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USER'S MANUAL FOR THE EVALUATION AND SENSITIVITY ANALYSIS PROGR--ETC(U)
MAR 81 J MUMPOWER, L BOLLACKER DACW39-78-C-0085

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The Evaluation and Sensitivity Analysis Program (ESAP) is an environmental planning technique for the evaluation of alternative water resource management plans. ESAP is based on a weighting-scaling approach to impact assessment and alternative evaluation. The evaluation of the desirability or acceptability of an alternative is based on a systematic combination of information about the impacts on the natural and cultural resources and information about the importance (weight) and preferred levels of such resources. Information for a
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number of individuals or groups is used to determine how sensitive their evaluations are to differences in judgments about the importance and preferred levels of resources or to uncertainty in projections of resource impacts.

The analysis performed by ESAP provides the user with two basic types of information: (a) an evaluation of alternatives for each individual or group considered and (b) an analysis of how the individuals or groups differ in their evaluation of alternatives. The analysis requires the user to provide a hierarchical description of the evaluation problem, which includes the variables or resources affected by the alternatives, projected levels of the variables or resources for each of the alternatives, and information about the weights or importance values and the variables for each of the groups under consideration. If the user wishes to examine the effects of uncertainty on evaluation, data describing uncertainty must also be input into the program.

The evaluation procedures evaluate the alternatives for one group at a time. The evaluation systematically combines the groups' judgments on the weights or importance and preferred levels for resources with projections for each of the alternatives. These two pieces of information for each variable or resource are combined to form an overall evaluation score that expresses the desirability or acceptability of each alternative. The different types of output from the evaluation allow the user to determine how the public group evaluates the alternatives, the difference between alternatives in the overall evaluation, and which variables are most important in the evaluation and, conversely, which variables contribute relatively little to discriminating between the acceptability of alternatives for that group. The evaluation of alternatives can be based on either the projected resource levels or on resource projections in conjunction with data describing the uncertainty about the projections.

The second type of analysis can provide the basis for determining how groups differ in their evaluation as well as the effect of uncertainty of resource projections on alternative evaluation. The procedures that compare groups allow the user to determine which alternatives are most acceptable to which public group, which resources or variables are responsible for the greatest difference in evaluation across all groups for all alternatives, and how pairs of groups differ in their overall evaluation and their evaluation of each variable or resource being considered.

PREFACE

The work described in this report was performed under Contract No. DACW39-78-C-0085, between the U. S. Army Engineer Waterways Experiment Station (WES) and the Center for Research on Judgment and Policy, Institute of Behavioral Science, University of Colorado, Boulder. The research was sponsored by the Office, Chief of Engineers, U. S. Army, Washington, D. C., as part of the Environmental and Water Quality Operational Studies (EWQOS), directed by the Environmental Laboratory (EL), WES.

This report was prepared by Dr. Jeryl Mumpower, research associate, and Mr. Lee Bollacker, computer programmer, of the Center for Research on Judgment and Policy. This report is a user's manual for the Evaluation and Sensitivity Analysis Program (ESAP). ESAP is an environmental evaluation technique to be used in water resources planning to evaluate alternatives. ESAP utilizes data on the projected impacts on resources affected by alternatives in conjunction with judgments on the importance of the resources to evaluate the acceptability or desirability of the alternatives. ESAP allows the user to identify which resources are responsible for differences in the evaluations given by different groups or individuals. In addition, ESAP has the capability of showing the effects of uncertainty in projections on the evaluation of alternatives.

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The contract was managed by Dr. Stanley A. West, Ms. Sue E. Richardson, Messrs. Jim E. Henderson and William J. Hansen, Environmental Resources Division (ERD), EL. Dr. Jerome L. Mahloch served as Program Manager, EWQOS. The study was under the general supervision of Dr. Conrad J. Kirby, Chief, ERD, and Dr. John Harrison, Chief, EL.

During the period of the contract, COL John L. Cannon, CE, and COL Nelson P. Conover, CE, served as Commanders and Directors of WES. Technical Director was Mr. Fred R. Brown.

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1.0 INTRODUCTION TO THE EVALUATION AND SENSITIVITY ANALYSIS PROGRAM (ESAP)

Evaluating alternative water resources plans requires consideration of many different pieces of information. Information about the projected economic, environmental, and social effects of each alternative needs to be taken into account. In addition, information about public values and preferences must be considered.

The first purpose of the Evaluation and Sensitivity Analysis Program (ESAP) is to help program users incorporate both scientific/technical and value information into the evaluation of alternatives. ESAP begins by requiring users to lay out in a systematic fashion:

a. Best available estimates of the effects of alternative water resources management plans on important environmental, economic, and/or social variables.

b. Best available estimates of the public(s)' judgments about the most desirable levels of each variable and the relative importance of each.

ESAP then systematically and analytically combines these two types of information in order to address several crucial questions:

a. How does each public rank the alternatives and why?

b. How acceptable to the public is the alternative to be recommended?

c. To what extent do various public groups differ in their evaluations of alternatives?

d. When public groups conflict in their evaluation of alternatives, which variables are the primary focus of such disagreement?

The second purpose of ESAP is to help users investigate the effects of uncertainty--about either scientific/technical information or public values--on the evaluation of alternatives. Giving adequate attention to all relevant pieces of information in a water resources evaluation problem is a difficult task, even if the precise values of all relevant pieces of information are known with certainty. But, of course, the precise values of all relevant pieces of information are never known with perfect certainty. Uncertainty exists about both scientific/technical issues and public values and preferences. For instance, uncertainty may exist about the environmental effects of a proposed alternative--e.g., the extent to which a plan will decrease (or increase) the trout population in a study area may be very difficult to anticipate before the fact. Similarly, uncertainty may exist about the relative importance the public associates with potential effects of alternatives--e.g., how much do various public groups care about potential effects on the trout population? Uncertainty and imprecision in the information used in water resources evaluations therefore makes the appropriate use of such information an even more difficult task than it already is.

ESAP permits its users to indicate the degree of uncertainty associated with alternatives' projected effects on important environmental, economic, or social variables; several important issues can then be addressed:

a. How sensitive to such uncertainty are public evaluations of alternatives?

b. For which variables does uncertainty have a significant impact on public evaluations of alternatives?

c. For which variables does uncertainty have an insignificant impact on public evaluations of alternatives?

d. Which alternatives are so unacceptable that they need not be considered further, even taking into consideration uncertainty about their effects as well as differences within the public about the desirability of those effects?

In summary, ESAP provides a method for systematically making use of scientific, engineering, and technical information, as well as information about public values and preferences, in the evaluation of water resources alternatives. In addition, ESAP enables project managers and their staff members to consider explicitly some of the uncertainties involved in the planning process.

1.1 APPLICABILITY TO CORPS WATER RESOURCES PLANNING

ESAP is directly applicable to the alternative evaluation task in Corps planning activities. It can be used to distinguish between alternatives that deserve further serious consideration and those that do not. Furthermore, it helps users identify those resources that are most important for the overall evaluation of alternatives and those that play relatively minor roles. It helps to identify those resources where estimates of projected effects need to be refined or improved as well as those areas of public conflict that are most likely to require attention during public involvement activities. By identifying those aspects of the planning process that are most important (or likely to prove most important), it alerts users to devote greatest effort to documenting the resources most germane to decisionmaking.

Although ESAP will be most useful for evaluating alternatives, it may also prove useful during the alternative formulation and impact assessment tasks. Application of ESAP during the alternative formulation task using preliminary rough estimates, may aid in early identification of alternatives that are clearly unacceptable to the public. It may also aid in identifying those instances in which none of the alternatives is likely to gain public support, suggesting the need for continued generation of new alternatives. In the impact assessment task, ESAP can identify those resources where uncertainty about projected effects seems most likely to make a significant difference for the final evaluation of alternatives. Time and effort can then be allocated to trying to reduce uncertainty about those effects that appear to be most relevant for the final decisionmaking process.

1.2 ADVANTAGES AND DISADVANTAGES OF ESAP

The use of ESAP in water resources planning offers several advantages over current procedures. Its use is also attended, of course, by certain disadvantages. Major advantages and disadvantages are:

Advantages of ESAP

a. Provides a systematic procedure for conducting water resources evaluation.

b. Is based upon explicit data that are available for ready inspection, refinement, and correction.

c. Can handle the extensive data sets required by large, complex studies.

d. Facilitates updating and reanalysis as the planning study evolves from one stage to another (as well as during iterations within steps).

e. Can be applied to any study in any location, for projects of any type and size.

f. Facilitates comparable analysis and integration of environmental (or other types of) data originating in various disciplines and professions.

g. Facilitates detailed documentation of the bases for recommending a particular alternative.

Disadvantages of ESAP

a. Requires access to computer facilities.

b. Requires numeric specification of all important effects of water resources management plans.

c. Requires description of public preferences and values in considerably greater detail (and in a different format) than is currently the case.

2.0 PURPOSES AND CAPABILITIES OF ESAP

2.1 INTRODUCTION

The purpose of ESAP is to provide a tool for helping study managers and their staff evaluate water resources management plans. ESAP is designed to enable water resources planners

a. to specify and make use of information about the projected effects of alternative water resources plans on environmental (or other) variables,

b. to specify and make use of information about the preferences and values of various public groups, and

c. to combine information about the projected effects of alternative plans with information about public preferences and values in order to establish a clear rationale for selecting a particular alternative.

In addition, ESAP allows users to take into systematic account uncertainties about both the projected effects of plans and descriptions of public values.

The purpose of this section of the manual is to familiarize users with the general purposes and capabilities of ESAP. It gives a broad overview of the program and its potential uses, describing in very general terms the major procedures of ESAP, the data inputs required by these procedures, and the steps that must be followed in order to use them and the outputs produced by each procedure.

The purpose of this section of the manual is <u>not</u> to provide step-by-step instructions for using the program. Such "how-to" instructions will be found in chapters 3.0 through 9.0. This section is intended only to provide a general overview of ESAP and its uses.

2.2 SETTING UP THE ANALYSIS

Four procedures in ESAP are used for setting up the analysis. These four procedures are TITLE, TREE, VARIABLES, and RANGES. Although necessary for conducting the subsequent analyses described below, these procedures need not be repeated each time users wish to conduct an analysis. Users will generally have to go through the four procedures for setting up an analysis only once. Use of the SAVE and CONTINUE procedures will ordinarily allow users to conduct additional analyses with little or no further effort beyond that required for the initial setup.

2.2.1 TITLE PROCEDURE

The TITLE procedure enables users to assign an identifying title of up to 79 characters for each run of ESAP. The ability to label and identify each run is particularly useful when ESAP is used in an iterative fashion, as it is designed to be used. As new information or revisions of old data estimates become available, new runs of ESAP can be conducted. Each run can be labeled according to the purpose of the new analysis and/or other distinguishing characteristics.

2.2.2 TREE PROCEDURE

The TREE procedure is the most important procedure in ESAP because it creates an in-depth description of the evaluation problem. It requires users to specify all the variables they wish to take into account during later analyses. Users start by identifying the general classes, types, or categories of variables (e.g., terrestrial resources or aquatic resources) they wish to consider in the analysis. They then break down each class, type, or category into more discrete, specific variables that define or exhaust the meaning of the general class, type, or category.

The output of the TREE procedure, as the name suggests, is a tree, or hierarchy, that provides a graphic picture of how the variable elements of the evaluation problem fit together. This description of the water resources evaluation problem provides a framework upon which all other procedures, as well as the analyses they produce, are based.

A hypothetical example of a tree describing a simple water resources evaluation problem appears in Figure 2.1. This type of graphic display identifies clearly all the general variables entering into the evaluation problem (e.g., terrestrial resources, etc.), as well as the more specific variables that make up or define more general variables (e.g., terrestrial habitat, terrestrial ecosystems, and land quality). The TREE procedure permits users to break down variables into multiple levels (e.g., the variable historical resources is broken down into historic resources and archeologic resources; historic resources is broken down into sites and areas and structures, etc.).

2.2.3 VARIABLES PROCEDURE

The VARIABLES procedure enables users to identify each of the variables involved in the water resources evaluation problem by specifying up to a 10-character label and a 68-character description for

TREE:

```
                                          |FOREST/HAB
                           |TERR/HAB---|CLEAR/HAB
                           |
                           |              |TER/SP/DV
              |TERRESTRAL-|TERR/ECOS--|WETLANDS
              |            |
              |            |              |FLOODS
              |            |LAND/QUAL--|SOIL/NUTR
              |
              |                           |FISH
              |            |AQUA/HAB---|RIPARIAN
              |            |                                |TEMP
              |            |              |PHYSICAL---|TURBID
              |            |              |
EQ---------|AQUATIC----|WATERQUAL--|                       |PH
              |            |              |CHEM-------|DO
              |            |
              |            |              |AQ/SP/DV
              |            |AQUA/ECOS--|AQ/PLNTS
              |AIR
              |                           |SITE/AREA
              |            |HISTORIC----|STRUCTURE
              |            |
              |HIST/RES   |              |PRECOLUM
                           |ARCHEOLOGIC |COLUMBIAN
```

Figure 2.1. Output from TREE procedure: description of a water resources evaluation problem

each. Constraints on space require that ESAP use no more than 10 characters in its displays to identify variables. The VARIABLES procedure allows users to construct a reference table in which each variable is described or defined in greater detail. This reference table provides a useful catalog of all the variables included in any analysis produced by ESAP. An example of output from the VARIABLES procedure appears in Figure 2.2.

VARIABLE	DESCRIPTION
EQ	ENVIRONMENTAL QUALITY
TERRESTRAL	TERRESTRIAL RESOURCES
AQUATIC	AQUATIC RESOURCES
AIR	AIR QUALITY
HIST/RES	HISTORICAL AND CULTURAL RESOURCES
TERR/HAB	TERRESTRIAL HABITAT
TERR/ECOS	TERRESTRIAL ECOSYSTEMS, COMMUNITY RELATIONSHIPS
LAND/QUAL	LAND QUALITY
AQUA/HAB	AQUATIC HABITAT
WATERQUAL	WATER QUALITY
AQUA/ECOS	AQUATIC ECOSYSTEMS, COMMUNITY RELATIONSHIPS
HISTORIC	HISTORIC SITES, AREAS, AND PLACES
ARCHEOLOGIC	EARLY HUMAN SETTLEMENTS
FOREST/HAB	FOREST HABITAT
CLEAR/HAB	CLEARED LAND, AGRICULTURAL HABITAT
TER/SP/DV	TERRESTRIAL SPECIES DIVERSITY
WETLANDS	WETLANDS, FLOOD PLAINS, MARSHES, SWAMP ACREAGE
FLOODS	ACREAGE FLOODED EACH YEAR
SOIL/NUTR	PRESENCE OF SOIL NUTRIENTS

Figure 2.2. Output from VARIABLES procedure

2.2.4 RANGES PROCEDURE

The RANGES procedure requires users to specify variables' minimum and maximum levels, as projected for any of the alternatives under consideration. These minimum and maximum levels are specified only for those variables at the leaves (or far righthand side) of the hierarchy created by the TREE procedure. That is, the RANGES procedure requires specification of minimum and maximum levels only for those variables for which data will be entered. Users also specify the units in which each of these leaf variables will be measured (e.g., parts per million, number per acre, etc.). The output of the RANGES procedure is a reference table that identifies each of the leaf variables in the tree, the minimum and maximum expected levels for each variable, and the unit of measurement for each. An example of output from the RANGES procedure appears in Figure 2.3.

RANGES:

VARIABLE	MINIMUM	MAXIMUM	UNIT
AIR	.00	500.00	AIR/INDEX
FOREST/HAB	25000.00	71300.00	ACRES
CLEAR/HAB	15000.00	55000.00	ACRES
TER/SP/DV	.00	100.00	INDEX
WETLANDS	.00	350.00	ACRES
FLOODS	.00	75000.00	ACRES
SOIL/NUTR	.18	.60	INV.SCALE
FISH	150.00	1250.00	AC-FT
RIPARIAN	20.00	45.00	STRM/MILE
AQ/SP/DV	.00	100.00	DIV.INDEX
AQ/PLNTS	.00	400.00	ACRES
SITE/AREA	.00	4.00	ACRES
STRUCTURE	.00	35.00	BUILDINGS
PRECOLUM	.00	1.00	SITES
COLUMBIAN	.00	6.00	SITES
TEMP	3.00	30.00	DEG/CENT
TURBID	20.00	100.00	JTU
PH	3.00	12.00	PH-UNIT
DO	.00	12.00	MG/L

Figure 2.3. Output from RANGES procedure

2.3 SPECIFYING VALUES AND PREFERENCES

Two procedures in ESAP are used for specifying the public values and preferences used to evaluate the overall desirability of various alternatives. These two procedures are WEIGHTS and FORMS. Users employ these two procedures to describe the relative importances that a public group places on variables and the most desirable (optimal) levels of each variable for that group, respectively. The two procedures fit together to create a comprehensive description of the values or preferences of a particular public group. Sets of weights and forms can be specified for one or more public groups; such descriptions are then used in the EVALUATE procedure, in conjunction with the information specified in the DATA or UNCERTAIN procedure, to evaluate the degree to which each alternative satisfies particular public groups. The PUBLICS procedure can be used to create brief one-line descriptions of each public group included in the analysis.

2.3.1 WEIGHTS PROCEDURE

The WEIGHTS procedure requires users to indicate the relative importance of variables for defining the more general variable with which they are directly linked in the tree. For example (referring to the output from the TREE display that appeared in Figure 2.1), the WEIGHTS procedure requires users to specify the relative importances of terrestrial, aquatic, air, and historical resources for evaluating the desirability of alternatives' effects on environmental quality. Similarly, users must specify the relative importance of terrestrial habitat, terrestrial ecosystems, and land quality for evaluating alternatives' effects on terrestrial resources, and so forth.

Output from the WEIGHTS procedure can take two forms. The first type of display indicates the relative importance of each variable for the more general variable with which it is directly linked in the tree. An example of this type of display appears in Figure 2.4. For each variable two numbers are displayed. The first is the number entered for that variable by the user. The second number is the normalized relative importance of that variable for the more general variable with which it is linked. The normalization of these relative importances results in each relative importance value being scaled between 0 and 1;

```
PUBLIC:  PRESRVATOR
ORIGINAL WEIGHTS:

                                    |FOREST/HAB
                                    |  85.00/.85
                        |TERR/HAB---|CLEAR/HAB
                        |  40.00/.40|  15.00/.15
                        |
                        |
                        |           |TER/SP/DV
                        |           |  75.00/.75
            |TERRESTRAL-|TERR/ECOS--|WETLANDS
            |  30.00/.30|  40.00/.40|  25.00/.25
            |           |
            |           |
            |           |           |FLOODS
            |           |           |   8.00/.80
            |           |LAND/QUAL--|SOIL/NUTR
            |           |  20.00/.20|   2.00/.20
            |
            |
            |           |           |FISH
            |           |           |   6.00/.60
            |           |AQUA/HAB---|RIPARIAN
            |           |  60.00/.60|   4.00/.40
            |           |                       |TEMP
            |           |                       |   5.00/.50
            |           |           |PHYSICAL---|TURBID
            |           |           |   5.00/.50|   5.00/.50
            |           |           |
            |           |           |
 EQ---------|AQUATIC----|WATERQUAL--|           |PH
            |  35.00/.35|  15.00/.15|           |   5.00/.50
            |           |           |CHEM-------|DO
            |           |           |   5.00/.50|   5.00/.50
            |           |
            |           |
            |           |           |AQ/SP/DV
            |           |           |   8.00/.80
            |           |AQUA/ECOS--|AQ/PLNTS
            |           |  25.00/.25|   2.00/.20
            |AIR
            |   5.00/.05
            |                       |SITE/AREA
            |                       |   4.00/.40
            |           |HISTORIC---|STRUCTURE
            |           |   5.00/.50|   6.00/.60
            |           |
            |           |
            |HIST/RES---|           |PRECOLUM
            |  30.00/.30|           |  25.00/.25
            |           |ARCHEOLOGIC|COLUMBIAN
            |           |   5.00/.50|  75.00/.75
```

Figure 2.4. Display from WEIGHTS procedure: original weights

the sum of the relative importance values for all the variables directly linked to another more general variable is always 1. For example, the relative importance of terrestrial resources for environmental quality (EQ) in Figure 2.4 is .30. Similarly, the relative importance of aquatic resources for environmental quality is .35; the relative importance of air resources is .05; and, the relative importance of historical resources is .30. The sum of the relative importances for the four variables linked to EQ thus equals 1.

The second type of output available from the WEIGHTS procedure is derived directly from the first. It indicates the relative importance of each variable in the tree for the root, or initial variable, of the tree. An example of this type of display appears in Figure 2.5. In the present example, the relative importance weights appearing in the tree indicate the relative importance of each variable for EQ. The derived weights are computed by multiplying each variable's relative importance by the relative importance of all those variables in the tree with which it is directly linked. For instance, the relative importance of wetlands for EQ is computed by multiplying the relative importance (.25) of wetlands for terrestrial ecosystems, times the relative importance (.40) of terrestrial ecosystems for terrestrial resources, times the relative importance (.30) of terrestrial resources for overall EQ. This method of computation provides an indication of the relative importance of each variable in the tree for evaluating a plan's overall desirability.

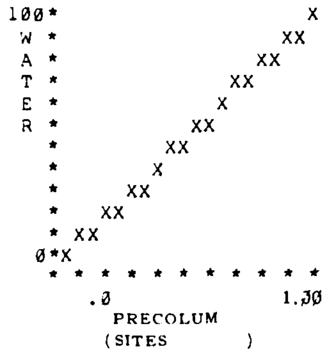
```
PUBLIC:  PRESRVATOR
DERIVED WEIGHTS:

                                              |FOREST/HAB
                                              |   .10
                                |TERR/HAB---|CLEAR/HAB
                                |   .12       |   .02
                                |
                                |
                                |             |TER/SP/DV
                                |             |   .09
                  |TERRESTRAL-|TERR/ECOS--|WETLANDS
                  |   .30       |   .12       |   .03
                  |             |
                  |             |
                  |             |             |FLOODS
                  |             |             |   .05
                  |             |LAND/QUAL--|SOIL/NUTR
                  |             |   .06       |   .01
                  |
                  |
                  |                           |FISH
                  |                           |   .13
                  |             |AQUA/HAB---|RIPARIAN
                  |             |   .21       |   .06
                  |             |                           |TEMP
                  |             |                           |   .01
                  |             |             |PHYSICAL---|TURBID
                  |             |             |   .03       |   .01
                  |             |             |
                  |             |             |
EQ---------|AQUATIC----|WATERQUAL--|                           |PH
                  |   .35       |   .05       |                           |   .01
                  |             |             |CHEM-------|DO
                  |             |             |   .03       |   .01
                  |             |
                  |             |
                  |             |             |AQ/SP/DV
                  |             |             |   .07
                  |             |AQUA/ECOS--|AQ/PLNTS
                  |             |   .09       |   .02
                  |AIR
                  |   .05
                  |                           |SITE/AREA
                  |                           |   .06
                  |             |HISTORIC----|STRUCTURE
                  |             |   .15       |   .09
                  |             |
                  |             |
                  |HIST/RES----|             |PRECOLUM
                  |   .30       |             |   .04
                                |ARCHEOLOGIC |COLUMBIAN
                                |   .15       |   .11
```

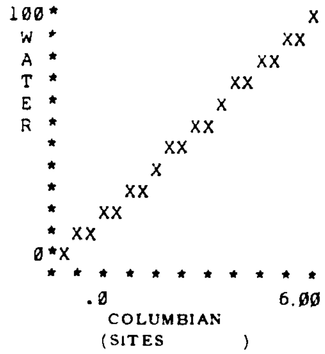
Figure 2.5. Display from WEIGHTS procedure: derived weights

2.3.2 FORMS PROCEDURE

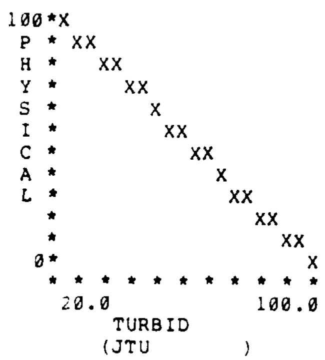
The FORMS procedure requires users to specify the relation between each variable in the tree and the more general variable with which it is directly linked in the tree. An example of displays from the FORMS procedure appears in Figure 2.6. Figure 2.6.a indicates that the relationship between <u>precolumbian sites</u> and <u>archeologic resources</u> is positive linear, that is, the more the better, and the optimal point within the



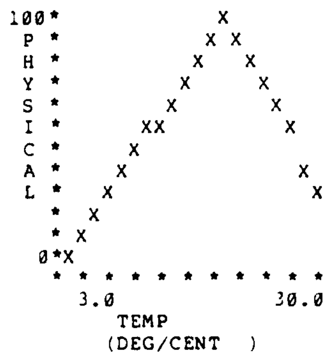
a. <u>Archeologic resources/ precolumbian sites</u>



b. <u>Archeologic resources/ columbian sites</u>



c. <u>Physical water quality/turbidity</u>



d. <u>Physical water quality/ temperature</u>

Figure 2.6. Display from FORMS procedure: archeologic resources and physical water quality relationships

specified feasible range is the maximum, 1 site. Similarly, Figure 2.6b indicates that the relationship between Columbian sites and archeologic resources is positive linear, again, the more the better, and the optimal point within the specified feasible range is the maximum, or 6 sites. Figure 2.6c indicates, however, that the relationship between turbidity and physical water quality is negative linear, that is, the less the better, and the optimal point within the specified feasible range would be the minimum level of 20 JTUs. Finally, Figure 2.6d indicates that the relationship between temperature and physical water quality is nonlinear within the specified feasible range. The optimal point for temperature is 16.5°C; temperatures cooler or warmer than this temperature are less desirable.

The FORMS procedure allows users to describe the functional relationship between any variable and the more general variable with which it is linked in the tree by selecting among eight prespecified forms. The most frequently used of these will ordinarily be positive linear (the more the better) and negative linear (the less the better) forms. Users can also specify, however, any form that can be approximated by two straight lines.

Two types of displays are available from the FORMS procedure. The first type of display consists of graphic descriptions of the relationship between two variables, as illustrated by Figure 2.6. Such graphic descriptions are produced for all pairs of variables that are immediately connected in the tree. For example, if a variable, say aquatic resources, is defined in the TREE procedure as being defined by aquatic habitat, water quality, and aquatic ecosystems, the FORMS procedure would produce graphs depicting the relationships between (a) aquatic resources and aquatic habitat, (b) aquatic resources and water quality, and (c) aquatic resources and aquatic ecosystems. The horizontal axis of the FORMS output represents the range of the variable; the vertical axis is always a 0-to-100 scale.

A potential disadvantage of such graphic output from the FORMS procedure is that it requires considerable processing time and can use substantial amounts of paper. The FORMS procedure therefore provides the option of describing functional relationship curves in numeric rather than graphical format. This option may be particularly useful in those analyses in which most functional relationship curves are positive (or negative) linear, in reiterations of previous analyses, or for experienced users.

2.3.3 PUBLICS PROCEDURE

The PUBLICS procedure enables users to identify each of the public groups for which a set of weights and forms has been specified. Up to a 10-character label and a 68-character description can be specified for each group. Constraints on space require that ESAP use no more than 10 characters in its displays to identify each public group. The PUBLICS procedure allows users to construct a reference table in which each public group is described or defined in greater detail. This reference table provides a useful listing of all the public groups included in analyses conducted by ESAP; an example of a display from PUBLICS appears in Figure 2.7.

PUBLIC	DESCRIPTION
PRESRVATOR	HISTORICAL PRESERVATIONISTS, HISTORIANS, AND ANTHROPOLOGISTS
NATURE	ENVIRONMENTALISTS, CONSERVATIONISTS
FARMERS	AGRICULTURAL INTERESTS, LAND OWNERS

Figure 2.7. Output from PUBLICS procedure

2.4 ENTERING PROJECTIONS

Two procedures in ESAP are used for specifying the levels of variables expected to result if particular alternatives are selected. These procedures are DATA and UNCERTAIN. In both procedures, the projected values of variables are specified in numeric terms; for example, the value of the variable water temperature might be expressed in terms of degrees centigrade. The ALTERNS. procedure allows users to create a table describing each of the alternatives under consideration.

2.4.1 DATA PROCEDURE

The DATA procedure requires users to specify best available estimates of the projected levels of variables for each alternative included in the analysis. Users identify each alternative by a 10-character label; for each alternative they specify the projected levels or values for all variables at the leaves of the tree; that is, they specify expected levels or values for all variables that are not further subdivided into more specific variables. For example, referring to the evaluation problem previously described (Figure 2.1), terrestrial resources was subdivided into terrestrial habitats, terrestrial ecosystems, and land quality; terrestrial habitats was subdivided into forest habitats and cleared land, agricultural habitat; terrestrial ecosystems, community relationships was subdivided into terrestrial species diversity and wetlands, flood plains, marshes, and swamp acreage; and land quality was subdivided into acreage flooded each year and presence of soil nutrients. Since the DATA procedure requires users to specify the projected levels of each variable in the tree that is not further subdivided, projected levels must be specified for forest habitat, cleared land, agricultural habitat, terrestrial species diversity, wetlands, flood plains, marshes, and swamp acreage, acreage flooded each year, and presence of soil nutrients (or in terms of the abbreviations used in TREE, projected levels must be specified for FOREST/HAB, CLEAR/HAB, TER/SP/DV, WETLANDS, FLOODS, and SOIL/NUTR).

Levels of these six variables, and of all other variables included in the analysis, must be specified in numeric terms (even though the numeric scale may be quite simple -- say, a 1-to-3 scale). The projected levels of variables that users specify must, of course, be expressed in the appropriate unit of measurement and within the range of minimum and maximum values previously specified in the RANGES procedure. In the present example, for instance, the projected levels of FOREST/HAB must fall within the specified range of 25,000 to 71,300 acres.

Output from the DATA procedure is a table in which the projected levels of each leaf variable are presented for each alternative. An example of the type of display produced by DATA appears in Figure 2.8. This output echoes input from users, providing an easy check for errors in data entry.

PRECISE DATA VALUES:

ALT.	AIR	FOREST/HAB	CLEAR/HAB	TER/SP/DV	WETLANDS	FLOODS
ALT.1	300.00	30000.00	45000.00	65.00	100.00	12000.00
ALT.2	300.00	40000.00	50000.00	70.00	35.00	45000.00
ALT.3	300.00	35000.00	45000.00	75.00	250.00	50000.00
ALT.4	300.00	65000.00	25000.00	80.00	300.00	60000.00

ALT.	SOIL/NUTR	FISH	RIPARIAN	AQ/SP/DV	AQ/PLNTS	SITE/AREA
ALT.1	.50	1000.00	35.00	75.00	250.00	4.00
ALT.2	.40	250.00	25.00	35.00	100.00	1.00
ALT.3	.47	800.00	20.00	65.00	190.00	2.00
ALT.4	.30	600.00	35.00	80.00	400.00	.50

ALT.	STRUCTURE	PRECOLUM	COLUMBIAN	TEMP	TURBID	PH
ALT.1	30.00	1.00	6.00	13.00	70.00	6.50
ALT.2	14.00	1.00	4.00	22.00	86.00	9.00
ALT.3	21.00	1.00	5.00	13.00	60.00	6.50
ALT.4	7.00	.00	2.00	14.00	75.00	6.50

Figure 2.8. Output from DATA procedure

2.4.2 UNCERTAIN PROCEDURE

The UNCERTAIN procedure allows users to specify for each alternative a range of potential levels for each variable. More often than not, the effects of alternative plans on variables are impossible to project with great certainty. Rather, a range of effects is possible. The UNCERTAIN procedure permits users to specify a range of numerical values within which the true value of a variable can be expected to fall, if a particular alternative were selected. This range can be thought of as analogous to a confidence interval.

The UNCERTAIN procedure permits users several options for specifying the range of variable levels projected for each alternative. The first option permits users to specify for each alternative specific LOW and HIGH values for each variable. This option permits users to enter very precise estimates of the degree of uncertainty associated with alternatives' impacts on variables. For instance, users can specify a broad range of potential levels for a variable for one alternative, and a narrow range of levels for that variable for a different alternative. Similarly, for the same alternative, users can specify a broad range of uncertainty for one variable and a narrow range for another. The display from the UNCERTAIN procedure is similar to that for the DATA procedure. A table is produced that presents the LOW and HIGH values for each variable, as entered by the user (see Figure 2.9).

UNCERTAIN DATA VALUES:

ALT.	AIR	FOREST/HAB	CLEAR/HAB	TER/SP/DV	WETLANDS	FLOODS
ALT.1						
LOW	270.00	27000.00	40500.00	52.00	90.00	11400.00
HIGH	330.00	33000.00	49500.00	78.00	110.00	12600.00
ALT.2						
LOW	270.00	36000.00	45000.00	56.00	31.50	42750.00
HIGH	330.00	44000.00	55000.00	84.00	38.50	47250.00
ALT.3						
LOW	270.00	31500.00	40500.00	60.00	225.00	47500.00
HIGH	330.00	38500.00	49500.00	90.00	275.00	52500.00
ALT.4						
LOW	270.00	58500.00	22500.00	64.00	270.00	57000.00
HIGH	330.00	71300.00	27500.00	96.00	330.00	63000.00

Figure 2.9. Output from UNCERTAIN procedure

Although this option allows users to specify with precision the degree of uncertainty associated with each alternative's effect on each variable, its use can be a very time consuming process, particularly for studies involving large numbers of variables or alternatives. Moreover, users often do not have sufficient information to specify confidently the degree of uncertainty associated with each effect, particularly in the earlier stages of the planning process. Often users will know or suspect that estimates of alternatives' effects are very approximate or uncertain, but will not know the extent of such imprecision or uncertainty.

A second option in the UNCERTAIN procedure permits users to specify a percentage for computing the LOW and HIGH levels of variables. For example, a user might specify a 20 percent uncertainty factor. For all variables to which a user applied this PERCENTAGE option, the LOW level would be computed by subtracting 20 percent from the value specified in the DATA procedure; the HIGH level would be computed by adding 20 percent to the value specified in DATA.

Yet another option permits users to specify a constant value for computing the LOW and HIGH levels of variables. For example, a user might specify a constant value of 10 units. For all variables to which this CONSTANT option was applied, the LOW level would be computed by subtracting 10 units from the value specified in the DATA procedure. The HIGH level would be computed by adding 10 units. A final option, SPAN, enables users to indicate that the level might fall anywhere between the minimum and maximum values specified for a variable in RANGES.

In general ESAP is very flexible in the interactive mode, permitting users to use many different combinations of these four options for creating the particular array of LOW and HIGH values they desire for each variable/alternative combination. In batch mode, however, ESAP is somewhat more restrictive; in general, users can use only one option for any set of data specifications. (Any data set that can be specified in the interactive mode can be specified through the batch mode, however, only the degree of difficulty in doing so varies across modes.)

2.4.5 ALTERNS. PROCEDURE

The ALTERNS. procedure enables users to identify each of the water resources management plans included in the analysis. Up to a 10-character label and a 68-character description can be specified for each alternative. Constraints on space require that ESAP use no more than 10 characters in its displays to identify each alternative. The ALTERNS. procedure allows users to construct a reference table in which each alternative is described or defined in greater detail. The table created by ALTERNS. constitutes a useful catalog describing each alternative included in the analyses. An example of a display from ALTERNS. appears in Figure 2.10.

ALTE [illegible]	DESCRIPTION
ALT.1	RESERVOIR W. REC. FACILITIES, MANAGED FISH AND WILDLIFE HABITAT
ALT.2	CHANNELIZATION OF TRIBUTARIES
ALT.3	DAMS ACROSS TRIBUTARIES
ALT.4	NO ACTION

Figure 2.10. Output from ALTERNS. procedure

2.5 EVALUATING ALTERNATIVES

The EVALUATE procedure permits users to combine the information specified in earlier procedures into analyses of the overall desirability of various alternatives. The EVALUATE procedure can be used with any PUBLIC for which a set of weights and forms has been specified, although EVALUATE can be used with only one public group at a time.

EVALUATE can be used with either the PRECISE data values specified in the DATA procedure or with the UNCERTAIN data values specified in the UNCERTAIN procedure. A number of options are available with either type of data.

2.5.1 EVALUATING ALTERNATIVES WITH PRECISE DATA

A total of 10 options are available in the EVALUATE procedure when using PRECISE data. Each is discussed briefly.

2.5.1.1 OPTION 1, OVERALL SCORES. The OVERALL SCORES option displays the overall desirability score for each alternative, based on a 0-to-100 scale, where a score of 100 indicates an alternative that leads to most desirable (optimal) levels for every variable included in the analysis. These overall scores indicate the desirability of the projected effects of each alternative, taking into account the differential importance that the public group being analyzed associates with each variable. An example of output from the OVERALL SCORES option appears in Figure 2.11. Note that alternatives are rank-ordered in terms of their overall scores, thereby indicating which alternatives are preferred and the degree to which they are judged preferable to other alternatives. In the present example, alternative ALT.1 is the most overall desirable alternative for public group FARMERS.

```
PUBLIC: FARMERS
OVERALL SCORES

                              OVERALL SCORE
         0    10   20   30   40   50   60   70   80   90  100
ALT.     +----+----+----+----+----+----+----+----+----+----+      VALUE
ALT.1                                     *                        64.9
ALT.3                              *                               53.4
ALT.2                             *                                51.9
ALT.4                         *                                    43.3
```

Figure 2.11. Output from EVALUATE with PRECISE data: OPTION 1, OVERALL SCORES

2.5.1.2 <u>OPTION 2, OVERALL SCORES RELATIVE</u>. Often times in water resources planning, users may wish to evaluate all other alternatives with respect to one particular alternative, usually the without project alternative. ESAP permits users to make such comparisons with the OVERALL SCORES RELATIVE option. In this option the user specifies the name of the alternative to which all other alternatives are to be compared. The OVERALL SCORES RELATIVE option then produces a display identical to that produced by the OVERALL SCORES option, with the exception that scores are expressed in terms of their difference (positive or negative) from the specified alternative. An example of the output from the OVERALL SCORES RELATIVE option appears in Figure 2.12.

```
PUBLIC: FARMERS
OVERALL SCORES RELATIVE TO ALTERNATIVE ALT.3

              OVERALL SCORE RELATIVE TO ALTERNATIVE ALT.3
       -50  -40  -30  -20  -10    0   10   20   30   40   50   60
ALT.     +----+----+----+----+----+----+----+----+----+----+----+      VALUE
ALT.1                                  *                               11.5
ALT.3                              *                                     .0
ALT.2                             *                                    -1.5
ALT.4                        *                                        -10.1
```

Figure 2.12. Output from EVALUATE with PRECISE data: OPTION 2, OVERALL SCORES RELATIVE

2.5.1.3 OPTION 3, ALTERN. SCORES. In addition to learning how desirable a particular public rates each of the various alternatives, users will ordinarily wish to learn about reasons for differences in such ratings. The ALTERN. SCORES permits users to learn how the overall score was computed for each alternative. An example of a display from ALTERN. SCORES appears in Figure 2.13.

As can be seen, the ALTERN. SCORES option produces output in the same tree format as is used by the TREE procedure. The scores associated with leaf variables in the tree simultaneously indicate the desirability of the projected level of the variable and the relative importance of that variable. This variable score is computed by multiplying the rating for a variable level (on the 0-to-100 scale specified in FORMS) by the derived relative weight for that variable (as specified in WEIGHTS). The variable scores for higher level variables in the tree are then computed by summing the scores of those variables that make up or define that variable. (Technically, this description of the method of computation is an oversimplification; see the section on EVALUATE and Appendix D for details). For example, in Figure 2.13, the overall score for EQ is 64.9; 12.5 of the score for EQ comes from HIST/RES; 9.5 of the score for HIST/RES comes from ARCHEOLOGIC; and 9.0 of the score for ARCHEOLOGIC comes from COLUMBIAN.

By comparing the ALTERN. SCORES displays for two or more alternatives, users can quickly identify the variables that are primarily responsible for differences between the alternatives' overall scores.

```
PUBLIC: FARMERS
SCORES FOR ALTERNATIVE ALT.1

                                   |FOREST/HAB
                                   |    1.4
                       |TERR/HAB---|CLEAR/HAB
                       |    6.2    |    4.8
                       |
                       |
                       |           |TER/SP/DV
                       |           |    2.6
           |TERRESTRAL-|TERR/ECOS--|WETLANDS
           |   30.9    |    5.5    |    2.9
           |           |
           |           |
           |           |           |FLOODS
           |           |           |   10.1
           |           |LAND/QUAL--|SOIL/NUTR
           |           |   19.2    |    9.1
           |
           |
           |                       |FISH
           |                       |    1.4
           |           |AQUA/HAB---|RIPARIAN
           |           |    3.9    |    2.5
           |           |                       |TEMP
           |           |                       |     .0
           |           |           |PHYSICAL---|TURBID
           |           |           |    1.3    |    1.3
           |           |           |
EQ---------|AQUATIC----|WATERQUAL--|           |PH
   64.9    |   15.5    |    8.7    |           |    5.5
           |           |           |CHEM-------|DO
           |           |           |    7.3    |    1.8
           |           |
           |           |
           |           |           |AQ/SP/DV
           |           |           |    1.3
           |           |AQUA/ECOS--|AQ/PLNTS
           |           |    2.9    |    1.6
           |AIR
           |    6.0
           |                       |SITE/AREA
           |                       |     .3
           |           |HISTORIC---|STRUCTURE
           |           |    2.9    |    2.6
           |           |
           |           |
           |HIST/RES---|           |PRECOLUM
           |   12.5    |           |     .5
                       |ARCHEOLOGIC|COLUMBIAN
                       |    9.5    |    9.0
```

Figure 2.13. Output from EVALUATE with PRECISE data: OPTION 3, ALTERN. SCORES

2.5.1.4 OPTION 4, ALTERN. SCORES RELATIVE. The ALTERN. SCORES RELATIVE option enables users to compare the overall and variable scores of all other alternatives to those of one particular alternative selected by the user. It thus permits users to identify those variables which are primarily responsible for differences in desirability scores among alternatives. Often users may wish to compare all other alternatives to a without project alternative; users can then readily discover for which variables structural or nonstructural alternatives have desirable effects in comparison with no action, and for which variables such alternatives have undesirable effects in comparison with the without project alternative. The scores for all other alternatives will be expressed in terms of positive or negative deviations from the scores of the without project alternative.

An example of a display from the ALTERN. SCORES RELATIVE option appears in Figure 2.14. Note how this display aids users in learning the reasons for differences between the two alternatives, ALT.1 and ALT.3, for the public group FARMERS. The display indicates that the FARMERS group assigns an overall score for ALT.1 that is 11.5 points higher than the score for ALT.3. The display further indicates that the primary source of differences in the overall desirability of the two alternatives stems from differences about the desirability of their effects on TERRESTRAL (i.e., terrestrial resources), with a difference of 8.4 points between the two alternatives on this variable; the differences between the two alternatives with respect to TERRESTRAL appears to derive mainly from differences in the desirability of their

```
PUBLIC: FARMERS
SCORES FOR ALTERNATIVE ALT.1 RELATIVE TO ALTERNATIVE ALT.3

                                             |FOREST/HAB
                                             |     .2
                                 |TERR/HAB---|CLEAR/HAB
                                 |     .2    |     .0
                                 |
                                 |
                                 |           |TER/SP/DV
                                 |           |     -.4
                     |TERRESTRAL-|TERR/ECOS--|WETLANDS
                     |     8.4   |     1.3   |     1.7
                     |           |
                     |           |
                     |           |           |FLOODS
                     |           |           |     6.1
                     |           |LAND/QUAL--|SOIL/NUTR
                     |           |     6.9   |     .9
                     |
                     |
                     |                       |FISH
                     |                       |     .3
                     |           |AQUA/HAB---|RIPARIAN
                     |           |     2.8   |     2.5
                     |           |                       |TEMP
                     |           |                             .0
                     |           |           |PHYSICAL---|TURBID
                     |           |           |     -.5   |     -.4
                     |           |           |
                     |           |           |
EQ-------------------|AQUATIC----|WATERQUAL--|           |PH
     11.5            |     1.9   |     -.5   |           |     .0
                     |           |           |CHEM-------|DO
                     |           |           |     .0    |     .0
                     |           |
                     |           |
                     |           |           |AQ/SP/DV
                     |           |           |     .2
                     |           |AQUA/ECOS--|AQ/PLNTS
                     |           |     -.5   |     -.6
                     |AIR
                     |     .0
                     |                       |SITE/AREA
                     |                       |     -.8
                     |           |HISTORIC---|STRUCTURE
                     |           |     -.4   |     .4
                     |           |
                     |           |
                     |HIST/RES---|           |PRECOLUM
                     |     1.1   |           |     -.7
                                 |ARCHEOLOGIC|COLUMBIAN
                                 |     1.5   |     2.3
```

Figure 2.14. Output from EVALUATE with PRECISE data: OPTION 4, ALTERN. SCORES RELATIVE

effects on LAND/QUAL (i.e., land quality), with a difference of 6.9 points between the two. Finally, the differences between the two alternatives with respect to LAND/QUAL appear to stem principally from differences between the two alternatives in the desirability of their effects on FLOODS, with a difference of 6.1 points. The analyses and display from the ALTERN. SCORES RELATIVE option thus helps to identify the major sources of differences concerning the overall desirability of various alternatives.

2.5.1.5 OPTION 5, RATINGS. When comparing alternatives it is often useful to determine just how desirable a public group rates the projected levels of various individual variables. The RATINGS option permits users to learn for each alternative how the projected levels of each variable were rated on the 0-to-100 scale specified in FORMS. An example of output from RATINGS appears in Figure 2.15. The desirability of the projected level of each variable in the tree is indicated on a 0-to-100 scale, for each alternative. For instance (see arrow, Figure 2.15), the FOREST/HAB rating for ALT.1 equalled 89.2; for ALT.2, 67.6; for ALT.3, 78.4; and for ALT.4, only 13.6. The derived weight for each variable is also displayed by RATINGS. Multiplying variables' ratings by their derived weights would produce the same scores that appeared in the ALTERN. SCORES displays.

PUBLIC: FARMERS
RATINGS GIVEN TO EACH VARIABLE

VARIABLE		DERIVED WEIGHT	RATING ALT.1	ALT.2	ALT.3	ALT.4
LEVEL 0:						
EQ			64.9	51.9	53.4	43.3
LEVEL 1:						
TERRESTRAL		.40	77.3	60.4	56.2	28.5
AQUATIC		.30	51.7	43.9	45.2	43.0
AIR		.10	60.0	60.0	60.0	60.0
HIST/RES		.20	62.3	43.0	56.8	64.9
LEVEL 2:						
TERR/HAB	(TERRESTRAL)	.08	77.8	83.5	75.7	22.7
TERR/ECOS	(TERRESTRAL)	.08	68.2	80.0	51.8	47.1
LAND/QUAL	(TERRESTRAL)	.24	80.1	46.2	51.2	24.3
AQUA/HAB	(AQUATIC)	.06	65.2	16.7	17.7	54.3
WATERQUAL	(AQUATIC)	.18	48.1	46.5	50.6	45.6
AQUA/ECOS	(AQUATIC)	.06	48.7	63.0	56.2	24.0
HISTORIC	(HIST/RES)	.06	49.1	48.7	56.2	41.2
ARCHEOLOGIC	(HIST/RES)	.14	68.0	40.5	57.0	75.0
LEVEL 3:						
FOREST/HAB	(TERR/HAB)	.02	89.2	67.6	78.4	13.6
CLEAR/HAB	(TERR/HAB)	.06	75.0	87.5	75.0	25.0
TER/SP/DV	(TERR/ECOS)	.04	65.0	70.0	75.0	80.0
WETLANDS	(TERR/ECOS)	.04	71.4	90.0	28.6	14.3
FLOODS	(LAND/QUAL)	.12	84.0	40.0	33.3	20.0
SOIL/NUTR	(LAND/QUAL)	.12	76.2	52.4	69.0	28.6
FISH	(AQUA/HAB)	.02	77.3	9.1	59.1	40.9
RIPARIAN	(AQUA/HAB)	.04	60.0	20.0	.0	60.0
PHYSICAL	(WATERQUAL)	.09	15.0	31.4	20.0	12.5
CHEM	(WATERQUAL)	.09	81.3	61.6	81.3	78.8
AQ/SP/DV	(AQUA/ECOS)	.02	75.0	35.0	65.0	80.0
AQ/PLNTS	(AQUA/ECOS)	.04	37.5	75.0	52.5	.0
SITE/AREA	(HISTORIC)	.03	10.6	75.0	37.5	82.5
STRUCTURE	(HISTORIC)	.03	87.5	22.5	75.0	.0
PRECOLUM	(ARCHEOLOGIC)	.04	12.5	55.0	30.0	20.0
COLUMBIAN	(ARCHEOLOGIC)	.10	91.7	34.3	68.6	98.6
LEVEL 4:						
TEMP	(PHYSICAL)	.05	.0	40.7	.0	.0
TURBID	(PHYSICAL)	.04	37.5	17.5	50.0	31.2
PH	(CHEM)	.06	87.5	64.8	87.5	87.5
DO	(CHEM)	.03	66.7	54.2	66.7	58.3

Figure 2.15. Output from EVALUATE with PRECISE data: OPTION 5, RATINGS

2.5.1.6 OPTION 6, RATINGS RELATIVE. Users may sometimes wish to generate a display that compares the ratings for all other alternatives to the ratings of one particular alternative, frequently the without project alternative. The RATINGS RELATIVE option allows users to make such comparisons. An example of output from this option appears in Figure 2.16.

2.5.1.7 OPTION 7, AVERAGE SCORES. Users may sometimes wish to learn the average values of overall and variable scores, across all alternatives, particularly for large planning studies involving a number of alternatives and variables. Such information enables users to obtain a better feel for the relative importance of the variables for determining alternatives' overall scores. This option produces displays both in the tree format and in a tabular format. An example of the tabular output appears in Figure 2.17.

