ECONOMIC EVALUATION OF WATERSHED MANAGEMENT ALTERNATIVES THE BEAVER CREEK WATERSHEDS

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INTRODUCTION

In semi-arid areas, water for home use, industry, and agriculture is at a premium. Usually, water availability is the limiting factor for continuing economic growth. One possible way to augment water supplies is to change the vegetation on upstream watersheds. Such changes in vegetation, deliberately made to alter the amount of water available to particular hydrologic processes, are included in the category of watershed management practices.

There are a number of options open to a watershed manager to achieve a particular objective. Some of these alternatives require sweeping changes of the plant cover on lands where increased water yields might be expected. Some could jeopardize other land uses and values. Some are "irreversible" in the sense that they can be made easily, but they can't be undone except through long years and at great expense.

Before such practices are conducted on a large scale, then, an economic evaluation is required to estimate the advantages and disadvantages of the alternatives. The economic evaluation is not considered a final answer, but rather as additional information to help managers make a better decision. The evaluation must analyze the effects of the alternatives on other resources as well as direct and indirect benefits and costs of increased water. Comparisons can then provide a basis for deciding on the best course of multiple-use land management.

Such an evaluation is the purpose of the Beaver Creek Pilot Watershed Project in northern Arizona. (1) It involves testing the multiple-use effects of watershed management on an operational scale.

THE DESIGN ANALYSIS

The economic evaluation, within the framework of multiple use and sustain yield, was subjected to a linear program analysis which was used to help design the Beaver Creek project. To do this it was assumed that the project was completed and we had data about the outcomes of watershed management alternatives. We needed this information to

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evaluate the effectiveness of a potential action program. The objective assumed in the design analysis was to maximize benefits, with streamflow increases, timber markets, and costs used as restraints. Restraints as used here specify the levels of these items that must be met for analysis.

The design analysis required us to measure the yields of forest-based products (water, timber, range for livestock, wildlife, and recreation) so that we could determine their responses to each watershed management alternative. We were obliged to collect costs of implementing management changes, and costs of maintaining the watersheds in a treated condition. Also, "outside" costs due to the change in management were needed, as, for example, costs due to possible increases in sediment yields or additional costs of conducting other activities as fire control. Finally, the design required us to estimate appropriate values for watershed multiple-use products.

It was further decided that we should determine product response to management change directly by making before-and-after measurements of production on small watersheds. Thus, these small watersheds will describe what actually happened on the ground rather than form a paper synthesis of what might have happened. We also decided to develop prediction techniques which will enable us to extrapolate results from small watersheds to other similar areas. The design analysis indicated that we should be prepared to make these extensions on other larger watersheds in such a way that we could verify our findings and methods.

The design analysis led to dividing the whole Beaver Creek area into smaller units, and indicated the studies to be undertaken.

THE BEAVER CREEK WATERSHEDS

The entire watershed area, 275,000 acres, contains four different vegetation types, each with a different streamflow potential. Only the three types containing trees--the lower woodland (Utah juniper), upper woodland (alligator juniper), and the Ponderosa pine types--are being considered for testing watershed practices (Figure 1). The smallest watersheds are being treated first, with a single treatment on each. For example, the juniper types are being converted from juniper tree cover to grass, herb, and shrub cover. Pine-covered watersheds, on the other hand, will be subjected to a variety of clearing and thinning treatments.

The larger watersheds--Bar-M Canyon and Woods Canyon--will be used to test combinations of treatments found effective on the smaller watersheds. It is here we will test our findings and methods to see if they can be extended to other areas. Extensive areas have been reserved for operational studies, where techniques are being developed for conducting treatment operations and for determining costs of treatments applied to project-sized areas.

