TRADE-OFF ANALYSIS FOR ENVIRONMENTAL PROJECTS:

AN ANNOTATED BIBLIOGRAPHY

August 1995

TRADE-OFF ANALYSIS FOR ENVIRONMENTAL PROJECTS:

AN ANNOTATED BIBLIOGRAPHY

by:

Timothy D. Feather
Keith W. Harrington
Donald T. Capan

of

Planning and Management Consultants, Ltd.
6352 South US Highway 51
P.O. Box 1316
Carbondale, Illinois 62903
(618) 549-2832

for

U.S. Army Corps of Engineers
Water Resources Support Center
Institute for Water Resources
Alexandria, VA 22315-3868

U.S. Army Corps of Engineers
Waterways Experiment Station
Vicksburg, MS 39180-6199

Evaluation of Environmental
Investments Research Program

IWR Report 95-R-8
August 1995

PREFACE

This study was conducted as part of the Evaluation of Environmental Investments Research Program (EEIRP). The EEIRP is sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE). It is jointly assigned to the U.S. Army Engineer Water Resources Support Center (WRSC), Institute for Water Resources (IWR), and the U.S. Army Engineers Waterways Experiment Station (WES), Environmental Laboratory (EL). Mr. William J. Hansen of IWR is the Program Manager, and Mr. H. Roger Hamilton is the WES Manager. Program Monitors during this study were Mr. John W. Bellinger and Mr. K. Brad Fowler, HQUSACE. The field review group members that provide complete Program direction and their District or Division affiliations are: Mr. David Carney, New Orleans District; Mr. Larry M. Kilgo, Lower Mississippi Valley Division; Mr. Richard Gorton, Omaha District; Mr. Bruce D. Carlson, St. Paul District; Mr. Glendon L. Coffee, Mobile District; Ms. Susan E. Durden, Savannah District; Mr. Scott Miner, San Francisco District; Mr. Robert F. Scott, Fort Worth District; Mr. Clifford J. Kidd, Baltimore District; Mr. Edwin J. Woodruff, North Pacific Division; and Dr. Michael Passmore, Walla Walla District. The work was conducted under the Evaluation Framework Work Unit of the EEIRP. Ms. Joy Muncy of the Technical Analysis and Research Division (TARD), IWR and Mr. Jim Henderson of the Natural Resources Division (NRD), WES are the Principal Investigators.

The work was performed by Planning and Management Consultants, Ltd. (PMCL) under Task Order No. 8, Contract No. DACW72-94-D-0003 managed by Ms. Joy Muncy. Dr. Timothy D. Feather was the principal investigator in collaboration with Mr. Donald Capan and Mr. Keith Harrington. Dr. David Schkade, University of Texas, and Dr. Leonard Shabman, Virginia Polytechnic Institute and State University, supported PMCL in advisory roles. Dr. Shabman was also principally responsible for the summary of "shared vision" modeling in Appendix A of this report.

The report was prepared under the general supervision at IWR of Mr. Michael R. Krouse, Chief, TARD; and Mr. Kyle E. Schilling, Director, IWR; and at EL of Dr. Robert M. Engler, Chief, NRD and Dr. John W. Keeley, Director, EL.

At the time of preparation of this report, Mr. Kenneth H. Murdock was Director of WRSC.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

BACKGROUND

Environmental restoration and mitigation projects receive input from many sources. As the Corps evaluates the potential configuration of an environmental effort, it has to consider this range of multiple inputs in forming a decision. This essentially constitutes the guiding research questions of the Corps Evaluation of Environmental Investments Research Program (EEIRP):

(1) How can the Corps determine whether the recommended action from a range of alternatives is the most desirable in terms of the environmental objective being addressed?

(2) How should the Corps allocate limited resources among many "most desirable" environmental investment decisions?

The two questions, referred to respectively as the "site" and "portfolio" questions, are being addressed through the EEIRP work units found in Table I-1.

TABLE I-1

EEIRP WORK UNITS

- Determining and Describing Environmental Significance
- Determining Objectives and Measuring Outputs
- Objective Evaluation of Cultural Resources
- Engineering Environmental Investments
- Cost Effectiveness Analysis Techniques
- Monetary and Other Valuation Techniques
- Incorporating Risk and Uncertainty into Environmental Evaluation
- Environmental Databases and Information Management
- Evaluation Framework

The range of information suggested by the EEIRP work units alone implies a spectrum of evidence to create "most desirable" environmental investment decisions. Planning for an environmental project rests upon what appears to be three cumulative foundations of complexity. First, the environmental problem is itself complex. It is usually multifaceted and typically has a range of technical solutions. Second, the players involved in the decision-making process form the next layer of complexity. All have individual missions, professional backgrounds, histories with the Corps, and political agendas. Finally, Corps managers must decide which projects to recommend for funding, given a range of environmental opportunities.

Trade-off analysis is composed of many tools for identifying optimal solutions to complex problems. Tools must be appropriate to the specific context. In some circumstances, a single evaluation technique may be appropriate; in others, combinations may be most effective. Trade-off analyses takes many forms, including mathematical techniques and simulations. Group process techniques are formal steps for finding agreed upon and workable solutions when multiple stakeholders have different values, perspectives, etc. The Corps plan formulation process for environmental projects invites the use of trade-off analysis. Finding the specific tools that are appropriate to the Corps environmental planning contexts will promote an efficient and effective plan formulation process.

This study explores the literature for analytical techniques that can support the complex decision-making process surrounding Corps environmental projects. Specifically, this literature review focuses on opportunities for using trade-off methodologies in the plan formulation process. This effort falls under the *Evaluation Framework* work unit of the EEIRP which has the following goals:

(1) Provide a process to systematically identify national, regional, and local objectives and priorities.

(2) Identify information needs of the public, sponsors and decision-makers, and study participants and appropriate communication media.

(3) Develop and describe trade-off processes incorporating all benefits and costs, including opportunity costs.

(4) Identify appropriate processes for facilitating public, organizational, and institutional involvement.

STUDY PURPOSE

The objectives of this research are twofold:

(1) Develop an annotated bibliography of articles, books, monographs, and reports that specifically address: multiobjective planning and evaluation in regards to environmental investigations; trade-off analysis processes incorporating all benefits and costs including opportunity costs in regards to environmental investigations; and appropriate processes for facilitating public, organizational, and institutional involvement in the plan formulation stage in regards to environmental investigations.

(2) Create a report that summarizes the opportunities for the Corps in trade-off analysis based on the information collected from the annotated bibliography and other sources.

This review and report focuses on the accessibility, communication, success, and application of various types of trade-off analysis with respect to various types of groups and challenges.

RECENT DIRECTIONS REGARDING TRADE-OFF ANALYSIS

Several recently published reports directed at the Corps enhanced environmental mission have suggested that trade-off methodologies should and will play an important role in the plan formulation in the near term. Many opportunities exist for trade-off techniques, as shown in a review of recently completed Corps environmental projects (Feather and Capan, 1995), but in most cases only informal negotiation takes place.

The idea of participatory, cooperative plan formulation is a prominent topic within the Corps. Local sponsors are now being called partners or stakeholders. Environmental projects are typically brought to the Corps attention by well-informed local interests. However, the added emphasis on participation can increase opportunities for disagreement. According to Shabman (1993):

> *If a participatory model is to be the conceptual touchstone of the future environmental decision-making in the agency, the Corps will find itself engaged in observing, reacting to various types of conflict.*

Strong consideration is being given to working within a multiple stakeholder negotiation framework, as opposed to the executive decision-maker mode the Corps has used in the past (Russell in Feather et al., 1994). This perspective implies that a purpose of the analysis is to help stakeholders disclose their preferences rather than find optimal solutions. Schkade suggested (in Feather et al., 1994):

> *The most useful position the Corps can take is to assume that the value of a resource is constructed through some social interaction or negotiation, and is therefore influenced by the particulars of the process of construction.*
>
> *Therefore, the Corps should place high priority on learning how to design and conduct the process of value construction in ways that produce acceptable and implementable value representations.*

The purpose of this effort is to accommodate the seemingly inevitable direction of a participatory process by examining opportunities in the literature. As will be seen in the following chapters, trade-off methodologies take several forms. This report provides a sampling of these methodologies and offers likely avenues for pursuit by the Corps in its endeavor to find an evaluation framework for environmental projects. In Appendix A, Dr. Leonard Shabman indicates that the "shared vision modeling" research by the Corps is a promising start to the investigation of these methodologies in an environmental evaluation framework.

II. METHODOLOGY

The research methodology was comprised of a three-part process: (1) a literature search of multiobjective planning, trade-off analysis, game theory, and group processes; (2) annotation of selected references representative of these topics; and (3) analysis and interpretation of the literature for application in the EEIRP. This methodology evolved over time. As the structures of the literature under these topics were investigated, the research methodology was modified to pursue newly discovered research opportunities.

INITIAL SEARCH PARAMETERS

The initial direction of this research effort was to identify theory, methods, and applications of the literature for multiobjective planning, trade-off analysis, and negotiation processes. Using these terms and related subjects as key words, a broad literature search was conducted. The Internet, various electronic databases (e.g., Water Resources Abstracts; Aquatic Sciences and Fisheries Abstracts), and university library access systems were invaluable in provided efficient access to important references, new bodies of literature, and additional key words to refine the search parameters.

What quickly emerged from this initial survey of the literature was the absence of a discrete body of information pertaining to "trade-off analysis." Many references were identified that assessed trade-offs between competing interests using quantitative models, qualitative methods, and combinations of both. However, the references on this subject displayed little coherence, and instead were contained within diverse literature categories oriented to the respective methodologies. Most of the trade-off references were found in multiobjective (or "multicriterion") planning. As a result, these categories were merged.

As one distinct literature category disappeared, another emerged. Game theory quickly appeared as a separate category during the search. This rapidly evolving research area was recognized as a large body of literature that has significant potential for Corps environmental planning. The literature search continued with a three-pronged advance, although not the original three categories. In addition, information on negotiation processes inevitably led to the broader subject of group processes, which now serves as an umbrella for negotiation, mediation, public involvement, and facilitated group techniques.

LITERATURE STRUCTURE

Many trade-off references were contained within the subject of group processes. This suggested that trade-off analyses can be conducted using multiobjective planning, game theory, or group processes. What became increasingly apparent was that rather than discrete literature categories, these subjects represented shades of grey with respect to several different criteria. As a consequence, "trade-off analysis" is used in this study as an umbrella term for all three areas of research.

The structure of the literature for multiobjective analysis, game theory, and group processes is illustrated in Figure II-1. Trade-off analysis falls in the space between three continua: (1) the number of decision-makers; (2) the number of objectives; and (3) the degree of empiricism in the analysis. The space within this cube is similar to decision theory. This field of research seeks

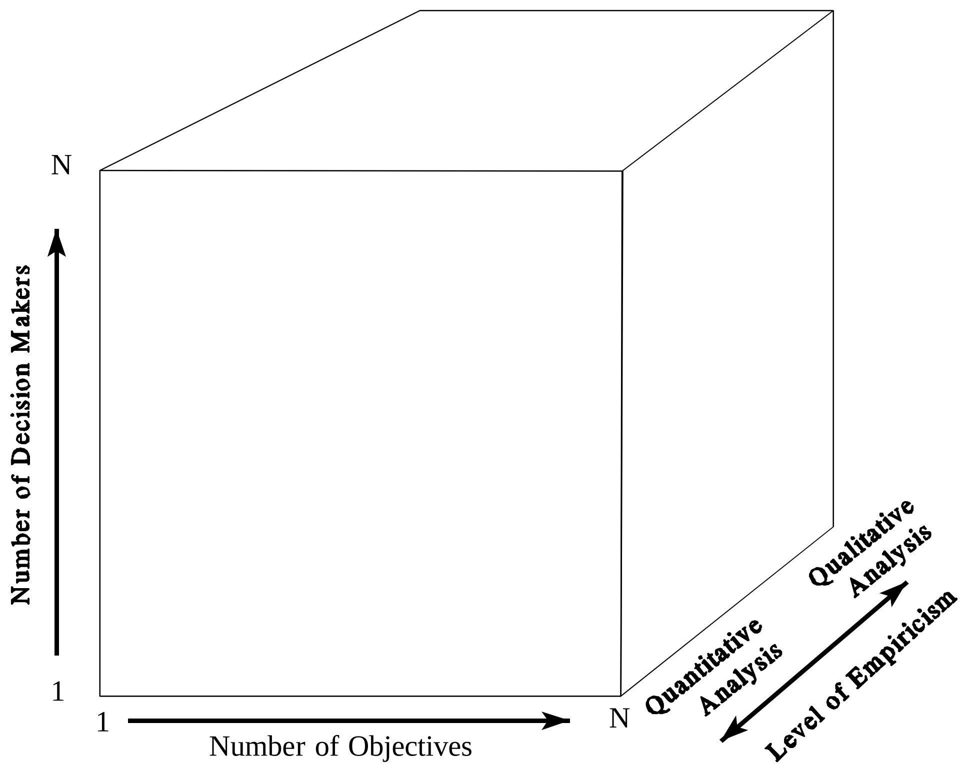


FIGURE II-1

DIMENSIONS OF TRADE-OFF ANALYSIS

(Adapted from Hipel, 1992)

commonalities of decision-making between these three axes (Mullen and Roth, 1993; Arrow and Raynaud, 1986; Raiffa, 1968).

The empiricism of the different trade-off techniques is a parameter characterized by many shades of grey and exaggerated distinctions between the research fields within trade-off analysis. Quantitative and qualitative analyses are presented as the two extremes of this axis in Figure II-1. Other dichotomies of this dimension of empiricism might be ordinal/cardinal or model/group determinations. Mullen and Roth (1991) have a perspective on these distinctions that softens these edges:

> *In the area of decision research, there are those who believe that formulating decisions quantitatively by use of mathematical language, is crucial to thinking clearly and rigorously. There are others who believe that most decision problems are too complex to be usefully formulated mathematically. This issue is sometimes formulated in terms of "hard" vs. "soft" science, with the quantitative types describing themselves as doing the hard science. We do not see it that way. There is research in the field that is rigorously experimental, but in which the overarching theory is non-quantitative. The research on attribution theory is a very good example of rigorous science that is not based upon any quantitatively formulated paradigm. The nonmathematical theorists sometimes claim that the important factors involved in decision-making cannot be measured, and so any numerical formulation will represent an overly simplified decision environment. This view we also believe is mistaken.*

The trade-off analysis space within the cube of Figure II-1 can be interpreted using the following examples. One decision-maker using quantitative methods such as systems analysis techniques for one objective is engaged in what is known as operations research. Operations research might be found in the lower left corner toward the front of the cube. Multiobjective planning typically involves one decision-maker, more than one objective, and quantitative techniques (e.g., models, simulations). This would be found in the lower right corner toward the front of the cube. Game theory differs from multiobjective planning in that it has more than one decision-maker. Game theory, therefore, might be found in the upper right corner, also toward the front of the cube. Finally, there are a wide range of group processes that can encompass very small or very large numbers of decision-makers and objectives, but they are generally more qualitative than quantitative. As a result, the far half of the cube would be occupied by group processes.

Figure II-1 illustrates the dimensions of trade-off analysis. Over the course of this research, the relative locations of multiobjective analysis, game theory, and group processes within the space of the cube began to materialize. It became increasingly apparent that these families of techniques could be used separately or jointly in the environmental planning process.

In some planning contexts these techniques can be considered substitutes, in other compliments. The characteristics of a project, including its scale, budget, and degree of contentiousness, will require a specific set of trade-off techniques. In addition, specific trade-off techniques will be appropriate to particular planning activities. Recognizing these qualifications regarding their applications, the three categories of trade-off techniques can be viewed from the following perspectives. Multiobjective analysis and game theory are information-generating tools that can support the decision-making process. Group processes, however, can be used to make decisions and generate information.

The detailed review of the literature was initiated after its structure was identified. Critical references were verified and retrieved. Eventually, over 350 references pertaining to trade-off analysis were identified. The works cited from these lists were used to identify their predecessors and trace the lineages of their respective research fields. As the literature review went further in depth, prominent researchers in the different fields were identified. The search was concluded when new reference lists failed to produce new sources of information, indicating that the search had backtracked sufficiently to identify seminal works in the literature. In the case of group processes, there is a vast body of literature. Given the focus of this effort, a comprehensive search was impractical and instead representative references were identified.

The bibliographic database software *Papyrus* was an invaluable tool in the literature search. The citation information was input to the database. The software allowed sorting of the database by author, key word, date, or alphabetical sequence. This ability allowed continual review of the database for balanced and current coverage of the subject areas.

The search of the literature for multiobjective planning, game theory, and group processes was directed toward identification of theories, models, and applications of the methodologies. Since this document is directed toward a successful integration with Corps environmental programs, the focus of the literature review was primarily on water and environmental resources, with some treatment of other types or general technique applications to characterize the research.

ANNOTATION SELECTION

References were selected for annotation based upon representativeness of the subject, prominence of the author, recency of the work, and significance of the research based upon the number of citations. In some cases, the content was found to belie the significance of work, and these references were not annotated. The annotations are presented in Appendix B organized by subject area. In many cases, a single reference may span more than one subject category. However, each reference is presented with its main affiliations for ease of review. They are organized into the following categories:

- Multiobjective Planning
  - Water Resources
  - Environmental
  - Other/General

- Game Theory
  - Water Resources
  - Environmental
  - Other/General

- Group Processes
  - Negotiation
  - Mediation
  - Public Involvement
  - Group Techniques

Note that the structure for Group Processes is different than the others. This is to accommodate the diversity of techniques in this field. The larger list of references, including those annotated, are presented in Appendix C. These references are also organized using the above framework, except that the group processes in Appendix C are also arranged into the same subcategories as multiobjective planning and game theory framework (water resources, environmental, and other/general).

ANNOTATION FORMAT

The annotations in Appendix B were prepared using a formatted template. However, different references required some flexibility for each annotation. Following the citation and appropriate key words, the annotations were written using the three-part process below. Readers are encouraged to retrieve and evaluate references themselves.

- Define the purpose of the reference, identifying the methodology and research contexts (e.g. case studies, applications).

- Present the manner in which the research objectives were achieved, outlining the data sources, analytical methods, and findings.

- Interpret the value of the reference relative to Corps environmental evaluations and objectives of the EEIRP.

LITERATURE SYNTHESIS AND ANALYSIS

Following review of the different research topics and annotation of the references that effectively represent each subject, an analysis of each subject was conducted for the various components of trade-off analysis. The literature for the three main subject areas, multiobjective analysis, game theory, and group processes, was synthesized and interpreted with respect to their potential utility to the Corps in the following three chapters. Their applicability to the planning of Corps environmental projects will become increasingly evident. In general, multiobjective analysis can be used to identify impacts of alternative resource allocations. Game theory can provide insight into the structures of conflicts and the implications of alternative courses of action. Group processes may best serve as a means for structuring stakeholder preferences and for overcoming obstacles to cooperative decision-making. A summary of the entire literature review is presented in the final chapter with conclusions about the trade-off analysis literature and recommendations for incorporating this information into the EEIRP. References cited in the these discussions can be found in the respective category of research in Appendix C or in the alphabetical listing of references in Appendix D.

III. MULTIOBJECTIVE ANALYSIS

The complex nature of managing environmental resources requires resource planners to consider and balance the many benefits society realizes from environmental services. Thus, it is not surprising that multiobjective analysis has found its way into the environmental management tool chest. Application and development of multiobjective techniques spans many disciplines and scales. This chapter provides an overview of multiobjective analysis and highlights the opportunities for application in the Corps environmental management setting.

OVERVIEW

Given the appropriate circumstances, multiobjective analysis (MOA) is a robust and sound technique for considering complex problems. MOA's robustness is reflected in the many ways it has been successfully applied over time. For example, the present effort is aimed at MOA in environmental planning, although the technique was originally developed to accommodate military operations. This reflects quite a range of subject areas, but probably underestimates the range of problems to which MOA has been applied in the last 50 years in academic research, governmental planning, and business operations.

As noted Chapter II of this report, MOA has its roots in systems analysis and operations research which necessarily leads to the fertile research and development activities of the defense industry in the early and mid-1900s. Hipel (1992) traced the first use of MOA to the development of radar systems in the 1930s in Britain. Since then, the technique has been widely used in American military operations for allocating limited resources among competing military activities. Detailed accounts and discussions of MOA applications in the military can be found in Blackett (1962) and Waddington (1973).

Creation of MOA is often initiated through textual information that forms an objective statement with a set of constraints. For example, a restoration project may be planned which maximizes the amount of habitat restoration while maintaining flood control capabilities and limiting mosquito-related nuisances. Here, the leading objective is to maximize habitat; the latter elements are considered objectives also, but serve as constraints. Frequently, a MOA setting guides broader policy inquiries. For example, the Corps was involved in a study in 1990 that examined management options for reducing Federal expenditures on recreation while maintaining or enhancing public recreational opportunities at Corps projects. Here, the chief aim was to reduce Federal spending (objective), but not at the sacrifice of recreational opportunities (constraint).

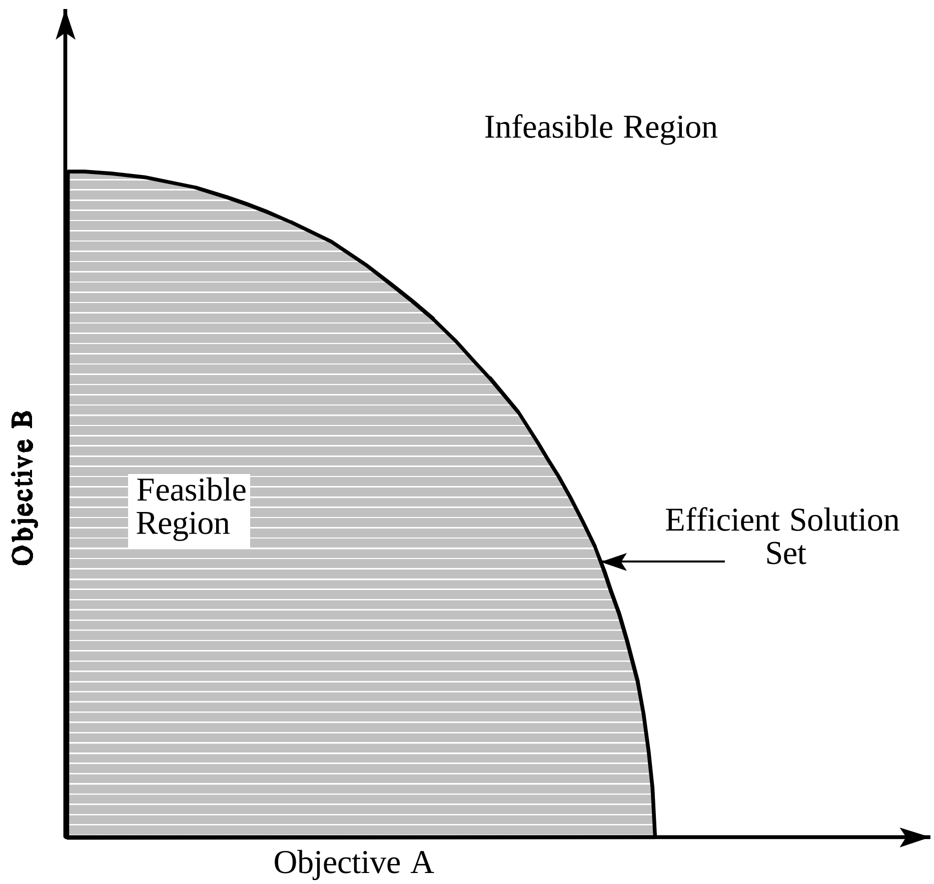


FIGURE III-I

GENERAL MULTIOBJECTIVE FRAMEWORK

The essence of MOA is translating the textual statements of objectives and constraints into mathematical functions and graphical relationships. The basic relationship portrayed in MOA is found in Figure III-1. In the two-objective case, the curved line represents the set of combinations of objectives A and B. The space between the origin and the curve, including the points that make the curve, depicts the set of all possible combinations of objectives. This is typically referred to as the feasible region. Points outside the curve simply cannot be achieved, thus are termed the infeasible region. The points forming the curve represent the maximum combination of objectives A and B that are feasible under existing technology and understanding and constitute the efficient solution set. Reaching a point on the curve is the goal in most MOA settings. Borrowing from economics, this is referred to as "Pareto" optimal. Movement along the efficiency frontier increases the amount of one objective and reduces the other. This trade-off should be evaluated by comparing the benefit of the additional amount of the increased objective against the opportunity cost of foregoing the lost increment of the other objective.

This very simple illustration (Figure III-1) creates the setting for MOA, but becomes much more complicated, as well as powerful, as additional competing objectives are considered. This is where numerical methods and computers play an important role in finding a solution. The formulations of these techniques are found in several texts. See Haimes (1977), Cohon (1978), and Goodman (1984) for comprehensive discussions of these techniques in their application to water resources.

In its most powerful form, MOA can provide a single decision-maker with the optimal solution to an elaborate problem. Well-defined mathematical functions representing all objectives are a prerequisite. This allows the numerical method to produce an undisputed optimal solution. If the clarity of the objective function diminishes, the certainty surrounding the solution is also reduced. This can occur if well-defined models or data are unavailable or if stakeholders have are uncertain or dynamic interests regarding the project. Users of MOA are often queried for subjective information, such as weight assignments to objectives being analyzed. This can introduce another source of fuzziness to the analysis and can raise questions regarding the accuracy and/or applicability of the MOA results. Another complication in using purer forms of MOA is that decisions regarding environmental projects are rarely developed by a lone executive decision-maker. Rather, environmental projects typically involve many stakeholders who have a say in the project outcome and design features. As the discussions in the remaining sections of this chapter focus on applications to water and environmental resource decisions, the reader will see that it is common for elements of MOA to be represented by information that is qualitative in nature and has input from several decision-makers.

WATER RESOURCES APPLICATIONS

Planning, design, and operation of water resource systems have benefitted significantly from MOA. On the quantitative end of the spectrum, MOA has been used extensively in engineering design, testing, and reservoir operations. MOA has also been used in a more qualitative way through development of planning goals and policies. The Corps has played a prominent role in the development and application of MOA.

Evolution of the Methods

The popularity of MOA was certainly on the rise in the 1970s when the Federal government specified the use of a multiobjective perspective in the development of land and water resources (U.S. Water Resources Council, 1973). This was also the time that Cohon and his associates published extensively and played an important role in the proliferation of MOA (Cohon and Marks, 1973; Cohon and Marks, 1975; Cohon, 1978; Cohon, Church, and Sheer, 1979). Standard graduate school textbooks which cover the historical development, techniques, and application of MOA in the field of water resources include Haimes (1977), Cohen (1978), and Goodman (1984). Multiple-criterion decision-making with its more subjective information gradually found home within the domain of MOA. To see a sampling of how MOA has evolved since the 1970s, the reader is directed to the February 1992 volume of *Water Resources Bulletin*, which was dedicated in its entirety to multiobjective decision-making. The lead article by Hipel provided an overview of the volume contents and effectively summarized many of the features of MOA.

Reservoir operations could probably be considered the classic application of MOA in water resources planning and in the Corps. The quantity and stage of water in the system (or element of the system) have direct impacts on the system's ability to produce hydropower, navigation, water supply, and recreation. Since regulation of water flow is a primary engineering feature of many Corps facilities, impacts on all users must be taken into consideration. Within a series of regulation structures, the relationship between inflows and outflows of each element becomes important. Fortunately, the Corps Hydrologic Engineering Center (HEC) has been successful in developing models that track the stage throughout reservoir and river systems. Thus, reservoir/river stage is a common driver in these MOA applications.

Simulation and optimization models play an important role in MOA. The models maintained at HEC simulate the processes of a waterway. Key outputs and relationships are formed mathematically within a computer program which allows for development of what-if scenarios. The simulation model facilitates sensitivity analysis. Another family of models common to MOA is optimization. Linear programming is typically used to find the optimal combinations involved with the project given an objective such as maximize dollars, or minimize damages. It is possible to find the optimal solution (i.e., optimize the combinations) by running a series of simulations with incremental changes in selected variables.

Duckstein and Opricovic (1980) highlighted MOA for water resources planning at two levels. The engineering level is technical and provides details of the impact of various alternatives. The managerial level defines the goals and objectives, and then makes a final decision regarding the water resource development being considered. Goodman (1984) suggested the following four situations for application of MOA to water resource projects:

1) Maximize one objective, with constraints (specified values or limits) on the other objectives.

2) Use an explicit system of weights to make several objectives commensurable, thus permitting maximization of a utility or welfare function.

3) Use target values for all objectives, with functions to express penalties for failures to meet these targets.

4) Evaluate alternative plans, each emphasizing a different objective, then develop a mixed objective plan through a consensus or bargaining process among the participants in the planning process.

This classification of MOA approaches traverses articles, reports, and books identified through the present literature review. In many cases, a combination of the four approaches is used to accommodate water resource planning challenges.

Several MOA scenarios were examined for reservoir operations by Harboe (1992). The objectives balanced were: hydropower production, water supply, flood control, low-flow augmentation, reliability, recreation, and water quality. Six multiobjective methods (goal programming, Tchebycheff method (min/max), compromised programming, consensus, ELECTRE I, and ELECTRE II) were used to examine the impact of five operating schedules. The resultant rankings of the alternatives was nearly the same for all the methods except ELECTRE I which was not comparable because the method does not yield complete rankings of more than two alternatives. Experimentation by Harboe (1992) illustrated the power and versatility of MOA when given well-defined supporting functions.

Consistency is desired among the results of decisions made using various MOA techniques. In other words, the priority of project alternatives using one approach should not be different when using another technique. Because many MOA techniques explored in the literature require subjective data, the search for consistency and external validity of MOA techniques has been the topic of several papers. Giocoechea, Stakhiv, and Li (1992) evaluated the consistency of results across decision-makers using MATS-PC, EXPERT CHOICE, ARIADNE, and ELECTRE I for examination of alternatives for a water supply study. A rigorous examination of the results among the 21 decision-makers in the experiment revealed some differences, but most of the statistical analyses conducted suggested the differences were insignificant. Duckstein, Treichel, and El Magnouni (1994) found a similar subset of solutions when comparing results of compromise programming, ELECTRE III, multiattribute utility function, and UTA technique for evaluating groundwater management alternatives. What was not tested in these analyses was the consistency in rankings given a change in the condition of the alternatives being examined. This suggests an important derivation of the experiment that would further characterize the techniques' robustness.

Another theme explored in these comparative analyses of MOA techniques was the general utility of the techniques. Features of the supporting computer software are typically discussed. Tecle (1992) examined applicability and usefulness of 15 MOA techniques over 24 criteria. The criteria generally follow these four groups: characteristics of the decision-maker, characteristics of the algorithm for solution, characteristic of the problem being examined, and nature of the solution (optimal and otherwise). Although Tecle made reference to 70 techniques, the 15 shown in Table III-1 are evaluated. Application of the water resource problem described in the article, and the process and algorithm developed by Tecle from the 24 criteria pointed toward the compromise programming and composite programming techniques. However, Tecle suggested that other techniques may be preferable under different conditions.

Multiobjective Analysis and Water Resources Policy

Water resources planning has been affected by the reference to MOA in the U.S. Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) published in 1983. Four accounts were named in the P&G for appraisal of a water resource project. Although these four accounts were not equally weighted in the evaluation, they provide an example of multiple objectives. The U.S. Water Resources Council (1983) indicated:

> *Four accounts are established to facilitate evaluation and display of the effects of alternative plans. These accounts are: national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE). The EQ account shows effects on ecological, cultural, and aesthetic attributes of significant natural and cultural resources that cannot be measured in monetary terms. The OSE account shows urban and community impacts and effects on life, health and safety. The NED account show effects on the national economy. The RED account shows the regional incidence of NED effects, income transfers, and employment effects.*

The predecessor to P&G, *Water and Land Resources; Establishment of Principles and Standards for Planning* (P&S), was published in 1973 by the U.S. Water Resources Council. The P&S influenced the role of MOA by designating it a required planning activity in which project alternatives balanced between national economic development (NED) and environmental quality (EQ) had to be considered. The environmental community considered this a victory because EQ and NED were deemed equal objectives in the evaluation of project alternatives.

TABLE III-1

MOA TECHNIQUES ANALYZED

Technique	Common Abbreviation	Reference
Analytic Hierarchy Process	AHP	Saaty, 1977; 1980
Composite Programming	CTP	Bardossy et al., 1985
Compromise Programming	CP	Zeleny, 1973; 1982
Cooperative Game Theory	CGT	Nash, 1953; Szidarovszky et al., 1984
Displaced Ideal	DISID	Zeleny, 1974; Nijkamp, 1979
ELECTRE	ELEC	Benayoun et al., 1966; Roy, 1968
Evaluation and Sensitivity Analysis Program	ESAP	Mumpower and Bollacker, 1981
Goal Programming	GP	Charnes and Cooper, 1961; Ignizio, 1976
Multiattribute Utility Theory	MAUT	Keeney and Raiffa, 1976
Multicriterion Q-Analysis	MCQA	Hiessl et al, 1985
Probabilistic Tradeoff Development Method	PROTR	Goicoechea et al., 1976
Zionts-Wallenius	Z-W	Zionts and Wallenius, 1976
Step Method	STEM	Benayoun et al., 1971
Surrogate Worth Trade-off	SWT	Haimes and Hall, 1974
PROMETHEE	PRM	Brans and Vincke, 1985

Source: Tecle (1992)

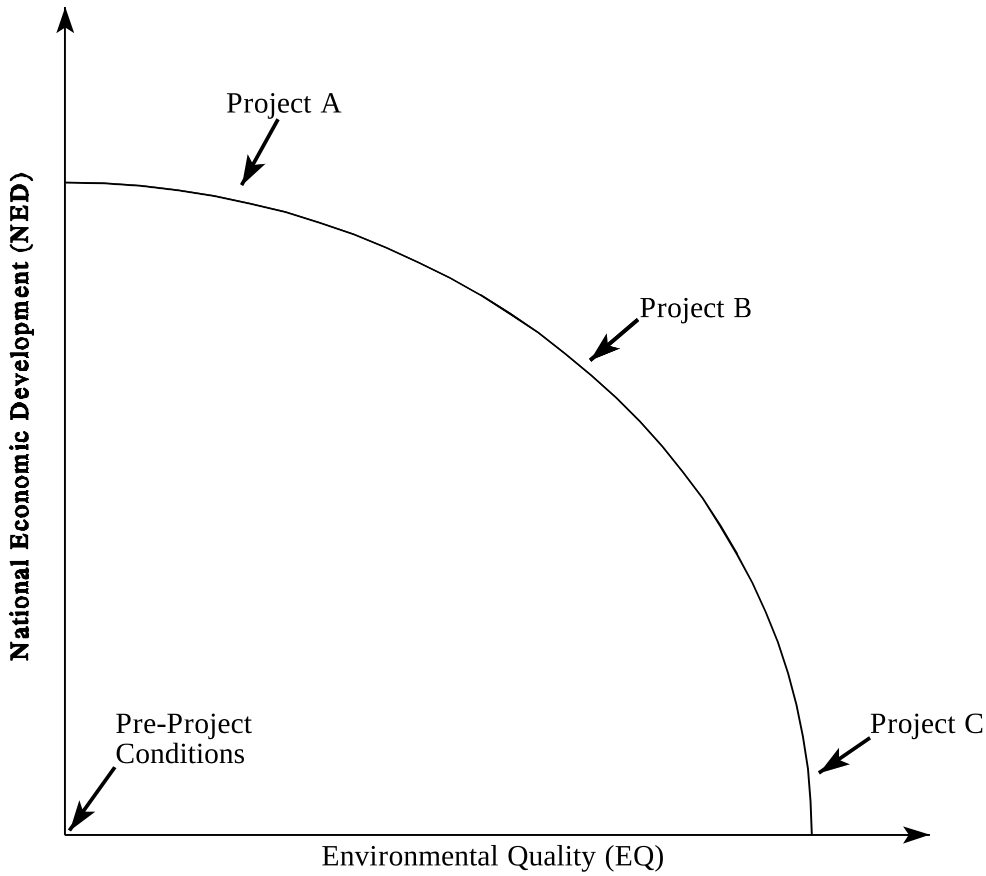


FIGURE III-2

COMPARISON OF NED AND EQ OBJECTIVES
(adapted from Shabman, 1993)

These equally weighted objectives constitute the axes in Figure III-2. Publishing of the P&G ten years later "down-graded" EQ by naming NED the chief planning objective:

> *The federal objective of water and related land resource planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements*. (U.S. Water Resources Council, 1983).

Although this was indeed a shift from equal billing between NED and EQ, many argue that the wording and intent left ample latitude for consideration of multiple objectives (Brown, 1984; Shabman, 1993). Brown (1984) asserted that:

> *If water resources planners narrowly construe the P&G and formulate plans only to maximize the NED objective, they may very well miss those alternatives that meet the NED objective and also address other issues that affect a plan's social, environmental, and political viability.*

The feasibility frontier represented in Figure III-2 represents maximum possibilities of combinations of NED and EQ objectives at a given point in time. As technology improves and innovations occur, the frontier could shift outward. Indeed, there is a great deal of effort ongoing in the Corps to enhance complementary aspects of these objectives. While MOA can help move resource allocations toward the frontier, it alone cannot determine an optimum point along the frontier. This requires either implicit or explicit weighting of the objectives (e.g., P&G or P&S). Some may interpret the P&G as suggesting that Project A (Figure III-2) is the appropriate combination of NED and EQ. Project A maximizes NED and provides marginal improvement to EQ through mitigation. Also, Project B or Project C could be recommended if, according to the P&G:

> *... there are overriding reasons for recommending another plan (plan other than the NED maximizing plan), based on other federal, state, local, and international concerns.* (U.S. Water Resources Council, 1983)

While our discussions of the P&G have centered around the importance of EQ and NED, the underlying argument being made is that MOA is an effective tool for discussing and presenting policy information. Using MOA in a P&G-type setting does not draw upon the intricate mathematical formulations and empirical data that some other MOA techniques do, but it does lend a clear format for macro level discussion of the planning issues and gives opportunity to discuss agency orientation in water resources development.

ENVIRONMENTAL APPLICATIONS

The confluence of MOA and environmental applications is typically discerned when one objective under consideration is an element of the environment. Several examples have already been given in this chapter such as the EQ-NED issue in the P&G. In the literature review conducted for the present study, there were very few cases where several environmental aspects were traded-off against one another. A common framing of environmental elements for Corps environmental restoration and mitigation is to provide some magnitude of habitat (e.g., acres of wetland) without increasing the flood hazard. As described in the previous section, application with an environmental element can consist of very specific data-driven functions, or MOA can be used to define policy. For this portion of the discussion, several examples with environment as a component are presented. Specific methods referred to in the previous section are generally applicable in an environmental project setting.

A typical example of environmental elements shared in river basin planning was provided by Gerson, Duckstien, and McAniff (1982). Balancing many interests in the Santa Cruz River Basin generated the set of objectives shown in Table III-2. This example illustrates the need to span qualitative and quantitative objectives in seeking a desirable solution. The flood protection objective in this case is measured on a continuous scale in dollars. The elements of the environmental objective are measured on an ordinal scale where *a* is best and *e* is worst. ELECTRE I was used to screen a large set of alternatives into a more refined set, ELECTRE II was used to prioritize the refined set. ELECTRE I utilizes a concordance matrix for the combinations of actions with weights assigned to the evaluation criteria by the user. Similarly,

TABLE III-2

MULTIOBJECTIVE RIVER BASIN PLANNING

	Objective	Specifications	Criteria
1.	Water supply	Aquifer level	net change in ft/yr
		Water quality, urban	*a, b, c, d, e*
		Water quality, agriculture	*a, b, c, d, e*
2.	Flood protection	Expected flood losses	expected dollars
		Expected frequency	expected number of floods (annual probability)
3.	Environmental	Preservation of designated areas	*a, b, c, d, e*
		Effect on wildlife and vegetation	*a, b, c, d, e*
4.	Utilization of resources	Implementation	present dollars
		Operation and maintenance	present dollars
		Indirect costs	*a, b, c, d, e*
		Natural resources	*a, b, c, d, e*
5.	Recreation	Preservation of existing facilities	*a, b, c, d, e*
		Creation of new opportunities	*a, b, c, d, e*

Source: Gershon et al., 1982

a discord matrix is developed for the combination of action that represent discomfort. The result is a graphical display of preferences. This is used as input into ELECTRE II which is a ranking procedure.

Trimble and Marban (1988) considered two environmental objectives in evaluating the operating schedules for Lake Okeechobee: downstream biological integrity and the lake's littoral zone as habitat. This investigation compared management strategies for environmental restoration and protection with those for flood control and water supply. The objectives and performance measures are shown in Table III-3.

The water/environmental resource system being analyzed in the MOA setting is typically characterized by a simulation model. Many of the hydrology and hydraulics models are maintained by the Corps HEC. These models typically provide empirical support for nonenvironmental objectives. One example is the case of Trimble and Martin (1988), where lake stage drove the analysis of environmental objectives. A simulation model was developed for large reservoirs in New Mexico that goes beyond a simple tracking of stage in the system. The model, called RIOFISH (Cole et al., 1990), simulated fish habitat and fish forage production, sportfish production, biomass and angler activity, water flow, and transport of biologically active materials. The focus of RIOFISH was to examine the effects of reservoir management on fish harvest. The general outputs of RIOFISH are shown in Table III-4.

TABLE III-3

MULTIOBJECTIVE ANALYSIS AND PERFORMANCE MEASURES USED IN RECENT STUDY OF OPERATING SCHEDULES FOR LAKE OKEECHOBEE

Four Competing Objectives	Performance Measure
1. Provide adequate flood protection for the regions around the lake.	Maximum stage on September 1
2. Meet the water use requirements of the agricultural and urban areas dependent on Lake Okeechobee for water supply.	Percent of demands not met
3. Preserve the biological integrity of the estuaries downstream from the lake.	Number of days of high discharge
4. Preserve and enhance the lake's littoral zone which provides a natural habitat for fish and wildlife.	Percent of days exceeding elevation of 15 feet

Source: Trimble and Marban, 1988.