2.5.1.8 OPTION 8, SCORE RANGES. The range of scores across alternatives, from the minimum to the maximum, gives users an idea of which variables are generally most important for distinguishing among alternatives in terms of their desirability. The SCORE RANGES option computes and displays the largest difference between any pair of alternatives, for each variable score. The SCORE RANGES option produces displays in both tree and tabular format. An example of the tabular displays produced by SCORE RANGES appears in Figure 2.18. Note that for Level 1 variables the largest range of scores is for

PUBLIC: FARMERS
RATINGS GIVEN TO EACH VARIABLE
RELATIVE TO ALTERNATIVE ALT.3

VARIABLE		DERIVED WEIGHT	RATING RELATIVE TO ALTERNATIVE ALT.3 ALT.1	ALT.2	ALT.4
LEVEL Ø:					
EQ			11.5	-1.5	-1Ø.1
LEVEL 1:					
TERRESTRAL		.4Ø	21.1	4.2	-27.7
AQUATIC		.3Ø	6.5	-1.3	-2.1
AIR		.1Ø	.Ø	.Ø	.Ø
HIST/RES		.2Ø	5.5	-13.8	8.1
LEVEL 2:					
TERR/HAB	(TERRESTRAL)	.Ø8	2.2	7.8	-53.Ø
TERR/ECOS	(TERRESTRAL)	.Ø8	16.4	28.2	-4.6
LAND/QUAL	(TERRESTRAL)	.24	28.9	-5.Ø	-26.9
AQUA/HAB	(AQUATIC)	.Ø6	47.5	-1.Ø	36.5
WATERQUAL	(AQUATIC)	.18	-2.5	-4.1	-5.Ø
AQUA/ECOS	(AQUATIC)	.Ø6	-7.5	6.8	-32.2
HISTORIC	(HIST/RES)	.Ø6	-7.2	-7.5	-15.Ø
ARCHEOLOGIC	(HIST/RES)	.14	1Ø.9	-16.5	18.Ø
LEVEL 3:					
FOREST/HAB	(TERR/HAB)	.Ø2	1Ø.8	-1Ø.8	-64.8
CLEAR/HAB	(TERR/HAB)	.Ø6	.Ø	12.5	-5Ø.Ø
TER/SP/DV	(TERR/ECOS)	.Ø4	-1Ø.Ø	-5.Ø	5.Ø
WETLANDS	(TERR/ECOS)	.Ø4	42.9	61.4	-14.3
FLOODS	(LAND/QUAL)	.12	5Ø.7	6.7	-13.3
SOIL/NUTR	(LAND/QUAL)	.12	7.1	-16.7	-4Ø.5
FISH	(AQUA/HAB)	.Ø2	18.2	-5Ø.Ø	-18.2
RIPARIAN	(AQUA/HAB)	.Ø4	6Ø.Ø	2Ø.Ø	6Ø.Ø
PHYSICAL	(WATERQUAL)	.Ø9	-5.Ø	11.4	-7.5
CHEM	(WATERQUAL)	.Ø9	.Ø	-19.6	-2.5
AQ/SP/DV	(AQUA/ECOS)	.Ø2	1Ø.Ø	-3Ø.Ø	15.Ø
AQ/PLNTS	(AQUA/ECOS)	.Ø4	-15.Ø	22.5	-52.5
SITE/AREA	(HISTORIC)	.Ø3	-26.9	37.5	45.Ø
STRUCTURE	(HISTORIC)	.Ø3	12.5	-52.5	-75.Ø
PRECOLUM	(ARCHEOLOGIC)	.Ø4	-17.5	25.Ø	-1Ø.Ø
COLUMBIAN	(ARCHEOLOGIC)	.1Ø	23.1	-34.3	3Ø.Ø
LEVEL 4:					
TEMP	(PHYSICAL)	.Ø5	.Ø	4Ø.7	.Ø
TURBID	(PHYSICAL)	.Ø4	-12.5	-32.5	-18.7
PH	(CHEM)	.Ø6	.Ø	-22.7	.Ø
DO	(CHEM)	.Ø3	.Ø	-12.5	-8.3

Figure 2.16. Output from EVALUATE with PRECISE data: OPTION 6, RATINGS RELATIVE

```
PUBLIC: FARMERS
                                                     AVERAGE SCORE          PERCENT OF
                                  AVERAGE      0    20    40    60    80   100    OVERALL
VARIABLE                           SCORE       +-----+-----+-----+-----+-----+     SCORE

LEVEL 0:
   EQ                               53.4       XXXXXXXXXXXXXXX

LEVEL 1:
   TERRESTRAL                       22.2       XXXXXX                              41.7 %
   AQUATIC                          13.8       XXXX                                25.8 %
   AIR                               6.0       XX                                  11.2 %
   HIST/RES                         11.3       XXXX                                21.3 %

LEVEL 2:
   TERR/HAB    (TERRESTRAL)          5.2       XX                                   9.7 %
   TERR/ECOS   (TERRESTRAL)          4.9       XX                                   9.3 %
   LAND/QUAL   (TERRESTRAL)         12.1       XXXX                                22.7 %
   AQUA/HAB    (AQUATIC    )         2.3                                            4.3 %
   WATERQUAL   (AQUATIC    )         8.6       XXX                                 16.1 %
   AQUA/ECOS   (AQUATIC    )         2.9                                            5.4 %
   HISTORIC    (HIST/RES   )         2.9                                            5.5 %
   ARCHEOLOGIC (HIST/RES   )         8.4       XXX                                 15.8 %

LEVEL 3:
   FOREST/HAB  (TERR/HAB   )         1.0                                            1.9 %
   CLEAR/HAB   (TERR/HAB   )         4.2       XX                                   7.9 %
   TER/SP/DV   (TERR/ECOS  )         2.9                                            5.4 %
   WETLANDS    (TERR/ECOS  )         2.0                                            3.8 %
   FLOODS      (LAND/QUAL  )         5.3       XX                                  10.0 %
   SOIL/NUTR   (LAND/QUAL  )         6.8       XX                                  12.7 %
   FISH        (AQUA/HAB   )          .8                                            1.6 %
   RIPARIAN    (AQUA/HAB   )         1.5                                            2.8 %
   PHYSICAL    (WATERQUAL  )         1.8                                            3.3 %
   CHEM        (WATERQUAL  )         6.8       XX                                  12.8 %
   AQ/SP/DV    (AQUA/ECOS  )         1.1                                            2.2 %
   AQ/PLNTS    (AQUA/ECOS  )         1.7                                            3.2 %
   SITE/AREA   (HISTORIC   )         1.5                                            2.9 %
   STRUCTURE   (HISTORIC   )         1.4                                            2.6 %
   PRECOLUM    (ARCHEOLOGIC)         1.2                                            2.3 %
   COLUMBIAN   (ARCHEOLOGIC)         7.2       XX                                  13.5 %

LEVEL 4:
   TEMP        (PHYSICAL   )          .5                                            1.0 %
   TURBID      (PHYSICAL   )         1.2                                            2.3 %
   PH          (CHEM       )         5.2       XX                                   9.7 %
   DO          (CHEM       )         1.7                                            3.1 %
```

Figure 2.17. Output from EVALUATE with PRECISE data: OPTION 7, AVERAGE SCORES

PUBLIC: FARMERS
RANGE OF SCORES

VARIABLE		RANGE OF SCORES	AVERAGE SCORE	SCORE 0 20 40 60 80 100 +----+----+----+----+----+
LEVEL 0:				
EQ		21.6	53.4	L-*--H
LEVEL 1:				
TERRESTRAL		19.5	22.2	L--*--H
AQUATIC		2.6	13.8	L*H
AIR		.0	6.0	L*H
HIST/RES		4.4	11.3	L*H
LEVEL 2:				
TERR/HAB	(TERRESTRAL)	4.9	5.2	L*H
TERR/ECOS	(TERRESTRAL)	2.6	4.9	L*H
LAND/QUAL	(TERRESTRAL)	13.4	12.1	L-*H
AQUA/HAB	(AQUATIC)	2.9	2.3	L*H
WATERQUAL	(AQUATIC)	.9	8.6	L*H
AQUA/ECOS	(AQUATIC)	2.3	2.9	L*H
HISTORIC	(HIST/RES)	.9	2.9	L*H
ARCHEOLOGIC	(HIST/RES)	4.8	8.4	L*H
LEVEL 3:				
FOREST/HAB	(TERR/HAB)	1.2	1.0	L*H
CLEAR/HAB	(TERR/HAB)	4.0	4.2	L*H
TER/SP/DV	(TERR/ECOS)	.6	2.9	L*H
WETLANDS	(TERR/ECOS)	3.0	2.0	L*H
FLOODS	(LAND/QUAL)	7.7	5.3	L*H
SOIL/NUTR	(LAND/QUAL)	5.7	6.8	L*H
FISH	(AQUA/HAB)	1.2	.8	L*H
RIPARIAN	(AQUA/HAB)	2.5	1.5	L*H
PHYSICAL	(WATERQUAL)	1.7	1.8	L*H
CHEM	(WATERQUAL)	1.8	6.8	L*H
AQ/SP/DV	(AQUA/ECOS)	.8	1.1	L*H
AQ/PLNTS	(AQUA/ECOS)	3.1	1.7	L*H
SITE/AREA	(HISTORIC)	2.2	1.5	L*H
STRUCTURE	(HISTORIC)	2.6	1.4	L*H
PRECOLUM	(ARCHEOLOGIC)	1.8	1.2	L*H
COLUMBIAN	(ARCHEOLOGIC)	6.3	7.2	L*H
LEVEL 4:				
TEMP	(PHYSICAL)	2.2	.5	L*H
TURBID	(PHYSICAL)	1.2	1.2	L*H
PH	(CHEM)	1.4	5.2	L*H
DO	(CHEM)	.3	1.7	L*H

Figure 2.18. Output from EVALUATE with PRECISE data: OPTION 8, SCORE RANGES

TERRESTRAL (19.5 points); for Level 2 variables, the largest range of scores is for LAND/QUAL (13.4 points); for Level 3 variables, the largest range of scores is for FLOODS (7.7 points), and so forth.

2.5.1.9 OPTION 9, VARIABLE SCORES. Frequently users may wish to examine more closely the various alternatives' effects on individual variables. The VARIABLE SCORES option permits users to compare the scores for all alternatives on particular variables. An example of a display from VARIABLE SCORES appears in Figure 2.19. In this example, the four alternatives differ substantially in the scores associated with the variable TERRESTRAL (i.e., terrestrial resources). ALT.1, for instance, has a far more desirable effect on TERRESTRAL than does ALT.4 (i.e., 19.5 points higher).

```
PUBLIC: FARMERS
VARIABLE SCORES FOR TERRESTRAL

                                 TERRESTRAL SCORE
          0    10   20   30   40   50   60   70   80   90   100
ALT.      +----+----+----+----+----+----+----+----+----+----+      VALUE
ALT.1                    *                                          30.9
ALT.2                 *                                             24.2
ALT.3                *                                              22.5
ALT.4          *                                                    11.4
```

Figure 2.19. Output from EVALUATE with PRECISE data: OPTION 9, VARIABLE SCORES

2.5.1.10 OPTION 10, VARIABLE SCORES RELATIVE. The VARIABLE SCORES RELATIVE option simply permits users to conduct and display the same type of analyses as described above for the VARIABLE SCORES option, with the exception that all scores are expressed as deviations from the scores of the particular alternative specified by the user.

2.5.2 EVALUATING ALTERNATIVES WITH UNCERTAIN DATA

A total of seven options are available for evaluating alternatives with the data specified in the UNCERTAIN procedure. The options are discussed below.

2.5.2.1 OPTION 1, OVERALL SCORES. The analysis and display from the OVERALL SCORES option with UNCERTAIN data resembles that from the OVERALL SCORES option with PRECISE data. Alternatives are rank-ordered in terms of their overall scores (as computed using PRECISE data values). But in addition to such MOST PROBABLE scores, the MINIMUM and MAXIMUM scores are also computed and displayed. The minimum score for an alternative is the overall desirability score that would result if that alternative were to have the most undesirable possible effect on every variable included in the analysis. The maximum score for an alternative is the overall desirability score that would result if the alternative were to have the most desirable possible effect on every variable included in the analysis. The range of overall scores produced by using UNCERTAIN data will often reflect much more adequately the usual state of affairs in water resource planning than will the point estimates produced by using PRECISE data values.

An example of a display from the OVERALL SCORES option appears in Figure 2.20. Note that ALT.4 is the most desirable alternative for the

```
PUBLIC: NATURE

OVERALL SCORES

                        OVERALL SCORE--UNCERTAIN DATA
              0   10   20   30   40   50   60   70   80   90  100                     MOST
ALT.          +----+----+----+----+----+----+----+----+----+----+      MINIMUM    PROBABLE    MAXIMUM
ALT.4                              L--*--H                               51.9       59.3        67.6
ALT.3                           L-*---H                                  43.8       51.0        58.5
ALT.1                          L--*--H                                   42.2       50.2        58.1
ALT.2                         L--*--H                                    41.2       47.4        53.[illegible]

ALTERNATIVES STILL IN CONTENTION:      ALTERNATIVES TO BE ELIMINATED:
             ALT.4
             ALT.3
             ALT.1
             ALT.2
```

Figure 2.20. Output from EVALUATE with UNCERTAIN data: OPTION 1, OVERALL SCORES

NATURE group, with a most probable score of 59.3. But the minimum overall score might be as low as 51.9 and the maximum overall score might be as high as 67.6, given the uncertainty in the projected effects of this alternative. The OVERALL SCORES option depicts this range of scores graphically, as well as numerically, as can be seen in Figure 2.20. Note also that with UNCERTAIN data, the OVERALL SCORES option produces two columns entitled "ALTERNATIVES STILL IN CONTENTION" and "ALTERNATIVES TO BE ELIMINATED." An alternative can be eliminated if its maximum score (or the best case analysis for that alternative) is less desirable than the minimum overall score (or worst case analysis) for some other alternative. (Such alternatives can be eliminated, however, only for the particular public group included in the analysis; for other groups these same alternatives may be retained in consideration.) In the present example, none of the alternatives can be eliminated.

2.5.2.2 OPTION 2, OVERALL SCORE RELATIVE. Often in water resources planning, users may wish to make comparisons of all other alternatives with respect to one particular alternative, usually the without project alternative. EVAL permits such comparisons through use of the OVERALL SCORE RELATIVE option. The display is identical to that produced by the OVERALL SCORE option, with the exception that the minimum, most probable, and maximum scores are all expressed in terms of positive or negative deviations from the most probable score for the specified alternative. An example of output from the OVERALL SCORE RELATIVE option appears in Figure 2.21.

```
PUBLIC NATURE

OVERALL SCORES RELATIVE TO ALTERNATIVE ALT.

              OVERALL SCORE-- UNCERTAIN DATA
             RELATIVE TO ALTERNATIVE ALT.
       -40 -30 -20 -10  0  10  20  30  40  50  60                    MOST
ALT.     +----+----+----+----+----+----+----+----+----+----+   MINIMUM  PROBABLE  MAXIMUM
ALT.4                  L--*---H                                 [illegible] [illegible] [illegible]
ALT.3              L--*--H                                      [illegible]    .0
ALT.1             L--*---H                                      [illegible] [illegible] [illegible]
ALT.2             L-*--H                                        [illegible] [illegible] [illegible]

ALTERNATIVES STILL IN CONTENTION:     ALTERNATIVES TO BE ELIMINATED:
            ALT.4
            ALT.3
            ALT.1
            ALT.2
```

Figure 2.21. Output from EVALUATE with UNCERTAIN data: OPTION 2, OVERALL SCORES RELATIVE

2.5.2.3 OPTION 3, ALTERN. SCORES. The ALTERN. SCORES option is intended to aid users in assessing the effects of uncertainty (concerning variables, projected levels) on desirability scores for the alternatives. For any alternative, this option can analyze and display minimum and maximum scores (worst case and best case analyses, respectively) for each variable included in the tree. The output thus permits users to identify where uncertainty about projected levels of variables has greatest effect on judgments of the desirability of that alternative. An example of output from this option appears in Figure [illegible]. Note in this example that the range in scores for the HIST/RES variable for ALT.2 is only [illegible] (see arrow), that is, the best case and worst case analysis lead to very little difference in the projected degree of desirability for that variable. Uncertainty has a much larger effect, however, on the projected desirability of ALT.2's effects on the [illegible] variable ([illegible] points). From such an analysis and display, users can learn that although the results of the analysis would be little changed by conducting a study that reduced the amount of uncertainty affecting ALT.2's effects on the [illegible] variable, a study reducing the amount of uncertainty associated with the [illegible] variable might contribute considerably to reducing uncertainty about the overall desirability of ALT.2.

[illegible] users may sometimes want to analyze the effects of uncertainty on the variable scores for an alternative within the broader context of comparing that alternative to another alternative (e.g., the without project alternative). The [illegible] option enables users to compare one alternatives' minimum and maximum scores against another alternative's most probable scores (i.e., the scores for [illegible] data values). An example of output from this option appears in Figure [illegible]. In this

PUBLIC: NATURE
EFFECTS OF UNCERTAINTY ON SCORES FOR ALTERNATIVE ALT.2

VARIABLE		SCORES MIN.	SCORES MAX.	RANGE DUE TO UNCERTAINTY	RANGE OF SCORES DUE TO UNCERTAINTY 0 20 40 60 80 100 +----+----+----+----+----+
LEVEL 0:					
EQ		41.2	53.6	12.5	XXXX
LEVEL 1:					
TERRESTR'		9.0	13.0	4.0	XX
AQUATIC		8.7	13.6	4.8	XX
AIR		13.5	16.5	3.0	
HIST/RES		9.9	10.6	.6	
LEVEL 2:					
TERR/HAB	(TERRESTRAL)	1.8	3.7	1.9	
TERR/ECOS	(TERRESTRAL)	2.8	4.0	1.2	
LAND/QUAL	(TERRESTRAL)	4.4	5.3	.8	
AQUA/HAB	(AQUATIC)	.8	2.1	1.2	
WATERQUAL	(AQUATIC)	3.9	6.4	2.5	
AQUA/ECOS	(AQUATIC)	3.9	5.0	1.1	
HISTORIC	(HIST/RES)	5.5	5.9	.4	
ARCHEOLOGIC	(HIST/RES)	4.4	4.7	.3	
LEVEL 3:					
FOREST/HAB	(TERR/HAB)	1.8	3.1	1.3	
CLEAR/HAB	(TERR/HAB)	.0	.6	.6	
TER/SP/DV	(TERR/ECOS)	2.2	3.4	1.1	
WETLANDS	(TERR/ECOS)	.5	.7	.1	
FLOODS	(LAND/QUAL)	1.1	1.3	.2	
SOIL/NUTR	(LAND/QUAL)	3.3	4.0	.7	
FISH	(AQUA/HAB)	.3	.6	.2	
RIPARIAN	(AQUA/HAB)	.5	1.5	1.0	
PHYSICAL	(WATERQUAL)	1.5	3.0	1.5	
CHEM	(WATERQUAL)	2.4	3.4	1.0	
AQ/SP/DV	(AQUA/ECOS)	2.2	3.0	.8	
AQ/PLNTS	(AQUA/ECOS)	1.7	2.0	.3	
SITE/AREA	(HISTORIC)	2.7	2.9	.2	
STRUCTURE	(HISTORIC)	2.8	3.0	.2	
PRECOLUM	(ARCHEOLOGIC)	2.1	2.1	.0	
COLUMBIAN	(ARCHEOLOGIC)	2.3	2.6	.3	
LEVEL 4:					
TEMP	(PHYSICAL)	1.5	2.1	.6	
TURBID	(PHYSICAL)	.0	1.0	1.0	
PH	(CHEM)	1.0	1.6	.6	
DO	(CHEM)	1.5	1.8	.3	

Figure 2.22. Output from EVALUATE with UNCERTAIN data: OPTION 3, ALTERN. SCORES

BLIC: NATURE
FFECTS OF UNCERTAINTY ON SCORES FOR ALTERNATIVE ALT.2
ELATIVE TO ALTERNATIVE ALT.4

VARIABLE		SCORES MIN.	SCORES MAX.	RANGE DUE TO UNCERTAINTY	RANGE OF SCORES DUE TO UNCERTAINTY 0 20 40 60 80 100
LEVEL 0:					
EQ		-18.1	-5.7	12.5	XXXX
LEVEL 1:					
TERRESTRAL		-10.3	-6.3	4.0	XX
AQUATIC		-8.6	-3.8	4.8	XX
AIR		-1.5	1.5	3.0	
HIST/RES		2.3	2.9	.6	
LEVEL 2:					
TERR/HAB	(TERRESTRAL)	-6.6	-4.7	1.9	
TERR/ECOS	(TERRESTRAL)	-5.6	-4.3	1.2	
LAND/QUAL	(TERRESTRAL)	1.8	2.7	.8	
AQUA/HAB	(AQUATIC)	-4.2	-3.0	1.2	
WATERQUAL	(AQUATIC)	-2.4	.1	2.5	
AQUA/ECOS	(AQUATIC)	-2.0	-.9	1.1	
HISTORIC	(HIST/RES)	-1.3	-.9	.4	
ARCHEOLOGIC	(HIST/RES)	3.6	3.9	.3	
LEVEL 3:					
FOREST/HAB	(TERR/HAB)	-4.7	-3.4	1.3	
CLEAR/HAB	(TERR/HAB)	-1.9	-1.2	.6	
TER/SP/DV	(TERR/ECOS)	-1.0	.2	1.1	
WETLANDS	(TERR/ECOS)	-4.6	-4.5	.1	
FLOODS	(LAND/QUAL)	.5	.7	.2	
SOIL/NUTR	(LAND/QUAL)	1.3	2.0	.7	
FISH	(AQUA/HAB)	-1.7	-1.5	.2	
RIPARIAN	(AQUA/HAB)	-2.5	-1.5	1.0	
PHYSICAL	(WATERQUAL)	-1.3	.2	1.5	
CHEM	(WATERQUAL)	-1.1	-.1	1.0	
AQ/SP/DV	(AQUA/ECOS)	-3.8	-3.0	.8	
AQ/PLNTS	(AQUA/ECOS)	1.7	2.0	.3	
SITE/AREA	(HISTORIC)	-.4	-.2	.2	
STRUCTURE	(HISTORIC)	-.9	-.8	.2	
PRECOLUM	(ARCHEOLOGIC)	1.3	1.3	.0	
COLUMBIAN	(ARCHEOLOGIC)	2.3	2.5	.3	
LEVEL 4:					
TEMP	(PHYSICAL)	-.5	.0	.6	
TURBID	(PHYSICAL)	-.8	.2	1.0	
PH	(CHEM)	-.8	-.1	.6	
DO	(CHEM)	-.3	.0	.3	

Figure 2.23. Output from EVALUATE with UNCERTAIN data: OPTION 4, ALTERN. SCORES RELATIVE

example, ALT.2's minimum and maximum scores are compared to ALT.4's most probable scores. For this particular public, NATURE, even the maximum EQ score for ALT.2 does not exceed the most probable EQ score for ALT.4, as indicated in Figure 2.23 by the -5.7 score for EQ under the MAX. SCORE column.

2.5.2.5 <u>OPTION 5, AVERAGE EFFECTS</u>. Users may frequently be interested in learning about the average effects of uncertainty, across all alternatives, on the desirability scores of alternatives. The AVERAGE EFFECTS option permits users to analyze and display, in both a tree format and tabular format, the average range in VARIABLE SCORES due to uncertainty. An example of output from this option appears in Figure 2.24; this display indicates that uncertainty affects the variable scores for this particular public group most greatly for the AQUATIC variable, followed by the TERRESTRAL, AIR, and HIST/RES variables. This analysis might be interpreted as suggesting that any study designed to reduce uncertainty concerning alternatives' projected effects on variables might most profitably be focused on reducing uncertainty concerning projected effects on the AQUATIC variable.

2.5.2.6 <u>OPTION 6, VARIABLE SCORES</u>. Users may sometimes wish to examine the effects of uncertainty on individual variables. The VARIABLE SCORES option permits users to compare specified variables' minimum, most probable, and maximum scores for all alternatives. An example of a display from VARIABLE SCORES appears in Figure 2.25. In

```
PUBLIC: NATURE
AVERAGE EFFECTS OF UNCERTAINTY ON SCORES FOR ALL ALTERNATIVES

AVERAGE RANGE OF SCORES DUE TO UNCERTAINTY

                                              |FOREST/HAB
                                              |      1.4
                              |TERR/HAB---|CLEAR/HAB
                              |     1.9   |       .5
                              |
                              |
                              |           |TER/SP/DV
                              |           |      1.2
                |TERRESTRAL-|TERR/ECOS--|WETLANDS
                |     4.5   |     1.7   |       .6
                |           |
                |           |
                |           |           |FLOODS
                |           |           |       .2
                |           |LAND/QUAL--|SOIL/NUTR
                |           |      .9   |       .7
                |
                |
                |                       |FISH
                |                       |       .6
                |           |AQUA/HAB---|RIPARIAN
                |           |     1.7   |      1.0
                |           |                       |TEMP
                |           |                       |       .5
                |           |           |PHYSICAL---|TURBID
                |           |           |      1.4  |       .9
                |           |           |
                |           |           |
EQ---------|AQUATIC----|WATERQUAL--|            |PH
   14.7    |     6.0   |     2.4   |            |       .6
                |           |           |CHEM-------|DO
                |           |           |      1.0  |       .4
                |           |
                |           |
                |           |           |AQ/SP/DV
                |           |           |      1.4
                |           |AQUA/ECOS--|AQ/PLNTS
                |           |     2.0   |       .6
                |AIR
                |     3.0
                |                       |SITE/AREA
                |                       |       .4
                |           |HISTORIC----|STRUCTURE
                |           |      .7   |       .3
                |           |
                |           |
                |HIST/RES-              |PRECOLUM
                |     1.2               |       .0
                            |ARCHEOLOGIC |COLUMBIAN
                            |      .5   |       .5
```

Figure 2.24. Output from EVALUATE with UNCERTAIN data: OPTION 5, AVERAGE EFFECTS

```
PUBLIC: FARMERS

VARIABLE SCORES FOR TERRESTRAL

                 TERRESTRAL SCORE--UNCERTAIN DATA
           0  10  20  30  40  50  60  70  80  90 100               MOST
ALT.       +---+---+---+---+---+---+---+---+---+---+   MINIMUM   PROBABLE   MAXIMUM
ALT.1                L*H                                  28.6      30.9       33.2
ALT.2              L*-H                                   21.7      24.2       26.6
ALT.3              L*H                                    19.7      22.5       25.3
ALT.4          L*H                                         8.9      11.4       13.9
```

Figure 2.25. Output from EVALUATE with UNCERTAIN data: OPTION 6, VARIABLE SCORES

the present example, there appears to be roughly equal ranges of uncertainty around the TERRESTRAL variable, for each of the four alternatives.

2.5.2.7 <u>OPTION 7, VARIABLE SCORES RELATIVE</u>. The VARIABLE SCORES RELATIVE option permits users to conduct and display the same type of analyses as described above for the VARIABLE SCORES option, with the exception that all scores are expressed as deviations from the most probable scores of the specified alternative. An example appears in Figure 2.26. All scores are expressed as deviations from the most probable score for ALT.3.

```
PUBLIC: FARMERS

VARIABLE SCORES FOR TERRESTRAL RELATIVE TO ALTERNATIVE ALT.3

                 TERRESTRAL SCORE--UNCERTAIN DATA
                RELATIVE TO ALTERNATIVE ALT.3
         -40 -30 -20 -10   0  10  20  30  40  50  60               MOST
ALT.       +---+---+---+---+---+---+---+---+---+---+   MINIMUM   PROBABLE   MAXIMUM
ALT.1                        L*H                           6.2       8.4       10.7
ALT.2                     L-*H                             -.8       1.7        4.2
ALT.3                     L*H                             -2.8        .0        2.8
ALT.4                L*H                                 -13.6     -11.1       -8.5
```

Figure 2.26. Output from EVALUATE with UNCERTAIN data: OPTION 7, VARIABLE SCORES RELATIVE

2.6 COMPARING PUBLICS

For most water resources problems, more than one point of view can be found within the public. Groups who disagree about the relative importances of the various variables potentially affected by water resources alternatives, for instance, can nearly always be identified.

The EVALUATE procedure is designed for use with one public group at a time, although analyses can be repeated for numerous publics. The COMPARE procedure, however, permits users to make comparisons between two or more public groups. The COMPARE procedure thus enables users to learn how differences among public groups lead to differences in evaluations of the overall desirability of alternatives, just as the EVALUATE procedure enables users to learn how uncertainties in projected variable levels lead to uncertainties about overall desirabilities of alternatives. Similarly to the EVALUATE procedure, the COMPARE procedure offers users a number of options. Also similarly to the EVALUATE procedure, the COMPARE procedure can be used with either PRECISE or UNCERTAIN data values.

2.6.1 COMPARING PUBLICS WITH PRECISE DATA

A total of 4 options are available in the COMPARE procedure, using PRECISE data. Each is discussed briefly below.

2.6.1.1 OPTION 1, AVERAGE OVERALL SCORES. The AVERAGE OVERALL SCORES option provides users with information about how various public groups evaluate alternative water resources management plans.

An example of a display from this option appears in Figure 2.27; the alternatives are rank-ordered in terms of their average overall scores, where the average is computed on the basis of scores from all publics previously analyzed by the EVALUATE procedure. In addition to

```
AVERAGE OVERALL SCORES FOR ALL PUBLICS

                            OVERALL SCORE
            Ø  1Ø  2Ø  3Ø  4Ø  5Ø  6Ø  7Ø  8Ø  9Ø 1ØØ
ALT.        +---+---+---+---+---+---+---+---+---+---+  MINIMUM  AVERAGE  MAXIMUM
ALT.1                           2----*--1                5Ø.2     61.4     69.1
ALT.4                       3----*--1                    43.3     54.6     61.3
ALT.3                           2--*1                    51.Ø     53.8     57.1
ALT.2                     1--*--3                        37.7     45.7     51.9

PUBLICS:
---------------
1.  PRESRVATOR
2.  NATURE
3.  FARMERS


ALTERNATIVES STILL IN CONTENTION:     ALTERNATIVES TO BE ELIMINATED:
            ALT.1                              ALT.2
            ALT.3
            ALT.4
```

Figure 2.27. Output from COMPARE with PRECISE data: OPTION 1, AVERAGE OVERALL SCORES

displaying average scores, the minimum and maximum scores for each alternative are displayed. The display also indicates which particular public group assigned the minimum and maximum scores to each alternative. For instance, in the present example ALT.1 received an average overall score of 61.4; the lowest score for this alternative, 50.2, was assigned by PUBLIC 2, identified as the NATURE group; the highest score for this alternative, 69.1, was assigned by PUBLIC 1, identified as the PRESRVATOR group.

This option also produces two columns entitled "ALTERNATIVES STILL IN CONTENTION" and "ALTERNATIVES TO BE ELIMINATED." In the present example, ALT.2 is identified as a candidate for elimination. Alternatives can be eliminated if there exists at least one other alternative, based on a pairwise comparison of alternatives, which all public groups find more desirable. In the present example, both ALT.1 and ALT.3 are preferred to ALT.2 by all three publics. (This information was obtained from the OVERALL SCORES option; see 2.6.1.2, below.) Users should recall, however, that this analysis is based solely upon PRECISE data values; the case for eliminating alternatives will usually be weakened when uncertainties in alternatives' projected effects are taken into account.

2.6.1.2 OPTION 2, OVERALL SCORES. Users may sometimes be interested in learning how every public evaluates particular alternatives. The OVERALL SCORES option permits users to obtain such information. An example of a display from this option appears in Figure 2.28. The OVERALL SCORES option displays the overall scores assigned to each alternative, for every public previously analyzed by the EVALUATE procedure. The scores for any or all alternatives can be requested.

```
OVERALL SCORES FOR ALTERNATIVE ALT.4

                               OVERALL SCORE
           0    10   20   30   40   50   60   70   80   90  100
PUBLIC     +----+----+----+----+----+----+----+----+----+----+     VALUE
PRESRVATOR XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                          61.3
NATURE     XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                           59.3
FARMERS    XXXXXXXXXXXXXXXXXXXXXX                                   43.3
```

Figure 2.28. Output from COMPARE with PRECISE data: OPTION 2, OVERALL SCORES

2.6.1.3 OPTION 3, PAIR DIFFERENCES. Users frequently may wish to learn more about the reasons for differences between public groups in their evaluations of the overall desirability of alternatives, as reflected by the overall scores they assign them. In particular, users may wish to learn for which variables particular public groups make substantially different evaluations about the desirability of projected effects. The PAIR DIFFERENCES option allows users to examine the differences between any two public groups with respect to the variable scores they associate with alternatives. These differences are computed by taking the absolute difference between the variable scores attributed by the two groups to each alternative and averaging across all alternatives. For instance, in the example presented in Figure 2.29, the average difference between the NATURE and FARMERS groups in their scores for the TERRESTRAL variable is 11.4 points. This rather sizable difference indicates that there exists substantial disagreement between the two groups with respect to either (a) what constitutes a desirable effect on the TERRESTRAL variable, (b) the importance of the TERRESTRAL variable for evaluating alternatives, or (c) both. The analyses presented by the PAIR DIFFERENCES option thus can aid users in identifying minor versus major points of disagreement among various public groups. In this particular instance, considerable disagreement appears to exist between the NATURE and FARMERS groups about the desirability of impacts on the TERRESTRAL variable. In addition to the tree-format display presented in Figure 2.29, the PAIR DIFFERENCES option also displays results in a tabular format.

```
PUBLIC 1: NATURE
PUBLIC 2: FARMERS

DIFFERENCES IN SCORES FOR ALL ALTERNATIVES

                                               |FOREST/HAB
                                               |    2.1
                                   |TERR/HAB---|CLEAR/HAB
                                   |   4.8     |    3.5
                                   |
                                   |
                                   |           |TER/SP/DV
                                   |           |    .0
                       |TERRESTRAL-|TERR/ECOS--|WETLANDS
                       |   11.4    |   3.0     |    3.0
                       |           |
                       |           |
                       |           |           |FLOODS
                       |           |           |    4.0
                       |           |LAND/QUAL--|SOIL/NUTR
                       |           |   6.8     |    2.8
                       |
                       |
                       |                       |FISH
                       |                       |    1.5
                       |           |AQUA/HAB---|RIPARIAN
                       |           |   1.8     |    .3
                       |           |                       |TEMP
                       |           |                       |    1.5
                       |           |           |PHYSICAL---|TURBID
                       |           |           |   1.3     |    .4
                       |           |           |
                       |           |           |
EQ---------|AQUATIC----|WATERQUAL--|                       |PH
   9.4     |   3.4     |   2.4     |                       |    3.5
           |           |           |CHEM-------|DO
           |           |           |   3.3     |    .2
           |           |
           |           |
           |           |           |AQ/SP/DV
           |           |           |    3.6
           |           |AQUA/ECOS--|AQ/PLNTS
           |           |   2.9     |    .7
           |AIR
           |   9.0
           |                       |SITE/AREA
           |                       |    .4
           |           |HISTORIC---|STRUCTURE
           |           |   2.6     |    2.4
           |           |
           |           |
           |HIST/RES---|           |PRECOLUM
           |   6.1     |           |    .1
           |           |ARCHEOLOGIC|COLUMBIAN
           |           |   6.3     |    6.2
```

Figure 2.29. Output from COMPARE with PRECISE data: OPTION 3, PAIR DIFFERENCES

2.6.1.4 <u>OPTION 4, AVERAGE DIFFERENCES</u>. Users sometimes may wish to obtain the same type of information as is produced for pairs of public groups by the PAIR DIFFERENCES option, but for <u>all</u> public groups. In particular, users may wish to learn for which variables there exists greatest disagreement among publics about the desirability of projected effects. The AVERAGE DIFFERENCES option permits users to obtain such information. For each possible pair of public groups, the option first computes the absolute difference between the variable scores attributed by the two groups to each alternative, then averages across all alternatives, just as in the PAIR DIFFERENCES procedure. The AVERAGE DIFFERENCES option then takes the results from each possible pair-wise combination and averages them. The displays from this option are identical in format to those from the PAIR DIFFERENCES option; the results refer, however, to all public groups. An example of tabular output from this option appears in Figure 2.30. In this particular instance the analysis indicates that disagreement among the various publics appears to be rather diverse. No single variable or small group of variables stands out as a source of disagreement among the publics.

2.6.2 <u>COMPARING PUBLICS WITH UNCERTAIN DATA</u>

Two options are available in the COMPARE procedure, using UNCERTAIN data. Each is discussed briefly below.

AVERAGE DIFFERENCES IN SCORES ACROSS PUBLICS

VARIABLE		AVERAGE DIFFERENCE IN SCORES	AVERAGE DIFFERENCE IN SCORES 0 20 40 60 80 100 +----+----+----+----+----+
LEVEL 0:			
EQ		9.5	XXX
LEVEL 1:			
TERRESTRAL		8.3	XXX
AQUATIC		4.0	XX
AIR		8.0	XXX
HIST/RES		8.4	XXX
LEVEL 2:			
TERR/HAB	(TERRESTRAL)	3.8	XX
TERR/ECOS	(TERRESTRAL)	2.7	
LAND/QUAL	(TERRESTRAL)	6.2	XX
AQUA/HAB	(AQUATIC)	4.3	XX
WATERQUAL	(AQUATIC)	3.7	XX
AQUA/ECOS	(AQUATIC)	2.9	
HISTORIC	(HIST/RES)	4.9	XX
ARCHEOLOGIC	(HIST/RES)	5.9	XX
LEVEL 3:			
FOREST/HAB	(TERR/HAB)	2.4	
CLEAR/HAB	(TERR/HAB)	2.3	
TER/SP/DV	(TERR/ECOS)	2.4	
WETLANDS	(TERR/ECOS)	2.2	
FLOODS	(LAND/QUAL)	2.7	
SOIL/NUTR	(LAND/QUAL)	4.1	XX
FISH	(AQUA/HAB)	3.4	XX
RIPARIAN	(AQUA/HAB)	1.0	
PHYSICAL	(WATERQUAL)	1.1	
CHEM	(WATERQUAL)	3.4	XX
AQ/SP/DV	(AQUA/ECOS)	3.6	XX
AQ/PLNTS	(AQUA/ECOS)	.7	
SITE/AREA	(HISTORIC)	1.8	
STRUCTURE	(HISTORIC)	3.2	
PRECOLUM	(ARCHEOLOGIC)	1.2	
COLUMBIAN	(ARCHEOLOGIC)	4.8	XX
LEVEL 4:			
TEMP	(PHYSICAL)	1.1	
TURBID	(PHYSICAL)	.5	
PH	(CHEM)	2.8	
DO	(CHEM)	.7	

Figure 2.30. Output from COMPARE with PRECISE data: OPTION 4, AVERAGE DIFFERENCES

2.6.2.1 OPTION 1, AVERAGE OVERALL SCORES. The AVERAGE OVERALL SCORES option provides users with information about how the various public groups evaluate water resources management plans, taking into consideration uncertainty about the projected effects of alternatives. An example of a display from this option appears in Figure 2.31; the alternatives are rank-ordered in terms of their average overall scores, where the average is computed on the basis of the most probable scores (i.e., those scores generated with the PRECISE data values) for all public groups previously analyzed by the EVALUATE procedure.

```
AVERAGE OVERALL SCORES FOR ALL PUBLICS

                OVERALL SCORE--UNCERTAIN DATA
          Ø  1Ø  2Ø  3Ø  4Ø  5Ø  6Ø  7Ø  8Ø  9Ø 1ØØ
ALT.      +---+---+---+---+---+---+---+---+---+---+  MINIMUM  AVERAGE  MAXIMUM
ALT.1                    2-------*-----1              42.2     61.4     77.3
ALT.4                 3--------*----2                 36.4     54.6     67.6
ALT.3                     2---*---1                   43.8     53.8     64.7
ALT.2                1-----*-----3                    31.Ø     45.7     59.1

PUBLICS:
-------------
1. PRESRVATOR
2. NATURE
3. FARMERS


ALTERNATIVES STILL IN CONTENTION:     ALTERNATIVES TO BE ELIMINATED:
          ALT.1
          ALT.2
          ALT.3
          ALT.4
```

Figure 2.31. Output from COMPARE with UNCERTAIN data: OPTION 1, AVERAGE OVERALL SCORES

Recall that the EVALUATE procedure produces a minimum and maximum score for each public, when it is used with UNCERTAIN data, in addition to a most probable score. The minimum score constitutes a worst case analysis for each alternative; the maximum score constitutes a best case analysis. For the AVERAGE OVERALL SCORE option, minimum and maximum scores are also displayed for each alternative. The minimum score in these displays is the lowest score associated with that alternative by any public; it is the lowest minimum score from the EVALUATE procedure for any public, using UNCERTAIN data values. Similarly, the maximum score for each alternative is the highest score associated with that alternative by any public; it is the highest maximum score from the EVALUATE procedure for any public, using UNCERTAIN data values. In short, the minimum score for an alternative can be interpreted as the lowest score that alternative could receive from any public group, given the uncertainties in its projected effects. The maximum score can be interpreted as the highest score that alternative could receive from any public group, given the uncertainties in its projected effects. The display also indicates which particular public groups associated the minimum and maximum scores with each alternative. For instance, in the present example, ALT.1 received an average overall score of 61.4; the minimum score for this alternative, 42.2, was assigned by PUBLIC 2 (NATURE); the maximum score for this alternative, 77.3, was assigned by PUBLIC 1 (PRESRVATOR)

This option also produces two columns entitled "ALTERNATIVES STILL IN CONTENTION" and "ALTERNATIVES TO BE ELIMINATED." The present test is a far more rigorous test for elimination than any of the tests described previously. Alternatives can be eliminated only if there exists some other alternative such that the minimum score associated with it by each public group is greater than the maximum score each public group associates with the alternative to be eliminated. In other words, every public group must agree that there exists some other alternative that they find more desirable in its worst case analysis than they find the alternative to be eliminated in its best case analysis. In the present example no alternative can be eliminated on this ground.

2.6.2.2 OPTION 2, OVERALL SCORES. Users may sometimes be interested in learning how every public group evaluates particular alternatives, as well as how those evaluations are affected by uncertainty. The OVERALL SCORES option enables users to observe the minimum, most probable, and maximum scores that each public group assigns to any or all alternatives. In other words, it indicates the scores which each alternative would receive under worst case, most-likely case, and best case analyses for each public. An example of a display from this option appears in Figure 2.32. Scores are displayed for each public group previously analyzed by the EVALUATE procedure.

```
OVERALL SCORES FOR ALTERNATIVE ALT.1

                 OVERALL SCORE--UNCERTAIN DATA
            0  10  20  30  40  50  60  70  80  90 100                   MOST
PUBLIC      +----+----+----+----+----+----+----+----+----+----+   MINIMUM  PROBABLE  MAXIMUM
PRESRVATOR                                L--*--H                   60.7     69.1      77.3
NATURE                              L--*--H                         42.2     50.2      58.1
FARMERS                                 L--*--H                     57.1     64.9      72.3
```

Figure 2.32. Output from COMPARE with UNCERTAIN data: OPTION 2, OVERALL SCORES

2.7 UTILITY PROCEDURES AND COMMANDS

Four procedures are intended solely to facilitate or make more convenient use of ESAP and are not directly involved in data analysis. Each is described briefly below.

2.7.1 DISPLAY PROCEDURE (INTERACTIVE MODE ONLY)

At times users may wish to display some or all of the information previously specified by ESAP without conducting any additional analyses or changing previously specified information. The DISPLAY procedure allows users to display the contents of any of the following procedures: TREE, RANGES, WEIGHTS, FORMS, DATA, UNCERTAIN, VARIABLES, PUBLICS, or ALTERNS. The user simply enters the DISPLAY procedure and indicates the type of information he or she wishes to observe. The DISPLAY procedure is available only in interactive mode (see 3.0, below).

2.7.2 SAVE AND CONTINUE PROCEDURES

Users frequently will wish to set up a basic structure for analysis specifying information to the TREE, WEIGHTS, FORMS, DATA, and UNCERTAIN procedures, and so forth--then use this basic structure again and again as the planning study progresses and new information becomes available or old information is revised. The SAVE and CONTINUE procedures enable users to accomplish just that. The SAVE procedure can be employed at any point in the use of ESAP in order to create and name a file that contains all instructions entered to that point, as well as the results of any analyses already conducted. The CONTINUE procedure can then later access the file by name. After a file has been called by the CONTINUE procedure, use of ESAP can progress as if uninterrupted.

2.7.3 END PROCEDURE

The END procedure does just as its name implies. A request for the END procedure concludes that run of ESAP.

3.0 INTERACTIVE AND BATCH MODES IN ESAP

3.1 INTRODUCTION

ESAP can be used in either of two modes or manners. The first of these is the interactive mode in which users interact with the program through a remote on-line terminal. Users engage in a dialog consisting of a series of questions by ESAP and responses to those questions from users via a keyboard. The second mode of using ESAP is the batch mode, in which users submit a detailed set of instructions in the form of a deck of cards. The program then produces output in response to these instructions.

The differences between these two modes of use are substantial; the relative merits of each mode will not be discussed here. For all practical purposes, however, everything that can be accomplished through the use of one mode can also be accomplished, more or less easily, through the use of the other mode. The choice of which mode to use will thus ordinarily be a function of preference, convenience, or the availability of computer hardware resources, and not a decision based upon desired products from the program.

In this section, a brief description of each of the two modes is presented. The purposes of this section are primarily, for the interactive mode, to inform users about certain useful commands and responses and, for the batch mode, to inform users about some general guidelines for the preparation of cards. A discussion of the procedures for accessing ESAP in either mode and for using the Boeing Computer System, in general, appears in Appendix A, Accessing ESAP and Using BCS.

3.2 INTERACTIVE MODE OF ESAP

ESAP is designed primarily for use as an interactive program. An illustration of the interactive use of ESAP appears in Figure 3.1. Responses from ESAP appear in upper case; responses from the user appear in lower case. When used in this interactive mode, ESAP is designed to be quite flexible and to provide users with as much in the way of direction and assistance as possible. In other words, ESAP is intended to be what is described as a user-friendly program. At this writing, however, the first edition of ESAP has just been introduced, although the intent to provide an easy tool to use guided the development of ESAP, users will probably nonetheless find themselves sometimes in situations in which the appropriate response to the program is unclear. Use of the STOP command (described below) will ordinarily extract users from such difficulties and enable them to reenter a procedure or enter a new procedure, whichever is desired.

Some basic instructions for interacting with ESAP are given below.

3.2.1 INPUTTING NAMES

Users will be required at times to input names of variables, public groups, alternatives, and so forth, to ESAP. Names are strings

```
 ENTER PROCEDURE NAME:
I>title
 ENTERING TITLE PROCEDURE.

 ENTER TITLE FOR RUN (79 CHAR. MAX):
I>test of e.s.a.p.

 ENTER PROCEDURE NAME:
I>tree
 ENTERING TREE PROCEDURE.

 IS TREE DESCRIPTION TO COME FROM A FILE OR THE TERMINAL?
I>terminal

 WHAT IS THE NAME OF THE OVERALL DIMENSION TO BE EVALUATED?
I>eq
 ENTER NAMES OF COMPONENTS OF EQ:
I>animals,plants
 ENTER NAMES OF COMPONENTS OF ANIMALS:
I>aquatic,land
 ENTER NAMES OF COMPONENTS OF PLANTS:
I>typea,typeb
 ENTER NAMES OF COMPONENTS OF AQUATIC:
I>
 ENTER NAMES OF COMPONENTS OF LAND:
I>
 ENTER NAMES OF COMPONENTS OF TYPEA:
I>
 ENTER NAMES OF COMPONENTS OF TYPEB:
I>

 TREE DESCRIPTION COMPLETE. DO YOU WISH TO DISPLAY THE TREE?
I>yes

 TREE PROCEDURE. DATE: 80/06/18. TIME: 16.36.32.

 TEST OF E.S.A.P.

 TREE:

                          |AQUATIC
             |ANIMALS----|LAND
             |
  EQ---------|            |TYPEA
             |PLANTS-----|TYPEB

 ANY CHANGES?
I>no

 ENTER PROCEDURE NAME:
I>ranges
 ENTERING RANGES PROCEDURE.
```

Figure 3.1. Interactive Use of ESAP

of up to 10 characters, beginning with a letter, and containing any of the characters A-Z, 0-9, +-*/()$:;<>, and period. Names may not contain blanks or spaces (indicated by "_") unless enclosed in double quotes, e.g., "VAR_1" or "AIR_QUAL". Names may also begin with a character other than a letter if enclosed in quotes.

3.2.2 INPUTTING NUMBERS

Users will frequently be required to input numbers in response to requests from ESAP. Numbers are strings of characters chosen from the set [0-9, +, -, ., E]. Numbers may begin with a digit, a decimal point, or a sign (+ or -). Examples of valid numbers are:

1.2
-.06
45

3.2.3 INPUTTING NUMBERS IN EXPONENTIAL FORM

Numbers can be expressed in exponential form, if users so desire. In ESAP, the letter "E" is used to denote an exponent, that is, a power of ten. For example, the number 1.5E2 is interpreted as 1.5 times ten to the second power, or 150. Examples of valid numbers expressed in exponential form are:

1E5	(100,000)
.5E-4	(.00005)
3.8E+6	(3,800,000)

3.2.4 RESPONDING TO QUESTIONS FROM ESAP

Often the program will ask users questions requiring them to enter some input (a response) then press the carriage return (CR) key. For example, the program might ask

"DO YOU WISH TO DISPLAY THE TREE?"

in which case a yes-or-no response is appropriate. Users should reply

YES (CR)

if a display is desired, or

NO (CR).

At other times the program might ask users

"ARE THE DATA TO COME FROM A FILE OR THE TERMINAL?"

in which case users should type

FILE (CR)

if a file containing the data has been prepared, or

TERMINAL (CR)

if the data are to be typed in from the terminal.

If the user is not certain what the possible responses to the question are, the carriage return key may be pressed without typing any other characters. In most cases, the program will print a list of valid responses, then ask the user to enter one of them.

3.2.5 ABBREVIATING RESPONSES

All responses may be abbreviated to the minimum number of characters necessary to indicate the desired response. For example, if the legitimate responses to a question are:

EVALUATE

END

DATA

then users may enter "D" to indicate DATA, but must enter "EN" for END and "EV" for EVALUATE. Note that all characters entered are checked. Thus, if "DE" is entered instead of "D" or "DA", the response will be considered invalid and users will be asked to reenter the response.

3.2.6 USING CARRIAGE RETURN RESPONSE TO SIGNIFY END OF INFORMATION

In the interactive mode, ESAP frequently produces repeated requests for additional information from the user. If no further information is forthcoming, the user should make a carriage return (CR) response by depressing the RETURN key on the terminal. For instance, in the TREE procedure, if ESAP asks the user to specify the components of a variable that is not further subdivided, the user can advance to the next question simply by making the (CR) response. An example appears in Figure 3.2. The user has indicated that the variable FISH is not further subdivided by making the (CR) response; ESAP responds by progressing to the next question in the sequence. The (CR) response will frequently, but not always, lead to progression to the next

```
 ENTER NAMES OF COMPONENTS OF FISH:
I> (cr)

 TREE DESCRIPTION COMPLETE. DO YOU WISH TO DISPLAY THE TREE?
I>yes
```

Figure 3.2. Use of carriage return (CR) response

request for information by ESAP; the program will sometimes demand an explicit response before proceeding (see 3.2.4 above).

