yield for downstream delivery. From the Rocky Mountains westward to the Pacific coast, streamflow is derived chiefly from the mountain forest, brush and grasslands and alpine (above timberline) areas. These producing areas occur generally above the pinon-juniper woodland zone or corresponding plant types in parts of California and Arizona. For the most part these are areas where the average annual precipitation is over 16 to 18 inches and the greater part of it occurs as winter snow or as rain (Ariz-Calif.) during a relatively short winter season.

It is common knowledge that only a relatively small portion of the water that falls upon the land as rain or snow is ever discharged from the watershed in the form of streamflow. In our western country most of the precipitation returns to the atmosphere through evaporation or transpiration (release of water by vegetation) near where it falls. Since the two are difficult to separate they are commonly referred to as evapotranspiration. In New Mexico, for example, the average annual precipitation is a little less than 14 inches. It varies from about 8" in some semidesert areas to near 40" in a few places in the high Sangre de Cristo mountains. The average statewide streamflow runoff is about 0.47 inch or 3 1/3 percent of the precipitation. This runoff is estimated to vary from as little as 1/10 inch in the semidesert to as much as 20 to 30 inches in parts of the highest mountains. Other parts of the West have corresponding, although in some cases somewhat more extreme variations.

The opportunity for increasing water yield consists of reducing the evapotranspiration in the more humid parts of the watersheds by manipulation of the vegetation. An experiment laid out in 1909 on the headwaters of the Rio Grande in Colorado was the first to indicate the possibilities of increasing water yield by changing the nature of forest cover. Since then research projects in a number of western states including Arizona, California, Utah, and Colorado have further indicated that there is considerable promise of increasing water yield by modifying the plant cover - more especially trees and shrubs.

The chances for increasing water yield, however, vary widely, depending upon local conditions. Generally, the precipitation has to exceed about 18 inches. There must be a concentration of a large part of it during the nongrowing season, either as an accumulated snow fall or as winter rain. As a rule, the greater this seasonal precipitation, the greater is the proportionate amount, as well as the total amount, of the precipitation that emerges as streamflow. In most localities, except in the very high-rainfall belt in the Pacific Northwest, most of the precipitation that falls during the growing season is dispersed by evapotranspiration.

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Among the other factors that affect the percentage and total amount of yield, under natural undisturbed conditions, are the geology and topography of the watershed, the character and depth of the soil, and the amount and kind of plant cover. For example, a watershed with deep soils that have a high soil moisture retention capacity and a good cover of deep rooted plants are likely to yield a smaller percentage of the precipitation as runoff than a similar watershed with shallow soils. The soil-moisture reservoir within the root zone of the vegetation which has been exhausted during the past growing season must be recharged to capacity during the next snow-melt or winter rainy season. This recharge process may require 2 to 3 inches of water to recharge each foot of soil in the root zone in order that percolation to the water table may take place. This recharge quantity is exhausted again by the vegetation in the following growing season so that it is a loss so far as water yield is concerned. Some species like many of the grasses, concentrate their roots in the upper foot or two of soil. Other plants like many of the trees and shrubs may send their roots to a depth of 8 feet or even much more if the soil is deep. There will be considerably less transpiration loss if the deeper rooted vegetation is replaced by shallow rooted plants. There should also be less transpiration, for a time at least, where the deep rooted plants are thinned as in the case of timber stand improvement. However, there is little to be gained by changing from tree or shrub cover to grass, if the soil is less than 3 to 4 feet in depth. In that case most any kind of vegetation will use up the soil moisture in the shallow soil mantle.

Some plant species, more especially the evergreen trees and shrubs, also cause a greater net loss of snowfall or winter rain due to interception than deciduous species and grasses. Dense stands of conifer trees, especially, intercept a considerable quantity of snow or rain and a large portion of this moisture is returned directly to the atmosphere by evaporation. Consequently, water supply may be gained if this interception is reduced by thinning or by clear cutting strips or blocks of timber stands, or if there is conversion of tree or brush cover to grass.

It is to be kept constantly in mind that any treatment to increase yield must not be at the expense of reducing infiltration of water into the soil. Except on barren rock exposures or in rare extreme storms, the upper watersheds in natural condition yield but little surface runoff. The natural vegetation and soil conditions are such as to promote infiltration of water which later emerges as streamflow. But if the plant cover has been seriously reduced the infiltration capacity is reduced to an extent that surface runoff and excessive erosion usually take place. Any treatment of the vegetation, therefore must be such as to leave adequate plant material to promote high infiltration and prevent erosion which quickly creates serious damages:

The lower plant zones, and by this is meant the pinon-juniper, and mixed grass and desert shrub and grass areas, offer no sound opportunity for increasing water yield. These generally are the zones with less than 18" of precipitation. The high evaporation rate and transpiration draft coupled with low precipitation and long growing season result in such complete dissipation of the precipitation that there is very little if any contribution to ground water storage except through arroyo bottoms during flooding stages. The water yield in these lower watershed areas consist almost entirely of flash-flood runoff over the surface of the land from the occasional high intensity summer rains. The yield at best is so little, from 1/10 to 1/2 inch, that the chance for increasing it is very small. Except in the pinon-juniper zone any increase may be obtained chiefly by skinning off the vegetation as by over grazing, and the gain in yield will be small at best. The resulting increase in erosion will cause a far greater damage than the small gain from the increased muddy flow that would result. In the pinon-juniper zone the small gain in yield, if any, will scarcely justify the cost; treatment of such areas should be based on some other purpose.