TABLE III-4

GENERAL OUTPUT INFORMATION GENERATED BY RIOFISH

Output Category	Measurement Unit
Lake elevation	(feet)
Lake volume	(acre feet)
Lake surface area	(acres)
Lake exchange rate	(annual)
Catchable sportfish	(kg/hectare)
Total angler days	(days/year)
Fish catch rate	(number/hour)
Primary production and allochthonous organic load	(g C/M2/year)
Benthos production	(kg/hectare/year)
Zooplankton production	(kg/hectare/year)
Panfish production	(kg/hectare/year)
Gamefish production	(kg/hectare/year)
Carp and sucker production	(kg/hectare/year)
Statewide angler benefits	($1,000s)

Source: Green-Hamond et al., 1990.

Wetland evaluations are some of the more prominent management challenges faced by environmental planners. The services provided by wetlands, which included flood control, aquifer recharge, recreation, and biotic diversity, invite MOA. In recognizing this range of services that can be measured in economic and noneconomic terms, Bennett and Goulter (1989) concluded:

> *...the wetland manager is faced with the task of choosing management options from a set of alternatives with noncommensurate values. Multiobjective methods allow the manager to assess the impacts of alternatives and to present them in a concise understandable manner to the decision-maker. The best means of presenting the relationships between the various objectives is use of the concept of a transformation or trade-off function. Given the appropriate information available from this function it is then the decision-maker's role to choose the best alternative.*

POTENTIAL UTILITY TO CORPS ENVIRONMENTAL PLANNING

MOA has proven to be a useful tool to the Corps and other environmental resource agencies in supporting decision-making for complicated environmental problems. Continued efforts to refine MOA with specific emphasis on environmental restoration and mitigation projects would favorably serve the Corps. This is especially true given the heightened interest of the Corps and the general public in environmental projects. As interests heighten, so do the issues surrounding the project. Although many uses of MOA require subjective assignment of weights or scales to the problem, the analytical utility is that it can aid in mapping issues and identifying their relative importance. This, in turn, can be used by stakeholders to shape their values regarding environmental restoration and mitigation efforts.

Another potential use of MOA for the Corps environmental planning community's to describe, in general terms, the impacts of project alternatives. Simple graphics (see Figure III-2) and the basic foundations of MOA can be used to describe trends and influences of potential projects on the important goals and objectives for the project or the region (Shabman 1993).

Effective use of MOA requires its appropriate application to a given situation. The preference is to present objectives in a mathematical or numerical form)thus "clearly" representing issues being optimized. However, most environmental projects considered by the Corps are not fully supported in this way. Thus, a blending of quantitative and qualitative information is typically required. MOA tools that adequately handle both quantitative and qualitative data will be most useful to the Corps. Some existing software products and techniques certainly warrant further attention and consideration by the Corps planning community.

IV. GAME THEORY

While multiobjective analysis can generate insight into optimal resource allocations, game theory can help parties in a resource dispute understand the nature of the conflict and help identify possible resolutions. Since the Corps is frequently involved in resource conflicts, game theory may provide valuable tools to help identify likely trade-offs between competing interests.

OVERVIEW OF GAME THEORY AND CONFLICT ANALYSIS

Game theory arose from the discipline of economics (von Neumann and Morganstern, 1953). The focus of game theory is on understanding how and why individuals and groups make decisions. Game theory has evolved quantitative tools to model the interaction of the "players" under specific circumstances. Mullen and Roth (1991) provide an effective introduction to game theory:

> *The body of theory that deals with rational behavior when planners are faced with rational opponents is called game theory. The word "game" in the title is an unfortunate one, because the nuclear arms race is a classic example of a game theoretic problem. The prisoner's dilemma is but one type of strategic situation.*

The "prisoner's dilemma" is the classic example of game theory (Plous, 1993). Although it is only one type of game theory application, its simple structure and complex situation make it an excellent illustration. Two associated criminal suspects (Prisoners A and B), confined in separate cells, are offered the same deal by the prosecutor with the situation illustrated below and modeled in Table IV-1:

(1) If neither confesses, both prisoners will get one-year sentences;

(2) If Prisoner A confesses and B does not, B will get ten years, and A will go free;

(3) If Prisoner B confesses and A does not, A will get ten years, and B will go free;

(4) If both prisoners confess, A and B will both get five-year sentences.

In the prisoners dilemma situation, both prisoners will wish to maximize their own outcome by confessing. However, if both confessed, each would get five years of incarceration. This game theoretic analysis could be used to explain to the prisoners their situation and induce

TABLE IV-1

MODEL OF THE PRISONER'S DILEMMA

		Prisoner B	
		Confesses	**Doesn't Confess**
Prisoner A	**Confesses**	A & B both get 5 years	A: goes free B: 10 years
	Doesn't Confess	A: 10 years B: goes free	A & B both get 1 year

them to forego what seems to be their best option in favor of the option that generates an optimum for the group. This example illustrates how game theoretic analyses can be used to increase understanding of a situation and generate a stable group optimum through cooperation.

Most situations are more complicated than the hypothetical prisoner's dilemma. However, viewing the parties in a given situation as pursuing their objectives with a limited range of options can be very insightful. Game theory applied to conflicts has evolved into a separate subject known as conflict analysis, and in the following discussions, "conflict analysis" will refer to this usage.

Conflict analysis is a quantitative game theoretic process that is intended to help multiple competing parties reach a solution to their dispute. As such, it comprises a family of trade-off techniques that can resolve the multiple objectives of multiple parties (Hipel, 1992). Conflict analysis can be used to structure the conflict and identify potential solutions. For example, the analysis of the prisoner's dilemma in Table IV-1 does not predict a solution to the situation. Instead, it shows the results of alternative courses of action and identifies optimum solutions for the group which rational players could achieve.

Table IV-2 presents a hypothetical example of an environmental conflict that has a similar structure to the prisoner's dilemma. Stakeholder A, an environmental group, desires to restore a 200-acre tract of disturbed and degraded wetlands to its former condition as prime waterfowl habitat. Stakeholder B, a real estate developer, wants to use the tract to build a residential subdivision. Both parties could litigate aggressively or seek a negotiated settlement. Aggressive litigation could produce positive results (in this case, 150 of the 200 acres) for either party against an opponent who seeks a negotiated settlement. However, if both parties were to choose

TABLE IV-2

HYPOTHETICAL EXAMPLE OF ENVIRONMENTAL CONFLICT ANALYSIS

		Stakeholder B (Real Estate Developer	
		Litigate	**Negotiate**
Stakeholder A (Environmental Group)	**Litigate**	Expensive; no settlement	A: 150 acres restored B: 50 acres developed
	Negotiate	A: 50 acres restored B: 150 acres developed	A: 100 acres restored B: 100 acres developed

this option, the result would be years of expensive court battles with an uncertain outcome. The game theoretic modeling of this conflict could identify for both parties the benefits of negotiation and the advantages of foregoing their seemingly best option in favor of cooperation that produces a group optimum (in this case, 100 acres for each use).

Although conflict analysis contains many variants, the analysis generally follows the structure presented in Figure IV-1 (Hipel and Fraser, 1988). The components of conflict analysis are discussed below (Fraser and Hipel, 1984).

Identifying the Conflict

Some conflicts are more suited to game theoretic analysis than others. Many conflicts involve competing interests where a satisfactory solution cannot be reached on some resource or issue. Burton and Dukes (1990) emphasize the role of unfulfilled human needs as causal factors in conflicts. When the competitors have similar power, the conflict often becomes a stalemate. In many cases, the conflict is exacerbated by a lack of information. For example, the parties to the conflict (i.e. "players") often have incomplete technical information about the problem and frequently misperceive their situation relative to the other players. Stalemated conflicts make excellent subjects for conflict analysis since: (1) the interests are well defined; (2) the situation is stable (although with no progress toward a solution); and (3) no solutions acceptable to all parties has been identified.

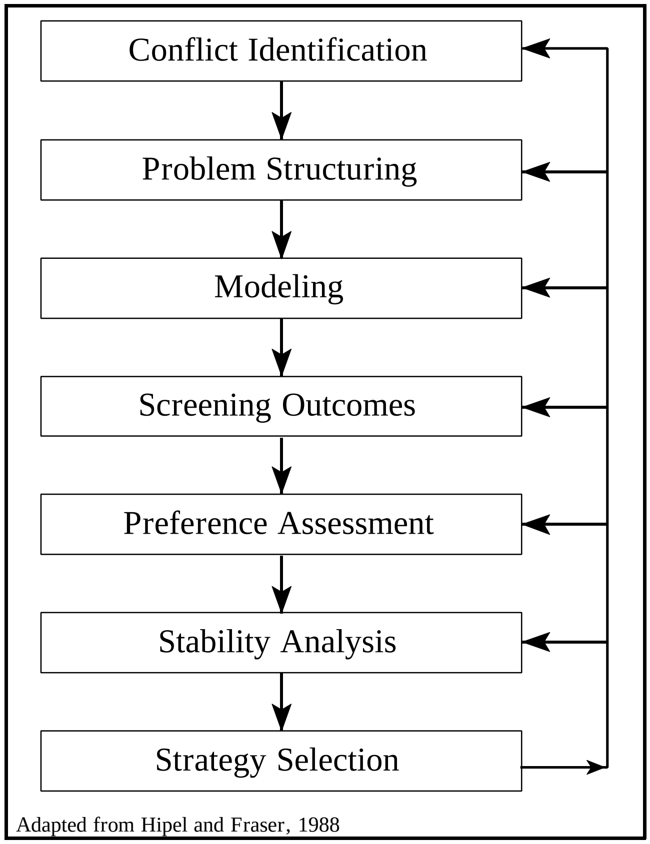


FIGURE IV-1

GENERAL STRUCTURE OF CONFLICT ANALYSIS

The case studies on conflict analysis are dominated by *ex post* applications to such stalemated situations. By looking back in time at conflicts that have since been resolved, conflict analysis researchers can: (1) identify the structure of the problem; (2) refine the methodologies; and (3) test the potential solutions identified through the analysis against the solutions actually achieved.

Structuring the Conflict

Modeling the conflict requires identification of all significant parties and their possible actions or "options." This can be a significant undertaking if the conflict is complex (i.e., with many different players and options). When possible, different parties with the same goals and options should be combined to reduce the number of different perspectives to be modeled. Similarly, the number of options identified for each player should be consolidated whenever possible to distinguish reasonable, rational courses of action. This will greatly reduce the complexity of the conflict analysis model as well as the time and expense required for the analysis.

Conflict analysis models the situation at a given point in time. This static view runs counter to a common misperception about conflict analysis derived from the "game" in game theory. Conflict analysis does not simulate the give and take, action and reaction that embody common games, such as card games or chess. Instead, it models a snapshot of the situation and identifies alternative actions that the players can take to meet their individual objectives and evaluates the collective results when the players pursue different courses of action.

Modeling the Conflict

As in Table IV-1, each player in conflict analysis has a limited number of options under the specific circumstances. A set of options open to a player is called a strategy. The potential strategies for each player can be combined into an array or "conflict model" that represents all possible combinations. Each combination of strategies (for all players) represents an "outcome." The arrays of outcomes consist of binary codes indicating whether or not the player in question exercises that option. For example, Prisoner A can confess or not confess, coded with either a 1 or 0. Similarly, Prisoner B can do the same. This would produce an array with four possible outcomes such as found in Table IV-3. Modeling a conflict with many players and/or options can require a large number of outcomes. This explains why the conflict structure should be refined to the most essential positions and possibilities.

TABLE IV-3
ARRAY OF POTENTIAL OUTCOMES
TO THE PRISONER'S DILEMMA

	Outcome 1	**Outcome 2**	**Outcome 3**	**Outcome 4**
A Confesses	0	1	0	1
B Confesses	1	0	0	1

Hipel and Fraser (1980) provided an effective application of conflict analysis to the Garrison Diversion unit (GDU), a proposed large-scale irrigation project in Montana. They combined more than 40 explicitly named participants into four players with similar interests and options: U.S. support, U.S. opposition, Canadian opposition, and the international perspective of the International Joint (U.S./Canadian) Commission. These players and their options are summarized in Table IV-4.

Screening Outcomes

The array of possible outcomes are screened to remove those not viable. Each outcome must be carefully considered by the modeler. Some outcomes are logically impossible. For example, if there were two alternative versions of the same project, it would not be logical for

TABLE IV-4

PLAYERS AND OPTIONS FOR THE GARRISON DIVERSION UNIT

Players	Options
U.S. support	1. Proceed to complete full GDU 2. Proceed to complete GDU modified to reduce Canadian impacts 3. Proceed to complete GDU modified to appease U.S. environmentalists
U.S. opposition	1. Legal action based on environmental legislation
Canadian opposition	1. Legal action based on the Boundary Treaty of 1909
International Joint Commission (IJC)	1. Support completion of full GDU 2. Support completion of GDU modified to reduce Canadian impacts 3. Support suspension of the GDU except for the Lonetree Reservoir 4. Support complete suspension of the GDU

Source: Hipel and Fraser, 1980.

a player to support both at the same time. In Fang and Hipel (1988), two versions of the Garrison Diversion Unit were under consideration. It would have been illogical for a player to support both versions simultaneously. Other outcomes would be irrational from the perspective of a given player. For instance, a player would not rationally support two contradictory options. Other outcomes may also be logically infeasible given the situation. These must be carefully considered by the modeler before their removal to avoid premature deletion of potential solutions to the conflict.

Preference Assessment

Through the screening process, the number of outcomes can be dramatically reduced. Remaining outcomes must be ranked in preference arrays or "vectors" according to the preferences of each player. Preference vectors can be generated by the modeler, who at this point in the process should be quite familiar with the preferences of the players. This requires careful consideration of each outcome by the modeler. However, the preferences are rarely subtle distinctions in valuation. Rather, the choices are typically clear if the model is well structured with distinct options.

Stability Analysis

The outcomes are then subjected to a stability analysis. If any player can benefit (i.e., achieve a higher preference value) with no loss (i.e., diminishing of the preference) of another player, the original outcome is considered "unstable." This is conducted through a methodical search for potential "unilateral improvements." In economics, this is similar to a move toward a Pareto optimum as found in an Edgeworth-Boley Box with the distinction that there are often more than two players. In some cases, there can also be inescapable improvement, when an option for one player can lead to a preferred solution regardless of the actions of other players. Outcomes with no potential for unilateral improvement for a particular player are considered "rational" for that party.

Strategy Selection

The outcomes that survive the screening process are also analyzed to identify equilibria. An equilibrium is defined when it is rational for all players. The stability analysis can further reduce the number of outcomes, often leaving just a few potential equilibrium solutions. Since conflict analysis is static, the analysis would have to be repeated if the situation changed in any substantial way. This is illustrated by the iterative loops shown in Figure IV-1.

Table IV-5 illustrates the complexity and power of conflict analysis. It is included to present the results of the analysis rather than explain the mechanics of the process. From the many potential combinations of players and options in Table IV-3, 22 possible outcomes of the

TABLE IV-5

METAGAME ANALYSIS OF REDUCED SET OF OUTCOMES FOR THE GARRISON DIVERSION UNIT

Outcomes Examined

U.S. support																						
Full GDU1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Reduced Canadian impacts	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Appease environmentalists	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
U.S. opposition																						
Legal, environmental	1	1	1	1	1	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0
Canadian opposition																						
Legal, treaty	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0	1	0	1	0	1	1
IJC																						
Support full	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Support reduced	0	0	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	0	0	0
Support Lonetree	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0
Support suspension	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
Stability																						
U.S. support	*r*	*r*	*i*	*i*	*i*	*i*	*i*	*r*	*r*	*r*	*r*	*r*	*i*	*r*	*i*	*i*	*i*	*i*	*i*	*r*	*r*	*r*

U.S. opposition	*r*	*r*	*r*	*r*	*r*	*i*	*r*	*i*	*r*	*i*	*r*	*i*	*r*	*i*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*
Canadian opposition	*r*	*i*	*r*	*r*	*r*	*i*	*i*	*r*	*r*	*i*	*i*	*r*	*r*	*r*	*r*	*r*	*i*	*i*	*i*	*i*	*r*	*r*
IJC	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*	*r*
Overall	*E*	*u*	*u*	*u*	*u*	*u*	*u*	*u*	*E*	*u*	*u*	*u*	*u*	*u*	*u*	*u*	*u*	*u*	*u*	*u*	*E*	*E*

Notation: *r* = rational, *i* = inescapable improvement, *u* = unstable for some player, and *E* = equilibrium.

Adapted from: Hipel and Fraser, 1980

Garrison Diversion Unit conflict survived the initial screening process (step 4 of Figure IV-1). The stability analyses of these outcomes are illustrated in Table IV-4. Of these 22 outcomes, four were considered equilibrium outcomes (denoted "*E*") and therefore possible solutions to the conflict (see bottom row). The other 18 outcomes were considered unstable (denoted "*u*").

Alternative Methodologies

The basic structure of conflict analysis contains many variations. Some are similar to the methodology described above (Lussier et al., 1989). Variations include hypergame, metagame, and graph model frameworks. Hypergame analysis structures the game by recognizing that there may be misperceptions between the players (Bennett, 1977, 1980; Hipel and Dagnino, 1988; Okada et al., 1985). The metagame is a variation designed to focus on the stability of outcomes (Hipel and Fraser, 1980). The graph form of the conflict model refines the insight into the strategic behavior of the players by focusing on outcomes rather than decisions as the basic analytic parameter (Fang et al., 1988).

The results of conflict analysis research have been favorable with respect to the ability of the modeling to generate feasible outcomes. However, since most of the case studies involve *ex post* analyses, the ability to forecast outcomes of an ongoing conflict is unclear. While results of the annotated articles (Appendix B) indicate favorable performance of the different variations of conflict analysis, there is little indication of the amount of effort required to structure the conflict, model the situation, and conduct the analysis.

WATER RESOURCES AND ENVIRONMENTAL APPLICATIONS

Water resources conflicts represent a large portion of conflict analysis case studies. This may stem from the fact that many leading conflict analysis researchers (e.g. Hipel and his colleagues) have a particular interest in water resources issues. Other explanations may be that water resources conflicts make prime candidates for case studies, since they typically are characterized by: (1) natural resource allocations with large impacts on society; (2) stalemates (i.e. none of the competing interests able to dominate the others); (3) well defined interests, (4) significant commitments of resources to resolve the conflict; (5) misperceptions among the parties to the conflict, and 6) long time periods required for water resources planning.

The applications of conflict analysis to water resources disputes span a diversity of scales and contexts. In the case studies of the Garrison Diversion Unit, the project had international effects

(Fang and Hipel, 1988; Hipel and Fraser, 1980). At the other end of the spectrum lies a minor subdivision that threatens water quality at a municipal water supply intake (Lussier et al., 1989). The case study of the Lake Biwa water allocation conflict in Japan illustrated the international potential of conflict analysis.

The various conflict analysis methodologies seem to be effective in water resources applications. The solutions identified through the analysis are generally in agreement with those actually achieved through negotiations. There are indications that in many cases conflict analysis could have complemented the negotiations by clarifying the situation and reducing misperceptions. In the case of Lake Biwa (Japan), the *expost* analysis generated the actual solution to the conflict, one that would have appeared unlikely to the parties at that time, since the parties misunderstood each others' positions and options (Okada et al., 1985).

The successful application of conflict analysis to past water resources conflicts indicates great promise for conflict analysis computer software. With the actual analysis streamlined, the bulk of the required effort would be to identify and structure the conflict. If results could be generated quickly, these methodologies could be used to clarify misperceptions and identify potential solutions.

The number of conflict analysis applications for environmental conflicts are relatively few. This could be explained by the interests of the conflict analysis researchers, the types of issues or groups involved, or the temporal or spatial scales of the conflicts. One interesting application of conflict analysis for an environmental issue concerns enforcement of environmental laws and regulations (Kilgour et al., 1992). This analysis identified the value of game theory models to policy making by describing patterns of behavior and the links between behavior and the structure of the situation. The authors concluded that these methods would be inappropriate for addressing specific policy questions.

POTENTIAL UTILITY IN CORPS ENVIRONMENTAL PROGRAMS

The aim of conflict analysis has been to develop usable methodologies that can be applied to ongoing conflicts. Conflict analysis has great potential for aiding the resolution of disputes, particularly stalemates. Specifically, conflict analysis could promote conflict resolution by: (1) illuminating the potential results of pursuing different strategies to the players; (2) identifying solutions that might be amenable to all parties; and (3) clarifying misperceptions of the interests and positions of the different parties. Conflict analysis should not be thought of as a decision-making methodology. Instead, it is a tool whose outputs could generate information inputs to the conflict resolution process, which might be negotiation, mediation, or resolution with some other group process.

Conflict analysis researchers are hopeful that the ongoing evolution of the techniques and development of real-time conflict analysis software will result in commonplace application of these methodologies. The quantitative basis of conflict analysis makes it a good candidate for standardized computer software that could be widely disseminated.

The *DecisionMaker* software illustrates the promise of a conflict analysis program (Fraser and Hipel, 1988). This software, which allows for up to 64 players, can accommodate a total of 64 options. Once the conflict has been identified, structured, and modeled, this software can process the above sequence of analytical activities in seconds. The model has a user-friendly interface that should increase its utility to conflict resolution processes.

Despite the promise of conflict analysis software, some aspects of conflict analysis limit its potential utility. First, significant resources may be required to research, structure, and model some conflicts. Second, these efforts can be time consuming, limiting the potential to develop information for ongoing conflicts. Third, the parties to the conflict may not be willing to reveal their options and/or preferences. Fourth, the static analysis requires a new run whenever the nature of the conflict changes. This would require either more analysis by the modeler or another round of preference elicitation from the players. Finally, the analytical assumptions about rational behavior and the ability to identify all options open to a player may be problematic in real world applications.

Conflict analysis methodologies appear promising for applications to water resources conflicts. However, these techniques have had few applications to ongoing conflicts and extensive field testing will be required to determine their potential for water resources planning and management. Some large-scale environmental conflicts such as the Kissimmee River restoration in Florida and the Pacific Northwest salmon restoration may also be potential candidates for conflict analysis application, since they too have stalemated situations, well defined interests, and the availability of significant resources available for conflict resolution. In contrast, the potential for application of these techniques in small-scale Corps environmental programs may be much less promising. Small environmental projects, such as Section 1135 projects, differ from traditional civil works projects in that they generally are: (1) less expensive; (2) more informal with respect to plan formulation (3) conducted in a much shorter time period; and (4) characterized by a less contentious atmosphere. These distinctions run counter to the conditions of need and applicability which might be optimal for application of conflict analysis. Conflict analysis may be most appropriate as training tools for Corps planners to help them understand the structures of conflicts and possible solutions based upon rational behavior. However, if the conflict analysis software are sufficiently refined and environmental conflicts can be easily structured, these techniques could have great utility in resolving environmental conflicts by identifying potential solutions, illustrating the consequences of alternative actions, and clarifying misperceptions in support of the group decision-making process. These processes are discussed in the following chapter.

V. GROUP PROCESSES

As this research progressed, the potential significance of group processes for Corps environmental planning became apparent. Environmental projects typically have multiple stakeholders that place quite different values on environmental resources and their outputs. The Corps is very familiar with group processes. Negotiation with local project sponsors, mediation of environmental conflicts, and public involvement programs are three areas of extensive Corps experience with group processes. This chapter is concerned with harnessing this experience with alternative group processes to promote efficient and effective planning of Corps environmental projects. The first step in this linkage is to recognize the dual roles that group processes can play in the Corps environmental planning.

DUAL ROLE

The preceding chapters of this report have identified multiobjective analysis techniques as predictive tools for evaluating alternative resource allocations (i.e., trade-offs). Game theory offers a different utility in trade-off analysis by simulating the structures of resource conflicts and identifying potential solutions (i.e., trade-offs with competing interests) to the conflict. Both of these families of techniques can be viewed as generating information inputs to the decision-making process.

As will be evident in this chapter, group processes differ from these two families of techniques in that they can also <u>generate information for decision-making</u> or <u>make the decisions</u> about resource allocations and trade-offs therein. The generation of information may require elicitation of values and preferences from stakeholders and/or actual construction of those stakeholder preferences using factual data about the resource and/or the values of other stakeholders. Recognizing the expansive utility of group processes, the next section provides an overview of its foundations.

OVERVIEW OF GROUP PROCESSES

From a historical perspective, decision-making in groups has only recently been the focus of formal research by professionals in the fields of psychology, sociology, and communications research. Group members share a common problem they are attempting to solve or a common goal they are trying to achieve. These members attempt to generate options to determine an optimal solution on which they can come to consensus.

Reaching Consensus

Consensus is the support of an option by a group. It is a key component in the completion of a planning effort among multiple stakeholders. Consensus does not necessarily imply that all group members support the option. Instead, it is the willingness of all stakeholders to abide by the decision and not impede its implementation. Moscovici and Doise (1994) indicated that stakeholder participation is the predominant concern in getting consensus. Stakeholders involved in a problem-solving group perceive their time and other resources used in the process as an investment. Their investment gives a sense of shared ownership in the process, making it more likely that all stakeholders will work toward a solution that is acceptable to all.

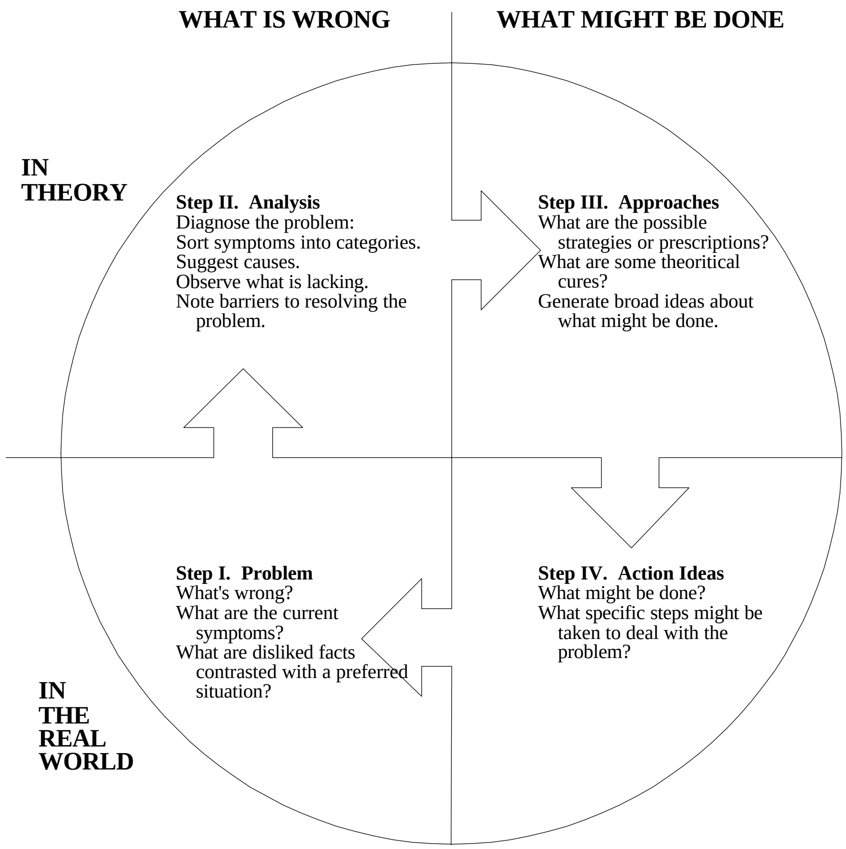
There are many "human-related" nuances (see discussion below) that affect efficient execution of group processes. Guidelines for managing or overcoming these difficulties have received a significant amount of attention in the literature. For example, Susskind and Weinstein (1980) proposed using nine steps:

(1) Identifying the parties that have a stake in the outcome of the dispute;
(2) Ensuring that groups or interests that have a stake in the outcome are appropriately represented;
(3) Narrowing the agenda and confronting fundamentally different values and assumptions;
(4) Generating a sufficient number of alternatives or options;
(5) Agreeing on the boundaries and time horizon for analysis;
(6) Weighting, scaling, and amalgamating judgments about costs and benefits;
(7) Determining fair compensatory actions;
(8) Implementing the bargains that are made; and
(9) Holding the parties to their commitments.

There are many variations of these nine steps, with the basic formula requiring input from all stakeholders, group generation of evaluation criterion, and consistent following of the rules. Probably the biggest challenge faced in the group process is that stakeholders typically enter the process with their own ideas about the topic at hand as well as perceptions of the expectations of others at the table.

Generating Options

Stakeholders involved in generating alternatives often have difficulty in exploring all possible options (Fisher, Ury, and Patten, 1991). There is often a tendency for stakeholders to create alternatives around a proposed solution-type that was recommended when the problem was identified. It also is easy to create alternatives based on local conditions and not anticipate the larger impacts in a watershed. Broadening options requires moving from the specific situation to a more general one. Figure V-1 presents a model for exploring more options. This sequence of activities could apply



(from Fisher, Ury, and Patton 1991)

FIGURE V-1

FOUR BASIC STEPS IN OPTION GENERATION

to an individual, but it is directed toward group applications.

In Step I, members identify the current situation and what makes it undesirable. Group members use Step II to identify the source of the problem. Possible causes of the problem are identified as potential barriers to its solution. Step III examines what might be done, theoretically, to solve the problem encountered. Step IV is the formulation of feasible options for resolving the problem.

The differences between practical (i.e., real world) and theoretical conditions are important avenues to option generation. Steps II and III are important in generating alternatives because, by moving to a general perspective, stakeholders are not limited to the perceived constraints the problem imposes. They are allowed to hypothesize about possible causes and solutions. Hypothetical recommendations may lead to more discussion and an eventual solution. The cyclical nature of the figure illustrates that actions determined in Step IV can undergo the same process as the problem.

Identifying the Human Element in the Group Process

Numerous studies have been conducted pertaining to human behavior in social situations. There are three important behavioral considerations for group processes: (1) the perceived positions of other participants; (2) participant expectations of the process; and (3) participant contributions to the process. These considerations are critical in the selection of a group process that is appropriate to a given situation.

Perceptions

Perceptions are used by group members to determine the positions of other participants. Fisher, Ury, and Patton (1991) advocated focusing on issues and interests, not positions or people, in a decision-making forum. With such a focus, decision-making becomes more objective, since the need for participants to support or reject an idea based on one individual's position regarding an issue is reduced. The potential for misperceptions to negatively impact decision-making is also reduced.

Plous (1993) described four positions an individual may take for interpreting limited perceptions of something or someone based on past experiences: dominance, compromise, disruption, and recognition. Dominance is the denial of what is actually seen. A judgement is made using a dominant criteria based on past experiences. Compromise notes an incongruity with past experiences in the perception, but change is not accurately recognized. Disruption identifies an incongruity, yet no judgement can be made. Finally, recognition is a correct perception and judgement of what is seen. Most individuals use dominance in evaluating limited perceptions of a situation.

Expectations

Members of a decision-making group have certain expectations of what will occur in the process. Some participants have negative perceptions of working in groups and experience what Sorensen (1981) termed "grouphate." This hate has been correlated to poor or nonexistent training in communication skills and can result from fears of ineffectiveness, lack of recognition, or perceived domination by others in the group.

Members also bring positive perceptions to group processes. Some recognize the value of working with others, utilizing what Moore (1987) termed "pooled intelligence." These members perceive the group process as something useful and feel their contributions will produce something of worth.

Roles

There are a number of definitions for the roles a group member can play. According to Goodall (1990) role types fall into three categories. These categories are: task-oriented roles, maintenance-oriented roles, and self-oriented roles. Task-oriented roles assist in accomplishing objectives, such as clarifying ideas, seeking opinions, and recommending times for voting on an issue. Maintenance-oriented roles preserve harmony in a group, often through support and encouragement of other group members. Self-oriented roles disrupt the progress and harmony of the group, usually through aggressive behavior or refusal to consider the opinions of others. Recognition of roles by participants can allow a group to function more effectively. More specifically, Cragan and Wright (1986) identified a condition called "role rut," in which a group member only assumes one role. This can hinder group efforts, especially if multiple roles are required for a specific group process. Role rut can be reinforced by other group members if they do not encourage an individual to change their behavior.

Classification of Group Structures

The structure of the group process is very dependant upon the situation (e.g., number of people, level of curiosity surrounding the situation, expected output from the process). This section presents four configurations of group processes that the Corps will likely face in environmental plan formulation. Negotiation, mediation, and public involvement are discussed below.

Negotiation

In situations where members are able to work together, a negotiation framework is created. There is a great deal of research on business negotiations (e.g., contracts and labor relations). Negotiation has also been applied to public policy formulation (see PMC Associates 1981) and, increasingly, environmental affairs (see Gorczynski, 1991). Feather and Capan (1995) discuss an example of negotiation in the North Central Division of the Corps. The Upper Mississippi River System Environmental Management Program unites the Corps with the U.S. Fish and Wildlife Service and the natural resource agencies of Illinois, Iowa, Minnesota, Missouri, and Wisconsin in selecting environmental project sites. Each state agency may favor particular sites for selection, but they are nonetheless willing to explore options that all the group members will support.

People are involved in negotiation processes almost daily. Practitioners of formal negotiation consider it an art to be mastered. According to Fisher, Ury, and Patton (1991), daily negotiations are disorganized. This forces stakeholders to take an adversarial stance ("position") as they attempt to get what they want. Groups involved may harbor some ill will toward each other, but they are willing to meet in an attempt to resolve the situation.

Generally, there are two perspectives regarding the concept of positioning in negotiation. The first perspective is that a stakeholder may enter negotiations in an attempt to persuade other participants to pursue a certain course of action by taking a particular position on an issue. Stakeholders may become entrenched and unwilling to yield their position. The second perspective is that stakeholders may enter negotiations to determine the appropriate solution regardless of initial preferences. Both perspectives advocate conducting initial research on the issues and the participants involved in a negotiation. This also suggests that a strategy should be developed from results of the research. Each of these perspectives prescribes techniques for achieving their respective goals.

Establishing positions provides stakeholders with data from which they can begin to bargain. However, theorists opposed to positioning indicate it is inefficient and damaging to relationships, and produces agreements that lack consensus (Fisher, Ury, and Patton 1991). It does not allow stakeholders to examine other alternatives for the situation which may allow for a resolution in which no one loses. Gorczynski (1991) asserts that analysis, reason, and communication are always preferable to extreme positions and intransigence.

Stakeholders entering negotiations usually have a Best Alternative to a Negotiated Agreement (BATNA). A BATNA is what can be achieved by a party if a successful agreement cannot be reached. It prevents parties from accepting agreements that should be rejected and helps to make the most of one's assets to satisfy interests.

One common theme in the literature is that stakeholders in the negotiation process need to have the opportunity to speak and be heard. This may create extensive conflict among participants. Moscovici and Doise (1994) indicated that when conflict develops while seeking consensus, it should not be suppressed. Conflict provides groups with opportunities for a more thorough examination of issues, improving the value of any consensus that is reached. Additionally, when a negotiation process allows participation and development of alternatives by stakeholders, it is more likely to be accepted and implemented, because participants have a sense of shared ownership of the solution.

A number of computer software packages are available to assist in negotiations. These programs can be used to prepare for negotiation or to actually facilitate real-time negotiations. One software package of note is ICANS (Thiessen and Loucks, 1992). ICANS collects information for determining a common base from stakeholders' BATNAs, and defines regions of mutual gain and possible alternatives.

Mediation

Sometimes people or agencies seeking a solution have difficulty in finding common ground. There might be animosity between involved parties, inadequate resources, or inabilities among the group members to resolve an issue. These instances can benefit from mediation, where a neutral third party is brought in to facilitate discussion and help participants come to agreement. An example of a need for a third party would be the natural resources agencies of two different states that have different objectives for an environmental restoration project that occur on the shared border. Another agency, such as the Corps or the U.S. Fish and Wildlife Service, could assist the state agencies in developing a solution that is beneficial to all.

The mediator's job is to open lines of communication between participants to move them beyond their present gridlock. A mediator does not make decisions for participants at any point in the process. Mediation is referred to as alternative dispute resolution because it provides a more efficient approach than litigation, because it requires less time and resources. Mediation results are often received more favorably because parties involved in the dispute have a sense of ownership because they created the solution.

Attitudes and perceptions brought into mediation by the participants dramatically influence the success of the process. It is important that parties involved are willing to consider opportunities for compromise. In some circumstances, the mediator may have a particular motivation for participation in a dispute. Kolb and Kressel (1994) showed two different goals mediators may have for the process. One is simply to open lines of communication. The other is to develop some form of solution. Problems could result in pursuing one of the goals explicitly because a resolution may not be reached, or forcing the parties toward a resolution may result in a poor decision.

Although the general perception of mediation is two parties with a mediator, Bingham (1986) indicated that most experts consider 15 parties to be the limit for involvement in a mediation. An increase in number of participants beyond this threshold was seen as making the task more difficult for the mediator.

Literature examined in this study indicates that there is significant use of mediation in environmental disputes. In 1986, 161 environmental mediations conducted since the early 1970s were examined (Bingham 1986). It was noted that the number of mediation cases had increased every year up to the time of publication. Rabe (1988) attributes the growth of environmental mediation to the reluctance of Congress to clearly define environmental policy and the resulting costs for those that pursue litigation.

The Corps has a history of involvement in mediation, both as stakeholder and as a mediator. The history is highlighted in a series of case studies compiled under the Alternative Dispute Resolution program (see multiple references under Susskind et al. 1989). One case study, Moore (1991), describes the initiative of a District Engineer who encouraged parties involved in a hydropower dispute to pursue mediation as an option to seeking a resolution. Previous attempts by a coordination committee composed of the stakeholders were unsuccessful. Five parties were involved in the process. After four sessions, a resolution was achieved. Delli Priscoli (1988) illustrated two examples of the Corps performing the role of mediator in disputes related to awarding Section 404 general permits. The mediations were structured to open lines of communication, identify all major stakeholders, and examine issues of stakeholder interest. The Corps experienced some initial difficulty in establishing its neutrality in these situations. Once established, however, the Corps maintained the momentum of the mediations and achieved successful resolutions in both cases.

Public Involvement

Public Involvement is a common process for gathering information during planning efforts or for developing consensus in decision-making. Within the last 15 years, public involvement has been modified and increased because of new trends in decision-making. Creighton et al. (1983) assembled a number of works that highlight the Corps public involvement experience in water resources planning. Five types of public involvement were identified: information-giving, information-receiving, interaction, consensus-forming, and summarizing. Points of consideration for facilitating public involvement were the anticipated audience, political climate, room arrangements, and the leadership style to be used.

Delli Priscoli (1989) indicated that a new trend for public involvement was occurring for the development of water resources projects. Alternatives are being created to meet stakeholder values, instead of presenting alternatives that have some inherent values. This shift in emphasis is a significant improvement to the overall planning process.

If planning efforts require extensive input from the public, citizen advisory groups may be formed. Landre and Knuth (1993) cited the successes of citizen advisory groups for water resources planning in the Great Lakes region. These groups provided consensus-building services in developing regional action plans for areas degraded by some form of pollution. Surveys of participants indicated there were a number of positive effects related to the advisory groups, but many did not perceive extensive support for their recommended planning outcomes.

Group Techniques

Throughout this report, references have been made to opportunities for gathering or creating new information that would be useful in conducting trade-off analyses for multiobjective planning. Gregory and Keeney (1994) have shown the positive results associated with open lines of communication and cooperation among stakeholders to provide opportunities to reach consensus. It has also been recognized that results generated by a group of people are superior to those generated separately by the same members (Moore 1987).

According to Deason and White (1984), four important steps for developing a group process were: identifying of problem and situation characteristics, selecting group members, selecting a technique, and planning the group interaction. Identification of the issue to be examined directs the completion of the other three steps. The approach for gathering information will be different from one that evaluates alternatives, and it may require different team members. The approach will also vary based on the need for quantitative or qualitative information. It should be recognized that group processes can be structures to generate both quantitative and qualitative information. Groups may be required to brainstorm a number of possible outcomes for a given alternative. After outcomes have been generated, participants could assign numeric weights for ranking them. Ranking is commonly used in multiattribute utility analysis and multiple-criteria analysis.

Many techniques are available for use in generating and evaluating information. Specific techniques identified in the literature were brainstorming, creative confrontation, delphi, ideawriting, interaction, interpretive structural modeling, and nominal group technique. These seven techniques are among the most frequently used in group processes and are often known by various pseudonyms. Table V-1 provides a brief description of these processes and indicates their primary purposes.

Brainstorming is perhaps the most commonly incorporated technique used to generate ideas. Variations on brainstorming may involve the use of an additional stimulus from which to start, whether drawing upon elements in nature or working with a "magical creature" using "guided fantasy" (Albrecht 1980) as inspiration. After ideas are generated, they must be clarified and ranked. Interpretive structural modeling provides a suitable framework for this purpose. Nominal group technique, which combines brainstorming with a ranking procedure, is a popular approach for incorporating all of these activities.

Using computer networks or mail service for executing the Delphi technique is useful for gathering input on an issue from experts in a number of different places. Requests for information are made from a central location. Participants in the process record their ideas and send them to the next respondent. Although it is time- and resource-intensive, this approach has an advantage in that group members are not influenced by dominant individuals and thus allows for a more thorough examination of an issue.

Criteria for selection of a specific technique vary. Moore (1987) developed categories in the following list: functions required from the process, problems the technique can overcome, the number of people it accommodates, allowance for further examination and refinement, and ease of implementation. All of these are important, but special consideration should be given to the problems a technique can overcome.