3.2.7 ENTERING LISTS OF ITEMS (NAMES OR NUMBERS)

When more than one item is to be entered in response to a request from ESAP, the items may be separated by one or more blanks or commas. For example, the list containing the number "5" and the names "ABC" and "DEF" could be entered any of the following ways:

5_ABC_DEF (CR)	(blanks between items)
5,ABC,DEF (CR)	(commas between items)
5,ABC_DEF (CR)	(mixed blanks and commas)
5,_ABC,_DEF (CR)	(multiple blanks and commas)

Note that the line

5,,,ABC,_,_,DEF (CR)

will still be interpreted as the number 5 followed by the names "ABC" and "DEF".

When the list of items to be entered is longer than will fit on one line of the terminal, the input list may be entered on more than one line provided that each line except the last ends with a comma. The program will prompt users with "MORE?" until a line not ending in a comma is entered.

3.2.8 PROMPTING BY ESAP

In cases where fewer items are entered than are requested, the program will ask users to enter the missing items based on the difference between the number of items entered and the number of items requested. The form of the prompt may vary from a standard "MORE?" in most cases to a request for a specific value, such as "FOR ALTERNATIVE ALT.1, LOW VALUE FOR DATA:" when the type of value being sought is known to the program.

3.2.9 RESPONSES TO ERRORS IN INPUT

When an error is detected in an input item (such as a number entered where a name is expected), the remainder of the input line will be discarded and users will be asked to reenter the item in error along with all items which follow it. Any items which appeared in the input list prior to the error are retained.

When more items are entered than the program is expecting, the entire list is discarded and users are asked to reenter the list.

3.2.10 USING STOP COMMAND

Users may sometimes find that they wish to halt processing of ESAP. For instance, they may find that they have erroneously called the wrong procedure or that for some reason they need to enter a different procedure. Users can halt the processing of ESAP and elicit a new request for instruction from the program simply by entering the word STOP. An illustration of the use of the STOP command appears in Figure 3.3. In this particular instance, the user discovered that the public group FARMER had not yet had FORMS specified. The STOP command was thus used to elicit a new request from ESAP for the desired procedure name--in

```
 ENTER PROCEDURE NAME:
I>eval
 ENTERING EVALUATE PROCEDURE.

 NAME OF PUBLIC?
I>farmers
 FORMS NOT SPECIFIED FOR PUBLIC FARMERS.

 NAME OF PUBLIC?
I>stop

 *** BREAK ***

 ENTER PROCEDURE NAME:
I>forms
 ENTERING FORMS PROCEDURE.
```

Figure 3.3. Use of STOP command

this case, the user entered the FORMS procedure in order to specify forms for the FARMER group.

3.2.11 READING INFORMATION FROM A FILE

The primary advantage of interactive use of ESAP is the flexibility and ease of use afforded by this mode. The interactive entry of large amounts of information, however, can be tedious, time consuming, and expensive. ESAP therefore permits users to create files of information which can be read in to the program on command from the interactive mode. The files should contain informatio the same format as is required for input to the batch versic ı ESAı see 3.3 below). Users simply indicate when asked by ESAP that the information is to come from a file rather than the terminal and the name of the file. (Instructions for creating a file on Boeing Computer Service (BCS) can be found in "MAINSTREAM-EKS Interactive Timesharing (KIT) Users'

Manual," number 10208-005, available from your local BCS representative.)

3.3 BATCH MODE OF ESAP

The batch mode of ESAP is not as convenient as the interactive mode, but it is less expensive and constitutes a more efficient manner of inputting large amounts of information. Moreover, it enables individuals with no access to remote interactive terminals to make use of the program.

3.3.1 CARD FORMAT

All information to the program is supplied in the form of card images that consist of 80 characters. The usual medium for input will be physical cards processed by a card reader.

In general, information begins in the 1st, 6th, 11th, etc. columns of a card, as specified in the instructions for the particular procedure. An example of the format for input to the TREE procedure appears in Figure 3.4.

3.3.2 PROCEDURE NAME CARD

In batch mode a card on which an asterisk (*) precedes the name of a procedure indicates that input to that procedure follows. For example, *TREE informs the program to expect information creating the tree describing the evaluation problem and *WEIGHTS informs it to

```
*TREE
EQ
     TERRESTRAL
          TERR/HAB
               FOREST/HAB
               CLEAR/HAB
          TERR/ECOS
               TER/SP/DV
               WETLANDS
          LAND/QUAL
               FLOODS
               SOIL/NUTR
     AQUATIC
          AQUA/HAB
               FISH
               RIPARIAN
          WATERQUAL
               PHYSICAL
                    TEMP
                    TURBID
               CHEM
                    PH
                    DO
          AQUA/ECOS
               AQ/SP/DV
               AQ/PLNTS
     AIR
     HIST/RES
          HISTORIC
               SITE/AREA
               STRUCTURE
          ARCHEOLOGIC
               PRECOLUM
               COLUMBIAN
*END
+    +    +    +    +    +    +
1    6    11   16   21   26   31
```

Figure 3.4. Input to ESAP in batch mode

expect information describing the relative importances that a particular public associates with the variables making up the tree.

3.3.3 END CARD

A card on which an asterisk (*) precedes the word END indicates that input or instructions for a particular procedure have ended. The program then expects a new procedure to be named using the *PROCEDURE NAME card. Two consecutive *END cards cease data input to ESAP.

3.4 DESCRIPTION OF INTERACTIVE AND BATCH PROCEDURES

Two choices were available for describing the various procedures available in ESAP. The first choice was to divide the manual into two sections describing the interactive and batch modes, respectively, for using each procedure. The second choice was to divide the manual according to the various procedures and to describe within those sections the interactive and batch modes for using each procedure.

The second option was selected for writing the present manual. Each procedure is described in a section of the manual. Both the interactive and batch modes for using that procedure are described within that section.

4.0 SETTING UP THE ANALYSIS

4.1 INTRODUCTION

This section of the manual is intended to help users learn about ESAP's procedures for setting up the analysis. Setting up the analysis is the most important step in any evaluation analysis because it requires users to develop a complete, comprehensive, and usable description of the evaluation problem. This step is particularly important in ESAP because all other procedures build upon what is done in the four setup procedures--TITLE, TREE, VARIABLES, and RANGES.

Unfortunately, there does not exist a clear, rigorous, step-by-step set of procedures for setting up an analysis. Some general guidelines are discussed below, but for the most part users must rely upon their own experience and judgment for developing an adequate description of their particular water resources evaluation problem. Each problem is different, possessing unique attributes that must be dealt with individually.

Although often difficult, frustrating, and time consuming, developing a complete concrete description of the evaluation problem is frequently regarded by users as the single most useful exercise involved in using ESAP, because it requires users to give hard thought to the nature of their problem. In particular, developing a useful description of the evaluation problem forces users to think about how all the various parts of the problem fit together.

Four procedures are involved in setting up the analysis: TITLE, TREE, VARIABLES, and RANGES. Ordinarily the TREE procedure will be entered first; it must be entered before the VARIABLES or RANGES procedures. The TREE procedure is also the most important because it specifies the organization or pattern in which the pieces of the evaluation problem fit together.

4.2 TITLE PROCEDURE

The procedure name, date, and time of day automatically appear as a heading for each display produced by ESAP. The TITLE procedure enables users to supplement this information by assigning an identifying title or label to each run of ESAP. The capability for labeling and identifying output from each run is particularly useful when the program is used in an iterative fashion in which new analyses are conducted as new or additional information becomes available. Frequently used elements in the title may include the study name, distinguishing characteristics of the run (e.g., Based on New Archaeological Data), and names of the user(s).

4.2.1 ERACTIVE TITLE PROCEDURE

The interactive TITLE procedure allows users to enter a title for the current run of the ESAP program (see Figure 4.1). This title is used in the heading for each display produced by the program.

```
ENTER PROCEDURE NAME:
I>title
 ENTERING TITLE PROCEDURE.

 ENTER TITLE FOR RUN (79 CHAR. MAX):
I>examples for users' manual
```

Figure 4.1. Entering title for run in interactive TITLE procedure

4.2.2 BATCH TITLE PROCEDURE

The batch TITLE procedure reads columns 11-80 of the *TITLE card and uses the characters there as a title for the run (see Figure 4.2). This title is used in the heading for each display produced by the program.

```
*TITLE    TITLE OF RUN...
+         +                                                                      +
1         11                                                                     80
```

Figure 4.2. Entering title of run in batch TITLE procedure

The title may be up to 70 characters in length and may contain any of the characters A-Z, 0-9, and special characters:

+ - * / ( ) *blank* $ = [ ] : ; < > , .

The title may be changed at any time during the run upon encountering a *TITLE card. If columns 11-80 are blank, no title will appear in the displays.

4.2.3 DISPLAY FROM TITLE PROCEDURE

An example of the type of heading produced by the TITLE procedure appears in Figure 4.3 (see arrows). In the present example, the

```
DISPLAY PROCEDURE. DATE: 80/06/18. TIME: 16.48.46.
TEST OF E.S.A.P.
```

```
TREE:

                                         |FOREST/HAB
                          |TERR/HAB---|CLEAR/HAB
                          |
                          |              |TER/SP/DV
             |TERRESTRAL-|TERR/ECOS--|WETLANDS
             |            |
             |            |              |FLOODS
             |            |LAND/QUAL--|SOIL/NUTR
             |
             |            |              |FISH
             |            |AQUA/HAB---|RIPARIAN
             |            |                            |TEMP
             |            |              |PHYSICAL---|TURBID
             |            |              |
EQ---------|AQUATIC----|WATERQUAL--|                  |PH
             |            |              |CHEM--------|DO
             |            |
             |            |              |AQ/SP/DV
             |            |AQUA/ECOS--|AQ/PLNTS
             |AIR
             |                           |SITE/AREA
             |            |HISTORIC----|STRUCTURE
             |            |
             |HIST/RES----|              |PRECOLUM
                          |ARCHEOLOGIC |COLUMBIAN
```

Figure 4.3. Sample heading from the TITLE procedure

heading produced by the TITLE procedure is for the display of an already-specified TREE.

4.3 TREE PROCEDURE

The TREE procedure is the most important procedure in the setting-up-the-analysis sequence and, indeed, is probably the most important procedure in the entire program. It describes the interrelationships of each of the variables in the evaluation problem. The description of the problem created by the TREE procedure serves as a basis for all subsequent analyses performed by other procedures in ESAP. A good specification of the evaluation problem in the TREE procedure will greatly increase the likelihood that subsequent analyses will produce meaningful and useful results. A poor specification of the problem almost ensures that subsequent analyses will not provide users with meaningful and useful results.

The TREE procedure receives its name because its output resembles a tree. Several branches diverge from a common origin; each branch has stems and at the end of each stem are leaves. A more formal term for this manner of describing evaluation problems is hierarchical description. In other words, the evaluation problem is described in increasing levels of detail, progressing from the more general and abstract to the more specific and concrete.

4.3.1 HIERARCHICAL DESCRIPTION OF WATER RESOURCES EVALUATION PROBLEMS

The idea of creating a tree or hierarchy for describing water resources evaluation problems is basically a very simple one. Start with a general description of the dimension, attribute, or factor that is the focus of the particular analysis to be conducted; for example, one might start with the concept Environmental Quality. Next, specify the major subheadings or components of Environmental Quality, such as terrestrial resources, aquatic resources, air, etc. Then, subdivide each of these component variables into their major components. For example, aquatic resources might be subdivided into aquatic habitats, water quality, and aquatic ecosystems. This process is continued until the meaning of each resources or variable is completely explained or defined (relative to the specificity required for the given stage of planning).

There are no hard and fast procedures for constructing such trees or hierarchies but a number of general rules or guidelines can be cited for evaluating the quality of the final product.

4.3.1.1 PROGRESSION FROM GENERAL TO SPECIFIC. The tree should progress from the general and abstract to the specific and concrete. Elements at lower levels of the tree (i.e., farther from the root) should be more specific, concrete, or particular than those elements to which they are connected at higher levels of the tree (i.e., closer to the root).

4.3.1.2 COMPLETENESS AND EXHAUSTIVENESS. The tree should be complete and exhaustive. All important resources involved in the evaluation problem should appear somewhere in the tree. No important variable for describing higher levels of the tree should be omitted at lower levels of the tree. In other words, the sum of the variables at lower levels of the tree should exhaust the meaning of variables at higher levels of the tree. For example, in a good tree the meaning (for the particular evaluation problem currently under consideration) of terrestrial resources should be completely defined by the variables at leaves of the terrestrial resources branch. In particular, in the example appearing in Figure 4.4, if the meaning of terrestrial resources (TERRESTRAL) is not completely defined and

TREE:

```
                                            |FOREST/HAB
                                |TERR/HAB---|CLEAR/HAB
                                |
                                |           |TER/SP/DV
                  |TERRESTRAL-|TERR/ECOS--|WETLANDS
                  |             |
                  |             |           |FLOODS
                  |             |LAND/QUAL--|SOIL/NUTR
                  |
                  |                         |FISH
                  |             |AQUA/HAB---|RIPARIAN
                  |             |                        |TEMP
                  |             |           |PHYSICAL---|TURBID
                  |             |           |
EQ---------|AQUATIC----|WATERQUAL--|                     |PH
                  |             |           |CHEM--------|DO
                  |             |
                  |             |           |AQ/SP/DV
                  |             |AQUA/ECOS--|AQ/PLNTS
                  |AIR
                  |                         |SITE/AREA
                  |             |HISTORIC ----|STRUCTURE
                  |             |
                  |HIST/RES-----|           |PRECOLUM
                                |ARCHEOLOGIC-|COLUMBIAN
```

Figure 4.4. Explication of the various resources defining Environmental Quality for a water resources evaluation problem

explicated by forest habitat (FOREST/HAB); cleared land, agricultural habitat (CLEAR/HAB); terrestrial species diversity (TERR/SP/DV); wetlands, flood plains, marshes, and swamp acreage (WETLANDS); acreage flooded each year (FLOODS); and presence of soil nutrients (SOIL/NUTR) then, the tree requires additional development.

4.3.1.3 SIMPLICITY. The tree should be as simple as possible. This guideline will sometimes be in conflict with the previous guidelines, but while it is important to include in the tree all meaningful distinctions for the planning study, it is also important to eliminate any nonmeaningful distinctions. For example, in Figure 4.4 the variable fish habitat (FISH) could be subdivided into trout habitat, bass habitat, etc., but unless these different types of habitat will be differentially affected by the alternatives and at least some members of the public judge effects on one type of habitat to be more important than effects on the other, there is no reason to make this distinction in the tree. Such extraneous detail merely serves to make the tree unnecessarily complicated.

4.3.1.4 NONREDUNDANCY. The tree should not include identical elements in multiple locations. Identical elements should not be included in multiple locations in the tree because such redundancy may lead to multiple-counting of effects. For example, if fish habitat is included in two places in the tree, then an alternative that has desirable impacts on fish habitat will be evaluated as even more desirable than it truly is and, conversely, an alternative that has undesirable impacts on fish habitat will be evaluated as even more undesirable than it truly is. This prohibition against including the same variable in different locations in the tree may sometimes lead to difficulties. For example, fish habitat might conceivably be associated in the tree with either fish, aquatic habitat quality or AQUA/ECOS. It is permissible to distinguish between these two aspects of fish and to include both in the tree, for instance, as fish, aquatic habitat quality and fish, AQUA/ECOS, as long as this distinction is kept clearly in mind throughout the analyses. Another strategy is simply to associate the variable with whichever component of the problem is most important. If FISH contributed far more to aquatic habitat quality than to AQUA/ECOS, for example, it might be simplest to associate it solely with aquatic habitat quality in the tree.

4.3.1.5 MEASURABILITY. The variables at the end of each branch of the tree, the so-called leaves, should be measurable. These variables are the ones for which the specific effects of alternatives will be assessed and evaluated. *It is therefore imperative that* it be possible to make measurements of these leaf variables. This guideline does not mean that all variables at the leaves of trees must be measurable using standard scales or instruments; it is quite permissible, for instance, to measure a leaf variable such as air quality on a, say, 0-to-10, 0-to-100, or other scale. The important point is that if a leaf variable does not appear to be measurable--at least in theory--it probably should be further subdivided. For example, it is much easier to measure water quality for drinking and water quality for fish than it is to measure the undivided variable, water quality. The more aggregated, general variable water quality is not as meaningfully measurable as are its more specific components, because measurement of water quality involves measurement or projection of both water quality for drinking and water quality for fish, as well as an implicit judgment about the relative importance of these two constituent components.

Space prohibits further description of the rationale and procedures for building hierarchies to describe water resources planning problems. These issues are discussed in greater length in Appendix B, Hierarchy Building. Users unfamiliar with constructing hierarchies to describe water resources planning problems are strongly encouraged to refer to this appendix.

4.3.2 <u>INTERACTIVE TREE PROCEDURE</u>

In the interactive TREE procedure, users have the choice of entering the tree description from the terminal or having the program read a file that contains the tree description.

4.3.2.1 <u>FILE ENTRY OPTION</u>. Users are asked by ESAP to enter the name of the file containing the tree description. The file is expected to be in the same format as is required for the batch version of the procedure (see 4.3.3 below).

4.3.2.2 <u>TERMINAL ENTRY OPTION</u>. The terminal entry option follows very closely the procedure described above for creating a hierarchy describing the problem. First, users are asked to enter the name of the overall dimension being evaluated (for example, EQ for <u>environmental quality</u>), then the names of the component variables of EQ, then the components of each of those variables, and so on. If a variable has no components (i.e., is a leaf), then users enter (CR) in response to the ENTER NAMES OF COMPONENTS. An example of the interactive creation of a tree appears in Figure 4.5.

```
 ENTER PROCEDURE NAME:
I>tree
 ENTERING TREE PROCEDURE.

 IS TREE DESCRIPTION TO COME FROM A FILE OR THE TERMINAL?
I>terminal

 WHAT IS THE NAME OF THE OVERALL DIMENSION TO BE EVALUATED?
I>eq
 ENTER NAMES OF COMPONENTS OF EQ:
I>terrestral,aquatic,air,hist/res
 ENTER NAMES OF COMPONENTS OF TERRESTRAL:
I>terr/hab,terr/ecos,land/qual
 ENTER NAMES OF COMPONENTS OF AQUATIC:
I>aqua/hab,water/qual,aqua/ecos
 ENTER NAMES OF COMPONENTS OF AIR:
I>
 ENTER NAMES OF COMPONENTS OF HIST/RES:
I>historic, archeologic
 ENTER NAMES OF COMPONENTS OF TERR/HAB:
I>forest/hab,clear/hab
 ENTER NAMES OF COMPONENTS OF TERR/ECOS:
I>ter/sp/dv
 ENTER NAMES OF COMPONENTS OF LAND/QUAL:
I>floods,soil/nutr
 ENTER NAMES OF COMPONENTS OF AQUA/HAB:
I>fish,riparian
 ENTER NAMES OF COMPONENTS OF WATER/QUAL:
I>physical,chem
 ENTER NAMES OF COMPONENTS OF AQUA/ECOS:
I>aq/sp/dv,aq/plants
 ENTER NAMES OF COMPONENTS OF HISTORIC:
I>site/area, structure
 ENTER NAMES OF COMPONENTS OF ARCHEOLOGIC:
I>precolum, columbian
 ENTER NAMES OF COMPONENTS OF FOREST/HAB:
I>
 ENTER NAMES OF COMPONENTS OF CLEAR/HAB:
I>
 ENTER NAMES OF COMPONENTS OF TER/SP/DV:
I>
 ENTER NAMES OF COMPONENTS OF FLOODS:
I>
                                  •
                                  •
                                  •
```

Figure 4.5. Entering tree description to interactive TREE procedure

4.3.2.3 DISPLAY AND CHANGE OPTIONS. When the tree description process is complete, users are asked if a display of the tree is desired. If no display is requested, the TREE procedure is ended.

If a display is requested, the tree is printed on the terminal. Following this, the program asks, "ANY CHANGES?" If the tree is acceptable as printed, users answer "NO" and the TREE procedure ends.

If changes are desired, the procedure enters the change option (see Figure 4.6). Users enter the name of the variable whose structure is to be changed. Next, the desired changes (such as adding or deleting components, or renaming the variable) are made.

Once all changes to the variable are made, users enter a carriage return in response to the "ENTER TYPE OF CHANGE" question. Users then have the opportunity to make changes to other variables.

If no more changes are desired, a carriage return is entered in response to the "ENTER NAME OF VARIABLE" question. The procedure then exits the change option and users are again asked if a display is desired. If a display is requested, the tree is printed and users are asked "ANY CHANGES?" If further changes are desired, the procedure reenters the change mode option and the above process is repeated.

If no display is requested or if no changes are desired, the TREE procedure ends.

4.3.2.4 FLOW DIAGRAM FOR INTERACTIVE TREE PROCEDURE. The interactive TREE procedure is one of the more complex procedures in ESAP. The flow diagram appearing in Figure 4.7 is intended to clarify the steps involved in using this procedure.

```
TREE DESCRIPTION COMPLETE. DO YOU WISH TO DISPLAY THE TREE?
I>yes

TREE PROCEDURE. DATE: 80/06/18. TIME: 17.03.01.

EXAMPLES FOR USERS' MANUAL

TREE:

                                    |FOREST/HAB
                        |TERR/HAB---|CLEAR/HAB
                        |
                        |TERR/ECOS--|TER/SP/DV
            |TERRESTRAL-|
            |           |           |FLOODS
            |           |LAND/QUAL--|SOIL/NUTR
            |
            |                       |FISH
            |           |AQUA/HAB---|RIPARIAN
            |           |                       |TEMP
            |           |           |PHYSICAL---|TURBID
            |           |           |
            |AQUATIC----|WATER/QUAL-|           |PH
EQ----------|           |           |CHEM-------|DO
            |           |
            |           |           |AQ/SP/DV
            |           |AQUA/ECOS--|AQ/PLANTS
            |AIR
            |                       |SITE/AREA
            |           |HISTORIC---|STRUCTURE
            |           |
            |HIST/RES---|           |PRECOLUM
                        |ARCHEOLOGIC|COLUMBIAN

ANY CHANGES?
I>yes
AVAILABLE CHANGES ARE:  ADD, DELETE, AND RENAME.

ENTER NAME OF VARIABLE TO WHICH CHANGES ARE DESIRED:
I>terr/ecos

ENTER TYPE OF CHANGE:
I>add,wetlands
WETLANDS ADDED.

ENTER TYPE OF CHANGE:
I>

ENTER NAME OF VARIABLE TO WHICH CHANGES ARE DESIREL:
I>

TREE DESCRIPTION COMPLETE. DO YOU WISH TO DISPLAY THE TREE?
I>yes
```

Figure 4.6. Changing tree structure in interactive TREE procedure

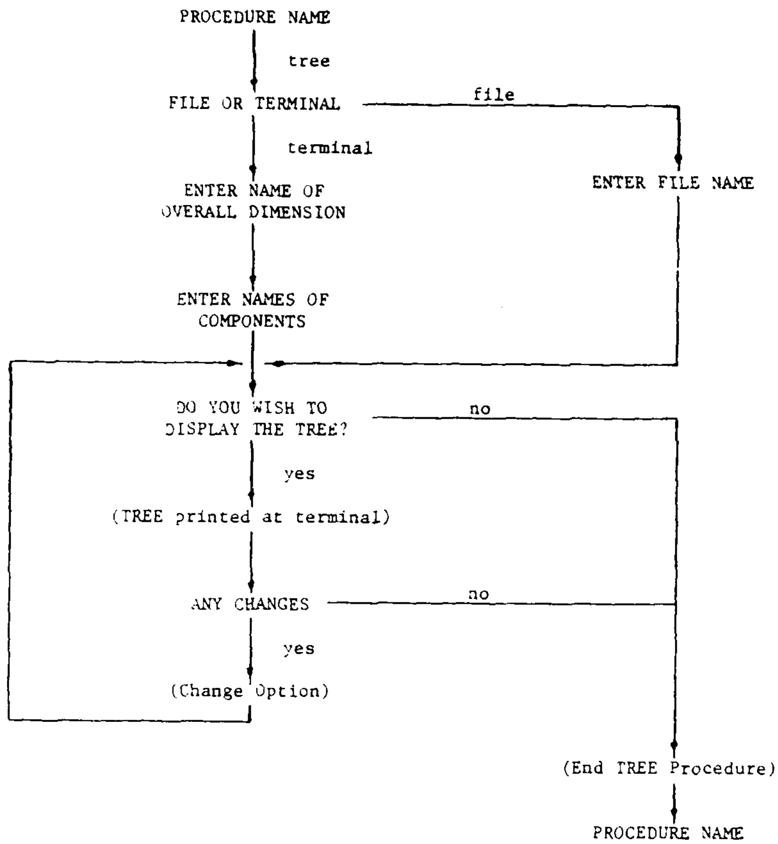


Figure 4.7. Flow diagram for use of interactive TREE procedure

4.3.3 BATCH TREE PROCEDURE

Input to the batch TREE procedure consists of a series of lines (cards) describing the structure of the hierarchy. The first card (after the *TREE card) contains the name of the overall dimension (root variable), left-justified in columns 1-10. The remaining cards define the tree structure. The cards for creating the same tree as appears in Figure 4.5 are shown in Figure 4.8.

```
*TREE
EQ
          TERRESTRAL
                    TERR/HAB
                              FOREST/HAB
                              CLEAR/HAB
                    TERR/ECOS
                              TER/SP/DV
                              WETLANDS
                    LAND/QUAL
                              FLOODS
                              SOIL/NUTR
          AQUATIC
                    AQUA/HAB
                              FISH
                              RIPARIAN
                    WATERQUAL
                              PHYSICAL
                                        TEMP
                                        TURBID
                              CHEM
                                        PH
                                        DO
                    AQUA/ECOS
                              AQ/SP/DV
                              AQ/PLNTS
          AIR
          HIST/RES
                    HISTORIC
                              SITE/AREA
                              STRUCTURE
                    ARCHEOLOGIC
                              PRECOLUM
                              COLUMBIAN
*END
+         +         +         +         +         +         +
1         6         11        16        21        26        31
```

Figure 4.8. Input to batch TREE procedure

AD-A099 307 COLORADO UNIV AT BOULDER CENTER FOR RESEARCH ON JUDG--ETC F/G 5/1
USER'S MANUAL FOR THE EVALUATION AND SENSITIVITY ANALYSIS PROGR--ETC(U)
MAR 81 J MUMPOWER, L BOLLACKER DACW39-78-C-0085

UNCLASSIFIED WES-TR-E-81-4 NL

2 OF 3
AD
A099307

There are three general rules to be followed for creating a card deck that will ensure proper input to the TREE procedure:

1. The card column in which a variable name begins is determined by its level in the tree. The formula for computing the column number from the level number is

   Column = (5 * level number) + 1

   where level number is 0 for the root, 1 for its components, etc.

2. The components for a variable are placed on the cards immediately following that variable. In the example, FOREST/HAB and CLEAR/HAB are on the cards following TERR/HAB, and PH and DO follow CHEM. The resulting card sequence can also be obtained by following the branches of the tree from root to leaves (left to right) and leftmost component to rightmost (top to bottom).

3. The maximum number of characters allowed in a name is ten (10). Names must begin with a letter and can contain any character other than blank or comma. (See 3.2.1 for more concerning rules for inputting names.)

The last card in the input to the batch TREE procedure is the *END card. This indicates the end of the tree description. When this card is read, the tree structure described by the preceeding cards is printed.

4.3.4 DISPLAYS FROM TREE PROCEDURE

The display produced by the TREE procedure is a graphic description of the evaluation problem, as specified by users through either the interactive or batch modes. Numerous examples of displays from this procedure have already appeared in the manual, but an additional example is shown in Figure 4.9. This example illustrates the capability of the TREE procedure to extend in depth for many levels. It

TREE:

```
                                                            |F1
                                                |E1---------|F2
                                    |D1---------|
                                    |           |E2
                        |C1---------|
                        |           |D2
            |B1---------|
            |           |C2
            |
            |           |B21
A-----------|           |B22
            |           |B23
            |           |B24
            |B2---------|B25
                        |B26
                        |B27
                        |B28
                        |B29
```

Figure 4.9. Example of display from TREE procedure

also illustrates an instance in which a large number of variables (i.e., B21-B29) stem from a single more general variable (i.e., B2).

In general, there are no strict limitations on the TREE procedure in terms of either the number of levels or number of variables that can be included. Certain practical limitations do exist, however. The number of levels should probably not exceed the capability of the user's printing device to display it; for an 80-character line printer, this would be six levels, including the root. The number of variables that can be specified will ordinarily be quite large. The precise number depends upon the number of alternatives and public groups also specified. Eventually, the storage limits of the Boeing Computer Service (or other system) are violated, as the numbers of variables, alternatives, and/or publics increase. A rough rule-of-thumb is that ESAP may be unable to perform <u>some</u> of its analyses if the number of variables exceeds 100, when the number of public groups exceeds 5 and the number of alternatives 25. In short, limitations exist for the number of variables that can be included in the TREE and in analyses, but these limits are rather high; the exact size of such limits depends on the other data specified to the program and which analyses are desired.

4.4 VARIABLES PROCEDURE

The VARIABLES procedure enables users to specify a one-line description or definition for every variable included in the hierarchy specified by the TREE procedure. In the TREE procedure, as well as in all other procedures in ESAP, no more than 10 characters can be used in displays to identify any variable, because of space limitations. Since it is frequently the case that variables cannot be adequately and unambiguously defined by a 10-character label, the VARIABLES procedure allows users to construct a dictionary, or reference table, in which each variable is defined or described in greater detail.

4.4.1 INTERACTIVE VARIABLES PROCEDURE

The interactive VARIABLES procedure allows users to enter a short, one-line description for each variable in the tree. ESAP asks users for descriptions of the variables one at a time, as illustrated in Figure 4.10.

The description for a variable may be up to 68 characters in length, and may contain any of the characters A-Z, 0-9, and special characters:

+ - * / ( ) *blank* $ = [ ] : ; < > , .

```
ENTER PROCEDURE NAME:
I>variables
ENTERING VARIABLES PROCEDURE.
ENTER DESCRIPTION FOR EQ (68 CHAR. MAX.):
I>environmental quality
ENTER DESCRIPTION FOR TERRESTRAL (68 CHAR. MAX.):
I>terrestrial resources
ENTER DESCRIPTION FOR AQUATIC (68 CHAR. MAX.):
I>aquatic resources
ENTER DESCRIPTION FOR AIR (68 CHAR. MAX.):
I>air auality
ENTER DESCRIPTION FOR HIST/RES (68 CHAR. MAX.):
I>historical and cultural resources
ENTER DESCRIPTION FOR TERR/HAB (68 CHAR. MAX.):
I>terrestrial habitat
ENTER DESCRIPTION FOR TERR/ECOS (68 CHAR. MAX.):
I>terrestrial ecosystems, community relationships
ENTER DESCRIPTION FOR LAND/QUAL (68 CHAR. MAX.):
I>land quality
ENTER DESCRIPTION FOR AQUA/HAB (68 CHAR. MAX.):
I>aquatic habitat
ENTER DESCRIPTION FOR WATERQUAL (68 CHAR. MAX.):
I>water quality
ENTER DESCRIPTION FOR AQUA/ECOS (68 CHAR. MAX.):
I>aquatic secosystems, community relationshipts
ENTER DESCRIPTION FOR HISTORIC (68 CHAR. MAX.):
I>historic sites, areas, and places
ENTER DESCRIPTION FOR ARCHEOLOGIC (68 CHAR. MAX.):
                    •
                    •
                    •
```

Figure 4.10. Entering variable descriptions to interactive VARIABLES procedure

If no description is desired for a variable, users may enter a carriage return in response to the "ENTER DESCRIPTION FOR" question.

After the description has been entered for the last variable, users are asked if a display of the descriptions is desired. If no display is requested, the VARIABLES procedure is ended.

If a display is requested, the descriptions are printed on the terminal in the form of a table (Figure 4.11). After the descriptions are printed, the program asks "ANY CHANGES?" If the descriptions are acceptable as printed, users reply "NO" and the VARIABLES procedure ends.

```
 VARIABLE DESCRIPTION COMPLETE.  DO YOU WISH TO DISPLAY THE DESCRIPTIONS?
I>yes

 VARIABLES PROCEDURE. DATE: 80/06/18. TIME: 17.21.12.


 VARIABLE   DESCRIPTION
 ------------------------------------------------------------------------------
 EQ         ENVIRONMENTAL QUALITY
 TERRESTRAL TERRESTRIAL RESOURCES
 AQUATIC    AQUATIC RESOURCES
 AIR        AIR AUALITY
 HIST/RES   HISTORICAL AND CULTURAL RESOURCES
 TERR/HAB   TERRESTRIAL HABITAT
 TERR/ECOS  TERRESTRIAL ECOSYSTEMS, COMMUNITY RELATIONSHIPS
 LAND/QUAL  LAND QUALITY
 AQUA/HAB   AQUATIC HABITAT
 WATERQUAL  WATER QUALITY
 AQUA/ECOS  AQUATIC SECOSYSTEMS, COMMUNITY RELATIONSHIPTS
 HISTORIC   HISTORIC SITES, AREAS, AND PLACES
                                •
                                •
                                •
 ANY CHANGES?
I>yes

 NAME OF VARIABLE:
I>air
 ENTER DESCRIPTION FOR AIR (68 CHAR. MAX.):
I>air quality

 NAME OF VARIABLE:
I>hist/res
 ENTER DESCRIPTION FOR HIST/RES (68 CHAR. MAX.):
I>historical and cultural resources

 NAME OF VARIABLE:
I>aqua/ecos
 ENTER DESCRIPTION FOR AQUA/ECOS (68 CHAR. MAX.):
I>aquatic ecosystems, community relationships

 NAME OF VARIABLE:
I>

 VARIABLE DESCRIPTION COMPLETE.  DO YOU WISH TO DISPLAY THE DESCRIPTIONS?
I>yes
```

Figure 4.11. Displaying and changing variable descriptions in interactive VARIABLES procedure

If changes are desired, the procedure enters the change option. The change option asks users to specify the name of the variable and its new description. The new description replaces the one originally printed in the table.

Once all changes are made, a carriage return is entered in response to the "NAME OF VARIABLE" question. The procedure then exits the change option, and users are asked if a display of the descriptions is desired. If a display is requested, the descriptions are printed, and users are again asked "ANY CHANGES?" If further changes are desired, the program reenters the change option and the process is repeated. If no display is requested or if no changes are desired, the VARIABLES procedure ends.

4.4.2 BATCH VARIABLES PROCEDURE

The batch VARIABLES procedure accepts input in the form of a table, as shown in Figure 4.12. Each line (card) is in the format:

Column	Information
1-10	Variable name, left-justified
11-78	Description of variable

The variables may be in any order. If a variable is omitted from the table, its description is assumed to be blank.

The last card in the input is the *END card, indicating the end of the table. Upon reading the *END card, the procedure displays a table of descriptions, described in 4.4.3.

```
*VARIABLES
EQ          ENVIRONMENTAL QUALITY
TERRESTRAL  TERRESTRIAL RESOURCES
AQUATIC     AQUATIC RESOURCES
AIR         AIR QUALITY
HIST/RES    HISTORICAL AND CULTURAL RESOURCES
TERR/HAB    TERRESTRIAL HABITAT
TERR/ECOS   TERRESTRIAL ECOSYSTEMS, COMMUNITY RELATIONSHIPS
LAND/QUAL   LAND QUALITY
AQUA/HAB    AQUATIC HABITAT
WATERQUAL   WATER QUALITY
AQUA/ECOS   AQUATIC ECOSYSTEMS, COMMUNITY RELATIONSHIPS
HISTORIC    HISTORIC, HISTORICAL SITES, AREAS, AND PLACES
ARCHEOLOGIC ARCHEOLOGIC, EARLY HUMAN SETTLEMENTS
FOREST/HAB  FOREST HABITAT
CLEAR/HAB   CLEARED LAND, AGRICULTURAL HABITAT
TER/SP/DV   TERRESTRIAL SPECIES DIVERSITY
WETLANDS    WETLANDS, FLOOD PLAINS, MARSHES, SWAMP ACREAGE
FLOODS      ACREAGE FLOODED EACH YEAR
SOIL/NUTR   PRESENCE OF SOIL NUTRIENTS
FISH        FISH HABITAT
RIPARIAN    RIPARIAN HABITAT
PHYSICAL    PHYSICAL PROPERTIES OF WATER
CHEM        CHEMICAL PROPERTIES OF WATER
AQ/SP/DV    AQUATIC SPECIES DIVERSITY
AQ/PLNTS    NOXIOUS OR NUISANCE AQUATIC PLANTS
SITE/AREA   SITE/AREA - HISTORICAL SITES
STRUCTURE   STRUCTURES, HISTORICAL PLACES
PRECOLUM    PRECOLUM, PREHISTORIC SITES
COLUMBIAN   COLUMBIAN, HISTORIC SITES
TEMP        TEMPERATURE OF THE WATER
TURBID      TURBIDITY
PH          PH MEASUREMENT,ACIDITY/ALKALINITY OF THE WATER
DO          DISSOLVED OXYGEN
+           +
1          11
```

Figure 4.12. Card input to batch VARIABLES procedure

4.4.3 DISPLAYS FROM VARIABLES PROCEDURE

Displays from the VARIABLES procedure echo inputs from users. The display consists of a table listing each VARIABLE and its DESCRIPTION. An example appears in Figure 4.13.

VARIABLE	DESCRIPTION
EQ	ENVIRONMENTAL QUALITY
TERRESTRAL	TERRESTRIAL RESOURCES
AQUATIC	AQUATIC RESOURCES
AIR	AIR QUALITY
HIST/RES	HISTORICAL AND CULTURAL RESOURCES
TERR/HAB	TERRESTRIAL HABITAT
TERR/ECOS	TERRESTRIAL ECOSYSTEMS, COMMUNITY RELATIONSHIPS
LAND/QUAL	LAND QUALITY
AQUA/HAB	AQUATIC HABITAT
WATERQUAL	WATER QUALITY
AQUA/ECOS	AQUATIC ECOSYSTEMS, COMMUNITY RELATIONSHIPS
HISTORIC	HISTORIC SITES, AREAS, AND PLACES
ARCHEOLOGIC	EARLY HUMAN SETTLEMENTS
FOREST/HAB	FOREST HABITAT
CLEAR/HAB	CLEARED LAND, AGRICULTURAL HABITAT
TER/SP/DV	TERRESTRIAL SPECIES DIVERSITY
WETLANDS	WETLANDS, FLOOD PLAINS, MARSHES, SWAMP ACREAGE
FLOODS	ACREAGE FLOODED EACH YEAR
SOIL/NUTR	PRESENCE OF SOIL NUTRIENTS
FISH	FISH HABITAT
RIPARIAN	RIPARIAN HABITAT
PHYSICAL	PHYSICAL PROPERTIES OF WATER
CHEM	CHEMICAL PROPERTIES OF WATER
AQ/SP/DV	AQUATIC SPECIES DIVERSITY
AQ/PLNTS	NOXIOUS OR NUISANCE AQUATIC PLANTS
SITE/AREA	SITE/AREA – HISTORICAL SITES
STRUCTURE	STRUCTURES, HISTORICAL PLACES
PRECOLUM	PRECOLUM, PREHISTORIC SITES
COLUMBIAN	COLUMBIAN, HISTORIC SITES
TEMP	TEMPERATURE OF THE WATER
TURBID	TURBIDITY
PH	PH MEASUREMENT, ACIDITY/ALKALINITY OF WATER
DO	DISSOLVED OXYGEN

Figure 4.13. Example of display from VARIABLES procedure

4.5 RANGES PROCEDURE

In order to evaluate the desirability of the various water resources management alternatives under consideration, ESAP requires users to specify the variable levels projected to result for each alternative. Users do not make projections for every variable in the tree, however. Levels are projected only for leaf variables, or those variables that are not subdivided into more discrete, specific variables. For instance, in the example appearing in Figure 4.14, projected levels must be specified only for the underlined variables. Note that

TREE:

```
                                        |FOREST/HAB
                         |TERR/HAB---   |CLEAR/HAB
                         |
                         |              |TER/SP/DV
             |TERRESTRAL-|TERR/ECOS--   |WETLANDS
             |           |
             |           |              |FLOODS
             |           |LAND/QUAL--   |SOIL/NUTR
             |
             |                          |FISH
             |           |AQUA/HAB---   |RIPARIAN
             |           |                                |TEMP
             |           |              |PHYSICAL---      |TURBID
             |           |              |
EQ---------- |AQUATIC----|WATERQUAL--   |                 |PH
             |           |              |CHEM-------      |DO
             |           |
             |           |              | AQ/SP/DV
             |           |AQUA/ECOS--   | AQ/PLNTS
             |AIR
             |                          | SITE/AREA
             |           |HISTORIC -----| STRUCTURE
             |           |
             |HIST/RES---|              | PRECOLUM
                         |ARCHEOLOGIC --| COLUMBIAN
```

Figure 4.14. TREE describing a water resources evaluation problem. Leaf variables are underlined

leaf variables need not be situated at the far right side of the tree, as for example with the variable AIR, although nothing will ever be attached to the right of any leaf variable in the TREE.

As part of setting up the analysis, users are required to specify the minimum and maximum levels of each variable, using the RANGES procedure. The unit in which each variable is measured (e.g., acres, parts per million, etc.) may also be specified. The RANGES procedure must be used before the projected levels of variables for specific alternatives can be entered in either the DATA or UNCERTAIN procedures.

In specifying the minimum and maximum levels for variables in RANGES, users should set the specified range so that it will not be so narrow that any value the user wishes to specify in subsequent procedures (including LOW and HIGH values in UNCERTAIN) would fall either below the minimum value or exceed the maximum value. A good rule-of-thumb is that the minimum value specified for a variable should be equal to the lowest value that will ever appear in the UNCERTAIN data for that variable; the maximum value of that variable should be equal to the highest value that will ever appear in the UNCERTAIN data for that variable. If in doubt, users should always err by specifying too large rather than too small a range.

4.5.1 INTERACTIVE RANGES PROCEDURE

In the interactive RANGES procedure, users have the choice of entering the ranges at the terminal or having the program read a file that contains the ranges information.

4.5.1.1 FILE ENTRY OPTION. Users are asked to enter the name of the file containing the ranges. This file is expected to be in the same format as is required by the batch RANGES procedure (see 4.5.2). (If the file name is the same as the one used by the TREE procedure, ESAP will simply continue reading from the point where input to the TREE procedure ended.) Errors detected during processing of this file cause a message consisting of the line in error and an explanation of the error to be printed at the terminal. Variables whose range specifications are in error have their range set to 0-100 with no measurement unit. Such variables may, however, have their ranges altered in order to correct the error during the change option in the RANGES procedure.

4.5.1.2 TERMINAL ENTRY OPTION. For the terminal entry option, the RANGES procedure scans the tree, looking for leaf variables. For each leaf it finds, the procedure asks "ENTER MIN, MAX VALUES AND UNIT FOR" the variable (see Figure 4.15). The user then enters the minimum and maximum values for the variable. The measurement unit, if entered, is used as a label on the x-axis of the graphic function form displays produced by the FORMS procedure (see 5.3).

4.5.1.3 DISPLAY AND CHANGE OPTIONS. When the range information has been obtained, either from file or the terminal, users are asked if a display of the ranges is desired. If no display is requested, the RANGES procedure is ended.

If a display is requested, the ranges are printed on the terminal, after which the program asks, "ANY CHANGES?" If the ranges are acceptable as printed, users reply "NO" and the RANGES procedure ends.

If changes are desired, the procedure enters the change option (Figure 4.16). The program asks for the name of a leaf variable and a new set of range values (and unit, if desired). The new values replace the ones printed in the table.

```
 ENTER PROCEDURE NAME:
I>ranges
 ENTERING RANGES PROCEDURE.

 ARE RANGES TO COME FROM A FILE OR THE TERMINAL?
I>terminal
 ENTER MIN, MAX VALUES AND UNIT FOR AIR:
I>0,500,air/index
 ENTER MIN, MAX VALUES AND UNIT FOR FOREST/HAB:
I>25000,713000,acres
 ENTER MIN, MAX VALUES AND UNIT FOR CLEAR/HAB:
I>15000,55000,acres
 ENTER MIN, MAX VALUES AND UNIT FOR TER/SP/DV:
I>0,100,index
 ENTER MIN, MAX VALUES AND UNIT FOR WETLANDS:
I>0,350,acres
 ENTER MIN, MAX VALUES AND UNIT FOR FLOODS:
I>0,75000,acres
 ENTER MIN, MAX VALUES AND UNIT FOR SOIL/NUTR:
I>.18,.6,incvscale
 ENTER MIN, MAX VALUES AND UNIT FOR FISH:
I>150,1250,ac-ft
 ENTER MIN, MAX VALUES AND UNIT FOR RIPARIAN:
I>20,45,strm/mile
 ENTER MIN, MAX VALUES AND UNIT FOR AQ/SP/DV:
I>0,100,div.index
 ENTER MIN, MAX VALUES AND UNIT FOR AQ/PLNTS:
I>0,400,acres
 ENTER MIN, MAX VALUES AND UNIT FOR SITE/AREA:
I>0,2.00, acres
 ENTER MIN, MAX VALUES AND UNIT FOR STRUCTURES:
I>0,35.00, buildings
 ENTER MIN, MAX VALUES AND UNIT FOR PRECOLUM:
I>0,1.00, site
 ENTER MIN, MAX VALUES AND UNIT FOR COLUMBIAN:
I>0,6.00, sites
 ENTER MIN, MAX VALUES AND UNIT FOR TEMP:
I>3,30,deg/cent
 ENTER MIN, MAX VALUES AND UNIT FOR TURBID:
I>20,100,jtu
 ENTER MIN, MAX VALUES AND UNIT FOR PH:
I>3,12,ph-unit
 ENTER MIN, MAX VALUES AND UNIT FOR DO:
I>0,12,mg/l

 RANGE SPECIFICATION COMPLETE. DO YOU WISH TO DISPLAY THE RANGES?
 I>yes
```

Figure 4.15. Entering ranges to interactive RANGES procedure

```
 RANGE SPECIFICATION COMPLETE. DO YOU WISH TO DISPLAY THE RANGES?
I>yes

 RANGES PROCEDURE. DATE: 80/06/18. TIME: 20.51.12.

 EXAMPLES FOR USERS' MANUAL

 RANGES:
 VARIABLE       MINIMUM     MAXIMUM     UNIT
 ----------------------------------------------
 AIR                .00      500.00     AIR/INDEX
 FOREST/HAB    25000.00   713000.00     ACRES
 CLEAR/HAB     15000.00    55000.00     ACRES
 TER/SP/DV          .00      100.00     INDEX
 WETLANDS           .00      350.00     ACRES
 FLOODS             .00    75000.00     ACRES
 SOIL/NUTR          .18         .60     INCVSCALE
 FISH            150.00     1250.00     AC-FT
 RIPARIAN         20.00       45.00     STRM/MILE
 AQ/SP/DV           .00      100.00     DIV.INDEX
 AQ/PLNTS           .00      400.00     ACRES
 SITE/AREA          .00        2.00     ACRES
 STRUCTURE          .00       35.00     BUILDINGS
 PRECOLUM           .00        1.00     SITES
 COLUMBIAN          .00        6.00     SITES
 TEMP              3.00       30.00     DEG/CENT
 TURBID           20.00      100.00     JTU
 PH                3.00       12.00     PH-UNIT
 DO                 .00       12.00     MG/L

 ANY CHANGES?
I>yes

 ENTER NAME OF VARIABLE, NEW MIN, NEW MAX, NEW UNIT:
I>forest/hab,25000,71300,acres

 ENTER NAME OF VARIABLE, NEW MIN, NEW MAX, NEW UNIT:
I>soil/nutr
 ENTER AT LEAST 2 MORE ITEMS:
I>.18,.6,inv.scale

 ENTER NAME OF VARIABLE, NEW MIN, NEW MAX, NEW UNIT:
I>

 RANGE SPECIFICATION COMPLETE. DO YOU WISH TO DISPLAY THE RANGES?
I>yes
```

Figure 4.16. Displaying and changing ranges in interactive RANGES procedure

Once all changes are made, users enter a carriage return response to the "ENTER NAME OF VARIABLE, NEW MIN, NEW MAX, NEW UNIT" question. The procedure then exits the change option and users are asked if a display is desired. If a display is requested the range is printed and users are again asked "ANY CHANGES?" If further changes are desired, the procedure reenters the change option and the process is repeated. If no display is requested, or if no changes are desired, the RANGES procedure ends.

4.5.1.4 FLOW DIAGRAM FOR INTERACTIVE RANGES PROCEDURE. The interactive RANGES procedure can be rather complex to use. The flow diagram appearing in Figure 4.17 is intended to clarify the steps involved in using this procedure.

4.5.2 BATCH RANGES PROCEDURE

The batch RANGES procedure accepts input in the form of a table, as shown in Figure 4.18. Each line (card) is in the format:

Column	Information
1-10	Variable name, left-justified
11-20	Minimum value (anywhere in field)
21-30	Maximum value (anywhere in field)
31-40	Measurement unit, left-justified (optional)

The variables may be in any order. If a variable is omitted from the table, its range is assumed to be 0 to 100, with no measurement unit. If a nonleaf variable (or a variable not in the tree) is encountered, a message is printed and the line is ignored.

