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Land Management Planning: a method of evaluating alternatives

Andres Weintraub **Richard Adams** **Linda Yellin**

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Table 4—*Values or ratings of aggregated impacts by alternative*[1]

Impacts	Alternatives		
	A	B	D
Physical:			
Wilderness, wildlife, fish, endangered species	−4(±1)	0(±1)	−3(±½)
Water quality availability	0(−1, +½)	4(−1½, +1)	5(±1)
Visual quality	−5(−1, +1½)	−1(±½)	−1(±½)
General environment	−4(−2, +1)	−2(±1)	−2(±1)
Economic:			
Timber	0(±½)	0(−1, +½)	6(±½)
Range	0(±½)	4(±½)	5(±½)
Goods and services produced in area	5(±1)	1(±½)	1(±½)
Tax receipts	4(±1)	1(±½)	2(±½)
Social:			
Recreation	5(±½)	2(±½)	2(±½)
Employment	4(±½)	2(±½)	2(±½)
Traffic, housing, social pressure	−4(−2, +1)	−1(±1)	−1½(±1)
Institutional:			
Conflicts (with other agencies and others)	−3	−2	−2
Irreversible, irretrievable commitment of resources	−5	−2	−3

[1]Alternatives:
A = current management direction continued
B = amenities affecting quality of life emphasized
D = timber production emphasized
Range of values (−10 to +10) shown in parentheses

carried out through detailed observation of the actions defined, the location of them, and the expected results of these actions. This process can lead to alternative E (U.S. Dep. Agric., Forest Serv. 1976). This alternative basically takes best suited areas for winter recreation sports from alternative C, other areas to be managed as in alternative B for amenity values and others for logging as in alternative D. This alternative leads to the aggregated impacts listed in *table 5*.

Another alternative that can be generated through this process, which includes public participation, is the Proposed Plan of Management, which is alternative P. Its main characteristic is a large reduction in areas assigned to winter recreation from alternative E. The areas eliminated are adjacent to lands which may be declared protected wilderness areas and as such would suffer from the heavy use of the ski areas. In this case, uncertainty plays a role in the decision of which lands to eliminate.

Presentation of Results

Several alternative formats are proposed to reflect both expected values of aggregated impacts and their range of deviation. Some of these have been suggested in previous works (Goeller, 1973). These formats are given for the comparison of alternatives A, E, P:

- Value of expected aggregated impacts and range (±) (*table 5*).
- Low, expected, and high values of the aggregated impacts (*table 6*).
- Expected value of the aggregated impacts, indicating with lines the range (*table 7*).
- Graphical description of the impacts (*table 8*).

Another possibility which is an extension of the format of *table 6* is to give, in addition to the expected value and degree of uncertainty, a cause for uncertainty and its direction. Consider the example of the recreation impact. Let **1** indicate a case whose soft information was used, let **2** indicate uncertainty about growth of demand for winter recreation, which could be quite larger than expected, leading to a value of the recreation impact of alternative E of up to 9. This recreation impact would then be presented as follows:

Impact	Alternative		
Recreation	A	E	P
	|5|	|7|[2]	|3|
	1	**1**	**1**

The **2** on the right hand side of the recreation impact of alternative E indicates that the demand for recreation facilities

Criteria or Goals

For this study, four broad types of goals were identified: physical, (or the preservation of environmental quality), economic, social, and institutional.

1. Physical goals:
   a. Maintain visual quality (scenic beauty)
   b. Maintain water quality, runoff
   c. Protect wildlife, wilderness
   d. Protect fish habitat
   e. Protect endangered species
   f. Maintain air quality within standards
   g. Protect cultural, historical, archaeological sites
   h. Maintain noise levels within standards
   i. Maintain soil quality (avoid erosion)
   j. Beware of hazards created (avalanche, landslide, fire)
   k. Have a good pattern of use of natural resources
   l. Dispose of solid and liquid wastes
   m. Use water within available allocations
2. Economic goals:
   a. Increase value of outputs and services at national level
   b. Enhance opportunities for economic development in region, especially in rural communities
   c. Have economically and environmentally consistent timber production in the long and short run
   d. Increase range capacity through improved management and controlled development
3. Social goals:
   a. Ensure equal opportunity for all people to use National Forests
   b. Provide for a variety of recreation opportunities in the present and the future
   c. Enhance social well being:
      • Promote a good distribution of income
      • Have acceptable patterns and distribution of employment
      • Do not harm social structures of communities
      • Have acceptable distribution of negative impacts of plan
      • Avoid overcrowding of community services and facilities; e.g., road congestion, housing, police, schools
4. Institutional goals:
   a. Maintain (or improve) National Forest landownership pattern that efficiently advances public programs
   b. Plan development with recognition of other governmental (local, State and Federal) plans