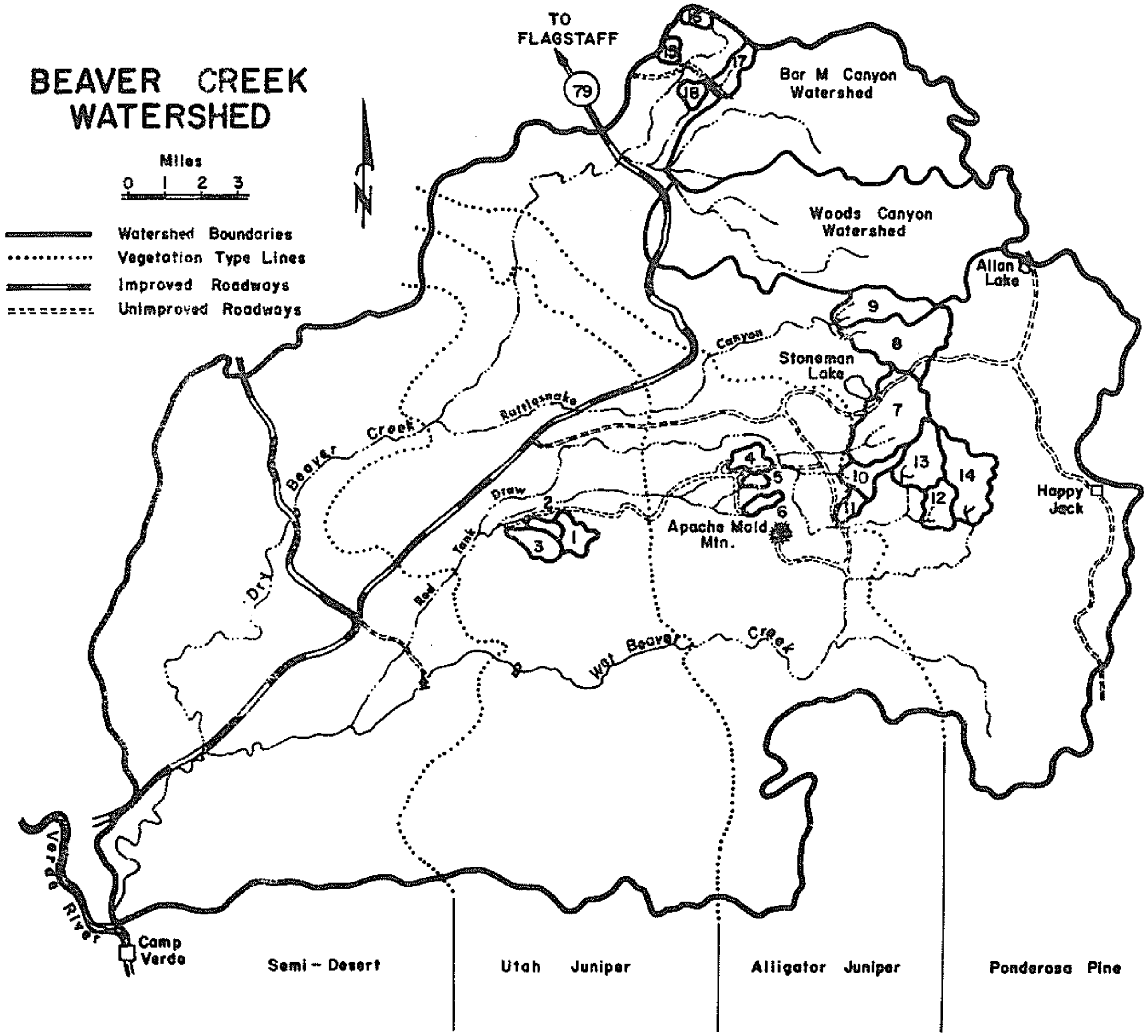

Figure 1. The Beaver Creek Pilot Watersheds in Northern Arizona.

Each of the watersheds shown in Figure 1 has been steamgaged to determine streamflow before and after treatment. Total sediment yield is measured on selected watersheds. Timber growth and quality are measured. Records are kept on forage production and utilization, and on ecological trends. Actual game use is recorded on the watersheds, as well as hunter use, to assess the affects of treatments on this major recreational use.

Special information is being collected to more fully describe the watershed themselves, and to form a basis for extending the data to other areas. A network of rain gages gives us data about the amount, intensity, duration, and form of this basic input to the watershed system. Topographic, geologic, soil, and vegetation maps and data provide us with basic information about some of the hydrologic processes involved. Special studies of watershed hydrographs give use insight into streamflow characteristics. Our timber inventory is designed to answer questions about (1) tree size distribution, (2) physical characteristics of trees, such as sweep, crook, mistletoe infection, dead top, etc., and (3) arrangement of trees on the area. With this information, we can accurately describe the tree cover, and assess suitability of different management practices for the watersheds.

Special studies are conducted to determine multiple-use interrelations to help us extend data to other areas. Other special studies seek to fill gaps in existing information which is needed to satisfy the design analysis.

THE UTILITY OF PILOT WATERSHEDS IN ECONOMIC EVALUATION

Thus far, our development of an economic evaluation has been measuring inputs, outputs, and costs, and making special studies to develop methods for extending the data to other areas. This is a straightforward task conceptually, but the practical, on-the-ground implementation is related to our pilot plant to enable us to understand the physical system.