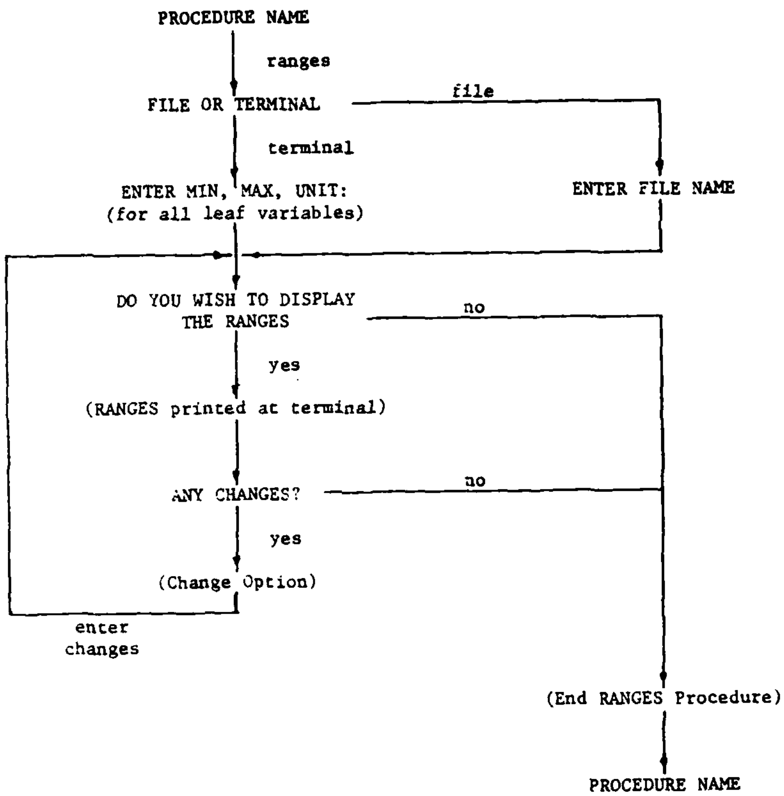


Figure 4.17. Flow diagram for use of interactive RANGES procedure

```
*RANGES
FOREST/HAB 25000      71300      ACRES
CLEAR/HAB  15000      55000      ACRES
TER/SP/DV  0          100        INDEX
WETLANDS   0          350        ACRES
FLOODS     0          75000      ACRES
SOIL/NUTR  .18        .6         INV.SCALE
FISH       150        1250       AC-FT
RIPARIAN   20         45         STRM/MILE
TEMP       3          30         DEG/CENT
TURBID     20         100        JTU
PH         3          12         PH-UNIT
DO         0          12         MG/L
AQ/SP/DV   0          100        DIV.INDEX
AQ/PLNTS   0          400        ACRES
AIR        0          500        AIR/INDEX
SITE/AREA  0          2          ACRES
STRUCTURE  0          35         BUILDINGS
PRECOLUM   0          1          SITES
COLUMBIAN   0         6          SITES
*END
+         +         +          +
1         11        21         31
```

Figure 4.18. Input to batch RANGES procedure

The last card in the input is the *END card, indicating the end of the table. Upon reading the *END card, the procedure prints a table of ranges, as described in 4.5.3.

4.5.3 DISPLAYS FROM RANGES PROCEDURE

The RANGES procedure produces a table in which each leaf variable in the tree is included. The table contains each variable name (VARIABLE), the minimum level (MINIMUM) for that variable, the maximum (MAXIMUM) level, and the UNIT in which the variable is measured. An example of the type of display produced by the RANGES procedure appears in Figure 4.19.

VARIABLE	MINIMUM	MAXIMUM	UNIT
AIR	.00	500.00	AIR/INDEX
FOREST/HAB	25000.00	71300.00	ACRES
CLEAR/HAB	15000.00	55000.00	ACRES
TER/SP/DV	.00	100.00	INDEX
WETLANDS	.00	350.00	ACRES
FLOODS	.00	75000.00	ACRES
SOIL/NUTR	.18	.60	INV.SCALE
FISH	150.00	1250.00	AC-FT
RIPARIAN	20.00	45.00	STRM/MILE
AQ/SP/DV	.00	100.00	DIV.INDEX
AQ/PLNTS	.00	400.00	ACRES
SITE/AREA	.00	2.00	ACRES
STRUCTURE	.00	35.00	BUILDINGS
PRECOLUM	.00	1.00	SITES
COLUMBIAN	.00	6.00	SITES
TEMP	3.00	30.00	DEG/CENT
TURBID	20.00	100.00	JTU
PH	3.00	12.00	PH-UNIT
DO	.00	12.00	MG/L

Figure 4.19. Display from RANGES procedure

5.0 SPECIFYING VALUES AND PREFERENCES

5.1 INTRODUCTION

This section of the manual is intended to help users learn about ESAP's procedures for specifying public values and preferences. In most water resources evaluation problems, different views can be found within the public concerning the most important variables to consider when choosing among water resources management plans. Different views can also usually be found concerning the most desirable, or optimal, level of various variables.

ESAP permits users to specify such information for one or more public groups, or PUBLICS, using the WEIGHTS and FORMS procedures. Brief one-line descriptions of these groups can be created using the PUBLICS procedure.

The methods for specifying information about public values and preferences used in ESAP may be unfamiliar to some program users. They represent an increasingly accepted trend, however, and can be traced back to theories of planning, economics, psychology, and operations research. The basic idea underlying this approach is that individuals' preferences and values can be described in terms of

a. the relative importances they associate with variables, when evaluating alternatives (addressed by the WEIGHTS procedure).

b. the relative desirability of various plausible levels of each variable (addressed by the FORMS procedure).

Some general guidelines for describing public values and preferences in this manner appear below. Additional guidelines for users unfamiliar with this approach appear in Appendix C: Specifying Weights and Functional Relations.

5.2 WEIGHTS PROCEDURE

The first step in ESAP for describing a public group's values and preferences is to indicate the relative importance that group associates with various variables, when evaluating the desirability of alternatives. Individuals frequently talk about variables in terms of their importance; individuals may speak of a variable as being "extremely important," "not very important," "more important than. . .," and so forth. The WEIGHTS procedure requires users to translate such information into quantitative terms by assigning numbers to each variable indicating its relative importance for a particular public group.

5.2.1 QUANTITATIVE DESCRIPTION OF VARIABLES' RELATIVE IMPORTANCE FOR EVALUATING ALTERNATIVES

Quantitative description of the relative importance of variables for making decisions is the subject of a considerable body of research and literature. Neither the underlying theory nor the various available methods for developing such descriptions will be discussed here. For those users unfamiliar with procedures for eliciting descriptions of individuals' weights, a common and simple procedure for doing so is described in Appendix C. Brief descriptions of some important issues attending the quantitative description of variables' relative importance appear below.

5.2.1.1 <u>LEGITIMACY OF THE USE OF NUMBERS TO DESCRIBE VALUES AND PREFERENCES</u>. The legitimacy of using numbers to describe individuals' preferences and values is itself far too fundamental an issue to be discussed here in any more than superficial terms. The issue arises so frequently, however, that it requires at least cursory attention.

If one thinks of numeric systems as justifiable only if they possess one-to-one correspondence with some palpable real-world entities, then the legitimacy of using numbers to describe people's preferences is obviously not justifiable. In fact, even from such a hard-nosed perspective a good theoretical case can be made for the legitimacy of describing individuals' preferences and values in quantitative terms. But if one bases conclusions about the legitimacy of using numbers to describe people's preferences on more pragmatic grounds, an even stronger case can be made. The case can be stated quite simply--numerically based models describing people's values and preferences work. Research by students of human judgment and decisionmaking clearly indicates that models can be built that will predict individuals' choice and decision behavior in new instances of the modeled situation. Support for the legitimacy of using quantitative methods is thus empirically based.

5.2.1.2 <u>MODELS OF VALUES AND PREFERENCES AND THE CONCEPT OF WEIGHT</u>. There are a variety of models for describing how individuals make judgments or decisions. The meaning of the concept <u>weight</u> can differ somewhat within these various models.

The model that ESAP assumes for describing individuals' judgments of value and preference is quite common and can be described as a <u>weighted averaging</u> model. It assumes that judgments about the desirability of alternatives can be described in the following manner:

$$D_j = \Sigma\, w_i\, f_i(x_{ij})$$

where

D_j = judgment of the overall desirability of alternative j

w_i = relative importance of variable i

f_i = functional relation between levels of variable i and judgments of overall desirability

x_{ij} = level of variable i for alternative j

This model is described as a weighted averaging model because weights (w_i's) must take values between 0 and 1 and are constrained to sum to 1.

Although ESAP assumes a weighted averaging model, users are not required to specify weights that meet the constraints of taking values between 0 and 1 or of summing to 1. The WEIGHTS procedure rescales numeric inputs from users so that they meet these requirements.

5.2.1.3 <u>EFFECTS OF INACCURACY IN WEIGHT SPECIFICATION</u>. How much difference does it make if weights are inaccurately specified? Suppose that an individual's true weights for two variables are .60/.40, but the weights entered to ESAP are .70/.30. How much difference will such inaccuracy make for evaluating alternatives? As with most such questions, the answer is "it depends."

Users should, of course, try to specify weights that reflect preference judgments as accurately as possible. If the weight of one variable is .10 and the weight of a second variable is .20, then the second variable should be "twice as important" (in the sense that a change from the least desirable level of the second variable to a level halfway between least and most desirable levels should be valued equally by the individual as a change from the least desirable to the most desirable level for the first variable in terms of the model described above. Such accuracy is difficult to achieve, however, and, indeed, may be illusory. There exist some basic questions both whether individuals' preferences are sufficiently stable to warrant attempts at such precise measurement. Perhaps the most useful rule-of-thumb for ESAP users is that the weights they specify to the program will <u>usually</u> (unfortunately, not <u>always</u>) be sufficiently accurate if they correctly reflect the rank-order of variables' importance. If the weights assigned to variables are consistent with an individual's rank-ordering of their importance, then the true most desirable alternative will usually be identified.

5.2.1.4 <u>SENSITIVITY OF WEIGHTS TO CHANGES IN VARIABLES' RANGES</u>. Often in planning studies, the minimum or maximum projected levels of variables will change as new information becomes available. Such changes in ranges should ordinarily be attended by changes in weights. As the range of a variable changes, one expects its relative importance to change. Users should be sensitive in general to the relation between a variable's range and its weight. The relative importance of alternatives' effects on SAFETY may be quite different depending on whether lives at risk range between 0 and 100 each year or between 0 and .01. ESAP users should remember that weights should indicate variables' importances, but only for the particular range of levels found among the alternatives under consideration.

5.2.1.5 DESCRIBING GROUPS OF INDIVIDUALS. Users of ESAP will ordinarily wish to describe the values and preferences of groups of individuals within the public. But what should users do when members of such a group disagree among themselves? Unfortunately, there is no perfect defensible method for combining descriptions of various individuals' values and preferences into descriptions of group values and preferences. Users may sometimes choose to divide groups into smaller subgroups until they have identified groups that appear to be relatively homogeneous. Another approach is to identify a spokesman for each group and to work with that individual. Some users may be familiar with statistical techniques for grouping and averaging similar individuals. The important point is simply that users should recognize that there exists no foolproof method for developing descriptions of group values and preferences; users must rely upon their own judgment and discretion in developing such descriptions.

5.2.2 INTERACTIVE WEIGHTS PROCEDURE

The interactive WEIGHTS procedure begins by asking users for the name of the public group for which weights are being specified. Users supply a name by which these weights will be called. The name may be the same as the name of a variable (although this may be confusing), but may not be "ALL". Next, users have the choice of entering weights from the terminal or having the program read a file containing the weights.

5.2.2.1 FILE ENTRY OPTION. Users are asked to enter the name of the file containing the weights. This file is expected to be in the same format as required by the batch WEIGHTS procedure (see 5.3 below). Errors detected during the processing of this file cause a message consisting of (a) the line in error and (b) an explanation of the error to be printed at the terminal. Variables whose weight specifications are in error are given a weight of zero. Such variables may be given a weight during the change option of the WEIGHTS procedure (5.2.2.3 below).

If the file name specified is the same as previously used in either the TREE or RANGES procedures, the program will continue reading from the file from where the previous procedure left off.

5.2.2.2 TERMINAL ENTRY OPTION. For the terminal option, the WEIGHTS procedure scans the tree looking for nonleaf variables. For each nonleaf variable, the weights for its component variables are requested (see Figure 5.1). These weights can be on any scale comfortable to users, such as 0-to-100 (dividing up 100 points among the components) or 0-to-1 (normalized weights). In any case, the program will compute a set of weights from the values entered such that the sum of the weights is one.

```
 ENTER PROCEDURE NAME:
I>weights
 ENTERING WEIGHTS PROCEDURE.

 NAME OF PUBLIC?
I>farmers

 ARE WEIGHTS TO COME FROM A FILE OR THE TERMINAL?
I>t
 WEIGHTS FOR TERRESTRAL,AQUATIC,AIR,HIST/RES?
I>40,30,20,10
 WEIGHTS FOR TERR/HAB,TERR/ECOS,LAND/QUAL?
I>2,2,8
 WEIGHTS FOR AQUA/HAB,WATERQUAL,AQUA/ECOS?
I>2,6,2
 WEIGHTS FOR HISTORIC, ARCHEOLOGIC?
I>3,7
 WEIGHTS FOR FOREST/HAB,CLEAR/HAB?
I>2,8
 WEIGHTS FOR TER/SP/DV,WETLANDS?
I>5,5
 WEIGHTS FOR FLOODS,SOIL/NUTR?
I>
 WEIGHTS FOR FISH,RIPARIAN?
I>3,7
 WEIGHTS FOR PHYSICAL,CHEM?
I>
 WEIGHTS FOR AQ/SP/DV,AQ/PLNTS?
I>3,7
 WEIGHTS FOR SITE/AREA, STRUCTURE?
I>
 WEIGHTS FOR PRECOLUM, COLUMBIAN?
I>3,7
 WEIGHTS FOR TEMP,TURBID?
I>6,4
 WEIGHTS FOR PH,DO?
I>7,3


 WEIGHT SPECIFICATION COMPLETE. DO YOU WISH TO DISPLAY THE WEIGHTS?
I>yes

 WHICH WEIGHTS--ORIGINAL, DERIVED, OR BOTH?
I>both
```

Figure 5.1. Entering weights to interactive WEIGHTS procedure

If all components have equal importance, a carriage return may be entered in response to the "WEIGHTS FOR" question. This will cause the program to supply equal weights which sum to 1.0 for all components.

5.2.2.3 DISPLAY AND CHANGE OPTIONS. When the weights have been obtained, either from the file or the terminal, users are asked if a display of the weights is desired. If no such display is requested, the WEIGHTS procedure is ended.

If a display is requested, users are asked which weights are to be displayed--original, derived, or both. If original weights are requested, the display will include both the numbers entered by the user and the weights computed by the program (normalized weights). If derived weights are requested, the display will contain the weights of the variables as they relate to the overall dimension (root variable).

After the weights are printed, the program asks "ANY CHANGES?" If the weights are acceptable as printed, users reply "NO" and the WEIGHTS procedure ends.

If changes are desired, the procedure enters the change option (Figure 5.2). The program asks for the name of a variable and a new weight. The new weight replaces the one originally entered (and therefore should be on the same scale as originally used rather than on the normalized or derived weight scale).

Once all changes are made, a carriage return is entered in response to the "ENTER NAME OF VARIABLE, NEW WEIGHT:" question. The procedure then exits the change option and users are again asked if a

```
 WEIGHT SPECIFICATION COMPLETE. DO YOU WISH TO DISPLAY THE WEIGHTS?
I>yes

 WHICH WEIGHTS--ORIGINAL, DERIVED, OR BOTH?
I>both

 WEIGHTS PROCEDURE. DATE: 80/06/18. TIME: 21.15.09.


 PUBLIC:  FARMERS
 ORIGINAL WEIGHTS:

                                         |FOREST/HAB
                                         |    2.00/.20
                            |TERR/HAB---|CLEAR/HAB
                            |    2.00/.17|    8.00/.80
                            |
                            |
                            |            |TER/SP/DV
                            |            |    5.00/.50
               |TERRESTRAL-|TERR/ECOS--|WETLANDS
               |  40.00/.40|    2.00/.17|    5.00/.50
               |            |
               |            |
               |            |            |FLOODS
               |            |            |    1.00/.50
               |            |LAND/QUAL--|SOIL/NUTR
               |            |    8.00/.67|    1.00/.50
                                  .
                                  .
                                  .
 ANY CHANGES?
I>y

 ENTER NAME OF VARIABLE, NEW WEIGHT:
I>air,10

 ENTER NAME OF VARIABLE, NEW WEIGHT:
I>recreation,20

 ENTER NAME OF VARIABLE, NEW WEIGHT:
I>land/qual,6

 ENTER NAME OF VARIABLE, NEW WEIGHT:
I>


 WEIGHT SPECIFICATION COMPLETE. DO YOU WISH TO DISPLAY THE WEIGHTS?
I>y
```

Figure 5.2. Displaying and changing weights in interactive WEIGHTS procedure

display of the weights is desired. As above, if a display is asked for, the weights of choice are printed and the program asks "ANY CHANGES?" If further changes are desired, the procedure reenters the change option and the process is repeated. If no display is requested, or if no changes are desired, the WEIGHTS procedure ends.

5.2.2.4 FLOW DIAGRAM FOR INTERACTIVE WEIGHTS PROCEDURE. A flow diagram describing the use of the interactive WEIGHTS procedure appears in Figure 5.3.

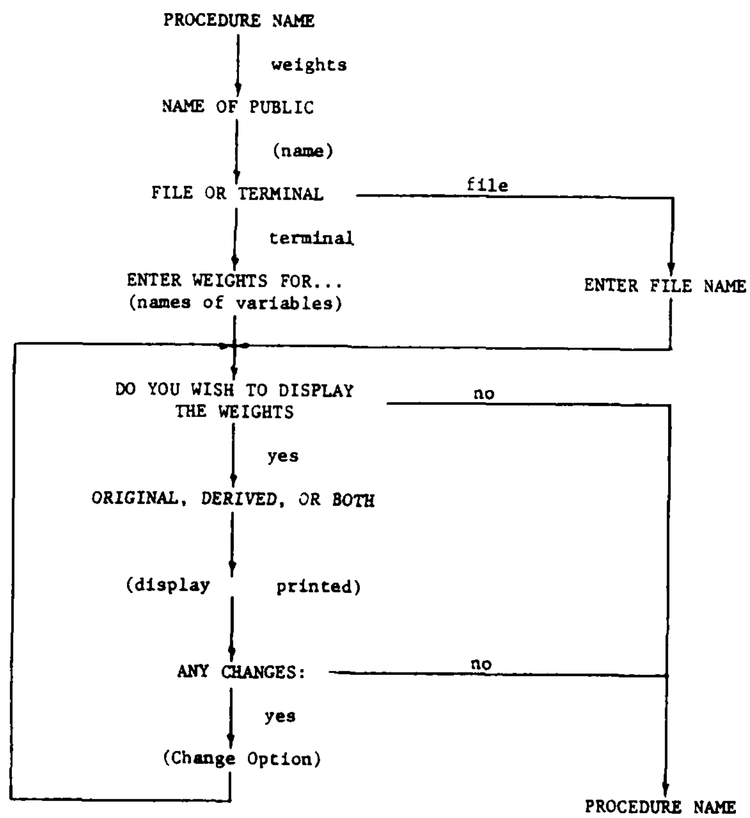


Figure 5.3. Flow diagram for interactive WEIGHTS procedure

5.2.3 BATCH WEIGHTS PROCEDURE

An example of the input to the batch WEIGHTS procedure is shown in Figure 5.4. The name of the public to which the weights belong is specified in columns 11-20 of the *WEIGHTS card. The rest of the input makes use of the cards created for the TREE procedure.

```
*WEIGHTS  FARMERS
EQ
     TERRESTRAL
     40
          TERR/HAB
          2
               FOREST/HAB
               2
               CLEAR/HAB
               8
          TERR/ECOS
          2
               TER/SP/DV
               5
               WETLANDS
               5
          LAND/QUAL
          6
               FLOODS
               5
               SOIL/NUTR
               5
     AQUATIC
     30
          AQUA/HAB
          2
               •
               •
               •
     AIR
     10
     HIST/RES
     20
          HISTORIC
          3
               SITE/AREA
               5
               STRUCTURE
               5
          ARCHEOLOGIC
          7
               PRECOLUM
               3
               COLUMBIAN
               7
*END
+    +    +    +    +    +    +
1    6    11   16   21   26   31
```

Figure 5.4. Input to batch WEIGHTS procedure

Using duplicates of the cards from the TREE procedure, the weights for all variables (except the root, which may be omitted from the deck if desired) are interleaved with the cards containing the names of the variables. The weight for a variable is placed on the card after the card with the variable name. The card containing the root variable name will be skipped if encountered by the procedure.

The weight values entered using the batch procedure are treated in the same manner as those entered into the interactive procedure; that is, they may be on any scale. There is one difference between the batch and interactive procedures' treatment of equal-weight components, however. Since all variables except the root must be given a weight, equally important components of a variable should be given equal weights, such as 1.0. (In the interactive procedure, a carriage return implies equal weights.) Note that there must be a number on the card following every variable except the root.

The last line of input to the batch WEIGHTS procedure is the *END card. Upon encountering this line, a display of both types of weights (see 5.2.4 below) is printed. The printing of the weight displays can be suppressed by entering "SUPPRESS PRINTING," beginning in column 21 of the *WEIGHTS card.

5.2.4 DISPLAYS FROM WEIGHTS PROCEDURE

Two types of displays are available from WEIGHTS. The first type of display is called "ORIGINAL WEIGHTS." An example appears in Figure 5.5. The ORIGINAL WEIGHTS display indicates the relative importance of

```
PUBLIC:  RECREATOR
ORIGINAL WEIGHTS:

                                   |FOREST/HAB
                                   |  85.00/.85
                       |TERR/HAB---|CLEAR/HAB
                       |  40.00/.40|  15.00/.15
                       |
                       |
                       |           |TER/SP/DV
                       |           |  75.00/.75
           |TERRESTRAL-|TERR/ECOS--|WETLANDS
           |  30.00/.30|  40.00/.40|  25.00/.25
           |           |
           |           |
           |           |           |FLOODS
           |           |           |   8.00/.80
           |           |LAND/QUAL--|SOIL/NUTR
           |           |  20.00/.20|   2.00/.20
           |
           |
           |                       |FISH
           |                       |   6.00/.60
           |           |AQUA/HAB---|RIPARIAN
           |           |  60.00/.60|   4.00/.40
           |           |                       |TEMP
           |           |                       |   5.00/.50
           |           |           |PHYSICAL---|TURBID
           |           |           |   5.00/.50|   5.00/.50
           |           |           |
           |           |           |
EQ---------|AQUATIC----|WATERQUAL--|           |PH
           |  35.00/.35|  15.00/.15|           |   5.00/.50
           |           |           |CHEM-------|DO
           |           |           |   5.00/.50|   5.00/.50
           |           |
           |           |
           |           |           |AQ/SP/DV
           |           |           |   8.00/.80
           |           |AQUA/ECOS--|AQ/PLNTS
           |           |  25.00/.25|   2.00/.20
           |
           |AIR
           |   5.00/.05
           |                       |SITE/AREA
           |                       |   4.00/.40
           |           |HISTORIC---|STRUCTURE
           |           |   5.00/.50|   6.00/.60
           |           |
           |           |
           |HIST/RES---|           |PRECOLUM
           |  30.00/.30|           |  25.00/.25
                       |ARCHEOLOGIC|COLUMBIAN
                       |   5.00/.50|  75.00/.75
```

Figure 5.5. Displays from WEIGHTS procedure: ORIGINAL WEIGHTS

each variable for the more general variable with which it is directly linked in the tree. For each variable two numbers are displayed. The first (to the left of the slash mark) is the number entered for that variable by the user during the weight specification procedure. The second number (to the right of the slash mark) is the normalized relative importance value of that variable for the more general variable to which it is linked. The normalization of relative importance values results in each relative weight being scaled between 0 and 1; the sum of the relative weights for all variables linked to another more general variable is always 1. For instance, the present display indicates that the user entered the number "5" for both PH and DO when specifying their relative weights for CHEM (see arrow, Figure 5.5); the relative weight of both PH and DO for CHEM, as normalized by ESAP, is thus .50.

The second type of display from the WEIGHTS procedure is called DERIVED WEIGHTS. An example appears in Figure 5.6. This display indicates the relative importance of each variable in the tree for the overall dimension to be evaluated. In the present example, the relative weights appearing in the tree indicate the relative importance of each variable for EQ (environmental quality). Derived weights are computed by multiplying each variable's relative weight by the relative weight of all those variables in the tree with which it is linked. For instance, the derived weights of PH and DO for EQ both equal .01 in the present example (see arrow, Figure 5.6). That is, only about 1 percent of judgments about the desirability of alternatives' effects on overall

```
PUBLIC:  RECREATOR
DERIVED WEIGHTS:

                                          |FOREST/HAB
                                          |  .10
                              |TERR/HAB---|CLEAR/HAB
                              |  .12      |  .02
                              |
                              |
                              |           |TER/SP/DV
                              |           |  .09
                |TERRESTRAL-|TERR/ECOS--|WETLANDS
                |  .30        |  .12      |  .03
                |             |
                |             |
                |             |           |FLOODS
                |             |           |  .05
                |             |LAND/QUAL--|SOIL/NUTR
                |             |  .06      |  .01
                |
                |
                |                         |FISH
                |                         |  .13
                |             |AQUA/HAB---|RIPARIAN
                |             |  .21      |  .08
                |             |                       |TEMP
                |             |                       |  .01
                |             |           |PHYSICAL---|TURBID
                |             |           |  .03      |  .01
                |             |           |
                |             |           |
EQ--------------|AQUATIC----|WATERQUAL--|           |PH
                |  .35        |  .05      |           |  .01
                |             |           |CHEM-------|DO
                |             |           |  .03      |  .01
                |             |
                |             |
                |             |           |AQ/SP/DV
                |             |           |  .07
                |             |AQUA/ECOS--|AQ/PLNTS
                |             |  .09      |  .02
                |AIR
                |  .05
                |                         |SITE/AREA
                |                         |  .06
                |             |HISTORIC----|STRUCTURE
                |             |  .15      |  .09
                |             |
                |             |
                |HIST/RES----|           |PRECOLUM
                |  .30        |           |  .04
                              |ARCHEOLOGIC|COLUMBIAN
                              |  .15      |  .11
```

Figure 5.6. Display from WEIGHTS procedure: DERIVED WEIGHTS

EQ are attributable to PH or DO. The derived weight for each was computed by multiplying the original weight (.50) for CHEM, times CHEM's original weight (.50) for WATERQUAL, times WATERQUAL's original weight (.15) for AQUATIC, times AQUATIC's original weight (.35) for EQ. This method of computation thus provides a general indication of the relative importance of each variable in the tree for evaluating alternatives' overall desirability.

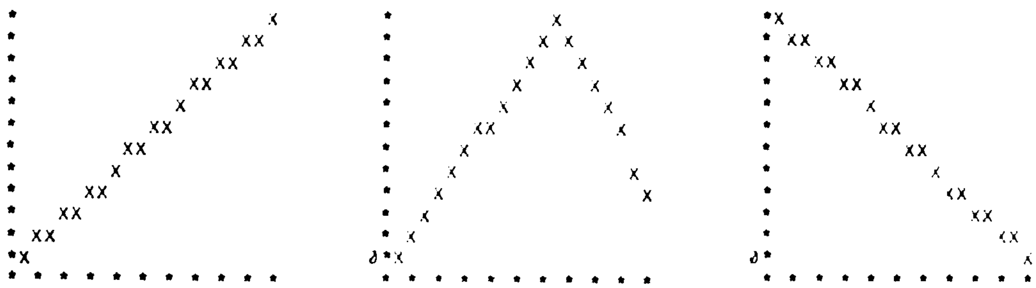
5.3 FORMS PROCEDURE

In addition to specifying the relative weights that a public group associates with the various variables in the tree, users must also specify the functional relations between each variable and the more general variable in the tree with which it is linked. The idea of a functional relation between two variables is common in everyday discourse. Individuals indicate that "more of X is better," "less of Y is better," or "a moderate amount of Z is best." The FORMS procedure requires users to translate this type of information into a graphic description of the relation between each pair of variables linked by the tree.

5.3.1 GRAPHIC DESCRIPTION OF VARIABLES' FUNCTIONAL RELATIONS

The FORMS procedure assumes that the relation between any two variables can be described graphically. The more specific variable appears on the x-axis; the more general variable appears on the y-axis.

Examples of several such graphic descriptions appear in Figure 5.7. The relation between variables depicted in 5.7a is positive linear (the more the better); the relation depicted in 5.7b is nonlinear (i.e., a moderately high level is best); and the relation appearing in 5.7c is negative linear (the less the better).



a. Positive Linear   b. Nonlinear   c. Negative Linear

Figure 5.7. Graphic descriptions of functional relations of variables

Methods and procedures for describing the functional relations between variables have been the topic of a considerable body of theoretical discussion and empirical research. A thorough discussion of this body of work is beyond the scope of this manual; however, for those users unfamiliar with this approach, a common and simple procedure for developing graphic descriptions of the relations between variables appears in Appendix C: Specifying Weights and Functional Relations. A few major issues in developing such graphic descriptions are discussed briefly below.

5.3.1.1 ASSUMPTION OF INDEPENDENCE. The specification of the functional relation between two variables is based upon the assumption that the relation would not change as a function of the values of other variables. In other words, it is assumed that specification of a relation such as the more X the better will not change regardless of the levels that variable Y assumes. Satisfaction of this assumption is necessary for legitimately employing the weighted averaging model (see 5.2.1.2) assumed by ESAP. Violation of this assumption may not completely invalidate the subsequent analysis, but it is difficult to anticipate *a priori* the effects of such violations. Users should therefore attempt to devise a tree structure in which the component variables are as independent as possible.

5.3.1.2 TRANSLATING GRAPHIC DESCRIPTIONS TO QUANTITATIVE DESCRIPTIONS. Users should recognize that graphic description of the relations between variables can easily be translated into or described in quantitative terms, as, indeed, they are by ESAP. An illustration of this point is presented in Figure 5.8. All three variables in the present example are scaled on arbitrary scales of 0 to 100. In Figure 5.8a, the relation between the variables PHYSICAL and CHEM and the variable WATERQUAL is graphically described. Figure 5.8a indicates that there is a direct relation between scores on the two more specific variables and scores on the more general variable. In other words, a score of 100 on PHYSICAL or CHEM corresponds to a score of 100 on WATERQUAL; a score of 50 on PHYSICAL or CHEM corresponds to a score of 50 on WATERQUAL, etc.

```
100*                A        100*                A
   *              AA            *              AA
   *             A              *             A
  W*           AA              W*           AA
  A*          A                A*          A
  T*        AA                 T*        AA
  E*       A                   E*       A
  R*     AA                    R*     AA
  Q*    A                      Q*    A
  U*   AA                      U*   AA
  A*  A                        A*  A
  L*AA                         L*AA
   *                            *
  0 ******************         0 ******************
    0              100           0              100
  PHYSICAL                     CHEM
```

a. Unweighted functional relations

```
100*                         100*
   *                            *
   *                            *
  W*                A          W*
  A*              AA           A*
  T*            AA             T*
  E*          AA               E*
  R*        AA                 R*
  Q*      AA                   Q*
  U*     AA                    U*               AAA
  A*   AA                      A*         AAAAAA
  L* AA                        L*   AAAAAA
  0 *A                         0 *AAA
    ******************           ******************
    0              100           0              100
  PHYSICAL                     CHEM
       (w = .75)                    (w = .25)
```

b. Weighted functional relations

Figure 5.5. Relation between graphic and quantitative descriptions of functional relations

The quantitative description of the relation between two variables is further clarified, however, when the concept of weight is introduced. Assume that the relative weights of PHYSICAL and CHEM for WATERQUAL are .75 and .25, respectively. If the score for PHYSICAL is 100 and the score for CHEM is 100, the score for WATERQUAL will also equal 100; this is computed by multiplying the score for PHYSICAL times its weight (100 x .75 = 75), multiplying the score for CHEM times its weight (100 x .25 = 25), and adding the resulting two numbers (75 + 25 = 100). The weighted relations between scores on PHYSICAL and CHEM and scores on WATERQUAL appear in Figure 5.8b. Graphic descriptions of functional relations between variables are thus combined with weights in order to create quantitative descriptions of the relations between variables.

5.3.1.3 EFFECTS OF INACCURACY IN SPECIFYING FUNCTIONAL RELATIONS. As with weights, ESAP users may wonder how accurately or precisely they need to specify the relations between two variables; and as with weights, the answer is, "It depends." ESAP permits users to specify functional relations in terms of either one or two straight lines; two straight lines should ordinarily provide sufficient precision for describing relations so that the true most desirable alternative can be identified.

5.3.1.4 SENSITIVITY OF FUNCTIONAL RELATIONS TO VARIABLES' RANGES. The form of the functional relation between two variables may change if the ranges of the variables change, just as weights may change when ranges alter (see 5.2.1.4). Imagine, for example, that one wishes to describe the functional relation between number of fish and quality of the aquatic environment. Within a certain range of number of fish, the relation might be positive linear--the more fish the better. If the range of number of fish were to expand drastically, however, this relation might change. If the number of fish might range so high as to constitute overpopulation, then, the relation between number of fish and quality of the aquatic environment might assume an inverted-V shape--the more fish the better, up to a point at which additional numbers lead to lower aquatic environment quality. Users should be careful to ensure that specified functional relations are appropriate for the variable ranges in their specific evaluation study.

5.3.2 INTERACTIVE FORMS PROCEDURE

The interactive FORMS procedure begins by asking for the name of the public group for which forms are being specified. This must be the name of a "PUBLIC" previously specified in the WEIGHTS procedure (see Figure 5.9).

Second, the program asks which set of variables is to be considered. If the user enters "ALL", forms for all variables in the tree will be requested; if "LEAF" is entered, only leaf variables will be considered, and the program will supply positive linear forms for all other variables. The LEAF option can save a considerable amount of time when entering forms from the terminal for large trees provided, of

```
 ENTER PROCEDURE NAME:
I>forms
 ENTERING FORMS PROCEDURE.

 NAME OF PUBLIC?
I>farmers

 LEAF VARIABLES OR ALL VARIABLES?
I>leaf

 ARE FORMS TO COME FROM A FILE OR THE TERMINAL?
I>term
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN AIR AND EQ?
```

Figure 5.9. Initial input to interactive FORMS procedure

course, that all nonleaf variables are described in such a way as to allow positive linear function forms to be used. When choosing the LEAF option, users should check carefully to ensure that the variables have been defined appropriately for use of positive linear function forms throughout the nonleaf portions of the tree.

Next, users have the choice of entering the forms from the terminal or having the program read a file containing the forms.

5.3.2.1 FILE ENTRY OPTION. Users are asked to enter the name of the file containing the forms. This file is expected to be in the same format as required by the batch FORMS procedure (see 5.3.3 below). Errors detected during the processing of this file cause a message consisting of (a) the line in error and (b) an explanation of the error to be printed at the terminal. Variables whose form specifications are in error are assigned a positive linear function form. Such variables may be given another form during the change option of the FORMS procedure (see 5.3.2.3).

If the file name specified is the same as previously used in the TREE, RANGES, or WEIGHTS procedure, the program will continue reading from the point where the previous procedures left off.

5.3.2.2 TERMINAL ENTRY OPTION. For the terminal entry option, if users indicate that forms are to be specified for all variables (see 5.3.2 above), ESAP begins by asking for the shape of the relationship between each of the first-level variables and the overall dimension, or tree root. The procedure proceeds, working its way down the tree from the more general to the more specific variables. If it has been indicated that forms are to be specified only for leaf variables (see 5.3.2), ESAP scans the tree, identifying leaves and asking users to specify the relation between each leaf and the variable of which it is a component. An example of interaction with the FORMS procedure appears in Figure 5.10.

```
 ARE FORMS TO COME FROM A FILE OR THE TERMINAL?
I>term
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN AIR AND EQ?
I>poslin
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN FOREST/HAB AND TERR/HAB?
I>neglin
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN CLEAR/HAB AND TERR/HAB?
I>poslin
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN TER/SP/DV AND TERR/ECOS?
I>1
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN WETLANDS AND TERR/ECOS?
I>4
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN FLOODS AND LAND/QUAL?
I>neglin
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN SOIL/NUTR AND LAND/QUAL?
I>poslin
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN FISH AND AQUA/HAB?
I>1
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN RIPARIAN AND AQUA/HAB?
I>1
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN AQ/SP/DV AND AQUA/ECOS?
I>poslin
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN AQ/PLNTS AND AQUA/ECOS?
```

Figure 5.10. Entry of forms information to interactive FORMS procedure

In responding to the FORMS procedure's questions about the functional relationship between two variables, users may choose from nine responses. The first eight of these are so-called standard forms (see Figure 5.11). Users can specify these forms by entering either the identifying abbreviation, e.g., "POSLIN," or the identifying number, e.g., "1". In other words, users can specify a positive linear relationship between two variables by entering either "POSLIN" or "1". The ninth response is "SPECIAL" or "9".

A SPECIAL form is made up of two line segments, A and B (see Figure 5.12). Segment A has its left endpoint at the lower end of the range for the variable and its right endpoint at a point specified by the user, somewhere in the range for the variable and called the <u>inflection point</u>. Segment B has its left endpoint at the inflection point and its right endpoint at the upper end of the range for the variable.

In order for the FORMS procedure to construct the line segments A and B, users must supply four numbers: the rating (on the 0-to-100 scale) at the left endpoint of A; the level of the variable at the inflection point; the rating at the inflection point; and the rating at the right endpoint. In the example in Figure 5.12, the four numbers required to describe the form are 0, 7, 100, and 12.

There are two restrictions on SPECIAL function forms. First, the inflection point may not fall at either the minimum or maximum value for the variable. Second, one of the ratings must be 0, and one must be 100; that is to say, the form must span the entire rating range.

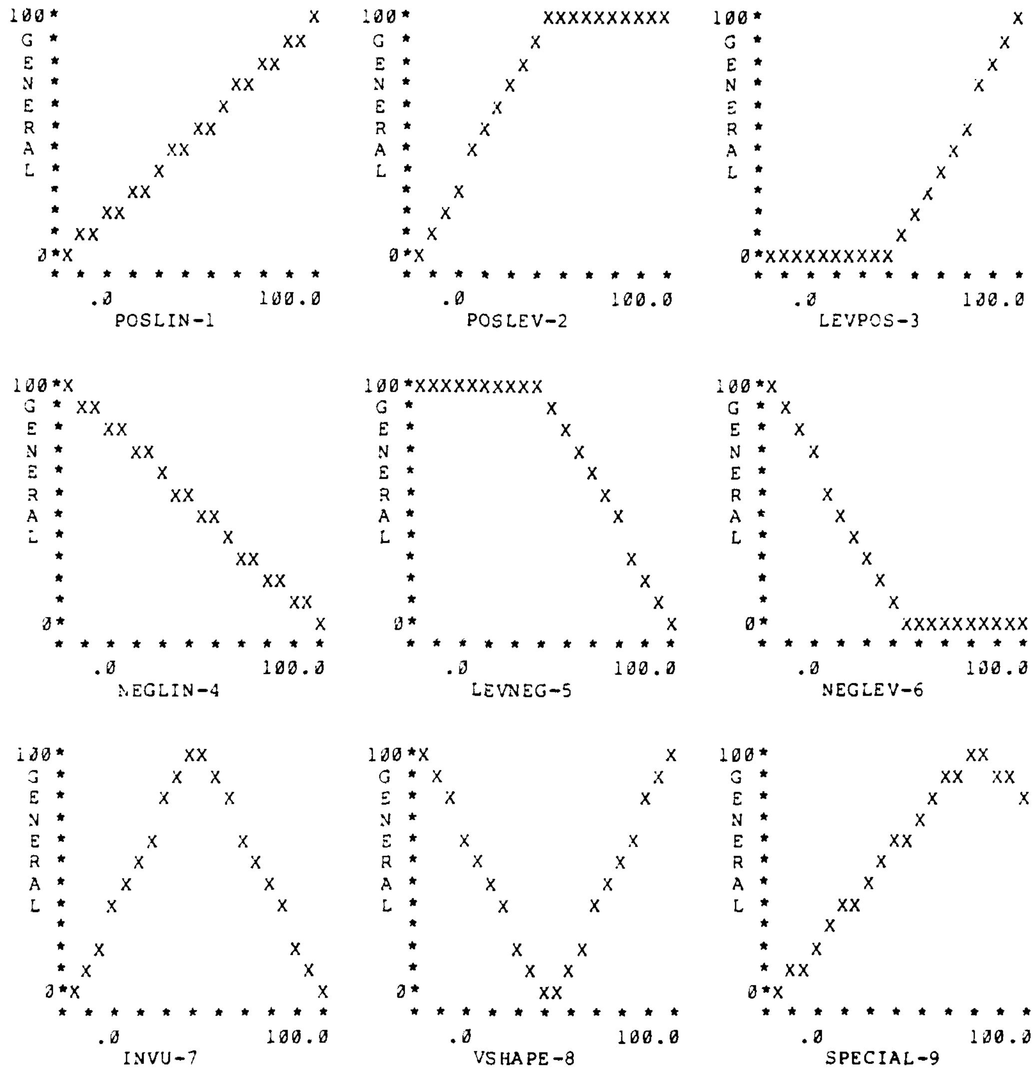
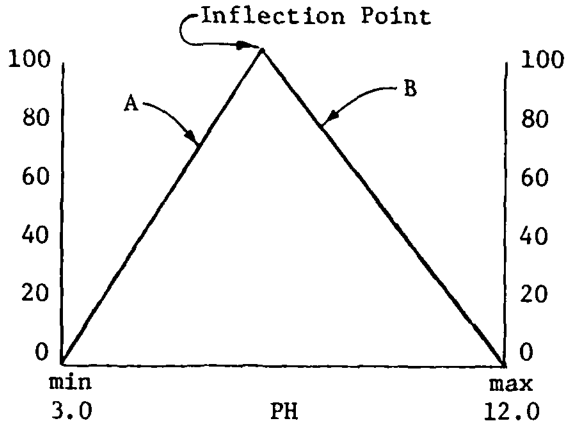


Figure 5.11. Standard functional relation forms




```
 WHAT IS THE SHAPE OF THE RELATIONSHIP BETWEEN PH AND CHEM?
I>special

 LEFTHAND INTERSECTION, INFLECTION POINT(X,Y), RIGHTHAND INTERSECTION?
I>0,7,100,12

 DO YOU WISH TO DISPLAY THE FORM?
I>y
 100*        XX
  C *       X  X
  H *           X
  E *      X     X
  M *     X       X
    *              X
    *    X          X
    *   X            X
    *  X              X
    *                  X
    * X                 X
   0*X
    * * * * * * * * * * *
      3.0            12.0
         PH
        (PH-UNIT    )

 VARIABLE                    FORM       LEFT-Y     INFL-X     INFL-Y    RIGHT-Y
 ------------------------------------------------------------------------------
 PH          (CHEM      )   SPECIAL        .00       7.00     100.00      12.00

 SATISFACTORY?
I>y
```

Figure 5.12. SPECIAL function form in interactive FORMS procedure

After the four numbers defining a SPECIAL function form have been entered, the program gives users the opportunity to display the form graphically. If users so desire, the form is printed, after which the program asks, "SATISFACTORY?" If the form is acceptable as printed, users answer "YES," and ESAP proceeds to the next variable for which a form is to be specified. If the form is not satisfactory, the program allows users to enter another set of four numbers, then asks if another display is desired. This process continues until users are satisfied with the shape of the form.

5.3.2.3 DISPLAY AND CHANGE OPTIONS. When forms have been specified for the appropriate variables, either from file or terminal, users are asked if a display of the forms is desired. If no display is requested, the FORMS procedure ends.

If a display is requested, users are asked to choose the format in which the forms are to be displayed. Two formats are available, graphic and tabular (see 5.3.4, below).

After the forms are printed, the program asks "ANY CHANGES?" If the forms are acceptable as printed, users reply "NO" and the FORMS procedure ends.

If changes are desired, the procedure enters the change option (Figure 5.13). The program asks for the names of a pair of variables and a new form name. The variable names may be in either of the two possible orders. The new form replaces the one displayed.

```
                 •
                 •
                 •
PH        (CHEM      )  SPECIAL     .00     7.00    100.00    12.00
DO        (CHEM      )  POSLIN      .30     6.00     50.00   100.00

ANY CHANGES?
I>y

ENTER VARIABLE PAIR, SHAPE OF RELATIONSHIP:
I>ph,chem,poslev

ENTER VARIABLE PAIR, SHAPE OF RELATIONSHIP:
I>fish,aqua/hab,neglin

ENTER VARIABLE PAIR, SHAPE OF RELATIONSHIP:
I>

FORMS SPECIFICATION COMPLETE.  DO YOU WISH TO DISPLAY THE FORMS?
I>n
```

Figure 5.13. Changing forms in interactive FORMS procedure

Once all changes are made, a carriage return is entered in response to the "ENTER VARIABLE PAIR, SHAPE OF RELATIONSHIP:" question. The procedure then exits the change option and users are asked if a display of the forms is desired. If a display is requested, the forms are printed in the desired format and the users are asked "ANY CHANGES?" If further changes are desired, the procedure reenters the change option and the process is repeated. If no display is requested, or if no changes are desired, the FORMS procedure ends.

5.3.2.4 FLOW DIAGRAM FOR INTERACTIVE FORMS PROCEDURE. A flow diagram describing use of the interactive FORMS procedure appears in Figure 5.14.

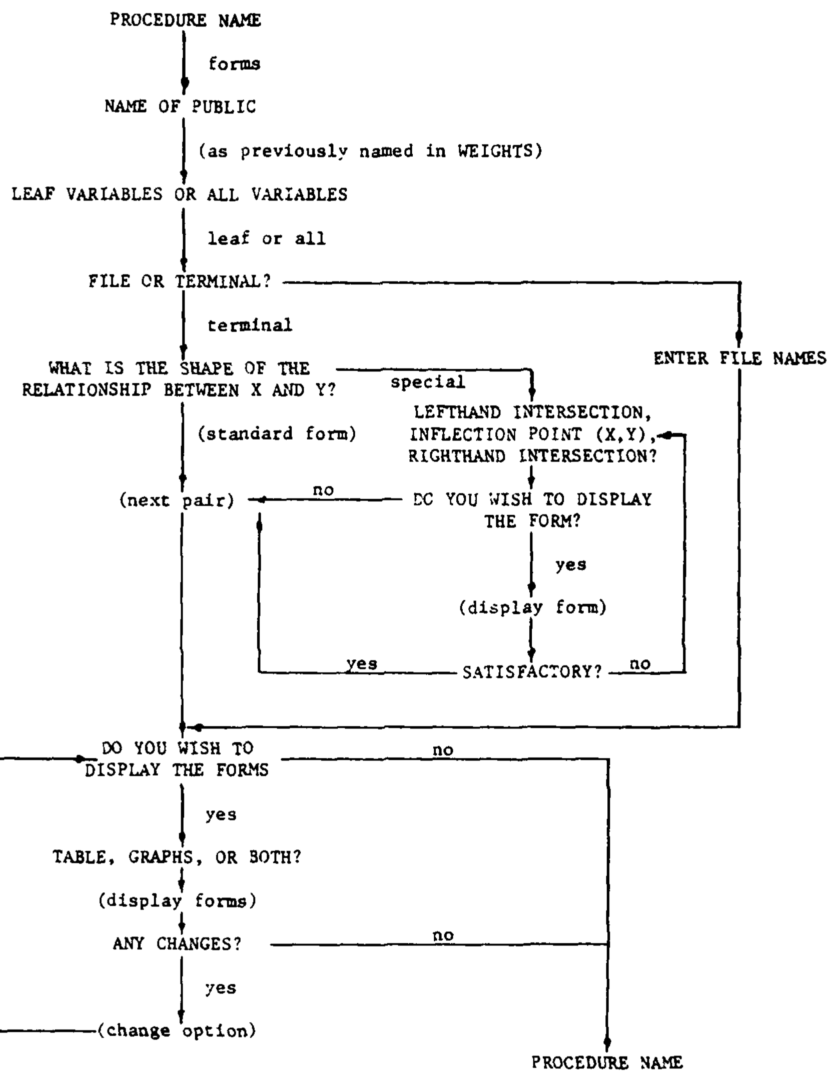


Figure 5.14. Flow diagram for interactive FORMS procedure

5.3.3 <u>BATCH FORMS PROCEDURE</u>

An example of input to the batch FORMS procedure is shown in Figure 5.15. The name of the public to which the forms belong is specified in columns 11-20 of the *FORMS card. Two additional options specify which variables are to be considered and the type of display desired.

The first *FORMS card option indicates the set of variables for which forms will be specified. The option is entered in columns 21-30 of the cards and may be either "ALL VARS" or "LEAF VARS." If "ALL VARS" is specified or if columns 21-30 are blank, then the ensuing cards must specify forms for all variables in the tree (except the root); if "LEAF VARS" is specified, then only leaf variables need be considered, and the program will supply positive linear function forms for all other variables. When the program is expecting only leaf variables, encountering a nonleaf variable in the input will cause the program to print a message and ignore the form specified for the variable.

The second *FORMS card option allows users to select the type of output format for the function forms display or to suppress the display altogether. The option is entered in columns 31-50. Available options are "PRINT GRAPHS," for graphs for all variables; "PRINT TABLES," for tabular output; and "SUPPRESS PRINTING," which will cause the printing of the function forms displays to be skipped, thus saving paper and time. The "SUPPRESS PRINTING" option is useful in cases where the output is not of interest to users, such as when only linear function

```
*FORMS    FARMERS   ALL VARS   PRINT GRAPHS
EQ
     TERRESTRAL
     1
          TERR/HAB
          1
               FOREST/HAB
               4
               CLEAR/HAB
               1
          TERR/ECOS
          1
               TER/SP/DV
               1
               WETLANDS
               4
          LAND/QUAL
          1
               FLOODS
               4
               SOIL/NUTR
               1
     AQUATIC
     1
          AQUA/HAB
          1
               FISH
               1
               RIPARIAN
               1
          WATERQUAL
          1
               PHYSICAL
               1
               .
               .
               .
               SITE/AREA
               4
               STRUCTURE
               1
          ARCHEOLOGIC
          1
               PRECOLUM
               4
               COLUMBIAN
               1
*END
+    +    +    +    +    +    +    +    +    +
1    6    11   16   21   26   31   36   41   46
```

Figure 5.15. Input to batch FORMS procedure

forms have been specified. If columns 31-40 are blank, the program behaves as though the "PRINT GRAPHS" option had been selected.

The remainder of the input cards to the FORMS procedure makes use of the cards created for the TREE procedure. Using duplicates of those cards, a card specifying a form for each variable is inserted after the card containing the name of that variable. If "LEAF VARS" has been selected, then the nonleaf variables should be omitted from the deck. A card containing the root variable name will be skipped if encountered by the procedure.

The function form information for a variable may begin in any column of the card but, as a matter of convention, usually starts in the same column as the variable name. The form is specified as an integer between 1 and 9, indicating the desired form, as described in Figure 5.11 (see 5.3.2.2). Unlike the interactive FORMS procedure, function forms MUST be identified by number, not by name, in the batch FORMS procedure.

