Using Priced and Unpriced Values to Make Environmental Decisions

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Abstract.–A process is described for making comparative valuations of a wide range of environmental management activities when the combined social, economic, managerial, and political benefits of some (but not all) of these activities cannot be adequately described in economic terms, and budgetary constraints do not permit funding all activities under consideration. The process accounts for subjective judgment and contains a formal rigorous decision strategy that takes the place of intuition when quantitative and qualitative values of environmental activities need to be evaluated.

The qualities that make a good manager come down to decisiveness. "You can use the fanciest computers in the world and you can gather all the charts and numbers, but in the end you have to bring all your information together, set up a time table, and act" (Iacocca 1984). The decision process described in this paper is intended to assist managers of natural environments in taking that action.

In many ways the quality and quantity of natural environments in the year 2000 and beyond are being determined and shaped by today's long-range planning activities and priorities. Yet, the expected benefits that may emerge from some of these activities can only be speculative at best. To be effective, long-range planning and priority-setting efforts must account for subjective judgment and contain formal, rigorous decision strategies that replace intuition (McCormack 1984, Peters and Austin 1985).

This paper describes a method to set priorities among a wide range of environmental management activities by using subjectively derived benefit scores and projected costs. The method was used initially in a variety of priority exercises in USDA Forest Service research but has also been applied by executives, negotiators, policymakers, analysts, and others who need to make decisions under uncertainty and risk when the dollar value of the benefits are unknown (Davis 1987; Davis and Schaffer 1984; Schaffer et al. 1977; National Agricultural Advisory Research and Extension Users Advisory Board 1983, 1984; USDA Forest Service 1983). The basic premise in the process is that human judgment is indispensable to decisionmaking in long-range planning (Harris 1964, Shelly and Ryan 1964).

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The Problem Of Setting Priorities

In any organization, budgetary constraints do not permit funding all the actions or initiatives the organization wishes to pursue. Inevitably, managers are forced to set priorities on what they do, and frequently priorities must be set on some projects or efforts that cannot be evaluated through conventional economic benefit-cost analysis.

For example, suppose a forest manager has to choose between concentrating limited financial resources on (1) an effort to increase saw timber volume production or (2) increase opportunities for nonmotorized, dispersed recreation opportunities in remote scenic areas. Economists can make a benefit-cost analysis of the benefits to be derived from the timber production, but the social benefits associated with an effort to enhance access to scenic quality are not easy, and sometimes impossible, to describe in economic terms. The problem is how to decide, given limited budgets, whether to invest in timber production or access to scenic quality.

The decision theory literature is filled with examples, some much more complex than the one just described, of how executives, when faced with a difficult, complex decision, traditionally gather information or appoint a committee to do it, or both (Austin 1966, Kahn et al. 1964, Richards and Greenlaw 1972). As a result, an executive may be overwhelmed with difficult to evaluate data, or become mired in trade-off considerations as proponents push favorite programs. When decisions are made, it may be difficult to discover why the choice was made. There is no "audit trail."

A Design For Making Decisive Decisions

The design described below does not make decisions and it does not portend what to decide. Rather, it helps facilitate consensus and defines priorities by using coherent decisions consistent with stated values ofthedecision makers themselves.

The design involves seven steps:

1. List items to be evaluated.
2. Select a panel of objective evaluators.
3. Survey the panel to evaluate the items in terms of their overall benefits.
4. Compute benefit scores.
5. Estimate the costs.
6. Compare initial benefit scores and costs.
7. Adjust benefit scores to reflect management's values and beliefs.

Each step is now described using a hypothetical example of a forest manager who must make tradeoffs between environmental quality and the production of goods and services from the forest land under his direction. The same methods could be applied also to such diverse problems as selecting the "best" location of a new electric transmission line or deciding which of several alternative methods that should be used in solid waste disposal.

List the Items

Suppose a forest manager needs to arrange the following 10 management activities, A through J, in order of priority, based on the overall benefits and estimated costs for each.