Some problems that a group may encounter include hierarchical imperative, territorial conflicts, interpersonal conflicts, "groupthink," and battered bureaucrat syndrome (Goodall 1985). Primarily, these problems can be attributed to positioning and personal needs. Groupthink and battered bureaucrat syndrome, however, both deserve additional consideration. Janis (1972) introduced the concept of "groupthink" to represent how groups will choose to be

TABLE V-1

SUMMARY OF GROUP TECHNIQUES

Technique	Primary Purpose	Description
Brainstorming	Idea Generation	Participants create information from the consideration of a problem or topic. The consideration triggers responses that are shared with the group.
Creative Confrontation	Idea Generation	Use of abstract analogies to induce solution ideas.
Delphi	Idea Improvement	A participant responds to a questionnaire and sends it to the next member for their comment. Used when participants are unable to meet.
Ideawriting	Idea Improvement	Similar to Delphi, but all members are present.
Interaction	Idea Generation/ Improvement/ Evaluation	Unstructured face-to-face interaction.
Interpretive Structural Modeling	Information Evaluation	Ranking technique for establishing a hierarchy among recommendations.
Nominal Group Technique	Idea Generation/ Information Evaluation	Combines brainstorming approach with a voting process to rank generated information.

silent about an issue in an effort to avoid conflict. Battered bureaucrat syndrome denotes a group member who has lost interest in participation due to excessive involvement or a perceived lack of value of the process.

POTENTIAL UTILITY TO CORPS ENVIRONMENTAL PLANNING

Planning Corps environmental projects typically includes the input of several decision-makers. Through a series of case studies of Corps environmental projects, Feather and Capan (1995) made several observations about the importance of cooperation of stakeholders in environmental projects. First, processing stakeholder inputs in an efficient manner is critical to efficient plan formulation. For example, participants in the Fern Ridge Lake (Oregon) waterfowl impoundment restoration, a Section 1135 project, concluded that early and close coordination between the project stakeholders was critical in efficient completion of the project. Second, issues surrounding environmental projects can be highly localized. The perspectives of local decision-makers and public figures must be shared to formulate both a technically sound and socially acceptable solution. An example of effective cooperation between multiple stakeholders with conflicting interests is the ongoing Snake River fish and wildlife restoration project in Jackson Hole, Wyoming (see Feather and Capan, 1995).

Management of stakeholder input through group processes is highlighted in this chapter. Enterprising use of group processes to support plan formulation will very likely result in efficiencies in the process. In fact, of the techniques and processes examined in the present study, group processes can be used in almost every plan formulation situation the Corps will face. It is through a group process that final decisions will be made on most environmental projects, and be supported by varying types of analytical aids and data. In Appendix A, Dr. Leonard Shabman identifies "shared vision modeling" as a particularly promising avenue to combine quantitative trade-off modeling with a group process of project stakeholders. The Corps developed shared vision models as part of the National Study of Water Management Under Drought. These models are computer simulations of water systems that are built, reviewed, and tested collaboratively with all stakeholders. The models support group process that (1) elicit and construct stakeholder values and (2) collectively balance competing objectives in resource allocation decision-making.

The game theory and multiple-objective techniques described in earlier chapters are inputs considered by stakeholders in making final project plans. Several group techniques that appear to be especially appropriate for Corps negotiation, mediation, and public involvement activities are discussed below.

Development of an appropriate negotiation effort requires significant amounts of input and consideration for generating a BATNA (Best Alternative To a Negotiated Agreement) by all participants. Each stakeholder's BATNA should be used to explore other options through the use of group techniques. It is important that stakeholders do not use their BATNA as a position on which to stand, but instead as a means for exploring alternatives in which all can benefit. When involved in negotiations, Corps personnel trained in pursuing positionless negotiations can facilitate communication among the participants and direct others away from a fixed position.

The Corps successes in a mediator role suggest greater opportunities for improving trade-off efforts in environmental and water resources planning. Mediation can be used, not only to reach consensus on difficult issues, but also to better understand the positions of stakeholders in a project. Another opportunity for enhancing the potential of mediation in trade-off analysis could be manifested by training personnel.

The Corps has extensive experience with public involvement. Citizen advisory groups facilitate and improve planning by raising Corps awareness of the public's perceived needs. Once these public needs are recognized, planners can develop alternatives to meet the needs. Such public involvement reduces public opposition to Corps plans.

Positioning, as illustrated previously, reduces the likelihood of achieving a decision where all stakeholders can benefit. Some group techniques are designed to aid in overcoming these positioning problems. In situations where particular difficulty is encountered by a group in generating information, the use of techniques that provide mental stimulation would be especially helpful. The compilation of these techniques would provide Corps planners and decision-makers with more opportunities for improving trade-off opportunities.

Nominal group techniques are used frequently to generate and evaluate ideas and alternatives. These techniques provide a standard method for idea generation and evaluation. An outside party could facilitate this process to allow full participation of all stakeholders as well as reduced potential for bias. Furthermore, some stakeholders may not fully participate if they perceive that another stakeholder is directing this process.

VI. CONCLUSIONS AND RECOMMENDATIONS

LITERATURE REVIEW SYNTHESIS

This review of the literature on trade-off analysis has focused on water resources and environmental applications. The complex nature of environmental improvements requires balancing many interests that are typically involved in project planning. The review of the trade-off literature has been necessary and appropriate to gain perspectives for inclusion in the Evaluation Framework work unit of the EEIRP. This study was initiated as a three-pronged effort to investigate the literature on multiobjective planning, trade-off analysis, and negotiation-based techniques. The initial research task was subsequently revised to address multiobjective analysis, game theory, and group processes. The distinctions between these subjects quickly blurred within the broad subject of trade-off analysis.

Trade-off analysis spans a wide variety of techniques and contexts. In general, it is bounded by three different parameters: (1) the number of decision-makers; (2) the number of objectives; and (3) the level of empiricism of the techniques. Each of these parameters is characterized by significant variation. As indicated in Table VI-1, the techniques that comprise trade-off analysis are distinguished by their specific combination of these parameters. As outlined in previous chapters, each of these subjects comprises a family of techniques. In general, multiobjective analysis occupies the more quantitative end of the trade-off spectrum of techniques, group processes generally reside at the qualitative end of the spectrum, and game theory lies between them.

TABLE VI-1

SUBJECT AREAS WITHIN TRADE-OFF ANALYSIS

Subject	Number of Decision-Makers	Number of Objectives	Level of Empiricism
Operations Research	1	1	High
Multiobjective Planning	1	>1	Low-High
Game Theory	>1	>1	High
Group Processes	>1	≥1	Low-High

The Corps has always been very diligent in planning and evaluating different engineering approaches to water resource problems and in designing and operating civil works projects to meet multiple objectives. The Corps openness to other perspectives should be continued with its planning partners in environmental projects. This openness could be enhanced by anticipating the perspectives, interests, and actions of stakeholders in these projects.

Although the number of decision-makers is a critical parameter for trade-off analyses, very few water resources or environmental decisions are currently made by one individual or organization. There are simply too many parties and interests involved with these resources. Even in the traditional application of multiobjective analysis to reservoir operations, decisions are routinely coordinated with other parties. As indicated in Chapter I, there are indications inside and outside the Corps that its decision-making will be increasingly inclusive of external parties. This spirit of cooperation provides an overarching theme for this research into the accommodation of competing interests in Corps environmental projects and the development and dissemination of trade-off analysis techniques throughout the Corps. The implications of more inclusive decision-making for water and environmental resources are that group processes will play a more prominent role.

The potential prominence of group processes in water and environmental resource planning and management does not diminish the utility of multiobjective planning or game theory techniques. These methodologies can play very important roles in decision-making by providing information to the decision-makers. However, they must be considered as tools supporting the decision-making process rather than generating decisions themselves.

Multiobjective planning can provide direct input of information to the decision-making process by identifying the optimal allocation of resources (i.e., trade-offs) to meet the planning or management objectives. As indicated in Table VI-1, these information feeds can be developed through quantitative or qualitative processes.

Game theory can buttress resource management decision-making through conflict analysis. Conflict analysis can support the trade-off of competing objectives in a water or environmental resource conflict by illustrating to the parties the consequences of their actions, clarifying misperceptions about the interests and options of other parties, and identifying potential solutions to the conflict that may not seem accessible due to misperceptions between the parties.

The Corps had significant experience with many of these trade-off analysis techniques through its traditional civil works program. Chapter III describes some of the Corps experience with multiobjective water resources planning. As outlined in Chapter IV, the Corps exposure to game theory may be less extensive, but water resources conflicts have been a prominent avenue for development of game theoretic conflict analysis techniques. In addition, as described in Chapter V, the Corps has many years of experience with group processes, particularly public involvement.

Finally, in Appendix A the Corps ongoing development of "shared vision modeling" shows particular promise as a means of integrating quantitative and qualitative trade-off methodologies.

Many trade-off analysis techniques are clearly relevant to the Corps traditional civil works program. While Corps environmental restoration efforts are typically associated with its water resources projects, the civil works and environmental projects (particularly small-scale projects) have important distinctions regarding the scale, cost, planning timeframe, and interests involved. To further explore the potential utility of these trade-off techniques for Corps environmental projects, the following implications for the EEIRP's Evaluation Framework work unit are identified below. Following these discussions are Appendices A, B, C, and D. Appendix A presents the discussion of "shared vision modeling" by Dr. Leonard Shabman. Appendix B contains the annotations of 50 references representing the different subject areas within trade-off analysis. These are organized by subject area. Appendix C presents the results of the literature search with the over 350 references organized by subject area. Finally, Appendix D is an alphabetical listing (by author) of all the references identified through this literature search.

IMPLICATIONS FOR ENVIRONMENTAL EVALUATION FRAMEWORK

The different trade-off analysis techniques could play very important and specific roles in Corps environmental planning. Toward this end, these techniques could greatly increase the effectiveness of the environmental evaluation framework by direct applications to the Corps traditional six-step plan formulation process and by their influence on the underlying issues within this framework. As specified in the *Principles and Guidelines*, the six steps of the Corps planning are: (1) Identify problems and opportunities; (2) Inventory, forecast, and analysis of conditions within study area relevant to identified problems and opportunities; (3) Formulation of plans; (4) Evaluation of effects of plans (measurements); (5) Comparison of plans; and 6) Plan selection. These potential effects on the environmental evaluation framework are discussed below.

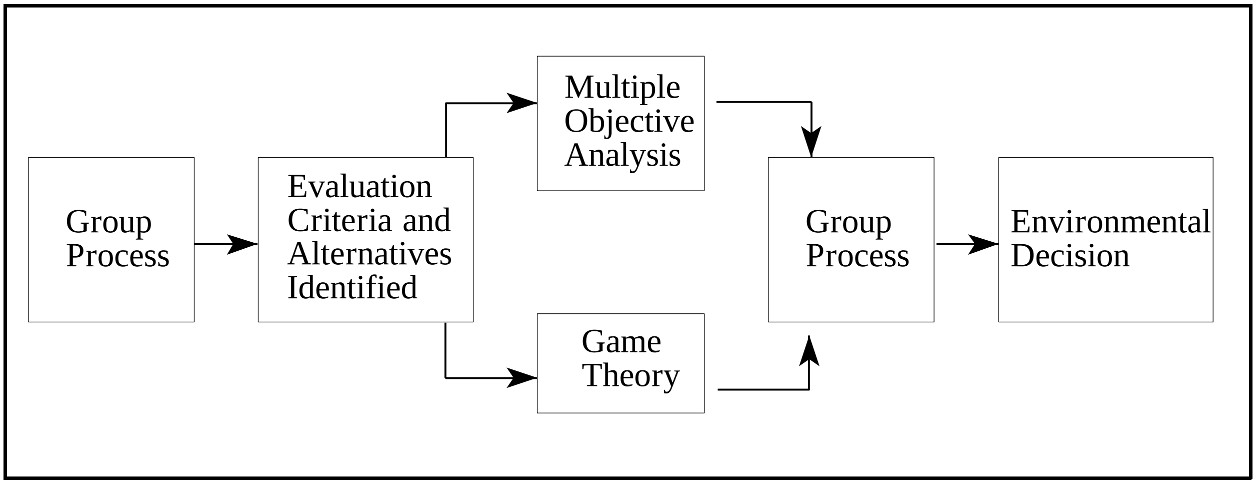


FIGURE VI-1

**USE OF TRADE-OFF ANALYSIS IN
EVALUATION FRAMEWORK FOR CORPS ENVIRONMENTAL PROJECTS**

Trade-Off Analysis in the Planning Process

The optimal combination of the trade-off analysis techniques in Corps environmental planning may be similar to the planning sequence illustrated in Figure VI-1. To help identify the environmental problem or opportunity (typically associated with a Corps civil works project), a group process assembling all of the stakeholders or their representatives could be conducted. This group process, which could be a public meeting and/or a meeting of critical stakeholders, would develop information for the decision-making process. The issues, options, and preferences of each interest could be elicited or constructed if necessary. This information could be used to develop planning objectives, evaluation criteria, and alternative responses to the environmental problem or opportunity. The use of multiobjective analysis and/or conflict analysis techniques could be used to support this process by: (1) evaluating alternative allocations of resources, in the case of multiobjective planning; or (2) identifying possible solutions to competing interests, in the case of conflict analysis. This information should then be carried forward into a group decision-making process that would evaluate alternative plans and come to a consensus for action. This might involve a small group technique to develop a prioritization of alternative actions.

The role of multiobjective analysis in the trade-off analyses of Figure VI-1 could be multifaceted. If a technical optimization of multiple objectives was required for the decision-making process, a "traditional" multiobjective analysis could be performed. However, other less traditional multiattribute analyses could also be conducted. For example, a group process that elicits quantitative preference values from stakeholders could be facilitated. This combination of multiobjective analysis and group processes illustrates the grey area between the different groups of trade-off analysis techniques.

The sequence of activities in Figure VI-1 would allow the Corps to progress from environmental problem identification activities through plan formulation to the decision-making process. However, the sequence of trade-off activities in Figure VI-1 are not suggested as a substitute for traditional six-step planning process. Instead, these trade-off analyses would complement the six steps of traditional Corps planning process. The activities shown are intended to highlight existing and potential roles of trade-off analyses in the planning process. Like the six-step process, each set of activities would have feedbacks to previous activities. These iterative loops are omitted in order to highlight the general flow of information. The components of trade-off analyses within the environmental planning process are outlined below. As discussed in the previous chapter, some group processes are designed to develop information, while others are more appropriate for decision-making.

Site and Portfolio Applications

The site and portfolio questions addressed through the EEIRP (see discussions in Chapter I) are:

1) How can the Corps determine whether the recommended action from a range of alternatives is the most desirable in terms of the environmental objective being addressed?
2) How should the Corps allocate limited resources among many "most desirable" environmental investment decisions?

These are the first of issues underlying the environmental evaluation framework for which this research on trade-off analysis techniques has applications. This literature review has concentrated on application of these techniques to specific sites. This is consistent with the orientation of the trade-off literature and is a necessary prerequisite for portfolio-level analyses. Nevertheless, trade-off analysis of the portfolio level may be applicable if the site evaluation parameters are standardized and well-defined and the objective functions for their optimization are agreed upon by the decision-making body, in this case, the Corps.

Project Scale

The scale of the environmental project is a second critical issue underlying the environmental evaluation framework. This issue encompasses the size of the project, as well as its budget, planning period, and importance relative to other projects. Scale has two major implications with respect to trade-off analyses within the environmental evaluation framework. First, the determination of the appropriate trade-off technique will be dependent on the size of the project. A Section 1135 project, which is small in scale and budget, would not warrant the same level of trade-off analyses as a large environmental project, such as the Kissimmee River restoration. The cost effectiveness of existing software packages for trade-off analyses could make them particularly appropriate for smaller projects. Guidance that assists the planner in identifying the appropriate trade-off technique for a given project could reduce current misunderstandings of field staff about appropriate levels of analysis (see Feather and Capan, forthcoming). Second, budget limitations of even the largest environmental projects suggest that there are limits to trade-off analyses. This reality encourages Corps planners to recognize that these limits may mean that there are no "right" answers to the trade-off questions. Indeed, the trade-off literature leads to the conclusion that unique, "optimal" resource allocations are rarely produced by these techniques (see Figure III-1).

Inputs to Decision-Making

The review of the trade-off literature identified a third underlying issue for the environmental evaluation framework. This issue regards the origin and format of the information inputs to environmental decision making. As revealed through this literature review, information produced by the various trade-off techniques can be objective or subjective, values or facts, and qualitative or quantitative. One important conclusion of this literature review is that subjective and objective information may be equally valuable. Corps planners must endeavor to recognize this fundamental proposition and make optimal use of subjective information.

Corps Role in Trade-Off Processes

A final implication for the environmental evaluation framework derived from this research concerns the various roles of the Corps in trade-off analyses. The Corps currently assumes different roles in the application of various trade-off techniques. For example, in multiobjective analysis such as reservoir operation, the Corps may be the objective analyst and executive decision maker. Conversely, in environmental conflicts, the Corps may be a neutral mediator or a partisan stakeholder.

Finally, in its public involvement programs, the Corps may be in the grey area between stakeholder, neutral party, and executive decision maker. These roles are not necessarily inappropriate to the circumstances. However, explicit recognition of roles in different planning contexts (or different planning activities for a single alternative project) would clarify the roles of Corps planners and ensure that they are appropriately trained and prepared for those different functions.

RECOMMENDATIONS

At the initiation of this research, the focus of the potential applicability of trade-off analyses was on Step 5 in the six-step planning process: evaluation of alternative plans. However, this review of the trade-off analysis literature has determined that these techniques have existing or potential applications throughout all six steps of the planning process. To further explore the potential of this environmental evaluation framework for Corps environmental programs, research to identify and evaluate appropriate tools for different information generating and decision-making contexts will be required. Toward this end, the following specific recommendations for further research under the Evaluation Framework work unit of the EEIRP are made. The first recommendation applies to the evaluation framework and the subsequent recommendations develop the components of this framework which apply to trade-off analyses.

1. Operationalize the Environmental Evaluation Framework. The Corps six-step planning process described in the P&G provides the structure for planning environmental projects. This effort will build upon this structure to develop a draft of the Environmental Evaluation Framework. The draft framework would clarify the roles of trade-off analyses in the planning process and initiate integration of the products of other EEIRP work units into a single operational framework. The framework would consist of a matrix with the six-step planning process on the vertical axis and operational guidance for environmental projects on the horizontal axis. The guidance would consist of required and alternative methodologies for the specific planning activities, as well as the results of EEIRP efforts to date (e.g., trade-off analysis techniques). The needs of reconnaissance and feasibility studies would be distinguished where appropriate, as would the distinctions between large and small environmental projects. The draft evaluation framework would be supported by documentation, including references to appropriate literature (including EEIRP documents) and case studies.

2. Develop and test appropriate small group processes for elicitation of interests, preferences, and options from stakeholders in environmental projects. Different techniques may be required for the information-generating and decision-making roles of group processes in Corps environmental planning. The construction of stakeholder

values may be required in the group processes that are designed to generate information. Multiattribute analyses within group processes may prove particularly appropriate in utilizing and generating quantitative and evaluative information.

3. Investigate *DecisionMaker* and other conflict analysis software to assess its utility in supporting Corps environmental planning. Particular emphasis should be placed on the resources required to understand the environmental conflict and structure the model within the software.

4. Determine through a case study of a Corps environmental project, the effectiveness of the conflict analysis software and/or multiobjective planning processes in providing information to Corps environmental project decision making. One option would be the generation and direct comparison of two analytic techniques via parallel implementation using two representatives of each interest in the case study. An example might be the side-by-side comparison of *DecisionMaker* and a small group multiattribute process.

5. Investigate information transfer alternatives that would provide Corps planners with the basic principles of group processes. This would supply the planner with an appreciation of the techniques and group dynamics. An opportunity to practice/experience this within the context of the training vehicle might prove especially helpful to planners who have limited experience with cooperative decision-making.

APPENDIX A

"SHARED VISION" MODELING
FOR ENVIRONMENTAL PROJECT PLANNING

"SHARED VISION" MODELING FOR ENVIRONMENTAL PROJECT PLANNING

Dr. Leonard Shabman
1901 Meadowview Circle
Blacksburg, VA 24060

INTRODUCTION

> Restoration planning for the USACE still poses the traditional planning question: are the costs of an alternative warranted by the values received? In the USACE tradition this question was answered by relying on calculations made by planners for the budgetary authorities of the agency. The challenge of doing these calculations is now being replaced by the challenge of building agreements on what costs for achieving restoration planning objectives are "acceptable". Such planning for the USACE will demand identifying the "relevant" decision-makers, determining what technical analysis is needed to support decision-making and then communicating the finding of that analysis in a way that is useful for reaching agreements.
> *Shabman in Feather et.al., 1994.*

Shabman (Feather et.al. 1994) argues that elements of the traditional planning model are applicable to environmental project planning. However each of the elements, from defining desired outputs to judging the merits of changes in a watershed, will need to be attuned to the particular concerns of decision-makers and to their understanding of the watershed.[1] Schkade (Feather et.al. 1994) argues that decision-makers construct their preferences for environmental outcomes from the particular choice circumstances they face.

Together these two arguments imply that the environmental project planning process must not be wedded to "experts'" definitions of environmental outputs, to particular measures of costs (e.g., forgone NED) or to standardized decision criteria for trading off between costs and outputs. Instead, the very process of making a decision yields its own measures of outputs and its own criteria for judging the acceptable costs for achieving different output levels. In the end acceptable tradeoffs can be described only after there has been an acceptance by stakeholders of a particular alternative.

[1] "Decision makers" are individuals, agencies or groups who are able to take political or legal action to advance or thwart implementation of a water management alternative. It is also common in the literature to refer to these decision makers as "stakeholders". The terms are used here as synonyms.

A decision support approach for this choice making model has been developed and employed by the U.S. Army Corps of Engineers, in its National Study of Water Management During Drought. The Corps has named the approach the "shared vision model"(SVM).[2]

SHARED VISION MODELING

Implementation of a water resources management alternative requires agreement among multiple decision-makers. Water resources modeling is expected to help in securing that agreement. However, as model building has become more complex and costly, models have become the domain of experts who are expected to develop models independent of decision-makers and then transfer (translate) the model results to those decision-makers.

Physical models are constructed to understand "in miniature" the hydrology of a watershed in order to design structurally adequate dams, channels and levees. Mathematical (computer based) simulation and optimization models can be developed for these same purposes. However, mathematical models are also required to understand matters that escape physical models, such as the effects of alternatives on fish and wildlife populations, on the general economy or on the income position of stakeholder groups.

Mathematical models are necessarily abstractions of the system being modeled and so approximations of some relationships are necessary in model building. The judgment of the modeler is important in deciding what these approximations will be. However, model results may be sensitive to model building judgments, or at least there is the prospect that this will be the case. Therefore, decision-makers must have confidence in the model construction if they are to use model results as a guide to decision-making. When there are multiple decision-makers who must reach agreement on a choice of actions, there must be agreement on the analytical models. Agreement on the models is a forerunner to agreement on an alternative.

In environmental project planning there often is uncertainty about how ecological systems and their components will respond to an alternative. As a result, agreements are often negotiated over "technical" matters such as model design and data bases. These agreements must be established among stakeholders including natural resource agencies of the Federal government and the states, traditional water development interest and environmental groups. The challenge is to have models that best represent technical, ecological and cost conditions (perhaps by peer review), while also securing the confidence of decision-makers.

---

[2]The Corps National Drought Study was conducted by the US Army Corps of Engineers, Institute for Water Resources. The IWR draft reports and extensive interviews with Mr. William Werick of IWR provide much of the basis for the following comments on the SVM approach. See: US Army Corps of Engineer, Institute for Water Resources, National Study of Water Management During Drought: The Report to Congress (DRAFT) IWR Report 94-NDS-12, September 1994; and, Werick, William and William Whipple, Jr. Managing Water for Drought. (DRAFT) IWR Report 94-NDS-8, September 1994.

Consider the example of modeling juvenile anadramous fish mortality as the fish pass down river from their spawning grounds. Mortality may be due to predation, to power houses at the hydro-electric dams or to extended residence time in the pools behind the power dams. How these mortality estimates are made, and how their relative magnitude is represented in a model, can affect the alternatives selected to meet the desired objective of increasing juvenile fish survival. In addition, the cost per fish saved will depend upon cost estimation models.

One way to help reach agreement on complex environmental issues that must be addressed through modeling is to integrate the stakeholders into the model building activity. The development of shared vision models is a way to achieve this result.

> "Shared vision models are *computer simulation models of water systems built, reviewed and tested collaboratively with all stakeholders*. The models represent not only the water infrastructure and operation, but also the most important effects of that system on society and the environment. Shared vision models take advantage of new, user friendly, graphical simulation software to bridge the gap between specialized water models and human decision-making processes. Shared vision models (help)...overcome differences in backgrounds, values and agency tradition." [emphasis added]
>
> *US Army Corps of Engineers, Institute for Water Resources.* <u>National Study of Water Management During Drought: The Report to Congress</u> (DRAFT) IWR Report 94-NDS-12, September 1994, p.xvi)

Several aspects and contributions of SVM are evident in this description of shared vision models.[3]

First, shared vision modeling is not directed to an isolated part of the decision problem. Instead the SVM integrates many aspects of a problem that often are modeled separately. SVM models are built in pieces (modules), are build methodically for each piece and are built to be open to comment and understanding by all model users. Making the connections among model components is central to the SVM building process. An SVM model of juvenile fish might include modules where all stakeholders agree on the relationships describing predation mortality, mortality at the power generating facilities and losses in the pools behind the dams. Also, the SVM process would be used to describe financial costs as well as opportunity costs (such as forgone power) that would be incurred for any alternative that would reduce mortality by a given amount from any of the causes. The connections among the modules would be used to describe the cost and effectiveness of each alternative in reducing juvenile mortality. By having stakeholders reach agreement on each module there is a basis for them to agree on the cost effectiveness estimates. Note however that the SVM must not be "garbage in and garbage out". The SVM needs to have expert participation in its development and must be peer reviewed <u>and</u> team reviewed.

Second, SVM is expected to include the elements of a standard rational planning process. The purpose of modeling in traditional planning was to identify how well alternatives meet pre-defined objectives. There were protocols for measuring the "values" achieved by an alternative in terms of

---

[3]This application of SVM employs a user friendly computer package called STELLA II[R.]

the objectives. Thus there might be reference to "NED value" or to "EQ value" of any alternative. The modeled effects of an alternative on these objectives were reported to a decision-maker who was expected to choose an alternative. In this approach, objectives are stated in conceptual terms and weights among objectives are established without regard to the particular choice situation. The modeler justified measuring the effects of alternatives on the pre-determined objectives by assuming that tradeoffs would be made among objectives.

Some modelers used surveys to elicit decision-makers weights on different objectives (and perhaps to even elicit the objectives). In these cases, the elicitation of weights (and objectives) is an intermediate data collection step that permitted the modeler to solve an optimization problem for a "decision-maker", thus defining the best alternative among those available.

However, there is a fundamental difference in the SVM approach. Models and data are expected to help people in decision-making and collectively *form* (construct) their preferences for different alternatives. SVM helps people discover objectives and the tradeoffs they are willing to make to reach agreement.[4] While there must be some initial definition of objectives and alternatives, these are subject to revision as new understanding is achieved. In creating the SVM, the objectives, the measurement metrics for the objectives, and the weights of the objectives are developed by the group through the modeling process. For example, an initial output objective of juvenile fish survival might shift to an objective adult fish returning to spawn some years later. In turn, this may demand a new module for the SVM model that represents fish growth and mortality once they leave the river where they spawned.

Third, SVM is built with the purpose of quickly answering "what if" questions for stakeholders. This capacity can assist in reaching agreements in two ways. One way is to test the sensitivity of the model to coefficients that might be in dispute. Given the scientific uncertainty and room for different views, the ability to accomplish rapid "what if" modeling can support agreement and allow rapid assessment of tradeoffs by letting stakeholders "experiment" with different alternatives which can form the basis for agreement. In this way tradeoff analysis can be rapidly accomplished. This is how modeling can be used in the consent agreement building process.

Fourth, shared vision models can provide the basis for the discovery of mutual gains.[5] Of course interests among decision-makers differ and different alternatives may have different effects on decision-makers. If winners occur but losers are able to block action then the SVM model provides a way to search for alternatives, including side agreements, that are acceptable to those who can advance or block a choice. For example, the loss of power generating capacity in order to pass fish might be addressed by funding of special energy conservation programs or by developing ways to provide replacement power though the wholesale power market. These options could be addressed by developing a power module for the SVM, and then through the SVM, the possibility of mutual gains (or losses) for all stakeholders might be assessed.

---

[4]The emergence and revision of objectives as a part of planning is not a finding of the IWR reports on drought applications of the SVM approach.

[5]One challenge will be to determine which stakeholders should be part of the negotiation process.

The idea of discovering mutual gain through modeling (called integrative bargaining in the negotiation literature) can be understood in terms of how preferences of decision-makers for particular outcomes are constructed (Schkade, in Feather et.al., 1994) and not recalled by individuals and how such preferences are discovered in and emerge from group decision-making settings (Shabman, in Feather et.al., 1994). In effect, the decision-making process as a value discovery process is an outcome of a decision-making setting and is not an external input to that setting.

APPLYING THE SVM APPROACH

SVM, by creating a common exercise of model building, provides the focal point for assembling a team that crosses interest, organizational and geographic boundaries. Once the team is assembled the shared vision model becomes a focal point of negotiation. In that sense the SVM becomes analogous to the single negotiating text approach to dispute resolution. However, SVM won't bring stakeholders to a negotiation if they are not willing to negotiate without a SVM. Stakeholders need to commit to a negotiation approach to conflict resolution (decision-making) for the SVM to apply. As a related point, SVM won't solve the problem of stakeholders trying to take advantage of a negotiation, by withholding information in an attempt to gain strategic advantage over others. In fact, stakeholders often act in a tactical manner, withholding data and information, and that same data and information may be needed for the building of the SVM.

Putting aside these difficulties and assuming that the stakeholders wish to bargain in good faith the construction of the SVM requires a user friendly, but powerful computer package.[6] STELLA II[R] is a software package that was chosen by the Corps to assist in its SVM modeling for its drought management case studies. STELLA II[R] is a graphically oriented simulation modeling package that can be purchased off-the-shelf. The software is a visual spreadsheet for system analysis where the process being modeled is displayed as a "picture" rather than as a series of equations. While there is a need to employ a sound understanding of the system (often in terms of equations) when building a SVM, it is also possible for users to enter relationships in graphical as opposed to equation form and to see output in the same terms.

User friendliness does not mean that all decision-makers (stakeholders) can be equally active or effective in building the SVM. Also the development of a SVM can be expensive in money and time and these costs will rise as the number of stakeholders increases. The stakeholders who are directly involved in the construction of the SVM must be technically competent, few in number but well connected to other stakeholders. In the end, all stakeholders must agree to be part of the SVM process and abide by its outcome, if they are satisfied that the process has provided a technically strong and "fair" consideration of alternatives.

This need to manage stakeholder involvement in developing the SVM is why the Corps developed the concept of "circles of influence". The circles of influence allows stakeholders to have varied levels of responsibility and influence on the SVM consistent with their own interest and

[6]The building of a SVM contributes to building trust among stakeholders. Such trust building can contribute to achieving a negotiated agreement.

expertise. The basic idea is have an inner most circle that includes technical agency personnel who have lead responsibility for building the operating SVM algorithm. Around this inner circle are representatives for each stakeholder class, such as environmental interest. This circle will review the model and reports. The next outer circle includes a representative of each specific stakeholder group for the issue. These people meet periodically in workshop format to use the model in a decision-making setting. The last, and outermost circle, includes those with legal and budget authority to implement the agreed upon alternative.

CONCLUSION

Future planning for environmental projects will require involving multiple stakeholders in model development and in decision-making. The shared vision modeling approach offers a computer assisted tool for facilitation negotiation and agreement. However, the SVM is not a substitute for negotiation, but rather is an aid to negotiation. If stakeholders are unwilling to negotiate, or if a negotiation based decision process is not to be used, then the SVM approach is not warranted.

APPENDIX B

ANNOTATIONS

APPENDIX CONTENTS

APPENDIX CONTENTS (Continued)

APPENDIX CONTENTS (Continued)

APPENDIX CONTENTS (Continued)

APPENDIX CONTENTS (Continued)

MULTIOBJECTIVE PLANNING

WATER RESOURCES

Brown, C. A. 1984. "The Central Arizona Water Control Study: A Case for Multiobjective Planning and Public Involvement." Water Resources Bulletin. 20. 331-337.

Key Words: conflict resolution, multiobjective planning, public involvement, water resources

This article describes applying a multiobjective framework analysis to plan a water resources project. This article identifies multiobjective planning as challenging the maximization of net economic benefits as the primary parameter for a water resources planning.

The Central Arizona Water Control Study, conducted by the Bureau of Reclamation, resulted from public demands for solving flooding problems in the area. The goal was to market a plan acceptable to all stakeholders. Study design was based on multiobjective plan formulation and evaluation in an open planning process. Its structure was composed of: (1) defining study goals and generating alternatives; (2) eliminating plan elements using critical criteria; (3) combining plan elements into groups that achieve the goal; (4) evaluating and screening new groupings; and (5) conducting a detailed multiattribute analysis on the remaining alternatives. Alternative screening aimed to eliminate those that could not be offset by benefits in other areas.

Six factors were identified as contributing to the study's success: (1) motivation to seek a solution; (2) public involvement; (3) multiobjective planning; (4) commitment of sufficient resources; (5) involvement of key decision makers; and (6) patience and flexibility of key decision makers. Public involvement was considered one of the key aspects in resolving sakeholder conflict. A public involvement program was developed, consisting of a governor's advisory committee, a technical agency group, and public information materials and meetings. Participants identified facts and values important to selecting an appropriate solution. The author noted that most people have few basic values that are readily applied to judgements regarding complex alternatives. Rather, the public needs time and information to understand how an action affects their goals and needs. A "public values assessment" was also conducted to identify stakeholder important evaluation factors. Evaluation factors for the study were water quality, stream habitat, lake habitat, threatened and endangered species, prehistoric cultural resources, historic sites, Indian relocations, non-Indian relocations, flood control, stream recreation, lake recreation, net economic benefits, total cost, and regulatory storage. Stakeholders assigned weights that reflected their values. Similar responses were aggregated into seven groups to generate a values profile of the proposed plans.

The article concludes by discussing implications of multiobjective planning related to the 1983 Principles and Guidelines for Federal Water and Land Resources Planning (P&G), noting that P&G emphasizes National Economic Development (NED) as the most important decision criteria. The author states that multiobjective planning does not exclude attaining NED benefits.

Deason, J. P. 1984. "Water Resources Planning in the New Principles and Guidelines." Eds. Y. Y. Haimes & D. J. Allee. Multiobjective Analysis in Water Resources: Proceedings of the Engineering Foundation Conference. New York: American Society of Civil Engineers. 37-45.

Key Words: decision making, multiobjective, water resources

Water resources planning on the Federal level has undergone a profound evolution in the last seventy years. In the Flood Control Act of 1936, Congress indicated that water resources projects are to be pursued if "benefits to whomsoever they accrue are in excess of the estimated costs." Since then there have been at least seven subsequent water resources development acts and guidance for their implementation, such as the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). This chapter addresses the role of multiobjective analysis with regard to the objectives set forth in the P&G.

The article identifies National Economic Development (NED) as the principal objective in Federal water resources planning. Although other aspects such as Environmental Quality, Regional Economic Development, and Other Social Effects should be considered, NED is to be the primary emphasis. What sets P&G apart from previous documents is that it provides a set of guidelines for the planning process as opposed to regulations to be met. This allows implementing agencies, such as the Corps, more freedom to tailor studies to fit program needs.

Federal planning of water resources traditionally has relied on a six-step process, but the author focused on three that were pertinent to multiobjective analysis: (1) formulation of alternative plans; (2) evaluation of effects and comparison of alternative plans; and (3) plan selection. The author states that there is a need for multiobjective analysis techniques in these three areas even if there is only one objective in the process. In the formulation process, the P&G provides a broad planning scope to accommodate federal, state, local, and international concerns as well as social, regional, and environmental goals not fully considered by the NED objective. Multiobjective analysis has an important role in examining all these concerns. Additionally, exceptions in the P&G allow plans to be considered if they have other benefits that outweigh NED losses.

The information presented by the author was intended to show the need for multiobjective analysis at a time when new guidance (P&G) was being implemented for water resources projects. It is not lengthy, but it does provide an examination of some significant changes that the P&G brings to the planning process. NED is the only required planning objective, but many other factors such as Environmental Quality and Other Social Effects, may be appropriate in multiobjective analysis.

This chapter is found in a text that addresses multiobjective analysis and water resources. The information is over ten years old, yet it still has significant relevance to the planning process since the P&G is still in effect. Its perspectives would be relevant in any future improvements in the P&G.

Duckstein, L., W. Treichel, and S. E. Magnouni. 1994. "Ranking Ground-Water Management Alternatives by Multicriterion Analysis." Journal of Water Resources Planning and Management. 120(4). 546-566.

Key Words: decision making, multicriterion, water resources management

Numerous, available multicriterion decision-making (MCDM) techniques can be used as decision aids for the management of groundwater. This article examines the suitability of four MCDM techniques that can be used for this purpose. They are compromise programming, ELECTRE III, multiattribute utility function (MUF), and the UTA (UTilité Additive). The examination is based on how the techniques rank solutions generated for a Pareto-solution set for three ground-water objectives.

Compromise programming identifies solutions determined to be the closest to an ideal solution. "Ideal" and "anti-ideal" limits are established and weights are placed on the objectives to determine the compromise set. Threshold functions and weights are used to create the compromise set. It has been used for river basin system development and to rank estimation techniques for fitting extreme floods. ELECTRE III examines alternatives using a fuzzy relationship. Models of indifference relation, weak-preference relation, and strict-preference relation can be created from ELECTRE III. A values index summarizes the results of the comparison of all possible alternatives. It has been used to program rural water supply systems. UTA assesses piecewise-linear value functions based on a subjective preference ranking. It examines an "optimal" value function and uses postoptimality analysis to identify zones of ambiguity for a set of value functions. UTA has been used in multicriteria analysis of rural water supply systems.

MUF is developed from multiattribute theory, which accounts for decision maker preferences based on a set of axioms regarding a decision maker's preference system. These include the preexistence of a complete system of preferences, the presence of risk, change in the decision maker's preferences, preference independence of each attribute, and assumptions about the rationality and consistency of the decision maker. Criteria are ordered by level of importance and trade-offs are evaluated. It is assumed that probabilities can be used to assess the parameters of this process. MUF has been applied to river basin planning.

The authors concluded that compromise programming was the easiest technique to use and was the least time consuming. ELECTRE III was found to be the least demanding regarding data accuracy. The methods generated similar subsets of recommended solutions. The authors emphasized that MCDM techniques are decision-making aids and should not take the place of the decision maker.

Duckstein, L. and S. Opricovic. 1980. "Multiobjective Optimization in River Basin Development." Water Resources Research. 16(1). 14-20.

Key Words: decision making, multiobjective, optimization, water resources

In the literature regarding multiobjective decision-making models, numerous mathematical techniques for decision making under uncertainty are available. In water resources planning, conflicting objectives can be expected because of limited resources and competing interests. Trade-offs between these conflicts must take place in space and time at various levels of the decision-making process. This article presents a method of multiobjective optimization in water resources which integrates both compromise programming and cost-effectiveness considerations.

Decisions made by a water resources agency occurs among managerial levels, intermediate engineering levels, and design engineering levels. The managerial level defines goals, identifies attribute levels, and selects the "optimal" alternative. Intermediate engineering level personnel define alternatives and assess consequences based on criteria or indices of effectiveness. The design engineering level creates options based on goals set at the managerial level and translates them into engineering specifications for the intermediate engineering level. The decision-making process can be seen as centered around arrays of cost effectiveness, attribute levels, or pay-offs.

Cost effectiveness was used in this study because it provides a means to evaluate and rank alternatives from both quantitative and qualitative criteria. Compromise programming was used because it can select solutions based on an alternative's distance from the ideal solution. Five alternatives for this examination of the Central Tisza River Basin, Hungary were taken from two previous studies of the area (David and Duckstein 1976, Keeney and Wood, 1977). Instead of compromise programming, David and Duckstein used ELECTRE to study the basin; Keeney and Wood used multiattribute utility theory. Each of these previous studies selected the same top two alternatives from the five available, but ranked them differently. Compromise programming, used in this examination of the Tisza, was found to reach the conclusions of the previous studies, depending on how criteria were ranked by the decision makers. Ranking differences between three approaches used above were identified under three criteria: cost, level of flood protection, and amount of land and forest used. It was suggested that negotiations be initiated to evaluate the importance of these criteria among the agencies responsible for them. Other recommendations included voting, dominance analysis by ranking and weighting, and group decision making.

Four important conclusions identified by the authors are useful in trade-off analysis. First, multiobjective optimization in water resources can occur at the engineering levels and at the level of the solution's acceptance. Second, systems arrays should be the central element of multiobjective decision making for a discrete set of alternatives. Third, a compromise programming algorithm can be applied to an array to obtain a compromise solution. Finally, selection of a final alternative is dependent on the ranking of the criteria.

Gershon, M., L. Duckstein, and R. McAniff. 1982. "Multiobjective River Basin Planning With Qualitative Criteria." Water Resources Research. 18(2). 193-202.

Key Words: river basin planning, multiobjective planning, water resources planning

The purpose of this paper was to demonstrate an approach for solving multiobjective water resources planning using qualitative criteria by combining the ELECTRE I and ELECTRE II methodologies into a method of ranking alternative systems. The authors used the Santa Cruz River in Arizona as a case study for testing the utility of this methodology. The methodology developed in this article differs from other multiobjective techniques in that it only requires an interval scale (not a cardinal scale) for generating solutions. The ELECTRE I and II techniques are both well-established methodologies for multiobjective planning of river basins.