For form number "9", the SPECIAL form, four additional numbers are required to specify the shape of the form (see 5.3.2.2). The four numbers are expected to be in fixed-length fields following the integer indicating the form number. The general rules for determining the correct columns for data entry are:

Column	Information
x	Form number
x + 5	Rating at minimum for variable (5 columns)
x + 10	Value of variable at inflection point (10 columns)
x + 20	Rating at inflection point (5 columns)
x + 25	Rating at maximum for variable (5 columns)

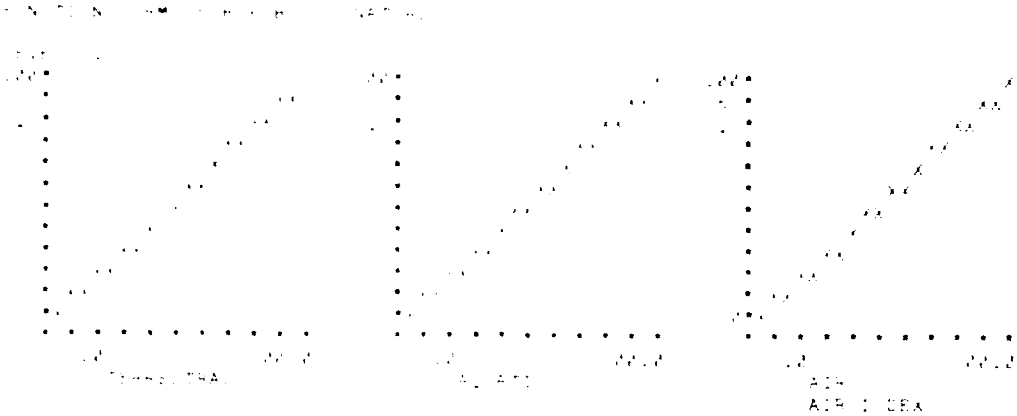
In the example in Figure 5.15, note that the card following variable PH has a "9" in column 21, while the rating at the minimum for PR starts in column 26 (21 + 5). The value of PR at the inflection point starts in column 31 (21 + 10), and the rating at the inflection point follows in column 41 (21 + 20). Finally, the rating at the maximum for PR starts in column 46 (21 + 25).

The last line of input to the batch FORMS procedure is the *END card. Upon encountering this line, the procedure prints out the forms in the desired format (or prints "FUNCTION FORMS SPECIFIED FOR PROBLEM : xxxxxxx" if printing is suppressed) and ends.

5.3.4 DISPLAY FROM FORMS PROCEDURE

Two types of displays are available from the FORMS procedure. The first type of these is graphic description of the functional relations between two variables, similar to those appearing in earlier examples in this chapter. These graphic displays are produced for every pair of variables that are directly connected with one another in the tree. The horizontal axis will always contain the more specific variable; the vertical axis will always contain the more general variable. An example of this type of display appears in Figure 5.16.

A potential disadvantage of graphic displays from the FORMS procedure is that they can require considerable processing time and substantial amounts of paper. The FORMS procedure therefore provides the option of displaying functional relationship curves in a numeric, tabular--rather than graphic--format. This option may be particularly useful in those analyses in which most of the functional relationship



[illegible] from FORM procedure

[illegible] linear, in reiterations of previous analyses, [illegible] the experienced user. An example of a display from this option appears in Figure 5.17. It provides the following information:

a. Name of the more specific variable (i.e., variable on the horizontal axis).

b. Name of the more general variable (i.e., variable on the vertical axis) in parentheses.

c. Name of the form (see Figure 5.11 for names of the nine standard forms).

d. Value of form on y-axis, at left-hand origin.

e. Value of variable on x-axis, at inflection point (all forms, even linear ones are described in terms of two connected straight lines).

f. Value of variable on y-axis, at inflection point.

g. Value of form on y-axis, at right-hand origin.

FUNCTION FORMS FOR PUBLIC: FARMERS

LEVEL: 1

VARIABLE		FORM	LEFT-Y	INFL-X	INFL-Y	RIGHT-Y
TERRESTRAL	(EQ)	POSLIN	.00	50.00	50.00	100.00
AQUATIC	(EQ)	POSLIN	.00	50.00	50.00	100.00
AIR	(EQ)	POSLIN	.00	250.00	50.00	100.00
HIST/RES	(EQ)	POSLIN	.00	50.00	50.00	100.00

LEVEL: 2

VARIABLE		FORM	LEFT-Y	INFL-X	INFL-Y	RIGHT-Y
TERR/HAB	(TERRESTRAL)	POSLIN	.00	50.00	50.00	100.00
TERR/ECOS	(TERRESTRAL)	POSLIN	.00	50.00	50.00	100.00
LAND/QUAL	(TERRESTRAL)	POSLIN	.00	50.00	50.00	100.00

VARIABLE		FORM	LEFT-Y	INFL-X	INFL-Y	RIGHT-Y
AQUA/HAB	(AQUATIC)	POSLIN	.00	50.00	50.00	100.00
WATERQUAL	(AQUATIC)	POSLIN	.00	50.00	50.00	100.00
AQUA/ECOS	(AQUATIC)	POSLIN	.00	50.00	50.00	100.00

VARIABLE		FORM	LEFT-Y	INFL-X	INFL-Y	RIGHT-Y
HISTORIC	(HIST/RES)	POSLIN	.00	50.00	50.00	100.00
ARCHEOLOGIC	(HIST/RES)	POSLIN	.00	50.00	50.00	100.00

LEVEL: 3

VARIABLE		FORM	LEFT-Y	INFL-X	INFL-Y	RIGHT-Y
FOREST/HAB	(TERR/HAB)	NEGLIN	100.00	48150.00	50.00	.00
CLEAR/HAB	(TERR/HAB)	POSLIN	.00	35000.00	50.00	100.00

•
•
•

Figure 5.17. Tabular display from FORMS procedure

5.4 PUBLICS PROCEDURE

The PUBLICS procedure enables users to identify each of the public groups for which a set of weights and forms has been specified. Up to a 10-character label and a 68-character description can be specified for each group. Constraints on space require that ESAP use no more than 10 characters to identify each public group in its displays. Such labels are frequently inadequate for identifying such groups unambiguously. The PUBLICS procedure allows users to construct a reference table in which each public group is identified by a one-line description.

5.4. INTERACTIVE PUBLIC PROCEDURES

The interactive PUBLICS procedure allows users to enter a one-line description for each public in the analysis. The program asks users for a description of the publics one at a time (Figure 5.18).

```
 ENTER PROCEDURE NAME:
I>publics
 ENTERING PUBLICS PROCEDURE.
 ENTER DESCRIPTION FOR FARMERS (68 CHAR. MAX.):
I>agriculturil interests, land owners
 ENTER DESCRIPTION FOR PRESRVATOR (68 CHAR. MAX.):
I>historical preservationists, historians, anthropologists
 ENTER DESCRIPTION FOR NATURE (68 CHAR. MAX.):
I>environmentalists, conservationists
```

Figure 5.18. Entering public group descriptions to interactive PUBLICS procedure

The description for a public may be up to 68 characters in length and may contain any of the characters A-Z, 0-9, and special characters:

+ - * / ( ) blank $ = [ ] : ; < > , .

If no description is desired for a public, users may enter a carriage return in response to the "ENTER DESCRIPTION FOR" question.

After the description has been entered for the last public, users are asked if a display of the descriptions is desired. If no display is requested, the PUBLICS procedure is ended.

If a display is requested, the descriptions are printed on the terminal in the form of a table (Figure 5.19). After the descriptions are printed, the program asks "ANY CHANGES?" If the descriptions are acceptable as printed, users reply "NO" and the PUBLICS procedure ends.

```
PUBLIC DESCRIPTION COMPLETE.  DO YOU WISH TO DISPLAY THE DESCRIPTIONS?
I>yes

PUBLICS PROCEDURE. DATE: 80/06/19. TIME: 16.49.06.


PUBLIC     DESCRIPTION
---------------------------------------------------------------------------
FARMERS    AGRICULTURIL INTERESTS, LAND OWNERS
PRESRVATOR HISTORICAL PRESERVATIONISTS, HISTORIANS, ANTHROPOLOGISTS
NATURE     ENVIRONMENTALISTS, CONSERVATIONISTS

ANY CHANGES?
I>yes

NAME OF PUBLIC:
I>farmers
ENTER DESCRIPTION FOR FARMERS (68 CHAR. MAX.):
I>agricultural interests, land owners

NAME OF PUBLIC:
I>

PUBLIC DESCRIPTION COMPLETE.  DO YOU WISH TO DISPLAY THE DESCRIPTIONS?
I>yes
```

Figure 5.19. Displaying and changing public group descriptions in interactive PUBLICS procedure

If changes are desired, the procedure enters the change option. The program asks for the name of a public and a new description for that public. The new description replaces the one printed in the table.

After all changes are made, a carriage return is entered in response to the "NAME OF PUBLIC" question. The procedure then exits the change option, and users are asked if a display of the descriptions is desired. If a display is requested, the descriptions are printed and the user is again asked "ANY CHANGES?" If further changes are desired, the program reenters the change option and the process is repeated. If no display is requested or if no changes are desired, the PUBLICS procedure ends.

5.4.2 BATCH PUBLICS PROCEDURE

The batch PUBLICS procedure accepts input in the form of a table, as shown in Figure 5.20. Each line (card) is in the format:

Column	Information
1-10	Public name, left-justified
11-78	Description of public

```
*PUBLICS
FARMERS   AGRICULTURAL INTERESTS, LAND OWNERS
PRESRVATORHISTORICAL PRESERVATIONISTS, HISTORIANS, ANTHROPOLOGISTS
NATURE    ENVIRONMENTALISTS, CONSERVATIONISTS
*END
+         +
1         11
```

Figure 5.20. Input to batch PUBLICS procedure

The publics may appear in any order. If a public is omitted from the table, its description is assumed to be blank.

The last card in the input is the *END card, indicating the end of the table. Upon reading the *END card, the procedure prints a table of descriptions, described below.

5.4.3 DISPLAYS FROM PUBLICS PROCEDURE

The PUBLICS procedure produces a table giving the name of each public and a one-line description. An example appears in Figure 5.21.

```
PUBLIC    DESCRIPTION
------------------------------------------------------------------------
FARMERS   AGRICULTURAL INTERESTS, LAND OWNERS
PRESRVATOR HISTORICAL PRESERVATIONISTS, HISTORIANS, ANTHROPOLOGISTS
NATURE    ENVIRONMENTALISTS, CONSERVATIONISTS
```

Figure 5.21. Example of display from PUBLICS procedure

6.0 ENTERING PROJECTIONS

6.1 INTRODUCTION

Two procedures are used for specifying the levels of variables that are projected to result if various alternatives are selected. The DATA procedure is used to specify point-estimate projections; the UNCERTAIN procedure is used to specify a range of projections. The ALTERNATIVES procedure enables users to create one-line descriptions of each alternative under evaluation.

ESAP does not aid users in developing projections of alternatives' effects on the variables included in the evaluation tree. These projections must be developed elsewhere on the basis of scientific or engineering analyses, simulation models, expert judgment, or whatever.

6.2 DATA PROCEDURE

The DATA procedure requires users to specify best available estimates of the projected levels of variables for each alternative under consideration. They should be regarded as the most probable level of that variable which would result from that particular alternative. These projections must be, of course, in the same metric as specified in the RANGES procedure and within the minimum and maximum levels specified in RANGES. Users identify each alternative by a 10-character label; for each alternative they specify the projected levels for all leaf variables or variables that are not further subdivided into more specific variables.

6.2.1 INTERACTIVE DATA PROCEDURE

The interactive DATA procedure gives users the choice of entering data values from the terminal or having the program read a file containing the data.

6.2.1.1 FILE ENTRY OPTION. Users are asked to enter the name of the file containing the data (Figure 6.1). This file is expected to be in the same format as required by the batch DATA procedure (see 6.2.2). Errors detected during the processing of this file cause a message consisting of (a) the line in error and (b) an

```
 ENTER PROCEDURE NAME:
I>data
 ENTERING DATA PROCEDURE.

 ARE THE DATA TO COME FROM A FILE OR THE TERMINAL?
I>file

 ENTER FILE NAME:
I>exdata


 DATA HAS BEEN READ FOR THE FOLLOWING ALTERNATIVES:
 ALT.1        ALT.2        ALT.3        ALT.4


 DO YOU WISH TO SPECIFY MORE ALTERNATIVES?
I>no

 DATA ENTRY COMPLETE.  DO YOU WISH TO DISPLAY THE DATA?
I>yes
```

Figure 6.1. Entering data from a file in interactive DATA procedure

explanation of the error to be printed at the terminal. Variables for which data values are missing or are in error cause the program to request values from users at the terminal.

If the file name specified is the same as previously used in other procedures, the program will continue reading from where the previous procedures ended.

After the data has been read, the program prints a message indicating the names of the alternatives for which data has been read, and asks if data for additional alternatives are to be entered. If this is the case, data for the additional alternatives are requested from users at the terminal (see 6.2.1.2).

6.2.1.2 TERMINAL ENTRY OPTION. For the terminal entry option, the DATA procedure first asks for the number of alternatives for which data are to be entered. Next, the program asks if standard alternative names are desired. Standard names are constructed by combining the phrase "ALT." with successive numbers, e.g., "ALT.3." If standard names are not acceptable, the user may enter descriptive names of 10 characters or less.

After names of alternatives have been specified, users have the option of entering data by variable or by alternative. In the BY VARIABLE option, ESAP requests data for every alternative for one leaf variable at a time. In the BY ALTERNATIVE option, data is requested for every leaf variable for one alternative at a time. Examples of entries for each option appear in Figure 6.2.

```
 ARE THE DATA TO COME FROM A FILE OR THE TERMINAL?
I>terminal

 HOW MANY ALTERNATIVES?
I>4

 ARE STANDARD NAMES (ALT.1, ALT.2,...) ACCEPTABLE?
I>yes

 DO YOU WISH TO ENTER THE DATA BY VARIABLE OR BY ALTERNATIVE?
I>variable
 FOR ALTERNATIVE ALT.1, VALUE FOR AIR:
I>300
 FOR ALTERNATIVE ALT.2, VALUE FOR AIR:
I>300
 FOR ALTERNATIVE ALT.3, VALUE FOR AIR:
I>300
 FOR ALTERNATIVE ALT.4, VALUE FOR AIR:
I>300
 FOR ALTERNATIV  ALT.1, VALUE FOR FOREST/HAB:
I>30000
 FOR ALTERNATIVE ALT.2, VALUE FOR FOREST/HAB:
I>40000
```

<u>a. Entering data by variable</u>

```
 ARE THE DATA TO COME FROM A FILE OR THE TERMINAL?
I>terminal

 HOW MANY ALTERNATIVES?
I>4

 ARE STANDARD NAMES (ALT.1, ALT.2,...) ACCEPTABLE?
I>yes

 DO YOU WISH TO ENTER THE DATA BY VARIABLE OR BY ALTERNATIVE?
I>alt
 FOR ALTERNATIVE ALT.1, VALUE FOR AIR:
I>300
 FOR ALTERNATIVE ALT.1, VALUE FOR FOREST/HAB:
I>30000
 FOR ALTERNATIVE ALT.1, VALUE FOR CLEAR/HAB:
I>45000
 FOR ALTERNATIVE ALT.1, VALUE FOR TER/SP/DV:
I>65
 FOR ALTERNATIVE ALT.1, VALUE FOR WETLANDS:
```

<u>b. Entering data by alternative</u>

Figure 6.2. Entering DATA in interactive DATA procedure by variable and by alternative

6.2.1.3 DISPLAY AND CHANGE OPTIONS. After data values have been obtained, either from the terminal or from a file, users are asked if a display of the data is desired. If no display is requested, the DATA procedure is ended.

If a display is requested, the data is displayed in a tabular format (Figure 6.3), after which the program asks "ANY CHANGES?" If the data is acceptable as printed, users reply "NO" and the DATA procedure ends.

If changes are desired, the procedure enters the change option. The program asks for an alternative name, a variable name, and a new data value. The new value replaces the one printed in the table for the variable and alternative specified.

After all changes have been made, a carriage return is entered in response to the "ENTER ALTERNATIVE, VARIABLE, VALUE" question. The procedure then exits the change option, and users are asked if a display of the data is desired. If a display is requested, the data are printed and users are asked "ANY CHANGES?" If further changes are desired, the procedure reenters the change option, and the process is repeated. If no display is requested or if no changes are desired, the DATA procedure ends.

6.2.1.4 FLOW DIAGRAM FOR INTERACTIVE DATA PROCEDURE. A flow diagram describing use of the interactive DATA procedure appears in Figure 6.4.

PRECISE DATA VALUES:

ALT.	AIR	FOREST/HAB	CLEAR/HAB	TER/SP/DV	WETLANDS	FLOODS
ALT.1	300.00	30000.00	45000.00	65.00	100.00	12000.00
ALT.2	300.00	40000.00	50000.00	70.00	35.00	45000.00
ALT.3	300.00	35000.00	45000.00	75.00	250.00	50000.00
ALT.4	300.00	65000.00	25000.00	80.00	300.00	60000.00

ALT.	SOIL/NUTR	FISH	RIPARIAN	AQ/SP/DV	AQ/PLNTS	SITE/AREA
ALT.1	.50	1000.00	35.00	75.00	250.00	4.00
ALT.2	.40	250.00	25.00	35.00	100.00	1.00
ALT.3	.47	800.00	20.00	65.00	190.00	2.00
ALT.4	.30	600.00	35.00	80.00	400.00	.00

ALT.	STRUCTURE	PRECOLUM	COLUMBIAN	TEMP	TURBID	PH
ALT.1	30.00	1.00	6.00	13.00	70.00	6.50
ALT.2	14.00	1.00	4.00	25.00	86.00	9.00
ALT.3	21.00	1.00	5.00	13.00	60.00	6.50
ALT.4	7.00	.00	2.00	14.00	75.00	6.50

ALT.	DO
ALT.1	8.00
ALT.2	8.00
ALT.3	8.00
ALT.4	7.00

```
ANY CHANGES?
I>yes

ENTER ALTERNATIVE, VARIABLE, VALUE:
I>alt.2,temp,22

ENTER ALTERNATIVE, VARIABLE, VALUE:
I>alt.2,do,6.5

ENTER ALTERNATIVE, VARIABLE, VALUE:
I>

DATA ENTRY COMPLETE.  DO YOU WISH TO DISPLAY THE DATA?
```

Figure 6.3. Displaying and changing data values in interactive DATA procedure

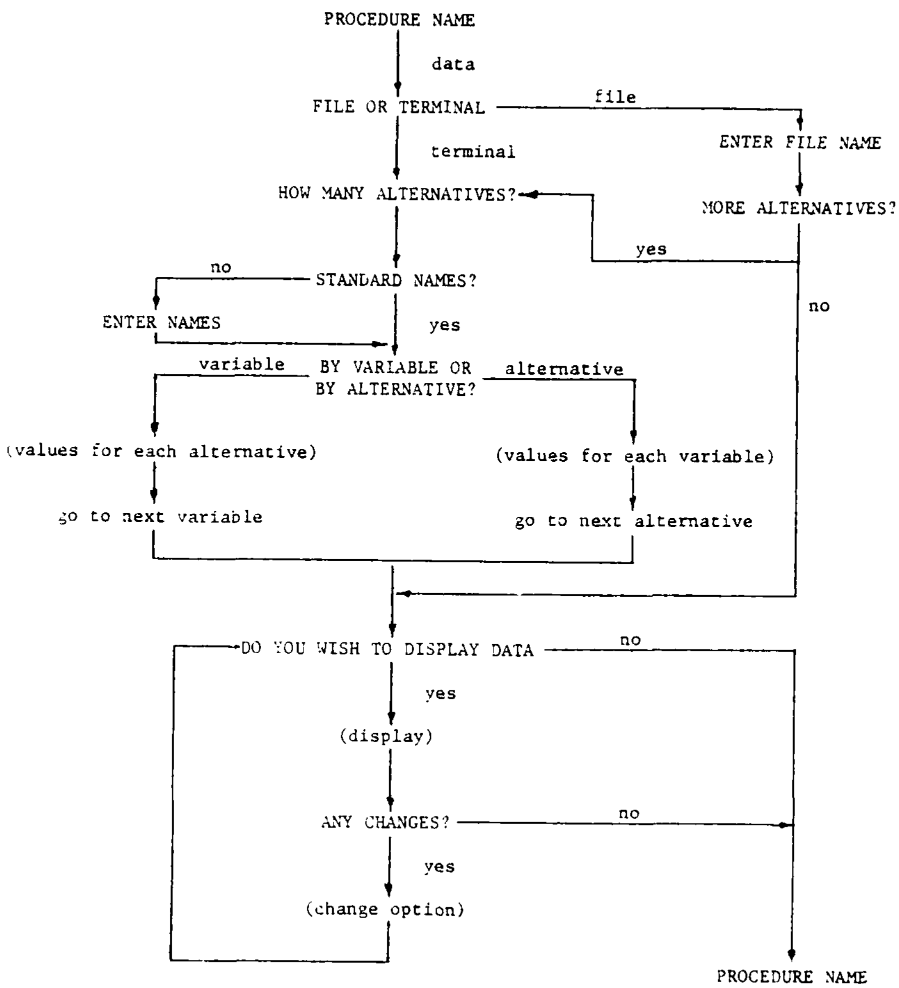


Figure 6.4. Flow diagram for interactive DATA procedure

6.2.2 BATCH DATA PROCEDURE

An example of the input to the batch DATA procedure is shown in Figure 6.5. The data values are entered in the form of one or more tables. Each table begins with a header card containing the names of the variables for which data values are being specified. The entries in the table are the data values for each of those variables, for the specified alternatives.

```
*DATA
ALT.      AIR       FOREST/HABCLEAR/HAB TER/SP/DV WETLANDS  FLOODS    SOIL/NUTR
ALT.1     300       30000     45000     65        100       12000     .5
ALT.2     300       40000     50000     70        35        45000     .4
ALT.3     300       35000     45000     75        250       50000     .47
ALT.4     300       65000     25000     80        300       60000     .3
ALT.      FISH      RIPARIAN  AQ/SP/DV  AQ/PLNTS  SITE/AREA STRUCTUREPRECOLUM
ALT.1     1000      35        75        250       4.00      30.00     1.00
ALT.2     250       25        35        100       1.00      14.00     1.00
ALT.3     800       20        65        190       2.00      21.00     1.00
ALT.4     600       35        80        400        .50       7.00      .00
ALT.      COLUMBIANTEMP       TURBID    PH        DO
ALT.1     6.00      13        70        6.5       8
ALT.2     4.00      22        86        9         6.5
ALT.3     5.00      13        60        6.5       8
ALT.4     2.00      14        75        6.5       7
*END
+         +         +         +         +         +         +         +
1         11        21        31        41        51        61        71
```

Figure 6.5. Input to batch DATA procedure

The header card for each table is broken up into eight 10-column fields. The first field (columns 1-10) contains the word "ALT." The remaining seven fields each contain the name of a leaf variable, left-justified.

The remaining cards in each table are also divided into eight fields of 10 columns each. The first field contains the name of the alternative to which the data values belong, left-justified. The remaining fields contain the data values for the variables named on the header card. The values may be located anywhere in the 10 columns allocated for the field. There should be a number in each field that has a variable name on the header card. Values of zero should be entered as "0" (not left blank).

Input to the DATA procedure may be divided up into as many tables as desired (or needed to hold the data values). There are three restrictions on the format of the input data:

a. The number of alternatives in the tables must be the same for all tables.

b. The names of the alternatives must be the same in all tables, but the order of alternatives is irrelevant.

c. Tables need not use all 7 fields for data values, but there must be no empty fields in the middle of the table. For example, it is permissible to use only the first 4 fields, but not fields 1-3 and 5-7.

The last line of input to the batch DATA procedure is the *END card. Upon encountering this line, the procedure prints out a table containing the data values (see 6.2.3) and ends.

6.2.3 DISPLAYS FROM DATA PROCEDURE

Displays from the DATA procedure echo data input from users. They consist of one or more tabular matrices in which the projected level of each variable is presented for each alternative. An example of a display from DATA appears in Figure 6.6.

6.3 UNCERTAIN PROCEDURE

The UNCERTAIN procedure permits users to specify a range of possible levels for variables. More often than not in water resources planning, the effects of alternative plans are impossible to project with

ALT.	AIR	FOREST HAB	CLEAR/HAB	TER SP DV	WETLANDS	FLOODS
ALT.1	300.00	50000.00	45000.00	65.00	100.00	[illegible]
ALT.2	300.00	40000.00	50000.00	70.00	25.00	45000.00
ALT.3	300.00	35000.00	45000.00	75.00	250.00	[illegible]
ALT.4	300.00	65000.00	15000.00	90.00	300.00	60000.00

ALT.	SOIL NUTR	FISH	RIPARIAN	AQ SP/DV	AQ/PLNTS	SITE/AREA
ALT.1	.50	1000.00	35.00	75.00	150.00	4.00
ALT.2	.40	250.00	25.00	35.00	100.00	1.00
ALT.3	.47	800.00	20.00	65.00	190.00	2.00
ALT.4	.30	600.00	35.00	80.00	400.00	.50

ALT.	STRUCTURE	PRECOLUM	COLUMBIAN	TEMP	TURBID	PH
ALT.1	30.00	1.00	6.00	13.00	70.00	5.50
ALT.2	14.00	1.00	4.00	22.00	56.00	9.00
ALT.3	21.00	1.00	5.00	13.00	60.00	6.50
ALT.4	7.00	.00	2.00	14.00	75.00	6.50

ALT.	DO
ALT.1	8.00
ALT.2	6.50
ALT.3	8.00
ALT.4	7.00

Figure 6.6. Display from DATA procedure

great certainty. Rather, a range of effects is possible. The UNCERTAIN procedure allows users to specify a range of levels within which the true level of each variable can be expected to fall, if a particular alternative were selected. This range can be thought of as analogous to a confidence interval. The UNCERTAIN procedure provides a number of options for specifying uncertainties in alternatives' projected effects on variables.

6.3.1 SPECIFICATION OF UNCERTAIN DATA

The information specified in the UNCERTAIN procedure is intended primarily for use in analyses concerning the degree to which alternatives' apparent desirabilities are in doubt because of uncertainties about their projected effects. Several guidelines for specifying UNCERTAIN data so that such analyses provide the most meaningful and useful possible results are discussed briefly below.

6.3.1.1 NEED FOR CONSISTENCY IN SPECIFICATIONS OF LOW AND HIGH VARIABLE LEVELS. The UNCERTAIN procedure requires users to specify a "LOW" and a "HIGH" value for each variable and every alternative. The LOW value should reflect the lowest plausible level of the variable, if a particular alternative were selected. The HIGH value should reflect the highest plausible level of the variable, if that particular alternative were selected. Different methods of defining and assigning the plausible levels of a variable can lead to quite different numbers for UNCERTAIN and, subsequently, to quite different analyses by EVALUATE and COMPARE.

Unfortunately, there are no hard-and-fast rules about precisely how one should go about defining and assigning lowest plausible and highest plausible levels. For users familiar with statistical theory, it might be useful to think of the specified range as defining the 95 percent confidence interval, the 80 percent confidence interval, or whatever. It might also be useful to think of the lower and upper limits as defining equal odds or bets. In other words, users might set the LOW and HIGH limits so that they believed there to be only a 1 in 10 chance that the true level would be lower than the LOW value or higher than the HIGH value.

Whatever method users choose to use for lower and upper limits for variables' levels, it is important that the method be applied consistently, across both alternatives and variables. Analyses conducted using UNCERTAIN data are concerned with such questions as "For which variables do uncertainties about projected effects have the greatest potential effect on alternatives' desirability scores?" and "for which alternatives are there the greatest uncertainties about their desirability?" The answers to such questions may be quite misleading if users are not consistent in their method for assigning upper and lower limits. For example, if the upper and lower limits of Variable X reflect a 95 percent confidence interval, while the upper and lower limits of Variable Y reflect a 60 percent confidence interval, then the analyses may indicate that Variable X is responsible for more uncertainty about the desirability of alternatives than is Variable Y, although that conclusion is a function of inconsistency in specifying upper and lower limits of uncertainty--not a function of the degree of uncertainty surrounding each variable per se.

6.3.1.2 TENDENCY TO UNDERESTIMATE UNCERTAINTY. Users of the UNCERTAIN procedure should be aware that a substantial body of psychological research indicates that most individuals tend to underestimate uncertainties, often by a substantial margin. Events that individuals estimate to have only a 1 in 20 chance of occurrence may have actual odds of 1 to 3 or 1 to 4. On the basis of such evidence, it is probably good advice for users to err on the side of what they believe to be overestimating uncertainty.

6.3.1.3 FLAT DISTRIBUTION OF UNCERTAINTY. Users with a more quantitative orientation may be curious about assumptions in ESAP concerning the shape of the distributions describing variables' potential levels, between the upper and lower limits specified in UNCERTAIN. The answer, in brief, is that the distribution is treated as if it were flat, or rectangular. This assumption will almost always be erroneous, but it is adopted for two reasons. First, in many cases users may not be able to describe the distribution any more precisely. Second, incorporating information about variables' distributions into the computations of the EVALUATE and COMPARE procedures would have greatly increased the complexity of the program, as well as the time and expense required for its use, while decreasing its capacity in terms of the number of alternatives, variables, and public groups that could be simultaneously considered.

6.3.2 INTERACTIVE UNCERTAIN PROCEDURE

The interactive UNCERTAIN procedure gives users the choice of creating uncertain data from the terminal or having the program read a file.

6.3.2.1 FILE ENTRY OPTION. The user is asked to enter the name of the file containing the data (Figure 6.7). This file is

```
 ENTER PROCEDURE NAME:
I>uncertain
 ENTERING UNCERTAIN PROCEDURE.

 DO YOU WISH TO READ UNCERTAIN DATA FROM A FILE?
I>y

 ENTER FILE NAME:
I>exunc


 UNCERTAIN DATA CREATED.  DO YOU WISH TO DISPLAY THE DATA?
I>yes
```

Figure 6.7. Reading uncertain data from a file in interactive UNCERTAIN procedure

expected to be in the same format as required by the *SPECIFY option of the batch UNCERTAIN procedure (see 6.3.3). Errors detected during the processing of this file cause a message consisting of (a) the line in error and (b) an explanation of the error to be printed at the terminal. Variables for which data values are missing or are in error cause the program to request new values from users at the terminal.

If the file name specified is the same as previously used in another procedure, the program will continue reading from where the previous procedure ended.

6.3.2.2 TERMINAL ENTRY OPTION. In the *terminal entry* option, users have the choice of creating uncertain data by variables or by alternative. In the BY VARIABLE option, users specify the uncertain data values for a particular variable for each alternative, then proceed to the next variable. In the BY ALTERNATIVE option, users specify the uncertain data values for a particular alternative for each variable, then proceed to the next alternative. See Figure 6.8 for an example of creating uncertain data by variable; see Figure 6.9 for an example of creating uncertain data by alternative.

Uncertain data values can be entered by the user at the terminal by means of four options: SPECIFY, PERCENT, CONSTANT, and SPAN. Each is described briefly in turn.

The SPECIFY option allows users to enter specific values for variables' LOW and HIGH uncertain data values. These may be entered in a list following the option name, e.g., "specify, 15, 30," or only "specify" may be entered, in which case the program will prompt for the necessary values. Note that the SPECIFY option allows the user to be very exact about the values entered for the particular variable or alternative being considered.

The PERCENT option creates data values from the precise data values, plus and minus the percentage indicated by the user. For example, if "percent, 10" is specified, the LOW value will be equal to the precise value minus 10 percent, and the HIGH value will be equal to the precise value plus 10 percent. This results in an uncertainty factor of 20 percent. Computed values that fall outside the range for a variable are replaced with the minimum or maximum value allowed for the variable.

The CONSTANT option creates data values computed from the precise data values plus and minus the constant indicated by the user. For example, if "constant, 10" is specified, the LOW value will be equal to the precise value minus 10 units, and the HIGH value will be equal to

```
DO YOU WISH TO ENTER THE DATA BY VARIABLE OR BY ALTERNATIVE?
I>var

OPTION FOR AIR?
I>percent,10

OPTION FOR FOREST/HAB?
I>constant,5

OPTION FOR CLEAR/HAB?
I>span

OPTION FOR TER/SP/DV?
I>specify
FOR ALTERNATIVE ALT.1, LOW VALUE FOR TER/SP/DV:
I>20
FOR ALTERNATIVE ALT.1, HIGH VALUE FOR TER/SP/DV:
I>60
FOR ALTERNATIVE ALT.2, LOW VALUE FOR TER/SP/DV:
I>10
FOR ALTERNATIVE ALT.2, HIGH VALUE FOR TER/SP/DV:
I>80
FOR ALTERNATIVE ALT.3, LOW VALUE FOR TER/SP/DV:
I>30
FOR ALTERNATIVE ALT.3, HIGH VALUE FOR TER/SP/DV:
I>50
FOR ALTERNATIVE ALT.4, LOW VALUE FOR TER/SP/DV:
I>40
FOR ALTERNATIVE ALT.4, HIGH VALUE FOR TER/SP/DV:
I>40

OPTION FOR WETLANDS?
                              •
                              •
                              •
OPTION FOR AQ/SP/DV?
I>altern

OPTION FOR ALT.1?
I>percent,10

OPTION FOR ALT.2?
I>span

OPTION FOR ALT.3?
I>constant,30

OPTION FOR ALT.4?
I>spec
FOR ALTERNATIVE ALT.4, LOW VALUE FOR AQ/SP/DV:
I>20
FOR ALTERNATIVE ALT.4, HIGH VALUE FOR AQ/SP/DV:
I>80

OPTION FOR AQ/PLNTS?
I>perc,20
```

Figure 6.8. Creating uncertain data by variable in interactive UNCERTAIN procedure

```
 DO YOU WISH TO READ UNCERTAIN DATA FROM A FILE?
I>no

 DO YOU WISH TO ENTER THE DATA BY VARIABLE OR BY ALTERNATIVE?
I>alt

 OPTION FOR ALT.1?
I>percent,5

 OPTION FOR ALT.2?
I>var

 OPTION FOR AIR?
I>percent,10

 OPTION FOR FOREST/HAB?
I>span

 OPTION FOR CLEAR/HAB?
I>constant,200

 OPTION FOR TER/SP/DV?
I>constant,10

 OPTION FOR WETLANDS?
                    •
                    •
                    •
 OPTION FOR ALT.3?
I>specify
 FOR ALTERNATIVE ALT.3, LOW VALUE FOR AIR:
I>10
 FOR ALTERNATIVE ALT.3, HIGH VALUE FOR AIR:
I>450
 FOR ALTERNATIVE ALT.3, LOW VALUE FOR FOREST/HAB:
I>27500
 FOR ALTERNATIVE ALT.3, HIGH VALUE FOR FOREST/HAB:
I>70000
 FOR ALTERNATIVE ALT.3, LOW VALUE FOR CLEAR/HAB:
                    •
                    •
                    •
 OPTION FOR ALT.4?
I>span
```

Figure 6.9. Creating uncertain data by alternative in interactive UNCERTAIN procedure

the precise value plus 10 units. This results in an uncertainty factor of 20 units. Computed values outside the specified range for a variable are replaced with the minimum or maximum value for the variable.

The SPAN option uses the minimum and maximum range values for the low and high uncertain data values. For example, if a variable's range is 0 to 100, the LOW value will be 0, and the HIGH value will be 100.

In most cases, entering uncertain data will be most easily accomplished using either the BY VARIABLE or BY ALTERNATIVE method for all data. Sometimes, however, it may be desirable to create most of the data using one method but switch to the other for a few variables or alternatives. An example of such a situation is shown in Figure 6.8. In this instance, the user chose to consider the variables one at a time, creating the uncertain data on the basis of the uncertainty in the measurement process for each variable and assuming that the uncertainty was the same for all alternatives.

For variable AQ/SP/DV, however, the uncertainty in the measurements varies according to the alternative. In order to create uncertain data for this variable, the user enters "ALTERN." in response to the "OPTION FOR AQ/SP/DV?" question. The program then responds by asking for a data creation option for each alternative (i.e., SPECIFY, SPAN, PERCENT, CONSTANT).

When uncertain data is being created by alternative, there is an option which is analogous to the ALTERN. option, called the VARIABLE option. This allows the user to enter uncertainty options for individual variables when in the ALTERNATIVE mode.

6.3.2.3 DISPLAY AND CHANGE OPTIONS. After uncertain data have been created, either at the terminal or by reading a file, users are asked if a display of the data is desired. If no display is requested, the UNCERTAIN procedure is ended.

If a display is requested, the data is displayed in a tabular format (see 6.3.2.4 below), after which the program asks "ANY CHANGES?" If the data is acceptable as printed, users reply "NO" and the UNCERTAIN procedure ends.

If changes are desired, the procedure enters the change option (Figure 6.10). The program asks for an alternative name, a variable name, and an option for creating uncertain data. To accomplish the same result as the BY VARIABLE and BY ALTERNATIVE options, either (but not both) of the names may be "all," indicating all variables or alternatives. For example, in Figure 6.10, to create an uncertainty range of 20 percent for DAY across all alternatives, the user enters "all, day, percent, 10."

After all changes are made, a carriage return is entered in response to the "ALTERNATIVE NAME, VARIABLE NAME, OPTION" question. The procedure then exits the change option and users are again asked if a display of the data is desired. If a display is requested, the data are printed and users are asked "ANY CHANGES?" If further changes are desired, the procedure reenters the change option and the process is repeated. If no display is requested or if no changes are desired, the UNCERTAIN procedure ends.

•
•
•

```
ALT.1
LOW            6.40
HIGH           9.60
ALT.2
LOW            5.20
HIGH           7.80
ALT.3
LOW            6.40
HIGH           9.60
ALT.4
LOW            5.60
HIGH           8.40

ANY CHANGES?
I>yes

ALTERNATIVE NAME, VARIABLE NAME, OPTION:
I>alt.4,ph,per,10

ALTERNATIVE NAME, VARIABLE NAME, OPTION:
I>all,day,per,10

ALTERNATIVE NAME, VARIABLE NAME, OPTION:
I>

UNCERTAIN DATA CREATED.  DO YOU WISH TO DISPLAY THE DATA?
I>yes
```

Figure 6.10. Changing uncertain data in interactive UNCERTAIN procedure

6.3.2.4 FLOW DIAGRAM FOR INTERACTIVE UNCERTAIN PROCEDURE. A flow diagram describing use of the interactive UNCERTAIN procedure appears in Figure 6.11.

6.3.3 BATCH UNCERTAIN PROCEDURE

Examples of input to the batch UNCERTAIN procedure appear in Figure 6.12. The option for creating uncertain data is indicated on

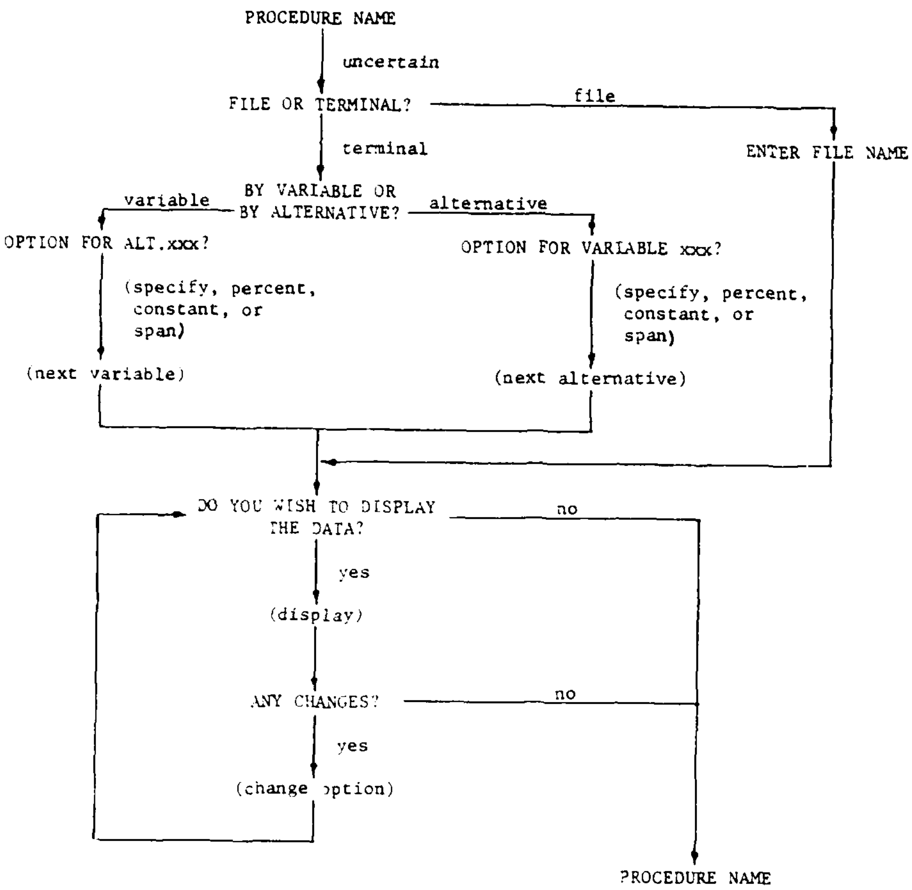


Figure 6.11. Flow diagram for interactive UNCERTAIN procedure

```
*UNCERTAIN
*SPECIFY
ALT.      AIR       FOREST/HABCLEAR/HAB TER/SP/DV WETLANDS  FLOODS    SOIL/NUTR
ALT.1
LOW       27Ø       29995     15ØØØ     2Ø        5Ø        114ØØ     .48
HIGH      33Ø       3ØØØ5     55ØØØ     7Ø        15Ø       126ØØ     .52
ALT.2
LOW       27Ø       39995     15ØØØ     1Ø        Ø         4275Ø     .38
HIGH      33Ø       4ØØØ5     55ØØØ     8Ø        85        4725Ø     .42
ALT.3
LOW       27Ø       34995     15ØØØ     3Ø        2ØØ       475ØØ     .45
HIGH      33Ø       35ØØ5     55ØØØ     8Ø        3ØØ       525ØØ     .49
ALT.4
LOW       27Ø       64995     15ØØØ     4Ø        25Ø       57ØØØ     .29
HIGH      33Ø       65ØØ5     55ØØØ     85        35Ø       63ØØØ     .32
ALT.      FISH      RIPARIAN  AQ/SP/DV  AQ/PLNTS  SITE/AREA STRUCTURE PRECOLUM
ALT.1
LOW       9ØØ       2Ø        67.5      2ØØ       Ø         Ø         Ø
HIGH      11ØØ      45        82.5      3ØØ       4.ØØ      3Ø.ØØ     1.ØØ
ALT.2
LOW       15Ø       2Ø        Ø         8Ø        Ø         Ø         Ø
HIGH      35Ø       45        1ØØ       12Ø       1.ØØ      14.ØØ     1.ØØ
ALT.3
LOW       7ØØ       2Ø        35        152       Ø         Ø         Ø
HIGH      9ØØ       45        95        228       2.ØØ      21.ØØ     1.ØØ
ALT.4
LOW       5ØØ       2Ø        2Ø        32Ø       Ø         Ø         Ø
HIGH      7ØØ       45        8Ø        4ØØ       Ø.5       7.ØØ      6.ØØ
ALT.      COLUMBIAN TEMP      TURBID    PH        DO
ALT.1
LOW       Ø         3         63        6.18      6.4
HIGH      6.ØØ      23        77        6.82      9.6
ALT.2
LOW       Ø         12        77.4      8.55      5.2
HIGH      4.ØØ      3Ø        94.6      9.45      7.8
ALT.3
LOW       Ø         3         54        6.18      6.4
HIGH      5.ØØ      23        66        6.82      9.6
ALT.4
LOW       Ø         4         67.5      6.18      5.6
HIGH      2.ØØ      24        82.5      6.82      8.4
*END
+         +         +         +         +         +         +         +
1         11        21        31        41        51        61        71
```

a. *SPECIFY option

```
*UNCERTAIN
*PERCENT  1Ø
+         +
1         11
```

b. *PERCENT option

```
*UNCERTAIN
*SPAN RANGE
+         +
1         11
```

c. *SPAN RANGE option

Figure 6.12. Input to batch UNCERTAIN procedure for *SPECIFY, *PERCENT, and *SPAN RANGE options

the card following the *UNCERTAIN card, in columns 1-10. There are three options available: *SPECIFY, *PERCENT, and *SPAN RANGE.

6.3.3.1 *SPECIFY OPTION. The *SPECIFY option (Figure 6.12a) allows users to enter the desired values for uncertain data in a series of tables similar to the input to the batch DATA procedure. Each table starts with a header card containing the names of the variables for which uncertain data values are being specified. The entries in the table are the low and high uncertain data values for the specified alternatives.

The header card for each table is divided into eight 10-column fields. The first field (columns 1-10) contains the word "ALT." The remaining seven fields each contain the name of a leaf variable, left-justified.

The low and high uncertain data values are specified for one alternative at a time. The name of the alternative is placed on a line by itself left-justified in columns 1-10. Following this card are two cards that contain the low and high uncertain data values for the variables specified in the header card. The cards are divided into eight 10-column fields, like the header card. The first field contains the word "LOW" or "HIGH," indicating which data values are on the card. The remaining seven fields contain the (low or high) uncertain data values for the variables named on the header card. The order of the cards is not important, as the program will read the first field to determine whether the values that follow are the "LOW" or "HIGH" values.

Note that there should be a number in each field that has a variable name on the header card. The value zero should be entered as "0", not left blank.

The input to the *SPECIFY option may be divided into as many tables as desired or needed to hold the data values. There are three restrictions on the format of the input data:

a. The number of alternatives in the tables must be the same as the number of alternatives created in the DATA procedure.

b. The names of the alternatives must be the same as those used in the DATA procedure, but the order is irrelevant.

c. Tables need not use all seven fields for data values, but there must be no empty fields in the middle of the table. For example, it is permissible to use only the first four fields, but not fields 1-3 and 5-7.

The last line of input to the *SPECIFY option of the batch UNCERTAIN procedure is the *END card. Upon encountering this line, the procedure prints out a table containing the data values (see 6.3.4) and ends.

6.3.3.2 *PERCENT OPTION. The *PERCENT option (Figure 6.12b) allows users to create uncertain data that vary from the precise data by a percentage specified in columns 11-15 of the *PERCENT card. For example, if a percentage of 10 is specified, the LOW data values are computed from the precise values minus 10 percent, and the HIGH values are computed from the precise values plus 10 percent, for an uncertainty factor of 20 percent. This range applies to all variables and alternatives. After the data is created, a table of data values (see 6.3.4) is printed and the procedure ends.

6.3.3.3 *SPAN RANGE OPTION. The *SPAN RANGE option (Figure 6.12c) creates uncertain data using the minimum and maximum values for all leaf variables, for all alternatives. Once the data is created, a table of data values (see 6.3.4) is printed, and the procedure ends.

6.3.4 DISPLAYS FROM UNCERTAIN PROCEDURE

Displays from the UNCERTAIN procedure are similar to the displays produced by the DATA procedure. These displays "echo" the data input from users. They consist of one or more tables in which the column headings consist of variable names. There are three rows for each alternative--a row identifying the alternative, a row containing the LOW values specified by the user for each variable, and a row containing the HIGH values for each variable. An example of a display from the UNCERTAIN procedure appears in Figure 6.13.

ALT.	AIR	FOREST/HAB	CLEAR/HAB	TER/SP/DV	WETLANDS	FLOODS
ALT.1						
LOW	270.00	29995.00	15000.00	20.00	50.00	11400.00
HIGH	330.00	30005.00	55000.00	70.00	150.00	12600.00
ALT.2						
LOW	270.00	39995.00	15000.00	10.00	.00	42750.00
HIGH	330.00	40005.00	55000.00	80.00	85.00	47250.00
ALT.3						
LOW	270.00	34995.00	15000.00	30.00	200.00	47500.00
HIGH	330.00	35005.00	55000.00	80.00	300.00	52500.00
ALT.4						
LOW	270.00	64995.00	15000.00	40.00	250.00	57000.00
HIGH	330.00	65005.00	55000.00	85.00	350.00	63000.00

Figure 6.13. Example of display from UNCERTAIN procedure

6.4 ALTERNS. PROCEDURE

The ALTERNS. procedure enables users to specify a one-line description for every alternative included in the analyses. The DATA and UNCERTAIN procedures, as well as in all other procedures in ESAP, can use no more than 10 characters in displays to identify any alternative because of space limitations. Since it is frequently the case that alternatives cannot be adequately and unambiguously defined by a 10-character label, the ALTERNS. procedure allows users to construct a dictionary, or reference table, in which each alternative is described in greater detail.

6.4.1 INTERACTIVE ALTERNS. PROCEDURE

The interactive ALTERNS. procedure allows users to enter a short one-line description for each alternative in the analysis. ESAP asks users for descriptions of the alternatives one at a time, as illustrated in Figure 6.14.

```
 ENTER PROCEDURE NAME:
I>alterns
 ENTERING ALTERNS. PROCEDURE.
 ENTER DESCRIPTION FOR ALT.1 (68 CHAR. MAX.):
I>reservoir w/rec. facilities, managed fish and wildlife habitat
 ENTER DESCRIPTION FOR ALT.2 (68 CHAR. MAX.):
I>channelization of tributaries
 ENTER DESCRIPTION FOR ALT.3 (68 CHAR. MAX.):
I>dams across tributaries
 ENTER DESCRIPTION FOR ALT.4 (68 CHAR. MAX.):
I>no actions
```

Figure 6.14. Entering alternative descriptions in interactive ALTERNS. procedure

The description for an alternative may be up to 68 characters in length and may contain any of the characters A-Z, 0-9, and special characters:

+ - * / ( ) [illegible] $ = [ ] : ; < [illegible] , .

If no description is desired for an alternative, users may enter a carriage return in response to the "ENTER DESCRIPTION FOR" question.

After the description has been entered for the last alternative, users are asked if a display of the descriptions is desired. If no display is requested, the ALTERNS. procedure is ended.

