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Multiple Attribute Evaluation for National Parks and Protected Areas

MANAGERS OF NATIONAL PARKS AND PROTECTED AREAS FACE THE CHALLENGE of evaluating management actions and selecting the preferred one for their units. Examples of this challenge abound. Yellowstone National Park must decide whether or not to allow snowmobiles in the park and the most desirable way to handle bison leaving the park. Banff National Park needs to decide how to allow for human use of the park without sacrificing ecological integrity. Great Smoky Mountains National Park must determine the best way to alleviate adverse impacts of air pollution on visibility and public enjoyment. Such decisions can be viewed in terms of selecting the preferred alternative future for national parks and protected areas. These decisions are not easy because different alternative futures provide different social, economic, and environmental values. This paper describes and critiques three analytical methods for identifying and comparing the preferred alternative future for national parks and protected areas.

Hypothetical Ecosystem

To facilitate understanding, the three methods are described in terms of the fictitious Greater Cimarron Ecosystem (GCE). GCE contains Cimarron National Park, two national forests containing wilderness areas, and several gateway communities. The GCE embodies features and issues common to real greater ecosystems in North America. First, there is a symbiotic relationship between protected areas and gateway communities in the GCE. Visitors to the GCE spend money on lodging, food, meals, gifts, entertainment, and other services in gateway communities. These expenditures support income and employment in those communities. Conversely, the social infrastructure and amenities provided by gateway communities benefit visitors to protected areas in the GCE. Second, environmental amenities attract permanent and seasonal residents to the GCE, which contributes to economic development of private lands and landscape fragmentation. Third, the GCE contains a population of grizzly bear, a threatened species whose home range extends beyond the boundaries of the protected areas. Landscape fragmentation from economic development is not only reducing the quality of habitat for grizzly bear and other species, but also increasing the number of encounters between humans and bears. Such encounters have the potential to harm people and increase bear mortality.

The planning staffs for the protected areas and gateway communities, developers, and environmental groups in the GCE have created the Cimarron Landscape Analysis Group (CLAG). The primary goal of CLAG is to identify the preferred alternative future for the GCE—one that balances the benefits of greater regional income and employment (economic development) with potential impairment to the population of grizzly bear caused by development. CLAG decides to use *alternative futures analysis* to achieve this goal (Baker et al. 2004; Steinitz et al. 1996, 2003). Alternative futures analysis defines future development scenarios for a region in terms of growth in human population and economic activity, and evaluates how those scenarios and alternative policies for residential and commercial zoning, infrastructure (road and utilities) expansion, and conservation of biodiversity influence social, economic, and ecological values. Table 1 describes the reasons and advantages for alternative futures analysis, and gives an example of alternative futures.

Benefit–Cost Analysis

The first method CLAG can use to compare alternative futures is *benefit–cost analysis* (BCA; Prato 1998). This method calculates and compares the net present values (NPVs) of alternative futures. The NPV of an alternative future equals discounted total quantifiable benefits minus discounted total costs, namely:

$$\mathrm{NPV} = \sum_{t=0}^{T} B_t\,(1+r)^{-t} - \sum_{t=0}^{T} C_t\,(1+r)^{-t},$$

where $B_t\,(1+r)^{-t}$ is discounted total benefits and

$$\sum_{t=0}^{T} C_t \cdot (1+r)^{-t}$$

is discounted total costs of an alternative future in year t, r is the discount rate, and T is the number of years over which alternative futures are evaluated. Discounting is done because receiving a dollar now is preferred to receiving a dollar at a future date. It causes the present value of a dollar of benefits or costs to decrease exponentially over time. If an alternative future has a positive NPV, then it is considered efficient because it increases benefits more than costs. Conversely, an alternative future with a negative NPV is not efficient. The most efficient alternative future is the one having the highest NPV. An efficiency criterion that is closely related to NPV is the benefit–cost ratio (BCR). If $\mathrm{NPV} \geq 0$, then $\mathrm{BCR} \geq 1$. Conversely, if $\mathrm{NPV} < 0$, then $\mathrm{BCR} < 1$.