The Santa Cruz basin is characterized by multiple, competing water interests, including water supply, flood control, and groundwater development. The authors combined these different basin management objectives with alternative actions into an array of reasonable alternative systems. Quantitative data were used whenever possible in the array. However, when this was not possible, qualitative ratings were assigned using an interval scale. In such circumstances where quantitative and qualitative criteria were being used, the ELECTRE I and ELECTRE II techniques had demonstrated effectiveness.

ELECTRE I is intended to help choose systems preferred by the decision maker for most of the evaluation criteria (i.e., objectives), and yet do not cause an unacceptable level of discontent from any one criteria. This involves developing a concordance matrix for the different combinations of actions. The weights on the particular criteria are elicited from the decision maker. Similarly, a discord matrix for the combinations of actions is also developed to represent the discomfort from different actions. A third matrix of threshold values is used to synthesize the concordance and discordance. The result is a graph of the decision maker's preferences with a partial ordering of the alternative systems. The output of ELECTRE I serves as input to ELECTRE II. Two preference graphs (strong and weak) are generated using ELECTRE I. These rankings are transformed, and the preferences are averaged and then ranked.

The two-part process described in this article incorporated quantitative and qualitative criteria based upon the decision maker's judgement and ordered the preferences to select the most appropriate combination of actions. The ELECTRE I process was used to screen the alternatives and select the most desirable actions. The ELECTRE II methodology carries the process one step further and ranks the top alternatives selected through ELECTRE I. This two-part methodology is effective in ordering the multiple objectives of the decision maker. However, the results are very dependent on the judgement and preferences of the decision maker. If the professional judgement of the decision maker is insightful, this decision making tool could prove very valuable in multiobjective planning of water resources.

Giocoechea, A., E. Z. Stakhiv, and F. Li. 1992. "Experimental Evaluation of Multiple Criteria Decision Models for Application to Water Resources Planning." Water Resources Bulletin. 28(1). 89-102.

Key Words: water resources planning, multiple criteria, decision making

This article describes a comparative analysis of the application of four multiple criteria decision making (MCDM) methods. As methods are introduced to the water resources planning field that require subjective input, it is necessary to compare their results to gauge the level of consistency and precision. The specific objectives of this effort were to: (1) investigate the impact of explicit weighting of critical decision-making criteria; (2) determine the utility of computer-based procedures; (3) evaluate the differences between computer-based decisions and pure intuition; (4) compare the intuition-computer decisions if among the four MCDM models; and, (5) examine the consistency between decision-makers and compare among the four MCDM models.

The four MCDM models examined, MATS-PC, EXPERT CHOICE, ARIADNE, and ELECTRE, were used to generate computer-assisted rankings for a set of ten water resource project alternatives considered for water supply in the Washington Metropolitan Area. Two groups of human subjects, eleven professionals from the Corps of Engineers (Corps Group) and ten graduate students (Student Group), prioritized rankings for the water supply alternatives first using the four computer programs, and later using professional intuition alone. A qualitative assessment of the four MCDM computer programs was conducted which focused on the user-friendliness and general utility that they offered the user in decision-making. The main focus of the discussion was the quantitative comparison (non-parametric tests of significance) of the agreement/disagreement between rankings using the selected methods.

The test results indicated that the rankings were statistically similar across the four methods for the Corps Group and the Student Group. Examination of the "between persons" differences in rankings indicated that the rankings within the Student Group were more aligned than those in the Corps Group. It was argued that the Student Group, which had a higher comfort level with computers than the Corps Group, was able to achieve greater consistency. Also, members of the Corps Group, which had extensive experience in actual planning activities, were probably biased toward their individual experiences, thus causing differences in ranking. The experience within the Student Group, on the other hand, was directed closely by the parameters of the experiment, thus allowing limited opportunity for development of diverging opinions. In the "between methods" comparison, EXPERT CHOICE and ARIADNE displayed the greatest consistency of ranking results of both groups. Overall, the EXPERT CHOICE model was identified as the most user-friendly of the four but there was a greater degree of consistency in the ranking results when the ARIADNE model was used.

This study discusses the details of four popular decision support systems and gives valuable references. Continued use of MCDM models will require external validation of test results to ensure consistency. The comparative analysis provided in this study leads to increased confidence in the MCDM model results, but also reveals that individual experience and preference can create an analytical challenge.

Green-Hammond, K., R. A. Cole, F. A. Ward, S. Bolton, R. A. Deitner and J. Fiore. 1990. User's Guide for RIOFISH, A Fishery Management Model for Large New Mexico Reservoirs. Las Cruces, NM: New Mexico Water Resources Research Institute. New Mexico State University.

Key Words: multiobjective planning, environmental modeling, fishery management, lake management

RIOFISH is a simulation model that identifies the effects of alternative fishery management actions on the hydrology, ecology, and economy of rivers and reservoirs in a particular river basin. This user's guide describes how to use RIOFISH and advises operators how to best employ this software in their fishery management programs. While RIOFISH can generate optimum management actions, it is not a linear optimization model. It is an interactive model that provides input to the management process. The authors caution that RIOFISH "helps, but does not replace … experience and intelligence in making management decisions."

For input to reservoir fishery management, RIOFISH simulates (1) water flows and transport of biologically active materials; (2) fish habitat and forage production; (3) sportfish production and angler activity; and (4) economic benefits generated by sportfishing. RIOFISH contains linked submodels of hydrologic, biologic, and economic features of reservoirs. These submodels require operator input about the conditions of these features. Management options can be assessed by changing this information and running "before" and "after" sensitivity scenarios.

Inputs to the hydrologic submodel include flow data from the United States Geologic Survey, the shapes of reservoirs and tailwaters, lake evaporation, and operational constraints. Outputs from this submodel include concentrations of nutrients and suspended solids, and reservoir depth, area, and contents. These outputs feed into the biological submodel. The economic submodel requires user input on angler travel cost, road accessibility, boat ramp access, availability of substitutes, and user populations. This submodel also produces data for the biological model, including angler days. The biological submodel uses the information from other submodels and the user inputs on solar radiation, air temperature, organic material from the watershed, and initial fish densities to generate outputs about the biomass, density, and productivity of catchable fish, catch rates, and fish population characteristics.

The user inputs to the submodels can be changed by the user to run alternative scenarios and formulate the best combination of management measures based upon the desired outcomes. The effectiveness of a management action can be anticipated using the model through modification of a single management parameter or some combination of parameters.

The RIOFISH model is in the forefront of environmental management models since it combines physical modelling (in this case hydrologic) with biological response (in this case fisheries) and socio-economic effects. The power of RIOFISH lies within its ability to evaluate the sensitivity of the ecosystem to alternative management actions.

Harboe, R. 1992. "Multiobjective Decision Making Techniques for Reservoir Operation." Water Resources Bulletin. 28(1). 103-110.

Key Words: multiobjective decision making, reservoir operation, water resources

In this article, six systems analysis techniques were compared for their utility in formulating optimal operating rules for a system of reservoirs. The case studies include the Shasta and Folsom reservoirs in California and the Wupper River System in Germany. Trade-offs between different operational objectives (e.g., hydropower, water supply, low flow, reliability, recreation, and water quality) were explored.

The author described multiobjective decision making as divided into the following three classifications: (1) methods that require *a-priori* establishment of weights by the decision maker; (2) those that require *a-posteriori* establishment of weights and are used only to find Pareto optimal solutions; and (3) methods that use an interactive procedure in which weights are varied by the decision maker during the application until the results are acceptable. Techniques that the author explores in this article are found in the first category. Optimized alternative solutions were generated with systems analysis techniques, including the constraint method, compromise programming, goal programming, the Tchebycheff maximum-minimum (max-min), consensus, and ELECTRE I and II.

In determining optimal operating rules for hydropower and water supply, one of the purposes (water supply) is considered a constraint and the other (hydropower) is optimized, thereby obtaining a Pareto optimal solution. By varying water supply yields, several optimal targets for hydropower are obtained using physical and max-min objective functions. The model was applied to the two California reservoirs, Shasta and Folsom. The result of the analysis is a transformation function (with Pareto optimal solutions) between water supply and hydropower production.

Similarly, the author then considered the low-flow and flood control trade-offs involved in the operation of the six reservoirs of the Wupper River System. A sequential dynamic programming model was developed with the objective of maximizing the minimum flow of the river. This involved compromise programming with tradeoffs of reservoir storage allocations between low flow releases and flood control. The analysis produced two optimal storage allocations that the author suggests the decision maker should weigh regarding other performance criteria not included in the analysis. Other simulations formulated the optimum operating rule of the Wupper system to meet five operational objectives (four concerned with the reliability of low flow augmentation and a measure of recreation performance). In addition, Pareto optimal solutions for a single multipurpose reservoir were developed to balance low-flow, recreation, and water quality objectives.

This article provides an effective overview of the alternative techniques for finding optimal operating rules for reservoir systems and individual reservoirs. The alternative tradeoffs for different operational objectives provide diverse examples and important decision support techniques for reservoir operators.

Hipel, K. W. 1992. "Multiple Objective Decision Making in Water Resources." Water Resources Bulletin. 28(1). 3-12.

Key Words: decision making, multiple objective, optimization, water resources management

Conflicts among project stakeholders can arise in water resources projects of any size. A methodological approach that solves both simple and complex decision making problems is needed. This article examines the latest developments in multiobjective decision making for managing water resources related to the field of Operational Research (OR).

OR originated from the British development of radar systems and has been applied to a wide diversity of systems. Recent water resource studies using OR have gained a better understanding of the problems being examined. The author uses OR to categorize multiobjective decision making under three groups: Multiple Criterion Decision Making, Team Theory, and Game Theory.

Multiple criterion modeling finds preferred alternatives for one decision maker when evaluating the qualitative and quantitative criteria. Evaluation methods are so numerous that some authors have promoted the use of a multicriterion technique for selecting the appropriate multicriterion method. Team Theory is based on a number of stakeholders preferring a different alternative that are trying to achieve the same goal. Game Theory is used for multiple stakeholders with multiple alternatives to achieve their goals.

This article introduces a special issue of Water Resources Bulletin that is devoted entirely to multiobjective planning. It summarizes the models used and the contributions of different areas of multiple objective decision making in water resources planning and management. The use of the methods discussed requires flexible decision support systems. It was also noted that game theory has not received much research attention for use in managing water resources. The recency of this article indicates that more attempts should be made to apply game theory to water resources planning.

Lee, Y. W., I. Bogardi, and J. Stansbury. 1991. "Fuzzy Decision Making in Dredged-Material Management." Journal of Environmental Engineering. 117(5). 614-630.

Key Words: decision making, multiple objective

Many decisions regarding water resources projects have been based on the minimization of costs. Recently, a greater emphasis has been placed on the importance of risks to human and environmental health. This article examines the use of modified fuzzy-composite programming to select among conflicting objectives as related to dredged material disposal.

Fuzziness is based on the theory that a numerical degree between 0 and 1 can be used to determine membership parameters for groups not clearly defined. Developing fuzzy sets accommodates the idea that transitions between groups are gradual, not abrupt. The method in this example uses a composite procedure to group basic indicators into a single indicator. Mathematical functions described in the article are used to derive levels of confidence for the indicators. Indicator values are determined using expert judgement based on experience and observed measurement variability. Indices are used to overcome differences in measurement units. Weights and balances are attributed to reflect the importance of indicators and maximal deviations in the equations. Computer software is available that provides the trade-off information in numerical and graphical form. A pyramid format is used to graphically display the results in an easily understandable manner.

In the case study example, the basic indicators were cancer risk, noncancer risk, chemical risk to fish, burial risk to fish, chemical risk to shellfish, burial risk to shellfish, chemical risk to terrestrial species, burial risk to terrestrial species, and cost. The options for a disposal area were an unconfined aquatic disposal site, a capped aquatic disposal site, a confined disposal facility, an upland site, and a hazardous waste disposal site. The modified fuzzy-composite programming methodology determined that the capped aquatic disposal site was the best compromise between environmental risks and costs.

This method provides a means for assessing trade-offs for project planning purposes. The authors note that economic benefits can be considered in this process. If they are, a sensitivity analysis should be conducted to investigate effects on weights and balancing factors. This could be used to reduce some of the risk associated with trade-off analysis.

McKinney, M. J. 1990. "State Water Planning: A Forum for Proactively Resolving Water Policy." Water Resources Bulletin. 25(2). 323-331.

Key Words: environmental dispute resolution, water resources planning, state water planning

This article describes the potential of state water planning to proactively resolve water resources conflicts. The state of Montana was presented as a case study of the challenges and opportunities inherent in state water planning. The emphasis of the article was on using the process to aggressively identify and address existing and potential water conflicts. In the case of the Montana state water plan, the mistakes provided lessons at least as valuable as the successes.

The author suggests that negotiation processes will play an increasingly important role in water resources planning. Environmental dispute resolution techniques are identified as particularly relevant for water resources conflicts. However, among the problems of environmental dispute resolution are the representation of interests, the relative power of participants, and the implementation of agreements. This article offers state water planning as a collaborative, consensus-building process that can provide a comprehensive, integrative forum for resolving water resources disputes proactively.

The process to develop the Montana state water plan was initiated in 1987. The author traced the development of the plan using the basic stages of a collaborative problem solving process as a framework for the analysis of the planning process. This framework includes the following stages: initiation, process design, mutual education, problem definition and analysis, option generation, option evaluation, decision making, links to the formal decision process, and implementation. Montana's Department of Natural Resources and Conservation was responsible for the development of the plan. The author indicated that this agency came to realize that its most valuable efforts would be directed at how decisions would be made rather than what decisions would be made. The process of formulating and building a consensus for the plan was initially problematic. Difficulties with the process included: (1) important decision makers were not included; (2) the public was invited too late; and (3) public input was poorly handled with loud minority perspectives receiving undue weight.

The underlying goal of this article was to develop a model process for state water planning. The key features of such a model would be: (1) involve all affected parties; (2) jointly identify problems and solutions; (3) pursue consensus solutions; (4) coordinate water management across jurisdictions; (5) balance competing water uses; and (6) allow for continuous updating and revision of the plan.

This article is valuable as a source of experience and as a portent of the future importance of proactive consensus building for water resources conflict resolution. This issue of scale is an important one for Corps environmental planning. A small Section 1135 project may have radically different planning contexts and criteria than a large watershed restoration program. The challenge to the EEIRP is to determine appropriate techniques for different project scales. The perspective of this article is on the state scale. However, the potential of the process and the lessons learned would be applicable on many different scales.

Sheer, D. P., M. L. Baeck, and J. R. Wright. 1989. "The Computer as Negotiator. " Journal of the American Water Works Association. 81. 68-73.

Key Words: conflict resolution, negotiation, water resources, multiobjective planning

This article discusses the utility of computer-aided negotiation (CAN) in addressing complex water resources conflicts. The article is designed to introduce CAN to the reader, outline its potential applications, and identify parameters of design and application that would promote its effectiveness. Several examples are provided to illustrate the flexibility of the model in different water resources decision-making contexts.

The authors highlight the benefits of CAN in fostering communication and reducing misunderstandings between different parties involved in the management of a river basin or water system. By using CAN to bring the different parties together under relaxed circumstances, the authors report great success in helping the parties: (1) quantify their objectives; (2) understand the legal and operational limits of system management; and (3) recognize the importance of hydrologic uncertainty. In addition, the development of the basin or system model serves the practical function of combining the technical databases of the different organizations.

The authors have successfully used CAN to simulate drought conditions in a variety of decision-making contexts, including Kansas, Texas, and the Potomac River Basin. In CAN drought simulations, the parties dialogue with the model, which combines a user friendly interface with detailed information about the conditions in the basin or system. The process elicited the interaction of the participants to experience rare situations without the pressure of emergency circumstances. One of the strengths of using CAN for drought simulations is that it can illustrate how cooperative behavior can lead to optimal outcomes for all parties.

Improvements in computer hardware and software have increased the use of CAN due to the recognized need for the cooperation it can elicit between different individuals and organizations. In addition, the real-time results provide immediate feedback to the participants, who can perceive the results of their own actions as well as others in short order. Since this article was written, the use of CAN in drought simulations has lead to the concept of "virtual" droughts and application of STELLA and other simulation software to drought planning.

This article describes the use of CAN in water management and does not explicitly address its potential role in environmental projects. However, the water quality and flood control functions of wetlands could be easily incorporated into the described models adding another dimension to the simulations.

Tecle, A. 1992. "Selecting a Multicriterion Decision Making Technique for Watershed Resources Management." Water Resources Bulletin. 28(1). 129-140.

Key Words: multicriterion decision making, watershed resources management

Project planners have a number of multicriterion decision making (MCDM) techniques available to assist them in their endeavors. This can lead to difficulty in selecting which approach will provide the best opportunities for project development. The author promotes the use of a composite programming algorithm for selecting the most appropriate (MCDM) technique for application in water resources management.

Selection of a MCDM is done at two levels. Evaluations are conducted based on four groupings: characteristics of the decision maker, characteristics of the solution algorithm, the type of problem being examined, and the nature of generated solutions. There are 24 weighted criteria in these four groups which use a numeric system to rate the ease or difficulty associated with an MCDM technique. Personal familiarity and experience with the technique being examined guides the decision-maker through a rating process. Therefore, it is likely that the results of the selection processes among different people could vary significantly.

The analysis conducted in this article was based on a specific watershed resources problem identified by the author in a previous work. The author recommended the use of compromise programming and composite programming as optimum choices. It is noted that each project has distinct qualities, so it is not unreasonable that other MCDM techniques may be more appropriate than these mentioned above.

With regard to multiobjective planning efforts, this approach provides a unique opportunity for planners to improve the formation of a project through the use of this technique. The author noted that over 70 MCDM techniques are available. Although most planners will only be knowledgeable of a fraction of that number, the composite programming algorithm approach is a tool that deserves serious consideration for use in future water resources planning efforts.

ENVIRONMENTAL

Bennett, J. and I. Goulter. 1989. "The Use of Multiobjective Analysis for Comparing and Evaluating Environmental and Economic Goals in Wetland Management." Geojournal. 18(2). 213-220.

Key Words: multiobjective analysis, optimize, trade off, water resources, wetland management

Water resources planning involves the accommodation of numerous objectives from many project stakeholders. This article discusses the role of multiobjective analysis in generating feasible alternatives and useable techniques, and in identifying how objectives for wetlands are affected. The authors emphasize that objective conflicts are resolved by decision makers, not by their tools.

Three classes of multiobjective analysis tools for water resources are: generation techniques, prior preference evaluations, and the progressive articulation of preferences. Each class contains several tools or techniques, but the majority are impractical because of intensive calculations or difficulties in establishing common social preferences for a project. Optimal methods for water resources were weighting and constraints methods, optimal for three or less objectives, and the surrogate worth trade-off method for more than three.

Economic valuation is the traditional approach for managing water resources. Wetlands prove difficult to assess because of the many functions they provide and the social and environmental values of those functions. Twelve goals for managing wetlands with regard to these functions were identified that incorporated economic and social environmental objectives. They are:

- Maintenance of water quality
- Flood protection
- Use as a buffer zone between residential and industrial areas
- Wildlife production
- Spawning habitat
- Rapid increase in scenic inquiry
- Erosion reduction
- Processing of airborne pollutants
- Maintenance of a gene pool for marsh plants
- Aesthetic and psychological support for humans
- Insect abatement
- Food, fiber, and fodder production

Overall, the authors document past literature that proved useful in the management of water resources. Recognition is given to the values provided by wetlands and several examples of how economic and ecological goals can be achieved were presented. Weighting and scaling of alternatives was recommended for use in wetlands management, but a trade-off prioritization was not provided.

Chechile, R. A. and S. Carlisle, eds. 1991. Environmental Decision Making: A Multidisciplinary Perspective. New York. Van Nostrand Reinhold.

Key Words: decision making, environment

This book was produced by the Tufts University Center for the Study of Decision Making. It provides a general overview of environmental decision making as well as information regarding economics, risks, ethics, and the roles of players. This annotation focuses on Chapters 9, 10, and 11, all of which discuss the roles of players in the decision making process.

Chapter 9 examines citizens' roles in environmental decision making. This chapter notes that there are two primary approaches to decision making: positivist-oriented and policymaking-process. The positivist approach excludes citizens from the decision process; policymaking includes them throughout the process. In the latter process, citizens can affect decisions that are made through voting, supporting an interest group, or direct participation. A table is provided that classifies the dimensions of risk acceptance in decision making. The authors noted that actions that are perceived as having multiple high-risk characteristics are likely to be overestimated by the public.

Two major points regarding the roles of governmental agencies in environmental decision making are discussed in Chapter 10. First, regulations issued by federal agencies can be preempted by more stringent state regulations. Although a Federal environmental program may have specific requirements, states may impose more demanding standards. Second, in many cases there is a significant overlap among the policies of different federal agencies.

Chapter 11 addresses environmental decision making in the private sector. Influences on private sector decisions come from market demand, government regulation, public opinion, liability issues, and competition. In recent history, public pressure has increased to demand higher environmental standards for industry. This has caused more companies to hire environmental personnel to address regulations and issues. Companies have to consider materials to be used (including natural resources), production techniques, treatment of by-products, company location, accounting methods, and profitability as well as environmental regulations and other aspects of environmental compliance.

The book provides a good general overview of the components of environmental decision-making. The quality of the information varies by chapter because of different authorship. For example, all the chapters provide information on criteria for decision making, but only Chapter 11 specifically addresses how decision making information is gathered. Further information could be gathered from the bibliographies presented at the end of each chapter.

The review of these three chapters indicates that the present environmental decision-making process is extremely complex, especially at the federal level. This would suggest that some streamlining is necessary among federal agencies. Also, since state regulations may supersede federal mandates, federal programs need to be flexible to adjust to state processes.

McAllister, D. M. 1980. "Environmental Evaluation System and Judgmental Impact Matrix." Evaluation in Environmental Planning. Cambridge: The MIT Press. 217-234.

Key Words: decision making, environmental planning

Information gathered from the evaluation of environmental systems is an important component of any planning effort. Chapter 12 from McAllister examines two systems that incorporated the Delphi method for obtaining and processing expert judgement, the Environmental Evaluation System (EES) and the Judgmental Impact Matrix (JIM).

The Delphi method was developed by the Rand Corporation as a means of getting expert opinion in an anonymous manner. This is done to prevent the influence of participants by a particularly vocal person. Responses are gathered in a first round of questions, and then those results are sent out again for further consideration. EES uses this method to generate value weights and JIM produces impact assessments and value weights.

EES is a means for determining environmental and social impacts of water resource projects. The use of Delphi allows for interdisciplinary participation and is intended to be systematic in generating replicable answers. EES arranges environmental factors into four levels: categories, components, parameters, and measurements. The categories for this process are Ecology, Environmental Pollution, Esthetics, and Human Interest, and these are used to incorporate 78 parameters. After values have been determined, the information generated is used to indicate potential problems based on significant parameter changes.

JIM was created to assess alternative wastewater management systems for Chicago and southern Lake Michigan for the Corps of Engineers. The evaluation of impacts from a project differs from many other systems in that it examines component impacts separately instead of an overall impact. Determined social impacts are converted into an index of social welfare change. As with EES, JIM's use of Delphi allows for multidisciplinary participation and removes the chance of influence by a dominant participant if the group met face to face.

In addition to the use of Delphi, each of these techniques provide unique aspects to the evaluation process, other than the. Both have categories that can be used to examine impacts from projects. The major drawback in using these techniques is the needed resources and time required to solicit expert opinion from a selected multidisciplinary team. Also, there is the risk that not all of the parameters reflect the end result of the impacts made. Furthermore, the information generated by these methods will not be readily understandable by decision makers and the public.

This chapter presents a common problem encountered in planning, the difficulty of generating information that is readily understood by others. The author notes that this transfer of information does not always convey uncertainty that may be taken for granted in the science community but not known by decision-makers and the public. Future research needs to address this communication gap, which may be accommodated by developing clear and concise explanations of the information that is generated by methods such as EES and JIM.

Peterson, D. L., D. G. Silsbee, and D. L. Schmoldt. 1994. "A Case Study of Resources Management Planning with Multiple Objectives and Projects." Environmental Management. 18(5). 729-742.

Key Words: multiobjective planning, natural resources, environmental management, linear programming

---

This article presents a case study of the application of the Analytic Hierarchy Process (AHP) to the management of the Olympic National Park. There are two principal objectives of this case study: (1) to demonstrate the utility of AHP in balancing multiple objectives; and (2) to improve management of the national parks by developing a process to prioritize allocations of scarce resources among competing management projects.

Every four years, national parks produce detailed Resource Management Plans (RMPs), which identify management objectives and formulate plans to meet them. The authors indicate that while RMPs are effective in defining objectives, most parks have no defined process to prioritize these projects under budgetary and personnel constraints. This article examines current RMP procedures at national parks, describes the AHP structure, and applies it to the case study.

In this case study, the AHP was used to elicit from a group of managers a prioritized action list. This prioritization process in national parks has traditionally been informal, what park personnel refer to as BOGSAT (Bunch of Guys/Gals Sitting Around the Table). The AHP facilitates the analysis of complex problems by structuring the problem into a hierarchy consisting of a goal and subordinate features of the problem (in this case, objectives) and through subsequent pairwise comparisons of the subordinate features.

Five members of the management staff participated for two days in the AHP process for the Olympic Park case study. The authors used the software *Expert Choice* as a facilitation tool. Using a single computer monitor for the software input, the pairwise comparisons of alternative projects were made by the group through open discussion and consensus building. The software then developed a ranking for the different projects with full consideration of the park's management budget. In addition, different scenarios were considered by applying different weights to the management objectives. The AHP rankings were then compared to those actually selected in 1990. The AHP results were found to be significantly different than those of 1990. The authors attributed this discontinuity to policy changes since 1990. When policy at that time was included in the analysis, the AHP became closely aligned with the decisions actually made.

This application of AHP to the Olympic Park management produced optimal but not unique outcomes. If greater details of the planning parameters (e.g., budget, timing, etc.) were included in the analysis, the AHP should produce a single optimal outcome (i.e., ranking of management projects). This case study provides an excellent example of a process that uses a combination of group techniques and computerized multiobjective prioritization to formulate a management plan for executive decision making.

Seo, F. and M. Sakawa. 1988. Multiple Criteria Decision Analysis in Regional Planning. Boston: D. Reidel Publishing.

Key Words: multicriteria decision making, regional planning, decision analysis

The authors present the fundamentals of multiple criteria decision making with particular emphasis on real-world decision making in this text. Their approach is based on economic theory and methods. They establish the basic concepts for addressing society's complex problems, especially those of regional planning.

Multiple criteria decision making is composed of two phases)analytical and judgmental. The analytical phase is quantitative modeling of systems to determine the optimal combination of actions to maximize the objective functions. The judgmental phase is based on preference analyses of the different objectives. This text attempts to discuss both phases with an aim to their integration. The author's integration of the two phases is based on the use of Kuhn-Tucker multipliers derived from mathematical programming with the mediation functions of the decision makers.

A major thrust of this text is to address the theoretical evaluation problem. This results from market failure, when the market price mechanism is not functioning properly and the subsequent allocation of resources is inefficient. To address this and other problems within multiple criteria decision making, the authors use a three-part approach: (1) evaluation of the marginal rates of substitution among objectives; (2) heuristic construction of the decision maker's preference function; and (3) the utilization of the Kuhn-Tucker multiplier as the basic evaluation factor in a transformation.

The initial chapters of this text address the first phase of multiple criteria decision making, the analytical phase. The next series of chapters address the judgmental phase, and the final chapters attempt to integrate the two phases. The authors acknowledge the challenges and criticisms of the practical application of multiple criteria decision making. One criticism is the presumption that a single person is making the decisions. Another presumption regards the existence and function of reason in human behavior. An additional criticism is the disregard for the social and cultural contexts in which the decision would be made. The authors attempt to address these criticisms, but their arguments are unconvincing in light of the realities that surround public policy decision making and implementation.

While this text has some shortcomings based on unrealistic presumptions, it is nonetheless a valuable compilation of the theoretical foundations of multiple criteria decision making. The integration of the analytical and judgmental phases of multiple criteria decision making is particularly significant.

OTHER

Edwards, W. 1977. "Use of Multiattribute Utility Measurement for Social Decision Making. Conflicting Objectives in Decisions. Eds. D. E. Bell, R. L. Keeney, and H. Raiffa. New York: John Wiley & Sons. 244-276.

Key Words: decision making, multiattribute

Public planning decisions are dependant on values and probabilities. These decisions should reflect a social consensus with regard to values, as opposed to a single person's viewpoint. The author promotes the use of multiattribute utility measurement for achieving social consensus for planning projects.

Multiattribute utility measurement consists of ten steps. The first four steps require identification of the persons and/or organizations involved, the relevant issues, the outcomes of possible actions, and the goals to be used for evaluating the outcomes. The goals are ranked according to importance in Step Five, and then weighted based on importance-preserving ratios in Step Six. Step Seven sums the generated weights, divides each weight by the sum, and multiplies the divided weights by 100 to create numbers that reflect probabilities. The locations of outcomes as they relate to goals are identified in Step Eight. Goals determinations are designated as purely subjective, partly subjective, and purely objective. In Step Nine, the utilities for the outcomes are calculated using an equation. Decisions are made in Step Ten.

Three examples are provided in this discussion. One was actually used to plan a research program for the Office of Child Development. All of the examples required Steps Five and Six to be completed individually, whether they were controlled by use of questionnaires or as part of a workshop. The accurate and timely completion of Steps One through Four was cited as being extremely important in this process. Another factor addressed was the need to keep the list of goals as small as possible. In cases where 40 goals were generated, it was necessary to reduce the amount based on importance and relevance. When discussions were held in these instances, the participants provided clarification regarding the definition of the goals and helped to reduce redundancies.

This system provides a means for creating a consensus in the planning process. It would be difficult in some instances to solicit a wide number of responses from a community because of the amount of mathematical applications involved. However, one of the more important issues to come out of this discussion is the fact that the clarification of goal definitions contributed significantly to the improvement of the overall process.

Multiattribute decision making appears to be a useful tool in creating consensus. However, there are some simplifications within the process as well as a lack of needing objective evidence. Although goals are identified as subjective or objective, decision makers should remember that this method aggregates the views of the participants. Even if the participants are experts in a field, the indices created are the averages of their responses.

Bunn, D. 1992. "Synthesis of Expert Judgement and Statistical Forecasting Models for Decision Support." Expertise and decision support. Eds. G. Wright and F. Bolger. New York: Plenum Press. 251-268.

Key Words: decision making, decision-support systems

This chapter is part of a book that discusses the nature of expertise in decision making and interaction of expertise with decision support systems. The book examines the nature of experts and issues regarding the interaction of experts and decision support systems. The focus of this chapter is the perceptions of models and the experts using them.

The history of decision-support systems has its roots in operations research and management science. Much of the work in those fields resulted in the development of simple models that could be easily used by managers to learn about a problem, rather than attempting to solve a problem. Current methods of forecasting models do not allow for intuitive interaction by the user, thus deviating from lessons learned in the past. Furthermore, social scientists have concentrated on the biases of experts and their performance in unfavorable circumstances. Therefore, experts have had to defend themselves more than the developers of the models used by experts.

Some research has focused on expert performance under favorable conditions. Experts can be reliable in forecasting situations. Difficulty usually arises with models because experts are unable to adjust endogenous variables in the models they use. Expert judgement for model adjustment becomes necessary when theories are inaccurate, variables are omitted, data quality is suspect, coefficients change, or political policy dictates it.

Most decision models are based on analytical hierarchy processes that subjectively rate factors for extrapolation. Further extrapolations of this model include influence diagrams, interactive decomposition structure, and hierarchial inference frameworks. Combining models, which provide statistical forecasts and subjective judgements can be advantageous because they allow adaptivity based on historical information, flexibility in interpretations of performance, efficiency in comparison of practical statistical models, and reduction of influence by outlying information or non-normality errors.

Selection of a model requires the consideration of several factors examined for areas of research. Those most notable are: (1) how quality was achieved in best practices of model specifications; (2) whether judgments are based on an individual or group; (3) the facilitation of judgmental interaction; (4) the presence of interactive graphics; (5) the fit, meaning, and diagnostics of statistical models; (6) information bases; (7) opportunities for feedback; and (8) assessments of success.

The most difficult factor to fulfill is the interaction of the user during the modeling process. In favorable conditions, experts and interactive models should have the capacity to accurately forecast information for use by decision makers. This indicates that the use of any computer modeling for trade-off analysis should allow for as much user interaction as possible.

GAME THEORY

WATER RESOURCES

Hipel, K. W. and N. M. Fraser. 1980. "Metagame Analysis of the Garrison Conflict." Water Resources Research. 16(4). 627-637.

Key Words: water resources, conflict analysis, game theory, international conflict

This article applied metagame analysis to the domestic and international conflicts surrounding the Garrison Diversion Unit, a large-scale irrigation proposal in North Dakota. The authors modeled the conflict according to the situation in August 1976 and were able to use hindsight to test the results of the analysis against the actual outcome. The Garrison Diversion Unit was a proposal to divert water from the Missouri River to the Sioux and Red rivers, which drain into the Hudson Bay. Canada feared the runoff would produce environmental damage to the Bay watershed and U.S. environmentalists also opposed the project on environmental grounds. The International Joint Commission (IJC) was also an important participant, given its political power in Canadian/U.S. border disputes.

In metagame analysis, the conflict is considered a game where the players have limited options. The authors modeled the conflict by identifying the major players and their options. These strategies were then mixed in all possible combinations, or "outcomes." Metagame analysis assesses the stability of the potential outcomes from the perspectives of each of the players. A unilateral improvement occurs when one player can move to a more preferred position at no cost to another player. Additionally, one player can select a strategy that would block another player's position making it less preferred. This is called an inescapable sanction. Finally, there can be inescapable improvements, where an option exercised by a player would lead to a preferred outcome that could not be effected by the actions of other players. Such a position would be considered unstable. An outcome is considered unstable if a change of strategy by one player: (1) would be a unilateral improvement; (2) would be an inescapable sanction; and (3) would be an inescapable improvement.

In analyzing the Garrison conflict, the authors categorized over 40 different parties into taking one of four basic positions regarding the conflict: U.S. support, U.S. opposition, Canadian opposition, and the international perspective of the IJC. The authors identified potential solutions to the conflict by discarding illogical outcomes. The remaining solutions were analyzed for stability from the perspectives of the four positions. Outcomes that were stable for all players were identified as potential equilibria.

The authors concluded that the model predictions closely matched the observed behavior of the players subsequent to the date of analysis. The authors view metagame analysis as having great potential utility in complex political conflicts. They foresee the analysis as providing information to the players as well as anticipating potential resolutions and compromises.

Lussier, B., G. E. Mohr, and I. C. Goulter. 1989. "Conflict Analysis of the Shoal Lake Subdivision." Water Resources Bulletin. 25(1). 111-116.

Key Words: conflict analysis, water supply, game theory

This article applied the techniques of conflict analysis to a water supply conflict which revolved around the desire of the Shoal Lake Indian Band No. 40 to develop cottage lots near the water supply intake of the City of Winnipeg on Shoal Lake in Manitoba. The authors clearly indicated that the intent of the article was to examine the utility of conflict analysis techniques for clarifying issues with resource conflicts and identifying strategies that might lead to their resolution. Conflict analysis, a derivation of game theory, dissects a conflict at a particular point in time. This example was especially relevant since the conflict had become a stalemate.

The main actors in this conflict were the Indian Band, the City of Winnipeg, the Minister of the Bureau of Indian Affairs and Northern Development, and the Federal Environmental Assessment Review Office (FEARO). Since the proposed development had the potential to adversely impact the lake water quality at the intake, the City of Winnipeg objected on environmental grounds. The Indian Band had prepared an environmental impact statement (EIS) for FEARO that suggested adverse effects on Winnipeg's water supply could result from the project and recommended alternative actions to mitigate its impacts. FEARO requested additional information. While the Indian Band prepared this supplemental follow-up information for FEARO, it negotiated with the City, which was interested in purchasing the development rights. The two parties could not agree on a buyout price and the process stalled. The City was unwilling to continue buyout negotiations until the FEARO review was complete. The Band was unwilling to continue the FEARO process until the City resumed its buyout negotiations.

The authors modeled this conflict to illustrate the value of conflict analysis techniques. They identified the players and their objectives and options, which resulted in 64 possible outcomes. Infeasible or inappropriate outcomes were removed, narrowing the list to 13 possible outcomes. Finally, they constructed the preference vectors (i.e., ranking) for each player and assessed the stability of each possible outcome. The product of this conflict analysis was a series of alternative outcomes that would resolve the stalemate to the satisfaction (at least partially) of all parties. The key to resolving this conflict was the continuation of the FEARO review process.

The authors were successful in using this case study to illustrate the value of conflict analysis techniques. However, they were very cautionary regarding the static perspective of these techniques. Their model examined this conflict at one particular point in time. If the conflict changed significantly over time, a new analysis would be required.

Okada, N., K. W. Hipel, and Y. Oka. 1985. "Hypergame Analysis of the Lake Biwa Conflict." Water Resources Research. 21(7). 917-926.

Key Words: game theory, water resources, conflict analysis, water allocation

Hypergame analysis is a variant of conflict analysis in which the conflict model is structured to recognize that misunderstandings occur between participants. This article presents the case study of Lake Biwa in Japan, which has been the center of a long standing conflict between upstream and downstream water users. Lake Biwa, the largest lake in Japan, is relied upon by several large cities downstream of its outflow. Upstream residents wanted to use the lake to attract water-dependent industry. This article was intended to illustrate the utility of hypergame analysis for water resources conflicts and demonstrate its accuracy by comparing its outputs to the actual outcome.

The Lake Biwa conflict provided an opportunity to test conflict analysis techniques in Japan. The authors indicate that while Japanese are generally more accepting of group solutions than Americans, this tendency toward early resolution was offset at least to some degree by their reluctance to reveal their true positions. As a result, the participants knew the options of others but did not clearly understand their preferences. These circumstances made this case study a particularly challenging test of the accuracy of the hypergame conflict analysis modeling structure.

The conflict was modeled for three main actors: the upstream water users, the downstream users, and the national government. For each participant, the authors identified several alternative actions, the different combinations of which produced a spectrum of mathematically possible outcomes for the group. These outcomes were then screened for feasibility, reducing the number of potential outcomes from 128 to 32. The participants' preferred outcomes were ranked in preference vectors and were used to determine the degree of understanding of the other participants' preferences. The potential outcomes were then assessed for their stability. If any of the participants could unilaterally improve their position with no detriment to the others, the original position was considered unstable. If an outcome was stable for all participants, it was considered an equilibrium. In this case, none of the players fully understood the others' true preferences. This hypergame analysis indicated that the misunderstanding of the participants lead them to consider unstable outcomes as potential equilibria. In this case, the most favorable outcome to all participants, the one in which the most cooperation would occur, was not considered viable by any of the participants since they misunderstood the preferences of the other players.

The Lake Biwa analysis clearly illustrated how misunderstandings of preferences can preclude an outcome that would be desirable to all parties. The authors also suggest that hypergame analysis would be very helpful in resolving an ongoing dispute where the potential for misunderstandings is high.

Wang, M., K. W. Hipel, and N. M. Fraser. 1988. "Resolving Environmental Conflicts Having Misperceptions." Journal of Environmental Management. 27. 163-178.

Key Words: conflict analysis, environmental management, hypergames

Planning projects that affect natural resources often receive criticism from the stakeholders that would be affected. Positions taken by the players involved in such a conflict are often based on misperceptions of others' attitudes toward the project in question. This case study uses the hypergame approach to analyze conflict in the proposed construction of a dam for a power company.

The power company was in conflict with a coalition of farmers, environmentalists, and state officials. The power company was seen as misperceiving the position of their opposition. They assumed that stakeholders were voicing opposition to the construction of the dam. In reality, it was not the construction of the dam that generated the conflict, but the potential losses of water resources and endangered species habitat. Power company personnel chose to take a hard-line stance to the opposition and have the issue decided in court. Eventually, a compromise was reached out of court which allowed the construction of the dam and the maintenance of both water rights and habitat for endangered species.

Hypergame analysis shows the possible outcomes that could have resulted in this situation. It appears that this technique could be used to forecast possible outcomes to assist in future planning efforts. Hypergame analysis could be used as a tool to guide stakeholders through a decision making process and also be utilized as a means for reducing misperceptions.

ENVIRONMENTAL

Bojorquez-Tapia, L. A., E. Ongay-Delhumeau, and E. Ezcurra. 1994. "Multivariate Approach for Suitability Assessment and Environmental Conflict Resolution." Journal of Environmental Management. 41(3). 187-198.

Key Words: conflict resolution, environmental assessments, land use planning

Environmental planning should incorporate people's concerns and expectations of natural resources management. Suitability assessments and analyses can be used to provide information about land uses patterns that could reduce social conflicts. The incorporation of multivariate statistical methods can help identify biases in the suitability assessments. This article discusses application of a multivariate approach for regional developmental planning in Mexico.

Suitability assessment for the case study consisted of two stages: (1) identification of the environmental criteria for different land uses and (2) classification and ordination. An interdisciplinary team was assembled based on consultations with policy makers, socioeconomic sector representatives, and nongovernmental organizations. The team identified land uses and listed 57 physical, biological, and socioeconomic criteria for assessing suitability of those uses. The land uses evaluated in this study were agriculture, cattle ranching, urban development, industry, hunting, forestry, water use, bioconservation, tourism, and infrastructure for sport fishing. A binary matrix was used to indicate the favorability of conditions for a particular land use. In addition, regional land uses were classified.

The authors noted that the suitability for land use is relative to the needs and possibilities of the social actors. Alternatives should be formulated to minimize potential conflicts, especially on a regional planning level. The use of local experts proved to be efficient, since it reduced the need for long-term studies and data gathering. The authors indicated that suitability scores may not reflect sectoral preferences but rather the particular biases of those making judgements for certain social actors.