A. Increase saw timber volume production.

B. Initiate water yield improvement measures.

C. Increase scenic highway development.

D. Increase nonmotorized, dispersed recreation opportunities.

E. Develop a project for range grazing use improvement.

F. Increase the opportunities for developed recreation.

G. Improve wildlife habitat areas.

H. Improve fish habitat including spawning areas.

I. Reclaim areas adversely impacted in past mining operations.

J. Increase and improve winter sports and ski area development.

The manager estimates the total cost of all of the projects to be 250,000 dollars but only has a current operating budget of 150,000 dollars. The manager decides that each activity is independent of any other and that it will be more effective to complete as many projects as possible, rather than use a "piecemeal" approach in which several will be partly completed.

The words used to describe the 10 efforts (A through J) are typical statements involved in priority setting. For example, members of the National Agricultural Research and Extension Users Advisory Board (1984) used these kinds of broad, general descriptions of research (or management) efforts within the decision design described here--when recommending program priorities to Congress. At other management levels, the activities may need to be described more specifically. The question of "how specific" is a difficult one for two reasons. First, the number of alternative investment strategies available to the decisionmaker, even in the hypothetical example used here, may be extensive. Heterogeneous information bears on each investment strategy. Second, the decisionmaker is faced with imperfect knowledge about the expected costs of each activity, as well as considerable uncertainty about their benefits that may be difficult (in many cases impossible) to specify in a totally objective way. Many times total benefits of a given activity cannot be described very well even by the manager(s) most intimately involved with the program prioritization or selection (USDA Forest Service 1981). Nonetheless, the programs and their expected results should be described in the context of the combined political, social, economic, managerial, and environmental values of each one. The degree of generality or specificity of the description of each management activity is kept as uniform or as parallel as possible. This is not easy--especially if there are a large number of activities to be evaluated and prioritized.

In addition, the expected results from management activities within each of the 10 activities must be described. For example, some of the potential results under project F--Increase nonmotorized, dispersed recreation opportunities might be:

> Physical experience--the opportunity for physical exercise and exertion that stimulates the body.
>
> Emotional experience--the thrill of experiencing new sensations and exploring wild regions--experiences that deal with an achievement of some sort.
>
> Aesthetic experiences--the enjoyment of the beauties and variety of relationships that exist in natural environments.
>
> Educational experiences--the opportunity to gain new knowledge or teach others about the soil, water, wildlife, plant, and other scenic resources.
>
> Social experiences--the chance to engage in conversations ranging from brief casual meetings to more lengthy conversations with companions or during stops at overnight camps (Schaffer and Mietz 1969).

Select a Panel

The second step is to select a panel of knowledgeable people to make judgments about the importance of the items to be evaluated. The number to include on the panel depends on the variation in the subjects to be considered. It is not always easy to separate scientific competence from policy involvement; indeed, that may be partly due to involvement in policy. On the other hand, selecting panelists purely for managerial or scientific competence may give results that are tilted toward one side of a policy debate. Select panelists who are "honest brokers," people who are willing to be objective in judging overall program benefits of the items being evaluated.

Conduct a Survey

Third, panelists are given or mailed a description of the activities (10 in our example), background information such as a list of the results from each activity, and a survey form (table 1). Everyone compares the 10 activities, two at a time, on the bases of overall perceived environmental, social, economic, managerial, and political benefits. Timeliness is an important consideration. Programs whose benefits may only be derived in the distant future usually should not be considered as valuable as a program that will show immediate benefits.

An important limitation on the paired comparison method is the practical limit on how many items can be compared. The equation is:

$$f = \frac{n(n-1)}{2}$$

where "f" is the number of paired comparisons and "n" is the number of things compared. In the hypothetical example, "n" equaled 10; consequently there were 45 comparisons--about as many as one can expect from a panel of busy people.

There are at least three major reasons why a mailed survey is recommended over group discussions. One is cost. Second, fuzzy thinking abounds in initial group discussions of this kind. The desire for solidity among panelists can cloud the initial analysis and thinking necessary to reach a balanced decision (Janis 1983). The third is "band wagon jumping." There is a strong desire for many to agree with others even though they believe or possess information that might lead to a different conclusion.