Major Activities

Six major activities for the area were identified. Most of the planning unit provides for recreation. In the summer recreation is developed along the Truckee River from Tahoe City to Truckee in the complex containing Boca, Prosser and Stampede Reservoirs in Dog Valley, along the Little Truckee River and Sagahen Creek and the Roadside Rest on Interstate Highway 80 at Donner Summit. In the winter, most of the major winter recreation activities are found in this planning unit. Ski resorts are located at Alpine Meadows, Boreal Ridge, Powder Bowl, Sugar Bowl and Blythe Arena. Possible development in Mt. Lola-Independence Lake region is being considered. Visitors to recreation areas often spill over to neighboring communities.

Timber and range production is found throughout the unit. Range production is or could be developed in the 13 grazing allotments of Boca, Sagahen, Kyburz, Summit, Webber Lake, Truckee River, Anderson Peak, Ever, Payen, Perazzo, Bickford, Independence, Smithneck, and Big Meadows. Timbering takes place throughout National Forest lands.

Fishery and wildlife resources exist in abundance. Fish are stocked in most of the major lakes in the unit, as well as the Truckee River, Little Truckee River, and Donner Creek. A pure strain of the Lahotan cutthroat trout is native to Independence Lake.

The major water resources consist of the Truckee River Basin. The Little Truckee River and Prosser Creek contribute to the Stampede, Boca and Prosser Reservoirs. Other lakes in the unit include Donner, Independence and Webber Lakes.

The planning unit has no area classified as a wilderness. Possible wilderness areas include the Castle Peak area, the Pacific Crest Trail, and the Granite Chief inventoried roadless areas.

Basic Alternatives

In the study, four basic alternatives were identified. In text and tables, each alternative is designated by the letter in parentheses:

- Continue current management direction into the future *(A)*
- Emphasize those natural and cultural amenities that affect the quality of human life *(B)*
- Emphasize production of goods and services *(C)*
- Emphasize timber production *(D)*

Impacts from Alternatives

The impact or effect that an alternative may have in relation to the goals established must be defined. Following is a list of physical, economic and social, and administrative effects resulting from the alternative chosen (shown in parentheses).

Physical Impacts

1. Scenic beauty deteriorates (C, D)
2. Water quality deteriorates (C, D)
3. Wilderness decreases (C, D)
4. Wildlife habitat deteriorates (C, D)
5. Fish habitat deteriorates (C, D)

Table 3—*Quantifying disaggregated impacts, by alternatives (continued)*

Impacts	Alternatives[1]				Type of information[2]
	P	A	B	D	
Level 4 ..... acre	6,640	9,465	2,390	2,150	
Level 5 ..... acre	10	15	10	10	4
Timber resources by year 2000:					
Increased timber outputs ..... MMBF	1.1	0	0	2.7	3,4
Increase in intensive management ..... acre	29,100	14,100	14,700	40,800	3,4
Range resources by year 2000					
Increase ..... animal-unit month	2,960	400	2,400	2,720	3,4
Type conversion ..... acre	3,700	500	2,610	3,200	3,4
Net present worth @ 7 pct interest ..... million dollars	166	200	194	208	3,4
Increase in Federal 25 pct receipts to counties ..... dollars/year	269,237	327,500	189,500	220,680	4
Increase in gross value of goods and services ..... million dollars	10.1	17.2	2.5	2.3	3,4
Increase in annual value of costs of production ..... million dollars	8.3	12.5	0.1	0.2	3,4
Mineral resources:					
Withdrawn from mineral entry ..... acre	5,177	5,177	5,177	5,177	2
Proposed mineral withdrawal ..... acre	1,995	1,385	1,995	1,995	2
Weeks Law status ..... acre	71,360	71,360	71,360	71,360	2
Open for mineral entry ..... acre	78,423	79,033	78,423	78,423	2
Employment:					
Average annual number of direct jobs[8] ..... no.	1,050	1,050	600	650	3,4
Traffic congestion by year 2000					
Increased yearly vehicle trips (thousands) ..... no.	500	1,237	50	559	4
Increase in average daily traffic on Highway I-80 west of Highway 89-S	3,000	6,190	750	2,800	4
Population by year 2000:					
Increase in permanent population	0	0	0	0	4
Average daily number of transients in affected area:					
Summer ..... no.	66,000	128,000	62,000	56,000	3,4
Winter ..... no.	77,000	88,000	37,000	37,000	3,4
Housing availability[9]					