This type of analysis provides a framework that can be useful in identifying areas of potential conflict during regional planning efforts. Public input to this process was determined to occur during the consultations with various groups to identify the region's principal actors. The study did not indicate what constituted socioeconomic groups or nongovernmental organizations. Identification of the interests involved are critical to meeting the project goals.

Overall, this is a unique approach that could be used to forecast possible land use conflicts and initiate the development of alternatives for areas in conflict. Problems with this approach could surface in attempting to incorporate public concerns. Public input is only required at the beginning, and the public does not comment on the results until they have been developed. The design of a mechanism to incorporate public opinions during the process would increase its utility for multiobjective planning.

Fang, L., W. Hipel, and D. M. Kilgour. 1988. "The Graph Model Approach to Environmental Conflict Resolution." Journal of Environmental Management. 27. 195-212.

Key Words: conflict analysis, water resources, environmental conflict resolution, game theory

This article presents a case study of a graph model conflict analysis of an international water resources conflict, the Garrison Diversion Unit (GDU) in North Dakota. The intention of the authors was to illustrate the power of the graph model analysis through this complex conflict and demonstrate the rigorous design and ease of application of this methodology.

The GDU conflict was modeled according to the situations in 1976 and 1984. In 1976, the conflict was peaking. At that time, the Bureau of Reclamation intended to divert water from the Missouri River Basin to irrigate a portion of the Hudson Bay Basin in the United States. The plan was strongly opposed by the Canadian government and the U.S. environmental community which feared the water quality and flood impacts on the rivers draining toward the Bay, as well as biological contamination of the Bay with nonnative species. During the 1970s, the Canadian government expressed its concerns through diplomatic channels. In 1976, the International Joint Commission (IJC), an international mediator for U.S./Canadian boundary waters disputes, became involved. In an effort to defuse the dispute, the IJC established the Garrison Diversion Unit Commission (GUDC) to make recommendations to the U.S. government. The 1984 analysis modeled the dispute just before the GUDC released its report.

The two analyses applied the same procedures to the different situations. The graph model presented in this article was based on conflict analysis methodologies. However, it differs from them in that it takes outcomes rather than individual decisions as the basic units for describing the conflict. The 1976 situation was modeled with four players: U.S. supporters of the project, U.S. opposition, Canadian opposition, and the IJC. As in other conflict analyses, the options of the players were arrayed in a matrix to present the different combinations of options open to each player and the range of potential outcomes. For example, in 1976 the U.S. supporters of the project could have chosen among three logical options: (1) proceed to complete the GDU, (2) modify the plan to reduce Canadian concerns, or (3) modify the plan to respond to U.S. environmentalists. The potential outcomes were then screened for their stability. If the satisfaction level of one player could improve without reducing the satisfaction of other parties, the outcome was considered unstable. Outcomes that were stable for all players were considered equilibria and therefore potential resolutions. The graph model of the conflict consisted of a set of directed graphs and a set of payoff functions that illustrate possible types of behavior of the parties.

This article is an effective application of a graph model to a water resources conflict. This case study illustrated accuracy and systemic methodology. In the 1976 analysis, the model produced a resolution that in fact was achieved, although at the time it would have appeared to be an unlikely outcome. In the 1984 analysis, the model produced a compromise that was satisfactory to all parties and was also achieved. These backcasts have been used to refine the techniques. When they can be applied on a real-time basis, they should prove equally effective as forecasting tools that provide information to the parties in the conflict.

Fraser, N. M. and K. W. Hipel. 1988. "Using the DecisionMaker Computer Program for Analyzing Environmental Conflicts." Journal of Environmental Management. 27. 213-228.

Key Words: conflict analysis, computer programs, decision support systems, environmental management

---

DecisionMaker Version 2 is a computer program that facilitates rapid solutions for modeling and analyzing multiple stakeholder disputes. This article examines a past water resources conflict between the Environmental Protection Agency and the Tennessee Eastman Company. The conflict concerned a National Pollution Discharge Elimination System permit for the company's discharge into the Holston River in Tennessee. DecisionMaker is used to show how the conflict could have been resolved in a shorter timeframe.

DecisionMaker evolved from a conflict analysis program developed by Fraser and Hipel in 1979. The program is simple to use, does not require extensive computer knowledge by the user, determines possible resolutions, and suggests optimal paths for stakeholders. This information can be used to explain the conflict to others. DecisionMaker can accommodate 64 players and 64 options and is run in the Microsoft Windows environment.

Users of the program are asked to determine infeasible options after all the players and options have been input. The computer removes all impossible scenarios based on this information. Users are then asked to rank their preferences toward the remaining feasible options. The computer queries the user if the chosen option should be: followed, not followed, or followed under certain conditions. A preference tree is generated from the responses. DecisionMaker locates option trends among users during this process.

The program has potential for applications in water resource planning. In the Holston River case study the model identified a mutually satisfactory outcome that was eventually reached. However, the authors note that some concepts are being incorporated into future DecisionMaker software not found in the present version. These concepts include Hypergames, Cooperation, Coalitions, Intransitive Preferences, Conflict Dynamics, Sensitivity Analysis, Backtracking, Multiuser Conflict Analysis, Probability and Risk Considerations, Solution Concepts, Integration with other Decision Making Techniques, and Artificial Intelligence.

Overall, DecisionMaker appears promising for water resources applications. Prudent skepticism should be exercised in its actual use during active conflict, since this was a simulation based on a past situation. The program may expedite the decision making process, but it cannot force an unwilling stakeholder to participate.

Kilgour, D. M., L. Fang, and K. W. Hipel. 1992. "Game-Theoretic Analyses of Enforcement of Environmental Laws and Regulations." Water Resources Bulletin. 28(1). 141-154.

Key Words: decision making, game theory, environmental policy

The authors of this article develop and analyze simple game-theoretic models related to the inspection and enforcement of environmental regulations in Canada and the United States. These countries were chosen because of the similarities in their enforcement policies. Verification theory, the application of game theory to multiple participant decision making, was the impetus for the study.

Two models were developed to determine the incentive for private owners to violate regulations and the means of improving compliance rates. One model allowed violators to appeal charges levied by an inspector; the other did not. Models were designed as decision trees and incorporated random effects to represent uncertainties in the process. Probabilities were used to determine the likelihood of certain events taking place. Finally, payoff parameters for the decision makers were generated to determine the value of a decision, such as to violate or to inspect a possible violation.

Both models were determined to have a unique equilibrium which constitutes the ability to predict the behavior of decision makers consistent with their interests. One conclusion was that there is no trade-off between inspection costs and severity of punishment. Another conclusion was that use of the courts for determining guilt and punishment has mixed results for environmental protection.

This article is valuable to this research from several perspectives. It displays the applicability of game theoretic tools to broad environmental issues and to situations other than conflicts. The authors state that these models do not provide numerical answers for policy questions, but they are useful in assessing behavior patterns and in facilitating comparisons of the effects of different structures. This approach was seen as contributing to selecting cost-effective methods of enforcement structures. With regard to trade-off efforts, this approach would be useful if a planner was attempting to determine the behavior of certain individuals or groups based on use of a particular alternative.

Maguire, L. A. and L. G. Boiney. 1994. "Resolving Environmental Disputes: A Framework Incorporating Decision Analysis and Dispute Resolution Techniques." Journal of Environmental Management. 42(1). 31-48.

Key Words: conflict resolution, decision analysis, environmental dispute resolution, group decision making

---

Policy disputes are characterized by a number of factors. These include: (1) limited information regarding processes that affect outcomes; (2) outcomes that may be irreversible; (3) persons who can influence outcomes; (4) differences in subobjectives; (5) disagreements in the effectiveness of policy implementation; and (5) a need for consensus. The authors' goal of this article was to link conflict resolution and quantitative decision making into a systematic framework and show how it facilitates consensus in a case study involving an endangered species.

Decision aids generally are comprised of a probability model that incorporates uncertainties and a utility model that incorporates decision maker values. Aids mentioned include initial decision analysis, adaptive environmental assessment, cost-benefit analysis, multiattribute theory, and decision conferencing. Alternative dispute resolution (conflict resolution) was integrated with the aforementioned tools to provide a framework for resolving policy disputes.

The resolution framework consists of three phases: clarification and communication, information gathering and sharing, and generation of new alternatives. There are 15 steps within the phases. Execution of these steps is designed to graphically show stakeholders' views within common measurement criteria. Conflict resolution techniques in this process allow for determining a compromise among stakeholders, showing where differences in beliefs can be dovetailed to construct contingency plans, and revealing underlying values for exploiting differences in subgoals.

This article provides a listing of several tools that could be used in facilitating multiobjective planning. The authors recognize that there is the potential of participants to manipulate parameters, but suggest using an intervenor during the decision analysis to reduce the likelihood of this occurring. Although this article does not specifically address implications for water resources, this strategy could be applied to multiobjective water resources planning.

OTHER

Hipel, K. W., A. Dagnino, and N. M. Fraser. 1988. "A Hypergame Algorithm for Modeling Misperceptions in Bargaining." Journal of Environmental Management. 27. 131-152.

Key Words: conflict analysis, decision making, game theory

Disputes in environmental decision making are due to disagreements regarding participants' environmental concerns and economic interests. When decision making is for a community, it is advantageous to find a compromise that provides at least some benefits to everyone. The authors present a game theoretical model for bargaining situations in which two or more decision makers are involved and have misperceptions regarding each other.

Bargaining is an approach being used more often in environmental disputes for a number of reasons. Resolutions result from a better understanding of the problems and positions of the participants, making a negotiated solution more fair than a legal judgement. Also, bargainers will strive to get the most tenable position since they have to live with the negotiated agreement. Finally, a negotiated settlement is easier to implement than a litigated one.

Two significant obstacles to successful negotiation are strategic interactions among stakeholders and misperceptions of other stakeholders' positions. A hypergame cooperative conflict analysis system (HCCAS) is developed for the examination of bargaining interactions. The stages of HCCAS are collecting information from the real world, structuring the problem situation, modeling the options and outcomes of the decision makers, defining the structure of the bargaining situation, assigning decision makers' preferences, forecasting stable outcomes or resolutions, and selecting a strategy. The article puts forth the algorithm to be used for HCCAS and provides a case study for its application.

The benefit of this analysis is the ability to analyze and compare cooperative and noncooperative options of the stakeholders. This could prove useful in a difficult planning process where stakeholders do not have a history of cooperation. By forecasting options and determining those that are most feasible to all players, a negotiator or planner can provide some options of mutual gain to reduce tensions and focus stakeholders toward a group solution.

GROUP PROCESSES

DECISION ANALYSIS

Keeney, R. L., D. von Winterfeldt, and T. Eppel. 1990. "Eliciting Public Values for Complex Policy Decisions." Management Science. 36(9). 1011-1030.

Key Words: group processes, consensus building, focus group, public involvement, energy

This article reviewed techniques for eliciting public values in policy making. It concentrated on evaluating the effectiveness of public value forums via a case study application to long-term energy policy in West Germany. The case study focused on determining if values can be systematically elicited from the lay public and combined with factual inputs from experts. In addition, the case study was designed to: (1) assess the extent to which formally elicited values conflict with values elicited informally; (2) compare values elicited with and without specific knowledge of policy alternatives; and (3) to evaluate how these discrepancies can be resolved by the lay public.

Public value forums are combinations of focus group and direct value elicitation techniques. The latter consists of facilitators interacting with groups to elicit valuations of competing objectives and determine their trade-off ranking through a multiattribute utility analysis. Public value forums are essentially the application of direct value elicitation techniques in a focus group setting. The participants in a public value forum can be either stakeholders or randomly selected citizens who represent the general public. The authors facilitated two separate forums for the case study. One forum consisted of engineers (i.e., the "experts"), the other with social science teachers (i.e., the lay public). In preparation for the forum, the energy problem was structured into four paths that could lead Germany into a sustainable energy future. In addition, interviews were held with representatives of ten major German organizations and a hierarchy of general concerns (i.e., the "value tree") was constructed. The participants reviewed and modified the value tree, and provided their intuitive evaluations of the energy futures, and evaluated each future based on attributes identified in the value tree. To this end, they then ranked the different objectives to determine trade-offs, which were combined into a multiattribute utility model for each participant. The authors compared the models of engineers and teachers as informed and intuitive valuations of objectives and energy futures.

The authors concluded with four observations. First, the value forum is feasible, and values can be systematically elicited from the lay public and combined with the factual inputs from experts. Second, values elicited formally disagreed with values elicited informally, but such discrepancies can be resolved through the forum process. Third, values elicited with specific knowledge of the policy alternatives disagreed with values elicited without that knowledge, but such discrepancies can also be resolved. Finally, the value forum can provide important value information relevant to the policy formulation process. The authors did indicate that it is an expensive and time consuming process.

Mullen, J. D. and B. M. Roth. 1991. Decision-Making: Its Logic and Practice. Savage, MD: Rowman & Littlefield.

Key Words: decision theory, game theory

This text was designed by the authors to help the reader, as an individual, make better decisions regarding virtually any subject. It is a comprehensive introduction to decision theory and the presentation is accessible to the uninitiated.

The text breaks down decisions into their component elements, including problem recognition and values analysis, generating alternative choices, evaluating choices, binding the will, and ignoring sunk costs. The authors acknowledge the differences between normative decision theory (i.e., what people should do) and empirical decision theory (i.e., what people actually do) and attempt to synthesize the diverse literature in the multidisciplinary field of decision theory.

The authors begin by discussing decision-making through an examination of the broad contexts. The psychological aspects of decision making are the first category, with particular attention to identifying psychological impediments to sound decisions. The formulation of rational decisions and the resolution of internal conflicts are particular emphases of the discussions of psychological decision context. These conceptual foundations are followed by discussions of how to evaluate complex outcomes. The roles of values in decision making and the optimal balancing of multiple objectives in a single decision process are outlined. The authors then describe the importance of risk, correlation, and causality as decision parameters. These subjects are laden with common misconceptions and fallacies that the authors undermine. With these concepts as components, complex situations can be analyzed, and rational decisions can be made. The case studies effectively illustrate the utility of the decision framework, with applications to situations as diverse as the problem of breast cancer, the Nicaraguan civil war, and the purchase of a car.

When multiple parties are attempting to decide the outcome of a conflict, the decision making is transformed from individual to collective. Game theory is presented as an insightful device for understanding the rationality of behavior of parties in different types of conflict situations. The final subjects that the authors address are bargaining and negotiation. Under different negotiation contexts, the behavior and strategies of the participants can be very different. A crucial element to a successful negotiation process is that each person understand his/her own needs and those of the other players. This process inevitably involves tradeoffs of competing objectives, but in many circumstances a consensus can be reached that represents a "fair" balance of competing interests.

This text provides an effective overview of decision processes for individuals and groups. Multiple objective analysis, tradeoffs, and negotiation processes are all addressed in detail as part of a continuum of decision making. Perhaps the greatest utility of the text is that it illustrates that the same decision processes can be applied to many different types of problems over many different scales.

Plous, S. 1993. The Psychology of Judgement and Decision Making. Philadelphia: Temple University Press.

Key Words: decision analysis, psychology, social psychology

This text is an introduction for nonspecialists to the psychological research on decisions and judgements, primarily those of individuals. The focus is on experimental results rather than psychological theory. Similarly, conclusions rather than intuitions are emphasized and descriptive prose is preferred to mathematics.

The major components of decision and judgement processes were identified, including perception, cognitive dissonance, memory, context, and challenges of the wording in experimental survey questions. These discussions were followed by the presentation of different models of decision making. Among these models were expected utility theory, paradoxes in rationality, and various models of decision making. In addition, different biases in decisions and judgement and perceptions of risk were explored to explain complex decisions and behaviors.

The social psychology of group judgements was described. Sources of group errors in judgement were explored and tendencies toward group polarization were described. The author explains that while group judgements tend to be somewhat more accurate than individual judgements, this is not necessarily always true. Group dynamics can sometimes suppress hidden biases and propagate it in others.

This text is an effective introduction to the psychology of decisions and judgements of individuals and groups. Its relevance for multiattribute planning, tradeoff analysis, and negotiation processes is twofold. First, it is helpful in understanding an individual's perceptions and behavior as he or she makes internal trade-off analyses. Second, this text gives insight to the perspectives of individuals when they enter into group processes.

von Winterfeldt, D. and W. Edwards. 1986. Decision Analysis and Behavioral Research. New York: Cambridge University Press.

Key Words: decision analysis

Decision analysis (DA) is a means for individuals and organizations to determine an optimal choice. It has evolved from its roots in psychological economic theory to provide a prescriptive rules set for decision making. The authors discuss a range of topics. This range includes history, basic concepts of DA, structuring, decision trees, measuring uncertainty, inference, value and utility measurement, multiattribute theory, sensitivity analysis, pitfalls of DA, and cognitive illusions. This annotation will emphasize the basic concepts of decision analysis as discussed in Chapter One of this book.

Most decision making in life is not difficult because the best option is usually obvious or the topic itself is trivial. When the decision is complex, tools like DA structure simplify the components of a situation. Rationality is an important component in decision making, but rarely is there a distinction between rationality in selecting ends and rationality in selecting means. The suggested focus is means since the quality of decisions is related to the quality of the process used and the quality of information available.

Structuring the problem is the most important part of any DA. Creating the structure is not an easy task but often an art because of the need to specify relevant values, identify options, and define relationships among options and outcomes. Within the structure, analysts can use descriptive or normative models for decision making. Descriptive models describe people environments, or tasks; normative models prescribe actions and specify environmental conditions.

DA serves several other important functions. DA can be used to define objectives, quantify subjective variables, and identify or reformulate options. If there are a large group of decision makers, DA helps to establish lines of communication as well as a common understanding of issues and positions among stakeholders and decision makers.

Software is available to assist decision makers in their tasks. Yet, none can account for all the factors affecting the decision making process. Efforts aimed at educating decision makers about the components of DA could provide utility in two ways. First, they would be better prepared to address pitfalls associated with decision making. Second, software tools could be better utilized because their use in the decision making process would be more clearly defined.

MEDIATION

Bingham, G. 1986. Resolving Environmental Disputes: A Decade of Experience. Washington, D.C.: The Conservation Foundation.

Key Words: Dispute Resolution, Mediation, Negotiation, Water Resources

Environmental mediation is a rapidly developing subset of alternative dispute resolution method due to the increasing awareness of the value of preserving natural resources and the services they provide. This book examines the growth of the environmental dispute resolution field, the utility of the process, and the factors affecting success. One hundred sixty-one environmental mediation cases were examined in the development of this text.

Environmental dispute resolution refers to a variety of approaches where involved parties voluntarily meet face-to-face to resolve difficult issues or situations that fall in one of six general categories. These categories are land use, natural resource management and use of public lands, water resources, energy, air quality, and toxics. Seventy of the cases examined were identified as land use problems, which included wetlands protection and recreational issues. Mediation in these instances does not always produce an immediate solution, but it can serve as a means for successful communication between involved parties.

In seventy-eight percent of the cases examined the involved parties reached a successful resolution. The author indicated that it is not always in a party's best interest to negotiate a compromise since some disputes involve parties with unequal power. Pursuing litigation can give the party in the weaker position the opportunity to demonstrate aggressiveness to the constituency they represent.

The book describes important components and factors of mediation. The author identifies a common misconception regarding the number of parties involved in mediation. Although many resolution experts indicate that no more than 15 groups should be involved in mediation, there was no support for this general rule in the cases examined.

It is important to note that this book is somewhat dated since the case study information provided only runs through 1984. However, the information is valuable and includes a brief summary of the cases examined. The summaries indicate the objective of the mediation, pertinent issues, the parties involved, and what person or organization provided mediation services. The mediation organizations identified in the text could be an important source of current information and techniques to be used in future trade-off analyses.

Kolb, D. M. and K. Kressel, eds. 1994. "The Realities of Making Talk Work." When Talk Works: Profiles of Mediators. San Francisco: Jossey-Bass. 459-494.

Key Words: conflict resolution, mediation, negotiation

This book provides profiles of twelve prominent mediation professionals practicing their craft. The mediators were grouped into professionals, field builders, and those extending the reach of mediation. This information was used to determine common mediation practices. This annotation discusses the results of the study presented in the last chapter of the edited text.

Mediation theories have engendered common rules to which all mediation activities are supposed to adhere. Practitioners are supposed to be neutral, without authority, and not wanting to impose personal views on the disputing parties. The mediation process is to be voluntary and noncoercive, and can be a positive experience in spite of the numerous ethical, moral, and psychological requirements. This scenario was not found to exist in real mediation situations. This is because mediation situations encounter different issues, stresses, and circumstances. Also, the motivations for mediator participation can vary, especially if there is a vested interest, such as a former president negotiating a peace treaty between two countries in conflict.

Practitioners may have differing prospectives regarding the goals of mediation, which often go beyond achieving an agreement. Two perspectives identified in this study are transformative and pragmatic visions. Those with a transformative vision see the mediation process as a means for empowering individuals, changing a system of behavior, and setting new societal standards. Pragmatic-oriented mediators seek change, but within a system. Pragmatists favor efficient approaches and solutions. Each vision has problems; transformations rarely occur and pragmatism usually provides short-term solutions.

Mediator perceptions about goals can affect the outcome. Some mediators see the end product as a settlement to be reached. This involves concrete problem solving and making suggestions based on substance. Others see mediation as a way to open lines of communication between those involved in a dispute. The disputants will have a better understanding of the issues and perceptions of those involved even if a settlement is not reached.

This discussion indicates that mediation requires more attention and development even though the techniques have been in place for many years. It also provides an important reality check in the development of trade-off approaches and planning situations: No matter how concrete the rules may seem, interpretation and application of them by an individual will be different depending on one's disposition. The implementation of any programs to enhance multiple objective planning should keep these dispositions in mind.

Moore, C. W. 1991. Corps of Engineers Uses Mediation to Settle Hydropower Disputes. Fort Belvoir, VA: Institute for Water Resources.

Key Words: alternative dispute resolution, hydropower, mediation

This document is a case study of the Army Corps of Engineers alternative dispute resolution program that encourages Corps managers to develop and utilize new ways of resolving disputes. Alternative dispute resolution (ADR) can be used to prevent conflicts, resolve them quickly, and provide an alternative to litigation.

The operation of dams and reservoirs has become increasingly contentious. Different groups seek to advance one project purpose, whether flood control, recreation, hydropower, or environmental, to become the highest operational parameter for that particular project. In 1988, the Corps initiated a mediation effort for the operation of the Harry S. Truman Dam and Reservoir in Missouri. Hydropower operation of the project was problematic due to fluctuating reservoir levels, entrainment of fish in the turbines, and during the pumped storage operations. The Missouri Department of Natural Resources opposed the hydropower operations on environmental grounds. After a period of contention between (1) the Corps and hydropower proponents and (2) the state agency and opponents of hydropower at this project, an interagency Coordination Committee was formed to facilitate resolution of this conflict.

The Coordination Committee and supporting technical studies were unable to resolve the hydropower controversy which widened as both sides sought the political support of elected officials and the public. The respective campaigns to develop support only widened the conflict and polarized positions. The conflict was ripe for mediation, since (1) both parties concluded time was not in their favor, (2) each of the parties was strong enough to support a compromise, (3) there were options available to meet the needs of each party, and 4) the parties were frustrated by prior procedures used to resolve the dispute.

The author was chosen as mediator and met with the parties separately prior to a joint meeting. The mediation commenced with representations of the perspectives of the parties. The discussions then focused on identifying: (1) general principles which might structure the terms of the negotiated settlement and (2) elements of the current operations acceptable to both parties. In successive meetings, the scope of the focus narrowed toward the operational details by building upon the positive foundation and subsequent commonalities. Despite a temporary backslide in the mediation, the parties were able to maintain the positive direction of the negotiations and eventually reach a settlement.

This document illustrates the power of mediation in solving water resources conflicts and depicts the details of the mediation process. It also represents the trend toward ADR in environmental management and how commonalities serve as the basis for solutions. In this case, the proactive role of the mediator was particularly important in maintaining momentum in a process that, at one point, began to drift away from resolution.

Delli Priscoli, J. 1988. "Conflict Resolution in Water Resources: Two 404 General Permits." Journal of Water Resources Planning and Management. 114(1). 66-77.

Key Words: regulatory negotiation, conflict resolution, water resources, wetlands, permits

This article presents the application of alternative dispute resolution techniques to two water resources conflicts and evaluates them in light of current negotiation theory. The two case studies revolved around the Army Corps of Engineers involvement in the negotiation and ultimate award of two Section 404 (Clean Water Act) general permits. Both cases can best be described as regulatory negotiations. The first case concerned a general permit for filling of wetlands on Sannibel Island, Florida. The Jacksonville District facilitated and later mediated negotiations between conflicting interests, including landowners, developers, environmentalists, and the local (island) government. The second case involved permits for the disturbance of wetlands for hydrocarbon exploration drilling in Louisiana and Mississippi. The Vicksburg District facilitated and later mediated negotiations, primarily between environmental groups, industry representatives, and the state environmental agencies.

Rather than process individual permits for each proposed activity through traditional in-house permit reviews, the Corps Districts proposed that it facilitate negotiations between the conflicting interests. In both cases, the parties were initially suspicious of the Corps, the opposition, and the process. However, the Corps was able to appeal to the interests of conflicting parties in having a single general permit (as opposed to multiple separate permits) and their desires to have their views represented in the permit processes.

Each of the negotiation efforts was carefully planned by the Corps to identify all major parties interested in these permits and create an atmosphere that fostered open communication between the conflicting interests. Through a series of four workshops, the suspicion between the different parties was reduced and the interests of all parties were identified. Eventually, the different parties were able to cooperate in the development of the details of the permits and agree on the outcomes. The Corps representatives worked hard to establish the neutrality and credibility of the Corps in the negotiations and maintain their momentum and direction.

After the presentation of the details of the case studies, the author interpreted them in light of current negotiation theory. The successful resolution of these cases was attributed to a combination of positive elements. Among the favorable circumstances were the perceived potential for favorable outcomes, the clarity of the differences between parties, the range of available alternatives, and the equal footing of all participants.

These case studies demonstrate the power of negotiation as a conflict resolution tool for water resources decision making. Parties that were initially antagonistic were able to discuss their differences and achieve mutually satisfactory results. The importance of neutral facilitation is repeatedly emphasized by the author as are the contributions of careful design and sensitive facilitation of the group processes.

Rabe, B. G. 1988. "The Politics of Environmental Dispute Resolution." Policy Studies Journal. 16(3). 585-601.

Key Words: alternative dispute resolution, environmental conflict, policy, litigation, mediation, negotiation

---

This article provides a review of the role of an alternative dispute resolution method for environmental conflicts (EDR) in American environmental policy formulation and implementation. The intention is to caution against a blind rush to embrace EDR as the panacea for current environmental problems. The author describes the ongoing penchant for using litigation as an environmental policy tool and the current and potential role of EDR in this antagonistic context.

The author traces the current litigious atmosphere to a reluctance of Congress to formulate detailed environmental policy and the difficulties faced by the judiciary in rendering consistent, balanced, and often very technical policy interpretations of legislation in situations with many different interests and actors. The laborious process of judicial interpretation of environmental policy helps explain the high dollar and time costs of environmental litigation. Since the early 1980s, EDR has gained widespread recognition as a viable alternative to litigation.

Citing past searches for environmental panaceas, the author calls for a careful consideration of EDR before wholesale incorporation of it into U.S. environmental policy making. The author notes that many of the glowing reports of the utility of EDR have been made by professional mediators. He cautions that more objective evaluations of the processes are required before embracing them.

Perhaps the foremost impediment to widespread adoption of EDR may be the political realities of American policy making. In the adversarial democracy of the U.S., EDR may not have the same potential as in a unitary democracy such as the U.K., where social interests are more often perceived as common. The author notes that some environmental groups may be reluctant to abandon adversarial, litigation-based strategies which can generate significant and highly visible results for organizations with limited resources. The lack of public confidence in environmental management institutions could also inhibit applications of EDR techniques. In addition, the perception that the EDR processes are exclusive during a period of more open public policy formulation could further constrain its adoption. Finally, the public's aversion to environmental risks may limit their acceptance of negotiated, subjective risk levels.

The author also notes that in western Europe, where the environmental policy making is far more consensual than in the U.S., the superior effectiveness of environmental policy is not evident. The author is not antagonistic toward EDR techniques. Rather, there is recognition of its utility and its promise in future efforts.

Thiessen, E. M. and D. P. Loucks. 1992. "Computer Assisted Negotiation of Multiobjective Water Resource Conflicts." Water Resources Bulletin. 28(1). 163-177.

Key Words: conflict resolution, decision making, multiobjective, negotiation, water resources

A growing number of computer software programs are entering the market that can be used to assist in the negotiation or mediation process among conflicting groups. Some of these programs can accommodate a large number of parties involved in a conflict. This article describes a negotiation process support system called ICANS and its use in bringing conflicting groups to an agreement involved in a water resources dispute.

Negotiation support systems are categorized as either a preparation system that supports a prenegotiation planning stage or an information management system that facilitates real-time negotiations. Some of the existing negotiation preparation systems currently available include DECISION MAKER, CONAN, NEGOPLAN, DECISION TREE, DIPLOMAT, NEGOTIATION EDGE, and SPAN. Negotiation information management systems that have been developed include ICANS, SYSTEMS INTERVENTION, SYSTEMS THINKING, OIL SPILL CLEANUP COST MODEL, IMAGE, RAINS MODEL, POLICY-PC, PERSUADER, MEDIATOR, NEGOMASTER, PARETO RACE, and DECISION ANALYSIS.

ICANS is designed to present information which will help disputing parties reach an agreement. ICANS requires goal information from each party to begin the process, and this information is kept secret from all other parties involved. The required information is a range of possible decision values for each issue to be examined. ICANS processes this information under the assumption that the issues being examined are exclusive of each other, and not interdependent on another. If there are mutually dependent issues, they should be combined into one.

Information collected is processed to determine a common base from which to continue. Parties can use the common base to define regions of mutual gain, find alternatives equivalent to party proposals, find improved alternatives, or search for a better alternative. Throughout these attempts, information may be updated if a party's position has changed. The model is able to generate graphs and charts to pictorially communicate information and indicate where possible solutions exist. (However, without being able to run the program, it is difficult to determine how much effort is required to operate the system.)

Overall, the article provides a good description of the ICANS model and its capabilities. ICANS is a negotiation tool which may have limited use in a planning setting unless there are significant sticking points in a trade-off process. It may be useful for training personnel regarding the process for resolving conflicts. Other computer tools are mentioned in the article that could be examined to determine their applicability in trade-off situations.

NEGOTIATION

Fisher, R., W. Ury, and B. Patton B. 1991. <u>Getting to Yes: Negotiating Agreement Without Giving In</u> (2nd ed.). New York: Penguin.

Key Words: negotiation

Negotiation is something that people do throughout their lives, but rarely do they realize it. Whether it is haggling over the price of a used car, selecting a movie to see with someone, or mediating a peace treaty, negotiation is a part of everyday life. Most daily negotiations are disorganized and cause those involved to take a positional stance. The authors of this book recommended shifting from a positional stance (selecting a side to argue from) to a principled one (negotiation based on objective standards). By doing so, more options can be considered in the negotiation process.

Positioning in negotiation can (1) be inefficient, (2) endanger relationships, and (3) produce unwise agreements. Selecting a position requires the determination of using a "soft" or "hard" approach based on who is involved and what the relationship is between those in the negotiation. The authors recommend using principled negotiation via four steps. They are: (1) separate the people from the problem; 2) focus on interests, not positions; (3) create a variety of possibilities before deciding what to do; and (4) insist that the result be based on some objective standard. These steps reduce the emotional influence on the situation, examine issues, and create more opportunities for a successful resolution.

People involved in a dispute rarely consider examining many options because each believes they have the "right" answer. The obstacles associated with examining other options include making premature judgements, searching for a single answer, assuming there is a fixed sum, and believing that solving the problem should not involve anyone else. These obstacles can be overcome by inventing options without judging them, broadening options instead of searching for a single answer, seeking opportunities for mutual gain, and inventing ways to make decisions easy. This approach can be used by one party or in cooperation with others in dispute. When a decision is to be reached, it should be based on specific objective criteria.

This book further examines the development of a Best Alternative To a Negotiated Agreement and methods for avoiding traps associated with people who attempt negotiation with "dirty tricks." It is important to note that people often fall into positional negotiation, even when they have the best of intentions because they did not have an organized approach.

In multiobjective planning efforts in water resources, project planners need to be aware of the positional approach and direct stakeholders away from it to the principled approach. Planners should be prepared to assist with negotiations among the stakeholders. The use of the techniques discussed above could lead to projects with a better design and a higher approval rate by the participants involved.

Gorczynski, D. M. 1991. Insider's Guide to Environmental Negotiation. Chelsea, MI: Lewis Publishers.

Key Words: environmental conflict, negotiation, alternative dispute resolution, conflict resolution

This text is a practitioner's guide to environmental negotiation. The author's perspective is based on 11 years of service on the Houston City Council. In contrast to academic and theoretical treatments of negotiation processes, this text presents the hard-won experiences of a public official who was involved in a wide diversity of environmental projects. It is an insider's view from the "trenches." The informal writing style presents the practitioner's perspective as friendly advice, but the casual style belies the very practical guidance.

The author describes the entire process of environmental negotiation in a sequence of discussions that moves from general to specific. First, the setting is characterized by outlining the level of formality, the degree of privacy of the negotiations, and the role of the media. Environmental negotiations take place under varying circumstances, and the setting can be a crucial factor in determining the success of the process and the achievement of your goals. The next discussion focuses on the players in the "game" of environmental negotiation. This may include elected officials, bureaucrats, industrialists and developers, environmental activists, the lay public, lawyers and lobbyists, and the personality types that can be helpful in the negotiation process. The author describes the process as a game)to perceive actions as they move and countermove, and to avoid excessive emotional involvement because of the potential loss of reason in perception and behavior.

Having established the context, the author outlines alternative strategies for environmental negotiation. He suggests that negotiators follow a five-part process to formulate negotiation strategy, including research of the issue and the opposition, taking stock of the negotiator's position, organizing a negotiating team, and developing a plan of action and reaction. The author also discusses a variety of tactical approaches to achieve the strategic goals in the negotiation process. This discussion includes the evaluation of alternative approaches under different negotiation circumstances as well as the most effective countermoves when these approaches are employed by one opponent against another.

This text is comprehensive and offers the valuable experience of a seasoned practitioner. Its discussion of the aftermath of the environmental negotiation process is particularly valuable. Regardless of the outcome with respect to who won or lost, the author suggests ways to exit the negotiation process gracefully without permanently antagonizing opponents. This may exemplify one of the most important points of the text: Negotiation with the individuals or groups where there is an antagonistic relationship is a relationship nonetheless. While the author identifies kamikaze techniques that can be used as a last resort, particularly when defeat is imminent, analysis, reason, and communication are always preferable to extreme positions and intransigence.

Moscovici, S. and W. Doise. 1994. Conflict and Consensus: General Theory of Collective Decision. London, England: Sage.

Key Words: conflict, consensus, decision making

Public decisions play a predominant role in everyone's life. Seeking consent from the public in making a decision requires more than reaching an agreement based on a discussionless vote. Debate, discussion, or a public statement allow for a more objective examination of the matter at hand. This book explores the theory of collective decisions among people and how consensus can be achieved.

Numerous studies have been conducted to determine the roles of elements of consensus without much success. Ownership of a problem is an important component in achieving consensus. If people view a problem as growing in importance to them, they will do more to clarify definitions and generate alternatives to provide solutions. Voicing the importance of a situation in the public arena can cause others to speak out either for or against, thus motivating others to act and work together in solving a problem. In solving the mystery of the nature of groups, attention should be given to the way individuals and groups change instead of how group processes bring people together.

Participation is an important part of the human experience and provides meaning to one's life. This is true as long as the freedom of action and speech are guaranteed among members of a group. A person's participation leads to an investment of resources in a process, whether monetary, physical, or time. These investments increase the value of what is being examined, thus increasing the need of the investor to be heard. Conflict can result from this, and the greater the number of people who want to speak, the more likely it is conflict will occur. Consensus should tolerate these conflicts rather than suppress them. This validates an individual's right to active expression within the group and the right to scrutinize an issue. A suppression of conflict removes these validations.

There are further discussions on values and persuasion, the physical setting where a group meets, how group members communicate with one another, and differences among open and closed groups. The final chapter in the book discusses decision making, with an emphasis on divergent and convergent thinking. Convergent thinking was recognized as accommodating conflict and leading to better decisions.

Facilitating conflict in a group is important to good decision making. This book provides the theoretical basis for addressing conflict in a manner that will assist in bringing groups to consensus. Planning efforts require the attendance of all stakeholders, which will bring some adversaries face-to-face. Corps planners can assist in developing better plans if they are able to recognize the needs of individuals and what motivates them to seek consensus.

PUBLIC INVOLVEMENT

Creighton, J., J. Delli Priscoli, and C. M. Dunning, eds. 1983. Public Involvement Techniques: A Reader of Ten Years Experience at the Institute for Water Resources. Fort Belvoir, VA: Institute for Water Resources.

Key Words: public involvement, water resources, environmental management

This document was developed to provide an overview of the public involvement (PI) research and training of the Corps Institute for Water Resources (IWR) over the first ten years of the Corps PI effort. The Corps was one of the first resource agencies to fund PI research and training, tracing its origins to a Corps-wide PI conference held in February 1971. This document commemorates the great strides made in PI that resulted from IWR's aggressive follow-up to that initial event.

A great deal of research, consulting, and training materials were developed by IWR during this decade. These materials are organized in this reader through the sequence of sections that address the following questions:

What are the purposes of public involvement?
How should a PI program be structured?
What institutional implications and constraints apply to public involvement?
Who is the "public"?
How should public meetings be conducted?
What other PI techniques can complement public meetings?
How might PI be used for regulatory programs?
How should PI programs be evaluated?
What are the future directions of public involvement?

Each chapter provides a snapshot of the state-of-the-art (1983) techniques for the different aspects and perspectives of PI activities. Within each section, the chapters are presented in chronological order to trace the evolution of PI strategies. In many cases, the chapters are excerpts from larger training documents to provide a representative sample of that particular aspect of public involvement.

This reader serves as an excellent introduction to PI and its role in the planning and decision making processes. It explains the need for PI and alternative strategies. While it does not contain extensive discussion of group processes, it places PI in the larger social and organizational contexts crucial for appreciating the subtleties of these processes. Although this reader is somewhat dated, it continues to be cited in the literature of PI and group processes. Perhaps the message most timeless in this document is that PI is an art and not a science. As the approaches to PI become more refined and often more technical, this message provides a cautionary note that resonates today.

Delli Priscolli, J. 1989. "Public Involvement, Conflict Management: Means to EQ and Social Objectives." Journal of Water Resources Planning and Management. 115. 31-42.

Key Words: conflict management, decision making, water resources planning and management

The development of water resources projects is seen by most as a primarily analytical task. Yet, much of the work to be completed requires numerous interactions with people to solve a problem, agree on facts, or simply improve the relationships of the planning team. This article presents seven observations regarding social and environmental objectives related to water resources planning and management.

It is somewhat difficult to separate the roles of conflict management and public involvement. Conflict management provides a means for consensus building and power sharing. Public involvement techniques emphasize the discussion and exchange of information. Both provide opportunities to bring people together for creating alternatives based on interests and values.

Public involvement and conflict management are useful tools for a planner. Their incorporation into a planning effort can assist in defining the balance between environmental concerns and economic development. They can clarify relationships between social values and structure, address competing visions of how projects should be developed for society, define dimensions of social acceptability, create partnerships, and provide a new awareness of how our tools affect those for whom the project is designed. Finally, they recognize the influence a particular process has on planning efforts.

This article discusses the human element and its importance to a successful planning process. It also provides a new paradigm for engineers in developing projects: Creating alternatives to meet the values of stakeholders, as opposed to presenting alternatives with inherent values. Much of the article attempts to reinforce this paradigm by emphasizing the importance of conflict resolution and public involvement for learning the values a project is attempting to meet. Even the structure of the room for a public meeting can temper the responses that a planner is attempting to gather, thus preventing a clear conveyance of values.

Landre, B. K., and B. A. Knuth. 1993. "Success of Citizen Advisory Committees in Consensus-Based Water Resources Planning in the Great Lakes Basin." Society and Natural Resources. (6). 229-257.

Key Words: consensus, decision making, public involvement, water resources planning

Many proponents of public involvement in environmental planning identify the role of consensus building as a means for improving decision making among diverse interests. The authors of this article conducted four case studies with groups involved in developing Regional Action Plans (RAP) for water resources. Forty-two localities requiring RAPs were identified through an International Joint Commission initiative in the Great Lakes Basin. These Areas of Concern (AOC) were recognized as having beneficial resources, such as fisheries and navigable waters, impaired by pollution.

This study examines consensus-building in the decision making process of four communities that completed the first step in the development of their respective RAPs. Consensus building provides a number of benefits to a planning process, including focus on relevant issues of conflict, an open forum to voice concerns, broadening ranges of opportunity, encouragement of data sharing, community support, development of trust among stakeholders, shared responsibility, and development of better solutions.

Overall, this study shows the value of citizen advisory planning committees in the water resources planning process. Although many participants expressed uncertainty regarding the outcomes of the planning activities, they felt that significant improvements had been made by their involvement. Five measures of citizen advisory committee success were developed for this study. They were: (1) a decision-making process conducive to consensus-building; (2) support for planning outcomes; (3) a sense of effectiveness in priority planning roles; (4) positive personal changes through participation; and (5) overall satisfaction with RAP. Three of the four case studies were scored as high in all but measure (2). Though one study area did not score high in the five success measures, its participants did see the RAP as important, but they were not satisfied with many of its aspects. Part of this dissatisfaction was attributed to the negative economic impacts that may result if a RAP is implemented in their AOC. The other three AOCs examined in the study were going to receive significant economic benefits as a result of implementing their respective RAPs. One point not explored is that more dissatisfaction experienced in the one study could be attributed to the fact that there were more people in that group than any of the others examined.