Use of NPV or BCR requires all benefits and costs to be expressed in monetary terms. Certain benefits and costs of alternative futures are naturally expressed in dollar terms, such as total economic output, household income, and expenditures for roads, buildings, water, light, power, and other infrastructure. However, impacts of alternative futures on grizzly bear populations are difficult to express in monetary terms because markets do not exist for valuing the ecological services provided by grizzly bear. A lack of markets implies a lack of market prices, and a lack of market prices means there is no direct way to assign monetary values to grizzly bear. While economists have developed several methods to estimate monetary values for ecological services (Prato 1998), those methods have been criticized for a variety of reasons (Mitchell and Carson 1989; Bishop 1993;

Table 1. Elements of alternative futures analysis (ALFA).

Reasons for ALFA

- It is difficult for planners and stakeholders to foresee the potential ecological and economic consequences of their choices, policies, and plans because no one knows for sure what the future will bring.
- No single vision of the future is likely to be accurate or superior to all others. Therefore, it is useful to consider a set of alternative futures for a region that encompasses a spectrum of possibilities.

Advantages of ALFA

- Allows stakeholders to assess the possible outcomes of alternative assumptions about future growth and development in a region.
- Helps stakeholders identify policies to reduce adverse ecological and economic consequences of future growth and development in a region.
- Permits stakeholders to create and evaluate a variety of futures for a region, and identify the most likely way of achieving them.

*Example of alternative futures**

- *Baseline* — Continuation of current land use zoning and regulations, current population projections, and historical rates of economic growth.
- *High Development* — Maximize short-term economic gain. Assumes low-density housing and substantially higher population and economic growth than the baseline.
- *Moderate Development* — Maximize short-term economic gain subject to environmental restrictions. Assumes moderate housing density and moderately higher population and economic growth than the baseline.
- *Low Conservation* — Moderate protection of ecological functions achieved by restricting development in ecologically sensitive areas and requiring moderate use of conservation practices in agricultural and forest lands. Assumes moderately high housing density and population and economic growth slightly lower than the baseline.
- *High Conservation* — Maximum protection of ecological functions achieved by imposing strong restrictions on development in ecologically sensitive areas and requiring extensive use of conservation practices in agricultural and forest lands. Assumes high-density housing and population and economic growth significantly lower than the baseline.

* Adapted from alternative futures used in Oregon's Willamette River Basin (Baker et al. 2004) and the Upper San Pedro River Basin in Arizona and Sonora (Mexico) (Steinitz et al. 2003).

Perrings 1994; Bjornstad and Kahn 1996; Kahn 1996; Cummings 1996; Cameron 1997; Goulder and Kennedy 1997; Smith 1992; Prato 1999). For example, contingent valuation, which is a non-market valuation method, has been criticized because: (1) it is a single-attribute valuation technique that is poorly suited for evaluating the multifaceted ecological impacts of resource management decisions; (2) asking people to assign monetary values to ecological services has been rejected based on ethical considerations; (3) willingness-to-pay measures used in contingent valuation are likely to be biased by imperfect information on the part of the respondent, embedding of the value of other goods in stated willingness-to-pay values and other response biases (Kahn 1996); and (4) survey respondents tend to express their willingness to pay or willingness to accept compensation for a good or service from the viewpoint of a concerned citizen rather than as a consumer or user of that good or service (Sagoff 1988). In summarizing CV's weaknesses, Kahn (1996) indicates that contingent valuation "is associated with controversy and is far from universally accepted, even among environmental economists." In summary, BCA is not sufficient to identify the preferred alternative future for ecosystems encompassing national parks and protected areas.