Alternative A

2. Evaluate impacts.
   - Main positive impacts: More than triples current value of goods and services produced, enhances opportunities for private economic development of rural communities, provides wide variety of recreation opportunities.
   - Main negative impacts: Limits future options, has environmental drawbacks, creates pressures on social structure in nearby communities and local services, creates institutional conflicts derived from increased development.
3. Reduce number of recreation visitors. This will reduce both environmental problems to the National Forest area, and social problems in nearby communities.
4. Reduce availability of overnight camping and dispersed recreation.

Alternative B

2. Evaluate impacts.
   - Main positive impacts: Low harm to environment, low pressure in community social structure and services, leaves many options open to future, high regard for amenity values.
   - Main negative impacts: Low production of goods and services, low rural economic growth and tax receipts for counties, limited recreation opportunities.
3. Increased level of recreation, goods and services.
4. Increased facilities for camping, skiing, dispersed recreation.

Alternative C

2. Evaluate impacts.
   - Main positive impacts: Provides very good skiing facili-

Table 2—*Analysis of how alternatives satisfy screening criteria*

Screening criteria	Alternatives[1]			
	A	B	C	D
Overall low performance	no	no	yes-[2]	no
Unacceptable socioeconomic impact	no-[3]	no	yes	no
Unacceptable harm to environment	yes-	no	yes-	no
Dominated alternative	no	no	no	no
Legal problems	no	no	yes-	no
	pass	pass	fail	pass

[1]Alternatives
A = current management direction continued
B = amenities affecting quality of life emphasized
C = goods and services emphasized
D = timber production emphasized
[2]Yes- = closer to yes
[3]No- = closer to no

considerations—poor landownership pattern, conflicts with other agencies, and high irreversible and irretrievable commitment of resources. Alternative C has an overall low rating—except for stimulus to recreation activities and related industry (*table 2*).

Disaggregate Evaluation

The impacts of the alternatives to be evaluated are determined in a disaggregated and as quantified as possible form. Under "Type of information" a 1 indicates that the information is relatively hard, a 2 indicates problems in quantifying the information, while 3 and 4 indicate soft and uncertain information respectively (*table 3*). We define as soft, information with insufficient data, and uncertain information reflects significant lack of certainty on future events.

The evaluation process leading to ratings can be guided through an intermediate stage evaluation. One form of doing this is to determine differences among alternatives by impacts in percentages. For example, in the average number of direct jobs, if alternative P is 100 percent, then A would be 109 percent, B 57 percent, and D would be 62 percent.

A more elaborate approach would be to try to standardize the ratings, by assigning numbers to results in the impacts (for example, increase of 10 percent in jobs). While this process is more structured, it also is more complex, requiring a tailoring for each particular planning situation.

In studies carried out up to the present, whenever ratings have been assigned they have been based on intuitive judgment.

Aggregation of Impacts

This process led to the aggregated impacts listed below (*table 4*). Since no physical quantity can be assigned to these impacts, ratings were given values going from −10 (most negative) to +10 (most positive). For example, the decisionmaker derived one rating for visual quality by using the five numerical impacts given for visual quality (acreage of preservation, retention, partial retention, modification and maximum modification), knowledge of the location of these acreages, and his judgment. The type of information used (hard, qualitative, soft, uncertain) provides a range of possible deviations from the expected value of the rating.