If a display is requested, the descriptions are printed on the terminal in the form of a table (Figure 6.15). After the descriptions are printed, the program asks "ANY CHANGES?" If the descriptions are acceptable as printed, users reply "NO" and the ALTERNS. procedure ends.

```
 ALTERNATIVE DESCRIPTION COMPLETE.  DO YOU WISH TO DISPLAY THE DESCRIPTIONS?
I>yes

 ALTERNS. PROCEDURE. DATE: 80/06/19. TIME: 17.32.32.


 ALTERN.    DESCRIPTION
 ---------------------------------------------------------------------------
 ALT.1      RESERVOIR W/REC. FACILITIES, MANAGED FISH AND WILDLIFE HABITAT
 ALT.2      CHANNELIZATION OF TRIBUTARIES
 ALT.3      DAMS ACROSS TRIBUTARIES
 ALT.4      NO AACTIONS


 ANY CHANGES?
I>yes

 NAME OF ALTERNATIVE:
I>alt.4
 ENTER DESCRIPTION FOR ALT.4 (68 CHAR. MAX.):
I>no action

 NAME OF ALTERNATIVE:
I>

 ALTERNATIVE DESCRIPTION COMPLETE.  DO YOU WISH TO DISPLAY THE DESCRIPTIONS?
I>yes
```

Figure 6.15. Displaying and changing alternative descriptions in Interactive ALTERNS. procedure

If changes are desired, the procedure enters the change option. The change option asks users to specify the name of the alternative and its new description. The new description replaces the one originally printed in the table.

After all changes are made, a carriage return is entered in response to the "NAME OF ALTERNATIVE" question. The procedure then exits the change option and users are asked if a display of the descriptions is desired. If a display is requested, the descriptions are printed and users are again asked "ANY CHANGES?" If further changes are desired, the program reenters the change option and the process is repeated. If no display is requested or if no changes are desired, the ALTERNS. procedure ends.

6.4.2 BATCH ALTERNS. PROCEDURE

The batch ALTERNS. procedure accepts input in the form of a table, as shown in Figure 6.16. Each line (card) is in the format:

Column	Information
1-10	Alternative name, left-justified
11-78	Description of alternative

```
*ALTERNS.
ALT.1     RESERVOIR W/REC. FACILITIES, MANAGED FISH AND WILDLIFE HABITAT
ALT.2     CHANNELIZATION OF TRIBUTARIES
ALT.3     DAMS ACROSS TRIBUTARIES
ALT.4     NO ACTION
*END
+         +
1         11
```

Figure 6.16. Input to batch ALTERNS. procedure

The alternatives may be in any order. If an alternative is omitted from the table, its description is assumed to be blank.

The last card in the input is the *END card, indicating the end of the table. Upon reading the *END card, the procedure displays a table of descriptions, described below (6.4.3).

6.4.3 DISPLAYS FROM ALTERNS. PROCEDURE

Displays from the ALTERNS. procedure echo inputs from users. The display consists of a table listing each ALTERNS. and its DESCRIPTION. An example appears in Figure 6.17.

ALTERN.	DESCRIPTION
ALT.1	RESERVOIR W/ REC. FACILITIES, MANAGED FISH AND WILDLIFE HABITAT
ALT.2	CHANNELIZATION OF TRIBUTARIES
ALT.3	DAMS ACROSS TRIBUTARIES
ALT.4	NO ACTION

Figure 6.17. Display from ALTERNS. procedure

7.0 EVALUATING ALTERNATIVES

7.1 INTRODUCTION

The construction of a hierarchy describing the water resources evaluation problem (through use of the TREE procedure), the specification of public values and preferences (by the WEIGHTS and FORMS procedure), and the specification of projected effects of alternative plans (by the DATA and UNCERTAIN procedures) are all preparatory to evaluation of the overall desirability of the various alternatives competing for selection as the recommended water resources management plan. The purpose of the EVALUATE procedure is to combine and integrate information about public values (from WEIGHTS and FORMS) with the facts about the effects of alternatives (from DATA and UNCERTAIN) in a systematic and analytical fashion (as prescribed by TREE), in order to analyze how well the various alternatives satisfy public values. In short, EVALUATE is intended to analyze in a clear and explicit fashion which alternatives are most desirable and why.

The EVALUATE procedure is designed for use with one PUBLIC at a time, although analyses can obviously be repeated with multiple groups. EVALUATE can be used with either the PRECISE data values specified in DATA or the UNCERTAIN data values specified in the procedure of the same name. Use of EVALUATE with each type of data will be discussed separately. A discussion of the formulae which EVALUATE uses to combine values and facts into an evaluation of the desirability of alternatives appears in Appendix D.

7.2 INTERACTIVE EVALUATE PROCEDURE

The interactive EVALUATE procedure begins by asking users to identify (a) the name of the public that is to evaluate the data and (b) the type of data (precise or uncertain) to be evaluated (Figure 7.1).

```
 ENTER PROCEDURE NAME:
I>evaluate
 ENTERING EVALUATE PROCEDURE.

 NAME OF PUBLIC?
I>farmers

 PRECISE OR UNCERTAIN DATA?
I>p
 PRECISE DATA BEING EVALUATED FOR PUBLIC FARMERS.
```

Figure 7.1. Initial input to interactive EVALUATE procedure

Next, users have the choice of operating the program in either guide or expert mode. The guide mode is intended for first-time or novice users, who may not be certain about which displays are most useful. The expert mode is intended for users who are more familiar with ESAP and know which displays are desired. Guide mode does not permit users to obtain all the displays from the options available in EVALUATE; expert mode does. The operation of each mode is discussed below.

7.2.1 GUIDE MODE

In guide mode (Figure 7.2), EVALUATE first prints a display of the overall scores given each alternative (see OPTION 1, OVERALL SCORES, for precise and uncertain data, 7.4.1.1 and 7.4.2.1, below).

```
 GUIDE OR EXPERT MODE?
I>guide

 EVALUATE PROCEDURE. PRECISE DATA. OPTION 1:  OVERALL SCORES.
 DATE: 80/06/19. TIME: 17.39.35.


 PUBLIC: FARMERS
 OVERALL SCORES

                                 OVERALL SCORE
              0   10   20   30   40   50   60   70   80   90  100
 ALT.         +----+----+----+----+----+----+----+----+----+----+     VALUE
 ALT.1                                        *                       64.9
 ALT.3                                  *                             53.4
 ALT.2                                 *                              51.9
 ALT.4                            *                                   43.3

 DO YOU WISH TO DISPLAY OVERALL SCORES RELATIVE TO A PARTICULAR ALTERNATIVE?
I>yes

 WHICH ALTERNATIVE?
I>alt.4

 EVALUATE PROCEDURE. PRECISE DATA. OPTION 2:  OVERALL SCORES RELATIVE.
 DATE: 80/06/19. TIME: 17.39.35.


 PUBLIC: FARMERS
 OVERALL SCORES RELATIVE TO ALTERNATIVE ALT.4

                     OVERALL SCORE RELATIVE TO ALTERNATIVE ALT.4
          -30  -20  -10    0   10   20   30   40   50   60   70   80
 ALT.         +----+----+----+----+----+----+----+----+----+----+----+     VALUE
 ALT.1                              *                                      21.6
 ALT.3                        *                                            10.1
 ALT.2                       *                                              8.6
 ALT.4                   *                                                   .0

 DO YOU WISH TO SEE THE CONTRIBUTION OF VARIABLES TO VARIATION IN THE
 OVERALL EVALUATION?
           .
           .
           .
```

Figure 7.2. Guide mode in interactive EVALUATE procedure

Next, users are asked a series of questions regarding whether they wish to have selected displays printed. Each question incorporates a very brief description of the kind of information the display will provide. For each question, users may decide either to print the display or go on to the next question. A total of 6 types of displays are available in guide mode for PRECISE data; 4 are available for UNCERTAIN data. For some displays, the names of one or more alternatives are requested. In response to such a request, users may enter a list of alternative names or the keyword "all," meaning all alternatives. Caution should be exercised when using the "all" keyword, as doing so may result in the generation of large amounts of output.

7.2.2 EXPERT MODE

In the expert mode, EVALUATE repeatedly asks users for the option number of the desired display (Figure 7.3). Users may select from among all ten displays for PRECISE data and all seven displays for UNCERTAIN data. For options that request users to specify the names of alternatives or variables for which information is desired, users may enter a list of one or more names or the keyword, "all," which indicates all variables or alternatives. The "all" keyword should be used sparingly, as it is possible to ask for very large amounts of output with only a few keystrokes.

To exit from the EVALUATE procedure in expert mode, users enter a carriage return in response to the "ENTER OPTION NUMBER" question.

```
GUIDE OR EXPERT MODE?
I>expert

ENTER OPTION NUMBER (1 - 10 OR 99 FOR LIST):
I>1

EVALUATE PROCEDURE. PRECISE DATA. OPTION 1:  OVERALL SCORES.
DATE: 80/06/19. TIME: 17.39.35.


PUBLIC: FARMERS
OVERALL SCORES

                                    OVERALL SCORE
           0    10    20    30    40    50    60    70    80    90   100
ALT.       +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+      VALUE
ALT.1                                                *                         64.9
ALT.3                                          *                               53.4
ALT.2                                         *                                51.9
ALT.4                                   *                                      43.3

ENTER OPTION NUMBER (1 - 10 OR 99 FOR LIST):
I>4

FOR WHICH ALTERNATIVES?
I>alt.3

RELATIVE TO WHICH ALTERNATIVE?
I>alt.1

EVALUATE PROCEDURE. PRECISE DATA. OPTION 4:  ALTERN. SCORES RELATIVE.
DATE: 80/06/19. TIME: 17.39.35.


PUBLIC: FARMERS
SCORES FOR ALTERNATIVE ALT.3 RELATIVE TO ALTERNATIVE ALT.1


                       |FOREST/HAB
                       |    -.2
           |TERR/HAB---|CLEAR/HAB
           |    -.2    |    .0
           |
           |
           |           |TER/SP/DV
           |           |    .4
                 •
                 •
                 •
```

Figure 7.3. Expert mode in interactive EVALUATE procedure

7.2.3 FLOW DIAGRAM FOR INTERACTIVE EVALUATE PROCEDURE

A flow diagram describing the use of the interactive EVALUATE procedure appears in Figure 7.4.

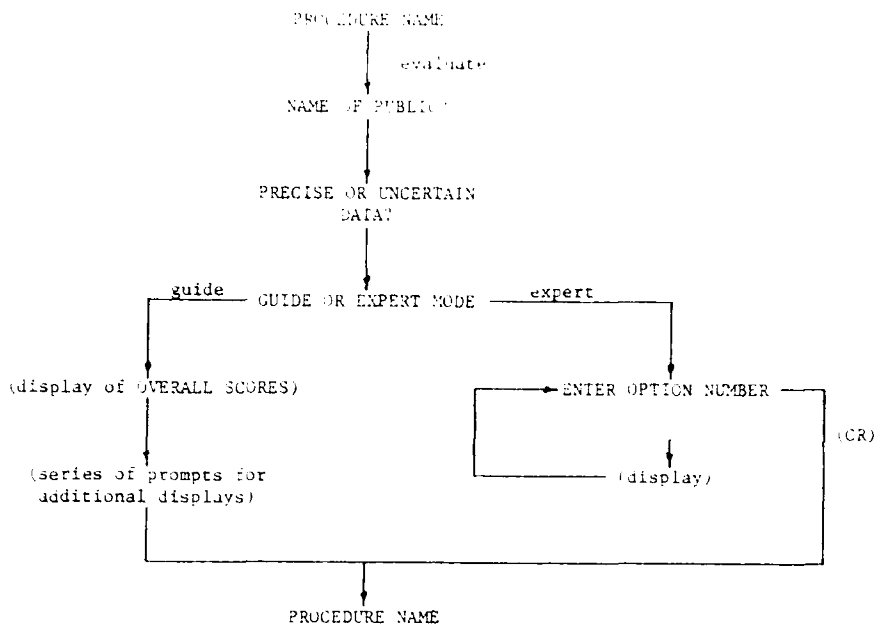


Figure 7.4. Flow diagram for use of interactive EVALUATE procedure

7.3 BATCH EVALUATE PROCEDURE

An example of input to the batch EVALUATE procedure is shown in Figure 7.5. The *EVALUATE card contains two fields for indicating (a) the public name and (b) the type of data to be used by the procedure. The remainder of the cards (called DISPLAY cards) request by name specific displays to be printed.

```
*EVALUATE FARMERS   PRECISE DATA
DISPLAY   OVERALL SCORES
DISPLAY   OVERALL SCORES RELATIVE TO    ALT.4
DISPLAY   WATER     SCORES
DISPLAY   RATINGS
DISPLAY   ALTERN. SCORES
*END
+         +         +         +         +
1         11        21        31        41
```

Figure 7.5. Input to batch EVALUATE procedure

The *EVALUATE card is divided into two fields, the public field and the data field. The public field occupies columns 11-20, and contains the name (left-justified) of the public for which the data is to be evaluated. The data field occupies columns 21-35 and should specify either "PRECISE DATA" or "UNCERTAIN DATA." If this field is left blank, the program behaves as if "PRECISE DATA" had been specified.

The DISPLAY cards (all optional) are divided into two fields, the option name field and the alternative name field. The option name field occupies columns 11-40, and contains the name of the desired display option. Valid option names for each set of data are shown in Table 7.1. These options are discussed in detail in section 7.4.

Table 7.1

Display Options Available in EVALUATE Procedure

PRECISE DATA	UNCERTAIN DATA
1. OVERALL SCORES	1. OVERALL SCORES
2. OVERALL SCORES RELATIVE	2. OVERALL SCORES RELATIVE
3. ALTERN. SCORES	3. ALTERN. SCORES
4. ALTERN. SCORES RELATIVE	4. ALTERN. SCORES RELATIVE
5. RATINGS	5. AVERAGE EFFECTS
6. RATINGS RELATIVE	6. VARIABLE SCORES
7. AVERAGE SCORES	7. VARIABLE SCORES RELATIVE
8. SCORE RANGES	
9. VARIABLE SCORES	
10. VARIABLE SCORES RELATIVE	

For all display options except OPTIONS 9 and 10, VARIABLE SCORES and VARIABLE SCORES RELATIVE, the names of the options are based in the option name field. For OPTIONS 9 and 10, however, the option name field is further divided into a variable name (columns 11-20) and a display name field (columns 21-40). The variable name field indicates the variable for which the scores are to be printed, while the display name field is either "SCORES" or "SCORES RELATIVE." For example, to request the variable scores for AQUATIC, the DISPLAY card would be:

```
DISPLAY   AQUATIC   SCORES
+         +         +
1         11        21
```

while the VARIABLE SCORES RELATIVE for AQUATIC would be requested with:

```
DISPLAY   AQUATIC   SCORES RELATIVE TO  ALT.3
+         +         +                   +
1         11        21                  41
```

The alternative name field of the DISPLAY card occupies columns 41-50. This field is used only for those options that require the name of an alternative for computing relative scores or ratings (OPTIONS 2, 4, 6, and 10). The name of the alternative is entered, left-justified, in this field.

The last card in the input to the EVALUATE procedure is the *END card. Note that there must be a *END card in the input, even if no DISPLAY cards are present. Upon encountering the *END card, the EVALUATE procedure ends.

7.4 DISPLAYS FROM EVALUATE PROCEDURE

Different displays are available from EVALUATE depending on whether PRECISE or UNCERTAIN data has been used. The use of EVALUATE with PRECISE data yields analyses concerning the relative desirability of alternatives, if those alternatives were all to have their most likely effects; the use of EVALUATE with UNCERTAIN data yields more complicated analyses, based on worst case and best case projections. Each type of display is discussed in turn.

7.4.1 WITH PRECISE DATA

A total of 10 options are available from the EVALUATE procedure when it is used with PRECISE data. Each of these displays is based upon results from the computations described in Appendix D.

7.4.1.1 OPTION 1, OVERALL SCORES. The OVERALL SCORES option displays the overall desirability score for each alternative. The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: 1. OPTION 1 is automatically produced.

Expert: 1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"

2. User responds, "1"

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and "*END" cares:

```
DISPLAY    OVERALL SCORES
+          +
1          11
```

Overall desirability scores are based on a 0 to 100 scale, where a score of 100 indicates an alternative that leads to most desirable (optimal) levels for every variable included in the analysis. Similarly, a score of 0 indicates an alternative that leads to most undesirable levels for every variable included in the analysis. Intermediate scores reflect the degree of desirability of projected variable levels for a particular public group, taking into account the relative importance of each variable. In other words, the OVERALL SCORES option weighs and combines the various projected effects of alternatives into a score reflecting overall desirability. The procedure for accomplishing this weighting and combining is based on the values and preferences previously specified in WEIGHTS and FORMS for the particular public group being analyzed.

An example of a display produced by the OVERALL SCORES option appears in Figure 7.6. The alternatives are rank-ordered in terms of their overall scores, indicating which alternatives are most preferred and the degree to which they are judged preferable to other alternatives. In the present example, the alternative ALT.1 is top-ranked for public group FARMERS with a score of 64.9. This is approximately 11.5 points higher, on a 0-to-100 scale, than the second-ranked alternative.

Users should be careful to note that at no time did ESAP call upon public groups to review specific alternatives and directly assign them desirability scores. That is, no group called FARMERS was asked to assign a score between 0 and 100 for each of the four alternatives under consideration. Rather the most desirable variable levels and the

```
PUBLIC: FARMERS
OVERALL SCORES

                           OVERALL SCORE
          0    10   20   30   40   50   60   70   80   90   100
ALT.      +----+----+----+----+----+----+----+----+----+----+      VALUE
ALT.1                                       *                      64.9
ALT.3                                  *                           53.4
ALT.2                                 *                            51.9
ALT.4                           *                                  43.3
```

Figure 7.6. Example of display from EVALUATE with PRECISE data: OPTION 1, OVERALL SCORES

relative importance of variables for each public group were specified through the WEIGHTS and FORMS procedure. This specification was then applied to the projected effects for the four alternatives in order to generate overall scores for them. Overall scores for alternatives, therefore, are based solely upon an analytical evaluation of their projected effects--not upon an intuitive evaluation made directly by a public group. While the analytical approach found in ESAP possesses significant strengths, it is also attended by certain limitations. Users of ESAP should be careful not to lose sight of the particular methods and procedures, and the assumptions underlying them, that are used to produce the numbers appearing in this and other displays.

7.4.1.2 OPTIC 2, OVERALL SCORES RELATIVE. Often when evaluating water resources alternatives, users may wish to compare all other alternatives to one particular alternative, usually the without project alternative. ESAP permits users to make such comparisons with the OVERALL SCORES RELATIVE option. The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: 1. ESAP asks, "DO YOU WISH TO DISPLAY OVERALL SCORES RELATIVE TO A PARTICULAR ALTERNATIVE?"

2. User responds, "YES"

3. ESAP asks, "WHICH ALTERNATIVE?"

4. User identifies alternative, e.g., "ALT.3"

Expert: 1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"

2. User responds, "2"

3. ESAP asks, "WHICH ALTERNATIVE?"

4. User identifies alternative, e.g., "ALT.3"

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and "*END" cards:

```
DISPLAY   OVERALL SCORES RELATIVE TO    ALT.3
+         +                             +
1         11                            41
```

where "ALT.3" can be replaced by the name of any alternative.

The OVERALL SCORES RELATIVE option then produces a display identical to that produced by the OVERALL SCORES option (see 7.4.1.1), with the exception that scores are expressed in terms of their differences (positive or negative) from the specified alternative. An example of a display from the OVERALL SCORES RELATIVE option appears in Figure 7.7. Note that the top-ranked alternative, ALT.1, exceeds the overall score for ALT.3 by 11.5 points, while the overall score for ALT.2 is 1.5 points lower and ALT.4 is 10.1 points lower than the score for ALT.3.

7.4.1.3 OPTION 3, ALTERN. SCORES. In addition to learning how desirable a particular public group regards specific alternatives, users will frequently wish to learn more about the reasons for those evaluations. The ALTERN. SCORES option enables users to learn

```
PUBLIC: FARMERS
OVERALL SCORES RELATIVE TO ALTERNATIVE ALT.3

              OVERALL SCORE RELATIVE TO ALTERNATIVE ALT.3
        -50  -40  -30  -20  -10    0    10   20   30   40   50   60
ALT.      +----+----+----+----+----+----+----+----+----+----+----+----+    VALUE
ALT.1                                    *                             11.5
ALT.3                              *                                     .0
ALT.2                             *                                    -1.5
ALT.4                         *                                       -10.1
```

Figure 7.7. Display from EVALUATE with PRECISE data: OPTION 2, OVERALL SCORES RELATIVE

how the overall scores for alternatives were arrived at. In particular, the ALTERN. SCORES option assigns a score to each variable that approximates its contribution to the overall score (see Appendix D). The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide:
1. ESAP asks, "DO YOU WISH TO SEE THE SCORES FOR INDIVIDUAL ALTERNATIVES?"
2. User responds, "YES"
3. ESAP asks, "WHICH ALTERNATIVES?"
4. User identifies alternatives, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.

Expert:
1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"
2. User responds, "3"
3. ESAP asks, "FOR WHICH ALTERNATIVES?"
4. User identifies alternatives, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and "*END" cards:

```
DISPLAY   ALTERN. SCORES
+         +
1         11
```

In batch mode for this option, ESAP produces displays for all alternatives.

An example of the type of display produced by ALTERN. SCORES appears in Figure 7.8. As can be seen, the ALTERN. SCORES option produces output in the same tree format created by the TREE procedure. The scores associated with leaf variables in the tree indicate (a) the degree of desirability for the projected level of that variable as well as (b) the relative importance of that variable. This variable score is computed by multiplying the rating for a variable level (on the 0-to-100 scale specified in FORMS) by the derived relative weight for that variable (as specified in WEIGHTS). The scores for higher-level variables in the tree are then computed by summing the scores of those variables that make up or define that variable. (Technically, this description of the method of computation constitutes an oversimplification; see Appendix D for details.) For example, in Figure 7.8, the OVERALL score for EQ is 64.9; 12.5 of the EQ score comes from HIST/RES; 9.5 of the HIST/RES score comes from ARCHEOLOGIC and 9.0 of that 9.5 score comes from COLUMBIAN. The largest contribution to the overall EQ score, however, comes from the TERRESTRAL variable (30.9 points).

By comparing ALTERN. SCORES displays for two or more alternatives, users can identify the variables that are primarily responsible for differences between the variables in their overall scores.

7.4.1.4 <u>OPTION 4, ALTERN. SCORES RELATIVE</u>. The ALTERN. SCORES RELATIVE option enables users to compare OVERALL and VARIABLE scores for all other alternatives with those of one particular alternative selected by the user. It thus permits users to identify those

```
PUBLIC: FARMERS
SCORES FOR ALTERNATIVE ALT.1

                                               |FOREST/HAB
                                               |    1.4
                                  |TERR/HAB---|CLEAR/HAB
                                  |    6.2    |    4.8
                                  |
                                  |
                                  |            |TER/SP/DV
                                  |            |    2.6
                     |TERRESTRAL-|TERR/ECOS--|WETLANDS
                     |    30.9   |    5.5    |    2.9
                     |           |
                     |           |
                     |           |            |FLOODS
                     |           |            |   10.1
                     |           |LAND/QUAL--|SOIL/NUTR
                     |           |   19.2    |    9.1
                     |
                     |                        |FISH
                     |                        |    1.4
                     |           |AQUA/HAB---|RIPARIAN
                     |           |    3.9    |    2.5
                     |           |                        |TEMP
                     |           |                        |      .0
                     |           |            |PHYSICAL---|TURBID
                     |           |            |    1.3    |     1.3
                     |           |            |
                     |           |            |
EQ---------|AQUATIC----|WATERQUAL--|                      |PH
    64.9   |    15.5   |    8.7    |                      |     5.5
           |           |           |CHEM-------|DO
           |           |           |    7.3    |     1.8
           |           |
           |           |
           |           |            |AQ/SP/DV
           |           |            |    1.3
           |           |AQUA/ECOS--|AQ/PLNTS
           |           |    2.9    |    1.6
           |AIR
           |    6.0
           |                        |SITE/AREA
           |                        |     .3
           |           |HISTORIC----|STRUCTURE
           |           |    2.9     |    2.6
           |           |
           |           |
           |HIST/RES  -|            |PRECOLUM
           |    12.5   |            |     .5
                       |ARCHEOLOGIC |COLUMBIAN
                       |    9.5     |    9.0
```

Figure 7.8. Display from EVALUATE with PRECISE data: OPTION 3, ALTERN. SCORES

variables that are primarily responsible for differences in desirability scores between the one specified alternative and any or all of the other alternatives. Often users may wish to compare all other alternatives to a without project alternative; users can then readily discover where structural or nonstructural alternatives have desirable effects in comparison with no action, and for which variables such alternatives have undesirable effects in comparison with the without project alternative. The scores for all other alternatives will be expressed in terms of positive or negative deviations from the scores of the without project alternative.

The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: OPTION 4 is not available in guide mode.

Expert:
1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"
2. User responds, "4"
3. ESAP asks, "FOR WHICH ALTERNATIVES?"
4. User identifies alternatives, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.
5. ESAP asks, "RELATIVE TO WHICH ALTERNATIVES?"
6. User identifies alternative, e.g., "ALT.3," "ALT.1," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and "*END" cards:

```
DISPLAY   ALTERN. SCORES RELATIVE TO   ALT.3
+         +                            +
1         11                           41
```

where "ALT.3" can be replaced by the name of any alternative. In batch mode for this option, ESAP produces displays for all alternatives.

An example of the type of display produced by the ALTERN. SCORES RELATIVE option appears in Figure 7.9. Note how this display aids users in learning about the reasons for differences between alternatives ALT.1 and ALT.3 for FARMERS. The display indicates that the FARMERS group assigns an OVERALL SCORE for ALT.1 that is 11.5 points higher than the score for ALT.3. The display further indicates that the primary source of disagreement about the overall desirability of the two alternatives stems from differences about the desirability of their effects on TERRESTRAL (i.e., terrestrial resources), with a difference of 8.4 points between the two alternatives on this variable; the differences between the two alternatives with respect to TERRESTRAL appears to derive mainly from their differences on LAND/QUAL (i.e., land quality), with a difference of 6.9 points between them. Finally, differences between the two alternatives with respect to LAND/QUAL appear to stem principally from differences between them in the desirability of their effects on FLOODS, with a difference of 6.1 points. The analyses from the ALTERN. SCORES RELATIVE option thus help identify major sources of differences concerning the overall desirability of alternatives.

7.4.1.5 OPTION 5, RATINGS. When comparing alternatives it is often useful to determine just how desirable a public group found the projected levels of various individual variables, independent of the group's ratings of the importances of those particular variables. The RATINGS option permits users to learn for each alternative how

```
PUBLIC: FARMERS
SCORES FOR ALTERNATIVE ALT.1 RELATIVE TO ALTERNATIVE ALT.3

                                        |FOREST/HAB
                                        |       .2
                            |TERR/HAB---|CLEAR/HAB
                            |      .2   |       .0
                            |
                            |
                            |           |TER/SP/DV
                            |           |      -.4
                |TERRESTRAL-|TERR/ECOS--|WETLANDS
                |      8.4  |     1.3   |      1.7
                |           |
                |           |
                |           |           |FLOODS
                |           |           |      6.1
                |           |LAND/QUAL--|SOIL/NUTR
                |           |     6.9   |       .9
                |
                |
                |                       |FISH
                |                       |       .3
                |           |AQUA/HAB---|RIPARIAN
                |           |     2.8   |      2.5
                |           |                       |TEMP
                |           |                       |       .0
                |           |           |PHYSICAL---|TURBID
                |           |           |      -.5  |      -.4
                |           |           |
                |           |           |
EQ--------------|AQUATIC----|WATERQUAL--|           |PH
     11.5       |      1.9  |     -.5   |           |       .0
                |           |           |CHEM-------|DO
                |           |           |       .0  |       .0
                |           |
                |           |
                |           |           |AQ/SP/DV
                |           |           |       .2
                |           |AQUA/ECOS--|AQ/PLNTS
                |           |     -.5   |      -.6
                |AIR
                |       .0
                |                       |SITE/AREA
                |                       |      -.8
                |           |HISTORIC---|STRUCTURE
                |           |     -.4   |       .4
                |           |
                |           |
                |HIST/RES---|           |PRECOLUM
                |      1.1  |           |      -.7
                            |ARCHEOLOGIC|COLUMBIAN
                            |     1.5   |      2.3
```

Figure 7.9. Display from EVALUATE with PRECISE data: OPTION 4, ALTERN. SCORES RELATIVE

projected levels for each variable were rated on the 0-to-100 scale specified in FORMS.

The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: 1. ESAP asks, "DO YOU WISH TO SEE THE RATINGS GIVEN BY THIS PUBLIC TO EACH VARIABLE?"

2. User responds, "YES"

3. ESAP asks, "FOR WHICH ALTERNATIVES?"

4. User identifies alternatives, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.

Expert: 1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"

2. User responds, "5"

3. ESAP asks, "FOR WHICH ALTERNATIVES?"

4. User identifies alternatives, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and "*END" cards:

```
DISPLAY   RATINGS
+         +
1         11
```

In batch mode for this option, ESAP produces displays for all alternatives.

An example of output from RATINGS appears in Figure 7.10. The desirability of the projected level of each variable in the tree is indicated on a 0-to-100 scale, for each alternative. For instance (see arrow), the FOREST/HAB rating for ALT.1 equalled 89.2; for ALT.2, 67.6; for ALT.3, 78.4; and for ALT.4, only 13.6. The derived weight for each variable is also displayed by RATINGS. Multiplying variables' ratings

PUBLIC: FARMERS
RATINGS GIVEN TO EACH VARIABLE

VARIABLE		DERIVED WEIGHT	RATING ALT.1	ALT.2	ALT.3	ALT.4
LEVEL Ø:						
EQ			64.9	51.9	53.4	43.3
LEVEL 1:						
TERRESTRAL		.4Ø	77.3	6Ø.4	56.2	28.5
AQUATIC		.3Ø	51.7	43.9	45.2	43.Ø
AIR		.1Ø	6Ø.Ø	6Ø.Ø	6Ø.Ø	6Ø.Ø
HIST/RES		.2Ø	62.3	43.Ø	56.8	64.9
LEVEL 2:						
TERR/HAB	(TERRESTRAL)	.Ø8	77.8	83.5	75.7	22.7
TERR/ECOS	(TERRESTRAL)	.Ø8	68.2	8Ø.Ø	51.8	47.1
LAND/QUAL	(TERRESTRAL)	.24	8Ø.1	46.2	51.2	24.3
AQUA/HAB	(AQUATIC)	.Ø6	65.2	16.7	17.7	54.3
WATERQUAL	(AQUATIC)	.18	48.1	46.5	5Ø.6	45.6
AQUA/ECOS	(AQUATIC)	.Ø6	48.7	63.Ø	56.2	24.Ø
HISTORIC	(HIST/RES)	.Ø6	49.1	48.7	56.2	41.2
ARCHEOLOGIC	(HIST/RES)	.14	68.Ø	4Ø.5	57.Ø	75.Ø
LEVEL 3:						
FOREST/HAB	(TERR/HAB)	.Ø2	89.2	67.6	78.4	13.6
CLEAR/HAB	(TERR/HAB)	.Ø6	75.Ø	87.5	75.Ø	25.Ø
TER/SP/DV	(TERR/ECOS)	.Ø4	65.Ø	7Ø.Ø	75.Ø	8Ø.Ø
WETLANDS	(TERR/ECOS)	.Ø4	71.4	9Ø.Ø	28.6	14.3
FLOODS	(LAND/QUAL)	.12	84.Ø	4Ø.Ø	33.3	2Ø.Ø
SOIL/NUTR	(LAND/QUAL)	.12	76.2	52.4	69.Ø	28.6
FISH	(AQUA/HAB)	.Ø2	77.3	9.1	59.1	4Ø.9
RIPARIAN	(AQUA/HAB)	.Ø4	6Ø.Ø	2Ø.Ø	.Ø	6Ø.Ø
PHYSICAL	(WATERQUAL)	.Ø9	15.Ø	31.4	2Ø.Ø	12.5
CHEM	(WATERQUAL)	.Ø9	81.3	61.6	81.3	78.8
AQ/SP/DV	(AQUA/ECOS)	.Ø2	75.Ø	35.Ø	65.Ø	8Ø.Ø
AQ/PLNTS	(AQUA/ECOS)	.Ø4	37.5	75.Ø	52.5	.Ø
SITE/AREA	(HISTORIC)	.Ø3	1Ø.6	75.Ø	37.5	82.5
STRUCTURE	(HISTORIC)	.Ø3	87.5	22.5	75.Ø	.Ø
PRECOLUM	(ARCHEOLOGIC)	.Ø4	12.5	55.Ø	3Ø.Ø	2Ø.Ø
COLUMBIAN	(ARCHEOLOGIC)	.1Ø	91.7	34.3	68.6	98.6
LEVEL 4:						
TEMP	(PHYSICAL)	.Ø5	.Ø	4Ø.7	.Ø	.Ø
TURBID	(PHYSICAL)	.Ø4	37.5	17.5	5Ø.Ø	31.2
PH	(CHEM)	.Ø6	87.5	64.8	87.5	87.5
DO	(CHEM)	.Ø3	66.7	54.2	66.7	58.3

Figure 7.10. Display from EVALUATE with PRECISE data: OPTION 5, RATINGS

by their derived weights will (almost always) produce the same scores that appear in the ALTERN. SCORES displays.

(Note that in the displays produced by this option, as is the case for all tabular displays produced by any option in EVALUATE, the more general variable with which more specific variables are immediately linked is always identified in parentheses. The user can thus readily learn (see arrow) that FOREST/HAB is linked to TERR/HAB.)

7.4.1.6 OPTION 6, RATINGS RELATIVE. Users may sometimes wish to generate a display that compares the ratings for all other alternatives to the ratings of one particular alternative, for example, the without project alternative. The RATINGS RELATIVE option allows users to make such comparisons. The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide:
1. ESAP asks, "DO YOU WISH TO DISPLAY RATINGS RELATIVE TO A PARTICULAR ALTERNATIVE?"
2. User responds, "YES"
3. ESAP asks, "FOR WHICH ALTERNATIVE?"
4. User identifies alternative, e.g., "ALT.3"

Expert:
1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"
2. User responds, "6"
3. ESAP asks, "FOR WHICH ALTERNATIVES?"
4. User identifies alternatives, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.
5. ESAP asks, "RELATIVE TO WHICH ALTERNATIVES?"
6. User identifies alternative, e.g., "ALT.3," "ALT.1," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and "*END" cards:

```
DISPLAY   RATINGS RELATIVE TO          ALT.3
+         +                            +
1         11                           41
```

where "ALT.3" can be replaced by the name of any alternative. In batch mode for this option ESAP produces displays for all alternatives.

An example of the type of display produced by RATINGS RELATIVE appears in Figure 7.11. In the example, ratings for the three other alternatives are compared to ratings for ALT.3. Referring again to the FOREST/HAB variable (see arrow), the display indicates that the rating for this variable is 10.8 points higher for ALT.1 than for ALT.3, 10.8 points lower for ALT.2 than for ALT.3, and 64.8 points lower for ALT.4 than for ALT.3.

7.4.1.7 OPTION 7, AVERAGE SCORES. Users may sometimes wish to learn the average values of overall and variable scores, across all alternatives, particularly for large planning studies involving a number of alternatives and variables. Such information enables users to obtain a better feel for the relative importance of the variables for determining alternatives' overall scores.

The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: OPTION 7 is not available in guide mode.

Expert: 1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"

2. User responds, "7"

PUBLIC: FARMERS
RATINGS GIVEN TO EACH VARIABLE
RELATIVE TO ALTERNATIVE ALT.3

VARIABLE		DERIVED WEIGHT	RATING RELATIVE TO ALTERNATIVE ALT.3 ALT.1	ALT.2	ALT.4
LEVEL 0:					
EQ			11.5	-1.5	-10.1
LEVEL 1:					
TERRESTRAL		.40	21.1	4.2	-27.7
AQUATIC		.30	6.5	-1.3	-2.1
AIR		.10	.0	.0	.0
HIST/RES		.20	5.5	-13.8	8.1
LEVEL 2:					
TERR/HAB	(TERRESTRAL)	.08	2.2	7.8	-53.0
TERR/ECOS	(TERRESTRAL)	.08	16.4	28.2	-4.6
LAND/QUAL	(TERRESTRAL)	.24	28.9	-5.0	-26.9
AQUA/HAB	(AQUATIC)	.06	47.5	-1.0	36.5
WATERQUAL	(AQUATIC)	.18	-2.5	-4.1	-5.0
AQUA/ECOS	(AQUATIC)	.06	-7.5	6.8	-32.2
HISTORIC	(HIST/RES)	.06	-7.2	-7.5	-15.0
ARCHEOLOGIC	(HIST/RES)	.14	10.9	-16.5	18.0
LEVEL 3:					
FOREST/HAB	(TERR/HAB)	.02	10.8	-10.8	-64.8
CLEAR/HAB	(TERR/HAB)	.06	.0	12.5	-50.0
TER/SP/DV	(TERR/ECOS)	.04	-10.0	-5.0	5.0
WETLANDS	(TERR/ECOS)	.04	42.9	61.4	-14.3
FLOODS	(LAND/QUAL)	.12	50.7	6.7	-13.3
SOIL/NUTR	(LAND/QUAL)	.12	7.1	-16.7	-40.5
FISH	(AQUA/HAB)	.02	18.2	-50.0	-18.2
RIPARIAN	(AQUA/HAB)	.04	60.0	20.0	60.0
PHYSICAL	(WATERQUAL)	.09	-5.0	11.4	-7.5
CHEM	(WATERQUAL)	.09	.0	-19.6	-2.5
AQ/SP/DV	(AQUA/ECOS)	.02	10.0	-30.0	15.0
AQ/PLNTS	(AQUA/ECOS)	.04	-15.0	22.5	-52.5
SITE/AREA	(HISTORIC)	.03	-26.9	37.5	45.0
STRUCTURE	(HISTORIC)	.03	12.5	-52.5	-75.0
PRECOLUM	(ARCHEOLOGIC)	.04	-17.5	25.0	-10.0
COLUMBIAN	(ARCHEOLOGIC)	.10	23.1	-34.3	30.0
LEVEL 4:					
TEMP	(PHYSICAL)	.05	.0	40.7	.0
TURBID	(PHYSICAL)	.04	-12.5	-32.5	-18.7
PH	(CHEM)	.06	.0	-22.7	.0
DO	(CHEM)	.03	.0	-12.5	-8.3

Figure 7.11. Display from EVALUATE with PRECISE data: OPTION 6, RATINGS RELATIVE

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and"*END" cards:

```
DISPLAY   AVERAGE SCORES
+         +
1         11
```

This option produces displays both in the tree format and in a tabular format. An example of the tree format display appears in Figure 7.12a; an example of the tabular format display appears in Figure 7.12b.

In the example it is clear from casual inspection of either display that the TERRESTRAL branch is playing by far the largest role in determining alternatives' overall desirability scores, followed by the AQUATIC and RECREATION branches. AIR, on the average, is the least important branch for determining overall desirability scores.

7.4.1.8 OPTION 8, SCORE RANGES. Variables' contributions to differences among alternatives in overall desirability will frequently be more important to users than their average contributions to overall desirability (7.4.1.7). The range of scores across alternatives generally gives a reasonably valid idea of which variables are most important for distinguishing among alternatives in terms of their desirability. The SCORE RANGES option computes and displays the largest difference between any pair of alternatives, for the variable scores associated with alternatives.

The procedures for requesting this option can be summarized as follows:

```
PUBLIC: FARMERS

AVERAGE SCORES

                                 |FOREST/HAB
                                 |    1.0
                     |TERR/HAB---|CLEAR/HAB
                     |    5.2    |    4.2
                     |
                     |
                     |           |TER/SP/DV
                     |           |    2.9
         |TERRESTRAL-|TERR/ECOS--|WETLANDS
         |   22.2    |    4.9    |    2.0
         |           |
         |           |
         |           |           |FLOODS
         |           |           |    5.3
         |           |LAND/QUAL--|SOIL/NUTR
         |           |   12.1    |    6.8
         |
         |
         |                       |FISH
         |                       |     .8
         |           |AQUA/HAB---|RIPARIAN
         |           |    2.3    |    1.5
         |           |                       |TEMP
         |           |                       |     .5
         |           |           |PHYSICAL---|TURBID
         |           |           |    1.8    |    1.2
         |           |           |
         |           |           |
EQ-------|AQUATIC----|WATERQUAL--|           |PH
  53.4   |   13.8    |    8.6    |           |    5.2
         |           |           |CHEM-------|DO
         |           |           |    6.8    |    1.7
         |           |
         |           |
         |           |           |AQ/SP/DV
         |           |           |    1.1
         |           |AQUA/ECOS--|AQ/PLNTS
         |           |    2.9    |    1.7
         |AIR
         |    6.0
         |                       |SITE/AREA
         |                       |    1.5
         |           |HISTORIC---|STRUCTURE
         |           |    2.9    |    1.4
         |           |
         |           |
         |HIST/RES---|           |PRECOLUM
         |   11.3    |           |    1.2
                     |ARCHEOLOGIC|COLUMBIAN
                     |    8.4    |    7.2
```

a. Tree format display

Figure 7.12. Displays from EVALUATE with PRECISE data: OPTION 7, AVERAGE SCORES

PUBLIC: FARMERS

VARIABLE		AVERAGE SCORE	AVERAGE SCORE 0 20 40 60 80 100	PERCENT OF OVERALL SCORE
LEVEL 0:				
EQ		53.4	XXXXXXXXXXXXXXX	
LEVEL 1:				
TERRESTRAL		22.2	XXXXXX	41.7 %
AQUATIC		13.8	XXXX	25.8 %
AIR		6.0	XX	11.2 %
HIST/RES		11.3	XXXX	21.3 %
LEVEL 2:				
TERR/HAB	(TERRESTRAL)	5.2	XX	9.7 %
TERR/ECOS	(TERRESTRAL)	4.9	XX	9.3 %
LAND/QUAL	(TERRESTRAL)	12.1	XXXX	22.7 %
AQUA/HAB	(AQUATIC)	2.3		4.3 %
WATERQUAL	(AQUATIC)	8.6	XXX	16.1 %
AQUA/ECOS	(AQUATIC)	2.9		5.4 %
HISTORIC	(HIST/RES)	2.9		5.5 %
ARCHEOLOGIC	(HIST/RES)	8.4	XXX	15.8 %
LEVEL 3:				
FOREST/HAB	(TERR/HAB)	1.0		1.9 %
CLEAR/HAB	(TERR/HAB)	4.2	XX	7.9 %
TER/SP/DV	(TERR/ECOS)	2.9		5.4 %
WETLANDS	(TERR/ECOS)	2.0		3.8 %
FLOODS	(LAND/QUAL)	5.3	XX	10.0 %
SOIL/NUTR	(LAND/QUAL)	6.8	XX	12.7 %
FISH	(AQUA/HAB)	.8		1.6 %
RIPARIAN	(AQUA/HAB)	1.5		2.8 %
PHYSICAL	(WATERQUAL)	1.8		3.3 %
CHEM	(WATERQUAL)	6.8	XX	12.8 %
AQ/SP/DV	(AQUA/ECOS)	1.1		2.2 %
AQ/PLNTS	(AQUA/ECOS)	1.7		3.2 %
SITE/AREA	(HISTORIC)	1.5		2.9 %
STRUCTURE	(HISTORIC)	1.4		2.6 %
PRECOLUM	(ARCHEOLOGIC)	1.2		2.3 %
COLUMBIAN	(ARCHEOLOGIC)	7.2	XX	13.5 %
LEVEL 4:				
TEMP	(PHYSICAL)	.5		1.0 %
TURBID	(PHYSICAL)	1.2		2.3 %
PH	(CHEM)	5.2	XX	9.7 %
DO	(CHEM)	1.7		3.1 %

b. Tabular format display

Figure 7.12 (continued)

Interactive Mode

Guide: 1. ESAP asks, "DO YOU WISH TO SEE THE CONTRIBUTION OF VARIABLES TO VARIATION IN THE OVERALL EVALUATION?"

2. User responds, "YES"

Expert: 1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"

2. User responds, "8"

Batch Mode

User requires this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and "*END" cards:

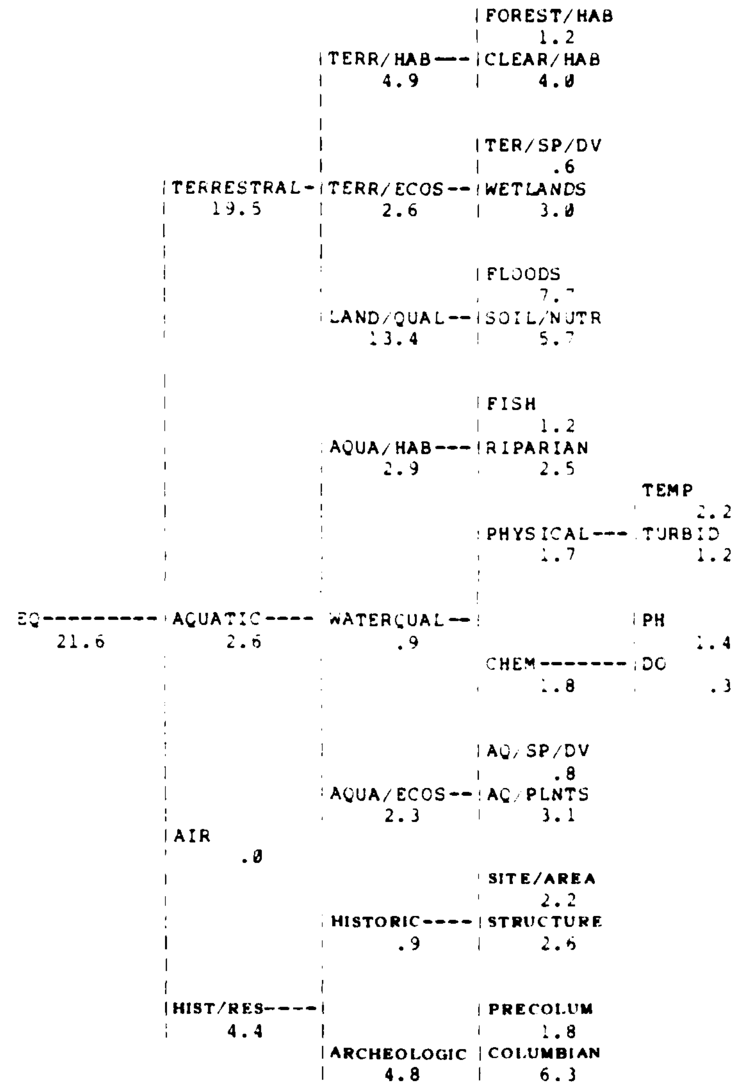
```
DISPLAY  SCORE RANGES
+        +
1        11
```

SCORE RANGES produces displays in both the tree format and in a tabular format. An example of a display in tree format appears in Figure 7.13a; an example of the type of tabular display produced by SCORE RANGES appears in Figure 7.13b. Note that for Level 1 variables, the largest range in variable scores is for TERRESTRAL (19.5 points); for Level 2 variables, the largest range in scores is for LAND/QUAL (13.4 points); for Level 3 variables, the largest range in scores is for FLOODS (7.7 points), and so forth.

Other variables, however, can be identified as unimportant for distinguishing among alternatives in terms of desirability. Most conspicuously in the example, AIR, with zero variation across alternatives, obviously has no discriminatory effect on evaluations by the FARMERS groups of alternatives' desirability.

7.4.1.9 OPTION 9, VARIABLE SCORES. Frequently users may wish to examine more closely the alternatives' effects on individual

PUBLIC: FARMERS
RANGE OF SCORES



a. Tree format display

Figure 7.13. Displays from EVALUATE with PRECISE data: OPTION 8, SCORE RANGES

PUBLIC: FARMERS
RANGE OF SCORES

VARIABLE		RANGE OF SCORES	AVERAGE SCORE	SCORE 0 20 40 60 80 100
LEVEL 0:				
EQ		21.6	53.4	L-*--H
LEVEL 1:				
TERRESTRAL		19.5	22.2	L--*--H
AQUATIC		2.6	13.8	L*H
AIR		.0	6.0	L*H
HIST/RES		4.4	11.3	L*H
LEVEL 2:				
TERR/HAB	(TERRESTRAL)	4.9	5.2	L*H
TERR/ECOS	(TERRESTRAL)	2.6	4.9	L*H
LAND/QUAL	(TERRESTRAL)	13.4	12.1	L-*H
AQUA/HAB	(AQUATIC)	2.9	2.3	L*H
WATERQUAL	(AQUATIC)	.9	8.6	L*H
AQUA/ECOS	(AQUATIC)	2.3	2.9	L*H
HISTORIC	(HIST/RES)	.9	2.9	L*H
ARCHEOLOGIC	(HIST/RES)	4.8	8.4	L*H
LEVEL 3:				
FOREST/HAB	(TERR/HAB)	1.2	1.0	L*H
CLEAR/HAB	(TERR/HAB)	4.0	4.2	L*H
TER/SP/DV	(TERR/ECOS)	.6	2.9	L*H
WETLANDS	(TERR/ECOS)	3.0	2.0	L*H
FLOODS	(LAND/QUAL)	7.7	5.3	L*H
SOIL/NUTR	(LAND/QUAL)	5.7	6.8	L*H
FISH	(AQUA/HAB)	1.2	.8	L*H
RIPARIAN	(AQUA/HAB)	2.5	1.5	L*H
PHYSICAL	(WATERQUAL)	1.7	1.8	L*H
CHEM	(WATERQUAL)	1.8	6.8	L*H
AQ/SP/DV	(AQUA/ECOS)	.8	1.1	L*H
AQ/PLNTS	(AQUA/ECOS)	3.1	1.7	L*H
SITE/AREA	(HISTORIC	2.2	1.5	L*H
STRUCTURE	(HISTORIC	2.6	1.4	L*H
PRECOLUM	(ARCHEOLOGIC)	1.8	1.2	L*H
COLUMBIAN	(ARCHEOLOGIC)	6.3	7.2	L*H
LEVEL 4:				
TEMP	(PHYSICAL)	2.2	.5	L*H
TURBID	(PHYSICAL)	1.2	1.2	L*H
PH	(CHEM)	1.4	5.2	L*H
DO	(CHEM)	.3	1.7	L*H

b. Tabular format display

Figure 7.13 (continued)

variables. The VARIABLE SCORES option permits users to compare the scores for all alternatives on particular variables. The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: OPTION 9 is not available in guide mode.

Expert:
1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"
2. User responds, "9"
3. ESAP requests, "FOR WHICH VARIABLE?"
4. User identifies variable, e.g., "PH," "TERRESTRAL," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and "*END" cards:

```
DISPLAY   TERRESTRALSCORES
+         +         +
1         11        21
```

where "TERRESTRAL" can be replaced by the name of any variable.