Cost-Effectiveness Analysis

The second method available to CLAG is a variant of BCA known as *cost-effectiveness analysis* (CEA). This method is appropriate when the costs of alternative futures are known, but not the benefits. In CEA, the preferred alternative future is the one that minimizes the total cost of achieving a certain management objective, such as protecting grizzly bear. For example, suppose alternative futures are arrayed in ascending order of the cost of protecting grizzly bear habitat, which equals the cost of the habitat protection program plus the opportunity cost. An example of the latter is the potential loss in regional income and employment, if any, from eliminating development in critical habitat areas for grizzly bear.

Figure 1 depicts CEA for habitat protection. The shape of the marginal cost curve implies that the cost of achieving an additional unit of habitat protection increases exponentially with the level of protection. If h* is the level of habitat protection needed to recover the population of grizzly bear, then the preferred alternative based on least cost is the one that has a marginal cost of c*. The minimum total cost of achieving h* is the area under the marginal cost curve between 0 and h*. While CLAG can use CEA to identify the habitat protection plan that minimizes the cost of any level of habitat protection, it cannot use CEA to determine the preferred alternative future.

Multiple Attribute Evaluation

The third method CLAG can use to compare alternative futures is *multiple attribute evaluation* (MAE). This method evaluates and ranks alternative futures based on a set of attributes chosen by CLAG members and their preferences for attributes. MAE has several advantages relative to BCA (Joubert et al. 1997) and CEA. First, MAE does not require ecological services to be expressed in monetary terms. Second, unlike CBA which optimizes on monetary benefits and costs, and CEA, which optimizes on just cost, MAE allows alternatives to be compared in terms of multiple attributes, be they quantitative or qualitative. Third, MAE facilitates public partic-

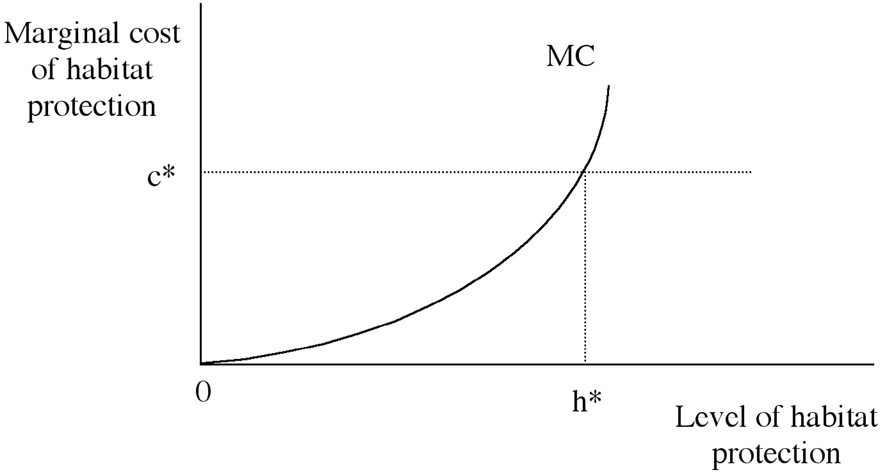


Figure 1. Cost-effective level of habitat protection.

ipation and is well suited for collaborative decision-making (Yaffee and Wondolleck 1997) and scientific assessments (Johnson 1997).

Applying MAE involves five steps: (1) selecting and measuring attributes for alternative futures, (2) determining efficient futures, (3) eliminating unsustainable futures, (4) determining members' preferences for attributes, and (5) ranking alternative futures and resolving conflicts (Prato 1999). Each of these steps is discussed below in the context of the goal of CLAG.

Selecting and measuring attributes. In order to use MAE, CLAG would need to select the multiple attributes of alternative futures. Attributes are typically defined in terms of the potential social, economic, and ecological impacts of alternative futures. Graphical analysis is used to explain how attributes are measured. The graphical analysis uses two attributes because two-dimensional graphs are relatively easy to understand. While MAE can handle any number of attributes, most individuals find it difficult to deal with more than seven attributes.