The aggregated impacts were assigned values or ratings for each alternative (*table 4*). For example, all through the elimination and aggregation process, air quality, noise, and hazards were not considered individually, as in all cases, these impacts were well within nondisturbing limits. They were included in an overall environmental rating for each alternative. Wildlife, fisheries, wilderness and endangered species where aggregated were given the relative similarities of impacts, and that none of these impacts had dramatic weight.

Acceptability of Alternatives

All alternatives are within legal bounds. Alternative A has drawbacks in environmental and social impacts, and positive impacts in recreation and overall production of goods and services. Alternative B has positive environmental impacts, but has drawbacks in recreation and production of other goods and services. And alternative D has positive impacts in production of timber and range, but is weaker than either alternative A or B in other aspects. At this stage, the consideration of public response would be especially important.

Additional Alternatives

Additional alternatives can be generated within the present scheme, but lack of data does not allow us to carry out thoroughly this step. The additional alternatives were proposed in the Truckee-Little Truckee Rivers study—and are designated P and E.

The step for generating new alternatives are these: For each alternative already considered, describe the main actions involved and location of them. Maps are provided, describing the location of all actions taken under different alternatives. Steps 2, 3, and 4 are presented sequentially for each alternative. For each action in any alternative, evaluate the main positive and negative impacts on defined goals, and check what changes could decrease major negative impacts or increase major positive impacts. Determine corresponding action to bring about these changes.

Table 3—*Quantifying disaggregated impacts, by alternatives*

Impacts	Alternatives[1]				Type of information[2]
	P	A	B	D	
Physical:					
Visual quality:					
Preservation ... acre	0	0	0	0	1,2
Retention ... acre	87,965	87,565	92,355	92,355	1,2
Partial retention ... acre	63,830	64,200	59,600	59,600	1,2
Modification ... acre	4,716	9,730	4,700	4,700	1,2
Maximum modification ... acre	444	460	300	300	1,2
Water quality:					
Increased sedimentation ... cu ft/yr	−2,900	−900	−5,600	−3,900	1
Increased water yield by year 2000 ... acre-ft/yr	1,000	0	0	1,000	1
Wilderness:					
Unroaded areas where development allowed ... acre	820	3,283	0	3,173	1,2
Wildlife:					
Wildlife improvement projects by year 2000 ... acre	1,480	500	1,000	200	1,2
Increased hunting by year 2000 ... visitor-day/yr	45,000	45,000	45,000	45,000	4
Increased annual vehicle trips (thousands) per year by year 2000 ... no.	6,000	1,237	50	559	4
Average per acre change in habitat ... [3]	0	−2	0	1	2
Fish habitat ... [4]	2	2	2	2	2
Endangered species ... [4]	1	3	1	2	2
Air quality ... [4]	4	3	4	2	2,3
Archaeological, cultural sites ... [4]	3	3	4	1	2
Noise ... [3]	3	3	4	1	2,3
Erosion ... [4]	4	3	4	1	2
Hazards ... [4]	16	20	15	14	2,4
Fire frequency ... [5]	16	20	15	14	2,4
Domestic water use ... [6]	47	52	39	37	3,4
Socioeconomic:					
Recreation services by year 2000 ... [7]					
Overnight camping (249,000) ... visitor-day/yr	1,679,500	2,890,000	1,679,500	1,260,000	4
Dispersed recreation (400,000) ... visitor-day/yr	600,000	1,720,000	545,000	450,000	4
Downhill skiing (184,000) ... visitor-day/yr	570,000	650,000	276,000	276,000	4
Cross country skiing (23,000) ... visitor-day/yr	90,000	100,000	90,000	56,000	4
Snowmobiling (32,000) ... visitor-day/yr	51,000	56,000	51,000	55,000	4
Off-road vehicle use (33,000) ... visitor-day/yr	31,000	40,000	29,000	31,000	4
Hunting (80,000) ... visitor-day/yr	125,000	125,000	125,000	125,000	4
Day-use activities (146,000) ... visitor-day/yr	300,000	496,000	365,000	464,000	4
Water-related activities (161,000) ... visitor-day/yr	379,000	379,000	379,000	379,000	4
Hunting (open) ... acre	154,955	153,955	155,055	155,355	4
Hunting (closed) ... acre	2,000	3,000	1,900	1,600	4
Overnight camping permitted outside developed sites ... acre	111,467	110,742	117,457	148,855	4
Overnight camping prohibited outside developed sites ... acre	45,488	46,213	39,498	8,100	4
Off-road vehicle use on-the-ground:					
Nonuse ... acre	11,708	11,708	12,348	9,790	4
Limited use ... acre	97,040	97,040	144,607	86,375	4
Dispersed open use ... acre	48,063	48,063	0	60,790	4
Concentrated open use ... acre	144	144	0	0	
Over snow vehicle:					
Nonuse ... acre	24,968	0	21,068	18,525	4
Open ... acre	131,987	156,955	135,887	138,430	
Cross country skiing:					
Permitted ... acre	148,220	156,955	148,220	148,220	4
Prohibited ... acre	8,735	0	8,735	8,735	4
Recreation experience levels:					
Primitive ... acre	0	0	0	0	
Level 1 ... acre	14,400	12,960	14,400	10,500	4
Level 2 ... acre	19,405	75,015	85,455	83,305	4
Level 3 ... acre	56,500	59,500	54,700	61,000	4

