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# Understanding the Social Acceptability of Natural Resource Decisionmaking Processes by Using a Knowledge Base Modeling Approach

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## Abstract

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Natural resource managers are being confronted with increasing conflict and litigation with those who find their management plans unacceptable. Compatible and sustainable management decisions necessitate that natural resource agencies generate plans that are not only biologically possible and economically feasible but also socially acceptable. Currently, however, we lack a framework to integrate socially acceptable judgments with the biological and economic factors that help define successful forest management plans. This research examines the ability of a knowledge base approach to assess the social acceptability of natural resource decisionmaking processes and to determine its suitability for use in forest management planning.

We note four main caveats with using knowledge bases for evaluating social acceptability: (1) the importance of asking and answering the right question, (2) the ability of the knowledge base to become a "black box," (3) problems associated with using a numerical value to estimate a concept as complex as social acceptability, (4) and our incomplete understanding of the factors that influence social acceptability judgments. Acknowledging the caveats, however, can make the knowledge base model a useful tool in forest management planning. We determined that knowledge bases can account for various factors affecting social acceptability and can facilitate discussions about the compatibility and links among social, biological, and economic decision factors.

Keywords: Social acceptability, forest management, decisionmaking, public participation, knowledge base.

## Summary

Land management agencies, such as the USDA Forest Service, manage the Nation's natural resources for many differing and competing interests. In recent decades, natural resource management has been characterized by increasing conflict and litigation with public constituencies who find current forest practices unacceptable. Social acceptability necessitates that management decisions are consistent with public values and beliefs. If these values and beliefs are neglected, regardless of perceptions as to the "validity" of public concerns, agencies will continue to struggle with efforts to implement forest plans as public opposition increases. The intense gridlock of the past few decades demonstrates that sustainable management decisions require public acceptance.

Although social acceptability of natural resource decisionmaking is recognized, it is not understood how social acceptability judgments are formed, sustained, and altered. In addition, we lack a framework for organizing and understanding how to integrate social acceptability judgments with biological and economic decision factors for successful forest management plans. To overcome this deficiency in natural resource management, the Pacific Northwest Research Station through its compatibility initiative is supporting research to improve our understanding of how to enhance the compatibility of differing forest uses and values.

Our research examines the potential of using a knowledge base framework as a tool to organize our understanding of social acceptability of natural resource decisionmaking processes for the compatibility initiative. We conducted this research with two fundamental operating assumptions about the Pacific Northwest Research Station's compatibility initiative: first, it is critical for natural resource agencies to generate management plans that are acceptable to the public; second, socially acceptable management plans are one component that—in addition to economic and physical feasibility—form compatible and sustainable forest management decisions. This study used a NetWeaver® modeling program to organize our understanding of social acceptability into a knowledge base system and to determine whether this approach could improve our ability to achieve compatible forest management. In particular, we conducted our analysis to achieve two objectives:

1. To examine the ability of a knowledge base modeling approach to account for the factors influencing social acceptability of natural resource decisionmaking processes
2. To evaluate the suitability of this knowledge base modeling approach for forest management planning

This report derives from assessments of management experience–primarily from research on social acceptability in the Pacific Northwest–and a synthesis of related research literature. These data were used to organize our existing knowledge and define its critical gaps about public acceptability of decisionmaking processes for integration into a knowledge base prototype. From the synthesis of the literature and the development of the prototype, four social issues of concern were identified.

Issue 1. Natural resource agencies focus more on the social acceptability of their decisions than on the acceptability of their decisionmaking processes.

Issue 2. The NetWeaver® knowledge base modeling program allows managers or other users to adjust the knowledge base design for a specific context. Unless the modifications

are well documented, however, this flexibility can potentially reduce the transparency of the process by which the knowledge base evaluates agency decisionmaking.

Issue 3. Natural resource management and science programs are dominated by the technical-rational paradigm; a model of thinking and acting that rests on a rational, scientifically based analytic process, which also acts to constrain incorporation of subjective, qualitative knowledge.

Issue 4. Our understanding of the social acceptability of decisionmaking processes is incomplete and needs further study.

Based on our research, we offer the following recommendations:

- Continue to develop an awareness within all levels of the agency about the importance of decision processes on public judgments of acceptability as opposed to focusing solely on decision outcomes.
- Improve strategies for including broad public interest at the beginning of decisionmaking processes.
- Continue to study the strengths and shortcomings of agency decisionmaking processes to refine protocols and improve agency implementation of the techniques.
- Recognize the caveats associated with having managers modify the knowledge base design.
- Use the social acceptability knowledge base primarily as a guide to understanding the factors influencing public acceptance of decisionmaking.
- Create more interdisciplinary forums where scientists can convene to:
  - Discuss links among social, biological, and economic data
  - Develop integrated approaches and methods that include public acceptance of processes and outcomes
- Develop studies to improve our understanding of:
  - Collaborative decisionmaking processes
  - Factors that influence the development of citizen-agency relations
  - Trust-building
  - Incorporating values into decisionmaking
  - How context influences public beliefs and attitudes
  - Risk in forest management planning, including risk to future generations

Overall, we found that a knowledge base approach is a potentially valuable tool in forest management planning for identifying factors that affect social acceptability. The process of examining the social science literature, synthesizing major ideas, and carefully constructing an experimental model is helpful in clarifying the social acceptability concept. In addition, placing factors into a formal representation of social acceptability helps reveal research gaps associated with specific components of that concept. This provides a basis for discussion among scientists and managers about future information needs.

On the other hand, this analysis also revealed that there are many caveats associated with the use of a NetWeaver® knowledge base to test social acceptability. Although these limitations, described fully under "Social Issues of Concern," are not specific to knowledge bases, our ability to effectively use NetWeaver® to achieve socially acceptable decisionmaking is certainly constrained by them. For instance, despite the fact that these assumptions and caveats can be documented in NetWeaver®, the generation of one numerical value representing the level of social acceptability has the potential to lead forest managers to develop inappropriate conclusions about the level of acceptance by the public of a particular decision.

If the caveats of the knowledge base are taken into account, however, the knowledge base can be used effectively to examine the social acceptability of natural resource decisionmaking processes. Nonetheless, we believe that the greatest value of this approach for compatibility lies in the construction of various knowledge bases from which scientists of varying disciplines can visualize and discuss the links between social, economic, and biological knowledge. When knowledge bases are used as a method of discussing the compatibility between differing forest uses and values in this manner, this approach can serve as an important integrative tool for forest research and management planning.

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## Introduction

Land management agencies, such as the USDA Forest Service, manage the Nation's natural resources for many different and competing interests. There is growing conflict, however, between the processes and decisions generated by resource agencies and those favored by public constituents. Widespread public and media attention is now focused on forest management issues. Since 1983, nearly 1,200 appeals of forest plans were filed (Steelman 1999), thereby preventing the Forest Service from implementing their forest plans. In addition, many of these disputes have received national political attention. In 1993, the Clinton administration intervened, creating a forest conference to break the gridlock that has characterized forest management in the Pacific Northwest. Even with the direct involvement of the highest office in the Nation, however, the success of this effort remains problematic. To effectively resolve forest management issues, new approaches are needed to address these conflicts.