Methods for estimating the overall value of a large number of diverse items under these circumstances have been developed in a wide range of disciplines--including economics, political science, psychology, and sociology. Despite differences in approach, these methods tend to blend. Pair-wise comparing all items, two at a time, may be used; for example, to derive an attitude scale for a psychologist (Bock and Jones 1968, Edwards 1957, Torgerson 1958) or a utility scale for an economist (Sinden and Worrell 1979). In fact, the various disciplines often use different terms for the same thing. Economists make the most use of these methods as value indicators for making priority decisions.

Compute Benefit Score

Fourth, the benefit scores are computed. The percentage of times all respondents select each activity over every other provides the basic data for computing (Edwards 1957, Ross 1934) the benefit scores (table 2). Note that the benefit scores are normalized (values systematically changed), so that they sum to 1000. The units of "benefit" are not specified--they can be considered as units of utility if one wishes.

Table 1.--Survey forms and hypothetical entries of how one panelist compared all two-way sets of 10 projects.

Items	A Sawtimber production	B Water yield	C Scenic highway	D Dispersed recreation	E Range improvement	F Developed recreation	G Wildlife habitat	H Fish habitat	I Mining & oil	J Ski development
A. Sawtimber production	X		1		0		1	0		0
B. Water yield		X	1	1	0	1	1	0	0	0
C. Scenic highway			X	1	0	0	1	0	0	0
D. Dispersed recreation				X	0	0	0	0	0	0
E. Range improvement					X	1	1	1	1	1
F. Developed recreation						X	1	0	0	0
G. Wildlife habitat							X	0	0	0
H. Fish habitat								X	1	0
I. Mining & oil									X	0
J. Ski development										X

A "1" indicates the benefits of the column item judged more favorable than the benefits of the row item. A "0" means just the opposite.

Table 2.--Hypothetical example of how benefit scores were calculated for 10 land management activities.1,2,3.

Items	A Sawtimber production	B Water yield	C Scenic highway	D Dispersed recreation	E Range improvement	F Developed recreation	G Wildlife habitat	H Fish habitat	I Mining & oil	J Ski development
	--Proportion of times column research effort was judged more favorable than row research effort--									
A. Sawtimber production	.00	.70[1]	.15	.10	.15	.15	.60	.00	.60	.10
B. Water yield	.30[2]	.00	.00	.00	.15	.30	.45	.25	.45	.25
C. Scenic highway	.85	1.00	.00	.30	.60	.70	.60	.25	.60	.30
D. Dispersed recreation	.90	1.00	.70	.00	.85	.70	.75	.55	.75	.85
E. Range improvement	.85	.85	.40	.15	.00	.55	.60	.40	.75	.60
F. Developed recreation	.85	.70	.30	.30	.45	.00	.75	.30	.60	.55
G. Wildlife habitat	.40	.55	.40	.25	.40	.25	.00	.25	.55	.25
H. Fish habitat	1.00	.75	.75	.45	.60	.70	.75	.00	.75	.70
I. Mining & oil	.40	.55	.40	.25	.25	.40	.45	.25	.00	.25
J. Ski development	.90	.75	.70	.15	.40	.45	.75	.30	.75	.00
Totals (Grand Total = 45.00)	6.45	6.85	3.80	1.95	3.85	4.20	5.70	2.55	5.80	3.85
Benefit scores (Total benefit scores = 1000)	143[3]	152	84	43	86	93	127	57	129	86

[1]*Let's assume 10 panelists were used in this survey. We add the individual raw scores from the survey forms (for example 1+1+0+1+1+0+1+1+1 = 7) and divide the number of panelists (7/10 = 0.70).*

[2]*The value in a cell to the left of the diagonal dashed line is: 1.00 minus the corresponding pair-wise comparison value to the right of the diagonal. For example, the 0.30 in the first column, row two, is the result of 1.00-0.70; the 0.70 is being located in the second column, row one.*

[3]*Benefit scores are normalized so that they sum to 1000; for example, 6.45/45.0 x 1000 = 143. Multiplying by 1000 is a convenience to avoid the use of decimal points in the benefit scores.*

Estimate the Costs

Fifth, the annual cost of each activity needs to be estimated. This step should be done concurrently with, and independent of, the panel survey to develop benefit scores. Experienced persons should estimate the costs of each activity being evaluated without being influenced by the values of the benefit scores.