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Increase in intensive management ..... acre	29,100	14,100	14,700	40,800	3,4
Range resources by year 2000					
Increase ..... animal-unit month	2,960	400	2,400	2,720	3,4
Type conversion ..... acre	3,700	500	2,610	3,200	3,4
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Proposed mineral withdrawal ..... acre	1,995	1,385	1,995	1,995	2
Weeks Law status ..... acre	71,360	71,360	71,360	71,360	2
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Employment:					
Average annual number of direct jobs[8] ..... no.	1,050	1,050	600	650	3,4
Traffic congestion by year 2000					
Increased yearly vehicle trips (thousands) ..... no.	500	1,237	50	559	4
Increase in average daily traffic on Highway I-80 west of Highway 89-S	3,000	6,190	750	2,800	4
Population by year 2000:					
Increase in permanent population	0	0	0	0	4
Average daily number of transients in affected area:					
Summer ..... no.	66,000	128,000	62,000	56,000	3,4
Winter ..... no.	77,000	88,000	37,000	37,000	3,4
Housing availability[9]					

Alternative A

2. Evaluate impacts.
   - Main positive impacts: More than triples current value of goods and services produced, enhances opportunities for private economic development of rural communities, provides wide variety of recreation opportunities.
   - Main negative impacts: Limits future options, has environmental drawbacks, creates pressures on social structure in nearby communities and local services, creates institutional conflicts derived from increased development.
3. Reduce number of recreation visitors. This will reduce both environmental problems to the National Forest area, and social problems in nearby communities.
4. Reduce availability of overnight camping and dispersed recreation.

Alternative B

2. Evaluate impacts.
   - Main positive impacts: Low harm to environment, low pressure in community social structure and services, leaves many options open to future, high regard for amenity values.
   - Main negative impacts: Low production of goods and services, low rural economic growth and tax receipts for counties, limited recreation opportunities.
3. Increased level of recreation, goods and services.
4. Increased facilities for camping, skiing, dispersed recreation.

Alternative C

2. Evaluate impacts.
   - Main positive impacts: Provides very good skiing facili-

Table 3—*Quantifying disaggregated impacts, by alternatives (continued)*

Impacts	Alternatives[1]				Type of information[2]
	P	A	B	D	
Institutional:					
Conflicts with other plans[4]					
Nevada County General Plan	2	1	3	3	2
Sierra County General Plan	2	1	3	2	2
Placer County General Plan	1	1	2	1	2
Martis Valley General Plan.	1	2	2	2	2
Bear Creek General Plan	0	0	0	1	2
Washoe County General Plan	1	1	1	1	2
Tahoe Basin Management Unit	1	1	1	1	2
Irreversible and irretrievable commitments of resources					
Additional roads developed					
Recreation sites ..... acre	7,164	8,804	3,310	2,890	1,4
Developed roadless or undeveloped areas ..... acre	820	3,283	0	3,173	1,4
Mining ..... acre	200	200	200	200	1,4
Special use permits ..... acre	500	500	500	500	4
Total ..... acre	9,134	12,787	4,010	6,753	