Although these disputes culminated in the 1990s, their roots trace back several decades. During the environmental movement of the 1960s and 1970s, public scrutiny of natural resource management decisions intensified, resulting in increasing confrontations with the traditional decisionmaking processes of natural resource agencies. As the public demanded a greater voice and role in decisions affecting public land, legislation was passed that mandated public participation in natural resource decisionmaking. With the passage of the National Environmental Protection Act (NEPA) in 1969, the Forest and Rangeland Renewable Resources Planning Act (RPA) in 1974, and the National Forest Management Act (NFMA) in 1976, natural resource agencies were directed to formally obtain the views of the public about possible management decisions.

The existence of legislation requiring public involvement did not diminish conflicts. Citizen disagreements with agencies over land management decisions became increasingly prevalent (Wondolleck 1988). Legal requirements to engage the public increased public expectations that input from public involvement efforts would influence natural resource decision outcomes. There is, however, increasing public sentiment that agency decisionmaking processes are not legitimately concerned with incorporating public values and knowledge (McGee-Brown et al. 1995, Smith and McDonough 2001), and consequently, lack public support.

When citizens and interest groups encounter management plans that do not take their concerns into consideration, they bypass what they perceive as inadequate decision-making processes and resort to other means (courts, legislators, and the media) to demand representation in agency decisions. Consequently, public groups and land management agencies have become mired in costly litigation and emotional discourse over public land management decisions. This legal gridlock makes it essential that the Forest Service alter traditional decisionmaking practices to incorporate public concerns more effectively.

To devise management strategies that will be supported by the public, it is critical to understand how the public judges and forms opinions about the acceptability of forest management practices and the decisionmaking processes that create them. In addition, it is important to learn how agencies can integrate these judgments with other decision

factors to generate compatible decisions. To assist agencies in accomplishing these goals, we examined the utility of the NetWeaver®[1] knowledge base approach to organizing and analyzing the social acceptability of natural resource management processes.

We first review the complex natural resource issues that led to our examining knowledge bases to incorporate social concerns into natural resource management. We then describe the basic rationale for, and structure of knowledge bases. Based on a literature review of various components of social acceptability, we outline the design of a social acceptability knowledge base. In "Social Issues of Concern," we discuss potential challenges that will affect the utility of knowledge bases for examining social acceptability and its integration into other decision factors. Our focus was to examine complex problems that arose when we created a knowledge base model to adequately reflect social acceptability concerns.

## Program Goals

The work described in this document arose out of research conducted on social acceptability by the People and Natural Resources (PNR) Program of the Pacific Northwest Research Station. Research began with Stankey and Clark's (1992) problem analysis on the integration of social values in forest management and the work of Brunson and others (1996) on the social acceptability of ecosystem management. It continued with the problem analysis of Shindler and others (in press) on social acceptability and the work contained in this document for the compatibility initiative.

Although this research was initially designed to provide the framework for the social component of the integrated study on the compatibility between wood production and other values and uses on forested lands, its primary objective was broadened after consultations with the core team of Oregon State University (OSU) and PNR researchers. Discussions with the core team suggested that the broader notion of the social acceptability of decisionmaking processes was more appropriate for understanding how social issues influence our ability to work toward compatible forest management. To achieve compatibility, management policies must take into account public values and beliefs; otherwise, efforts to implement these management plans will not succeed when they face the same obstacles–public conflict and litigation–that have confronted them in the past. We conducted this research project with the following fundamental operating assumptions about the compatibility initiative:

1. It is critical for natural resource agencies to generate management plans acceptable to the public.
2. Socially acceptable management plans are one component that, in addition to economic and physical feasibility, form compatible and sustainable forest management decisions.

[1] The use of firm or trade names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

Although the importance of public acceptance of natural resource decisionmaking is recognized, we lack a framework for organizing and understanding how public judgments of these decisionmaking processes are formed. To resolve this problem, OSU researchers worked with core team members from the PNR Program to study the potential of using a knowledge base framework as a tool to organize understanding of social acceptability for the compatibility initiative. Issues of acceptability are highly complex and multifaceted; thus, it appeared appropriate that the knowledge base framework had the potential to provide insight into such problems. In particular, we conducted our analysis to achieve the following objectives.

1. To examine the ability of a knowledge base modeling approach to account for the factors influencing social acceptability of natural resource decisionmaking processes.
2. To evaluate the suitability of this knowledge base modeling approach for forest management planning.

This work has resulted in two major products that can be used in conjunction with one another.

1. A preliminary prototype of the social component knowledge base to help assess the acceptability of natural resource decisionmaking processes by organizing a base of relevant social science research.
2. A conceptual framework for understanding the utility of the prototype.

To identify and incorporate these factors into the decision–support knowledge base, relevant literature was reviewed and synthesized. These data were used to organize the current knowledge and knowledge gaps in public acceptability of decisionmaking processes. This report represents our analysis of using a knowledge base as a tool for understanding social acceptability and for facilitating socially acceptable natural resource management. This information helps managers understand how the public judges and forms opinions about the acceptability of decisionmaking processes and how such judgments should be integrated with other decision factors to create compatible forest management decisions.

## Background

### Importance of Compatible Forest Management Practices

Learning how natural resource agencies can achieve compatibility among differing values and uses on forest lands is a goal of the compatibility initiative. Underlying this goal is the implicit assumption that although it is possible to achieve compatibility, a lack of knowledge constrains our ability to do so. It is important to acknowledge, however, that this presumption of compatibility might not hold true. Clawson (1974) noted that compatibility is not always attainable because certain forest uses are incompatible. Instead, a range of compatibility exists among differing forest uses with some being very compatible with each other, such as timber harvesting and hunting, and some, such as timber harvesting and wilderness use, being completely incompatible. Efforts to achieve compatibility, therefore, need to include many forest management scenarios within an entire region to represent forest uses that are potentially incompatible with each other.

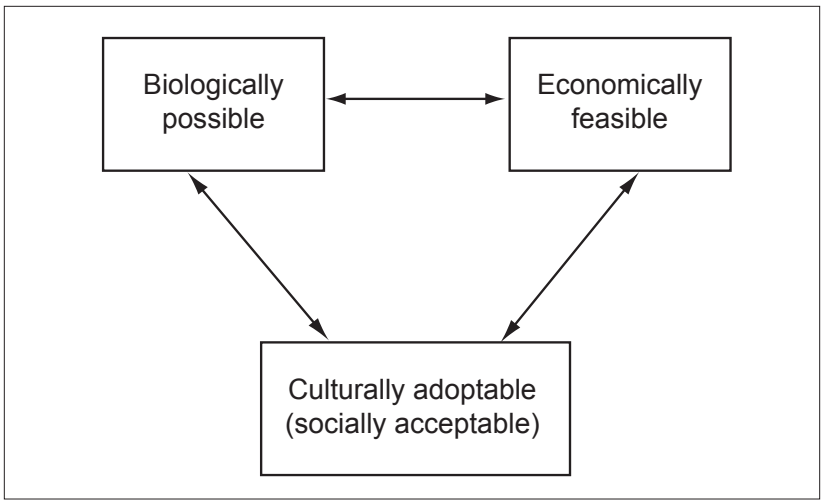


Figure 1—Required characteristics for the implementation of long-term resource management.