THE CONTEXT FOR EVALUATION

Multiple-use management involves coordination of the various management functions. In terms of the watershed management function, other functions--timber, range for livestock, wildlife, and recreation--constitute an array of "outside" factors which need to be coordinated with a watershed proposal in a multiple-use framework. These "outside" factors are very important, since they point out that the choice between two watershed management options for a particular watershed can't be determined by general formula, and that each case (watershed in this instance) must be decided on its own merits. While a general formula can be developed for a large area, such as a National Forest or a river basin, its results can only be used to indicate the general direction watershed management should take. Analyses of individual watersheds which make up the larger area and account for the required coordination are necessary for actual management planning.

These evaluation requirements suggest that two sets of background data are required for economic evaluation: (1) data for analyzing a river basin, where watershed management for increased water yield is being seriously contemplated, to estimate the potential of the broad area for accomplishing the objective, to give clues as to its economic worthwhileness, and to suggest the direction which watershed management might take, and (2) data for detailed management planning on individual project-sized watersheds. Finally, of course, the river basin can be reanalyzed by summing the analyses of the individual watersheds.

ECONOMIC CRITERIA AND DATA

To make an economic evaluation of watershed management alternatives, we need to define the criteria which will form a basis for comparing alternatives. The criteria selected will dictate how the physical data will be used, and show what economic data will be required.

Our thinking to date suggests three criteria to form the basis for choice: (1) maximize benefits, (2) maximize returns on investment, and (3) achieve specified physical production goals at least cost. No single alternative is likely to satisfy all three of these criteria at once. It seems important, though, that these solutions should at least be considered in the overall evaluation. They would give decision makers a better picture of the various economic implications of potential courses of watershed management action.

Data required for the first two criteria include values of multiple-use products as well as the physical responses and cost data learned from the small pilot watersheds. Values should be considered for different points of view. For example, on-site values represent a net-benefits point of view. Income flows and employment generation at various stages of processing can be combined to represent local, state, regional, or national points of view. For the cost minimization analysis production goals must be set for the various products. In the real world production goals commonly are derived through the political process. For an analysis, value judgments can be fed back from the benefit maximizing analysis to help establish reasonable goals.

ECONOMIC ANALYSIS

It is anticipated that the economic analyses themselves will be stimulated by linear programs and systems analysis. Early efforts at this are being made currently in consultation with economists at the Pacific Southwest Forest and Range Experiment Station at Berkeley, California. The initial model just completed seeks first to maximize on-site benefits to establish national production goals, and then to minimize the cost of achieving these specific production goals. The analysis is based on a linear program followed by parametric programs. Data requirements for the computer program are estimates of current costs, values, and physical outcomes. All these vary from site to site. The arrangement of conditions is hypothesized on a dummy area of 1,000,000 acres of ponderosa pine-covered watersheds. Potential pine-covered watersheds can thus be ranked according to cost, value, and watershed conditions. At present, it is a static analysis. Later we will make it dynamic by changing projected costs and values. Other changes planned will vary the use levels of different products. Thus, we will take into account sets of circumstances (such as market potentials) which simulate actual multiple-use coordination problems. These circumstances will probably take the form of efficiency factors for making use of the products being produced. Such efficiency factors will then be incorporated into a basic program to show the relative importance of different kinds of tension areas in multiple-use coordination.

Such analyses will be continually refined and updated as experience on the ground and in computer analysis further sharpens the issues to be resolved.

ECONOMIC EVALUATION

The economic evaluation itself, then, will consist of an array of pertinent economic analyses to help decision makers make a better decision. Each individual economic analysis may yield a determinant, one-answer, solution to the problem of selecting a watershed management alternative within the framework of specific assumptions and criteria. A group of such analyses, however, based on different criteria, will result in an array of items for decision makers:

1. Estimates of product yield response associated with the changes in management.

2. Estimates of costs of different management alternatives.

3. Least-cost solutions for different goals of multiple-use production.

4. Net and/or gross benefits to be associated with the range of management alternatives.

5. Investment returns and benefit/cost ratios associated with the alternatives.

6. Pertinent coefficients and incremental ratios associated with the individual analyses.

With such a spectrum of economic relationships, the decision makers should be better able to choose the best course of action.

SUMMARY

The Beaver Creek Pilot Watersheds were established (1) to measure and evaluate the effects of management practices, intended to increase streamflow, upon water supply, sediment, timber and forage production, wildlife populations, and recreational use of watershed lands, and (2) to formulate concepts and processes for economic evaluation of alternative watershed management practices, and develop guides for making multiple-use management decisions.

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