The total cost for each activity is discounted to present worth--the money needed today in order to fund the activity in total. The rate of interest is selected by the manager and based on prevailing discount rates. Only activities with similar timeframes should be compared. A project that will be quickly terminated, or one for which funding will be delayed, usually should not be compared with the others. Since costs are explicitly discounted, it is important that there be an implicit discounting of the benefits also, based on their expected delivery time.

Compared Initial Benefit Scores and Costs

A computer can quickly summarize results of the individual benefit scores provided by each panel member, as well as the costs for the 10 activities (table 3).

Each activity is then ranked and plotted according to benefit scores to form a benefit-only criterion curve. That is, the program with the highest benefit score (in this case B--initiate water yield improvement measures) is plotted first, against its cost. The program with the next highest benefit score (A--saw timber volume production) is plotted second, in a cumulative manner, until all projects are arranged along a curve (fig. 1).

Efforts are also plotted by a cost-benefit criterion. In this case, D (nonmotorized, dispersed recreation opportunities) is plotted first because it has the largest benefit-cost value (table 3), H (fish habitat improvement) is next, etc. (fig. 1).

Table 3.–Initial and final results after fine tuning the benefit scores of the 10 activities.

	Initial results			Final results	
Research effort	Initial benefit score	Discounted cost (millions)	Initial benefit/cost criterion value	Final benefit score	Final benefit/ cost criterion value
B. Water yield	152	16	9.50	216	13.50
A. Sawtimber production	143	36	3.97	123	3.41
I. Mining & oil	129	56	2.30	164	2.93
G. Wildlife habitat	127	9	14.11	110	12.22
F. Developed recreation	93	30	3.10	80	2.67
E. Range improvement	86	20	4.30	74	3.70
J. Ski development	86	35	2.46	74	2.11
C. Scenic highway	84	26	3.23	72	2.77
H. Fish habitat	57	2	28.50	49	24.50
D. Dispersed recreation	43	1	43.00	38	38.00
Totals	1000	231		1000	

The two resulting curves provide a tool that can be used, along with other considerations, for making decisions about the priorities of the activities under various cost constraints. As figure 1 shows, the cost-benefit criterion curve always provides more benefit for a fixed investment. For example, if a program budget is set at 150,000 dollars, a program that contains efforts

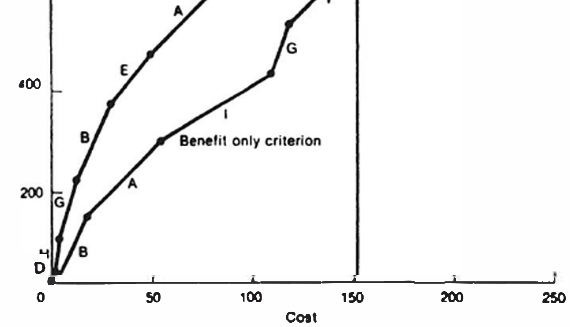

Figure 1.–Cost-benefit versus benefit-only criteria: initial results.

D, H, G, B, E, A, F, and C--with a total benefit score 800--is preferred, rather than a program with efforts B, A, I, G, and E--with a total benefit score of only 660 (fig. 1).

Adjustment by Management

The primary advantage of the decision-analytic approach, up to this point, is that it provides an organizing and clarifying framework for facilitating consensus in complex decisionmaking situations. However, since management is responsible for the final content and success of activities being considered, final decisions on content and benefits of the activities is theirs. Thus, management may wish to adjust the initial benefit scores based on social, political, economic, scientific, or environmental information not evident or important to panel members.

Such adjustment is a systematic method whereby management examines and may change benefit scores (and thus the location) of the activities along the cost-benefit criterion curve (Armstrong 1987). The only constraint is that regardless of the number of changes that are made, the sum of the scores must equal 1000. For example, if management wants to increase the benefit score of one activity, it needs to reduce the value of another, or others, an appropriate amount.

