Analytical Aids in Land Management Planning

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Abstract: Quantitative techniques may be applied to aid in completing various phases of land management planning. Analytical procedures which have been used include a procedure for public involvement, PUBLIC; a matrix information generator, MAGE5; an allocation procedure, linear programming (LP); and an input-output economic analysis (EA). These techniques have proven useful in the development of lane management plans for a number of National Forests in the United States.

INTRODUCTION

The typical planning process used for developing land management plans follows a sequence of several phases. Although this overall process might be described in many ways, the major steps, shown in detail in Table 1, are (1) the identification of issues and objectives, (2) the development of the resource system and management options, (3) the analysis of tradeoffs, with the decision and feedback.

Various quantitative techniques may be applied to aid in completing these basic phases. The Systems Application Unit for Land Management Planning (SAU-LMP) of the Forest Service, U.S. Department of Agriculture, has utilized several types of analytical procedures in the successful development of land management plans for National Forests in the United States. Specifically, those used most often by SAU-LMP are a procedure for public involvement, abbreviated PUBLIC; a matrix information generator, called MAGE5; an allocation procedure, known as linear programming, LP; and an input-output economic analysis, called EA.

Table 1--The land management planning process

Systems Approach Terminology	Major Phases	Detailed Phases	SAU-LMP Analytic tools
	I. ISSUE IDENTIFICATION	Pre-Plan Organization -Establish time frame for plan -Establish personnel requirements for plan -Define degree of public involvement	
Set Objectives	II. FORMALIZATION OF PLANNING	Identify Issues and Set Objectives -Define critical issues and their source -Define assumptions concerning decisions environment -Define hierarchial set of goals -Define criteria to be used to test performance	PUBLIC
System Design	III. DEVELOPMENT OF ALTERNATIVES	Define Resource System -Stratify land base to address issues -Designate management options -Define resources and products	
		Define the Responses -Identify information needs, sources of information and detail necessary -Determine resources and economic responses to manage activities	MAGE5
System Analysis	IV. ANALYSIS OF TRADEOFFS AND FORMULATION OF A RECOMMENDED	Analyze the Resource System -Define the processes to be used in analysis -Generate alternative manage ment strategies -Define tradeoffs between strategies -Develop a scenario to describe tradeoffs -Test each alternative in terms of meeting criteria of performance	LP EA

Decision and Feedback	<u>Decision</u> -Select a preferred alternative -Prepare a written plan directive and draft impact statement <u>Feedback</u> -Describe procedures for monitoring plan implementation and re vision when necessary -Insure tasks are carried out effectively and efficiently -Insure work plans are developed

PUBLIC

PUBLIC is the procedure used curing the issue-identification and objective-setting phase to make quantitative estimates of public preferences and of conflicts among those preferences (Case and others 1976). The program is used at public workshops where the participants are asked to rank ordinally the uses of various National Forest resources from what "should be most emphasized" to what "should be least emphasized." PUBLIC is then used to analyze this input, to estimate agreement and disagreement in the total group, and to determine the least disliked priority ranking of Forest resource uses. The program constructs this ranking by creating an array of responses which indicate the "votes" for each preference. Then through a process of elimination, it assigns preferences to an order on the base of whether a use preference receives either the majority of first-place votes or the majority of the "most disliked" votes. At the same time the procedure identifies subgroups which seem to have like interests or preferences. A statistical procedure, factor analysis, is used to subdivide the respondents into these subgroups. An estimate of the level of agreement within these subgroups is measured by the Kendal Concordance Coefficient. This is a statistic which generates on a scale of 0 to 1 a measure of subgroup agreement, 1 representing total agreement and 0 total disagreement.

This type of information is useful during the workshop session to group participants with like interests so they can work on specific alternative descriptions and resource-use levels or requirements. The procedure also supplies information which is useful for many different types of analyses to be conducted later, inducing comparisons of local preferences to overall regional preferences, comparisons of U.S. Forest Service staff preferences to local preferences, and analysis of public perception of agency priorities. Further, and most importantly, PUBLIC helps develop the type of public involvement information necessary to construct alternatives for analysis in subsequent phases of Forest level planning. The following table shows an ordering arrived at by means of PUBLIC:

Overall ordering entire workshop	Subgroup 1	Subgroup 2
Wildlife	Watershed	Wilderness
Scenic beauty	Range	Scenic Beauty
Dispersed Rec.	Timber	Dispersed Rec.
Watershed	Wildlife	Wildlife
Timber	Dispersed Rec.	Range
Developed Rec.	Developed Rec.	Developed Rec.
Mineral Extraction	Mineral Extraction	Timber
Wilderness	Wilderness	Mineral Extraction

The preference patterns shown could be used to develop strategies which might be described in scenario form as:

> Strategy 1 (Overall ordering): Emphasize wildlife, scenic beauty, and dispersed recreation, with less emphasis on watershed, range, and timber, and give low priority to developed recreation, mineral extraction, and wilderness.
>
> Strategy 2 (Subgroup 1): Emphasize watershed, range, and timber, with less emphasis on wildlife, scenery, and dispersed recreation, and give low priority to wilderness, mineral extraction, and developed recreation.
>
> Strategy ; (Subgroup 2): Emphasize wilderness, scenic beauty, and dispersed recreation, with less emphasis on wildlife, watershed, and range, and give low priority to timber , mineral extraction, and developed recreation.