On a broader scale, compatible forest management practices must endure. To explain why certain resource practices and processes persist and others do not, Firey (1960) identified three obligatory, fundamental factors (fig. 1).

1. First, practices must be physically possible. They must be grounded in sound scientific principles.
2. Second, practices must be economically feasible. They must generate benefits in excess of costs.
3. Third, practices must be culturally adoptable. They must be accepted by the wider community and consistent with public values and norms.

Firey's (1960) work suggests that we view a compatible practice as physically, economically, and culturally adoptable. This concept of "culturally adoptable" is generally described as the social acceptability of practices and conditions (Brunson and others 1996). Because these three factors are dynamic, what constitutes a socially acceptable or economically feasible practice changes dramatically over time. Although constantly shifting, social acceptability is necessary for long-term management. Natural resource management must adapt to changing social needs. Currently, more experience, attention, and research is focused on the biophysical and economic requirements rather than the social values of natural resource management practices (Decker and others 1987). Our research assumes that compatibility between forest uses and values implies a combination of these three factors influencing natural resource management. Each factor is imperative for the successful, long-term implementation of natural resource management plans; failure to meet these factors will result in unsustainable processes and, hence, an inherently incompatible decision process and set of outcomes.

Ignoring social acceptability in management decisions impedes or prevents implementation of natural resource management plans. For example, studies show that most citizens expect agencies to consider their opinions in final decisions. In a 1991 national study of federal forest practices, 78 percent of citizens surveyed believed that citizen

**Table 1—Major attributes of the dominant and new resource management paradigms**

| Dominant resource management paradigm | New resource management paradigm |
|---|---|
| Amenities are coincident to commodity production | Amenity outputs have primary importance |
| Nature to produce goods and services | Nature for its own sake |
| Commodity outputs over environmental protection | Environmental protection over commodity outputs |
| Primary concern for current generation | Primary concerns for current and future generations |
| Intensive forest management | Less intensive forest management |
| No resource shortages: emphasis on short-term production and consumption | Limits to resource growth: emphasis on conservation for long-term sustainability |
| Decisionmaking by experts | Consultive and participatory decisionmaking |
| Centralized decision authority | Decentralized decision authority |

Source: Brown and Harris 1992. Reprinted, by permission, from Taylor and Francis (1992).

participation is valuable even if it adds to the cost of government (Shindler and others 1993). Unacceptable management decisions will prove difficult, if not impossible, to implement if social acceptability is neglected. Although agencies have the authority to implement policies, the public ultimately controls the Nation's political power. Such power affords the public a wide array of legal and political mechanisms with which to challenge and override unacceptable decisions. The occurrence of about 1,200 forest plan appeals since 1983 (Steelman 1999) demonstrates that agencies can no longer afford to ignore public opinion of forest management decisions.

## Challenges in Generating Socially Acceptable Management Decisions

Natural resource agencies are recognizing the importance of understanding public views and involving the public in natural resource planning processes despite challenges. In particular, differing paradigms about the notion of natural resources, and the conflicts that result from them, challenge agency attempts to generate socially acceptable decisions.

**Differing paradigms**—One major obstacle in generating and implementing acceptable resource management decisions derives from dramatically different paradigms of the relation between society and natural resources. In particular, two predominant perspectives have emerged: the dominant resource management paradigm and the emerging social paradigm or new environmental paradigm (NEP), also known as the new ecological paradigm (Dunlap and Van Liere 1978, M'Gonigle 1989). The dominant resource management paradigm is based on economic and commodity concerns, whereas the new environmental paradigm includes more biocentric values (table 1). These two paradigms depict the extremes of a continuum of values toward the natural environment that result in widely varying implications for resource management.

The Forest Service was formed at the turn of the century when the United States was dominated by the traditional conservation and rural development movement (Kennedy and others 1995). Thus, the culture of the Forest Service is traditionally based on the long-standing practice of natural resource utilization (Twight and Lynden 1989). Due to the educational and occupational environment in the field of natural resources, many

scientists and agency employees continue to hold viewpoints that correspond closely with the dominant natural resource paradigm.

Twight and Lyden (1988, 1989) noted that Forest Service professionals held opinions similar to "utilizer" groups such as the forest, mining, and livestock industries. In a study of the attitudes of forestry professionals, environmentalists, and the public, Vining and Ebreo (1991) found that resource managers held a more traditional, commodity-oriented view toward resource use than the public or what the public expected them to have. Although forestry managers perceived their viewpoints as aligned closely with those of the public, the views of the public were more aligned with environmentalists viewpoints. Similarly, Steel and others (1997) observed that both Oregon and national publics tended to hold biocentric values and were less likely to support traditional forest practices.

Although this Forest Service paradigm emphasizing resource utilization continues to persist because of requirements for employment in resource agencies and within professional cultures and norms (Wondolleck 1988), events unfolding in the latter half of this century dramatically changed public viewpoints. After World War II, the United States shifted to a postindustrial society with increased wealth, disposable income, and increasing leisure time (Pierce and others 1992), thereby resulting in a dramatic increase in public recreational use of national forests. (FEMAT 1993). Inglehart (1977, 1990) argued that this shift to a postindustrial society was accompanied by a similar shift in dominant citizen values, moving from a predominant focus on material values such as economic security to "postmaterialist" values such as environmental protection, quality of life, and equity issues.

Building on Maslow's (1954) hierarchy of needs, Inglehart (1977) postulated that such a shift occurs because individuals are more concerned with current wants or threats than those already satisfied or overcome. Because monetary concerns were greater earlier this century, the state of the economy ranked relatively high in importance for people who grew up during this era (Inglehart 1977). Since then, as increasing affluence reduced material concerns, the public began to place more emphasis on quality of life issues such as environmental protection (Dunlap and Mertig 1991). Thus, the priorities of recent generations have reflected their ability to satisfy basic economic needs and their corresponding desire to satisfy higher order needs (Steel and Lovrich 1997).

The disparity between these two paradigms is based partly on the emergence of two differing prominent value orientations toward the environment: anthropocentrism, which arises out of the conservation philosophy of Gifford Pinchot, and biocentrism, which resulted from the philosophy of John Muir and Aldo Leopold (Dunlap and Van Liere 1978, Stern and others 1993). An anthropocentric orientation describes the value of nature in terms of its worth to humans, whereas a biocentrist orientation believes in the inherent value of nature (Steel and others 1997). In recent years, researchers have documented the increasing prominence of biocentric values in the public (Dunlap 1991). For example, surveys of public attitudes toward forest (Shindler and others 1993) and rangeland management (Brunson and Steel 1994) found that most of the respondents agreed with statements reflecting a biocentric orientation.

Although public values have shifted toward more biocentric ideals over the years, and agencies like the USDA Forest Service and the Bureau of Land Management (BLM) now have guidelines that call for ecosystem-based practices, the historical emphasis on

commodity-utilitarian values still persists (Manring 1998). As new generations of younger, more culturally and professionally diverse employees enter the Forest Service, this traditional paradigm is likely to change (Brown and Harris 1992). In the meantime, studies suggest that the traditional resource management paradigm of forestry professionals fails to reflect public opinion and may therefore create a barrier to the generation and implementation of publicly acceptable forest management policies (Steel and others 1997, Vining and Ebreo 1991). Thus, the discrepancy between the worldviews of the Forest Service and the greater public has resulted in a clash of values and preferences for natural resource management.