This study shows in a general way that community involvement is a benefit to the initial stages of water resources planning effort. The study is based on interviews and surveys with participants of the citizen advisory planning committees. There is not a discussion of what strategies were used to develop consensus in the studies, which may be an area of additional research.

GROUP TECHNIQUES

Deason, J. P., and K. P. White, Jr. 1984. "Specification of Objectives by Group Processes in Multiobjective Water Resources Planning." Water Resources Research, 20(2). 189-196.

Key Words: decision making, multiobjective planning, water resources

Numerous multiobjective decision making techniques for water resources have been developed, yet application of these techniques has lagged. The authors conducted a case study regarding the development of specific objectives for water resources planning. The objectives were generated using the nominal group technique (NGT), and they were prioritized using interpretive structural modeling (ISM). Two groups were used in this process. One group generated potential objectives, the other determined relationships for ranking them.

The study examines the development of Federal investments for Indian water resources under the Bureau of Indian Affairs (BIA). Focus was given to the formation of objectives, noting that objectives need to be small enough to maintain specificity but still be measurable with the alternatives used to attain them.

Techniques were chosen to identify the problem, select group members, choose the appropriate method, and plan for group interaction. Additional criteria were put forth as subcategories under these guidelines. Six techniques were considered for use in this study. These techniques were interaction, brainstorming/brainwriting, NGT, delphi, creative confrontation, and ISM. Advantages and disadvantages were listed for each technique. The NGT session created 35 weighted objectives. The ISM session edited these objectives and created a hierarchy of 19 objectives. The top four objectives were Increase National Welfare, Increase Water Conservation, Increase Indian Welfare, and Minimize Total Cost.

In this case study of water resources planning, the authors present valuable information regarding idea generation techniques for groups and the importance of creating specific measurable objectives. The authors' description of the six techniques provides a concise inventory of capabilities and outcomes that could be the basis for a compilation of other similar techniques.

Gregory, R., and R. L. Keeney. 1994. "Creating Policy Alternatives Using Stakeholder Values." Management Science. 40(8). 1035-1048.

Key Words: environment, stakeholder involvement, tradeoffs

Difficulty is often encountered in public decision making due to differing objectives and misconceptions of available alternatives. In many cases, stakeholders involved in decision making are not open to explicit discussion of tradeoffs. The authors of this article describe the success of bringing together stakeholders with differing objectives to create new alternatives. This study is the result of a three-day workshop held to discuss the possibility of implementing a coal mining operation in a pristine wilderness forest in East Malaysia. The two alternatives that existed prior to the workshop were no action and implement mining activities.

Three interdependent steps are used to structure stakeholder decisions: (1) setting the decision context; (2) specifying the objectives to be achieved; and (3) identifying alternatives to achieve these objectives. Within these steps, the participants are allowed to include the alternatives that they regarded as important. This allowed for the representation of all concerns in the process and a fostering of the importance of all the players in the group context.

Five fundamental categories of objectives were identified. They were Environmental Impacts, Economic Impacts, Social Impacts, Political Impacts, and International Prestige. Goals that provided a means for meeting fundamental objectives were identified. This information was ranked by the stakeholders and used to create four additional project alternatives: (1) granting protected status to the region in question; (2) developing limited tourism for the region; (3) combining mining and conservation efforts; (4) and combining mining and tourism efforts.

The authors noted that the cooperation of the participants was vital to the success of the workshop. The participants may have been cooperative because the workshop was not conducted to make a decision, but to record all the stakeholders' values and create more alternatives. If a meeting was held to make a final decision, it is likely that the stakeholders would have taken more adversarial positions.

The strength of this study is its emphasis on how new alternatives are reached when all the stakeholders can meet to discuss alternatives. One of the realizations by the participants was that if no action was taken, poaching and timber harvesting would deplete the region of endangered species. The combination of some alternatives, with specific limits, was seen as a more advantageous position for all the stakeholders involved.

Goodall, H. L. 1985. Small Group Communication in Organizations. 2nd Ed. Dubuque, IA: William C. Brown Publishers.

Key Words: group processes, decision making

This text provides an excellent overview of group processes within organizations. However, the insights to these processes are equally relevant to group processes between different organizations or parties or in different settings such as conflict resolution forums or ongoing interagency coordination meetings.

The author describes small group processes and functions as well as the dynamics of communication in this setting. Participation in, and leadership of, small groups are discussed in detail. Small group decision making and strategies to improve communication are also particular emphases of this text. The author maintains throughout the text a pragmatic, application-oriented perspective that includes guidance for implementing recommendations.

The discussions of problems with small group processes is particularly pertinent to multiobjective planning and tradeoff analysis. These problems include the hierarchical imperative, territorial conflicts, interpersonal conflicts, groupthink, and the battered bureaucrat syndrome. The hierarchical imperative refers to the natural tendency to establish hierarchies of needs, values, and status and the challenges that this imperative can create for group processes. Territorial conflicts refers to the propensity for physical and mental territories that individuals and groups seek to establish. Territories within small groups can inhibit open communication and reduce the potential for compromise. Examples of interpersonal conflict are the suspicion and hostility that group members can exhibit either overtly or covertly. These conflicts can emerge from many sources, including differences of opinion, values, physical appearance, or personal style. Groupthink is when members tend to avoid conflicts of ideas and thereby suppress expression of their true interests or concerns. Finally, the battered bureaucrat syndrome refers to burnout, which can reduce the will of individuals to participate in the process.

The dynamics of small groups and the challenges to the small group process would be helpful in understanding the interpersonal dynamics of conflict resolution processes. However, the real utility of this text lies in understanding the dynamics of small groups that meet regularly, rather than conflict resolution forums. Such groups that might characterize multiattribute planning and tradeoff analysis include interagency coordination groups attempting to resolve competing objectives or interests of different agencies in water resources projects.

Moore, C. M. 1987. Group Techniques for Idea Building. Newbury Park, CA: Sage.

Key Words: planning, problem solving.

Comprehensive planning efforts require the examination of a wide variety of alternatives. In some cases, it is necessary for planners and stakeholders to generate possible options for consideration in the planning process. The author discusses the importance of group processes, describes four approaches, and provides criteria for the optimal use of these techniques.

Four reasons are given for using group processes: (1) Groups can do some things better than an individual; (2) Understanding social phenomena requires the views of the stakeholders; (3) Involvement of stakeholders validates a decision-making process; and (4) Complex problems often can be addressed only by pooled intelligence. These benefits are examined through the use of Nominal Group Technique, Ideawriting, Delphi method, and Interpretive Structural Modeling. Each of these techniques was selected because they are designed to overcome problems that occur in groups. Their execution is described in the book.

Criteria are mentioned for selecting the appropriate method or methods. These criteria are grouped under the following categories: (1) functions needed; (2) problems the technique overcomes; (3) secures participation of a wide range of people; (4) allowing further examination and development; and (5) ease of implementation. The final chapter describes the principles important to facilitating groups regardless of the technique selected. These principles emphasize development of participation, improving the quality of the group process, and improving levels of satisfaction.

The information put forth in this book provides valuable opportunities for enhancing planning processes. Many people may agree that "two head are better than one," but they may not be familiar with the tools available for maximizing "pooled intelligence." Incorporation of the above techniques, as well as others not listed, could provide the planner with opportunities for developing a wider variety of alternatives. This diversity could be useful for accommodating the needs of multiobjective projects.

APPENDIX C

TRADE-OFF ANALYSIS FOR ENVIRONMENTAL PROJECTS REFERENCES (BY LITERATURE CATEGORY)

APPENDIX CONTENTS

MULTIOBJECTIVE PLANNING

WATER RESOURCES

Babcock, S. D. and C. J. Lynch. 1994. Report on the Cedar River and Green River Basins (Washington) Drought Preparedness Study. Washington, D.C.: Directorate of Civil Works, Policy and Planning Division, Headquarters, U.S. Army Corps of Engineers.

Bardossy, A. and L. Duckstein. 1992. "Analysis of Karstic Aquifer Management Problem by Fuzzy Composite Programming." Water Resources Bulletin. 28(1). 63-74.

Biswas, A. K., ed. 1976. Systems Approach to Water Management. New York: McGraw-Hill.

Brown, C. A. 1984. "The Central Arizona Water Control Study: A Case For Multiobjective Planning and Public Involvement." Water Resources Bulletin. 20. 331-337.

Brown, C. A., D. P. Stinson, and R. W. Grant. 1986. "Multiattribute Tradeoff System: Personal Computer Version User's Manual (MATS-PC). Denver: Bureau of Reclamation.

Burke, R. B., J. P. Heaney, and E. E. Pyatt. 1973. "Water Resources and Social Choices." Water Resources Bulletin. June. 433-447.

Cohon, J. L., R. L. Church, and D. P. Sheer. 1979. "Generating Multiobjective Trade-Offs: An Algorithm for Bicriterion Problems." Water Resources Research. 15(5).

Cohon, J. L. and D. H. Marks. 1973. "Multiobjective Screening Models and Water Resource Investments." Water Resources Research. 9(4). 826-836.

Croley, T. E. II. 1974. "Reservoir Operation through Objective Trade-offs." Water Resources Bulletin. 10(6).

Croley, T. E. II. and N. R. R. Kuchibhotla. 1979. "Multiobjective Risks in Reservoir Operation." Water Resources Research. 15(4).

Das, P. and Y. Y. Haimes. 1979. "Multiobjective Optimization in Water Quality and Land Management." Water Resources Research. 15(4).

David, L. and L. Duckstein. 1976. "Multi-Criterion Ranking of Alternatives Long-Range Water Resource Systems." Water Resources Bulletin. 12(4). 731-754.

Downs, P. W., K. J. Gregory, and A. Brookes. 1991. "How Integrated Is River Basin Management?." Environmental Management. 15(3). 299-309.

Duckstein, L. and S. Opricovic. 1980. "Multiobjective Optimization in River Basin Development." Water Resources Research. 16(1). 14-20.

Duckstein, L., W. Treichel, and S. E. Magnouni. 1994. "Ranking Ground-Water Management Alternatives by Multicriterion Analysis." Journal of Water Resources Planning and Management. 120(4). 546-566.

Fronza, G., A. Karlin, and S. Rinaldi. 1977. "Reservoir Operation under Conflicting Objectives." Water Resources Research. 13(2).

Gershon, M. and L. Duckstein. 1984. "A Procedure for Selection of a Multiobjective Technique with Application to Water and Mineral Resources." Applied Mathematics and Computation. 14(3). 245-271.

Gershon, M., L. Duckstein, and R. McAniff. 1982. "Multiobjective River Basin Management with Qualitative Criteria." Water Resources Research. 18(2). 193-202.

Goicoechea, A. 1994. Multiple Criteria Decision-Making (MCDM) Models and Software for Wetland Mitigation Banking. West Chester, PA: The Greeley-Polhemus Group, Inc.

Goicoechea, A., L. Duckstein, and M. M. Fogel. 1976. "Multiobjective Programming in Watershed Management: A Study of the Charleston Watershed." Water Resources Research. 12(6). 1085-1092.

Goicoechea, A., E. Z. Stakhiv, and F. Li. 1992. "Experiment Evaluation of Multiple Criteria Decision Models for Application to Water Resources Planning." Water Resources Bulletin. 28(1). 1-14.

Goodman, A. S. 1984. Principles of Water Resource Planning. Englewood Cliffs, NJ: Prentice-Hall.

Goulter, I. C. and R. Castensson. 1988. "Multiobjective Allocation of Water Shortage in the Svarta River, Sweden." Water Resources Bulletin. 24(4). 761-773.

Grigg, N. S. 1985. Water Resources Planning. New York: McGraw-Hill.

Grygier, J. C. and J. R. Stedinger. 1985. "Algorithms for Optimizing Hydropower Sytem Operation." Water Resources Research. 21(1). 1-10.

Gum, R. L., T. G. Roefs, and D. B. Kimball. 1976. "Quantifying Societal Goals: Development of a Weighting Methodology." Water Resources Research. 12(4).

Haimes, Y. Y. 1977. Hierarchical Analysis of Water Resources Systems. New York: McGraw-Hill.

Haimes, Y. Y. and D. J. Allee, eds. 1982. Multiobjective Analysis in Water Resources. New York: American Society of Civil Engineers.

Haimes, Y. Y. and W. A. Hall. 1974. "Multiobjective in Water Resource Systems Analysis: The Surrogate Worth Trade-Off Method." Water Resources Research. 10(4). 615-624.

Haimes, Y. Y., W. A. Hall, and H. T. Freedman. 1975. Multiobjective Optimization in Water Resources Systems: The Surrogate Worth Trade-off Method. Amsterdam: Elsevier.

Haimes, Y. Y., J. H. Lambert, and D. Li. 1992. "Risk of Extreme Events in a Multiobjective Framework." Water Resources Bulletin. 28(1). 201-210.

Haimes, Y. Y., K. A. Loparo, S. C. Olenik, and S. K. Nanda. 1980. "Multiobjective Statistical Method for Interior Drainage Systems." Water Resources Research. 16(3).

Harboe, R. 1992. "Multiobjective Decision Making Techniques for Reservoir Operation." Water Resources Bulletin. 28(1). 89-102.

Harmancioglu, N. B. and N. Alpaslan. 1992. "Water Quality Monitoring Network Design: A Problem of Multi-Objective Decision Making." Water Resources Bulletin. 28(1). 179-192.

Heaney, J. P. and R. E. Dickinson. 1982. "Methods for Apportioning the Cost of a Water Resources Project." Water Resources Research. 18(3). 476-482.

Hipel, K. W. 1981. "Operational Research Techniques in River Basin Management." Canadian Water Resources Journal. 6(4). 205-226.

Hipel, K. W. 1992. "Multiple Objective Decision Making in Water Resources." Water Resources Bulletin. 28(1). 3-12.

Hobbs, B. F., V. Changkong, and W. Hamadeh. 1990. Screening Water Resources Plans Under Risk and Multiple Objectives: A Comparison of Methods. Fort Belvoir, VA: U.S. Army Corps of Engineers Institute for Water Resources.

Ikebuchi, S. and T. Kojiri. 1992. "Multi-Objective Reservoir Operation Including Turbidity Control." Water Resources Bulletin. 28(1). 223-232.

Keeney, R. L. and E. F. Wood. 1977. "An Illustrative Example of the Use of Multiattribute Utility Theory for Water Resources Planning." Water Resources Research. 13(4). 705-712.

Ko, S. K., D. G. Fontane, and J. W. Labadie. 1992. "Multiobjective Optimization of Reservoir System Operation." Water Resources Bulletin. 28(1). 111-128.

Krzysztofowicz, R. 1992. "Performance Tradeoff Characteristic of a Flood Warning System." Water Resources Bulletin. 28(1). 193-200.

Laabs, H. and G. A. Schultz. 1992. "Reservoir Management Rules Derived with the Aid of Multiple Objective Decision Making Techniques." Water Resources Bulletin. 28(1). 211-222.

Loganathan, G. V. and D. Bhattacharya. 1990. "Goal-Programming Techniques for Optimal Reservoir Operations." Journal of Water Resources Planning and Management. 116(6). 820-838.

Loucks, D. P., J. R. Stedinger, and D. A. Hath. 1981. Water Resource Systems Planning and Analysis. Englewood Cliffs, NJ: Prentice-Hall.

Loughlin, J. C. 1977. "The Efficiency and Equity of Cost Allocation Methods for Multipurpose Water Resources Projects." Water Resources Research. 13(1). 8.

Lynne, G. D. 1976. "Incommensurables and Tradeoffs in Water Resources Planning." Water Resources Bulletin. 12(6).

Mades, D. M. and G. Tauxe. 1980. Models and Methodologies in Multiobjective Water Resources Planning. Urbana, IL: Water Resources Center, University of Illinois.

Major, D. C. 1977. Multiobjective Water Resources Planning. Washington, D.C: American Geophysical Union.

Major, D. C. and R. L. Lenton. 1979. Applied Water Resource Systems Planning. Englewood Cliffs, NJ: Prentice-Hall.

Miller, W. L. and D. M. Byers. 1973. "Development and Display of Multiobjective Project Inputs." Water Resources Research. 9(1).

Monarchi, D. E., C. C. Kisiel, and L. Duckstein. 1973. "Interactive Multiobjective Programming in Water Resources: A Case Study." Water Resources Research. 9(4). 837-850.

Mumpower, J. and L. Bollacker. 1981. User's Manual: Evaluation and Sensitivity Analysis Program (ESAP). Waterways Experiment Station. U.S. Army Corps of Engineers.

Neely, W. P., R. M. North, and J. C. Fortson. 1976. "Planning and Selecting Multiobjectives by Goal Programming." Water Resources Bulletin. 12(1).

North, R. M. 1993. "Application of Multiple Objective Models to Water Resources Planning and Management." Natural Resources Forum. 17(3). 216-227.

Opricovic, S. and B. Djordevic. 1976. "Optimal Long-Term Control of a Multipurpose Reservoir with Indirect Users." Water Resources Research. 12(6). 1286-1290.

Passy, U. 1978. "On the Cobb-Douglas Functions in Multiobjective Optimization." Journal of Water Resources Planning and Management. 14(4).

Roy, B., R. Slowinski and W. Treichel. 1992. "Multicriterion Programming of Water Supply Systems for Rural Areas." Water Resources Bulletin. 28(1). 13-32.

Shabman, L. 1993. Environmental Activities in the Corps of Engineers Water Resources Programs: Charting a New Direction. Fort Belvoir, VA. U.S.Army Corps of Engineers, Insitute for Water Resources.

Shafike, N. G., L. Duckstein, and T. I. II. Maddock. 1992. "Multicriterion Analysis of Groundwater Contamination." Water Resources Bulletin. 28(1). 34-45.

Shamir, U. 1979. "Optimization in Water Distribution System Engineering." Mathematical Programming Study. 11. 65-84.

Slowinski, R. 1986. "A Multicriterion Fuzzy Linear Programming Method for Water Supply System Development Planning." Fuzzy Sets and Systems. 19. 217-237.

Slowinski, R. and W. Treichel. 1986. "Multicriteria Analysis of Regional Water Supply Systems." Large Scale Systems: Theory and Applications. Eds. H. P. Geering and M. Mansour. Oxford. Pergamon Press. 745-748.

Stakhiv, E. Z. 1986. "Achieving Social and Environmental Objectives in Water Resources Planning: Theory and Practice." Social and Environmental Objectives in Water Resources Planning and Management. Eds. W. Viessman and K. E. Schilling. New York. ASCE. 107-125.

Tauxe, G. W., D. M. Mades, and R. R. Inman. 1979. "Multiple Dynamic Programming with Application to a Reservoir." Water Resources Research. 15(6).

Tauxe, G. W., D. M. Mades, and R. R. Inman. 1979. "Multiobjective Dynamic Programming: A Classic Problem Redressed." Water Resources Research. 15(6).

Taylor, B. W., K. R. Davis, and R. M. North. 1975. "Approaches to Multiobjective Planning in Water Resources Projects." Water Resources Bulletin. 11(5).

Tecle, A. 1992. "Selecting a Multicriterion Decision Making Technique for Watershed Resources Management." Water Resources Bulletin. 28(1). 129-140.

Tecle, A., L. Duckstein, and M. Fogel. 1987. "Multicriterion Selection of Waste Water Management Alternatives." Journal of Water Resources Planning and Management. 114(4). 383-398.

Trimble, P. and J. Marban. 1988. Preliminary Evaluation of the Lake Okeechobee Regulation Schedule. West Palm Beach, FL. South Florida Water Management District.

Vemuri, V. 1974. "Multiple-Objective Optimization in Water Resources Systems." Water Resources Bulletin. 10(1).

Vemuri, V. 1976. "Multiple Objective Optimization in Water Resource Systems." Water Resources Research. 10(1). 40-44.

Woldt, W. and I. Bogardi. 1992. "Ground Water Monitoring Network Design Using Multiple Criteria Decision Making." Water Resources Bulletin. 28(1). 45-62.

Yeh, W. W.-G. 1985. "Reservoir Management and Operations Models: A State-of-the-Art Review." Water Resources Research. 21(12). 1797-1818.

Yeh, W. W.-G. and L. Becker. 1982. "Multiobjective Analysis of Reservoir Operations." Water Resources Research. 18(5). 1326-1336.

ENVIRONMENTAL

Bennett, J. and I. Goulter. 1989. "The Use of Multiobjective Analysis for Comparing and Evaluating Environmental and Economic Goals in Wetland Management." Geojournal. 18(2). 213-220.

Charles, A. T. 1989. "Bio-Socio-Economic Fishery Models: Labour Dynamics and Multi-Objective Management." Canadian Journal of Fisheries and Aquatic Sciences. 46(8). 1313-1322.

Chechile, R. A. and S. Carlisle, eds. 1991. Environmental Decision Making: A Multidisciplinary Perspective. New York: Van Nostrand Reinhold.

Cole, R. A., T. J. Ward, F. A. Ward, R. A. Deitner, S. Bolin, J. Fiore, and K. Green-Hammond. RIOFISH, A Fishery Management Planning Model for New Mexico Reservoirs. Technical Report No. 252. Water Resources Research Institute. New Mexico State University, Las Cruces, New Mexico.

de Groot, R. S. 1992. Functions of Nature: Evaluation of Nature in Environmental Planning, Management, and Decision Making. Netherlands(?): Wolters-Nordhoff.

Dennis, R. L., T. R. Stewart, P. Middleton, M. W. Downton, D. W. Ely, and M. C. Keeling. 1983. "Integration of Technical and Value Issues in Air Quality Policy Formulation: A Case Study." Socio-Economic Planning Sciences. 17(3). 95-105.

Green-Hammond, K., R. A. Cole, F. A. Ward, T. J. Ward, S. Bolton, R. A. Detner, and J. Fiore. 1990. User's Guide for RIOFISH, A Fishery Management Model for Large New Mexico Reservoirs. Water Resources Research Institute, New Mexico State University. Las Cruces, New Mexico.

Janssen, R. 1992. Multiobjective Decision Support for Environmental Management. Boston: Kluwer Academic.

Kangus, J. and J. Kuusipalo. 1993. "Integrating Biodiversity into Forest Management Planning and Decision-Making." Forest Ecology and Management. 61(1-2). 1-15.

McAllister, D. M. 1980. Evaluation in Environmental Planning: Assessing Environmental, Social, Economic, and Political Trade-offs. Cambridge, MA: The MIT Press.

North, R. M., W. P. Neely, and R. L. Carlton. 1977. "Balancing Economic and Environmental Objectives." Proceedings, Forty-second North American Wildlife Conference. Athens, GA. Institute of Natural Resources of Georgia University. 190-202.

Ortolano, L. 1984. Environmental Planning and Decision Making. New York: Wiley.

Peterson, D. L., D. G. Silsbee, and D. L. Schmoldt. 1994. "A Case Study of Resources Management Planning with Multiple Objectives and Projects." Environmental Management. 18(5). 729-742.

Sandiford, F. 1986. "An Analysis of Multiobjective Decision-Making for the Scottish Inshore Fishery." Journal of Agricultural Economics. 37(2). 207-219.

Seldner, B. J. and J. P. Cothrel. 1994. Environmental Decision Making for Engineering and Business Managers. New York: McGraw-Hill.

Sylvia, G. 1992. "Concepts in Fisheries Management: Interdisciplinary Gestalts and Socioeconomic Policy Models." Society & Natural Resources. 5(2). 115-133.

OTHER

Antunes, C. H., L. A. Almeida, V. Lopes, and J. N. Climaco. 1994. "A Decision Support System Dedicated to Discrete Multiple Criteria Problems." Decision Support Systems. 12(4-5). 327-335.

Bardossy, A., I. Bogardi, and L. Duckstein. 1985. "Composite Programming as an Extension of Compromise Programming." Mathematics of Mulitobjective Organization. Ed. P. Serafine. New York: Springer-Verlag. 375-408.

Benayoun, R., J. de Montgolfier, J. Tergny, and O. I. Larichev. 1971. "Linear Programming with Multiple Objective Functions: STEP Methods (STEM)." Mathematical Programming. 1(3). 36675.

Benayoun, R., B. Roy, and B. Sussman. 1966. "ELECTRE: Une Methode Pour Guider le Choix en Presence de Points de Vue Multiples." Direction Scientifique. Note de Travail 49.

Bishop, B. A., M. McKee, T. W. Morgan, and R. Narayanan. 1976. "Multiobjective Planning: Concepts and Methods." Journal of Water Resources Planning and Management. 2. 239-253.

Blackett, P. M. S. 1962. Studies of War. Edinburgh. Oliver and Boyd.

Bogardi, J. J. and L. Duckstein. 1992. "Interactive Multiobjective Analysis Embedding the Decision Maker's Implicit Preference." Water Resources Bulletin. 28(1). 75-88.

Brans, J. P. and P. Vincke. 1985. "A Preference Ranking Organization Method (the PROMETHEE Method for Multiple Criteria Decision Making)." Management Science. 31(6). 647-656.

Buchanan, J. T. 1994. "An Experimental Evaluation of Interactive MCDM Methods and the Decision Making Process." Journal of the Operational Research Society. 45(9). 1050-1059.

Charnes, A. and W. W. Cooper. 1961. Management Models and Industrial Applications of Linear Programming. New York: John Wiley and Sons.

Cochrane, J. L. and M. Zeleny, eds. 1973. Multiple Criteria Decision Making. Columbia: University of South Carolina Press.

DeWispelare, A. R. and A. P. Sage. 1981. "On Combined Multiple Objective Optimization Theory and Multiple Attribute Utility Theory for Evaluation and Choicemaking." Large-Scale Systems. 2. 1-19.

Fandel, G. and J. Spronk, eds. 1985. Muliple Criterion Decision Methods and Applications. Berlin: Springer Verlag.

Gibson, J. E. 1979. The Design of Large-Scale Systems. Charlottesville, VA: University of Virginia Press.

Goicoecha, A., L. Duckstein, and S. Zionts, eds. 1990. Multiple Criteria Decision Making--Proceedings of the Ninth International Conference: Theory and applications in Business, Industry, and Government. Berlin, Germany: Springer-Verlag.

Goicoechea, A., D. R. Hansen, and L. Duckstein. 1982. Multiple Objective Decision Making with Engineering and Business Applications. New York: Wiley.

Goicoechea, A. and T. R. Harris. 1987. "Allocation of Energy Supplies Among Economic Sectors: An Application of Interindustry and Multiobjective Analysis." Journal of Environmental Systems. 17(2). 149-163.

Goicoechea, A., E. Z. Stakhiv, and F. Li. 1990. "A Framework for Qualitative Experimental Evaluation of Multiple Criteria Decision Support Systems (MCDSS)." Proceedings of the IX-th International Conference on Multiple Criteria Decision Making and Support Systems at the Interface of Industry, Business, and Government. Fairfax, VA. 16.

Grandzol, J. and M. Gershon. 1994. "Multiple Criteria Decision Making." Quality Progress. 27(1). 69-73.

Hansen, P., ed. 1983. Essays and Surveys on Multicriterion Decision Making. New York: Springer-Verlag.

Hiessl, H., L. Duckstein, and E. J. Plate. 1985. "Multiobjective Analysis with Concordance and Discordance Concepts." Applied Mathematics and Computation. 17. 107-122.

Hobbs, B. F. 1986. "What We Can Learn from Experiments in Multiobjective Decision Analysis." IEEE Transactions on Systems, Man, and Cybernetics. 16(3). 384-394.

Ignizio, J. P. 1976. Goal Programming and Extensions. New York: Lexington Books.

Karni, R., P. Sanchez, and V. M. R. Tummala. 1990. "A Comparative Study of Multiattribute Decision Making Methodologies." Theory and Decision. 29. 203-222.

Keeney, R. L. and H. Raiffa. 1976. Decisions with Multiple Objectives: Preferences and Value Tradeoffs. New York: John Wiley and Sons.

Keeny, R. L. and H. Raiffa. 1976. Decision with Multiple Objectives. New York: Wiley.

Musselman, K. and J. Talavage. 1980. "A Tradeoff Cut Approach to Multiple Objective Optimization." Operations Research. 28(6). 425-1435.

Nijkamp, P. 1979. "A Theory of Displaced Ideals: An Analysis of Interdependednt Decisions Via Nonlinear Multiobjective Optimization." Environment and Planning. 11. 1165-1178.

Radford, J. K. 1977. Complex Decision Problems. Reston, VA: Reston Publishing Company.

Roy, B. 1968. "Classement et Choix en Presence de Points de Vue Multiple (La Methode ELECTRE)." Revue d'Informatique et de Recherche Operationelle. 8. 57-75.

Saaty, T. L. 1977. "A Scaling Method for Priorities in Hierarchical Structures." Journal of Mathematical Psychology. 15(3). 234-281.

Saaty, T. L. 1980. The Analytic Hierarchy Process: Planning, Priority Setting, and Resources Allocation. New York: McGraw-Hill.

Schilling, D. A., C. ReVelle, and J. Cohon. 1983. "An Approach to the Display and Analysis of Multiobjective Problems." Socio-Economic Planning Sciences. 17(2). 57-63.

Serafine, P., ed. 1985. Mathematics of Multiobjective Organization. New York: Springer-Verlag.

Skaburskia, A. 1988. "Criteria for Compensating for the Impacts of Large Projects." Journal of Policy Analysis and Management. 7. 668-686.

Stewart, T. J. 1994. "Data Envelopment Analysis and Multiple Criteria Decision Making--A Response." Omega International Journal of Management Science. 22(2). 205-206.

Szidarovszky, F., M. Gershon, and L. Duckstein. 1986. Techniques for Multicriterion Decision-Making with Sytem Applications. New York: Elsevier.

Tabucanon, M. T. 1988. Multiple Criterion Decision Making in Industry. New York: Elsevier.

Tamura, H., S. Fujita, and H. Koi. 1994. "Decision Analysis for Environmental Impact Assessment and Consensus Formation Among Conflicting Multiple Agents) Including Case Studies for Road Traffic." Science of the Total Environment. 153(3). 203-210.

Votruba, L., Z. Kos, K. Nachazel, A. Patera, and V. Zeman. 1988. Analysis of Water Resources Systems. Amsterdam: Elsevier.

Whaddington, C. H. 1973. Operations Research in World War II. London: Elek Science.

Wierzbicki, A. P., L. Krus, and M. Makowski. 1993. "The Role of Multi-Objective Optimization in Negotiation and Mediation Support." Theory and Decision. 34(3). 201-214.

Zeleny, M. 1973. "Compromise Programming." Multiple Criteria Decision Making. Eds. J. L. Cochran and M. Zeleny. Columbia: University of South Carolina Press. 263-301.

Zeleny, M. 1974. "A Concept of Compromise Solutions and the Method of the Displaced Ideal." Computers and Operations Research. 1(14). 479-496.

Zeleny, M., ed. 1981. Multiple Criteria Decision Making. New York: McGraw-Hill.

Zionts, S. and J. Wallenius. 1976. "An Interactive Programming Method for Solving the Multiple Criteria Problem." Management Science. 22(6). 652-663.

GAME THEORY

WATER RESOURCES

Dufournaud, C. M. 1982. "On the Mutually Beneficial Co-Operative Scheme: Dynamic Change in the Payoff Matrix of International River Basin Schemes." Water Resources Research. 18(4). 764-772.

Hipel, K. W. and N. M. Fraser. 1980a. "Metagame Analysis of the Popular River Conflict." Journal of the Operational Research Society. 31. 377-385.

Hipel, K. W. and N. M. Fraser. 1980b. "Metagame Analysis of the Garrison Conflict." Water Resources Research. 16(4). 629-637.

Hipel, K. W., R. K. Ragade, and T. E. Unny. 1976. "Metagame Theory and Its Applications to Water Resources." Water Resources Research. 12(3). 331-339.

Hipel, K. W., R. K. Ragade, and T. E. Unny. 1980. "Metagame Analysis and Its Application to Water Resources." Water Resources Research. 12(3).

Kilgour, D. M., N. Okada, and A. Nishikori. 1988. "Load Control Regulation of Water Pollution: An Analysis using Game Theory." Journal of Environmental Management. 27(2). 179-195.

Lee, Y. W., I. Bogardi, and J. Stansbury. 1991. "Fuzzy Decision Making in Dredged-Material Management." Journal of Environmental Engineering. 117(5). 614-630.

Lussier, B., G. E. Mohr, and I. C. Goulter. 1989. "Conflict Analysis of the Shoal Lake Subdivision." Water Resources Bulletin. 25(1). 111-116.

Mohan, S. and K. U. Saravana. 1993. "Interstate Multivalley Multireservoir Simulation: A Case Study." International Journal of Water Resources Development. 9(3). 305-317.

Ng, E. K. 1986. Efficiency/Equity Analysis of Water Resources Problems-A Game Theoretic Approach. Ph.D. Dissertation, University of Florida, Gainesville.

Okada, N., K. W. Hipel, and Y. Oka. 1985. "Hypergame Analysis of the Lake Biwa Conflict." Water Resources Research. 21(7). 917-926.

Straffin, P. D. and J. P. Heaney. 1981. "Game Theory and the Tennessee Valley Authority." International Journal of Game Theory. 10. 1.

ENVIRONMENTAL

Blackburn, J. B. 1994. "Ethics, Science, and Environmental Decision-Making." Environmental Toxicology and Chemistry. 13(5). 679-681.

Howell, D. J. 1992. Scientific Literacy and Environmental Policy: The Missing Prerequisites for Sound Decision Making. New York: Quorum Books.

Kilgour, D. M., L. Fang, and K. W. Hipel. 1992. "Game-Theoretic Analyses of Enforcement of Environmental Laws and Regulations." Water Resources Bulletin. 28(1). 141-154.

McBean, E. A. and N. Okada. 1988. "Use of Metagame Analysis in Acid Rain Conflict Resolution." Journal of Environmental Management. 27(2). 153-162.

Okada, N. and Y. Mikami. 1992. "A Game-Theoretic Approach to Acid Rain Abatement: Conflict Analysis of Environmental Land Allocation." Water Resources Bulletin. 28(1). 155-162.

Pitelka, L. F. and F. A. Pitelka. 1993. "Environmental Decision Making: Multidimensional Dilemmas." Ecological Applications. 3(4). 566-568.

Reckhow, K. H. 1994. "Importance of Scientific Uncertainty in Decision Making." Environmental Management. 18(2). 161-166.

Sellers, J. 1993. "Information Needs for Water Resources Decision-Making." Natural Resources Forum. 17(3). 228-234.

Ward, H. 1993. "Game Theory and the Politics of the Global Commons." Journal of Conflict Resolution. 37(2). 203-235.

Xiang, W. N., M. Gross, J. G. Fabos, and E. B. MacDouigall. 1992. "A Fuzzy-Group Multicriteria Decisionmaking Model and Its Application to Land Use Planning." Environment and Planning. 19. 61-84.

OTHER

Arrow, K. J. and H. Raynaud. 1986. Social Choice and Decision Making. Cambridge: MIT Press.

Benedine, M. 1988. "Developments and Possibilities of Optimization Models." Agricultural Water Management. 13(2). 189-196.

Bennett, P. G. 1977. "Toward a Theory of Hypergames." Omega International Journal of Management Science. 5(6). 749-751.

Bennett, P. G. 1980. "Hypergames: The Development of an Approach to Modelling Conflicts." Futures. 12(6). 489-507.

Carnahan, J. V., D. L. Thurston, and T. Liu. 1994. "Fuzzy Ratings for Multiattribute Design Decision-Making." Journal of Mechanical Design. 116. 511-522.

Carroll, J. D. and G. De Soete. 1991. "Toward a New Paradigm for the Study of Multiattribute Choice Behavior: Spacial and Discrete Modeling of Pairwise Preferences." The American Psychologist. 46. 342-352.

Chankong, V. and Y. Y. Haimes. 1983. Multiobjective Decision Making: Theory and Methods. Amsterdam. North-Holland.

Checkland, P. 1981. Systems Thinking, Systems Practice. Chichester, UK: John Wiley.

Cohon, J. 1978. Multiobjective Programming and Planning. New York: Academic Press.

Cohon, J. L. and D. H. Marks. 1975. "A Review and Evaluation of Multiobjective Programming Techniques." Water Resources Research. 11(2). 208-220.

Druckman, D. 1994. "Tools for Discovery: Experimenting with Simulations." Simulation and Gaming. 25(4). 446-455.

Fast, J. C. and L. T. Looper. 1988. Multiattribute Decision Modeling Techniques: A Comparative Analysis. Brooks Air Force Base, TX. Air Force Human Resources Laboratory, Air Force Systems Command.

Flood, R. L. and M. C. Jackson. 1991. Creative Problem Solving: Total Systems Intervention. Chichester, UK: John Wiley.

Fraser, N. M. and K. W. Hipel. 1984. Conflict Analysis. New York: North Holland.

Fraser, N. M. and K. W. Hipel. 1987. "Conflict Analysis as a Negotiation Support System." Compromise, Negotiation, and Group Decision. Ed. B. Munier and M. Shakun. Dordrecht. D.Reidel. 225-243.

Gauthier, D. P. 1993. "Fairness and Cores: A Comment on Laden." Philosophy and Public Affairs. 22. 44-52.

Geschka, R. H., G. R. Schaude, and H. Schlicksupp. 1973. "Modern Techniques for Solving Problems." Chemical Engineering. 80. 91-97.

Greenberg, J. H. 1990. The Theory of Social Situations: An Alternative Game-Theoretic Approach. New York: Cambridge University Press.

Harsanyi, J. C. 1977. Rational Behavior and Bargaining Equilibrium in Games and Social Situations. New York: Cambridge University Press.

Herman, J. L. 1987. Multilevel Evaluation Systems Project: Final Report. Los Angeles, CA. Center for the Study of Evaluation, Graduate School of Education, University of California.

Hillier, F. S. and G. J. Lieberman. 1990. Operations Research. San Francisco: Holden-Day.

Hipel, K. W., A. Dagnino, and N. M. Fraser. 1988. "A Hypergam Algorithm for Modeling Misperceptions in Bargaining." Journal of Environmental Management. 27(2). 131-152.

Hoeveler, D. L. 1992. "Game Theory and Ellison's King of the Bingo Game." Journal of American Culture. 15. 39-42.

Hollis, M. and R. Sugden. 1993. "Rationality in Action." Mind. 102. 1-35.

Howard, N. 1971. Paradoxes of Rationality: Theory of Metagames and Political Behavior. Cambridge: MIT Press.

Iida, K. 1993. "When and How Do Domestic Constraints Matter: 2-Level Game With Uncertainty." Journal of Conflict Resolution. 37(3). 403-426.

Keeney, R. L. 1988. "Structuring Objectives for Problems of Public Interest." Operations Research. 36. 396-405.

Keeny, R. L. 1992. Value-Focused Thinking. Cambridge, MA: Harvard University Press.

McKinney, R. M. 1988. "Towards the Resolution of Paradigm Conflict: Holism Versus Postmodernism." Philosophy Today. 32. 299-311.

Merkhofer, M. 1987. Decision Science and Social Risk Management. Dordrecht, Holland. Reidel.

Midrt, H. J. and E. S. Quade, eds. 1988. Handbook of Systems Analysis: Craft Issues and Procedural Choices. New York: North-Holland.

Moulin, H. 1986. Game Theory for the Social Sciences. New York: New York University Press.

Moulin, H. 1988. Axioms of Cooperative Decision Making. New York: Cambridge University Press.

Nash, J. F. 1953. "Two-Person Cooperative Games." Econometrica. 21. 128-140.

Nathan, A. 1984. "False Expectations." Philosophy of Science. 51. 128-136.

Owen, G. 1968. Game Theory. Philadelphia. W.B. Saunders.

Rasmusen, E. 1989. Games and Information: An Introduction to Game Theory. Oxford. Basil Blackwell.

Roy, B. 1989. "Main Sources of Inaccurate Decision Models." Mathematical and Computer Modeling. 12(10/11). 1245-1254.

Sage, A. P. 1991. Decision Support Systems Engineering. New York: Wiley.

Sainfort, F. C., D. H. Gustafson, K. Boshforth, and R. P. Hawkins. 1990. "Decision Support Systems Effectiveness: Conceptual Framework and Empirical Evaluation." Organizational Behavior and Human Decision Processes. 45. 232-252.

Sarin, R. K. 1977. "Interactive Evaluation and Bounds Procedure for Selecting Multi-Attributed Alternatives." Management Science. 6. 211-224.

Sarin, R. K. 1977. "Screening of Multiattribute Alternatives." Omega International Journal of Management Science. 13. 481-489.

Schmoldt, D. L., D. L. Peterson, and D. G. Silsbee. 1994. "Developing Inventory and Monitoring Programs Based on Multiple Objectives." Environmental Management. 18(5). 707-727.

Singh, M. G. and L. Trave-Massuyes, eds. 1991. Decision Support Systems and Qualitative Reasoning. New York: North-Holland.

Stephenson, B. Y. and S. G. Franklin. 1981. "Better Decision Making for a 'Real-World' Environment." Administrative Management. 42. 24-36.

Stumph, S. A., D. E. Zand, and R. D. Freedman. 1979. "Designing Groups for Judgemental Decisions." Academic Management Journal. 4. 589-600.

Swales, J. K. 1993. "A Game Theoretic Approach to Subsidizing Employment." Regional Studies. 27(2). 109-119.

Szidarovsky, F., L. Duckstein, and I. Bogardi. 1984. "Multiobjective Management of Mining under Water Hazard by Game Theory." European Journal of Operations Research. 15(2). 251-258.

Takahashi, M. A., N. M. Fraser, and K. W. Hipel. 1984. "A Procedure for Analyzing Hypergames." European Journal of Operations Research. 18(1). 111-112.

Van de Ven, A. and A. L. Delbecq. 1971. "Nominal Versus Interacting Group Processes for Committee Decision-Making Effectiveness." Academic Management Journal. 14. 203-211.