These strategies could be used as part of the basis for construction goals and priorities for a Forest plan.

MAGE5

The next planning phase involves defining various aspects of the resource system. This phase of planning employs both the information concerning use preferences described above and information concerning the land base, to construct specific management options and resource uses for each of the management strategies previously identified. Once the management options have been determined, the consequences of each on the environmental resource, and the economic responses, must be defined. The U.S. Forest Service uses MAGE5, a matrix generator, to help the planner identify, develop, and store the necessary bits of information (U.S. Dep. Agric., Forest Serv. 1973). Since most plans cover a planning horizon of several years, one of the most significant benefits of using MAGE5 is that it allows for the time factor and attendant time changes in developing the appropriate dynamic data for the matrix. MAGE5 uses a concept called "timestreams" to adjust resource uses, benefits, and costs to changes which occur with time; it automatically constructs a matrix whose coefficients reflect this time dimension.

For example, suppose that the planning horizon is ten years subdivided into two periods of five years. A management option involving timber harvest might be applied either during the first period or during the second period. The values calculated for MAGE5 for the matrix rows and columns are as follows:

		Management option involving timber harvest applied in	
	Present condition	First period	Second period
Average sediment/ha/yr in the first period	0.4	0.64	0.4
Average sediment/ha/yr in the second period	0.4	0.68	0.64

Since the sediment yields are constant under present conditions in this land area, the average yields in each period are 0.4 cubic meter per hectare per year provided nothing changes. The average values for sediment yields where timber harvest is involved assume that the application of the option to an acre might occur at different years in the period. For example, the timber harvest might take place in any one of the five years of the first period. The various possibilities and the subsequent timestreams for sediment yield per year during the first period are as follows:

Option applied in	Year 1	Year 2	Year 3	Year 4	Year 5
First year	0.8	0.8	0.8	0.8	0.8
Second year	0.4	0.8	0.8	0.8	0.8
Third year	0.4	0.4	0.8	0.8	0.8
Fourth year	0.4	0.4	0.4	0.8	0.8
Fifth year	0.4	0.4	0.4	0.4	0.8

Note that if the option is not applied until a later year in the period, the present condition yield of 0.4 applies to all preceding years. The average value 0.64 for the sediment yield in the first period is the sum of the possibilities divided by their number, or 16/25 = 0.64. The other matrix entries are calculated in a similar manner, with the timestream depending on what period is being considered.

This concept is used to develop average yearly values for resource uses or commodities and for costs and benefits. These values are stored in a matrix format which can be utilized along with other tools, such as LP, which are used in later phases of the planning process.

LINEAR PROGRAMMING AND ECONOMIC ANALYSIS

Once the phases described so far are completed, the next step in the planning process is to analyze the resource system in order to determine how to allocate management options that best meet the preferences specified by the various strategies, and in order to identify the biological and socio-economic tradeoffs among strategies. In making these assessments the planner uses the information developed thus far in conjunction with two analytical aids: linear programming (LP) and an input-output economic analysis (EA). in the process of land management planning, a separate LP analysis is made for each management strategy so that the allocations which best meet the requirements and constraints stated for each strategy may be determined. For example, a separate analysis might be mace far~ each of the three strategies specified earlier. Requirement levels are typically based on both the information developed in the earlier stage of public involvement and the kind of production of which the land is capable. Limiting factors might be such things as the number of acres available for possible options, the available budget, environmental constraints, and policy considerations such as nondeclining timber yield from the Forest. The objective functions might include such considerations as the maximization of present net benefits or minimization of costs over the term of the planning horizon.

The management options are selected on the basis of lava suitability and in line with the public involvement process. There is usually a wide range of possibilities inducing wilderness management, big game management at various levels, various types of recreation management, and various kinds of timber management treatments. Each of these options might require a number of activities. For example, recreation management (type I) might require monitoring use, closing roads, and constructing trails.