**Conflicts resulting from these paradigms**—These radically different paradigms underlie the rise of conflicts over the goals of forest management. The worldview of an individual shapes how they define the problems facing forest management today which, in turn, limits the range of solutions under consideration (Caldwell 1990). It is important, therefore, to recognize that because the solutions will greatly differ depending on how the problem is framed, the question of who gets to define the problem is important.

For instance, an aspect of natural resource decisionmaking that has fostered public-agency conflict is the belief [espoused by forest managers] that forest issues are technical in nature and can only be solved through the increased use and distribution of scientific knowledge (M'Gonigle 1989). Because the dominant resource paradigm leads resource managers to view natural resource problems as technical, they continue to rely on technical expertise rather than public values to solve conflicts (Brunson 1992, Wondolleck 1988). Thus, agency personnel typically attempt to increase public acceptance of their decisions by presenting more data and results that support their perspectives.

This emphasis on scientific knowledge encourages resource professionals to place less importance on public input and values (Magill 1991). The experiential knowledge of the public is often undervalued and frequently dismissed as too emotional (McGee-Brown and others 1995, Vining and Schroeder 1987). In a study of the characteristics of successful and unsuccessful agency-public interactions, Wondolleck and Yaffee (1994) found that traditional approaches to management assign little value to public involvement. Furthermore, we noted that the Forest Service's "we know best" attitude also interfered with establishing productive agency relations with citizens (Wondolleck and Yaffee 1994). Resource professionals who rely only on technical expertise tend to feel a need to "educate" a misinformed public rather than acknowledge public input (Brunson 1992).

Traditional agency attempts, which rely on generating and presenting technical data to solve conflicts, fail to recognize that resources and their uses are social constructs (Stankey and Clark 1992). Resource conflicts arise because members of society hold different values for the environment and different beliefs on how to manage forests. These management dilemmas, termed "wicked problems," have no "correct" answers and are not determined by technical solutions (Allen and Gould 1986). Cortner and Richards (1983) note that the rational planning approach fails because it does not take into account that a decision about distribution and uses of natural resources is inherently a political process. As discussed in FEMAT (1993), the main role of science in natural resource management is to provide information between different alternatives that can assist managers in making decisions to achieve societal goals. We stress that scientific information should determine what options are feasible within an array of opportunities

rather than determine goals. Once society has chosen which goods and services to provide, technology can help achieve societal goals (Bardwell 1991).

In short, the current remedy of technical analyses is inappropriate for deciding how to allocate resources through a political process (Wondolleck 1988). To assume that public acceptability is solely a function of technical understanding will only prolong and aggravate the confrontations between agencies and the public. Social science research indicates that the scientific credibility of a plan is necessary but not sufficient for public acceptance of these forest management practices (Clark and Stankey 1994, Stankey 1996).

> Facts alone never tell us what we ought to do. The ought derives from considering the facts in light of human goals and objectives. This conclusion is particularly important for forestry and the other natural resource professions given the emphasis they have placed on fact-based solutions to problems (More and Glass 1995).

In summary, there continues to be major challenges to management efforts to generate socially acceptable decisions, thereby making a social science perspective essential for understanding current natural resource problems. Because judgments about the compatibility of diverse forest values and uses are social (Stankey and Clark 1992), it is necessary to better understand how people form these judgments in order know how to manage differing, and often conflicting, uses of forests. However, past attempts to understand and integrate social science information with other decision factors have often proved unsuccessful. To address this dilemma, we set out to examine whether the NetWeaver® knowledge base modeling approach had the potential to further our understanding of social acceptability and to address issues about the compatibility of forest management decisions.

## A Knowledge Base System as a Tool for Forest Management

Natural resource systems and the attempt of the compatibility initiative to integrate social, biological, and economic data are complex. To facilitate the study of such difficult issues, the NetWeaver® knowledge base system was developed to assist in compiling and organizing diverse types of information from different disciplines.

NetWeaver® has fundamentally different operating assumptions than mathematically-based models because it allows for a knowledge base assessment. A knowledge base system uses a metadatabase to interpret data. The distinguishing characteristic of a knowledge base system is that a knowledge base uses a fuzzy logic framework to organize information, recognizing that many complex and qualitative issues cannot be described with mathematical equations typically found in traditional rule-based models. Because the issue of social acceptability is broad and complex, the knowledge base reasoning of NetWeaver® was expected to hold more utility than traditional, rule-based models, which are often more appropriate for specific, well-defined problems (Reynolds and others 2000).

To initiate the design of a knowledge base, the overall issue or problem analyzed is stated in the form of a proposition such as “the natural resource management decision-making process was socially acceptable.” The proposition is simply a hypothesis. The designer of the knowledge base considers what factors influence the truth of the overall proposition and creates a hierarchy of lower order propositions in the knowledge base.

Once the hierarchy is created, the user is ready to assess the truth of the problem represented by the main proposition. To do so, the user inputs data into the lowest propositions. Based on the values that are entered into the knowledge base, the level of truth, ranging from completely false to completely true, is calculated for each proposition. The calculated truth value of each of the lower order propositions then contributes to the truth value of higher order propositions, which in turn contributes to the truth value of the main proposition. See Reynolds (1999) for further information on the design and application of a knowledge base.

**Potential of a Knowledge Base Approach**

One of the principal benefits of a knowledge base approach is that its formal representation can help users think more productively about the issue of concern. The process of constructing the knowledge base forces one to define, assemble, and organize fundamentally complex issues. It provides a way of depicting these issues in a formal representation that assists in defining key variables and portraying relations among these variables. Users also benefit from the graphical portrayal of the knowledge base. The hierarchical structure of the knowledge base suggests a "ranking" of the most critical aspects of the concept studied, helping forestry professionals to quickly prioritize the most important issues. The construction of a knowledge base is particularly valuable for representing social science problems because it forces the placement of concrete labels on relatively abstract social concepts. Thus, the process of designing a knowledge base can have value to researchers apart from any management application of it.

Another benefit of a knowledge base modeling approach arises from the capacity of NetWeaver® for documentation. NetWeaver® allows the researcher to document several pieces of information for each factor including the name of the individual who incorporated that piece into the knowledge base, the research literature that supports the inclusion of that factor into the knowledge base, and any assumptions surrounding the incorporation of that factor. The citations documented under each factor within the knowledge base let the user evaluate the basis for the item and its value. Unlike many models where assumptions behind the decisionmaking processes are concealed from the typical user, the ability to document assumptions in NetWeaver® will allow future users to critique the literature used to justify the incorporation of an item into the hierarchy. If the relevance of a particular item is in doubt, the user can refer back to the references to examine whether or not those research studies suggest the need to consider that factor. The capacity of NetWeaver® for documentation thus increases the likelihood that this approach does not become another "black box."[2]

Another value of the knowledge base modeling system is its capacity to draw partial inferences from incomplete information (Reynolds and others 1997). NetWeaver® can determine the importance of a factor in understanding the overall proposition based on the number of times that item was found in the knowledge base and the placement of that item within the hierarchy. The more often an item is included in the hierarchy and the higher up in the hierarchy that the factor is located, the more influence that item has on the main proposition. Even with incomplete data (a common occurrence), the knowledge base can determine the influence of missing data to produce assessments of natural

[2] The term "black box" has been used to describe models in which the assumptions underlying the model framework are known only to the programmer. Thus, when a number or answer is generated by the model, the user has little information with which to evaluate the validity of the factor.

resource information. In this way, the knowledge base also can help prioritize the acquisition of missing data. The ease of acquiring data can be entered into the program. NetWeaver® uses this information, combined with the relative importance of that data to the overall knowledge base proposition, to generate priorities for further data acquisition. In addition, NetWeaver® can graphically depict how each subset of factors within the knowledge base influences the value of the main proposition. Factors are then added or removed to observe the effect the change has on the final value. This allows the user to obtain a better understanding of how sensitive the final value of the knowledge base is to various components of the knowledge base structure.