The two attributes of alternative futures used in the graphical analysis are total economic output, or total output (TO) for short, and habitat conditions (HC) for grizzly bear. TO equals the estimated total final value of economic goods and services produced in the GCE in an alternative future. It is like gross national product, except for an ecosystem instead of the nation. TO for an alternative future can be estimated using IMPLAN. IMPLAN is a menu-driven computer software program that predicts changes in total economic output, household income, and employment in up to 528 economic sectors (Lindall and Olson 1993). To estimate TO for an alternative future, CLAG needs to specify final expenditures in all economic sectors of the GCE for each future time period of interest. HC for grizzly bear can be assessed in terms of the loss or degradation in grizzly bear habitat associated with alternative futures. In particular, CLAG can use a landscape model to assess the probable landscape fragmentation caused by future economic development and the likely impact of that fragmentation on HC for grizzly bears. TO is measured in dollars and HC by an index that takes on values between 0 and 100, where 0 represents extremely poor habitat and 100 represents excellent habitat for grizzly bear.

Determining efficient alternative futures. The preferred alternative future selected by CLAG must be efficient in terms of the two attributes. Efficient alternative futures can be determined graphically by plotting combinations of TO and HC, as illustrated in Figure 2. The figure illustrates seven alternative futures (F_1, F_2, F_3, F_4, F_5, F_6, and F_7). Each future provides a particular combination of TO and HC. For example, F_2 provides TO_2 and HC_2. Efficient futures provide combinations of TO and HC on the trade-off curve. For all futures on the trade-off curve, achieving more TO (HC) entails receiving less HC (TO). The trade-off curve shows F_2 and F_7 are inefficient futures because they provide less TO and/or HC than F_1, F_3, F_4, F_5, and F_6, which are on the trade-off curve. In other words, F_2 and F_7 are dominated by F_1, F_3, F_4, F_5, and F_6. It is not possible to achieve a combination of TO and HC above the trade-off curve. The trade-off curve can change shape and position over time.

Eliminating unsustainable futures.

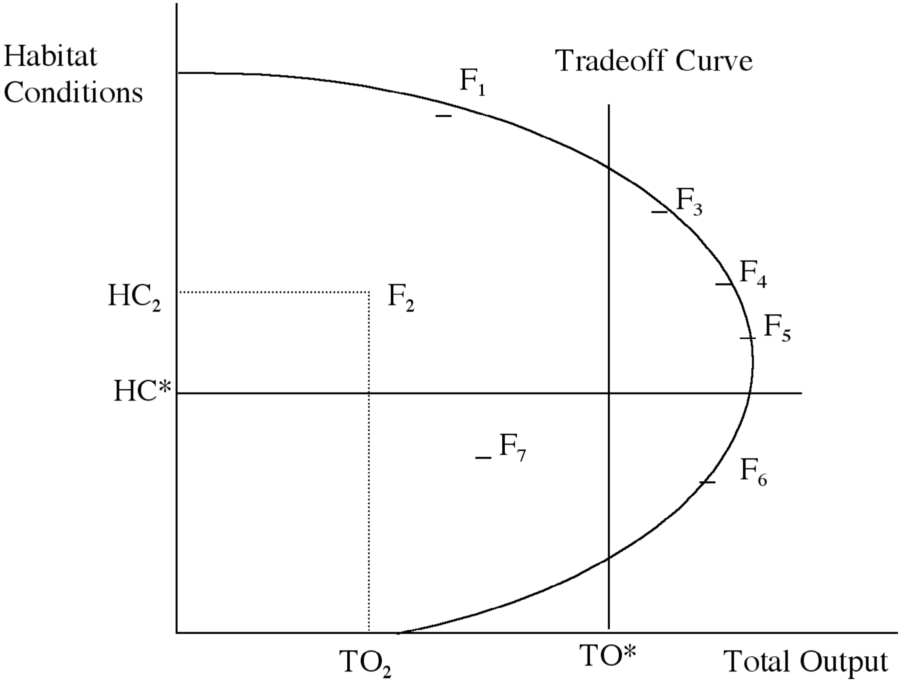


Figure 2. Trade-off curve between habitat conditions (HC) and total output (TO).