[1]Alternatives:
A = Current management direction continued
B = Amenities affecting quality of life emphasized
D = Timber production emphasized
P = Proposed plan of management, reduction of winter recreation areas with respect to alternative E (combination of alternative C [winter sports], B and D [logging areas])
[2]Type of information
1 = Relatively hard
2 = Problems in quantifying information
3 = Soft, informal
4 = Uncertain information
[3]Scale of 1 to 5; 3 = present habitat
[4]Scale of 1 to 5; 1 = lowest, 5 = highest
[5]Average number of human-caused fires per year (present condition = 12)
[6]Acre-feet per year (present condition = 8)
[7]Present condition shown in parentheses
[8]Present condition: 400
[9]Varies inversely in proportion to general level of economic activity, indicated by jobs.

ties, good overnight camping, high economic impact and tax receipts resulting from recreation activities.
- Main negative impacts: Environmental damage, pressure on social structure and services of communities, future options closed, institutional conflicts due to development.

3. Reduce visitors (skiers mainly) to area, reduce conflict caused by developments.
4. Reduce areas assigned to skiing developments.

Alternative D

2. Evaluate impacts.
   - Main positive impacts: Higher yield of timber.
   - Main negative impacts: Some problems in environment due to excessive logging, low overall economic impact, low recreation services provided.

3. Reduce logging, augment recreation (skiing) possibilities.
4. Reduce areas assigned to logging, define additional facilities for recreation (skiing).

New Alternatives

In the next step, an attempt is made to generate new alternatives. It is clear that in this case, combinations should consider the efficiency of the activities in defining trade-offs, i.e., if an alternative (X) emphasizing timber production is to be combined with one (Y) with intensive ski facilities, a new alternative generated should consider those areas which in alternative X have the most efficient timber yield for logging and use the areas most adequate for skiing from alternative Y for ski developments. This process of finding new alternatives can be

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Wilderness, wildlife, fish, endangered species	−4(±1)	0(±1)	−3(±½)
Water quality availability	0(−1, +½)	4(−1½, +1)	5(±1)
Visual quality	−5(−1, +1½)	−1(±½)	−1(±½)
General environment	−4(−2, +1)	−2(±1)	−2(±1)
Economic:			
Timber	0(±½)	0(−1, +½)	6(±½)
Range	0(±½)	4(±½)	5(±½)
Goods and services produced in area	5(±1)	1(±½)	1(±½)
Tax receipts	4(±1)	1(±½)	2(±½)
Social:			
Recreation	5(±½)	2(±½)	2(±½)
Employment	4(±½)	2(±½)	2(±½)
Traffic, housing, social pressure	−4(−2, +1)	−1(±1)	−1½(±1)
Institutional:			
Conflicts (with other agencies and others)	−3	−2	−2
Irreversible, irretrievable commitment of resources	−5	−2	−3

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carried out through detailed observation of the actions defined, the location of them, and the expected results of these actions. This process can lead to alternative E (U.S. Dep. Agric., Forest Serv. 1976). This alternative basically takes best suited areas for winter recreation sports from alternative C, other areas to be managed as in alternative B for amenity values and others for logging as in alternative D. This alternative leads to the aggregated impacts listed in *table 5*.

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Several alternative formats are proposed to reflect both expected values of aggregated impacts and their range of deviation. Some of these have been suggested in previous works (Goeller, 1973). These formats are given for the comparison of alternatives A, E, P:

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Another possibility which is an extension of the format of *table 6* is to give, in addition to the expected value and degree of uncertainty, a cause for uncertainty and its direction. Consider the example of the recreation impact. Let **1** indicate a case whose soft information was used, let **2** indicate uncertainty about growth of demand for winter recreation, which could be quite larger than expected, leading to a value of the recreation impact of alternative E of up to 9. This recreation impact would then be presented as follows:

Impact	Alternative		
Recreation	A	E	P
	|5|	|7|[2]	|3|
	1	**1**	**1**

The **2** on the right hand side of the recreation impact of alternative E indicates that the demand for recreation facilities