Another benefit of a knowledge base modeling system is that it helps reveal gaps in the research literature. Because the knowledge base derives from the documentation of previous research, missing data reveal areas of the literature where there is a scarcity of supporting information. The lack of adequate studies in these areas suggests future research priorities. Revealing these knowledge gaps within the literature is perhaps one of the most important benefits of a knowledge base for which our lack of understanding constrains effective action.

Awareness of these potential benefits of the NetWeaver® program urged us to further examine the potential of a knowledge base approach for forest management planning. Specifically, we examined the suitability of a knowledge base to account for our current understanding of the social acceptability of natural resource decisionmaking processes.

## What Is Social Acceptability?

We briefly outline the main concepts that helped form our understanding and construction of the decision-support system for social acceptability. Shindler and others (in press) provide a more comprehensive synthesis of social acceptability. They attempt to define this commonly used, but little understood, term and suggest that social acceptability refers to "some aggregate form of public consent whereby judgments are shared and articulated by an identifiable and politically relevant segment of the citizenry."

Although the literature in our review focused more on the public's acceptability of natural resource decisions rather than its acceptability of the decisionmaking processes (the focus of this paper) we were able to identify several critical factors for forming public acceptability judgments. Because of the lack of research on the acceptability of processes, the literature on the acceptability of outcomes was often used as a proxy.

**Context**—Previous research provides examples of natural resource decisions that were important for public acceptability (Brunson 1992, Hansis 1995). Judgments of acceptability are highly influenced by several aspects of context including situational, spatial, and social context. The situational context reflects the past management of the environment surrounding the proposed management location. George Stankey recounts a field tour in which several individuals listened to a description of an experimental harvest unit within the Willamette National Forest in Oregon. A member of the audience from the Wilderness Society stated that although the harvest was well done, the existing clearcut remained completely unacceptable to him. He pointed out that most of the surrounding drainage also had been harvested, and one more harvest, however well done, was still one too many. This example highlights the role that the situational context can play in people's judgments of acceptability and also illustrates the limitations of technical arguments on public opinion.

The spatial context of a management decision focuses more on the importance of a particular site for an individual or group and contains fewer references to management of the surrounding locale than would the situational context. In the research literature, this context is often referred to as "place," "sense of place" or "place attachment."

> Place attachment involves positively experienced bonds, sometimes occurring without awareness, that are developed over time from the behavioral, affective, and cognitive ties between individuals and/or groups and their sociophysical environment (Brown and Perkins 1992).

People's sense of place is a powerful sentiment that should not be underestimated or undervalued. People not previously involved in management decisions often become mobilized when an undesirable practice is slated to occur in a highly valued location. Williams and Carr (1993) suggest that the reason natural resource managers have so many conflicts with their decisions is partly because of their failure to recognize the importance of the strong bonds that people form with specific landscapes. There is an erroneous presumption that there are suitable substitutes for any particular recreation site, such as a campground or fishing hole. Individual sentimental sites, however, cannot be replaced without an emotional loss to the recreationist. These place-grounded sentiments are often ignored in natural resource decisionmaking because managers do not consider them to be valuable components of their technically-oriented management plans. Yet, Williams and Stewart (1998) note that "even what planners and scientists put forward as a data-driven description of a place in the form of a scientific assessment is itself another competing sense of place." Instead of viewing the public's sense of place as an obstacle to overcome in order to develop management decisions, Williams and Carr (1993) suggest managers make greater efforts to recognize and understand the strong meanings and ties that people have with the natural environment.

The spatial context of management decisions has many implications for the notion of social acceptability. Researchers studying forest management practices at the urban interface have observed that various timber harvesting scenarios found publicly acceptable in a general sense are often found unacceptable when situated in a familiar, highly valued location (Brandenburg and Carroll 1995, Johnson and others 1994). In particular, NIMBY (not in my backyard) responses to the siting of hazardous waste facilities are highly publicized cases of the importance of context to public judgments (Lober 1995).

The social context also influences how people judge the acceptability of management practices. Social context refers to the demographic characteristics of an individual or to a membership in a reference group (Brunson 1993). Although many studies have revealed mixed results, demographic characteristics such as gender, age, education, income, residence, and political ideology can influence people's level of environmental concern. In particular, females, younger generations, the highly educated, and people with high household incomes hold higher levels of environmental concern than their counterparts (Perry and Pope 1995).

Studies also have noted the effect of membership in a reference group on preferences for forest management. In a study of Oregon and national publics, for example, Steel and others (1994a) found that individuals employed in the timber industry were more likely to

have anthropocentric value orientations, whereas people associated with environmental groups held more biocentric orientations. The authors observed that these value orientations influenced preferences of people for forest management on federal lands. Vining and Ebreo (1991) also noted that resource managers, environmentalists, and the public varied in their ranking of the importance of 10 possible goals for resource management. In addition, membership in reference groups often serves to accentuate the notion of "insiders" and "outsiders" and leads to a polarization of beliefs in conflict situations. Thus, understanding the situational, spatial, and social context of a management decision is crucial to an overall understanding of public preferences for land management options. The ability to operationalize these different contexts within a knowledge base is discussed further under "Issue 2."

**Institutional and individual trust**—Research has consistently shown that public distrust in natural resource management agencies is one of the principal obstacles to increased public acceptance of forest management decisions (Wondolleck 1988). Brockner and others (1997) found that when outcomes are unfavorable, the support of people for an organization is based on their prior level of trust in that organization. A lack of trust in agencies can hinder public acceptability of agency decisions, such as siting toxic waste facilities (Lober 1996), because the public's lack of trust leads to a perception of increased risk (Binney and others 1996).

Although frequently used in the research literature, terms like trust and confidence lack consistent definitions. We use La Porte and Metlay's (1996) definition of trust as "the belief that those with whom you interact will take your interests into account . . ." and confidence as knowing that the other party "is able to empathize with your interests, is competent to act on that knowledge, and will go to considerable lengths to keep its word." In short, trustworthiness is a combination of trust and confidence.