There are many problems still to be resolved in attaining a sound watershed management program for increased water yield from the susceptible acreage in the western states. The necessary hydrologic research must be carried out for all of the major climatic, geologic, topographic and botanic conditions in the western upper watersheds. These studies require 5 to 10 years of measurement of precipitation and runoff from the selected experimental watersheds to calibrate them, before experimental treatment can start. Then there must also be practical tests on operating size watersheds to develop all phases of application. These tests, also, should be preceded by 5 to 10 years of streamflow and weather measurements to determine with an acceptable degree of accuracy the effects of the treatment.

There is also the evaluation phase. Economics will play a large part in carrying on programs. So there must be determination of the costs and returns from treatment practices. This also enters into the matter of where and to what extent the water can best be used. Timber is a needed commodity also. Decision must be made from time to time whether and to what extent timber growing or conflicting uses of watersheds should be curtailed for the advantage of water production. To be considered especially is recreational use of the watershed areas. These relative values are dynamic so there must be re-evaluation from time to time to determine what is prudent action in a changing world.

The manipulation of watershed cover for increasing water yield is new but does have promise. The important point is that in view of the preliminary time required to conduct the necessary research and practical tests, the research and testing programs should be started immediately to avoid "crash" programs when the need for water becomes highly urgent. At best, programs of watershed treatment are not going to sweep the mountains like wild fire. What may be termed as a form of culture for the practice must be developed gradually, but once started programs will extend further as the many conditions are found to warrant. We need to start today to be ready tomorrow..

But some additional points are important. Increasing the yield of water from the upper watersheds will not be worthwhile if the water thus temporarily gained is lost by evaporation and transpiration between the point where it is produced and the point of divergence downstream. Reference is made here to the non-beneficial use or waste caused by riparian vegetation, by phreatophytes, by stream channel losses, and by surface evaporation from rivers and reservoirs. This loss is heavy from those streams in the Southwest which span long distances through the deserts and semideserts. Among these streams are the main Colorado and many of its tributaries, the Rio Grande, the Pecos, the Canadian, and the Arkansas.

For example, in the 160 mile stretch of the Middle Rio Grande Valley between Otowi and San Marcial in New Mexico, there is an average annual stream depletion from all causes of approximately 560,000 acre-feet. Of this, 160,000 acre-feet or less than 1/3rd is put to beneficial consumptive use in crop production, but 400,000 acre-feet are lost by non-beneficial use. This water is lost chiefly by (1) evaporation from river bed and sand bars, (2) phreatophyte use, (3) canal conveyance loss and, (4) poor irrigation practices. It should be possible to salvage a large part of this current loss.

Others at this meeting have discussed phreatophyte control and reduction of evaporation losses. I wish to mention, briefly, a watershed angle of these problems; namely, management or protection of the lower watersheds. These areas pinon-juniper woodland, the mixed grassland and the semidesert shrub and grassland occupy over three-fourths of the area which drains into our Southwest streams. The mountain watersheds produce the water but these lower--lands produce the sediment that chokes the stream beds and clogs the storage reservoirs. Most serious, however, is the fact that these sediment deposits become the seed beds for phreatophytes like salt cedar.

Waste by phreatophytes in New Mexico is variously estimated to be 500,000 to 850,000 acre-feet each year. I would guess that the amount is greater than the larger of these figures and is even greater in Arizona, because phreatophytes are spreading far and wide.

The solution to this problem has several facets including phreatophyte control, channelization of stream valleys to hasten water delivery and lower the water table, and sediment storage reservoirs. The ultimate solution, however, is control of erosion on the watersheds to keep the soil in place. One of the troubles in this connection is that the very poorest lands, which produce most of the sediment, are so poor, as some one has said, that "they are not worth fixing." This is probably true so far as a private owner is concerned, but the public cannot afford to let these lands continue to produce sediment.

The solution of this erosion problem, I believe, lies in the following (without order of priority):

1) Greatly step up the soil and moisture conservation program on the public domain and other public lands, and also on state and Indian lands.

2) Classify all lower watershed lands to determine the "bad spots" or critical areas. Many of these sore spots are so far gone they have little or no forage value and should not be grazed at all. These spots should be fenced out of all use except for wildlife and for use of the minerals. Lands of this character in private ownership should be acquired by exchange or trade, and purchase using the money derived through the sale of Federal lands not needed by the Federal government for other purposes.

3) Step up and sharpen up the program under P.L. 566. In my state, at least, this program is moving at a snail's pace and on the basis of the "early bird getting the worm" rather than on a basis of the more urgent needs first. The classification of lands to determine the more critical areas mentioned above could be used to improve selection of projects on the basis of the most urgent need. Also, the cost-benefit aspects of the P.L. 566 program should be revised and put on a much broader basis than at present. Also there should

be land-conservation-practice requirement for all project lands rather than only half of them as at present. There should also be a more strict compliance requirement.