Just because an alternative future is biologically and institutionally feasible and efficient does not make it sustainable. In the next step, CLAG eliminates futures that are not sustainable. The strong sustainability criterion is used for this purpose (Pearce et al. 1990; Prato 2000). An alternative future is strongly sustainable if it provides amounts of TO and HC greater than a certain value, namely: $TO \geq TO^*$ and $HC \geq HC^*$. CLAG determines TO* and HC* using one of several approaches. In a consensus-based approach, CLAG members reach agreement on TO* and HC* through discussion and compromise. In majority-based decision-making, CLAG members vote on TO* and HC*. In both cases, scientific knowledge about sustainable values of TO and HC should be considered.

Requiring alternative futures to be strongly sustainable influences the selection of a preferred alternative future as illustrated in Figure 2. All alternative futures providing amounts of TO less than TO* and amounts of HC less than HC* are not strongly sustainable. For the values of TO* and HC* illustrated in Figure 2, F_1 is not strongly sustainable because it provides an amount of TO less than TO*. Similarly, F_7 is not strongly sustainable because it provides an amount of HC less than HC*. Therefore, of the seven futures, only F_3, F_4, and F_5 are efficient and sustainable.

Determining members' preferences for attributes. Selection of the preferred efficient and sustainable future is based on members' preferences for TO and HC. If CLAG members have similar preferences for TO and HC, their rankings of futures are likely to be similar. In this case, selecting the preferred future is relatively easy. However, if, as is likely to be the case, CLAG members have dissimilar preferences for TO and HC, then members' rankings of futures are likely to be different. Different preferences for attributes do not necessarily imply a different ranking of futures. Accounting for members' preferences for TO and HC involves two issues. First, what are an individual member's preferences for attributes and ranking of futures? Second, if members have different rankings of alternative futures, then how can those differences (or conflicts) be reconciled? Since graphical analysis is too complicated when there are several members and multiple attributes, preferences are explained mathematically.

Consider the following general mathematical explanation of how to rank alternative futures. Suppose alternative futures are ranked in terms of J socioeconomic attributes ($e_1,\ldots,e_J$) and K environmental attributes ($g_1,\ldots,g_K$). Examples of socioeconomic attributes are total output, total household income, and employment. Examples of environmental attributes are biodiversity, soil conservation, and water quality. Each CLAG member is expected to have unique preferences for attributes that can be represented by the following general utility function:

$$U_i(F_m) = U_k(e_{1m},\ldots,e_{Jm};\, g_{1m},\ldots,g_{Km}).$$

This function indicates that the total satisfaction or utility that future F_m provides to the i^{th} member, namely $U_i(F_m)$, depends on the amounts of socioeconomic attributes, $e_{1m},\ldots,e_{Jm}$, and ecological attributes, $g_{1m},\ldots,g_{Km}$, provided by F_m.

In order to rank futures for a member based on the utility function, it is necessary to specify its mathematical form. While there is limited theoretical justification for selecting a particular mathematical form, the additive form has been widely used due to its simplicity and relevance to real world problems (Keeney and Raiffa 1976; Yakowitz et al. 1993; Foltz et al. 1995; Tecle et al. 1995; Prato and Hajkowicz 1999). The mathematical form of the additive utility function is:

$$\mathbf{U_i(F_m) = \sum_{j=1}^{J} w_{ij}\, e^*_{jm} + \sum_{k=1}^{K} w_{ik}\, g^*_{km}.}$$