A comparison must be made between LP results in order to show the tradeoffs among allocations, resource outputs, constraint levels, costs, and benefits. A good deal of additional information can be derived from the sensitivity or post-optimality analysis, which indicates bow resource uses, constraints, and benefit values may change without affecting the LP optimal allocation. This is useful for a number of different purposes, such as determining what parameters may be most sensitive to changes in the plan and ascertaining whether additional inventory in certain areas may be appropriate.

The linear programming results are further utilized with the EA analysis package to estimate the impact which each of the possible strategies would be likely to have on local economic activity and employment levels (Palmer and Layton 1973). Given a particular strategy's predicted resource use or level of output, the LA analysis measures both the direct effects and the indirect or multiplier effect on various sectors of the local economy. This economic analysis results in a measure of the change in economic conditions likely to develop as a result of the application of a particular strategy. The significance of this impact depends, in part, on the magnitude of the change from what is the present condition and, in part, on the degree of influence this change has on the overall local or regional economy.

Table 2 is an example of the results of using the input-output portion of EA, which shows both the sectors affected directly and others which are indirectly affected as the impact of the change "ripples" through the economy. In the example, this effect amounts to $131,863 in total gross output. The EA package also estimates the effect the change will have on local employment according to individual occupation and month of the year.

Table 2--Sample results of using the input-output package of EA

SECTOR	FINAL DEMAND ($1000)	TOTAL GROSS OUTPUT ($1000)	CONSUMPTIVE WATER USE (ACRE-FEET)	LABOR MAN YEARS	INCOME $1000	VALUE ADDED $1000
1. AGRICULTURE	225.308	270.084	0.000	3.884	45.790	71.964
2. MINING	.001	.131	0.000	.003	.071	.106
3. CONSTRUCTION	9.339	13.495	0.000	.245	3.517	3.774
4. LOGGING	.005	.089	0.000	.004	.035	.049
5. SAWMILLS	.000	.206	0.000	.005	.045	.070
6. OTHER MANUFACTURING	.248	.321	0.000	.009	.088	.125
7. TRANSPORT & WAREHOUSING	.530	5.395	0.000	.179	2.114	2.902
8. COMMUNICATION & UTILITIES	3.742	14.806	0.000	.288	7.618	10.640
9. AUTO DEAL & GAS STATIONS	4.932	6.330	0.000	.427	4.265	4.855
10. EATING & DRINKING PLACES	3.056	3.291	0.000	.257	1.038	1.698
11. WHOLESALE & OTHER RETAIL	7.251	9.211	0.000	.544	5.378	6.200
12. FINANCE, INSUR. & R E	2.474	6.638	0.000	.267	3.669	5.571
13. LODGING	1.284	1.293	0.000	.051	.511	.701
14. SKI AREAS	.000	.000	0.000	.000	.000	.000

15. OTHER SERVICES	6.454	43.774	0.000	1.776	17.672	23.209
PRIVATE SEC-ICES, TOTAL	264.623	375.064	0.000	7.939	91.811	131.863
GOVERNIIENT & MISCELLANEOUS TOTAL POP. 26.		.000	0.000 0.000	1.553	.000	.000
TOTAL	264.623	375.064	0.000	9.492	91.811	131.863

The linear programming and input-output results provide quantitative estimates of differences between strategies which can be used to illustrate tradeoffs as well as to demonstrate compatible relationships between possible alternatives. This type of information, because it is presented in easily understandable formats, is valuable for public presentations of the various strategies illustrating what might be expected then a particular plan is implemented. The public reaction to these strategies and tradeoffs is useful in developing; a final plan which will be acceptable to the largest segment of the interested public.

APPLICATION

These techniques have proven successful in aiding in development of management plans for the Beaverhead, Willamette, Custer, Boise, Nezperce, Payette and Monongahela National Forests. In addition to being usable as a package for Forest plans, the techniques may be used individually for specific problems. For example, MAGE5 was used to help construct the area guides for U.S. Forest Service Rocky Mountain Region (R-2). EA is being used for a portion of the analysis necessary for the wilderness RARE II study. PUBLIC has been used in Alaska to develop local preference patterns and to compare these to preferences stated by Forest Service and Congressional representatives in Washington, D.C.

The programs have been used with UNIVAC and CDC computer systems. All these programs are coded in standard FORTRAN IV, and as such should be readily adaptable to other systems. Most of the problems related to National Forest applications have been solved through training and personal contact with technical staff provided at the Forest Service Regional Office or at the SAU-LNP in Fort Collins, Colorado.

The use of these quantitative techniques in planning provides for a comprehensive analysis of complex situations. The techniques offer an effective and efficient means to develop land management plans. They can handle information in large amounts, of differing types, and concerning diverse interrelationships between biological, social, and economic factors which would be impossible to deal with by any other means. The quantitative procedures used here otter a consistent, systematic approach to land management planning.

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