Although the formation of trust between the public and institutions develops over a long period, it can erode quickly (Glaser 1997). Both trust and confidence in government agencies have declined dramatically in recent decades. Polls taken have shown that, on average, public members expressing a "great deal of confidence" in the leadership of 10 different institutions including government, industry, and universities has declined from a high of 45 percent of respondents in the 1960s to a low of about 24 percent in the early 1980s (Kasperson and others 1992). More recently, in a study of public involvement in forest management, only 32 percent of the residents surveyed believed that the federal forest managers in their area were building trust and cooperation with citizens.[3]

It is important to note the distinction between institutional and individual trust. At the same time that public trust in institutions has declined, the public has often retained a high level of trust in individual employees with whom they interact. The formation of interpersonal relation is key to the establishment of trust between agency personnel and members of the public. Wondolleck and Yaffee (1994) found, however, that the Forest Service's policy of regularly transferring district employees often dampened public trust by preventing the establishment of long-term relation between agency employees and the local public. Although this policy was implemented to prevent officials from being dominated by local interests instead of the national mission of the agency, this policy

[3] Shindler, B. 1997. Unpublished data. On file with author.

has repercussions for issues of leadership, trust, and credibility. Because the establishing of trust takes time, public-agency relations often suffer when trusted personnel are transferred. For these reasons, the frequency of personnel transfers is incorporated into the social acceptability knowledge base as a component of trust.

In an examination of a wilderness task force in the U.S. and a National Park advisory committee in Australia, Moore (1996) notes the fragility and the importance of both interpersonal and organizational trust in establishing the decisionmaking networks necessary for natural resource management. Moore (1996) observed that interpersonal trust was based on factors such as honesty and benevolence, whereas organizational trust was based on the perceived fairness of the process, also known as procedural justice (Tuler and Webler 1999).

Public distrust in institutions occurs for various reasons. Trust is lost when the expectations of the people do not match their experiences (Binney and others 1996). Pijawka and Mushkatel (1991-92) note various reasons for the loss of trust in the Department of Energy including loss of scientific credibility resulting from making errors, not handling mistakes well, revealing mistakes only after extensive conflict, loss of institutional legitimacy, perceived lack of concern for the public, perceived agency mismanagement, use of secretive processes, mishandling of information, and poor performance records.

How to restore public trust in institutions is the focus of many previous studies. Binney and others (1996) suggested that agencies use public–and not just technical–input in decisionmaking, establish two-way public-agency communications, better understand the social impacts of decisions, and share power with local communities. La Porte and Metlay (1996) state several procedures that agencies should use to establish trust: involve stakeholder groups before decisions are made; respond rapidly to questions; fulfill agreements in a timely manner; inform, consult, and collaborate with state and community leaders and the public; make agency leaders accessible to the public; have agency personnel contribute to local communities; and secure benefits for communities affected by your decisions.

In another study of trust and credibility, Peters and others (1997) found that the greatest improvement in public perceptions of trust occur when the company or agency conducts themselves in a manner that defies their current negative stereotypes. In the context of natural resource agencies, an attempt to restore public trust could include, for example, working to change public opinions that forest management decisions were made before the public participation process. These types of efforts, such as using public input and sharing decisionmaking power, could go a long way toward improving public trust in natural resource management institutions. Because trust is such a critical component of acceptable natural resource decisions, an effort was made to incorporate the many factors found to influence the formation of trust into the social acceptability knowledge base.

**Risk**—Perceived risk influences public acceptability. The most important factor to note is that it is the public's perception of risk–not necessarily the quantitative risk assessment as calculated by scientific analyses–that influences public judgments of acceptability. These two estimations often differ greatly (Sullivan 1998). For instance, though risk assessors have determined the risk of toxic waste disposal as low in comparison to

other hazards, the public perceives the risk from these practices as high. In a study of risk assessments by various groups, Slovic (1987) found that citizens ranked nuclear power as the riskiest item out of 30 different activities or technologies, whereas experts ranked it 20th on the same list.

The reason for this disparity in public and scientific measures of risk is related to the difference in how the public and scientists form those risk judgments. In scientific assessments, risk is defined as a function of both the likelihood of a hazard and the consequences of the hazard (Hendershot 1996). Sullivan (1998) notes, however, that scientific measures of the consequences of a hazard are unrealistically low because they are based on our limited understanding of the consequences of various activities or technologies. At the same time, Arrandale (1999) observed that public judgments of these same risks were high for the very same reason.

The difference between the level of risk perceived by the public and the level of risk determined by experts has led some scientists to criticize the public's "irrationality" about particular technologies. Arguing against this criticism, Slovic (1997) maintains that the notion of risk is a social construct and, as a result, does not exist independently of our own conceptions and therefore cannot be measured "objectively." The author notes that although many risk assessments are based on expected annual fatalities, public assessments of risk are founded on many variables that are not well analyzed in technical risk assessments such as uncertainty, perceived inequity of benefits and costs, possibility of involuntary exposure, lack of control, lack of trust, risk to future generations, and the possibility of catastrophic consequences. Also, the notions of risk and trust are inextricably intertwined. A lack of trust in natural resource agencies has often led to a higher perception of risk for the processes undertaken by those agencies (Kasperson and others 1992).

Other variables that influence people's determination of risk include the probability of making an error, the extent and length of time of the consequences, the familiarity of the risk, the amount of media coverage, and the past history of management and accidents (Fischoff and others 1981, Sullivan 1998). In a study conducted to determine what variables influenced public attitudes toward the siting of hazardous waste facilities, Lober (1996) found that increased trust, familiarity with similar types of facilities, a high level of local control, a perception of need, and perception of the ability of the organization to operate the facility were all associated with decreased opposition, whereas an increased perception of risk was associated with increased opposition to the siting. Because the data indicated that an increased perception of need had a high association with support of the facilities, Lober (1996) suggests that managers discuss the need for the activity as one method of increasing public support for management decisions. These studies demonstrate that public perceptions of risk are influenced by various factors. It is the high complexity and variability of this "web" of influences that make operationalization of risk in the knowledge base difficult.

Determining the level of acceptable risk by the public should utilize a political process involving the affected parties (FEMAT 1993). In these negotiations, scientists should play an advisory role only and should not dictate how to define risk. The continued reliance of scientists on technical information to determine an "accurate" level of risk is inappropriate for addressing the public's level of acceptable risk. If public perceptions of risk are not

addressed in natural resource management, the perceived risk associated with an action can result in public attempts to alter or overturn the decision. For instance, the public's high perception of risk associated with hazardous waste disposal and the failure of siting authorities to gain public acceptance of decisions have often stopped the siting process (Pijawka and Mushkatel 1991-92). To lessen the perceived risks of manage-ment actions, Kasperson and others (1992) suggest agencies openly discuss public concerns, understand differences between processes and outcomes, share power with publics, use multiple strategies to reach various parties, and have participatory evaluation throughout the process. Both managers and experts will need to involve interested publics in decisionmaking to ensure that public risk concerns are effectively addressed.

**Knowledge**—The level of knowledge of the public is another factor affecting acceptability judgments. Whereas most managers focus on the distribution of scientific information to increase public understanding and support, experiential knowledge–traditional or local knowledge that results from personal experience–also contributes to judgments (Kearney and others 1996, Kloppenburg 1991). Again, an understanding of differing worldviews helps reveal the reasons for the focus on scientific knowledge. Because the worldviews of managers leads them to perceive natural resource conflicts as technical problems requiring technical knowledge for their solution, local, experien-tially-based knowledge is typically seen as inconsequential or even irrelevant to the decisionmaking process. Not only does this emphasis on technical knowledge exclude local knowledge from the decision process, it also can subtly convey a lack of legitimacy and respect of such knowledge. This perceived lack of respect, in turn, will only accentu-ate public distrust of the agency. Because natural resource conflicts are social, local knowledge is an important component of the decision process. In addition, there are important links between worldviews and knowledge. Individual worldviews affect a person's knowledge about their environment. Although the use of scientific information is one way of understanding the world, traditional knowledge is equally important. One concern with the knowledge base modeling approach is whether the complexity of these different dimensions of knowledge are adequately represented.