The term e^*_{jm} is the value of the j^{th} standardized socioeconomic attribute and g^*_{km} is the value of the k^{th} standardized ecological attribute provided by F_m, w_{ij} is the i^{th} member's weight for the j^{th} socioeconomic attribute, and w_{ik} is the i^{th} member's weight for the k^{th} ecological attribute. Each attribute weight is non-negative ($w_{ij} \geq 0$ and $w_{ik} \geq 0$) and weights sum to one :

$$\mathbf{\left(\sum_{j=1}^{J} w_{ij} + \sum_{k=1}^{K} w_{ik} = 1\right).}$$

Attribute values are standardized using the following formula to avoid biases in the utility scores that could arise from differences in the measurement units for raw attributes, e.g., TO is measured in dollars and HC in terms of an index. A common standardization formula is:

$s_{im} = (x_{im} - \min x_{im})/\max x_{im} - \min x_{im})$ for positive attributes

$s_{im} = (\max x_{im} - x_{im})/\min x_{im} - \max x_{im})$ for negative attributes

The term x_{im} is the raw value of the i^{th} attribute provided by F_m, $\min x_{im}$ is the minimum value of the i^{th} attribute for F_m, and $\max x_{im}$ is the maximum value of the i^{th} attribute for F_m. TO is an example of a positive attribute and loss of biodiversity is an example of a negative attribute.

While the additive utility function is relatively easy to apply, it is imposes strong restrictions on members' preferences for attributes. In particular, it assumes that each CLAG member is risk neutral and attributes are mutually independent. Risk neutrality implies that additional units of an attribute result in the same (constant) increment in utility. When attributes are mutually independent, the utility provided by an attribute depends only on the amount of that attribute, not on the amounts of other attributes.

Attribute weights for each CLAG member can be estimated using fixed-point scoring, paired comparisons (Saaty 1987), or judgment analysis (Cooksey 1996). Fixed-point scoring requires a member to allocate 100 percentage points among the attributes, and sets each attribute weight equal to the percentage points assigned to that attribute. Fixed-point scoring forces a member to consider trade-offs among attributes because it is not possible to assign a higher weight to one attribute without reducing the weight assigned to one or more of the other attributes. The paired comparisons method uses the Analytic Hierarchy Process (AHP) to derive quantitative weights for attributes. AHP requires each member to score on a scale of 0 to 9 the extent to which one attribute is more, less, or equally important relative to another attribute. In judgment analysis, a member is given the values of attributes for all alternative futures and asked to score those futures on a scale of 1 to 100. Attribute weights are estimated by regressing the scores for futures on their attribute values.

Other MAE methods used to compare alternative futures include the surrogate worth trade-off method (Haimes and Hall 1974, 1977), free iterative search (Tecle et al. 1994), the aspiration–reservation-based decision support system (Makowski 1994; Fischer et al. 1996), and the balancing and ranking method (Strassert and Prato 2002).

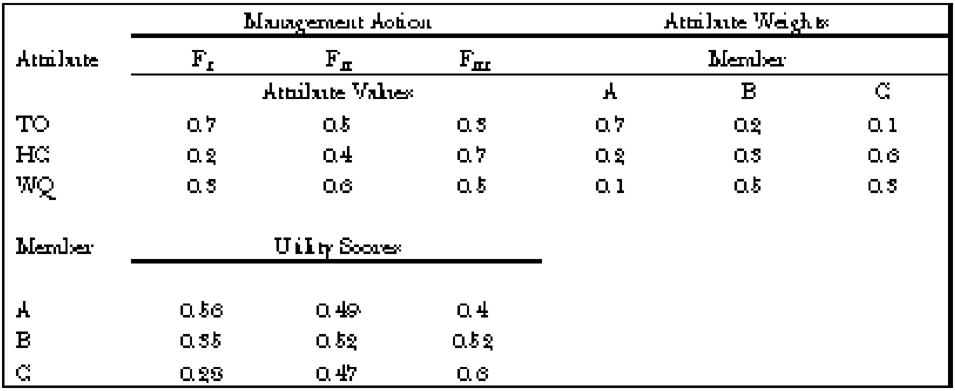
Ranking alternative futures and resolving conflicts. Utility scores for alternative futures are calculated by substituting the attribute values for sustainable and efficient alternative futures and a member's weights for attributes into the utility function given earlier. Alternative futures are then ranked from highest to lowest based on their utility scores. The preferred future for a member is the one with the highest utility score. While attribute values for an alternative future are the same for all members of CLAG, attributes weights are likely to differ among members. This can cause different members to have different rankings of futures.