Table 5—*Aggregated impacts of three alternatives*

Impacts	Alternatives[1]		
	A	E	P
Physical:			
Wilderness, wildlife, fish, endangered species	5(±1)	−5(±1)	0(±1)
Water quality availability	0(−1, +½)	0(±½)	3(±1)
Visual quality	−5(−1, +½)	−6(−1, +½)	−4(−1, +½)
General environment	−4(−2, +1)	−4(±1)	−2(±1)
Economic:			
Timber	0(±½)	2(±½)	2(±½)
Range	0(±½)	4(±½)	1(±½)
Goods and services produced in area	5(±1)	7(±1)	4(±1)
Tax receipts	4(±1)	6(±1)	3(±½)
Social:			
Recreation	5(±1)	7(−1, +2)	3(±½)
Employment	4(±½)	6(±1)	4(±1)
Traffic, housing, social pressure	−4(−2, +1)	−7(−2, +1)	−2(±1)
Institutional:			
Conflicts (with other agencies and others)	−1	−4	−2
Irreversible, irretrievable commitment of resources	−5	−7	−2

[1]Alternatives:
A = Current management direction continued
E = Combination of alternatives C (winter sports), B and D (logging areas)
P = Proposed plan of management; reduction of winter recreation areas with respect to E
Range of values (−10 to +10) shown in parentheses

could be quite larger than the expected value (bold numbers). The range of variation is shown by length of lines at each side of a value.

In many instances the process of working with multiple objectives goes further, trying to find in some form the relative importance of each objective and thus be able to assign to each alternative a single value, a monetary one, we hope (Keeney and Raiffa 1976). One usual form of doing this is through the generation of weight to describe the importance of goals.

This approach simplifies the selection of the preferred alternative, as all impacts can be reduced to a single weight average value. In some cases, users have defined weights to consider the relative importance of each impact. This approach, however, presents serious methodological problems, given the usual complexity of utility functions. These functions are difficult to express explicitly and present nonlinear characteristics. Thus, the weights associated with the impacts depend often in part on the level of the impacts. For example the importance given to air pollution will depend on whether the level of pollution is critical, how many people are subject to this pollution, etc. This makes the definition of weights *a priori* difficult to implement.

A more rigorous approach is to define relative importance of impacts interactively with the decisionmaker along the process. This requires, however, considerably more effort, and may not be even possible in many cases. To extract preferences, which are essentially subjective from decisionmakers is no simple task. It is a time-consuming process, and inconsistencies as well as errors may distort the results. For this reason, we preferred not to implement this stage in handling multiple objectives.

Stability of Solutions

The three alternatives considered are quite stable in their expected values. Alternative E presents some larger deviations in terms of predicting the level of recreation used and its impact on neighboring communities.

While there is lack of solid information in several aspects, these are not essential for the decisionmaking (e.g., noise level, as none of the possible values is critical).

Alternative P was selected as most attractive.

Generation of New Alternatives

There is not enough information to carry out the generation of new alternatives marginally different to alternative P.

Table 6—*Aggregated impacts of alternatives A, E, P*

Impacts	Alternatives[1]		
	A	E	P
Physical:			
Wilderness, wildlife, fish, endangered species	(−6, **−5**, −4)	(−6, **−5**, −4)	(−1, **0**, +1)
Water quality availability	(−1, **0**, +½)	(−½, **0**, +½)	(**2**, **3**, 4)
Visual quality	(−6, **−5**, −4½)	(−7, **−6**, −5½)	(−5, **−4**, −3½)
General environment	(−6, **−4**, −3)	(−5, **−4**, −3)	(−3, **−2**, −1)
Economic:			
Timber	(−½, **0**, +½)	(2½, **2**, 1½)	(2½, **2**, 1½)
Range	(−½, **0**, +½)	(3½, **4**, 4½)	(−1½, **−1**, −½)
Goods and services produced in area	(4, **5**, 6)	(6, **7**, 8)	(3, **4**, 5)
Tax receipts	(3, **4**, 5)	(5, **6**, 7)	(2½, **3**, 3½)
Social:			
Recreation	(4, **5**, 6)	(6, **7**, 9)	(2½, **3**, 3½)
Employment	(3½, **4**, 4½)	(5, **6**, 7)	(3, **4**, 5)
Traffic, housing, social pressure	(−6, **−4**, −3)	(−9, **−7**, −6)	(−3, **−2**, −1)
Institutional:			
Conflicts (with other agencies and others)	−1	−4	−2
Irreversible, irretrievable commitment of resources	−5	−7	−2

[1]Alternatives:
A = Current management direction continued
E = Combination of alternatives C (winter sports), B and D (logging areas)
P = Proposed plan of management; reduction of winter recreation areas with respect to E
Bold numbers indicate expected values, other numbers are estimated range

Preferred Alternative

Alternative P is chosen.