Research indicates that people with a better understanding of the purpose behind a forest practice are more likely to find the practice acceptable. One of the most consistent examples is the strong association between the level of knowledge about the role of fire in ecosystems and acceptance of prescribed fire (Shelby and Speaker 1990, Stankey 1976). Greater knowledge of fire management has led to increased support for practices other than total fire suppression. Although a person's knowledge influences their judgments, simply providing the public with additional information is not sufficient. Studies show knowledge as a rather poor predictor of public support for certain policies such as tax proposals (Steel and others 1994b). Although increased technical knowledge can give people a better understanding of the alternatives open to them, it can also potentially lead to lower levels of support for a particular management strategy (Stankey 1996).

Examining the role of knowledge in public acceptance of ecosystem management practices, Cheek and others (1997) note the importance of the type of information given, the method of delivering information, the credibility of information, and the source of information on the information provision process. For instance, television has proven successful for communicating natural resource information (Brothers and others 1991, Fortner and Lyon 1985). Issues such as these can affect how knowledge is accounted for in the social acceptability knowledge base.

Again, trust plays a central role in public acceptance. People need to trust the source of scientific information to believe the information is credible (Binney and others 1996). Research indicates a considerable level of variability exists. For example, although university scientists are frequently rated the most trustworthy source of reliable information (Pilisuk and others 1987), trust in other sources such as state and federal agencies, public interest groups, the media, and forest industry differs among communities and local circumstances (Wondolleck and Yaffee 1994). Current trust ratings for Congress are unilaterally low (Brunson and Steel 1994). Information from sources credible to the public will have the most influence on public knowledge and, potentially, public acceptability.

**Process variables**—Although factors such as context, risk, and trust are important, these are just a few of the factors to consider when attempting to generate socially acceptable policy decisions. History indicates that it is not enough to account for biological and economic values; agencies also must contend with public values and beliefs if their policy decisions are to survive without undue conflict.

The ability to account for public values and beliefs in decisionmaking is, at its core, a question of process–how can natural resource agencies generate management decisions? Until there is greater awareness and genuine acceptance among agency personnel about the role of process, it is unlikely that we will generate management policies that are socially acceptable. When process variables are accounted for in natural resource decisionmaking, socially acceptable programs and policies are likely.

## The Social Acceptability Knowledge Base[4]

This section provides a general description of the social acceptability knowledge base design and layout and reviews the structure and confidence of two different example pathways in the knowledge base. For more detailed information, refer to the glossary.

### Design of the Knowledge Base

Early in our research, we defined the primary issue of concern for designing the knowledge base. Based on consultations with PNW researchers, we determined that the knowledge base needed to address how the USDA Forest Service could generate socially acceptable policies. Because the ability to generate acceptable policies is a question of process, the main proposition or hypothesis in the knowledge base was constructed to state that the public believes that the natural resource decisionmaking process was socially acceptable.

The research literature was then reviewed to identify factors that have influenced public acceptance of decisionmaking processes. Our review revealed many factors important to public acceptance under various contexts. To better organize the knowledge base, these factors were compiled and assembled into larger categories that best described the overall theme of the items. These categories were then incorporated into the knowledge base framework as lower level propositions or hypotheses. Thus, the knowledge base consists of a hierarchy of factors found to influence social acceptability. The hierarchy

[4] Because this report is not intended to be a users manual for NetWeaver®, the following sections outlining the social acceptability knowledge base design and layout may be difficult to follow. To fully understand the description of the knowledge base discussed in these sections, we suggest that readers first peruse the prototype of the social acceptability knowledge base that accompanies this report.

attempts to account for the available knowledge about public acceptance of natural resource decisionmaking processes and the relation among various factors that affect the main proposition. This formal representation yields a better understanding of the state of the knowledge surrounding the acceptability of decisionmaking processes.

We believe these propositions are important for social acceptability based on our review of current research. Determining whether the propositions are important for social acceptability and including them in the knowledge base is open to judgment for managers to debate and alter as new information emerges. Other researchers also interested in social acceptability can review the components of the social acceptability knowledge base and make their own judgments. Thus, examining of the knowledge base design encourages mutual learning among researchers, managers, or other interested publics.

For knowledge bases to generate a truth value for the main problem statement, users must input values or responses into the lowest level of propositions, just as respondents would answer questions on a survey. NetWeaver® converts all those responses to values, which are then combined to evaluate the truth level of higher level propositions. The knowledge base ultimately generates one numerical value that corresponds to the level of truth (completely false to completely true) of the main proposition or hypothesis.

**Social Acceptability Knowledge Base Layout**

The knowledge base was constructed to find the truth value for the main proposition that the natural resource decisionmaking process was socially acceptable. This focus on process rather than outcomes allows the knowledge base to better contend with different contexts because the process is more transferable to a variety of management scenarios than is a particular decision outcome. Based on the procedural justice literature (Tuler and Webler 1999, Wondolleck 1988), this main proposition was split into both fairness and nonfairness principles, which also were stated as propositions in NetWeaver® (fig. 2). A review of the research literature from various fields was used to insert additional, important factors as propositions for public acceptability of natural resource decision-making processes. To illustrate, we trace the pathways of two contrasting items down through the hierarchy, describe the reasons for their inclusion into the knowledge base, and briefly discuss the confidence surrounding each item.

Before discussing specific pathways in the knowledge base, note that all factors are listed as propositions in NetWeaver® with undetermined truth values. NetWeaver® allows the individual who designs the knowledge base to add documentation for clarification of each factor. In this documentation window, each factor has a one- or two-word name, a longer, more explanatory definition, the name of the individual who decided to include that factor into the model, and the citations from the research literature used as a basis for including that concept into the decision-support model. The citations that we included in the documentation window of the item represent only a selection of research conducted in that arena and is by no means exhaustive. Although we tried to incorporate many citations, there was greater difficulty in finding research for such fields as understanding and using the public's local knowledge than for understanding the importance of sense of place. Therefore, it is possible from an examination of the number and type of research papers cited to obtain an imperfect estimation of whether that factor is well documented in the natural resource literature.