The adjustment process might work like this. Management compares the program package D, H, and G on the cost-benefit criterion curve with B on the benefit-only criterion curve. Both packages cost about the same, but the first has 1 1/2 times the benefit score value as the second. However, management may feel that B is more important than D, H, and G--regardless of what the data suggests (table 3). So, B's benefit score is adjusted--let's say 250. The reason(s) for the change is documented, and the scores of all of the other efforts along the curve are adjusted (that is normalized) so that their sum equals 1000.

Next, management observes that the package D, H, G, B, E, A, and F on the cost-benefit criterion curve have a higher total benefit for the same cost than the package with B, A, and I on the benefit-only criterion curve. Since B and A are common to both packages, and there is no interdependences among the efforts, I can be compared to D, H, G, E, and F. Let's assume management wants I's score changed to 190. The change is made, the data is renormalized, and the adjustment process continues until management is satisfied with the final benefit scores of all activities. Final benefit-cost data are computed (table 3), and a final set of curves are portrayed (fig. 2).

Figure 2 shows the optional order of investment for a dissimilar mix of activities. Note that for any arbitrary limit on cost, the best mix is defined (e.g., if the budget is $150,000, the best investment strategy is D, H, B, G, E, A, and I.

Limitations on the Design

1. The design for decision approximates the value of the items being considered--as perceived by panel members.

2. Results depend on the approximation used to define and specify the design.
3. Those approximations deal with the state-of-knowledge regarding interdependences, costs, benefits, uncertainties, risks, and timeliness of the effort.
4. Approximations are innate to complex problems and should be refined as better information becomes available.
5. Results reflect only the knowledge and judgment of the panel participants.
6. The system will be unfamiliar to most participants. However, when it is understood, it is usually accepted by managers and panelists and should have application to a wide range of environmental decisionmaking.

Advantages of the Design

1. Participants apply judgments to a set of well-designed, content-specific situations.
2. The procedure incorporates anticipated accomplishments; however, whenever this information is incomplete or unavailable, the panelists should use their judgment in keeping with their background and expertise.
3. The rational supporting subjective judgments is elicited and captured. Thus, the approach recognizes that human judgment is indispensable to the problem solution.

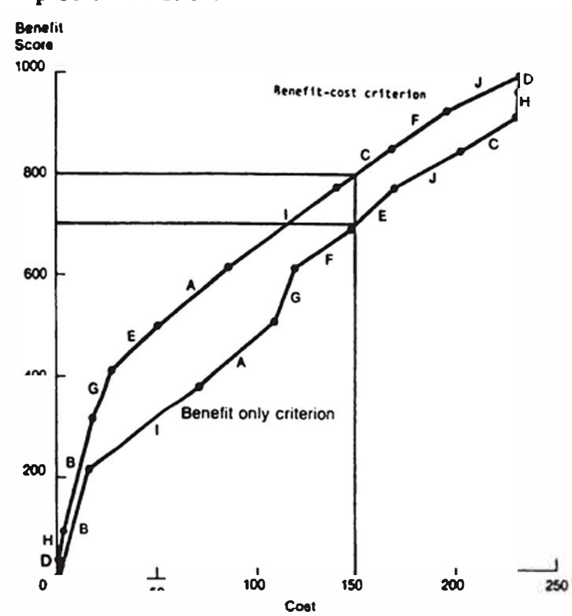

Figure 2.--Benefit-cost versus benefit-only criteria: final comparisons.

4. The system leaves an "audit trail" in which most decisions are made specific, many of them quantified.
5. The approach accommodates selective comparisons and tradeoff of dissimilar items. When comparing different items, panelists must evaluate relative consequences of various mixes of programs, no matter how diverse they might be.
6. Comparison through rational, informed, subjective judgment is an indispensable part of all decisions. The psychology of human choice requires it, and the design for decisions provides a logical foundation for capturing it.
7. The cost-benefit criterion curve is clearly linked to relative benefits with no issues hidden within the procedure.
8. The structure of decisions is visible and invites investigation, discovery, and constructive criticism. It facilitates challenge, sensitivity analysis, and improvement through debate.
9. Results can be used to gauge impacts of budget constraints and modifications.
10. This decisionmaking procedure under uncertainty can serve as the hub of an information system for overall program investment strategies. In turn, these strategies influence and promote decisive decisions that concern the social, economic, environmental, and practical realities of the environment.