The following empirical example demonstrates how alternative futures are ranked with the additive utility function. To simplify the calculations, the example uses three attributes (TO, HC, and water quality, or WQ), three CLAG members (A, B, and C), and three management actions (F_I, F_{II}, and F_{III}). TO and HC are the same attributes as used in the graphical analysis. F_I, F_{II}, and F_{III} are efficient and sustainable futures.

Hypothetical standardized values of TO, HC, and WQ for F_I, F_{II}, and F_{III} are in the top left portion of Table 2, and attribute weights for TO, HC, and WQ for members A, B, and C are in the top right portion. Standardized attribute values indicate that F_I provides considerably more TO than HC or WQ. It is referred to as the "high development future." F_{II} provides similar amounts of the three attributes. It is called the "neutral future." F_{III} provides more HC than TO and WQ. It is designated as the "conservation future." Since attributes weights for A strongly favor TO relative to HC and WQ, this member is called a "developer." B favors WQ relative to TO and HC and is designated as a "fisher." C assigns a substantially higher weight to HC than TO and a moderately higher weight to HC than WQ. C is called a "conservationist."

Utility scores for the three futures and members are in the bottom left portion of Table 2. Scores are derived using the formula for the additive utility function described in the previous section. In this case, the developer's preference ordering is $F_I > F_{II} > F_{III}$, where > means "is preferred to." The fisher's preference ordering is F_{III} F_{II}, $F_{III} > F_I$, and $F_{II} > F_I$, where means "is equally preferred." The conservationist's preference ordering is $F_{III} > F_{II} > F_I$. Hence, the developer and conservationist have opposite preferences, and the fisher and conservationist have similar preferences for the three futures. If CLAG made decisions based on majority rule, then the group would choose F_{III} as the preferred future. Since the fisher is indifferent between F_{II} and F_{III}, the fisher would not object to choosing F_{III} over F_{II}.

Conflicts in preferences are likely to be greater when there are numerous futures and members. There are several ways that CLAG can resolve conflicts in members' preferences for alternative futures. First, consensus-based decision-making could be used to reach agreement on a compromise set of weights for attributes. In this case, utility scores and rankings of alternative futures are determined using the compro-



	Management Action			Attribute Weights		
Attribute	F_I	F_{II}	F_{III}	Member		
	Attribute Values			A	B	C
TO	0.7	0.5	0.3	0.7	0.2	0.1
HC	0.2	0.4	0.7	0.2	0.3	0.6
WQ	0.3	0.6	0.5	0.1	0.5	0.3
Member	Utility Scores					
A	0.56	0.49	0.4			
B	0.35	0.52	0.52			
C	0.28	0.47	0.6			

Table 2. Hypothetical standardized values of attributes and weights, and utility scores.

mise set of weights. The preferred future is the one with the highest utility score.

Second, consensus-based decision-making could be applied directly to the rankings of futures. In this approach, each member determines his or her own ranking of alternative futures and a nominal group technique is used to develop a consensus ranking of futures. A nominal group technique involves facilitated responses, voting, and discussion (Meffe et al. 2002). A consensus-based approach is more likely to succeed when CLAG has relatively few members with similar preferences for attributes, and more likely to fail when CLAG has several members with diverse preferences for attributes. While not based on MAE, a citizen's advisory committee used a consensus-based approach in reaching agreement on its preferred alternative for reconstruction of the Going-to-the-Sun highway in Glacier National Park (National Park Service 2002).