Von Neumann, J. and O. Morgenstern. 1953. Theory of Games and Economic Behavior. Princeton, NJ: Princeton University Press.

von Winterfeldt, D. and W. Edwards. 1986. Decision Analysis and Behavioral Research. Cambridge University Press.

Wall, K. D. 1993. "A Model of Decision Making Under Bounded Rationality." Journal of Economic Behavior & Organization. 20(3). 331-352.

Wallsten, T., ed. 1980. Cognitive Processes in Choice and Decision Behavior. Hillsdale, NJ: Erlbaum.

Wang, M., K. W. Hipel, and N. M. Fraser. 1988. "Modelling Misperceptions in Games." Behavioral Sciences. 33.

Warfield, J. N. 1976. Societal Systems: Planning, Policy and Complexity." New York. John Wiley.

Weintraub, E. R. 1992. "Toward a History of Game Theory." History of Political Economy. Durham: Duke University Press. 306.

Zhu, J. H. 1992. "Issue Competition and Attention Distraction: A Zero-Sum Theory of Agenda Setting." Journalism Quarterly. 69. 825-836.

GROUP PROCESSES

WATER RESOURCES

Buck, S. J., G. W. Gleason, and M. S. Jofuku. 1993. "The Institutional Imperative: Resolving Transboundary Water Conflict in Arid Agricultural Regions of the United States and the Commonwealth of Independent States." Natural Resources Journal. 33(3). 595-628.

Burke, R. B. and J. P. Heaney. 1975. Collective Decision Making in Water Resource Planning. Lexington, MA: Lexington Books.

Carr, F. 1994. Partnership Councils: Building Successful Labor-Management Relationships. Fort Belvoir, VA. Institute for Water Resources.

Cowan, J. H., R. E. Turner, and D. R. Cahoon. 1988. "Marsh Management Plans in Practice: Do They Work in Coastal Louisiana, USA." Environmental Management. 12(1). 37-52.

Creighton, J., J. D. Priscoli, and C. M. Dunning. 1983. Public Involvement Techniques: A Reader of Ten Years Experience at the Institute for Water Resources. Fort Belvoir, VA. Institute for Water Resources.

Deason, J. P. and K. P. J. White. 1984. "Specifications of Objectives by Group Processes in Multiobjective Water Resources Planning." Water Resources Research. 20(2). 189-196.

Douglas, A. J. and R. L. Johnson. 1991. "Aquatic Habitat Measurement and Valuation: Inputing Social Benefits to Instream Flow Levels." Journal of Environmental Management. 32(3). 267-280.

Edelman, L., F. Carr, and J. L. Creighton. 1989. The MINI-TRIAL Alternative Dispute Resolution Series. Fort Belvoir, VA. Institute for Water Resources.

Edelman, L., F. Carr, C. Lancaster, and J. H. Creighton. 1990. Non-Binding Arbitration. Fort Belvoir, VA. Institute for Water Resources.

Edleman, L., F. Carr, and C. L. Lancaster. 1991. Partnering. Fort Belvoir, VA. Institute for Water Resources. U.S. Army Corps of Engineers

Endispute Inc. 1992. Brutoco Engineering and Construction. Fort Belvoir, VA. Institute for Water Resources.

Fang, L. and K. W. Hipel. 1988. "Graph Model Approach to Environmental Conflict Resolution." Journal of Environmental Management. 27(2). 195-212.

Humphries, W. R. 1990. "Costs and Benefits: What Is Sensible and Reasonable in the Realm of the Possible." Proceedings, 35th Annual New Mexico Water Conference, Toward a Common Goal: Forging Water-Quality Partnerships. Las Cruces, NM. New Mexico Water Resources Research Institute. 103-105.

Lancaster, C. L. 1990. ADR Round Table: U.S. Army Corps of Engineers (South Atlantic Division, Corporate Contractors, and Law Firms). Fort Belvoir, VA. Institute for Water Resources.

Lancaster, C. L. 1994. The J6 Partnering Case Study J6 Large Rocket Test Facility. Fort Belvoir, VA. Institute for Water Resources.

Landre, B. K. and B. A. Knuth. 1993. "Success of Citizen Advisory Committees in Consensus-Based Water Resources Planning in the Great Lakes Basin." Society & Natural Resources. 6(3). 229-257.

Lord, W. et al. 1979. Conflict Management in Federal Water Resources Planning. Boulder, CO. Institute of Behavioral Science, the University of Colorado.

Lord, W. B. 1980. "Water Resources Planning: Conflict Management." Water Spectrum. 2. 1-11.

McCabe, D. L. and J. E. Dutton. 1993. "Making Sense of the Environment: The Role of Perceived Effectiveness." Human Relations. 46(5). 623-643.

McKinney, M. J. 1990. "State Water Planning: A Forum for Proactively Resolving Water Policy Disputes." Water Resources Bulletin. 26. 323-331.

Moore, C. and J. D. Priscoli, eds. 1989. The Executive Seminar on Alternative Dispute Resolution (ADR) Procedures: The U.S. Army Corps of Engineers. Fort Belvoir, VA. Institute for Water Resources.

Moore, C. W. 1991. Mediation. Fort Belvoir, VA. Institute for Water Resources.

Moore, C. W. 1991. Corps of Engineers Uses Mediation to Settle Hydropower Disputes. Fort Belvoir, VA. Institute for Water Resources.

Newton, L. A. 1993. "The Prevention Test: Promoting High-Level Management, Shareholder, and Lender Participation in Environmental Decision Making Under CERCLA." Ecology Law Quarterly. 20(2). 313-345.

Pickering, H. 1994. "Practical Coastal Zone Management: Alternatives and Strategies." Marine Policy. 18(5). 393-406.

Podziba, S. 1994. Small Projects Partnering: The Drayton Hall Streambank Protection Project. Fort Belvoir, VA. Institute for Water Resources.

Potapchuk, W. R., J. H. Laue, and J. S. Murray. 1990. Getting to the Table - A Guide for Senior Managers. Fort Belvoir, VA. Institute for Water Resources.

Powell, J. M. 1993. "Negotiating Water: Conflict Resolution in Australian Water Management." Environment and Planning. 25. 597-598.

Priscoli, J. D. 1975. "Citizens Advisory Groups and Conflict Resolution in Regional Water Resources Planning." Water Resources Bulletin. 11(4).

Priscoli, J. D. 1988. "Conflict Resolution in Water Resources: Two 404 General Permits." Journal of Water Resources Planning and Management. 114(1). 66-77.

Priscoli, J. D. 1989. "Public Involvement, Conflict Management: Means to EQ and Social Observations." Journal of Water Resources Planning and Management. 115(1).

Priscoli, J. D. 1990. Public Involvement; Conflict Management; and Dispute Resolution in Water Resources and Environmental Decision Making. Fort Belvoir, VA. Institute for Water Resources.

Priscoli, J. D. 1991. Environmental Ends and Engineering Means: Becoming Environmental Engineers for the Nation and the World. Fort Belvoir, VA. Institute for Water Resources.

Rogers, P. 1993. "The Value of Cooperation in Resolving International River Basin Disputes." Natural Resources Forum. 17(2). 117-131.

Schierow, L. J. and G. Chesters. 1983. "Enhancing the Effectiveness of Public Participation in Defining Water Resources Policy." Water Resources Bulletin. 19. 107-114.

Shabman, L. 1984. "Emerging Concepts for the Conduct of State Water Resources Planning." Water Resources Bulletin. 20(2). 203-210.

Sheer, D. P., M. L. Baeck, and J. R. Wright. 1989. "Computer as Negotiator." Journal of the American Water Works Association. 81. 68-73.

Singg, R. N. and B. R. Webb. 1979. "Use of Delphi Methodology to Assess Goals and Social Impacts of a Watershed Project." Water Resources Bulletin. 15(1).

Smolowitz, R. J. and D. N. Wiley. 1992. "A Model for Conflict Resolution in Marine Mammal/Fisheries Interactions: The New England Harbor Porpoise Working Group." Proceedings from the Marine Technology Society Conference, Global Ocean Partnership. Washington, D.C. The Marine Technology Society. 354-360.

Susskind, L., E. Babbitt, and D. Hoffer. 1992. Bassett Creek Water Management Commission. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L., E. Babbitt, and D. Hoffer. 1992. General Roofing Company. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Tenn Tom Constructors, Inc. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Granite Construction Company. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Olson Mechanical and Heavy Rigging, Inc. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Bechtel National, Inc. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Goodyear Tire and Rubber Co. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. G. and J. G. Wofford. 1994. Fort Drum Disputes Review Panel: A Case Study. Fort Belvoir, VA. Institute for Water Resources.

Thiessen, E. M. and D. P. Loucks. 1992. "Computer Assisted Negotiation of Multiobjective Water Resource Conflicts." Water Resources Bulletin. 28(1). 163-177.

Viessman, W. 1988. "Technology, Institutions, and Social Goals." Water Resources Bulletin. 24(3). 581-584.

Viessman, W., Jr. and E. T. Smerdon, eds. 1989. Managing Water Related Conflicts. New York: ASCE.

Wengert, N. 1971. "Public Participation in Water Planning: A Critique of Theory, Doctrine, and Practice." Water Resources Bulletin. 7(1). 26-32.

Wiedemann, P. M. and S. Femers. 1993. "Public Participation in Waste Management Decision Making: Analysis and Management of Conflicts." Journal of Hazardous Materials. 33(3). 355-368.

Zentner, J. 1988. "Wetland Projects of the California State Coastal Conservancy: An Assessment." Coastal Management. 16(1). 47-67.

Zielinski, P., B. Kahn, B. Badr, P. Cumbie, and J. Dozier. 1991. Management of the Savannah River. Chelsea, MI. Lewis Publishers.

ENVIRONMENTAL

Amy, D. 1987. The Politics of Environmental Mediation. New York: Columbia University Press.

Bacow, L. S. and M. Wheeler. 1984. Environmental Dispute Resolution. New York: Plenum.

Bingham, G. 1986. Resolving Environmental Disputes. Washington, D.C.: The Conservation Foundation.

Blackburn, J. W. 1988. "Environmental Mediation as an Alternative to Litigation." Policy Studies Journal. 16(3). 562-574.

Bojorquez-Tapia, L. A., E. Ongay-Delhumeau, and E. Ezcurra. 1994. "Multivariate Approach for Suitability Assessment and Environmental Conflict Resolution." Journal of Environmental Management. 41(3). 187-198.

Carnes, S. A. 1983. "Incentives and Nuclear Waste Siting: Prospects and Constraints." Energy Systems and Policy. 7. 324-351.

Cormick, G. 1982. "The Myth, the Reality and the Future of Environmental Mediation." Environment. 24.

Fang, L., K. W. Hipel, and D. M. Kilgour. 1988. "Resolving Water Resources Conflicts." Proceedings of a Sixth IWRA Congress on Water Resources. May 29-June 3. Ottowa, Canada.

Fang, L., K. W. Hipel, and D. M. Kilgour. 1988. "Environmental Conflict Resolution." Journal of Environmental Management. 27(2). 195-212.

Feather T. D. and D. T. Capan. 1995. Compilation and Review of Completed Rewstoration and Mitigation Studies in Developing an Evaluation Framework for Environmental Resources. Institute for Water Resources. Alexandria, VA.

Frankena, F. and J. K. Frankena, eds. 1987. Citizen Participation in Environmental Decision Making: A Bibliography. Monticello, IL: Vance Bibliographies.

Fraser, N. M. and K. W. Hipel. 1988. "Using the DecisionMaker Computer Program for Analyzing Environmental Conflicts." Journal of Environmental Management. 27. 218-228.

Golton, B. 1980. "Mediation: A ‘Sellout’ for Conservation Advocates or a Bargain?" The Environmental Professional. 2. 62-66.

Gorczynski, D. M. 1991. Insider's Guide to Environmental Negotiation. Chelsea, MI: Lewis Publishers.

Gregory, R., R. Keeney, and D. von Winterfeldt. 1992. "Adapting the Environmental Impact Statement Process to Inform Decision Makers." Journal of Policy Analysis and Management. 11. 58-75.

Hanna, S. S. and C. L. Smith. 1993. "Resolving Allocation Conflicts in Fishery Management." Society & Natural Resources. 6(1). 55-69.

Hipple, W. and W. J. Werrick. 1994. "Drought and Water Supply Management: Roles and Responsibilities - Discussion." Journal of Water Resources Planning and Management. 120(6). 1003-1004.

Lake, M., ed. 1980. Environmental Mediation: The Search for Consensus. Boulder: Westview Press.

Levinson, A. 1988. "Environmental Dispute Resolution and Policy Making." Policy Studies Journal. 16(3). 575-584.

Lynn, F. and G. Busenberg (1993-94): Citizen Advisory Committees and Environmental Policy: What We Know, What's Left to Discover. Paper, University of North Carolina at Chapel Hill. 25 p.

MacDonnell, L. J. 1988. "Natural Resources Dispute Resolution: An Overview." Natural Reosurces Journal. 28(1). 5-20.

Maguire, L. A. and L. G. Boiney. 1994. "Resolving Environmental Disputes: A Framework Incorporating Decision Analysis and Dispute Resolution Techniques." Journal of Environmental Management. 42(1). 31-48.

McCarthy, J. and A. Shorett. 1984. Negotiation Settlements: A Guide to Environmental Mediation. New York: American Arbitration Association.

Meeks, G. 1985. Managing Environmental and Public Policy Conflicts. Denver, CO: National Conference of State Legislatures.

Ozawa, C. P. 1993. "Environmental Disputes: Community Involvement in Conflict Resolution." Society & Natural Resources. 6(1). 90-92.

Painter, A. 1988. "The Future of Environmental Dispute Resolution." Natural Resources Journal. 28(1). 145-170.

Rabe, B. G. 1988. "The Politics of Environmental Dispute Resolution." Policy Studies Journal. 16(3). 585-601.

Rhodes, T. C. and P. N. Wilson. 1995. "Sky Island, Squirrels, and Scopes: The Political Economy of an Environmental Conflict." Land Economics. 71(1). 106-121.

Sebenius, J. 1984. Negotiating the Law of the Sea. Cambridge, MA: Harvard University Press.

Shorett, A. J. 1980. "The Role of Mediation in Environmental Disputes." The Environmental Professional. 2. 58-61.

Susskind, L., L. Bacow, and M. Wheeler, eds. 1983. Resolving Environmental Regulatory Disputes. Cambridge, MA: Schenkman Publishing Company.

Susskind, L. E. 1994. Environmental Diplomacy: Negotiating More Effective Global Agreements. New York: Oxford University Press.

Susskind, L. A., and N. Weinstein. 1980. "Towards A Theory of Environmental Dispute Resolution." Boston College Journal of Environmental Affairs. 311, 336.

Talbot, A. 1983. Settling Things: Six Case Studies in Environmental Mediation. Washington, D.C.: Conservation Foundation.

The Conservation Foundation. 1983. Environmental Conflict Resolution: A Selected Bibliography. Washington, D.C.: The Conservation Foundation.

U.S. Environmental Protection Agency. 1991. Managing Contaminated Sediments (microform): EPA Decision-Making Processes. Washington, DC. Sediment Oversight Technical Committee.

Wang, M., K. W. Hipel, and N. M. Fraser. 1988. "Resolving Environmental Conflicts Having Misperceptions." Journal of Environmental Management. 27. 163-178.

OTHER

Albrecht, K. 1980. Brain Power: Learn to Improve Your Thinking Skill. New York: Prentice Hall.

Auerback, J. S. 1983. Justice Without Law. New York: Oxford University Press.

Borisoff, D. and D. A. Victor. 1989. Conflict Management: A Communication Skills Approach. Englewood Cliffs, NJ: Prentice Hall.

Bormann, E. G. 1982. "Symbolic Convergence Theory of Communication: Applications and Implications for Teachers and Consultants." Journal of Applied Communications Research. 10. 50-61.

Bormann, E. G. 1988. "'Empowering' as a Heuristic Concept in Organizational Communication." Communication Yearbook. 11. 391-404.

Burton, J. W., and F. Dukes. 1990. Conflict: Practices in Management, Settlement, and Resolution. New York. St. Martin's Press.

Cragan, J. F. and D. W. Wright. 1986. Communication in Small Group Discussions: An Integrated Approach. St.Paul, MN: West Publishing.

Creighton, J. L. 1981. The Public Involvement Manual. Cambridge, MA: ABT Books.

Crosby, N., J. Kelly, et al. 1986. "Citizen Panels: A New Approach to Citizen Participation." Public Management Forum. 46. 170-179.

Desario, J. and S. Langton. 1987. Citizen Participation in Public Decision Making. New York: Greenwood.

Deutsch, M. 1994. "Constructive Conflict-Resolution--Principles, Training, and Research." Journal of Social Issues. 50(1). 13-32.

Einstein, V. 1985. Conflict Resolution. St. Paul, MN: West Publishing Company.

Fisher, R., W. Ury, and B. Patton. 1991. Getting to Yes: Negotiating Agreement without Giving In. New York: Penguin.

Fisher, R. J. 1993. "Developing the Field of Interactive Conflict-Resolution: Issues in Training, Funding, and Institutionalization." Political Psychology. 14(1). 123-138.

Folberg, J. and A. Taylor. 1986. Mediation: A Comprehensive Guide to Resolving Conflicts Without Litigation. San Francisco, CA: Jossey-Bass.

Goldberg, S., E. Green, and F. Sander. 1985. Dispute Resolution. Boston, MA: Little, Brown and Company.

Gorney, C. 1987. "Workshop: How to Use Public Participation Groups Successfully." Public Relations Journal. 29-30.

Green, S. G. and T. D. Taber. 1980. "The Effects of Three Social Decision Schemes on Decision Group Processes." Organizational Behavior and Human Performance. 25. 97-106.

Gregory, R. and R. L. Keeney. 1994. "Creating Policy Alternatives Using Stakeholder Values." Management Science. 40. 1035-1048.

Gulliver, P. H. 1979. Disputes and Negotiations. New York: Academic Press.

Haimes, Y. Y. and A. Weiner. 1986. "Hierarchial Holographic Modeling for Conflict Resolution." Philosophy of Science. 53. 200-222.

Himes, J. S. 1980. Conflict and Conflict Management. Athens, GA: University of Georgia Press.

Hipel, K. W. 1990. "Decision Technologies for Conflict Analysis." Information and Decision Technologies. 16(3). 185-214.

Infante, D. A., A. S. Rancer, and D. F. Womack. 1993. Building Communication Theory. Prospect Heights, IL: Waveland Press.

Jandt, F. E. 1985. Win-Win Negotiating: Turning Conflict Into Agreement. New York: John Wiley and Sons.

Janis, I. 1972. Victims of Groupthink. Boston: Houghton Mifflin.

Kathlene, L. and J. Martin. 1991. "Enhancing Citizen Participation: Panel Designs, Perspectives, and Policy Formation." Journal of Policy Analysis and Management. 10(1). 46-63.

Katz, N. H. and J. W. Lawyer. 1992. Communication and Conflict Resolution Skills. Dubuque, IA: Kendall/Hunt.

Keeney, R. L., D. von Winterfeldt, and T. Eppel. 1990. "Eliciting Public Values for Complex Policy Decisions." Management Science. 36. 1011-1030.

Kelly, J. B. and L. Gigy. 1989. "Divorce Mediation: Characteristics of Clients and Outcomes." Mediation Research: The Process and Effectiveness of Third-Party Intervention. Eds. K. Kressel and D. Pruitt. San Francisco, CA: Jossey-Bass.

Kennedy, G., J. Benson, and J. McMillian. 1982. Managing Negotiations. Englewood Cliffs, NJ: Prentice Hall, Inc.

Kilgour, D. M., K. W. Hipel, and L. Fang. 1987. "The Graph Model for Conflicts." Automatica. 23. 41-55.

Kolb, D. 1983. The Mediators. Cambridge, MA: MIT Press.

Mohr, J. and R. Spekman. 1994. "Characteristics of Partnership Success: Partnership Attributes, Communication Behavior, and Conflict Resolution Techniques." Strategic Management Journal. 15(2). 135-152.

Moore, C. W. 1986. The Mediation Process. San Francisco, CA: Jossey-Bass.

Mullen, J. D. and B. M. Roth. 1991. Decision-Making: Its Logic and Practice. Savage, MD: Rowan and Littlefield.

Murnighan, J. K. 1981. "Group Decision Making: What Strategies Should You Use?." Management Review. 25. 55-62.

O'Hare, M., L. Bacow, and D. Sanderson. 1983. Facility Siting and Public Opposition. New York: Van Nostrand-Reinhold.

Ozawa, C. and L. Susskind. 1985. "Mediating Science-Intensive Policy Disputes." Journal of Policy Analysis and Management. 5(1). 23-39.

PMC Associates. 1981. The Role of the Chicago Federal Regional Council in the Experimental Application of the Negotiated Investment Strategy. Palo Alto, California. Prepared for the Charles F. Kettering Foundtion.

Pops, G. M. 1988. "Public Administrators and Conflict Resolution: Problems and Prospects." Policy Studies Journal. 16(3). 615-626.

Pruitt, D. and J. Rubin. 1986. Social Conflict: Escalation, Stalemate and Settlement. New York: Random House.

Putnam, L. L. and J. P. Folger. 1988. "Communication, Conflict, and Dispute Resolution: The Study of Interaction and the Development of Conflict Theory." Communications Research. 15. 349-359.

Raiffa, H. 1968. Decision Analysis: Introductory Lectures on Choice under Uncertainty. Reading: Addison-Wesley.

Raiffa, H. 1982. The Art and Science of Negotiation. Cambridge, MA: Belknap Press.

Richman, R., O. White, and M. Wilkinsin. 1986. Intergovernmental Mediation: Negotiation in Local Governmental Disputes. Boulder, CO: Westview Press.

Schellenburg, J. A. 1982. The Science of Conflict. New York. Oxford University Press.

Sew

Taylor, K. 1985. "Community Boards: Humanistic Conflict Resolution at the Neighborhood Level." The Humanist. 45. 18-19.

Wahrhaftig, P. 1986. "Nonprofessional Conflict Resolution." Mediation Contexts and Challenges. Eds. J. E. Palenski and H. M. Launer. Springfield, IL. Charles C. Thomas. 47.

Wall, J. 1985. Negotiation Theory and Practice. Glenview, IL: Scott, Foresman and Company.

Warschaw, T. A. 1980. Winning by Negotiation. New York: McGraw Hill.

Wilson, G. L. and M. S. Hanna. 1986. Groups in Context: Leadership and Participation in Small Groups. New York: Random House.

Yang, Q. 1992. "A Theory of Conflict-Resolution in Planning." Artificial Intelligence. 58(1-3). 361-392.

Young, P., ed. 1991. Negotiation Analysis. Ann Arbor: University of Michigan Press.

Zack, A. 1984. Arbitration in Practice. Ithaca, New York: ILR Press.

Zartman, I. W. and M. Berman. 1982. The Practical Negotiator. New Haven, CT: Yale University Press.

APPENDIX D

TRADE-OFF ANALYSIS FOR ENVIRONMENTAL PROJECTS REFERENCES (ALPHABETICAL)

Aberley, D., ed. 1994. Futures by Design: The Practice of Ecological Planning. Gabriola, B.C: New Society Publishers.

Albrecht, K. 1980. Brain Power: Learn to Improve Your Thinking Skill. New York: Prentice Hall.

Amy, D. 1987. The Politics of Environmental Mediation. New York: Columbia University Press.

Antunes, C. H., L. A. Almeida, V. Lopes, and J. N. Climaco. 1994. "A Decision Support System Dedicated to Discrete Multiple Criteria Problems." Decision Support Systems. 12(4-5). 327-335.

Arrow, K. J. and H. Raynaud. 1986. Social Choice and Decision Making. Cambridge: MIT Press.

Auerback, J. S. 1983. Justice Without Law. New York: Oxford University Press.

Babcock, S. D. and C. J. Lynch. 1994. Report on the Cedar River and Green River Basins (Washington) Drought Preparedness Study. Washington, D.C. Directorate of Civil Works, Policy and Planning Division, Headquarters, U.S. Army Corps of Engineers.

Bacow, L. S. and M. Wheeler. 1984. Environmental Dispute Resolution. New York: Plenum.

Bardossy, A., I. Bogardi, and L. Duckstein. 1985. "Composite Programming as an Extension of Compromise Programming." Mathematics of Mulitobjective Organization. Ed. P. Serafine. New York: Springer-Verlag. 375-408.

Bardossy, A. and L. Duckstein. 1992. "Analysis of Karstic Aquifer Management Problem by Fuzzy Composite Programming." Water Resources Bulletin. 28(1). 63-74.

Benayoun, R., J. de Montgolfier, J. Tergny, and O. I. Larichev. 1971. "Linear Programming with Multiple Objective Functions: STEP Methods (STEM)." Mathematical Programming. 1(3). 36675.

Benayoun, R., B. Roy, and B. Sussman. 1966. "ELECTRE: Une Methode Pour Guider le Choix en Presence de Points de Vue Multiples." Direction Scientifique. Note de Travail 49.

Benedine, M. 1988. "Developments and Possibilities of Optimization Models." Agricultural Water Management. 13(2). 189-196.

Bennett, J. and I. Goulter. 1989. "The Use of Multiobjective Analysis for Comparing and Evaluating Environmental and Economic Goals in Wetland Management." Geojournal. 18(2). 213-220.

Bennett, P. G. 1977. "Toward a Theory of Hypergames." Omega International Journal of Management Science. 5(6). 749-751.

Bennett, P. G. 1980. "Hypergames: The Development of an Approach to Modelling Conflicts." Futures. 12(6). 489-507.

Berger, J. J., ed. 1990. Environmental Restoration: Science and Strategies for Restoring the Earth. Covelo, CA: Island Press.

Bingham, G. 1986. Resolving Environmental Disputes. Washington, D.C.: The Conservation Foundation.

Bishop, B. A., M. McKee, T. W. Morgan, and R. Narayanan. 1976. "Multiobjective Planning: Concepts and Methods." Journal of Water Resources Planning and Management. 2. 239-253.

Biswas, A. K., ed. 1976. Systems Approach to Water Management. New York: McGraw-Hill.

Blackburn, J. B. 1994. "Ethics, Science, and Environmental Decision-Making." Environmental Toxicology and Chemistry. 13(5). 679-681.

Blackburn, J. W. 1988. "Environmental Mediation as an Alternative to Litigation." Policy Studies Journal. 16(3). 562-574.

Blackett, P. M. S. 1962. Studies of War. Edinburgh. Oliver and Boyd.

Bogardi, J. J. and L. Duckstein. 1992. "Interactive Multiobjective Analysis Embedding the Decision Maker's Implicit Preference." Water Resources Bulletin. 28(1). 75-88.

Bojorquez-Tapia, L. A., E. Ongay-Delhumeau, and E. Ezcurra. 1994. "Multivariate Approach for Suitability Assessment and Environmental Conflict Resolution." Journal of Environmental Management. 41(3). 187-198.

Borisoff, D. and D. A. Victor. 1989. Conflict Management: A Communication Skills Approach. Englewood Cliffs, NJ: Prentice Hall.

Bormann, E. G. 1982. "Symbolic Convergence Theory of Communication: Applications and Implications for Teachers and Consultants." Journal of Applied Communications Research. 10. 50-61.

Bormann, E. G. 1988. "'Empowering' as a Heuristic Concept in Organizational Communication." Communication Yearbook. 11. 391-404.

Brans, J. P. and P. Vincke. 1985. "A Preference Ranking Organization Method (the PROMETHEE Method for Multiple Criteria Decision Making)." Management Science. 31(6). 647-656.

Brown, C. A. 1984. "The Central Arizona Water Control Study: A Case For Multiobjective Planning and Public Involvement." Water Resources Bulletin. 20. 331-337.

Brown, C. A., D. P. Stinson, and R. W. Grant. 1986. "Multiattribute Tradeoff System: Personal Computer Version User's Manual (MATS-PC). Denver: Bureau of Reclamation.

Buchanan, J. T. 1994. "An Experimental Evaluation of Interactive MCDM Methods and the Decision Making Process." Journal of the Operational Research Society. 45(9). 1050-1059.

Buck, S. J., G. W. Gleason, and M. S. Jofuku. 1993. "The Institutional Imperative: Resolving Transboundary Water Conflict in Arid Agricultural Regions of the United States and the Commonwealth of Independent States." Natural Resources Journal. 33(3). 595-628.

Burke, R. B. and J. P. Heaney. 1975. Collective Decision Making in Water Resource Planning. Lexington, MA: Lexington Books.

Burke, R. B., J. P. Heaney, and E. E. Pyatt. 1973. "Water Resources and Social Choices." Water Resources Bulletin. June. 433-447.

Burton, J. W. and F. Dukes. 1990. Conflict: Practices in Management , Settlement, and Resolution. New York. St. Martin's Press.

Carnahan, J. V., D. L. Thurston, and T. Liu. 1994. "Fuzzy Ratings for Multiattribute Design Decision-Making." Journal of Mechanical Design. 116. 511-522.

Carnes, S. A. 1983. "Incentives and Nuclear Waste Siting: Prospects and Constraints." Energy Systems and Policy. 7. 324-351.

Carpenter, S. and W. Kennedy. 1988. Managing Public Disputes. San Francisco: Jossey-Bass.

Carr, F. 1994. Partnership Councils: Building Successful Labor-Management Relationships. Fort Belvoir, VA. Institute for Water Resources.

Carroll, J. D. and G. De Soete. 1991. "Toward a New Paradigm for the Study of Multiattribute Choice Behavior: Spacial and Discrete Modeling of Pairwise Preferences." The American Psychologist. 46. 342-352.

Chankong, V. and Y. Y. Haimes. 1983. Multiobjective Decision Making: Theory and Methods. Amsterdam: North-Holland.

Charles, A. T. 1989. "Bio-Socio-Economic Fishery Models: Labour Dynamics and Multi-Objective Management." Canadian Journal of Fisheries and Aquatic Sciences. 46(8). 1313-1322.

Charnes, A. and W. W. Cooper. 1961. Management Models and Industrial Applications of Linear Programming. New York: John Wiley and Sons.

Chechile, R. A. and S. Carlisle, eds. 1991. Environmental Decision Making: A Multidisciplinary Perspective. New York: Van Nostrand Reinhold.

Checkland, P. 1981. Systems Thinking, Systems Practice. Chichester, UK: John Wiley.

Cochrane, J. L. and M. Zeleny, eds. 1973. Multiple Criteria Decision Making. Columbia: University of South Carolina Press.

Cohon, J. 1978. Multiobjective Programming and Planning. New York: Academic Press.

Cohon, J. L., R. L. Church, and D. P. Sheer. 1979. "Generating Multiobjective Trade-Offs: An Algorithm for Bicriterion Problems." Water Resources Research. 15(5).

Cohon, J. L. and D. H. Marks. 1973. "Multiobjective Screening Models and Water Resource Investments." Water Resources Research. 9(4). 826-836.

Cohon, J. L. and D. H. Marks. 1975. "A Review and Evaluation of Multiobjective Programming Techniques." Water Resources Research. 11(2). 208-220.

Cole, R. A., T. J. Ward, F. A. Ward, R. A. Deitner, S. Bolin, J. Fiore, and K. Green-Hammond. RIOFISH, A Fishery Management Planning Model for New Mexico Reservoirs. Technical Report No. 252. Water Resources Research Institute, New Mexico State University. Las Cruces, New Mexico.

Cormick, G. 1982. "The Myth, the Reality and the Future of Environmental Mediation." Environment. 24.

Cowan, J. H., R. E. Turner, and D. R. Cahoon. 1988. "Marsh Management Plans in Practice: Do They Work in Coastal Louisiana, USA." Environmental Management. 12(1). 37-52.

Cragan, J. F. and D. W. Wright. 1986. Communication in Small Group Discussions: An Integrated Approach. St.Paul, MN: West Publishing.

Creighton, J., J. D. Priscoli, and C. M. Dunning. 1983. Public Involvement Techniques: A Reader of Ten Years Experience at the Institute for Water Resources. Fort Belvoir, VA. Institute for Water Resources.

Creighton, J. L. 1981. The Public Involvement Manual. Cambridge, MA: ABT Books.

Croley, T. E. II. 1974. "Reservoir Operation through Objective Trade-offs." Water Resources Bulletin. 10(6).

Croley, T. E. II. and N. R. R. Kuchibhotla. 1979. "Multiobjective Risks in Reservoir Operation." Water Resources Research. 15(4).

Crosby, N., J. Kelly, et al. 1986. "Citizen Panels: A New Approach to Citizen Participation." Public Management Forum. 46. 170-179.

Das, P. and Y. Y. Haimes. 1979. "Multiobjective Optimization in Water Quality and Land Management." Water Resources Research. 15(4).

Daubert, J. and R. Young. 1981. "Recreational Demand for Maintaining Instream Flows: A Contingent Valuation Approach." American Journal of Agricultural Economics. 63. 665-675.

David, L. and L. Duckstein. 1976. "Multi-Criterion Ranking of Alternatives Long-Range Water Resource Systems." Water Resources Bulletin. 12(4). 731-754.

Deason, J. P. and K. P. J. White. 1984. "Specifications of Objectives by Group Processes in Multiobjective Water Resources Planning." Water Resources Research. 20(2). 189-196.

de Groot, R. S. 1992. Functions of Nature: Evaluation of Nature in Environmental Planning, Management, and Decision Making. Netherlands: Wolters-Nordhoff.

Dennis, R. L., T. R. Stewart, P. Middleton, M. W. Downton, D. W. Ely, and M. C. Keeling. 1983. "Integration of Technical and Value Issues in Air Quality Policy Formulation: A Case Study." Socio-Economic Planning Sciences. 17(3). 95-105.

Desario, J. and S. Langton. 1987. Citizen Participation in Public Decision Making. New York: Greenwood.

Deutsch, M. 1994. "Constructive Conflict-Resolution--Principles, Training, and Research." Journal of Social Issues. 50(1). 13-32.

DeWispelare, A. R. and A. P. Sage. 1981. "On Combined Multiple Objective Optimization Theory and Multiple Attribute Utility Theory for Evaluation and Choicemaking." Large-Scale Systems. 2. 1-19.

Douglas, A. J. and R. L. Johnson. 1991. "Aquatic Habitat Measurement and Valuation: Inputing Social Benefits to Instream Flow Levels." Journal of Environmental Management. 32(3). 267-280.

Douglas, A. J. and R. L. Johnson. 1994. "Drainage Investment and Wetland Loss: An Analysis of the National Resources Inventory Data." Journal of Environmental Management. 40(4). 341-355.

Downs, P. W., K. J. Gregory, and A. Brookes. 1991. "How Integrated Is River Basin Management?." Environmental Management. 15(3). 299-309.

Druckman, D. 1994. "Tools for Discovery: Experimenting with Simulations." Simulation and Gaming. 25(4). 446-455.

Duckstein, L. and S. Opricovic. 1980. "Multiobjective Optimization in River Basin Development." Water Resources Research. 16(1). 14-20.

Duckstein, L., W. Treichel, and S. E. Magnouni. 1994. "Ranking Ground-Water Management Alternatives by Multicriterion Analysis." Journal of Water Resources Planning and Management. 120(4). 546-566.

Dufournaud, C. M. 1982. "On the Mutually Beneficial Co-Operative Scheme: Dynamic Change in the Payoff Matrix of International River Basin Schemes." Water Resources Research. 18(4). 764-772.

Edelman, L., F. Carr, and J. L. Creighton. 1989. The MINI-TRIAL Alternative Dispute Resolution Series. Fort Belvoir, VA. Institute for Water Resources.

Edelman, L., F. Carr, C. Lancaster, and J. H. Creighton. 1990. Non-Binding Arbitration. Fort Belvoir, VA. Institute for Water Resources.

Edleman, L., F. Carr, and C. L. Lancaster. 1991. Partnering. Fort Belvoir, VA. Institute for Water Resources. U.S. Army Corps of Engineers.

Einstein, V. 1985. Conflict Resolution. St. Paul, MN: West Publishing Company.

Endispute Inc. 1992. Brutoco Engineering and Construction. Fort Belvoir, VA. Institute for Water Resources.

Fandel, G. and J. Spronk, eds. 1985. Muliple Criterion Decision Methods and Applications. Berlin: Springer Verlag.

Fang, L. and K. W. Hipel. 1988. "Graph Model Approach to Environmental Conflict Resolution." Journal of Environmental Management. 27(2). 195-212.

Fang, L., K. W. Hipel, and D. M. Kilgour. 1988. "Resolving Water Resources Conflicts." Proceedings of a Sixth IWRA Congress on Water Resources. May 29-June 3. Ottowa, Canada.

Fang, L., K. W. Hipel, and D. M. Kilgour. 1988. "Environmental Conflict Resolution." Journal of Environmental Management. 27(2). 195-212.

Fast, J. C. and L. T. Looper. 1988. Multiattribute Decision Modeling Techniques: A Comparative Analysis. Brooks Air Force Base, TX. Air Force Human Resources Laboratory, Air Force Systems Command.

Feather T. D. and D. T. Capan. 1995. Compilation and Review of Completed Restoration and Mitigation Studies in Developing an Evaluation Framework for Environmental Resources. Institute for Water Resources. Alexandria, VA.

Fisher, R., W. Ury, and B. Patton. 1991. Getting to Yes: Negotiating Agreement without Giving In. New York: Penguin.

Fisher, R. J. 1993. "Developing the Field of Interactive Conflict-Resolution: Issues in Training, Funding, and Institutionalization." Political Psychology. 14(1). 123-138.

Flood, R. L. and M. C. Jackson. 1991. Creative Problem Solving: Total Systems Intervention. Chichester, UK: John Wiley.

Folberg, J. and A. Taylor. 1986. Mediation: A Comprehensive Guide to Resolving Conflicts Without Litigation. San Francisco, CA: Jossey-Bass.

Frankena, F. and J. K. Frankena, eds. 1987. Citizen Participation in Environmental Decision Making: A Bibliography. Monticello, IL: Vance Bibliographies.

Fraser, N. M. and K. W. Hipel. 1984. Conflict Analysis. New York: North Holland.

Fraser, N. M. and K. W. Hipel. 1987. "Conflict Analysis as a Negotiation Support System." Compromise, Negotiation, and Group Decision. Ed. B. Munier and M. Shakun. Dordrecht. D.Reidel. 225-243.

Fraser, N. M. and K. W. Hipel. 1988. "Using the DecisionMaker Computer Program for Analyzing Environmental Conflicts." Journal of Environmental Management. 27. 218-228.

Fronza, G., A. Karlin, and S. Rinaldi. 1977. "Reservoir Operation under Conflicting Objectives." Water Resources Research. 13(2).

Gauthier, D. P. 1993. "Fairness and Cores: A Comment on Laden." Philosophy and Public Affairs. 22. 44-52.

Gershon, M. and L. Duckstein. 1984. "A Procedure for Selection of a Multiobjective Technique with Application to Water and Mineral Resources." Applied Mathematics and Computation. 14(3). 245-271.

Gershon, M., L. Duckstein, and R. McAniff. 1982. "Multiobjective River Basin Management with Qualitative Criteria." Water Resources Research. 18(2). 193-202.

Geschka, R. H., G. R. Schaude, and H. Schlicksupp. 1973. "Modern Techniques for Solving Problems." Chemical Engineering. 80. 91-97.

Gibson, J. E. 1979. The Design of Large-Scale Systems. Charlottesville, VA: University of Virginia Press.

Goicoecha, A., L. Duckstein, and S. Zionts, eds. 1990. Multiple Criteria Decision Making--Proceedings of the Ninth International Conference: Theory and applications in Business, Industry, and Government. Berlin, Germany: Springer-Verlag.

Goicoechea, A. 1994. Multiple Criteria Decision-Making (MCDM) Models and Software for Wetland Mitigation Banking. West Chester, PA: The Greeley-Polhemus Group, Inc.

Goicoechea, A., L. G. Antle, C. Yoe, and J. Urie. 1995. "Physical Condition Indicator Estimate for Primary Lock-and-Dams in the Fuel Taxed System." Presentation at the XX Meeting of the Transportation Research Board.

Goicoechea, A., L. Duckstein, and M. M. Fogel. 1976. "Multiobjective Programming in Watershed Management: A Study of the Charleston Watershed." Water Resources Research. 12(6). 1085-1092.

Goicoechea, A., D. R. Hansen, and L. Duckstein. 1982. Multiple Objective Decision Making with Engineering and Business Applications. New York: Wiley.

Goicoechea, A. and T. R. Harris. 1987. "Allocation of Energy Supplies Among Economic Sectors: An Application of Interindustry and Multiobjective Analysis." Journal of Environmental Systems. 17(2). 149-163.

Goicoechea, A., E. Z. Stakhiv, and F. Li. 1990. "A Framework for Qualitative Experimental Evaluation of Multiple Criteria Decision Support Systems (MCDSS)." Proceedings of the IX-th International Conference on Multiple Criteria Decision Making and Support Systems at the Interface of Industry, Business, and Government. Fairfax, VA. 16.

Goicoechea, A., E. Z. Stakhiv, and F. Li. 1992. "Experiment Evaluation of Multiple Criteria Decision Models for Application to Water Resources Planning." Water Resources Bulletin. 28(1). 1-14.

Goldberg, S., E. Green, and F. Sander. 1985. Dispute Resolution. Boston, MA: Little, Brown and Company.

Golton, B. 1980. "Mediation: A ‘Sellout’ for Conservation Advocates or a Bargain?" The Environmental Professional. 2. 62-66.

Goodman, A. S. 1984. Principles of Water Resource Planning. Englewood Cliffs, NJ: Prentice-Hall.

Gorczynski, D. M. 1991. Insider's Guide to Environmental Negotiation. Chelsea, MI. Lewis Publishers.

Gorman, R. H. and H. K. Baker. 1978. "Brainstorming Your Way to Problem-Solving Ideas." Personnel Journal. 57. 438-440.

Gorney, C. 1987. "Workshop: How to Use Public Participation Groups Successfully." Public Relations Journal. 29-30.