An example of a display from VARIABLE SCORES appears in Figure 7.14. In the example, the four alternatives differ substantially in the scores associated with the variable TERRESTRAL (i.e., terrestrial resources). ALT.1, for instance, has a far more desirable effect on TERRESTRAL than does ALT.4 (i.e., 19.5 points higher).

```
PUBLIC: FARMERS
VARIABLE SCORES FOR TERRESTRAL

                               TERRESTRAL SCORE
              0    10   20   30   40   50   60   70   80   90   100
ALT.          +----+----+----+----+----+----+----+----+----+----+        VALUE
ALT.1                         *                                          30.9
ALT.2                       *                                            24.2
ALT.3                      *                                             22.5
ALT.4               *                                                    11.4
```

Figure 7.14. Display from EVALUATE with PRECISE data: OPTION 9, VARIABLE SCORES

7.4.1.10 OPTION 10, VARIABLE SCORES RELATIVE. The VARIABLE SCORES RELATIVE option permits users to conduct and display the same type of analyses as described above (7.4.1.9) for the VARIABLE SCORES option, with the exception that all scores are expressed as deviations from the scores of a particular alternative specified by the user. The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: OPTION 10 is not available in guide mode.

Expert:
1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"
2. User responds, "10"
3. ESAP requests, "FOR WHICH VARIABLE?"
4. User identifies variable, e.g., "PH," "TERRESTRAL," etc.
5. ESAP requests, "RELATIVE TO WHICH ALTERNATIVE?"
6. User identifies alternative, e.g., "ALT.3"

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnamePRECISE DATA" and "*END" cards:

```
DISPLAY   TERRESTRALSCORES RELATIVE TO  ALT.3
+         +         +                   +
1         11        21                  41
```

where "TERRESTRAL" can be replaced by the name of any variable and "ALT.3" can be replaced by the name of any alternative.

An example of the type of display produced by this option appears in Figure 7.15. The scores for TERRESTRAL in the present example range from 8.4 points higher than ALT.3 for ALT.1 to 11.1 points lower than ALT.3 for ALT.4.

```
PUBLIC: FARMERS
VARIABLE SCORES FOR TERRESTRAL RELATIVE TO ALTERNATIVE ALT.3

                 TERRESTRAL SCORE RELATIVE TO ALTERNATIVE ALT.3
           -60   -50   -40   -30   -20   -10     0    10    20    30    40    50
ALT.         +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+      VALUE
ALT.1                                                  *                                8.4
ALT.2                                              *                                    1.7
ALT.3                                            *                                       .0
ALT.4                                     *                                           -11.1
```

Figure 7.15. Display from EVALUATE with PRECISE data: OPTION 10, VARIABLE SCORES RELATIVE

7.4.2 WITH UNCERTAIN DATA

When EVALUATE is used with UNCERTAIN data, it computes desirability and variable scores according to the same formulae as when PRECISE data are used (see Appendix D for a discussion of the computation of overall desirability scores for alternatives). While EVALUATE uses the point estimates specified in PRECISE data to generate most probable scores for alternatives, the procedure uses the range of projected variable levels specified in UNCERTAIN to generate minimum and maximum (i.e., worst case and best case) scores for each alternative. Since uncertainty attends the effects of alternatives, it should probably also be taken into account when evaluating their desirability.

The method for computing the minimum and maximum scores for alternatives does <u>not</u> consist of evaluting alternatives by using first the LOW data values specified in UNCERTAIN and then the HIGH values, as one might initially imagine. Instead, the specified range of projected levels is searched to identify the lowest possible and highest possible ratings of any values within that range. The lowest possible rating is then associated with the minimum score computation, while the highest possible rating is associateu with the maximum score computation.

The method of computation thus leads to worst-case and best-case analyses. Moreover, it is assumed that effects are perfectly correlated. In the worst-case analysis it is assumed that everything simultaneously goes wrong; the best-case analysis assumes that everything turns out as well as is possible.

Finally, it is important to note that every variable level between the low and high values specified in RANGES is implicitly assumed to be equally likely (see 6.3.1.3). This assumption will frequently prove erroneous, and it tends along with the assumption that effects are perfectly correlated to exaggerate both the worst-case and best-case analyses. In other words, the worst-case analysis may appear even worse and the best-case analysis even better than is likely to be the case. Such exaggeration may serve, however, to counterbalance individuals' tendencies to underestimate uncertainty (see 6.3.1.2), tendencies which tend to provide optimistic worst-case analyses and pessimistic best-case analyses.

Seven options are available for evaluating alternatives with data specified in the UNCERTAIN procedure. Each is discussed in turn.

7.4.2.1 OPTION 1, OVERALL SCORES. Analyses and displays from the OVERALL SCORES option using UNCERTAIN data resemble those from the OVERALL SCORES option using PRECISE data. The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: 1. OPTION 1 is automatically produced.

Expert: 1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"

2. User responds, "1"

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnameUNCERTAIN DATA" and "*END" cards:

```
DISPLAY   OVERALL SCORES
+         +
1         11
```

An example of a display from the OVERALL SCORES option appears in Figure 7.16. Alternatives are rank-ordered in terms of their overall scores, as computed using PRECISE data values. But in addition to such most probable scores, the minimum and maximum scores are also computed and displayed. The minimum score for an alternative is the overall desirability score that would result if that alternative were to have the most undesirable possible effect on every variable included in the analysis (where the most undesirable possible effect is derived from the data previously specified in the UNCERTAIN procedure). The maximum score for an alternative is the overall desirability score that would result if the alternative were to have the most desirable possible effect on every variable included in the analysis (where the most desirable possible effect is derived from the data previously specified in the UNCERTAIN procedure). The range of overall scores produced by using UNCERTAIN data will often reflect much more adequately the true

```
PUBLIC: NATURE

OVERALL SCORES

                 OVERALL SCORE--UNCERTAIN DATA
           0  10  20  30  40  50  60  70  80  90 100                MOST
ALT.       +---+---+---+---+---+---+---+---+---+---+  MINIMUM  PROBABLE  MAXIMUM
ALT.4                          L--*--H                  51.9     59.3      67.6
ALT.3                       L-*---H                     43.8     51.0      58.5
ALT.1                      L--*--H                      42.2     50.2      58.1
ALT.2                     L--*--H                       41.2     47.4      53.6

ALTERNATIVES STILL IN CONTENTION:     ALTERNATIVES TO BE ELIMINATED:
            ALT.4
            ALT.3
            ALT.1
            ALT.2
```

Figure 7.16. Display from EVALUATE with UNCERTAIN data: OPTION 1, OVERALL SCORES

state of affairs in water resource planning than will the point estimates produced by using PRECISE data values.

Note in the present example that ALT.4 is the most desirable alternative for the NATURE group with a MOST PROBABLE score of 59.3. But the MINIMUM OVERALL SCORE might be as low as 51.9 and the MAXIMUM OVERALL SCORE might be as high as 67.6, given the uncertainties in the projected effects of this alternative. The OVERALL SCORES option depicts this range of scores graphically, as well as numerically, as can be seen in Figure 7.16. Note also that when used with UNCERTAIN data the OVERALL SCORES option produces two columns entitled "ALTERNATIVES STILL IN CONTENTION" and "ALTERNATIVES TO BE ELIMINATED." Alternatives can be eliminated if the maximum score (or the best case analysis for that alternative) is less desirable than the minimum score (or, worst-case analysis) for some other alternative. (Such alternatives can be eliminated, however, only for the particular public group included in the analysis; for other publics these same alternatives may be retained in consideration.) In the present example, none of the alternatives can be eliminated.

7.4.2.2 OPTION 2, OVERALL SCORES RELATIVE. Often in water resources planning, users may wish to make comparisons of all other alternatives with respect to one particular alternative, usually the without project alternative. ESAP permits such comparisons through use of the OVERALL SCORES RELATIVE option. The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: 1. ESAP asks, "DO YOU WISH TO DISPLAY OVERALL SCORES RELATIVE TO A PARTICULAR ALTERNATIVE?"

2. User responds, "YES"

3. ESAP asks, "WHICH ALTERNATIVE?"

4. User identifies alternative, e.g., "ALT.3"

Expert: 1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"

2. User responds, "2"

3. ESAP asks, "WHICH ALTERNATIVE?"

4. User identifies alternative, e.g., "ALT.3"

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnameUNCERTAIN DATA" and "*END" cards:

```
DISPLAY   OVERALL SCORES RELATIVE TO    ALT.3
+         +                             +
1         11                            41
```

where "ALT.3" can be replaced by the name of any alternative.

The type of display produced by OVERALL SCORES RELATIVE is identical to that produced by the OVERALL SCORES option (see 7.4.2.1, above) with the exception that the minimum, most probable, and maximum scores for all other alternatives are expressed in terms of positive or negative deviations from the most probable score for the specified alternative. An example of output from the OVERALL SCORES RELATIVE option appears in Figure 7.17. As can be seen, the maximum score for all alternatives exceeds the most probable score for ALT.3, while the minimum score for all except ALT.4 is lower than the most probable score for ALT.3.

```
PUBLIC: NATURE

OVERALL SCORES RELATIVE TO ALTERNATIVE ALT.3

                OVERALL SCORE--UNCERTAIN DATA
               RELATIVE TO ALTERNATIVE ALT.3
          -40 -30 -20 -10   0  10  20  30  40  50  60                MOST
ALT.        +---+---+---+---+---+---+---+---+---+---+---+   MINIMUM  PROBABLE  MAXIMUM
ALT.4                      L--*---H                             .8      8.3      16.6
ALT.3                   L--*--H                               -7.2       .0       7.5
ALT.1                  L---*---H                              -8.8      -.8       7.1
ALT.2                  L-*--H                                 -9.8     -3.7       2.6

ALTERNATIVES STILL IN CONTENTION:     ALTERNATIVES TO BE ELIMINATED:
            ALT.4
            ALT.3
            ALT.1
            ALT.2
```

Figure 7.17. Display from EVALUATE with UNCERTAIN data: OPTION 2, OVERALL SCORES RELATIVE

7.4.2.3 <u>OPTION 3, ALTERN. SCORES</u>. The ALTERN. SCORES option analyzes and displays the effects of uncertainty concerning an alternative's projected effects on the desirability scores for that alternative. For any alternative included in the analysis, this option can analyze and display the MIN. and MAX. scores (worst-case and best-case analyses, respectively) for each variable included in the tree. The output thus permits users to identify where in the tree uncertainty about the projected levels of variables has greatest effect on uncertainty about the desirability of an alternative.

The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: 1. ESAP asks, "DO YOU WISH TO SEE THE SCORES FOR INDIVIDUAL ALTERNATIVES?"

2. User responds, "YES"

3. ESAP asks, "WHICH ALTERNATIVES?"

4. User identifies alternatives, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.

Expert: 1. ESAP requests, "ENTER OPTION NUMBER (1-1C OR 99 FOR LIST):"

2. User responds, "3"

3. ESAP asks, "FOR WHICH ALTERNATIVES?"

4. User identifies alternatives, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnameUNCERTAIN DATA" and "*END" cards:

```
DISPLAY   ALTERN. SCORES
+         +
1         11
```

In batch mode for this option, ESAP produces displays for all alternatives.

An example of output from ALTERN. SCORES appears in Figure 7.18. Note that the range in scores for the HIST/RES variable for ALT.2 is only .6 (see arrow); that is, the best case and worst case analyses lead to very little difference in the projected degree of desirability for that variable. Uncertainty has a much larger effect, however, on the projected desirability of ALT.2's effects on the AQUATIC variable (i.e., 4.8 points). From this type of analysis, users can learn that

PUBLIC: NATURE
EFFECTS OF UNCERTAINTY ON SCORES FOR ALTERNATIVE ALT.2

VARIABLE		SCORES MIN.	SCORES MAX.	RANGE DUE TO UNCERTAINTY	RANGE OF SCORES DUE TO UNCERTAINTY 0 20 40 60 80 100 +----+----+----+----+----+
LEVEL 0:					
EQ		41.2	53.6	12.5	XXXX
LEVEL 1:					
TERRESTRAL		9.0	13.0	4.0	XX
AQUATIC		8.7	13.6	4.8	XX
AIR		13.5	16.5	3.0	
HIST/RES		9.9	10.6	.6	
LEVEL 2:					
TERR/HAB	(TERRESTRAL)	1.8	3.7	1.9	
TERR/ECOS	(TERRESTRAL)	2.8	4.0	1.2	
LAND/QUAL	(TERRESTRAL)	4.4	5.3	.8	
AQUA/HAB	(AQUATIC)	.8	2.1	1.2	
WATERQUAL	(AQUATIC)	3.9	6.4	2.5	
AQUA/ECOS	(AQUATIC)	3.9	5.0	1.1	
HISTORIC	(HIST/RES)	5.5	5.9	.4	
ARCHEOLOGIC	(HIST/RES)	4.4	4.7	.3	
LEVEL 3:					
FOREST/HAB	(TERR/HAB)	1.8	3.1	1.3	
CLEAR/HAB	(TERR/HAB)	.0	.6	.6	
TER/SP/DV	(TERR/ECOS)	2.2	3.4	1.1	
WETLANDS	(TERR/ECOS)	.5	.7	.1	
FLOODS	(LAND/QUAL)	1.1	1.3	.2	
SOIL/NUTR	(LAND/QUAL)	3.3	4.0	.7	
FISH	(AQUA/HAB)	.3	.6	.2	
RIPARIAN	(AQUA/HAB)	.5	1.5	1.0	
PHYSICAL	(WATERQUAL)	1.5	3.0	1.5	
CHEM	(WATERQUAL)	2.4	3.4	1.0	
AQ/SP/DV	(AQUA/ECOS)	2.2	3.0	.8	
AQ/PLNTS	(AQUA/ECOS)	1.7	2.0	.3	
SITE/AREA	(HISTORIC)	2.7	2.9	.2	
STRUCTURE	(HISTORIC)	2.8	3.0	.2	
PRECOLUM	(ARCHEOLOGIC)	2.1	2.1	.0	
COLUMBIAN	(ARCHEOLOGIC)	2.3	2.6	.3	
LEVEL 4:					
TEMP	(PHYSICAL)	1.5	2.1	.6	
TURBID	(PHYSICAL)	.0	1.0	1.0	
PH	(CHEM)	1.0	1.6	.6	
DO	(CHEM)	1.5	1.8	.3	

Figure 7.18. Display from EVALUATE with UNCERTAIN data: OPTION 3, ALTERN. SCORES

although the results of the evaluation would be little changed by conducting a study that reduces the degree of uncertainty attending ALT.2's effects on the HIST/RES variable, a study reducing the amount of uncertainty associated with the AQUATIC variable might reduce considerably the degree of uncertainty concerning the overall desirability of ALT.2.

7.4.2.4 OPTION 4, ALTERN. SCORES RELATIVE. Users may sometimes wish to analyze the effects of uncertainty on one alternative's variable scores, within the broader context of comparing that alternative to another alternative (e.g., the without project alternative). The ALTERN. SCORES RELATIVE option enables users to compare one alternative's minimum and maximum scores against another alternative's most probable scores.

The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: OPTION 4 is not available in guide mode.

Expert:
1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"
2. User responds, "4"
3. ESAP asks, "FOR WHICH ALTERNATIVES?"
4. User identifies alternative, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.
5. ESAP asks, "RELATIVE TO WHICH ALTERNATIVES?"
6. User identifies alternative, e.g., "ALT.3," "ALT.1," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnameUNCERTAIN DATA" and "*END" cards:

```
DISPLAY   ALTERN. SCORES RELATIVE TO    ALT.3
+         +                             +
1         11                            41
```

where "ALT.3" can be replaced by the name of any alternative. In batch mode for this option, ESAP produces displays for all alternatives.

An example of output from this option appears in Figure 7.19. In this example, ALT.2's minimum and maximum scores are compared to ALT.4's most probable scores. For this particular public group, even the maximum overall score for ALT.2 does not exceed the most probable score for ALT.4, as indicated by the -5.7 score for EQ under the MAX. SCORE column.

7.4.2.5 OPTION 5, AVERAGE EFFECTS. Users may frequently be interested in learning about the average effects of uncertainty across all alternatives on the desirability scores for alternatives. The AVERAGE EFFECTS option permits users to analyze and display, in both a tree format and tabular format, the average range in VARIABLE SCORES due to uncertainty.

The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide:
1. ESAP asks, "DO YOU WISH TO SEE THE AVERAGE EFFECTS OF UNCERTAINTY ON THE SCORES?"
2. User responds, "YES"

Expert:
1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"
2. User responds, "5"

PUBLIC: NATURE
EFFECTS OF UNCERTAINTY ON SCORES FOR ALTERNATIVE ALT.2
RELATIVE TO ALTERNATIVE ALT.4

VARIABLE		SCORES MIN.	SCORES MAX.	RANGE DUE TO UNCERTAINTY	RANGE OF SCORES DUE TO UNCERTAINTY 0 20 40 60 80 100
LEVEL 0:					
EQ		-18.1	-5.7	12.5	XXXX
LEVEL 1:					
TERRESTRAL		-10.3	-6.3	4.0	XX
AQUATIC		-8.6	-3.8	4.8	XX
AIR		-1.5	1.5	3.0	
HIST/RES		2.3	2.9	.6	
LEVEL 2:					
TERR/HAB	(TERRESTRAL)	-6.6	-4.7	1.9	
TERR/ECOS	(TERRESTRAL)	-5.6	-4.3	1.2	
LAND/QUAL	(TERRESTRAL)	1.8	2.7	.8	
AQUA/HAB	(AQUATIC)	-4.2	-3.0	1.2	
WATERQUAL	(AQUATIC)	-2.4	.1	2.5	
AQUA/ECOS	(AQUATIC)	-2.0	-.9	1.1	
HISTORIC	(HIST/RES)	-1.3	-.9	.4	
ARCHEOLOGIC	(HIST/RES)	3.6	3.9	.3	
LEVEL 3:					
FOREST/HAB	(TERR/HAB)	-4.7	-3.4	1.3	
CLEAR/HAB	(TERR/HAB)	-1.9	-1.2	.6	
TER/SP/DV	(TERR/ECOS)	-1.0	.2	1.1	
WETLANDS	(TERR/ECOS)	-4.6	-4.5	.1	
FLOODS	(LAND/QUAL)	.5	.7	.2	
SOIL/NUTR	(LAND/QUAL)	1.3	2.0	.7	
FISH	(AQUA/HAB)	-1.7	-1.5	.2	
RIPARIAN	(AQUA/HAB)	-2.5	-1.5	1.0	
PHYSICAL	(WATERQUAL)	-1.3	.2	1.5	
CHEM	(WATERQUAL)	-1.1	-.1	1.0	
AQ/SP/DV	(AQUA/ECOS)	-3.8	-3.0	.8	
AQ/PLNTS	(AQUA/ECOS)	1.7	2.0	.3	
SITE/AREA	(HISTORIC)	-.4	-.2	.2	
STRUCTURE	(HISTORIC)	-.9	-.8	.2	
PRECOLUM	(ARCHEOLOGIC)	1.3	1.3	.0	
COLUMBIAN	(ARCHEOLOGIC)	2.3	2.5	.3	
LEVEL 4:					
TEMP	(PHYSICAL)	-.5	.0	.6	
TURBID	(PHYSICAL)	-.8	.2	1.0	
PH	(CHEM)	-.8	-.1	.6	
DO	(CHEM)	-.3	.0	.3	

Figure 7.19. Display from EVALUATE with UNCERTAIN data: OPTION 4, ALTERN. SCORE RELATIVE

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnameUNCERTAIN DATA" and "*END" cards:

```
DISPLAY   AVERAGE EFFECTS
+         +
1         11
```

An example of tree format output from this option appears in Figure 7.20a; an example of tabular format output from this option appears in Figure 7.20b. The displays appearing in Figure 7.20 indicate that uncertainty affects this particular public group's desirability scores most greatly for the AQUATIC variable, followed by the TERRESTRAL, AIR, and HIST/RES variables. This analysis might be interpreted as suggesting that any study designed to reduce uncertainty concerning alternatives' projected effects on variables might most profitably be focused on reducing uncertainty concerning effects on the AQUATIC variable.

7.4.2.6 OPTION 6, VARIABLE SCORES. Users may sometimes wish to examine the effects of uncertainty on individual variables. The VARIABLE SCORES option permits users to compare specified variables' minimum, most probable, and maximum scores for all alternatives. The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: OPTION 6 is not available in guide mode.

Expert:
1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"
2. User responds, "6"
3. ESAP requests, "FOR WHICH VARIABLE?"

```
PUBLIC: NATURE
AVERAGE EFFECTS OF UNCERTAINTY ON SCORES FOR ALL ALTERNATIVES

AVERAGE RANGE OF SCORES DUE TO UNCERTAINTY

                                               |FOREST/HAB
                                               |     1.4
                                  |TERR/HAB---|CLEAR/HAB
                                  |    1.9     |      .5
                                  |
                                  |
                                  |            |TER/SP/DV
                                  |            |     1.2
                    |TERRESTRAL-|TERR/ECOS--|WETLANDS
                    |     4.5     |    1.7     |      .6
                    |             |
                    |             |
                    |             |            |FLOODS
                    |             |            |      .2
                    |             |LAND/QUAL--|SOIL/NUTR
                    |             |     .9     |      .7
                    |
                    |
                    |                          |FISH
                    |                          |      .6
                    |             |AQUA/HAB---|RIPARIAN
                    |             |    1.7     |     1.0
                    |             |                        |TEMP
                    |             |                        |      .5
                    |             |            |PHYSICAL---|TURBID
                    |             |            |     1.4   |      .9
                    |             |            |
                    |             |            |
EQ---------|AQUATIC----|WATERQUAL--|                      |PH
    14.7            |     6.0     |    2.4     |           |      .6
                    |             |            |CHEM-------|DO
                    |             |            |     1.0   |      .4
                    |             |
                    |             |
                    |             |            |AQ/SP/DV
                    |             |            |     1.4
                    |             |AQUA/ECOS--|AQ/PLNTS
                    |             |    2.0     |      .6
                    |AIR
                    |     3.0
                    |                          |SITE/AREA
                    |                          |      .4
                    |             |HISTORIC----|STRUCTURE
                    |             |     .7     |      .3
                    |             |
                    |             |
                    |HIST/RES   -|             |PRECOLUM
                    |     1.2     |            |      .0
                    |             |ARCHEOLOGIC |COLUMBIAN
                    |             |     .5     |      .5
```

a. Tree format display

Figure 7.20 Display from EVALUATE with UNCERTAIN data: OPTION 5, AVERAGE EFFECTS

PUBLIC: NATURE

AVERAGE EFFECTS OF UNCERTAINTY ON SCORES FOR ALL ALTERNATIVES

VARIABLE		AVERAGE MOST PROBABLE SCORE	AVERAGE RANGE DUE TO UNCERTAINTY	AVERAGE RANGE OF SCORES DUE TO UNCERTAINTY 0 20 40 60 80 100 +-----+-----+-----+-----+-----+
LEVEL 0:				
EQ		52.0	14.7	XXXX
LEVEL 1:				
TERRESTRAL		14.8	4.5	XX
AQUATIC		16.1	6.0	XX
AIR		15.0	3.0	
HIST/RES		6.0	1.2	
LEVEL 2:				
TERR/HAB	(TERRESTRAL)	3.7	1.9	
TERR/ECOS	(TERRESTRAL)	5.8	1.7	
LAND/QUAL	(TERRESTRAL)	5.3	.9	
AQUA/HAB	(AQUATIC)	4.1	1.7	
WATERQUAL	(AQUATIC)	6.2	2.4	
AQUA/ECOS	(AQUATIC)	5.8	2.0	
HISTORIC	(HIST/RES)	3.9	.7	
ARCHEOLOGIC	(HIST/RES)	2.1	.5	
LEVEL 3:				
FOREST/HAB	(TERR/HAB)	2.8	1.4	
CLEAR/HAB	(TERR/HAB)	.9	.5	
TER/SP/DV	(TERR/ECOS)	2.9	1.2	
WETLANDS	(TERR/ECOS)	2.9	.6	
FLOODS	(LAND/QUAL)	1.3	.2	
SOIL/NUTR	(LAND/QUAL)	4.0	.7	
FISH	(AQUA/HAB)	2.3	.6	
RIPARIAN	(AQUA/HAB)	1.7	1.0	
PHYSICAL	(WATERQUAL)	2.7	1.4	
CHEM	(WATERQUAL)	3.5	1.0	
AQ/SP/DV	(AQUA/ECOS)	4.8	1.4	
AQ/PLNTS	(AQUA/ECOS)	1.0	.6	
SITE/AREA	(HISTORIC)	1.9	.4	
STRUCTURE	(HISTORIC)	2.0	.3	
PRECOLUM	(ARCHEOLOGIC)	1.1	.0	
COLUMBIAN	(ARCHEOLOGIC)	1.0	.5	
LEVEL 4:				
TEMP	(PHYSICAL)	1.9	.5	
TURBID	(PHYSICAL)	.9	.9	
PH	(CHEM)	1.6	.6	
DO	(CHEM)	1.8	.4	

b. Tabular format display

Figure 7.20 (continued)

4. User identifies variable, e.g., "PH," "TERRESTRAL," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnameUNCERTAIN DATA" and "*END" cards.

```
DISPLAY    TERRESTRALSCORES
+          +            +
1          11           21
```

where "TERRESTRAL" can be replaced by the name of any variable.

An example of a display from VARIABLE SCORES appears in Figure 7.21. In the example, there appears to be roughly equivalent ranges of uncertainty around the TERRESTRAL variable for each of the four alternatives.

```
PUBLIC: FARMERS

VARIABLE SCORES FOR TERRESTRAL

                  TERRESTRAL SCORE--UNCERTAIN DATA
          0  10  20  30  40  50  60  70  80  90 100                  MOST
ALT.      +---+---+---+---+---+---+---+---+---+---+     MINIMUM   PROBABLE   MAXIMUM
ALT.1                 L*H                                 28.6      30.9      33.2
ALT.2              L*-H                                   21.7      24.2      26.6
ALT.3              L*H                                    19.7      22.5      25.3
ALT.4       L*H                                            8.9      11.4      13.9
```

Figure 7.21. Output from EVALUATE with UNCERTAIN data: OPTION 6, VARIABLE SCORES

7.4.2.7 <u>OPTION 7, VARIABLE SCORES RELATIVE</u>. The VARIABLE SCORES RELATIVE option permits users to conduct and display the same type of analyses as described above (7.4.2.6) for the VARIABLE SCORES option, with the exception that all scores are expressed as deviations from the most probable scores of the specified alternative. The procedures for requesting this option can be summarized as follows:

Interactive Mode

Guide: OPTION 7 is not available in guide mode.

Expert:
1. ESAP requests, "ENTER OPTION NUMBER (1-10 OR 99 FOR LIST):"
2. User responds, "7"
3. ESAP requests, "FOR WHICH VARIABLE?"
4. User identifies variable, e.g., "PH," "TERRESTRAL," etc.
5. ESAP requests, "RELATIVE TO WHICH ALTERNATIVE?"
6. User identifies alternative, e.g., "ALT.3"

Batch Mode

User requests this option by inserting the following card somewhere between the "*EVALUATE publicnameUNCERTAIN DATA" and "*END" cards:

```
DISPLAY   TERRESTRALSCORES RELATIVE TO  ALT.3
+         +         +                   +
1         11        21                  41
```

where "TERRESTRAL" can be replaced by the name of any variable and "ALT.3" can be replaced by the name of any alternative.

An example of output from VARIABLE SCORES RELATIVE appears in Figure 7.22. All scores are expressed as deviations from the most probable score for ALT.3.

```
PUBLIC: FARMERS

VARIABLE SCORES FOR TERRESTRAL RELATIVE TO ALTERNATIVE ALT.3

                TERRESTRAL SCORE--UNCERTAIN DATA
               RELATIVE TO ALTERNATIVE ALT.3
        -40 -30 -20 -10   0  10  20  30  40  50  60         MOST
ALT.      +---+---+---+---+---+---+---+---+---+---+  MINIMUM  PROBABLE  MAXIMUM
ALT.1                       L*H                          6.2       8.4     10.7
ALT.2                    L-*H                            -.8       1.7      4.2
ALT.3                    L*H                            -2.8        .0      2.8
ALT.4               L*H                                -13.6     -11.1     -8.5
```

Figure 7.22. Output from EVALUATE with UNCERTAIN data: OPTION 7, VARIABLE SCORES RELATIVE

8.0 COMPARING PUBLICS

8.1 INTRODUCTION

For most, if not all, water resources problems, more than one point of view can be found within the public. Groups who disagree about the relative importance of the various variables potentially affected by water resources alternatives, for instance can nearly always be identified. Similarly, it is usually possible to identify groups that disagree about the most desirable level of some variables.

ESAP permits users to describe multiple public groups through use of the WEIGHTS and FORMS procedure. The COMPARE procedure enables users to make comparisons among such groups. The COMPARE procedure allows users to learn how differences among public groups lead to differences in evaluating the overall desirability of alternatives, just as the EVALUATE procedure (when used with UNCERTAIN data) allows users to learn how uncertainties about projected variable levels lead to uncertainty about the overall desirability of alternatives.

Similar to the EVALUATE procedure, the COMPARE procedure offers users a number of display options. Also similarly to EVALUATE, the COMPARE procedure can be used with either PRECISE or UNCERTAIN data. The COMPARE procedure cannot be used to compare public groups, however, prior to those groups having been analyzed by EVALUATE.

8.2 INTERACTIVE COMPARE PROCEDURE

The interactive COMPARE procedure begins by asking users which type of data (precise or uncertain) is to be used (see Figure 8.1).

```
 ENTER PROCEDURE NAME:
I>compare
 ENTERING COMPARE PROCEDURE.

 PRECISE OR UNCERTAIN DATA?
I>p
```

Figure 8.1. Choosing data type in interactive COMPARE procedure

Next, the procedure asks users a series of questions that suggest the various types of displays that can be printed by the program. Each question states the type of comparison that can be made, and users may decide either to print the display or go on to the next question (Figure 8.2).

For some displays, the names of one or more alternatives or publics are requested. In response to such a request, the user may enter a list of names or the keyword "all," indicating all alternatives or variables, as the case may be. Caution should be exercised when using the "all" keyword, since doing so may result in large amounts of output being generated.

A flow diagram describing the interactive COMPARE procedure appears in Figure 8.3.

```
DO YOU WISH TO SEE ALL ALTERNATIVES COMPARED ON THE BASIS OF AVERAGE
OVERALL SCORES FOR ALL PUBLICS?
I>yes

COMPARE PROCEDURE. PRECISE DATA. OPTION 1:  AVERAGE OVERALL SCORES.
DATE: 80/06/19. TIME: 17.45.37.


AVERAGE OVERALL SCORES FOR ALL PUBLICS

                          OVERALL SCORE
           0  10  20  30  40  50  60  70  80  90 100
ALT.       +---+---+---+---+---+---+---+---+---+---+  MINIMUM  AVERAGE  MAXIMUM
ALT.1                          2---*--1                50.2     61.4     69.1
ALT.4                      3----*--1                   43.3     54.6     61.3
ALT.3                          2-*1                    51.0     53.8     57.1
ALT.2                    1--*--3                       37.7     45.7     51.9

PUBLICS:
---------------
1.  PRESRVATOR
2.  NATURE
3.  FARMERS


ALTERNATIVES STILL IN CONTENTION:     ALTERNATIVES TO BE ELIMINATED:
            ALT.1                                ALT.2
            ALT.3
            ALT.4

DO YOU WISH TO SEE THE PUBLICS COMPARED ON THE BASIS OF OVERALL SCORES
GIVEN TO INDIVIDUAL ALTERNATIVES?
I>yes

WHICH ALTERNATIVES?
I>alt.4


COMPARE PROCEDURE. PRECISE DATA. OPTION 2:  OVERALL SCORES.
DATE: 80/06/19. TIME: 17.45.37.


OVERALL SCORES FOR ALTERNATIVE ALT.4

                            OVERALL SCORE
           0    10    20    30    40    50    60    70    80    90   100
PUBLIC     +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+      VALUE
PRESRVATOR XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                   61.3
NATURE     XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                    59.3
FARMERS    XXXXXXXXXXXXXXXXXXXXXX                                            43.3
             .
             .
             .
```

Figure 8.2. Sample interaction in interactive COMPARE procedure

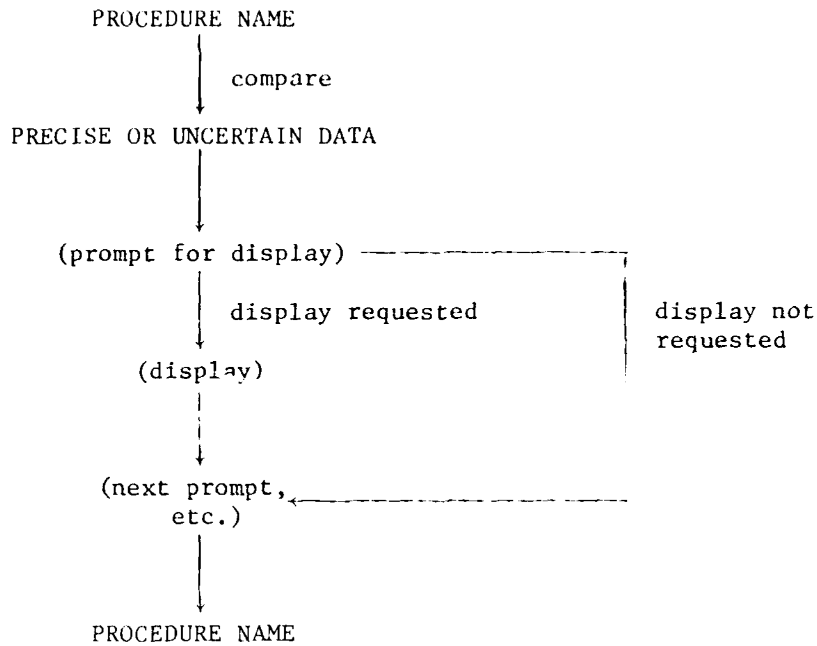


Figure 8.3. Flow diagram for use of interactive COMPARE procedure

8.3 BATCH COMPARE PROCEDURE

An example of input to the batch COMPARE procedure appears in Figure 8.4. The *COMPARE card contains a field for indicating the type of data to be used by the procedure. The remainder of the cards (called DISPLAY cards) requests by name the specific displays to be printed.

The type of data to be used in making comparisons is indicated in columns 11-25 of the *COMPARE card and must specify either PRECISE DATA or UNCERTAIN DATA. If this field is left blank the program behaves as if PRECISE DATA had been specified.

```
*COMPARE  PRECISE DATA
DISPLAY   AVERAGE OVERALL SCORES
DISPLAY   PAIR DIFFERENCES    FARMERS   PRESRVATOR
DISPLAY   AVERAGE DIFFERENCES
*END
+         +         +         +         +
1         11        21        31        41
```

Figure 8.4. Input to batch COMPARE procedure

The DISPLAY cards (which are optional) are divided into three fields, the option name field and two public name fields. The option name field occupies columns 11-35 and contains the name of the desired display option. Valid option names for each set of data are shown in Table 8.1. These options are described in greater detail in section 8.4.

Table 8.1

Display Options for Batch COMPARE Procedure

PRECISE DATA	UNCERTAIN DATA
1. AVERAGE OVERALL SCORES	1. AVERAGE OVERALL SCORES
2. OVERALL SCORES	2. OVERALL SCORES
3. PAIR DIFFERENCES	
4. AVERAGE DIFFERENCES	

The public name fields occupy columns 31-40 and 41-50. These fields are used by the PAIR DIFFERENCES option to indicate the pair of publics that are to be compared.

The last card in the input to the COMPARE procedure is the *END card. Note that there must be a *END card in the input, even if no

DISPLAY cards are present. Upon encountering the *END card, the COMPARE procedure ends.

8.4 DISPLAYS FROM COMPARE PROCEDURE

Displays can be produced by the COMPARE procedure using either PRECISE or UNCERTAIN data. Each is discussed in turn.

8.4.1 WITH PRECISE DATA

There are four options available using the COMPARE procedure with PRECISE data. Each is described below.

8.4.1.1 OPTION 1, AVERAGE OVERALL SCORES. The AVERAGE OVERALL SCORES option provides users with information about how the various public groups evaluated alternative water resources management plans. The procedures for requesting this option can be summarized as follows:

Interactive Mode

1. ESAP asks, "DO YOU WISH TO SEE ALL ALTERNATIVES COMPARED ON THE BASIS OF AVERAGE OVERALL SCORES FOR ALL PUBLICS?"
2. User responds, "YES"

Batch Mode

User requests this option by inserting the following card somewhere between the "*COMPARE PRECISE DATA" and "*END" cards:

```
DISPLAY   AVERAGE OVERALL SCORES
+          +
1         11
```

An example of a display from this option appears in Figure 8.5; the alternatives are rank-ordered in terms of their AVERAGE OVERALL SCORES, where the average is computed on the basis of scores from all public groups previously analyzed by the EVALUATE procedure. In addition to displaying AVERAGE SCORES, the MINIMUM and MAXIMUM scores for each alternative are displayed. The display also indicates which particular public group assigned the minimum and maximum scores to each alternative. For instance, in the present example ALT.1 received an AVERAGE OVERALL SCORE of 61.4; the lowest score for this alternative, 50.2, was assigned by PUBLIC 2, identified as the NATURE group; the highest score for this alternative, 69.1, was assigned by PUBLIC 1, identified as the PRESRVATOR group.

```
AVERAGE OVERALL SCORES FOR ALL PUBLICS

                            OVERALL SCORE
          Ø  1Ø  2Ø  3Ø  4Ø  5Ø  6Ø  7Ø  8Ø  9Ø 1ØØ
ALT.      +---+---+---+---+---+---+---+---+---+---+  MINIMUM  AVERAGE  MAXIMUM
ALT.1                         2----*--1               5Ø.2     61.4     69.1
ALT.4                      3----*--1                  43.3     54.6     61.3
ALT.3                         2-*1                    51.Ø     53.8     57.1
ALT.2                    1--*--3                      37.7     45.7     51.9

PUBLICS:
---------------
1.  PRESRVATOR
2.  NATURE
3.  FARMERS


ALTERNATIVES STILL IN CONTENTION:     ALTERNATIVES TO BE ELIMINATED:
            ALT.1                                ALT.2
            ALT.3
            ALT.4
```

Figure 8.5. Display from COMPARE with PRECISE data: OPTION 1, AVERAGE OVERALL SCORES

This option also produces two columns entitled "ALTERNATIVES STILL IN CONTENTION" and "ALTERNATIVES TO BE ELIMINATED." In the present example, ALT.2 is identified as a candidate for elimination. Alternatives can be eliminated if there exists at least one other alternative, based on a pairwise comparison of alternatives, that all public groups find more desirable. (In the example, both ALT.1 and ALT.3 are preferred to ALT.2 by all three groups.) Users should recall, however, that this analysis is based solely upon PRECISE data values; the case for eliminating alternatives will usually be weakened when uncertainties in alternatives' projected effects are taken into account.

8.4.1.2 OPTION 2, OVERALL SCORES. Users may sometimes be interested in learning how every public group evaluates some or all of the alternatives. The OVERALL SCORES option permits users to obtain such information; the procedures for requesting this option can be summarized as follows:

Interactive Mode

1. ESAP asks, "DO YOU WISH TO SEE THE PUBLICS COMPARED ON THE BASIS OF OVERALL SCORES GIVEN TO INDIVIDUAL ALTERNATIVES?"
2. User responds, "YES"
3. ESAP asks, WHICH ALTERNATIVES?"
4. User identifies alternatives, e.g., "ALT.3," "ALT.3, ALT.4," "ALL," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*COMPARE PRECISE DATA" and "*END" cards:

```
DISPLAY   OVERALL SCORES
+         +
1         11
```

In batch mode for this option, ESAP produces displays for all alternatives.

An example of a display from this option appears in Figure 8.6. The OVERALL SCORES option indicates the overall scores assigned to any or all alternatives for every public group previously analyzed using the EVALUATE procedure.

```
OVERALL SCORES FOR ALTERNATIVE ALT.4

                                     OVERALL SCORE
           0    10   20   30   40   50   60   70   80   90  100
PUBLIC     +----+----+----+----+----+----+----+----+----+----+      VALUE
PRESRVATOR XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                           61.3
NATURE     XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                            59.3
FARMERS    XXXXXXXXXXXXXXXXXXXXXX                                    43.3
```

Figure 8.6. Display from COMPARE with PRECISE data: OPTION 2, OVERALL SCORES

8.4.1.3 OPTION 3, PAIR DIFFERENCES. Users frequently may wish to learn more about the reasons for differences between public groups in their evaluations of the overall desirability of alternatives. In particular, users may wish to learn for which variables various public groups make substantially different evaluations about the desirability of projected effects. The PAIR DIFFERENCES option allows users to examine the differences between any two public groups with respect to the variable scores they associate with alternatives. These differences are computed by taking the absolute difference between the variable scores attributed by the two groups to each alternative, and then averaging across all alternatives.

The procedures for requesting this option can be summarized as follows:

Interactive Mode

1. ESAP asks, "DO YOU WISH TO SEE THE DIFFERENCES BETWEEN PAIRS OF PUBLICS ACROSS ALL ALTERNATIVES?"
2. User responds, "YES"
3. ESAP asks, "FOR WHICH PUBLICS?"
4. User identifies desired pair of public groups, e.g., "NATURE, FARMERS"

Batch Mode

User requests this option by inserting the following card somewhere between the "*COMPARE PRECISE DATA" and "*END" cards:

```
DISPLAY   PAIR DIFFERENCES    NATURE   FARMERS
+         +                   +        +
1         11                  31       41
```

where NATURE and FARMERS can be replaced by the names of any public groups.

In the example presented in Figure 8.7a, the average differences between the NATURE and FARMERS groups in their scores for the TERRESTRAL variable is 11.4 points. This rather sizable difference indicates that there exists substantial disagreement among the two groups with respect to either (a) what constitutes a desirable effect on the TERRESTRAL variable, (b) the importance of the TERRESTRAL variable for evaluating alternatives, or (c) both. The analyses presented by the PAIR DIFFERENCES option thus can aid users in identifying minor versus major points of disagreement among various public groups. In this particular instance, considerable disagreement appears to exist between the NATURE and FARMERS group about the desirability of impacts on the TERRESTRAL variable. In addition to the tree format display presented in Figure 8.7a, the PAIR DIFFERENCES option also displays results in a tabular format; the corresponding tabular display appears in Figure 8.7b.

```
PUBLIC 1: NATURE
PUBLIC 2: FARMERS

DIFFERENCES IN SCORES FOR ALL ALTERNATIVES

                                   |FOREST/HAB
                                   |     2.1
                       |TERR/HAB---|CLEAR/HAB
                       |    4.8    |     3.5
                       |
                       |
                       |           |TER/SP/DV
                       |           |      .0
           |TERRESTRAL-|TERR/ECOS--|WETLANDS
           |     11.4  |    3.0    |     3.0
           |           |
           |           |
           |           |           |FLOODS
           |           |           |     4.0
           |           |LAND/QUAL--|SOIL/NUTR
           |           |    6.8    |     2.8
           |
           |
           |                       |FISH
           |                       |     1.5
           |           |AQUA/HAB---|RIPARIAN
           |           |    1.8    |      .3
           |           |                       |TEMP
           |           |                       |     1.5
           |           |           |PHYSICAL---|TURBID
           |           |           |     1.3   |      .4
           |           |           |
           |           |           |
EQ---------|AQUATIC----|WATERQUAL--|           |PH
     9.4   |     3.4   |    2.4    |           |     3.5
           |           |           |CHEM-------|DO
           |           |           |     3.3   |      .2
           |           |
           |           |
           |           |           |AQ/SP/DV
           |           |           |     3.6
           |           |AQUA/ECOS--|AQ/PLNTS
           |           |    2.9    |      .7
           |AIR
           |     9.0
           |                       |SITE/AREA
           |                       |      .4
           |           |HISTORIC---|STRUCTURE
           |           |    2.6    |     2.4
           |           |
           |           |
           |HIST/RES  -|           |PRECOLUM
           |     6.1   |           |      .1
                       |ARCHEOLOGIC|COLUMBIAN
                       |    6.3    |     6.2
```

a. Tree format display

Figure 8.7. Displays from COMPARE with PRECISE data: OPTION 3, PAIR DIFFERENCES

DIFFERENCES IN SCORES FOR ALL ALTERNATIVES
PUBLIC 1: NATURE
PUBLIC 2: FARMERS

VARIABLE		DIFFERENCE IN SCORES	DIFFERENCE IN SCORES 0 20 40 60 80 100 +----+----+----+----+----+
LEVEL 0:			
EQ		9.4	XXX
LEVEL 1:			
TERRESTRAL		11.4	XXXX
AQUATIC		3.4	XX
AIR		9.0	XXX
HIST/RES		6.1	XX
LEVEL 2:			
TERR/HAB	(TERRESTRAL)	4.8	XX
TERR/ECOS	(TERRESTRAL)	3.0	
LAND/QUAL	(TERRESTRAL)	6.8	XX
AQUA/HAB	(AQUATIC)	1.8	
WATERQUAL	(AQUATIC)	2.4	
AQUA/ECOS	(AQUATIC)	2.9	
HISTORIC	(HIST/RES)	2.6	
ARCHEOLOGIC	(HIST/RES)	6.3	XX
LEVEL 3:			
FOREST/HAB	(TERR/HAB)	2.1	
CLEAR/HAB	(TERR/HAB)	3.5	XX
TER/SP/DV	(TERR/ECOS)	.0	
WETLANDS	(TERR/ECOS)	3.0	
FLOODS	(LAND/QUAL)	4.0	XX
SOIL/NUTR	(LAND/QUAL)	2.8	
FISH	(AQUA/HAB)	1.5	
RIPARIAN	(AQUA/HAB)	.3	
PHYSICAL	(WATERQUAL)	1.3	
CHEM	(WATERQUAL)	3.3	
AQ/SP/DV	(AQUA/ECOS)	3.6	XX
AQ/PLNTS	(AQUA/ECOS)	.7	
SITE/AREA	(HISTORIC)	.4	
STRUCTURE	(HISTORIC)	2.4	
PRECOLUM	(ARCHEOLOGIC)	.1	
COLUMBIAN	(ARCHEOLOGIC)	6.2	XX
LEVEL 4:			
TEMP	(PHYSICAL)	1.5	
TURBID	(PHYSICAL)	.4	
PH	(CHEM)	3.5	XX
DO	(CHEM)	.2	

b. Tabular format display

Figure 8.7 (continued)

8.4.1.4 <u>OPTION 4, AVERAGE DIFFERENCES</u>. Users sometimes may wish to obtain the same type of information as is produced for pairs of public groups by the PAIR DIFFERENCES option (see 8.4.1.3), but for <u>all</u> public groups. In particular, users may wish to learn for which variables there exists greatest disagreement among public groups about the desirability of projected effects. The AVERAGE DIFFERENCES option permits users to obtain such information.

The procedures for requesting this option can be summarized as follows:

<u>Interactive Mode</u>

1. <u>ESAP</u> asks, "DO YOU WISH TO SEE THE AVERAGE DIFFERENCES IN THE SCORES ACROSS PUBLICS?"
2. <u>User</u> responds, "YES"

<u>Batch Mode</u>

<u>User</u> requests this option by inserting the following card somewhere between the "*COMPARE PRECISE DATA" and "*END" cards:

```
DISPLAY   AVERAGE DIFFERENCES
+         +
1         11
```

For each possible pair of public groups, the option first computes the absolute difference between the variable scores attributed by the two groups to each alternative, then averages across all alternatives, just as in the PAIR DIFFERENCES procedure. The AVERAGE DIFFERENCES option then takes the results from each possible pair and averages them. The displays from this option are identical in format to those from the PAIR DIFFERENCES option; the results refer, however, to all public groups. An example of tabular output from this option appears in Figure 8.8a; the corresponding display in tree format appears in Figure 8.8b. In this particular instance the analysis indicates that

AVERAGE DIFFERENCES IN SCORES ACROSS PUBLICS

VARIABLE		AVERAGE DIFFERENCE IN SCORES	AVERAGE DIFFERENCE IN SCORES 0 20 40 60 80 100 +----+----+----+----+----+
LEVEL 0:			
EQ		9.5	XXX
LEVEL 1:			
TERRESTRAL		8.3	XXX
AQUATIC		4.0	XX
AIR		8.0	XXX
HIST/RES		8.4	XXX
LEVEL 2:			
TERR/HAB	(TERRESTRAL)	3.8	XX
TERR/ECOS	(TERRESTRAL)	2.7	
LAND/QUAL	(TERRESTRAL)	6.2	XX
AQUA/HAB	(AQUATIC)	4.3	XX
WATERQUAL	(AQUATIC)	3.7	XX
AQUA/ECOS	(AQUATIC)	2.9	
HISTORIC	(HIST/RES)	4.9	XX
ARCHEOLOGIC	(HIST/RES)	5.9	XX
LEVEL 3:			
FOREST/HAB	(TERR/HAB)	2.4	
CLEAR/HAB	(TERR/HAB)	2.3	
TER/SP/DV	(TERR/ECOS)	2.4	
WETLANDS	(TERR/ECOS)	2.2	
FLOODS	(LAND/QUAL)	2.7	
SOIL/NUTR	(LAND/QUAL)	4.1	XX
FISH	(AQUA/HAB)	3.4	XX
RIPARIAN	(AQUA/HAB)	1.0	
PHYSICAL	(WATERQUAL)	1.1	
CHEM	(WATERQUAL)	3.4	XX
AQ/SP/DV	(AQUA/ECOS)	3.6	XX
AQ/PLNTS	(AQUA/ECOS)	.7	
SITE/AREA	(HISTORIC)	1.8	
STRUCTURE	(HISTORIC)	3.2	
PRECOLUM	(ARCHEOLOGIC)	1.2	
COLUMBIAN	(ARCHEOLOGIC)	4.8	XX
LEVEL 4:			
TEMP	(PHYSICAL)	1.1	
TURBID	(PHYSICAL)	.5	
PH	(CHEM)	2.8	
DO	(CHEM)	.7	

a. Tabular format display

Figure 8.8. Displays from COMPARE with PRECISE data: OPTION 4, AVERAGE DIFFERENCES

```
AVERAGE DIFFERENCES IN SCORES ACROSS PUBLICS

                                                FOREST HAB
                                                       2.4
                                   TERR/HAB---  CLEAR/HAB
                                        3.8            2.3


                                                TER/SP DV
                                                       2.4
                     TERRESTRAL- TERR/ECOS--  WETLANDS
                          8.3           2.7            2.2


                                                FLOODS
                                                       2.7
                                   LAND/QUAL--  SOIL/NUTR
                                        6.2            4.1


                                                FISH
                                                       [illegible]
                                   AQUA/HAB---  RIPARIAN
                                        4.3            [illegible]
                                                              TEMP
                                                                   [illegible]
                                                PHYSICAL---  TURBID
                                                       [illegible]         .5

EQ---------- AQUATIC---- WATERQUAL--                          PH
        9.5          4.2          3.7                              2.8
                                                CHEM-------  DO
                                                       3.4          .7


                                                AQ/SP/DV
                                                       3.6
                                   AQUA/ECOS--  AQ/PLNTS
                                        2.9            .7
                     AIR
                          8.8
                                                SITE/AREA
                                                       1.8
                                   HISTORIC----  STRUCTURE
                                        4.9            3.2


                     HIST/RES     -                PRECOLUM
                          8.4                          1.2
                                   ARCHEOLOGIC  COLUMBIAN
                                        5.9            4.8
```

b. Tree format display

Figure 8.8 (continued)

disagreement among the various public groups appears to be rather diverse. No single variable or subgroup of variables stands out as a source of disagreement among the public groups.