DISCUSSION AND CONCLUSIONS

The method described herein allows the analyst to structure the decision process in an orderly way, so that alternatives, impacts, and evaluations are properly handled. Although the idea of presenting a systematic procedure is not new, the present work has novel aspects that are particularly relevant to the decisionmaking process and can help in providing a structured analysis format:

- A procedure for generating additional alternatives, which appears to be promising based on information already evaluated, through the modification (mitigating actions) and combination of alternatives already defined.
- An analysis on how to handle the problem of multiple objectives, including the use of visual aids for presentation of results in tables and scoreboards which show information to the decisionmaker and to the public in a clear, stable way.
- Indications on how to incorporate into the evaluation situations with uncertainty and lack of information.
- A hierarchical structuring of the problem, in which alternatives are first analyzed in a more general form, including a screening process where the obviously noncompetitive alternatives are disregarded. The impacts caused by the alternatives are then disaggregated, in order to derive physical measurements. The number of impacts are reduced to a few through an elimination and aggregation process, consistent with the defined goals.

The proposed method is flexible and applicable to a broad range of planning problems in land management. The decision process will differ according to the problem at hand. Land management plans involve more activities than individual single projects, and consequently, a richer variety of possibilities exists in combining the elements forming a plan.

Clearly different procedures could be employed in a planning process. The presented scheme attempts to provide a coherent and simple-to-use process, following a rational line

Table 7—*Expected values of aggregated impacts of alternatives A, E, P*

Impacts	Alternatives[1]		
	A	E	P
Physical:			
Wilderness, wildlife, fish, endangered species	|−5|	|−5|	|0|
Water quality availability	|0|	|0|	|3|
Visual quality	|−5|	|−6|	|−4|
General environment	‖−4‖	|−4|	|−2|
Economic:			
Timber	|0|	|2|	|2|
Range	|0|	|4|	|−1|
Goods and services produced in area	|5|	|7|	|4|
Tax receipts	|4|	|6|	|3|
Social:			
Recreation	|5|	|7‖	|3|
Employment	|4|	|6|	|4|
Traffic, housing, social pressure	‖−4‖	‖−7‖	|−2|
Institutional:			
Conflicts (with other agencies and others)	−1	−4	−2
Irreversible, irretrievable commitment of resources	−5	−7	−2

[1]Alternatives:
A = Current management direction continued
E = Combination of alternatives C (winter sports), B and D (logging areas)
P = Proposed plan of management; reduction of winter recreation areas with respect to E
Range of variation indicated by length of lines at each side of value

Table 8—*Aggregated impacts of alternatives A, E, P*[1]

Physical impacts	Range of values: −10 −9 −8 −7 −6 −5 −4 −3 −2 −1 0 1 2 3 4 5 6 7 8 9 10
Wilderness	
Wildlife, etc.	**— A —** **· · · P · · ·**
	--- E ---
Water quality-availability	**— A —** **--- P ---**
	--- E ---
Visual quality	
General environment	
Timber	
.	
.	

[1]Alternatives:
A = Current management direction continued
E = Combination of alternatives C (winter sports), B and D (logging areas)
P = Proposed plan of management; reduction of winter recreation areas with respect to E
Bold letters indicate expected values

of reasoning in planning procedures. Once basic alternatives are defined, a disaggregation process allows exploration of the full range of consequences of each alternative. The aggregation process is essential to reduce the impacts to a manageable format which allows for comparison among the alternatives by a decisionmaker.

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A method is described for developing and evaluating alternatives in land management planning. A structured set of 15 steps provides a framework for such an evaluation, when multiple objectives and uncertainty must be considered in the planning process. The method is consistent with other processes used in organizational evaluation, and allows for the interaction of decisionmakers, specialists, analysts, and the general public. The method incorporates several novel aspects that help in structuring the decision process. Application of the method is illustrated by replicating the development of an environmental study in the Truckee-Little Truckee Rivers Planning Unit, Tahoe National Forest, California.

Retrieval Terms: land management planning, evaluation of alternatives, multiple objectives, uncertainty, structured format