Literature Cited

Armstrong, A. A. 1987. Decisions by design. Information World. December: 24-25.

Austin, C. F. 1966. Managements self-inflicted wounds. New York, NY: Holt, Rinehart and Winston. 319 p.

Bock, R. D.; Jones, L. V. 1968. The measurement and prediction of judgement and choice. San Francisco, CA: Holden-Day. 370 p.

Davis, J. B. 1987. Assessing subjective preferences for future fire research. In: Proceedings, Wildland Fire 2000. Gen. Tech. Rep. PSW-101. Berkeley. CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station: 121-127.

Davis, J. B.; Schaffer, E. L. 1984. The use of paired comparison techniques for evaluating forest research. In: Proceedings, Society of American Foresters; Portland, OR: 4-8.

Edwards, A. L. 1957. Techniques of attitude scale construction. New York, NY: Appleton-Century-Crofts, Inc. 256 p.

Harris, J. G., Jr. 1964. Judgement versus mathematical prediction: an investigation by analogy of the clinical versus statistical controversy. Behavioral Science. 9: 324-335.

Iacocca, L. 1984. Iacocca, an autobiography. New York, NY: Bantam Books Inc. 352 p.

Janis, I. L. 1983. Groupthink: psychological studies of policy decisions and fiascoes. Boston, MA: Houghton Mifflin. 316 p.

Kahn, R.; Wolf, D. M.; Quinn, R. P.; Snoek, J. D.; Rosenthal, R. A. 1964. Organizational stress: studies in role conflict and ambiguity. New York, NY: John Wiley and Sons, Inc. 470 p.

McCormack, M. H. 1984. What they don't teach you at Harvard Business School. New York, NY: Bantam Books, Inc. 256 p.

National Agricultural Research and Extension Users Advisory Board. 1983. Appraisal of the proposed budget for food and agricultural sciences. Washington, DC: U.S. Department of Agriculture. 347 p.

National Agricultural Research and Extension Users Advisory Board. 1984. New directions for science, education, and agriculture: executive summary. Washington, DC: U.S. Department of Agriculture, AGR 101. 52 p.

Peters, T.; Austin, N. 1985. A passion for excellence. New York, NY: Random House, Inc. 437 p.

Richards, M. D.; Greenlaw, P. S. 1972. Management decisions and behavior. Homewood, IL: R. D. Irving, Inc. 655 p.

Ross, R. T. 1934. Optimum orders for the presentation of pairs in the method of paired comparisons. Journal of Educational Psychology. 25: 375-382.

Schaffer, E. L.; Mietz, J. 1969. Aesthetic and emotional experience rate high with Northwest wilderness hikers. Environment and Behavior. 1: 187-197.

Schaffer, E. L.; Moeller, G. M.; Getty, R. E. 1977. Future recreation environments. FS-316. Washington, DC: U.S. Department of Agriculture, Forest Service.

Shelly, M. W., II; Ryan, G. L. 1964. Human judgments and optimality. New York, NY: John Wiley and Sons. 436 p.

Sinden, J. A.; Worrell, A. C. 1979. Unpriced values--decision without market prices. New York, NY: John Wiley and Sons. 511 p.

Torgerson, W. S. 1958. Theory and methods of scaling. New York, NY: John Wiley and Sons. 460 p.

U.S. Department of Agriculture, Forest Service. 1981. Criteria for deciding about forestry research programs. Gen. Tech. Rep. WO-29. Washington, DC. 347 p.

U.S. Department of Agriculture, Forest Service. 1983. Draft environmental impact statement: 1985-2030 Resources Planning Act program staff report. Washington, DC. 52 p.