8.4.2 WITH UNCERTAIN DATA

Two options are available in the COMPARE procedure using UNCERTAIN data. Each is discussed briefly below.

8.4.2.1 OPTION 1, AVERAGE OVERALL SCORES. The AVERAGE OVERALL SCORES option provides users with information about how the various public groups evaluated water resources management plans, taking into consideration uncertainty about the projected effects of alternatives. The procedures for requesting this option can be summarized as follows:

Interactive Mode

1. ESAP asks, "DO YOU WISH TO SEE ALL ALTERNATIVES COMPARED ON THE BASIS OF AVERAGE OVERALL SCORES FOR ALL PUBLICS."
2. User responds, "YES"

Batch Mode

User requests this option by inserting the following card somewhere between the "*COMPARE UNCERTAIN DATA" and "*END" cards:

```
DISPLAY    AVERAGE OVERALL SCORES
+          +
1          11
```

An example of a display from this option appears in Figure 8.9; the alternatives are rank-ordered in terms of their average overall scores, where the average is computed from the most probable scores

```
AVERAGE OVERALL SCORES FOR ALL PUBLICS

                    OVERALL SCORE--UNCERTAIN DATA
             Ø  1Ø  2Ø  3Ø  4Ø  5Ø  6Ø  7Ø  8Ø  9Ø 1ØØ
ALT.         +----+----+----+----+----+----+----+----+----+----+  MINIMUM  AVERAGE  MAXIMUM
ALT.1                          2-------*-----1                      42.2     61.4     77.3
ALT.4                       3-------*----2                          36.4     54.6     67.6
ALT.3                            2---*---1                          43.8     53.8     64.7
ALT.2                     1-----*-----3                             31.Ø     45.7     59.1

PUBLICS:
---------------
1.  PRESRVATOR
2.  NATURE
3.  FARMERS

ALTERNATIVES STILL IN CONTENTION:     ALTERNATIVES TO BE ELIMINATED:
            ALT.1
            ALT.2
            ALT.3
            ALT.4
```

Figure 8.9. Display from COMPARE with UNCERTAIN data: OPTION 1, AVERAGE OVERALL SCORES

(i.e., those scores generated with the PRECISE data values) for all public groups previously analyzed by the EVALUATE procedure.

Recall that the EVALUATE procedure produces a minimum and maximum score for each public group, when it is used with UNCERTAIN data, in addition to a "MOST PROBABLE SCORE." The minimum score constitutes a "worst case" analysis for each alternative; the maximum score constitutes a "best case" analysis. For the AVERAGE OVERALL SCORES option, "minimum" and "maximum" scores are also displayed for each alternative. The minimum score in this option is the lowest "minimum" score associated with that alternative by any public group; similarly, the maximum score for each alternative is the highest maximum score associated with that alternative by any public group. In short, the minimum score for an alternative can be interpreted as the lowest score which that alternative could receive from <u>any</u> public group, given the uncertainties in its projected effects. The maximum score can be interpreted as the highest score which that alternative could receive from any public group, given the uncertainties in its projected effects. The display also indicates which particular groups associated the minimum and maximum scores with each alternative. For instance, in the example appearing in Figure 8.9, ALT.1 received an AVERAGE OVERALL SCORE of 61.4; the MINIMUM SCORE for this alternative, 42.2, was assigned by PUBLIC 2 (NATURE); the MAXIMUM SCORE for this alternative, 77.3, was assigned by PUBLIC 1 (PRESRVATOR).

This option also produces two columns entitled "ALTERNATIVES STILL IN CONTENTION" and "ALTERNATIVES TO BE ELIMINATED." The present test is a far more rigorous test for elimination than any of the tests described previously. Alternatives can be eliminated only if there exists some other alternative such that the minimum score associated with it by each group is greater than the maximum score each public group associates with the alternative-to-be-eliminated. In other words, every public group must agree that there exists some other alternative that they find more desirable in its worst-case analysis than they find the best-case analysis for the alternative-to-be-eliminated. In the present example no alternative can be eliminated on this ground.

8.4.2.2 OPTION 2, OVERALL SCORES. Users may sometimes be interested in learning how every public group evaluates particular alternatives, and how those evaluations are affected by uncertainty. The OVERALL SCORES option enables users to observe the minimum, most probable, and maximum scores that each group assigns to any or all alternatives. In other words, it indicates the scores that each alternative would receive under worst-case, most-likely-case, and best-case analyses, for each public group.

The procedures for requesting this option can be summarized as follows:

Interactive Mode

1. ESAP asks, "DO YOU WISH TO SEE THE PUBLICS COMPARED ON THE BASIS OF OVERALL SCORES GIVEN TO INDIVIDUAL ALTERNATIVES?"
2. User responds, "YES"
3. ESAP asks, "WHICH ALTERNATIVES?"
4. User identifies alternatives, e.g., "ALT.3," "ALT.1, ALT.3," "ALL," etc.

Batch Mode

User requests this option by inserting the following card somewhere between the "*COMPARE UNCERTAIN DATA" and "*END" cards:

```
DISPLAY   OVERALL SCORES
+         +
1         11
```

In batch mode for this option, ESAP produces displays for all alternatives.

An example of a display from this option appears in Figure 8.10. Scores are displayed for each public group which has been analyzed using the EVALUATE procedure.

```
OVERALL SCORES FOR ALTERNATIVE ALT.1

                 OVERALL SCORE--UNCERTAIN DATA
          Ø  1Ø  2Ø  3Ø  4Ø  5Ø  6Ø  7Ø  8Ø  9Ø 1ØØ              MOST
PUBLIC    +---+----+----+----+---+----+----+----+----+----+  MINIMUM  PROBABLE  MAXIMUM
PRESRVATOR                         L--*--H                     6Ø.7     69.1      77.3
NATURE                     L--*--H                             42.2     5Ø.2      58.1
FARMERS                          L--*--H                       57.1     64.9      72.3
```

Figure 8.10. Display from COMPARE with UNCERTAIN data: OPTION 2, OVERALL SCORES

9.0 UTILITY PROCEDURES

Four procedures (DISPLAY, SAVE, CONTINUE, and END) are intended solely to facilitate use of ESAP and are not directly involved in data analysis. Each is described briefly below. The procedure for changing information in the interactive mode is also discussed.

9.1 DISPLAY PROCEDURE (INTERACTIVE MODE ONLY)

At times users may wish to display some or all of the information previously specified to ESAP without conducting any additional analyses or changing previously specified information. The DISPLAY procedure allows users to display the contents of any of the following procedures: TREE, RANGES, WEIGHTS, FORMS, DATA, VARIABLES, PUBLICS, or ALTERNS.

The DISPLAY procedure is available only in the interactive ESAP program. Users may enter the DISPLAY procedure at any time and request that various pieces of information (e.g., weights, data) be printed (see Figure 9.1).

The DISPLAY procedure repeatedly asks users "WHAT IS TO BE DISPLAYED?" Users respond with the name of the information that is desired. For some displays, users are asked for the names of the alternatives or publics for which the information is to be printed. Users may enter either a list of names or the keyword "all," indicating all alternatives or publics, [illegible]e case may be. Caution should be exercised when using the "all" keyword, as doing so may result in large amounts of output to be generated.

```
 ENTER PROCEDURE NAME:
I>display
 ENTERING DISPLAY PROCEDURE.

 WHAT IS TO BE DISPLAYED?
I>tree

 DISPLAY PROCEDURE. DATE: 80/06/19. TIME: 18.05.02.


 TREE:

                                           |FOREST/HAB
                              |TERR/HAB---|CLEAR/HAB
                              |
                              |            |TER/SP/DV
                |TERRESTRAL-|TERR/ECOS--|WETLANDS
                |             |
                |             |            |FLOODS
                |             |LAND/QUAL--|SOIL/NUTR
                |
                |                          |FISH
                |             |AQUA/HAB---|RIPARIAN

 WHAT IS TO BE DISPLAYED?
I>data

 PRECISE OR UNCERTAIN?
I>p

 DISPLAY PROCEDURE. PRECISE DATA. DATE: 80/06/19. TIME: 18.05.02.

 PRECISE DATA VALUES:

 ALT.        AIR         FOREST/HAB CLEAR/HAB  TER/SP/DV  WETLANDS   FLOODS
 ---------------------------------------------------------------------------------
 ALT.1          300.00   30000.00   45000.00       65.00     100.00  12000.00
 ALT.2          300.00   40000.00   50000.00       70.00      35.00  45000.00
 ALT.3          300.00   35000.00   45000.00       75.00     250.00  50000.00
 ALT.4          300.00   65000.00   25000.00       80.00     300.00  60000.00

 WHAT IS TO BE DISPLAYED?
I>weights

 PUBLICS:
  1.   PRESRVATOR
  2.   NATURE
  3.   FARMERS

 ENTER NAMES OF PUBLICS FOR WEIGHTS DISPLAY:
I>all
```

Figure 9.1. Displaying selected information with interactive DISPLAY procedure

To end the DISPLAY procedure, users enter "end" (or any abbreviation thereof) in response to the "WHAT IS TO BE DISPLAYED?" question.

9.2 SAVE PROCEDURE

Users may sometimes wish to set up a basic structure for analysis--specifying information to the TREE, WEIGHTS, FORMS, DATA procedures, and so forth--and then use this basic structure again and again as the planning study progresses and new information becomes available or information is revised. Or for a host of other reasons, users may sometimes wish to cease use of the program and resume at some later time. The SAVE procedure permits users to store all information they have specified up to a particular time.

9.2.1 INTERACTIVE SAVE PROCEDURE

The interactive SAVE procedure asks users to specify the name of a file on which the current status of the program is to be saved (Figure 9.2). The name must be seven characters or less in length, must begin with a letter, and must contain only letters and digits. If the file named already exists in a user's permanent file storage area, the user is asked for permission to replace the contents of the file with the current program information. This feature is provided in order to help prevent accidental loss of data. If users do not want the contents of the named file to be replaced, a response of "NO" to the "OK TO REPLACE?" question will cause the program to request a new file name.

```
 ENTER PROCEDURE NAME:
I>save
 ENTERING SAVE PROCEDURE.

 ENTER NAME OF SAVE FILE:
I>example
 FILE 'EXAMPLE' ALREADY EXISTS.  OK TO REPLACE?
I>yes
 ESAP DATABASE SAVED ON FILE 'EXAMPLE' AT 18.14.53. ON 80/06/19.

 ENTER PROCEDURE NAME:
```

Figure 9.2. Input to interactive SAVE procedure

After saving all of the information currently in the program on the named file, the program prints a message confirming the action taken. The message contains the name of the file, the current time, and the date.

9.2.2 BATCH SAVE PROCEDURE

The name of the file on which the current program status is to be saved is entered on the *SAVE card in columns 11-17 (see Figure 9.3). The file name must begin with a letter and may contain only letters and digits. If the named file already exists, its contents will be replaced with the current program status.

```
*SAVE     EXAMPLE
+         +
1         11
```

Figure 9.3. Input to batch SAVE procedure

After saving all of the information currently in the program on the named file, the program prints a message confirming the action taken. The message contains the name of the save file, the current time, and the date.

9.3 CONTINUE PROCEDURE

The CONTINUE procedure is used to access the information stored on file by the SAVE procedure. It permits users to recover previously specified information and to continue use of ESAP as if uninterrupted.

9.3.1 INTERACTIVE CONTINUE PROCEDURE

The interactive CONTINUE procedure asks users for the name of a file on which the program status has been previously saved (Figure 9.4). If the named file cannot be found, a message, "CANNOT OPEN FILE," is printed and the procedure ends. If the named file exists but was not created by the SAVE procedure, the program prints "FILE IS NOT A VALID SAVE FILE" and the procedure ends.

```
 ENTER PROCEDURE NAME:
I>continue
 ENTERING CONTINUE PROCEDURE.

 ENTER NAME OF SAVE FILE:
I>example
 ESAP DATABASE RETRIEVED FROM FILE 'EXAMPLE', SAVED AT 18.14.53. ON 80/06/19.

 ENTER PROCEDURE NAME:
```

Figure 9.4. Input to interactive CONTINUE procedure

After the information has been read from the named file into the program, a message confirming the fact is printed, indicating the name of the save file and the time and date that the information was saved.

9.3.2 BATCH CONTINUE PROCEDURE

The name of the file from which to read the program information is entered in columns 11-17 of the *CONTINUE card (Figure 9.5). If the

```
*CONTINUE EXAMPLE
+         +
1         11
```

Figure 9.5. Input to batch CONTINUE procedure

file does not exist or does not contain information from a previous SAVE, the procedure flags a fatal error and the program stops.

After the information has been read from the named file into the program, a message confirming the fact is printed, indicating the name of the save file, and the time and date that the information was saved.

9.4 END PROCEDURE

The END procedure does just as its name implies. In the interactive mode, a response of "END" to the prompt "ENTER PROCEDURE NAME" concludes processing by ESAP. In the batch mode, an *END card directly following an earlier *END card (signifying the end of a procedure) concludes the run.

9.5 CHANGING INFORMATION ALREADY SPECIFIED (INTERACTIVE MODE ONLY)

Often it is the case that information previously entered into ESAP must be changed either because of changes in the available information or because of errors that are not discovered until some later date. Although there exists no CHANGE procedure in ESAP, the interactive mode allows users to change most of the information entered into it at a later time by simply reentering the procedure where the information was originally entered. (In the batch mode, users can make changes simply by altering the erroneous cards and resubmitting the deck.)

Changing information in the interactive mode is best illustrated by use of an example. In Figure 9.6, the weights for public group PRESRVATOR are discovered to be incorrect. To change the weights, the user reenters the WEIGHTS procedure and identifies PRESRVATOR as the name of the appropriate public. Since PRESRVATOR already has a specified set of weights, the WEIGHTS procedure gives the user the choice of respecifying the weights (if a completely new set of weights is desired), changing the existing weights, or neither (in case the public name has been mistyped). In the present example, the user chooses to change existing weights. The procedure then asks if a display of the weights is desired, then enters the change option for the WEIGHTS procedure (see section 5.2.2.3).

All of the procedures that obtain information from users (TREE, WEIGHTS, FORMS, DATA, UNCERTAIN, etc.) operate in this manner, allowing them to change information previously entered. In most cases, the program will also prompt users for information that is directly related to the information being changed, such as obtaining new data values when changes to ranges are made. Table 9.1 shows what information can be changed, along with what the program will do and what users must do if such changes are made.

```
 ENTER PROCEDURE NAME:
I>weights
 ENTERING WEIGHTS PROCEDURE.

 NAME OF PUBLIC?
I>presrvator
 WEIGHTS ALREADY SPECIFIED FOR PRESRVATOR.

 DO YOU WISH TO RESPECIFY, CHANGE OR EXIT?
I>change

 DO YOU WISH TO DISPLAY THE WEIGHTS?
I>yes

 WHICH WEIGHTS--ORIGINAL, DERIVED, OR BOTH?
I>original

 WEIGHTS PROCEDURE. DATE: 80/06/19. TIME: 18.16.14.


 PUBLIC:  PRESRVATOR
 ORIGINAL WEIGHTS:

                                        |FOREST/HAB
                                        |  85.00/.85
                               |TERR/HAB---|CLEAR/HAB
                               |   40.00/.40|  15.00/.15
                                     .
                                     .
                                     .
 ENTER NAME OF VARIABLE, NEW WEIGHT:
I>air,10

 ENTER NAME OF VARIABLE, NEW WEIGHT:
I>

 DO YOU WISH TO DISPLAY THE WEIGHTS?
I>yes

 WHICH WEIGHTS--ORIGINAL, DERIVED, OR BOTH?
I>o

 WEIGHTS PROCEDURE. DATE: 80/06/19. TIME: 18.16.14.


 PUBLIC:  PRESRVATOR
 ORIGINAL WEIGHTS:

                                        |FOREST/HAB
                                        |  85.00/.85
                               |TERR/HAB---|CLEAR/HAB
                               |   40.00/.40|  15.00/.15
                                     .
                                     .
                                     .
 MORE CHANGES?
I>no
 REMINDER--RE-RUN EVALUATE FOR PUBLIC PRESRVATOR.
```

Figure 9.6. Changing information already specified

Table 9.1

Consequences of Making Changes to Information Already Specified

If user changes:	User must also:	Program will:
TREE		
(a) Variable Names	Change names on files (if any)	---
(b) Structure	Respecify all weights, forms	Reset ranges of leaves that become interior variables Prompt for range info for newly created leaves Prompt for data for new leaves
RANGES	Run EVALUATE, with PRECISE and UNCERTAIN data, for all PUBLICS	Check all data and prompt for new values for out-of-range data values Instruct users to adjust FORMS and WEIGHTS to conform to new ranges
WEIGHTS, FORMS	Run EVALUATE, with PRECISE and UNCERTAIN data, for the PUBLIC changed	---
DATA		
(a) PRECISE	Run EVALUATE for all PUBLICS	Prompt for UNCERTAIN data values, if new alternatives created
(b) UNCERTAIN	Run EVALUATE for all PUBLICS	

APPENDIX A: ACCESSING ESAP AND USING BCS

A. Interactive:

1. Dial local BCS network access number

2. Establish connection with terminal and press RETURN key once. System will respond with

    WELCOME TO THE BCS NETWORK

    YOUR ACCESS PORT IS xxx yy

    SELECT DESIRED SERVICE:

3. Enter the service name for the computer on which ESAP is stored (EKS1):

    SELECT DESIRED SERVICE: eks1 (cr)

4. System will respond with greeting and request user number, e.g.:

    80/05/12. 12.42.48

    EKS1 750B.N0460.60 A 80/05/11.DS-0 03.27.18 80/05/12.

    USER NUMBER:

5. Enter your user number, a comma, and your password followed by a carriage return. The system will then print a series of characters to obliterate the user number and password.

6. The system will print a terminal number (used for identification if a disconnect occurs) and a prompt for a user identification (ID), e.g.:

    TERMINAL   274, TTY

    RECOVER/USER ID:

7. If not attempting to recover from a line disconnect, enter up to 42 characters which will be used by BCS for grouping computer usage charges. This ID could be your name, e.g., "JH BROWN", or a project name, e.g., "WATER RESOURCES".

If you are attempting to recover from a line disconnect, enter

    RECOVER, xxx (cr)

where xxx is the terminal number printed at the beginning of the terminal session which was interrupted. If it is possible to resume from the point of the interruption, the system will print:

    RECOVERY COMPLETE.
      LAST COMMAND = xxx
      JOB STATUS = yyy
      NEXT OPERATION = zzz
    ENTER *CR* TO CONTINUE:

If the RETURN key is pressed, the terminal session will be resumed at or near the point of interruption. CAUTION: typing anything other than the RETURN key will result in termination of any program (such as ESAP) that was being run at the time of the disconnect.

8. To run ESAP in the interactive mode, type

```
GET,ESAP/UN=CECELB (cr)
(cr) CALL,ESAP
```

The program will run, printing a heading similar to the following:

```
E.S.A.P. VERSION 1.0  12.34.56. 80/05/12.


ENTER PROCEDURE NAME:
```

9. Enter the name of the desired procedure (usually TITLE or TREE for a run that is being started from scratch, or CONTINUE for resuming a run in which the SAVE procedure was called to save the status of the run).

B. Batch:

1. For card input, prepare a deck containing the following cards:

```
ESAP,CM130000,T30,P01.
USER,userno,passwrd.
GET,ESAP/UN=CECELB.
CALL,ESAP.
```

7-8-9 card

batch input cards to ESAP

6-7-8-9 card

2. For submitting a batch job from an interactive terminal, the following commands may be used:

   a) NEW,xxx/ND (cr)   (xxx is name of user's choosing.)

   b) AUTO (cr)

      System will respond with line numbers, after each of which the user types one line of input, e.g.:

      ```
      00100 /JOB
      00110 ESAP,CM130000,T30,P01.  RUNNING E.S.A.P.
      00120 USER,userno,passwrd.
      00130 GET,ESAP/UN=CECELB.
      00140 GET,yyy.    (yyy is name of file containing
                         E.S.A.P. input.)
      00150 CALL,ESAP(INPUT=yyy)
      00160 *DEL*       (indicates BREAK key pressed)
      ```

   c) LNH (cr)   (to terminate AUTO input and list file.)

   d) SAVE (cr)   (save file for later use)

      or REPLACE (cr) (if already SAVED)

   e) ROUTE,xxx,DC=PR, (cr)
      UN=termid (cr)   (termid is user number of local remote batch terminal. See local BCS contact for further information.)

System will respond with the time and date and a name for the submitted job.

Further information on the use of the BCS system may be found in the BCS publication, "MAINSTREAM-EKS Interactive Timesharing (KIT) Users Manual," number 10208-005, available from your local BCS representative.

APPENDIX B: HIERARCHY BUILDING

Hierarchy building is a technique for defining the elements of a decision problem (such as an EQ evaluation problem) and creating a framework that describes the interrelations among these elements. The framework or structure that is created is referred to as a hierarchy or sometimes a tree because problem elements are organized hierarchically, with general categories of elements being broken down into successively more specific elements, that define the higher order (more general) elements.

INPUTS

Data. Hierarchy building requires information collection from numerous sources regarding the variables that should be considered in the evaluation and comparison of alternatives and, therefore, included in the evaluation framework. Sources of inputs include (a) background literature; newspaper articles, scientific books and articles, and, state, local, and federal agency documents and regulations, (b) public input through letters; telephone conversations, public meetings, surveys, etc., and (c) consultations with planners and substantive experts.

Personnel. One or several agency staffers can be assigned to the task of obtaining the necessary information and constructing the framework. Outside consultants are not required but may be helpful.

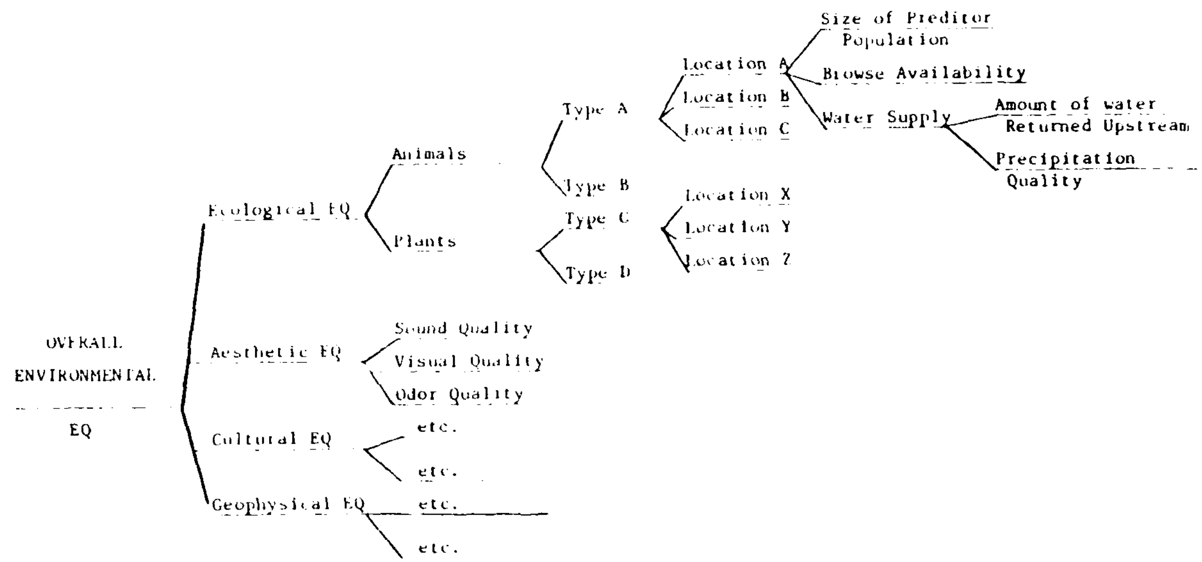
Resources. Staff time for creating the evaluation hierarchy may vary from several days to as long as several months depending on the complexity of the problem and the level of detail desired. No special materials are required to build a hierarchy.

OUTPUTS

The output of this technique is a graphical model of the relationships among a designated set of variables upon which the effects of planning alternatives are to be assessed, forecasted, and evaluated. In the evaluation framework, variables are organized hierarchically in an ascending order of specificity from general categories (e.g., aquatic environmental quality) to more and more specific variables (e.g., game fish; trout, etc.) that define the more general categories. A sample hierarchy or tree is presented in Figure B-1.

In the example overall environmental quality is "defined" in terms of four general categories: ecological EQ, aesthetic EQ, cultural EQ, and geophysical EQ. Each one of these general categories is then subdivided into more specific descriptions of the variables that define these general categories. For example, ecological EQ is defined in terms of animal and plant life; aesthetic EQ is defined in terms of sound quality, visual quality, and odor quality, etc. Each general category is repeatedly subdivided into a number of specific (and measurable) indicators that define the general categories, e.g., for ecological EQ, (a) number of type A animals in locations A, B, and C, (b) number of type C plants in locations X, Y, and Z, etc.

A hierarchy or tree (i.e., an evaluation framework) can be designed to go into as much detail as is deemed necessary or useful to the planners. It is generally appropriate to break down variables at



Example of a hierarchial evaluation framework

Figure B-1

least to the point where specific indicators that can be forecasted by substantive experts have been identified.

PROCEDURES

It should be emphasized that hierarchy building is an iterative procedure and that the hierarchy created at the onset of a planning process should not be regarded as a final product. Rather, the hierarchy should be revised as previously unidentified concerns emerge or as the requirements of the evaluation process change. Since specific procedures for constructing a hierarchy depend on the particular nature of the evaluation problem, general procedures, which can be adapted to specific problems, are outlined below.

Step 1: Background research. Background research on the nature of the evaluation problem is necessary for identifying concerns that will serve as a foundation for constructing the hierarchy. The purpose of this background research is to identify the types of public, governmental, institutional, and technical issues that are relevant to the particular evaluation problem being considered. The types of questions to be addressed by this background research include: What are the concerns that have been raised by the public or their representatives? What are the concerns that have been raised by local, state, or Federal regulatory agencies? What are the technical issues that have been raised by the scientific community?

A considerable amount of background information concerning public concerns can be obtained from reading and analyzing local newspaper articles on subjects directly or indirectly related to the water resources problem. Other sources of public inputs include informal interviews, letters to the agency, transcripts from previous public meetings, records of telephone conversations, results from surveys, input from citizen advisory groups, and so forth.

The research should ideally go back several years to track the various issues through time, in order to determine which issues have been resolved and which are of continuing concern, as well as to identify key concerns underlying each issue (e.g., Are people opposed to a type of flood control structure because it will be an eyesore or because it will negatively affect a particular species?). The issues raised by various segments of the public may range in specificity from very general (e.g., environmental quality, ecological responsibility, etc.) to moderately general (e.g., air quality, water pollution), to moderately specific (e.g., health affects of air pollution, effects of water pollution on fish, etc.), to very specific (e.g., danger to brown trout, concern about the affects of proposed projects on trout size, etc.). All relevant issues (i.e., those issues that would be affected by any of the planning alternatives) raised by members of the public should be addressed by the EQ evaluation process and, therefore, be considered for inclusion in the evaluation framework. (See section 4.3.1 for further discussion on how to decide what to include in the hierarchy.)

Background information concerning institutional and governmental concerns (and constraints) should be collected from both inside and outside the planning agency. Sources of written information include agency regulations and related government guidelines and technical reports from the planning agency and other governmental agencies. Consultations and meetings with agency personnel will often be required in order to clarify the content and implications of various documents and the agency's policies and objectives with regard to the problem being considered.

Finally, background information concerning _technical issues_ that should be considered in the evaluation process may be obtained from scientific journals and books and by consultation with substantive experts.

All the relevant information collected from preliminary research on the problems will be used in the construction of a rudimentary hierarchy that will serve as the basis for future hierarchy development. Scientific literature and government reports may contain previously developed hierarchies that constitute potentially useful references for developing the present hierarchy.

Step 2: Organizing and categorizing inputs obtained from background research. Collate and organize the information obtained from background research. First, attempt to list every issue raised. A very simple list of issues might include the following:

_a_. Federal regulations require protection of endangered species.
_b_. Indian archaeological sites should not be disturbed.
_c_. Flood protection is needed.
_d_. Levels of asbestos and other chemicals in the water are too high.

e. Lack of protective barriers on Smith Canal endangers our children.

f. Visual quality is important.

g. Health and safety are important.

h. Dust from construction is undesirable.

i. Concrete channels are ugly.

j. Save the brown trout!

k. Reduce damage to homes from flooding.

l. Bald Mountain should not be defaced.

m. Protect the quality of our environment.

Next, combine any issues that are clearly identical; if in doubt, leave them separate pending further investigation. Third, try to group each of the issues under the heading of general categories. Some items may seem applicable to more than one category; include them in all categories in which they seem potentially relevant. (Three-by-five cards may prove useful for this exercise.) Finally, attempt to order the issues within each category from the more general to the more specific--for example, in an ecological environmental category the issues might be ordered "Protect the environment," "Protect endangered species," "Protect the brown trout."

Step 3: Construct a rudimentary hierarchy. The next step is to construct a rudimentary hierarchy. The first level of the hierarchy will be the overall dimension to be evaluated; the next level will include general categories of variables. Additional levels will become successively more specific, defining the meaning of each of the categories. In general, it is a good idea to work with major branches of the hierarchy one at a time. A large blackboard can be a useful aid in this exercise. If each element is written on a three-by-five card, a large table may also be useful.

The development of a rudimentary hierarchy should not be restricted to dealing solely with the information generated in Steps 1 and 2. The developers should include in the hierarchy any other elements they have reason to think may be important to any potentially concerned party.

The information collected in Steps 1 and 2 should serve as a check for the development of the evaluation framework. The hierarchy should be continually evaluated to ensure that the issues identified during the previous steps are included somewhere within the hierarchy. An example of part of an evaluation framework appears in Figure B-2. It illustrates how the issues cited earlier might be included in an evaluation framework. It will ordinarily be rather easy and straightforward to locate some of the issues into the hierarchy. Note, for example, that brown trout fits readily under the ecological EQ category. Moreover, organizing these elements into a hierarchial evaluation framework may promote the identification of other elements that should be in the hierarchy by prompting questions such as, "Should there by anything else at this level?" or "Are there any endangered species with which we should be concerned?"

Some issues may be more difficult to locate in the hierarchy. For instance, why are concerns expressed with respect to Bald Mountain? Is it because of its aesthetic qualities? Does it have some special cultural or historical attributes? Does it constitute a significant

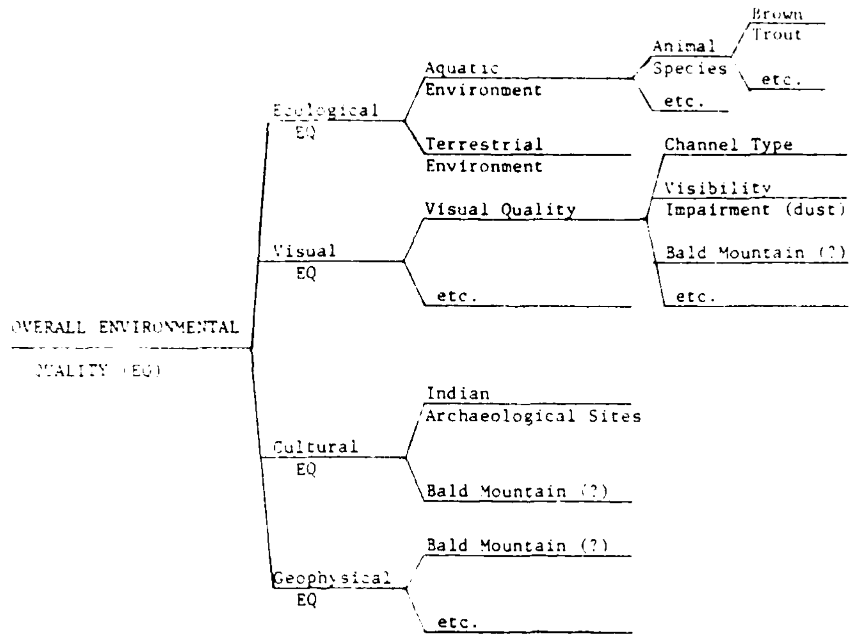


Figure B-2. Part of an evaluation framework reflecting issues identified earlier

geophysical resource? In Figure B-2, it was tentatively entered in all three places in the hierarchy, until such time as the reason for its importance could be clarified.

Still other issues probably cannot be located directly within the framework. That is, some issues will fairly obviously be of concern not because of their own importance, but rather because of beliefs about their connection to other entities that are valued and of themselves. For example, expressed concern about __ levels might in some circumstances be readily identified as reflecting more basic concerns about aquatic life. Attempts should be made in the next step of the hierarchy building procedure to identify precisely which variables are of direct concern.

Step 4: Seek information needed to fill-out and refine the rudimentary hierarchy. After a rudimentary hierarchy has been constructed, the next step should be to identify and fill in gaps in the hierarchy, as well as to trim the hierarchy of unimportant or redundant elements. Refinement of the hierarchy requires going to the public, substantive experts, and various agency (including other agencies) personnel with specific questions that are designed (a) to clarify and define more carefully the variables in the hierarchy, (b) to find out what important considerations are not addressed in the hierarchy, and (c) to eliminate unimportant variables.

The questions to be asked may be similar to the following:

a. What do you mean by (for example) water quality? Are you concerned with its impacts on fish, other plants or animals, aesthetic quality or what?

b. Why are you concerned with (for example) Bald Mountain? Are you concerned with aesthetic, historical significance, etc.?

c. Are you concerned with (for example) pH levels directly, or because of the effects you believe it will have on other things you are more concerned about?

d. Are all the issues included in this hierarchy important? Which could be eliminated?

e. What other issues should be included in the hierarchy? Why?

f. You may or may not know that some of the proposed alternatives might affect pre-historic Indian archaeological sites. Would such impacts be important to you? What particular types of impacts would be important?

In short, the types of questions to be asked are intended to accomplish the following specific aims:

a. clarification and improved definition of issues of concern.

b. determination of whether issues are of direct concern, or are of concern solely because of their judged relation to other objects of direct concern.

c. identification of important issues.

d. identification of additional important issues.

Obviously, asking specific questions in this fashion requires intensive individual or small group sessions with participants. This type of format is of course typical for obtaining information from experts, agency personnel, etc., although it deviates substantially from traditional mechanisms of public participation. It is highly useful, however, to identify and solicit the participation of a small group of citizens for aiding in developing an evaluation framework. Since only a few members of the public will be able and willing to participate in such a task, care should be taken to ensure that individuals representing all major viewpoint groups are included.

Step 5: Completing the hierarchy (first iteration). Use the information obtained from Step 4 to refine the hierarchy, developing it in more detail and filling in the gaps. If necessary, repeat Step 4, i.e., return to the members of the public or experts until all pressing questions have been answered. Check the Hierarchy. Does the framework progress from the general to the specific? Is it complete, containing all important issues? Is it redundant? Are the EQ resources specified by the framework measurable? Is the framework value-relevant? Is it as simple as possible? Revise, if necessary.

Step 6: Verifying the hierarchy. Show the hierarchy to a few individuals--members of the public representing various viewpoints, experts, and agency personnel. Ask them (a) if there are any important issues not addressed by the hierarchy, (b) if any of the specified relationships between variables are incorrect, and (c) for any other comments or criticisms.

The procedures described above represent one possible way to build a hierarchy. The procedures may be adapted to fit a particular planning problem depending on time, money, and staff availability. The sequencing of steps may be varied or some steps may be carried out simultaneously. The important thing is that the objectives of each step are met as fully as possible, by whatever means.

APPENDIX C: SPECIFYING WEIGHTS AND FUNCTIONAL RELATIONS

SPECIFYING WEIGHTS

(Adapted from Edwards, W., How to use multiattribute utility measurement for social decisionmaking. IEEE Transactions on Systems, Man, and Cybernetics, 1977 7, 326-339.)

Step 1: Rank the dimensions in order of importance. This ranking job can be performed either by an individual or by representatives of conflicting values acting separately or by those representatives acting as a group.

Step 2: Rate dimensions in importance, preserving ratios. To do this, start by assigning the least important dimension an importance of 10. (We use 10 rather than 1 to permit subsequent judgments to be finely graded and nevertheless made in integers.) Now consider the next-least-important dimension. How much more important (if at all) is it than the least important? Assign it a number that reflects that ratio. Continue on up the list, checking each set of implied ratios as each new judgment is made. Thus, if a dimension is assigned a weight of 20, while another is assigned a weight of 80, it means that the 20 dimension is 1/4 as important as the 80 dimension, and so on. By the time you get to the most important dimensions, there will be many checks to perform; typically, respondents will want to revise previous judgments to make them consistent with present ones. That's fine; they can do so.

Step 3: Sum the importance weights, and divide each by the sum. This is a purely computational step which converts importance weights into numbers that, mathematically, are rather like probabilities.

Other References:

Cook, R. L., and Stewart, T. R. A comparison of seven methods for obtaining subjective descriptions of judgmental policy. Organizational Behavior and Human Performance, 1975, 13, 31-45.

Dawes, R. M., and Corrigan, B. Linear models in decision making. Psychological Bulletin, 1974, 81, 95-106.

Sayehi, Y., and Vesper, K. H. Allocation of importance in a hierarchial goal structure. Management Science, 1973, 19, 667-675.

Wang, M. W., and Stanley, J. C. Differential weighting: A review of methods and empirical studies. Review of Educational Research, 40, 663-705.

SPECIFYING FUNCTIONAL RELATIONS

(Adapted from Kneppreth, N. P., Gustafson, D. H., Leifer, R. P., and Johnson, E. M., Techniques for assessment of worth. (Technical paper 254, U. S. Army Research Institute for the Behavioral and Social Sciences, Arlington, VA, 1975.)

Step 1

Ask the judge to specify the least and most preferred levels of the factor, and to assign utilities to these levels, 0 and 1 respectively (or 0 and 100, 1 and 10, etc. depending on the utility scale used).

Step 2

The judge is presented with a list of factor levels and asked to specify a number for each factor level in relationship to the first and last factor levels which have been arbitrarily assigned. A sample worksheet is presented in Figure below:

Fecal Coliforms	Utility (Desirability)
10,000	0
7,000	---
5,000	---
3,000	---
1,000	---
200	1

Step 3

Graph the points thus obtained, and interpolate a functional relationship curve.

Other References:

Brown, R. V., Kahr, A. S., and Peterson, C. Decision analysis for the manager. New York: Holt, Rinehart, & Winston, 1974.

Edwards, W. How to use multiattribute utility measurement for social decisionmaking. IEEE Transactions on Systems, Man, and Cybernetics, 1977, 7, 326-339.

Wascoe, N. Methods for elicitation of functional relationship curves. (Report No. 225, Center for Research on Judgment and Policy, Institute of Behavioral Science, University of Colorado, Boulder, CO. 80309).

APPENDIX D: FORMULAE FOR COMPUTING THE OVERALL DESIRABILITY OF ALTERNATIVES

The formulae used in EVALUATE for computing the overall desirability of alternatives can best be described in the context of a highly simplified example. Suppose that one wishes to evaluate EQ on the basis of two variables, Resource A and Resource B; furthermore, suppose that Resource A can be subdivided into Type 1 and Type 2. The situation would be described by the TREE procedure as shown in Figure D-1.

```
TREE:

                          |TYPE1
             |RESOURCEA--|TYPE2
EQ-----------|
             |RESOURCEB
```

Figure D-1. TREE describing simple hypothetical evaluation problem

Now, suppose that a public group, J. DOE, places greater relative weight on Resource A (.7) than on Resource B (.3); and, that for Resource A, the Type 1 variable is more important (.6) than Type 2 (.4). This situation would be represented by the WEIGHTS procedure as appears in Figure D-2. The functional relations between the relevant variable pairs, as represented by FORMS, appear in Figure D-3. The relation between Type 1 and Resource A is positive linear; the relation between Type 2 and Resource A is an inverted V shape; the relation between Resource A and EQ is positive linear; and, the relation between Resource B and EQ is negative linear.

For purposes of simplicity, assume that all leaf variables (Resource B, Type 1, Type 2) are measured on 0-to-10 scales.

```
PUBLIC:  J.DOE
ORIGINAL WEIGHTS:

                               |TYPE1
                               |    6.00/.60
                |RESOURCEA--|TYPE2
                |   7.00/.70|    4.00/.40
 EQ-----------|
                |
                |RESOURCEB
                |   3.00/.30
```

Figure D-2. WEIGHTS for J. DOE

Hypothetical data for projected levels of the leaf variable for two alternatives appear in Figure D-4.

How would EVALUATE use this information to compute the overall desirability of alternatives? The computation of this score for ALT.1 is worked through step-by-step:

A. First, level of Resource A is computed (see Figure D-5):

1. For Type 1,

   a. The projected level of Type 1 is 9 (see Figure D-4).

   b. This level corresponds to a rating of 90 as read from the function form (see Figure D-3).

   c. The rating of 90 is multiplied by a relative weight of .60 (see Figure D-2), equalling 54.

2. For Type 2,

   a. The projected level of Type 2 is 2 (see Figure D-4).

   b. This level corresponds to a rating of 40 as read from the function form (see Figure D-3).

   c. The rating of 40 is multiplied by a relative weight of .40 (see Figure D-2), equalling 16.

3. The weighted scores from Type 1 and Type 2 (54 and 16, respectively) are added together to compute the level of Resource A (i.e., 70).

FUNCTION FORMS FOR PUBLIC: J.DOE

```
LEVEL: 1
100*                          X    100*X
 E *                        XX      E * XX
 Q *                      XX        Q *    XX
   *                    XX            *       XX
   *                   X              *          X
   *                 XX               *           XX
   *               XX                 *              XX
   *              X                   *                 X
   *            XX                    *                  XX
   *          XX                      *                     XX
   *  XX    XX                        *                        XX
  0*X                                0*                          X
   * * * * * * * * * * *              * * * * * * * * * * *
      .0          100.0                  .0           10.0
       RESOURCEA                          RESOURCEB
```

```
LEVEL: 2
100*                          X    100*           XX
 R *                        XX      R *         X  X
 E *                      XX        E *        X    X
 S *                    XX          S *
 O *                   X            O *      X        X
 U *                 XX             U *     X          X
 R *               XX               R *    X            X
 C *              X                 C *   X              X
 E *            XX                  E *
 A *          XX                    A *  X                 X
   *  XX                              * X                   X
  0*X                                0*X                     X
   * * * * * * * * * * *              * * * * * * * * * * * *
      .0          10.0                   .0             10.0
       TYPE1                              TYPE2
```

Figure D-3. FORMS for J. DOE

PRECISE DATA VALUES:

ALT.	RESOURCEB	TYPE1	TYPE2
ALT.1	8.00	9.00	2.00
ALT.2	9.00	4.00	7.00

Figure D-4. Precise DATA for two hypothetical alternatives

```
TREE:                                    PROJECTED                                  WEIGHTED
                                         LEVEL        (RATING  *  WEIGHT)   =       SCORE
                          |TYPE1 -->       9      -->(  90     *    .6  )   =        54
          |RESOURCEA--|TYPE2 -->           2      -->(  40     *    .4  )   =        16
EQ----------|                                                                        70
          |RESOURCEB
```

Figure D-5. Computation of level of Resource A, ALT.1

B. Next, the overall score for EQ is computed (see Figure D-6):

1. For Resource A,

   a. The projected level of Resource A is 70 (see Figure D-5).

   b. This level corresponds to a rating of 70, as read from the function form (see Figure D-3).

   c. The rating of 70 is multiplied by a relative weight of .70 (see Figure D-2), equalling .49.

2. For Resource B,

   a. The projected level of Resource B is 8 (see Figure D-4).

   b. This level corresponds to a rating of 20, as read from the function form (see Figure D-3).

   c. The rating of 20 is multiplied by a relative weight of .30 (see Figure D-2), equalling 6.

3. The weighted scores from Resource A and Resource B (49 and 6, respectively) are added together to compute the overall score for EQ (i.e., 55).

```
TREE:                                    PROJECTED                                  WEIGHTED
                                         LEVEL        (RATING  *  WEIGHT)   =       SCORE
                          |TYPE1
          |RESOURCEA--|TYPE2        -->   70      -->(  70     *    .7  )   =        49
EQ----------|
          |RESOURCEB  ---------->          8      -->(  20     *    .3  )   =         6
                                                                                     55
```

Figure D-6. Computation of overall score for EQ, ALT.1

The preceding description is intended to help users gain some understanding of how the numbers displayed by the EVALUATE procedure are actually produced. Another useful way of thinking about the numbers produced by EVALUATE, however, is to regard the overall score as being made up of linear, additive contributions from each variable. This approach makes use of the concept of derived weights (see section 5.2.4); the derived weights for the present example are presented in Figure D-7.

```
PUBLIC:  J.DOE
DERIVED WEIGHTS:

                              |TYPE1
                              |  .42
                |RESOURCEA--|TYPE2
                |  .70         |  .28
 EQ------------|
                |
                |RESOURCEB
                |  .30
```

Figure D-7. DERIVED WEIGHTS for J. DOE

In this second approach, the ratings of projected effects on leaf variables are multiplied by those leaf variables' derived weights, producing a <u>variable score</u>. Variable scores at the more specific levels of the tree are then added together to compute variable scores for the more general variables with which they are connected. This approach is worked through step-by-step for ALT.2:

A. First, the variable score for <u>Resource A</u> is computed (see Figure D-8:

   1. For <u>Type 1</u>,

```
TREE:                                    PROJECTED   ( RATING * DERIVED )  =  VARIABLE
                                           LEVEL     (          WEIGHT  )      SCORE
                        |TYPE1  -->          4    -->  (  40   *   .42   )  =    16.8
          |RESOURCEA--|TYPE2  -->          7    -->  (  60   *   .28   )  =    16.8
EQ--------|                                                                      33.6
          |RESOURCEB
```

Figure D-8. Computation of variable scores for Resource A, ALT.2

a. The projected level of Type 1 is 4 (see Figure D-4).

b. This level corresponds to a rating of 40 as read from the function form (see Figure D-3).

c. The rating of 40 is multiplied by a derived weight of .42 (see Figure D-7), yielding a variable score for the Type 1 of 16.8.

2. For Type 2,

a. The projected level of Type 2 is 7 (see Figure D-4).

b. This level corresponds to a rating of 60, as read from the function form (see Figure D-3).

c. The rating of 60 is multiplied by a derived weight of .28 (see Figure D-7), yielding a variable score for Type 2 of 16.8.

3. The variable scores for Type 1 and Type 2 (16.8 each) are added together to compute the variable score for Resource A (i.e., 33.6).

B. Next, the variable score for Resource B is computed (see Figure D-9).

```
TREE:                                  PROJECTED   ( RATING * DERIVED )  =  VARIABLE
                                         LEVEL     (          WEIGHT  )      SCORE
                      |TYPE1
          |RESOURCEA--|TYPE2
EQ--------|
          |RESOURCEB ----------->        9    -->  (  10   *   .30   )  =      3
```

Figure D-9. Computation of variable score for Resource B, ALT.2

1. The projected level of Resource B is 9 (see Figure D-4).

2. This level corresponds to a rating of 10 as read from the function form (see Figure D-3).

3. The rating of 10 is multiplied by a derived weight of .30 (see Figure D-7), equalling a variable score for Resource B of 3.

C. Finally, the overall score for EQ is computed by adding the variable scores for Resource A and Resource B (see Figure D-10 D-10).

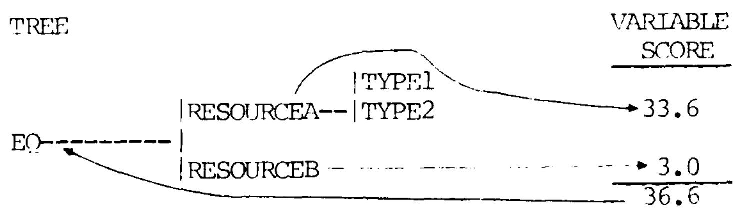


Figure D-10. Computation of overall score for EQ, ALT.2

The variable score approach to explaining how EVALUATE computes overall desirability scores is attractive in its simplicity and directness, but it constitutes a slight oversimplification. This approach will yield the same numbers as those generated by the first approach described, if the relations between all the variables connected with one another in a branch of the tree can be described by identically shaped function forms (e.g., positive linear). Although this will usually be the case, it is not always so. Variable scores are therefore computed in EVALUATE by calculating the unweighted rating of a variable for the overall dimension (at the root) and multiplying that number by the variable's derived weight.

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Mumpower, Jeryl.
  User's manual for the Evaluation and Sensitivity Analysis Program (ESAP) : final report / by Jeryl Mumpower, Lee Bollacker (Center for Research on Judgment and Policy, Institute of Behavioral Science, University of Colorado) ; prepared for Office, Chief of Engineers, U.S. Army ; monitored by Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station. -- Vicksburg, Miss. : U.S. Army Engineer Waterways Experiment Station ; Springfield, Va. : available from NTIS, 1981.
  [illegible], [illegible] p. : ill. ; 27 cm. -- (Technical report / U.S. Army Engineer Waterways Experiment Station ; E-81-4)
  Cover title.
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  "Under Contract No. DACW39-78-C-0095 (EWQOS Work Unit IVA)."

  1. Environmental engineering. 2. Impact. 3. Water resources development. 4. Weights and measures.

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  User's manual for the Evaluation and Sensitivity : ... 1981.
(Card 2)

I. Bollacker, Lee. II. University of Colorado. Institute of Behavioral Science. III. United States. Army. Corps of Engineers. Office of the Chief of Engineers. IV. United States. Army Engineer Waterways Experiment Station. Environmental Laboratory. V. Title VI. Series: Technical report (United States. Army Engineer Waterways Experiment Station) ; E-81-4.
TA7.W34 no.E-81-4


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