Third, CLAG can vote on attribute weights or alternative futures. If voting is used, then the weights receiving the most votes are used to calculate utility scores and the resulting scores used to rank futures. The preferred future is the one with the highest rank. Alternatively, members could vote directly for alternative futures. The preferred future is the one receiving a majority of the votes. A problem with both voting approaches is selecting the weights or alternative futures to include on the ballot. In addition, if each member of CLAG has one vote and there are a disproportionate number of members from one interest group, then ballot results would be biased toward that interest group. Voting has a lower transaction cost than consensus-based approaches, especially when there are numerous stakeholders and futures. In this context, "transaction cost" refers to the cost of reaching agreement on the preferred future.

Fourth, CLAG could use the analytical hierarchy process "to develop compromises between competing interests by pointing out areas of agreement, helping to isolate the areas of conflict, and illustrating the trade-offs between different options" (Kangas 1994).

Limitations of MAE

MAE has certain limitations. First, it is a static analysis. In most applications of MAE, the efficient and sustainable futures depend on the shape and position of the trade-off curve, and the minimum acceptable levels of attributes needed to ensure sustainability. The trade-off curve is likely to change over time in response to improvements in technology and scientific knowledge, and changes in natural and cultural resource conditions. The ranking of futures depends on the preferences for attributes, which are likely to change over time in response to changes in income, education, and attitudes toward economic development and ecological services. For these reasons, a MAE evaluation should be updated periodically.

Second, due to the complexity of economic and ecological systems, planning groups such as CLAG are not likely to know with certainty the combinations of attributes provided by alternative futures. In other words, there is not a one-to-one correspondence between alternative futures and attributes, as is implied by Figure 2. The same alternative future can result in more than one combination of attributes, which complicates the evaluation and ranking of alternative futures. One way to deal with this type of uncertainty is to evaluate alternative futures using fuzzy set theory and fuzzy logic (Klir and Yuan 1995).

Third, determining a member's (or stakeholder's) preferences for attributes is not a simple matter. Several kinds of biases can occur when individuals are asked questions, the responses to which are used to determine preferences for attributes. For example, strategic bias occurs when an environment-oriented person intentionally overstates the weights for environmental attributes, such as HC and WQ, in order to increase the ranking of futures that provide greater environmental protection. Conversely, a development-oriented person might overstate the weight for economic attributes, such as TO, in hopes of increasing the ranking of futures that favor economic development.

Conclusions

Several methods are available to determine the preferred alternative future for national parks and protected areas. BCA compares alternative futures in terms of their NPVs, which is the difference between discounted total benefits and discounted total costs for a future. The preferred alternative future is the one with the highest NPV. A limitation of BCA is that it cannot account for benefits and costs not measured in monetary terms. This is a significant limitation for national parks and protected areas that provide ecological services, such as habitat for grizzly bear and other species. Methods for estimating monetary values for ecological services, such as travel cost, hedonic pricing, and contingent valuation, would allow incorporation of ecological services in BCA, but have several deficiencies. CEA does not require monetizing benefits for ecological services. It selects the alternative future that minimizes the cost of achieving a particular management objective, such as protection of biological diversity. Unfortunately, CEA is based on a single cost criterion.

Advantages of MAE are that it does not require that the ecological services provided by national parks and protected areas be expressed in monetary terms, allowing alternatives to be compared in terms of multiple attributes. In addition, MAE facilitates public participation and is well suited for collaborative decision-making. Application of MAE entails five steps: (1) selecting and measuring attributes for alternative futures, (2) determining efficient alternative futures,

(3) eliminating unsustainable futures, (4) determining members' preferences for attributes, and (5) ranking alternative futures and resolving conflicts in rankings of alternative futures.

Limitations of MAE are that: (1) results need to be periodically updated to account for changes over time in the trade-offs between attributes, and members' preferences for attributes; (2) it does not account for variability or uncertainty in the combination of attributes provided by alternative futures; and (3) it requires determining members' preferences for attributes (attribute weights), which is complex and subject to bias. The advantages of MAE appear to outweigh the disadvantages. Accordingly, national park and protected area managers should consider using MAE to evaluate and rank alternative futures for their areas.

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