Goulter, I. C. and R. Castensson. 1988. "Multiobjective Allocation of Water Shortage in the Svarta River, Sweden." Water Resources Bulletin. 24(4). 761-773.

Grandzol, J. and M. Gershon. 1994. "Multiple Criteria Decision Making." Quality Progress. 27(1). 69-73.

Green, S. G. and T. D. Taber. 1980. "The Effects of Three Social Decision Schemes on Decision Group Processes." Organizational Behavior and Human Performance. 25. 97-106.

Greenberg, J. H. 1990. The Theory of Social Situations: An Alternative Game-Theoretic Approach. New York: Cambridge University Press.

Green-Hammond, K., R. A. Cole, F. A. Ward, T. J. Ward, S. Bolton, R. A. Detner, and J. Fiore. 1990. User's Guide for RIOFISH, A Fishery Management Model for Large New Mexico Reservoirs. Water Resources Research Institute, New Mexico State University. Las Cruces, New Mexico.

Gregory, R. and R. L. Keeney. 1994. "Creating Policy Alternatives Using Stakeholder Values." Management Science. 40. 1035-1048.

Gregory, R., S. Lichtenstein, and P. Slovic. 1993. "Valuing Environmental Resources: A Constructive Approach." Journal of Risk and Uncertainty. 7. 177-197.

Grigg, N. S. 1985. Water Resources Planning. New York: McGraw-Hill.

Grygier, J. C. and J. R. Stedinger. 1985. "Algorithms for Optimizing Hydropower Sytem Operation." Water Resources Research. 21(1). 1-10.

Gulliver, P. H. 1979. Disputes and Negotiations. New York: Academic Press.

Gum, R. L., T. G. Roefs, and D. B. Kimball. 1976. "Quantifying Societal Goals: Development of a Weighting Methodology." Water Resources Research. 12(4).

Haimes, Y. Y. 1977. Hierarchical Analysis of Water Resources Systems. New York: McGraw-Hill.

Haimes, Y. Y. and D. J. Allee, eds. 1982. Multiobjective Analysis in Water Resources. New York. American Society of Civil Engineers.

Haimes, Y. Y. and W. A. Hall. 1974. "Multiobjective in Water Resource Systems Analysis: The Surrogate Worth Trade-Off Method." Water Resources Research. 10(4). 615-624.

Haimes, Y. Y., W. A. Hall, and H. T. Freedman. 1975. Multiobjective Optimization in Water Resources Systems: The Surrogate Worth Trade-off Method. Amsterdam: Elsevier.

Haimes, Y. Y., J. H. Lambert, and D. Li. 1992. "Risk of Extreme Events in a Multiobjective Framework." Water Resources Bulletin. 28(1). 201-210.

Haimes, Y. Y., K. A. Loparo, S. C. Olenik, and S. K. Nanda. 1980. "Multiobjective Statistical Method for Interior Drainage Systems." Water Resources Research. 16(3).

Haimes, Y. Y. and A. Weiner. 1986. "Hierarchial Holographic Modeling for Conflict Resolution." Philosophy of Science. 53. 200-222.

Hanna, S. S. and C. L. Smith. 1993. "Resolving Allocation Conflicts in Fishery Management." Society & Natural Resources. 6(1). 55-69.

Hansen, P., ed. 1983. Essays and Surveys on Multicriterion Decision Making. New York: Springer-Verlag.

Harboe, R. 1992. "Multiobjective Decision Making Techniques for Reservoir Operation." Water Resources Bulletin. 28(1). 89-102.

Harmancioglu, N. B. and N. Alpaslan. 1992. "Water Quality Monitoring Network Design: A Problem of Multi-Objective Decision Making." Water Resources Bulletin. 28(1). 179-192.

Harsanyi, J. C. 1977. Rational Behavior and Bargaining Equilibrium in Games and Social Situations. New York: Cambridge University Press.

Heaney, J. P. and R. E. Dickinson. 1982. "Methods for Apportioning the Cost of a Water Resources Project." Water Resources Research. 18(3). 476-482.

Herman, J. L. 1987. Multilevel Evaluation Systems Project: Final Report. Los Angeles, CA. Center for the Study of Evaluation, Graduate School of Education, University of California.

Hiessl, H., L. Duckstein, and E. J. Plate. 1985. "Multiobjective Q-Analysis with Concordance and Discordance Concepts." Applied Mathematics and Computation. 17. 107-122.

Higashi, M. and N. Yamamura. 1994. "Resolution of Evolutionary Conflict: A General Theory and Its Applications." Researches on Population Ecology. 36(1). 15-22.

Hillier, F. S. and G. J. Lieberman. 1990. Operations Research. San Francisco: Holden-Day.

Himes, J. S. 1980. Conflict and Conflict Management. Athens, GA: University of Georgia Press.

Hipel, K. W. 1981. "Operational Research Techniques in River Basin Management." Canadian Water Resources Journal. 6(4). 205-226.

Hipel, K. W. 1990. "Decision Technologies for Conflict Analysis." Information and Decision Technologies. 16(3). 185-214.

Hipel, K. W. 1992. "Multiple Objective Decision Making in Water Resources." Water Resources Bulletin. 28(1). 3-12.

Hipel, K. W., A. Dagnino, and N. M. Fraser. 1988. "A Hypergam Algorithm for Modeling Misperceptions in Bargaining." Journal of Environmental Management. 27(2). 131-152.

Hipel, K. W. and N. M. Fraser. 1980a. "Metagame Analysis of the Popular River Conflict." Journal of the Operational Research Society. 31. 377-385.

Hipel, K. W. and N. M. Fraser. 1980b. "Metagame Analysis of the Garrison Conflict." Water Resources Research. 16(4). 629-637.

Hipel, K. W., R. K. Ragade, and T. E. Unny. 1976. "Metagame Theory and Its Applications to Water Resources." Water Resources Research. 12(3). 331-339.

Hipel, K. W., R. K. Ragade, and T. E. Unny. 1980. "Metagame Analysis and Its Application to Water Resources." Water Resources Research. 12(3).

Hipple, W. and W. J. Werrick. 1994. "Drought and Water Supply Management: Roles and Responsibilities - Discussion." Journal of Water Resources Planning and Management. 120(6). 1003-1004.

Hobbs, B. F. 1986. "What We Can Learn from Experiments in Multiobjective Decision Analysis." IEEE Transactions on Systems, Man, and Cybernetics. 16(3). 384-394.

Hobbs, B. F., V. Changkong, and W. Hamadeh. 1990. Screening Water Resources Plans Under Risk and Multiple Objectives: A Comparison of Methods. Fort Belvoir, VA. U.S. Army Corps of Engineers Institute for Water Resources.

Hoeveler, D. L. 1992. "Game Theory and Ellison's King of the Bingo Game." Journal of American Culture. 15. 39-42.

Hollis, M. and R. Sugden. 1993. "Rationality in Action." Mind. 102. 1-35.

Howard, N. 1971. Paradoxes of Rationality: Theory of Metagames and Political Behavior. Cambridge: MIT Press.

Howell, D. J. 1992. Scientific Literacy and Environmental Policy: The Missing Prerequisites for Sound Decision Making. New York: Quorum Books.

Humphries, W. R. 1990. "Costs and Benefits: What Is Sensible and Reasonable in the Realm of the Possible." Proceedings, 35th Annual New Mexico Water Conference, Toward a Common Goal: Forging Water-Quality Partnerships. Las Cruces, NM. New Mexico Water Resources Research Institute. 103-105.

Hyman, D. and J. A. Miller. 1985. Community Systems and Human Services: An Ecological Approach to Policy, Planning, and Management. Dubuque, IA: Kendall/Hunt.

Ignizio, J. P. 1976. Goal Programming and Extensions. New York: Lexington Books.

Iida, K. 1993. "When and How Do Domestic Constraints Matter: 2-Level Game With Uncertainty." Journal of Conflict Resolution. 37(3). 403-426.

Ikebuchi, S. and T. Kojiri. 1992. "Multi-Objective Reservoir Operation Including Turbidity Control." Water Resources Bulletin. 28(1). 223-232.

Infante, D. A., A. S. Rancer, and D. F. Womack. 1993. Building Communication Theory. Prospect Heights, IL: Waveland Press.

Jandt, F. E. 1985. Win-Win Negotiating: Turning Conflict Into Agreement. New York: John Wiley and Sons.

Janis, I. 1972. Victims of Groupthink. Boston: Houghton Mifflin.

Janssen, R. 1992. Multiobjective Decision Support for Environmental Management. Boston: Kluwer Academic.

Kangus, J. and J. Kuusipalo. 1993. "Integrating Biodiversity into Forest Management Planning and Decision-Making." Forest Ecology and Management. 61(1-2). 1-15.

Karni, R., P. Sanchez, and V. M. R. Tummala. 1990. "A Comparative Study of Multiattribute Decision Making Methodologies." Theory and Decision. 29. 203-222.

Kathlene, L. and J. Martin. 1991. "Enhancing Citizen Participation: Panel Designs, Perspectives, and Policy Formation." Journal of Policy Analysis and Management. 10(1). 46-63.

Katz, N. H. and J. W. Lawyer. 1992. Communication and Conflict Resolution Skills. Dubuque, IA: Kendall/Hunt.

Keeney, R. 1992. Value-Focused Thinking. Cambridge: Harvard University Press.

Keeney, R. L. 1988. "Structuring Objectives for Problems of Public Interest." Operations Research. 36. 396-405.

Keeney, R. L. and H. Raiffa. 1976. Decisions with Multiple Objectives: Preferences and Value Tradeoffs. New York: John Wiley and Sons.

Keeney, R. L., D. von Winterfeldt, and T. Eppel. 1990. "Eliciting Public Values for Complex Policy Decisions." Management Science. 36. 1011-1030.

Keeney, R. L. and E. F. Wood. 1977. "An Illustrative Example of the Use of Multiattribute Utility Theory for Water Resources Planning." Water Resources Research. 13(4). 705-712.

Keeny, R. L. 1992. Value-Focused Thinking. Cambridge, MA: Harvard University Press.

Keeny, R. L. and H. Raiffa. 1976. Decision with Multiple Objectives. New York: Wiley.

Kelly, J. B. and L. Gigy. 1989. "Divorce Mediation: Characteristics of Clients and Outcomes." Mediation Research: The Process and Effectiveness of Third-Party Intervention. Eds. K. Kressel and D. Pruitt. San Francisco, CA: Jossey-Bass.

Kennedy, G., J. Benson, and J. McMillian. 1982. Managing Negotiations. Englewood Cliffs, NJ: Prentice Hall, Inc.

Kilgour, D. M., L. Fang, and K. W. Hipel. 1992. "Game-Theoretic Analyses of Enforcement of Environmental Laws and Regulations." Water Resources Bulletin. 28(1). 141-154.

Kilgour, D. M., K. W. Hipel, and L. Fang. 1987. "The Graph Model for Conflicts." Automatica. 23. 41-55.

Kilgour, D. M., N. Okada, and A. Nishikori. 1988. "Load Control Regulation of Water Pollution: An Analysis using Game Theory." Journal of Environmental Management. 27(2). 179-195.

Ko, S. K., D. G. Fontane, and J. W. Labadie. 1992. "Multiobjective Optimization of Reservoir System Operation." Water Resources Bulletin. 28(1). 111-128.

Kolb, D. 1983. The Mediators. Cambridge, MA: MIT Press.

Krzysztofowicz, R. 1992. "Performance Tradeoff Characteristic of a Flood Warning System." Water Resources Bulletin. 28(1). 193-200.

Laabs, H. and G. A. Schultz. 1992. "Reservoir Management Rules Derived with the Aid of Multiple Objective Decision Making Techniques." Water Resources Bulletin. 28(1). 211-222.

Lake, M., ed. 1980. Environmental Mediation: The Search for Consensus. Boulder: Westview Press.

Lancaster, C. L. 1990. ADR Round Table: U.S. Army Corps of Engineers (South Atlantic Division, Corporate Contractors, and Law Firms). Fort Belvoir, VA. Institute for Water Resources.

Lancaster, C. L. 1994. The J6 Partnering Case Study J6 Large Rocket Test Facility. Fort Belvoir, VA. Institute for Water Resources.

Landre, B. K. and B. A. Knuth. 1993. "Success of Citizen Advisory Committees in Consensus-Based Water Resources Planning in the Great Lakes Basin." Society & Natural Resources. 6(3). 229-257.

Lave, L. and T. Romer. 1983. "Specifying Risk Goals: Inherent Problems with Democratic Institutions." Risk Analysis. 3. 217-227.

Lee, Y. W., I. Bogardi, and J. Stansbury. 1991. "Fuzzy Decision Making in Dredged-Material Management." Journal of Environmental Engineering. 117(5). 614-630.

Levinson, A. 1988. "Environmental Dispute Resolution and Policy Making." Policy Studies Journal. 16(3). 575-584.

Loganathan, G. V. and D. Bhattacharya. 1990. "Goal-Programming Techniques for Optimal Reservoir Operations." Journal of Water Resources Planning and Management. 116(6). 820-838.

Lord, W. et al. 1979. Conflict Management in Federal Water Resources Planning. Boulder, CO: Institute of Behavioral Science, the University of Colorado.

Lord, W. B. 1980. "Water Resources Planning: Conflict Management." Water Spectrum. 2. 1-11.

Loucks, D. P., J. R. Stedinger, and D. A. Hath. 1981. Water Resource Systems Planning and Analysis. Englewood Cliffs, NJ: Prentice-Hall.

Loughlin, J. C. 1977. "The Efficiency and Equity of Cost Allocation Methods for Multipurpose Water Resources Projects." Water Resources Research. 13(1). 8.

Lussier, B., G. E. Mohr, and I. C. Goulter. 1989. "Conflict Analysis of the Shoal Lake Subdivision." Water Resources Bulletin. 25(1). 111-116.

Lynn, F. and G. Busenberg (1993-94): Citizen Advisory Committees and Environmental Policy: What We Know, What's Left to Discover. Paper, University of North Carolina at Chapel Hill. 25 p.

Lynne, G. D. 1976. "Incommensurables and Tradeoffs in Water Resources Planning." Water Resources Bulletin. 12(6).

MacDonnell, L. J. 1988. "Natural Resources Dispute Resolution: An Overview." Natural Resources Journal. 28(1). 5-20.

Mades, D. M. and G. Tauxe. 1980. Models and Methodologies in Multiobjective Water Resources Planning. Urbana, IL: Water Resources Center, University of Illinois.

Maguire, L. A. and L. G. Boiney. 1994. "Resolving Environmental Disputes: A Framework Incorporating Decision Analysis and Dispute Resolution Techniques." Journal of Environmental Management. 42(1). 31-48.

Major, D. C. 1977. Multiobjective Water Resources Planning. Washington, D.C.: American Geophysical Union.

Major, D. C. and R. L. Lenton. 1979. Applied Water Resource Systems Planning. Englewood Cliffs, NJ: Prentice-Hall.

Mangun, W. R. and J. C. Mangun. 1993. "An Ecological Approach to Decision-Making in Renewable Resource Management." Policy Studies Review. 12(3-4). 197.

McAllister, D. M. 1980. Evaluation in Environmental Planning: Assessing Environmental, Social, Economic, and Political Trade-offs. Cambridge, MA: The MIT Press.

McBean, E. A. and N. Okada. 1988. "Use of Metagame Analysis in Acid Rain Conflict Resolution." Journal of Environmental Management. 27(2). 153-162.

McCabe, D. L. and J. E. Dutton. 1993. "Making Sense of the Environment: The Role of Perceived Effectiveness." Human Relations. 46(5). 623-643.

McCarthy, J. and A. Shorett. 1984. Negotiation Settlements: A Guide to Environmental Mediation. New York: American Arbitration Association.

McKinney, M. J. 1990. "State Water Planning: A Forum for Proactively Resolving Water Policy Disputes." Water Resources Bulletin. 26. 323-331.

McKinney, R. M. 1988. "Towards the Resolution of Paradigm Conflict: Holism Versus Postmodernism." Philosophy Today. 32. 299-311.

Meeks, G. 1985. Managing Environmental and Public Policy Conflicts. Denver, CO: National Conference of State Legislatures.

Merkhofer, M. 1987. Decision Science and Social Risk Management. Dordrecht, Holland: Reidel.

Midrt, H. J. and E. S. Quade, eds. 1988. Handbook of Systems Analysis: Craft Issues and Procedural Choices. New York: North-Holland.

Miller, D. G. M. 1987. "Modeling and Decision Making as Part of the Commission for the Conservation of Antarctic Marine Living Resources Management Regime." Selected Scientific Papers from the Meeting of the Scientific Committee and Working Groups of the Commission for the Conservation of Antarctic Marine Living Resources. Hobart, Australia. Commission for the Conservation of Antarctic Marine Living Resources. 295-322.

Miller, W. L. and D. M. Byers. 1973. "Development and Display of Multiobjective Project Inputs." Water Resources Research. 9(1).

Mohan, S. and K. U. Saravana. 1993. "Interstate Multivalley Multireservoir Simulation: A Case Study." International Journal of Water Resources Development. 9(3). 305-317.

Mohr, J. and R. Spekman. 1994. "Characteristics of Partnership Success: Partnership Attributes, Communication Behavior, and Conflict Resolution Techniques." Strategic Management Journal. 15(2). 135-152.

Monarchi, D. E., C. C. Kisiel, and L. Duckstein. 1973. "Interactive Multiobjective Programming in Water Resources: A Case Study." Water Resources Research. 9(4). 837-850.

Moore, C. and J. D. Priscoli, eds. 1989. The Executive Seminar on Alternative Dispute Resolution (ADR) Procedures: The U.S. Army Corps of Engineers. Fort Belvoir, VA. Institute for Water Resources.

Moore, C. W. 1986. The Mediation Process. San Francisco, CA: Jossey-Bass.

Moore, C. W. 1991. Mediation. Fort Belvoir, VA. Institute for Water Resources.

Moore, C. W. 1991. Corps of Engineers Uses Mediation to Settle Hydropower Disputes. Fort Belvoir, VA. Institute for Water Resources.

Moulin, H. 1986. Game Theory for the Social Sciences. New York: New York University Press.

Moulin, H. 1988. Axioms of Cooperative Decision Making. New York: Cambridge University Press.

Mullen, J. D. and B. M. Roth. 1991. Decision-Making: Its Logic and Practice. Savage, MD: Rowan and Littlefield.

Mumpower, J. and L. Bollacker. 1981. User's Manual: Evaluation and Sensitivity Analysis Program (ESAP). Waterways Experiment Station. U.S. Army Corps of Engineers.

Murnighan, J. K. 1981. "Group Decision Making: What Strategies Should You Use?." Management Review. 25. 55-62.

Musselman, K. and J. Talavage. 1980. "A Tradeoff Cut Approach to Multiple Objective Optimization." Operations Research. 28(6). 425-1435.

Nash, J. F. 1953. "Two-Person Cooperative Games." Econometrica. 21. 128-140.

Nathan, A. 1984. "False Expectations." Philosophy of Science. 51. 128-136.

Neely, W. P., R. M. North, and J. C. Fortson. 1976. "Planning and Selecting Multiobjectives by Goal Programming." Water Resources Bulletin. 12(1).

Newton, L. A. 1993. "The Prevention Test: Promoting High-Level Management, Shareholder, and Lender Participation in Environmental Decision Making Under CERCLA." Ecology Law Quarterly. 20(2). 313-345.

Ng, E. K. 1986. Efficiency/Equity Analysis of Water Resources Problems-A Game Theoretic Approach. Ph.D. Dissertation, University of Florida, Gainesville.

Nijkamp, P. 1979. "A Theory of Displaced Ideals: An Analysis of Interdependednt Decisions Via Nonlinear Multiobjective Optimization." Environment and Planning. 11. 1165-1178.

North, R. M. 1993. "Application of Multiple Objective Models to Water Resources Planning and Management." Natural Resources Forum. 17(3). 216-227.

North, R. M., W. P. Neely, and R. L. Carlton. 1977. "Balancing Economic and Environmental Objectives." Proceedings, Forty-second North American Wildlife Conference. Athens, GA: Institute of Natural Resources of Georgia University. 190-202.

O'Hare, M., L. Bacow, and D. Sanderson. 1983. Facility Siting and Public Opposition. New York: Van Nostrand-Reinhold.

Okada, N., K. W. Hipel, and Y. Oka. 1985. "Hypergame Analysis of the Lake Biwa Conflict." Water Resources Research. 21(7). 917-926.

Okada, N. and Y. Mikami. 1992. "A Game-Theoretic Approach to Acid Rain Abatement: Conflict Analysis of Environmental Land Allocation." Water Resources Bulletin. 28(1). 155-162.

Opricovic, S. and B. Djordevic. 1976. "Optimal Long-Term Control of a Multipurpose Reservoir with Indirect Users." Water Resources Research. 12(6). 1286-1290.

Ortolano, L. 1984. Environmental Planning and Decision Making. New York: Wiley.

Owen, G. 1968. Game Theory. Philadelphia. W.B. Saunders.

Ozawa, C. and L. Susskind. 1985. "Mediating Science-Intensive Policy Disputes." Journal of Policy Analysis and Management. 5(1). 23-39.

Ozawa, C. P. 1993. "Environmental Disputes: Community Involvement in Conflict Resolution." Society & Natural Resources. 6(1). 90-92.

Painter, A. 1988. "The Future of Environmental Dispute Resolution." Natural Resources Journal. 28(1). 145-170.

Passy, U. 1978. "On the Cobb-Douglas Functions in Multiobjective Optimization." Journal of Water Resources Planning and Management. 14(4).

Peterson, D. L., D. G. Silsbee, and D. L. Schmoldt. 1994. "A Case Study of Resources Management Planning with Multiple Objectives and Projects." Environmental Management. 18(5). 729-742.

Pickering, H. 1994. "Practical Coastal Zone Management: Alternatives and Strategies." Marine Policy. 18(5). 393-406.

Pitelka, L. F. and F. A. Pitelka. 1993. "Environmental Decision Making: Multidimensional Dilemmas." Ecological Applications. 3(4). 566-568.

PMC Associates. 1981. The Role of the Chicago Federal Regional Council in the Experimental Application of the Negotiated Investment Strategy. Palo Alto, California. Prepared for the Charles F. Kettering Foundtion.

Podziba, S. 1994. Small Projects Partnering: The Drayton Hall Streambank Protection Project. Fort Belvoir, VA. Institute for Water Resources.

Pops, G. M. 1988. "Public Administrators and Conflict Resolution: Problems and Prospects." Policy Studies Journal. 16(3). 615-626.

Potapchuk, W. R., J. H. Laue, and J. S. Murray. 1990. Getting to the Table - A Guide for Senior Managers. Fort Belvoir, VA. Institute for Water Resources.

Powell, J. M. 1993. "Negotiating Water: Conflict Resolution in Australian Water Management." Environment and Planning. 25. 597-598.

Priscoli, J. D. 1975. "Citizens Advisory Groups and Conflict Resolution in Regional Water Resources Planning." Water Resources Bulletin. 11(4).

Priscoli, J. D. 1988. "Conflict Resolution in Water Resources: Two 404 General Permits." Journal of Water Resources Planning and Management. 114(1). 66-77.

Priscoli, J. D. 1989. "Public Involvement, Conflict Management: Means to EQ and Social Observations." Journal of Water Resources Planning and Management. 115(1).

Priscoli, J. D. 1990. Public Involvement; Conflict Management; and Dispute Resolution in Water Resources and Environmental Decision Making. Fort Belvoir, VA. Institute for Water Resources.

Priscoli, J. D. 1991. Environmental Ends and Engineering Means: Becoming Environmental Engineers for the Nation and the World. Fort Belvoir, VA. Institute for Water Resources.

Pruitt, D. and J. Rubin. 1986. Social Conflict: Escalation, Stalemate and Settlement. New York: Random House.

Putnam, L. L. and J. P. Folger. 1988. "Communication, Conflict, and Dispute Resolution: The Study of Interaction and the Development of Conflict Theory." Communications Research. 15. 349-359.

Rabe, B. G. 1988. "The Politics of Environmental Dispute Resolution." Policy Studies Journal. 16(3). 585-601.

Radford, J. K. 1977. Complex Decision Problems. Reston, VA: Reston Publishing Company.

Raiffa, H. 1968. Decision Analysis: Introductory Lectures on Choice under Uncertainty. Reading: Addison-Wesley.

Raiffa, H. 1982. The Art and Science of Negotiation. Cambridge, MA: Belknap Press.

Rasmusen, E. 1989. Games and Information: An Introduction to Game Theory. Oxford: Basil Blackwell.

Reckhow, K. H. 1994. "Importance of Scientific Uncertainty in Decision Making." Environmental Management. 18(2). 161-166.

Rhodes, T. C. and P. N. Wilson. 1995. "Sky Island, Squirrels, and Scopes: The Political Economy of an Environmental Conflict." Land Economics. 71(1). 106-121.

Richman, R., O. White, and M. Wilkinsin. 1986. Intergovernmental Mediation: Negotiation in Local Governmental Disputes. Boulder, CO: Westview Press.

Rogers, P. 1993. "The Value of Cooperation in Resolving International River Basin Disputes." Natural Resources Forum. 17(2). 117-131.

Roling, N. 1994. "Communication Support for Sustainable Natural Resources Management." Institute of Developmental Studies Bulletin. 25(2). 125-133.

Roy, B. 1968. "Classement et Choix en Presence de Points de Vue Multiple (La Methode ELECTRE)." Revue d'Informatique et de Recherche Operationelle. 8. 57-75.

Roy, B. 1989. "Main Sources of Inaccurate Decision Models." Mathematical and Computer Modeling. 12(10/11). 1245-1254.

Roy, B., R. Slowinski, and W. Treichel. 1992. "Multicriterion Programming of Water Supply Systems for Rural Areas." Water Resources Bulletin. 28(1). 13-32.

Saaty, T. L. 1977. "A Scaling Method for Priorities in Hierarchical Structures." Journal of Mathematical Psychology. 15(3). 234-281.

Saaty, T. L. 1980. The Analytic Hierarchy Process: Planning, Priority Setting, and Resources Allocation. New York: McGraw-Hill.

Sage, A. P. 1991. Decision Support Systems Engineering. New York: Wiley.

Sainfort, F. C., D. H. Gustafson, K. Boshforth, and R. P. Hawkins. 1990. "Decision Support Systems Effectiveness: Conceptual Framework and Empirical Evaluation." Organizational Behavior and Human Decision Processes. 45. 232-252.

Sandiford, F. 1986. "An Analysis of Multiobjective Decision-Making for the Scottish Inshore Fishery." Journal of Agricultural Economics. 37(2). 207-219.

Sarin, R. K. 1977. "Interactive Evaluation and Bounds Procedure for Selecting Multi-Attributed Alternatives." Management Science. 6. 211-224.

Sarin, R. K. 1977. "Screening of Multiattribute Alternatives." Omega International Journal of Management Science. 13. 481-489.

Schellenburg, J. A. 1982. The Science of Conflict. New York: Oxford University Press.

Schierow, L. J. and G. Chesters. 1983. "Enhancing the Effectiveness of Public Participation in Defining Water Resources Policy." Water Resources Bulletin. 19. 107-114.

Schilling, D. A., C. ReVelle, and J. Cohon. 1983. "An Approach to the Display and Analysis of Multiobjective Problems." Socio-Economic Planning Sciences. 17(2). 57-63.

Schmoldt, D. L., D. L. Peterson, and D. G. Silsbee. 1994. "Developing Inventory and Monitoring Programs Based on Multiple Objectives." Environmental Management. 18(5). 707-727.

Sebenius, J. 1984. Negotiating the Law of the Sea. Cambridge, MA: Harvard University Press.

Seldner, B. J. and J. P. Cothrel. 1994. Environmental Decision Making for Engineering and Business Managers. New York: McGraw-Hill.

Sellers, J. 1993. "Information Needs for Water Resources Decision-Making." Natural Resources Forum. 17(3). 228-234.

Serafine, P., ed. 1985. Mathematics of Multiobjective Organization. New York: Springer-Verlag.

Sewell, W. R. D. and S. Phillips. 1979. "Models for the Evaluation of Public Participation Programmes." Natural Resources Journal. 19. 337-360.

Shabman, L. 1984. "Emerging Concepts for the Conduct of State Water Resources Planning." Water Resources Bulletin. 20(2). 203-210.

Shabman, L. 1993. Environmental Activities in the Corps of Engineers Water Resources Programs: Charting a New Direction. Fort Belvoir, VA. U.S.Army Corps of Engineers, Insitute for Water Resources.

Shafike, N. G., L. Duckstein, and T. I. Maddock. 1992. "Multicriterion Analysis of Groundwater Contamination." Water Resources Bulletin. 28(1). 34-45.

Shamir, U. 1979. "Optimization in Water Distribution System Engineering." Mathematical Programming Study. 11. 65-84.

Sheer, D. P., M. L. Baeck, and J. R. Wright. 1989. "Computer as Negotiator." Journal of the American Water Works Association. 81. 68-73.

Shorett, A. J. 1980. "The Role of Mediation in Environmental Disputes." The Environmental Professional. 2. 58-61.

Singg, R. N. and B. R. Webb. 1979. "Use of Delphi Methodology to Assess Goals and Social Impacts of a Watershed Project." Water Resources Bulletin. 15(1).

Singh, M. G. and L. Trave-Massuyes, eds. 1991. Decision Support Systems and Qualitative Reasoning. New York: North-Holland.

Skaburskia, A. 1988. "Criteria for Compensating for the Impacts of Large Projects." Journal of Policy Analysis and Management. 7. 668-686.

Slowinski, R. 1986. "A Multicriterion Fuzzy Linear Programming Method for Water Supply System Development Planning." Fuzzy Sets and Systems. 19. 217-237.

Slowinski, R. and W. Treichel. 1986. "Multicriteria Analysis of Regional Water Supply Systems." Large Scale Systems: Theory and Applications. Eds. H. P. Geering and M. Mansour. Oxford: Pergamon Press. 745-748.

Smolowitz, R. J. and D. N. Wiley. 1992. "A Model for Conflict Resolution in Marine Mammal/Fisheries Interactions: The New England Harbor Porpoise Working Group." Proceedings from the Marine Technology Society Conference, Global Ocean Partnership. Washington, D.C. The Marine Technology Society. 354-360.

Sorensen, S. 1981. "Grouphate." May 1981. Paper Presented to International Communication Association Annual Convention. Minneapolis.

Souder, W. E. 1977. "Effectiveness of Nominal and Interaction Group Decision Processes for Integrating Research and Development and Marketing." Management Science. 23. 595-605.

Stakhiv, E. Z. 1986. "Achieving Social and Environmental Objectives in Water Resources Planning: Theory and Practice." Social and Environmental Objectives in Water Resources Planning and Management. Eds. W. Viessman and K. E. Schilling. New York. ASCE. 107-125.

Stephenson, B. Y. and S. G. Franklin. 1981. "Better Decision Making for a 'Real-World' Environment." Administrative Management. 42. 24-36.

Stewart, T. J. 1994. "Data Envelopment Analysis and Multiple Criteria Decision Making--A Response." Omega International Journal of Management Science. 22(2). 205-206.

Straffin, P. D. and J. P. Heaney. 1981. "Game Theory and the Tennessee Valley Authority." International Journal of Game Theory. 10. 1.

Straus, D. B. and B. P. Clark. 1980. "Computer-Assisted Negotiations: Bigger Problems Need Better Tools." The Environmental Professional. 2. 75-87.

Stumph, S. A., D. E. Zand, and R. D. Freedman. 1979. "Designing Groups for Judgemental Decisions." Academic Management Journal. 4. 589-600.

Sullivan, T. 1984. Resolving Development Disputes Through Negotiation. New York: Plenum Press.

Susskind, L. A. and N. Weinstien. 1980. "Towards a Theory of Environmental Dispute Resolution." Boston College Journal of Environmental Affairs. 311, 336.

Susskind, L., E. Babbitt, and D. Hoffer. 1992. Bassett Creek Water Management Commission. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L., E. Babbitt, and D. Hoffer. 1992. General Roofing Company. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L., L. Bacow, and M. Wheeler, eds. 1983. Resolving Environmental Regulatory Disputes. Cambridge, MA: Schenkman Publishing Company.

Susskind, L. and J. L. Cruikshank. 1987. Breaking the Impasse: Consensual Approaches to Resolving Public Disputes. New York: Basic Books.

Susskind, L. E. 1994. Environmental Diplomacy: Negotiating More Effective Global Agreements. New York: Oxford University Press.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Tenn Tom Constructors, Inc. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Granite Construction Company. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Olson Mechanical and Heavy Rigging, Inc. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Bechtel National, Inc. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. E., S. L. Podziba, and E. Babbitt. 1989. Goodyear Tire and Rubber Co. Fort Belvoir, VA. Institute for Water Resources.

Susskind, L. G. and J. G. Wofford. 1994. Fort Drum Disputes Review Panel: A Case Study. Fort Belvoir, VA. Institute for Water Resources.

Swales, J. K. 1993. "A Game Theoretic Approach to Subsidizing Employment." Regional Studies. 27(2). 109-119.

Swingland, I. R. 1993. "The Ecological Stability in Southeast Asias Forests: Biodiversity and Common Resource Property." Global Ecology and Biogeographical Letters. 3(4-6). 290-297.

Sycara, K. P. 1993. "Machine Learning for Intelligent Support of Conflict-Resolution." Decision Support Systems. 10(2). 121-136.

Sylvia, G. 1992. "Concepts in Fisheries Management: Interdisciplinary Gestalts and Socioeconomic Policy Models." Society & Natural Resources. 5(2). 115-133.

Szidarovsky, F., L. Duckstein, and I. Bogardi. 1984. "Multiobjective Management of Mining under Water Hazard by Game Theory." European Journal of Operations Research. 15(2). 251-258.

Szidarovszky, F., M. Gershon, and L. Duckstein. 1986. Techniques for Multicriterion Decision-Making with Sytem Applications. New York: Elsevier.

Tabucanon, M. T. 1988. Multiple Criterion Decision Making in Industry. New York: Elsevier.

Takahashi, M. A., N. M. Fraser, and K. W. Hipel. 1984. "A Procedure for Analyzing Hypergames." European Journal of Operations Research. 18(1). 111-112.

Talbot, A. 1983. Settling Things: Six Case Studies in Environmental Mediation. Washington, D.C. Conservation Foundation.

Tamura, H., S. Fujita, and H. Koi. 1994. "Decision Analysis for Environmental Impact Assessment and Consensus Formation Among Conflicting Multiple Agents--Including Case Studies for Road Traffic." Science of the Total Environment. 153(3). 203-210.

Tauxe, G. W., D. M. Mades, and R. R. Inman. 1979. "Multiple Dynamic Programming with Application to a Reservoir." Water Resources Research. 15(6).

Tauxe, G. W., D. M. Mades, and R. R. Inman. 1979. "Multiobjective Dynamic Programming: A Classic Problem Redressed." Water Resources Research. 15(6).

Taylor, B. W., K. R. Davis, and R. M. North. 1975. "Approaches to Multiobjective Planning in Water Resources Projects." Water Resources Bulletin. 11(5).

Taylor, K. 1985. "Community Boards: Humanistic Conflict Resolution at the Neighborhood Level." The Humanist. 45. 18-19.

Tecle, A. 1992. "Selecting a Multicriterion Decision Making Technique for Watershed Resources Management." Water Resources Bulletin. 28(1). 129-140.

Tecle, A., L. Duckstein, and M. Fogel. 1987. "Multicriterion Selection of Waste Water Management Alternatives." Journal of Water Resources Planning and Management. 114(4). 383-398.

The Conservation Foundation. 1983. Environmental Conflict Resolution: A Selected Bibliography. Washington, D.C. The Conservation Foundation.

Thiessen, E. M. and D. P. Loucks. 1992. "Computer Assisted Negotiation of Multiobjective Water Resource Conflicts." Water Resources Bulletin. 28(1). 163-177.

Trimble, P. and J. Marban. 1988. Preliminary Evaluation of the Lake Okeechobee Regulation Schedule. West Palm Beach, FL. South Florida Water Management District.

U.S. Environmental Protection Agency. 1991. Managing Contaminated Sediments (microform): EPA Decision-Making Processes. Washington, DC. Sediment Oversight Technical Committee.

Van de Ven, A. and A. L. Delbecq. 1971. "Nominal Versus Interacting Group Processes for Committee Decision-Making Effectiveness." Academic Management Journal. 14. 203-211.

Vemuri, V. 1974. "Multiple-Objective Optimization in Water Resources Systems." Water Resources Bulletin. 10(1).

Vemuri, V. 1976. "Multiple Objective Optimization in Water Resource Systems." Water Resources Research. 10(1). 40-44.

Viessman, W. 1988. "Technology, Institutions, and Social Goals." Water Resources Bulletin. 24(3). 581-584.

Viessman, W., Jr. and E. T. Smerdon, eds. 1989. Managing Water Related Conflicts. New York. ASCE.

Von Neumann, J. and O. Morgenstern. 1953. Theory of Games and Economic Behavior. Princeton, NJ: Princeton University Press.

von Winterfeldt, D. and W. Edwards. 1986. Decision Analysis and Behavioral Research. Cambridge University Press.

Votruba, L., Z. Kos, K. Nachazel, A. Patera, and V. Zeman. 1988. Analysis of Water Resources Systems. Amsterdam: Elsevier.

Vry, W., J. M. Brett, and S. B. Goldberg. 1988. Getting Disputes Resolved: Designing Systems to Cut the Costs of Conflict. San Francisco, CA: Jossey-Bass.

Wahrhaftig, P. 1986. "Nonprofessional Conflict Resolution." Mediation Contexts and Challenges. Eds. J. E. Palenski and H. M. Launer. Springfield, IL. Charles C. Thomas. 47.

Wall, J. 1985. Negotiation Theory and Practice. Glenview, IL. Scott: Foresman and Company.

Wall, K. D. 1993. "A Model of Decision Making Under Bounded Rationality." Journal of Economic Behavior & Organization. 20(3). 331-352.

Wallsten, T., ed. 1980. Cognitive Processes in Choice and Decision Behavior. Hillsdale, NJ: Erlbaum.

Wang, M., K. W. Hipel, and N. M. Fraser. 1988. "Resolving Environmental Conflicts Having Misperceptions." Journal of Environmental Management. 27. 163-178.

Wang, M., K. W. Hipel, and N. M. Fraser. 1988. "Modelling Misperceptions in Games." Behavioral Sciences. 33.

Ward, H. 1993. "Game Theory and the Politics of the Global Commons." Journal of Conflict Resolution. 37(2). 203-235.

Warfield, J. N. 1976. Societal Systems: Planning, Policy and Complexity. New York: John Wiley.

Warschaw, T. A. 1980. Winning by Negotiation. New York: McGraw Hill.

Weintraub, E. R. 1992. "Toward a History of Game Theory." History of Political Economy. Durham: Duke University Press. 306.

Wengert, N. 1971. "Public Participation in Water Planning: A Critique of Theory, Doctrine, and Practice." Water Resources Bulletin. 7(1). 26-32.

Whaddington, C. H. 1973. Operations Research in World War II. London: Elek Science.

Wiedemann, P. M. and S. Femers. 1993. "Public Participation in Waste Management Decision Making: Analysis and Management of Conflicts." Journal of Hazardous Materials. 33(3). 355-368.

Wierzbicki, A. P., L. Krus, and M. Makowski. 1993. "The Role of Multi-Objective Optimization in Negotiation and Mediation Support." Theory and Decision. 34(3). 201-214.

Wilson, G. L. and M. S. Hanna. 1986. Groups in Context: Leadership and Participation in Small Groups. New York: Random House.

Woldt, W. and I. Bogardi. 1992. "Ground Water Monitoring Network Design Using Multiple Criteria Decision Making." Water Resources Bulletin. 28(1). 45-62.

Woodley, S. 1993. "Coastal Zone Management in the Tropics." Reef Resources. 3(3). 20-21.

Xiang, W. N., M. Gross, J. G. Fabos, and E. B. MacDouigall. 1992. "A Fuzzy-Group Multicriteria Decisionmaking Model and Its Application to Land Use Planning." Environment and Planning. 19. 61-84.

Yang, Q. 1992. "A Theory of Conflict-Resolution in Planning." Artificial Intelligence. 58(1-3). 361-392.

Yeh, W. W.-G. 1985. "Reservoir Management and Operations Models: A State-of-the-Art Review." Water Resources Research. 21(12). 1797-1818.

Yeh, W. W.-G. and L. Becker. 1982. "Multiobjective Analysis of Reservoir Operations." Water Resources Research. 18(5). 1326-1336.

Young, P., ed. 1991. Negotiation Analysis. Ann Arbor: University of Michigan Press.

Zack, A. 1984. Arbitration in Practice. Ithaca, NY: ILR Press.

Zartman, I. W. and M. Berman. 1982. The Practical Negotiator. New Haven, CT: Yale University Press.

Zeleny, M. 1973. "Compromise Programming." Multiple Criteria Decision Making. Eds. J. L. Cochran and M. Zeleny. Columbia: University of South Carolina Press. 263-301.

Zeleny, M. 1974. "A Concept of Compromise Solutions and the Method of the Displaced Ideal." Computers and Operations Research. 1(14). 479-496.

Zeleny, M., ed. 1981. Multiple Criteria Decision Making. New York: McGraw-Hill.

Zentner, J. 1988. "Wetland Projects of the California State Coastal Conservancy: An Assessment." Coastal Management. 16(1). 47-67.

Zhu, J. H. 1992. "Issue Competition and Attention Distraction: A Zero-Sum Theory of Agenda Setting." Journalism Quarterly. 69. 825-836.

Zielinski, P., B. Kahn, B. Badr, P. Cumbie, and J. Dozier. 1991. Management of the Savannah River. Chelsea, MI: Lewis Publishers.

Zionts, S. and J. Wallenius. 1976. "An Interactive Programming Method for Solving the Multiple Criteria Problem." Management Science. 22(6). 652-663.