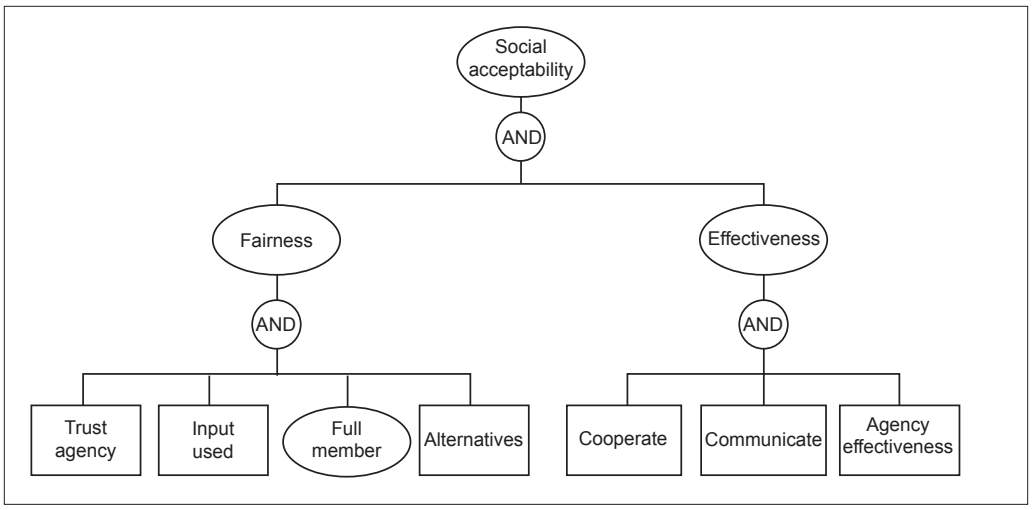


Figure 2—The three uppermost levels of propositions from the social acceptability knowledge base analyzes the extent to which a natural resource decisionmaking process was socially acceptable. Based on the level of truth of each of the factors beneath "fairness" and "effectiveness," NetWeaver® calculates a truth value for these higher order factors. The effect of the "AND" is to require that each one of the factors beneath an item are true in order for the higher order proposition to be true. Thus, the "AND" assumes a bias toward the most limiting factor underneath a proposition.

In addition, note that nearly all propositions in the social acceptability knowledge base are based on the premise that the public believes the statement to be true. In this way, the overall truth of the main proposition of social acceptability is arranged (much like a survey of the public) to reflect only public opinions of all the statements and not what an agency member might believe is true about that same statement. This aspect of the knowledge base design is important because the opinions of agency members about the acceptability of a decisionmaking process might not adequately reflect public opinions. Because of this arrangement, it is essential that the people who input their opinions about the truth values of lower order propositions are people who represent interested public opinion.

**Example pathways**—We now describe, compare, and contrast two differing pathways. The description of these pathways also will explain how NetWeaver® uses the inputted data to calculate truth values of the propositions. These pathways are only two in a large and complex hierarchy of factors that influence social acceptability. The main proposition, that a natural resource decisionmaking process was socially acceptable, overlies both these pathways. The first pathway will describe a factor categorized as a fairness principle, and the second pathway will describe a factor categorized as a non-fairness principle. Varying terms such as "competence," "efficiency," and "effectiveness" describe these nonfairness principles (Webler and Tuler 2000). For consistency, we categorize nonfairness principles as "effectiveness" principles.

Factors were included in the hierarchy based on whether research indicates the importance of a factor for socially acceptable decisionmaking. The greater the number and the consistency of the research studies, the greater our confidence for including that factor into the model. For example, a topic such as the need for effective public-agency communication, consistantly referred to in the literature suggests that it was appropriate to incorporate that item into the knowledge base.

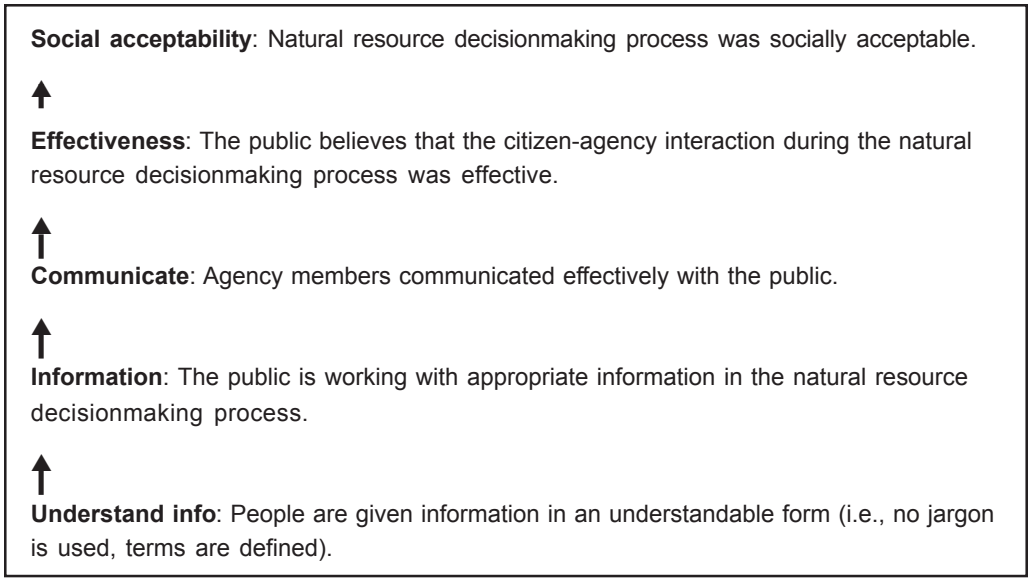


Figure 3—Pathway of the importance of "understand info" for social acceptability of natural resource decisionmaking. Comments contain the more complete definition of the proposition that is described by the short titles used in NetWeaver®.

The first example pathway describes the path, titled "understand info," that must be followed to learn the importance of giving the public understandable information (fig. 3). After determining the most suitable location for this factor in the decisionmaking hierarchy, it was placed under nonfairness or effectiveness principles of decisionmaking. The "effectiveness" pathway was divided into three categories of influence: cooperation, agency effectiveness, and communication. The latter category, communication, is a factor often discussed in studies that have agreed on the importance of communication for effective decisionmaking processes (Selin and Chavez 1993).

In the knowledge base, taking this pathway another step shows that factors that affect whether or not natural resource agencies communicate well with the public also are divided into three categories: trust, effective meetings, and information. Many research studies reveal the importance of giving the public good information (Shindler and Neburka 1997, Wondolleck 1988). The factors that influence whether or not the public was working with appropriate information reveals a list of four items: access to information, information dispersal, scientific information, and understanding information. Because scientific information and information dispersal contain further factors that influence them, it is possible to continue down these pathways. For this example on "understand info," though, the pathway terminates at this level.

At this point, the user needs to input the data necessary for NetWeaver® to calculate the truth value of this data link–whether or not people were given information in an understandable form. All data links in the knowledge base are constructed on a scale from -1 to +1 where -1 means the statement is 100 percent false and +1 means the statement is 100 percent true. To input the data, the user has to choose a value between -1 and +1 that corresponds to their best estimation of the truth of the statement. Because the choice of this number was considered vague for users, a set of ordinal categories were placed as answer choices. In response to the question of whether people were given information in an understandable form, the user could choose between five possible answers: barely, little, some, most, and unknown. Extreme choices such as "not at all" or "all" were not used to ensure the set of ordinal responses were limited to five instead of seven responses to reduce complexity. Instead, as currently arranged, anything equal to or worse than "barely" [i.e., people were given barely any information in an understandable form] was completely false and better than "most" [people were given most information in an understandable form] was completely true.

In NetWeaver®, a choice of "little" [information given in an understandable form] corresponds to a partially false value of -.5, whereas "some" [information given in an understandable form] corresponds to a partially true value of +.5. In addition, the choice of "unknown" automatically corresponds with a value of zero, which is considered half false and half true. In this way, the ordinal user response will compute to a numerical value that corresponds to the truth value of the entire "understand info" proposition. Going back up the hierarchy, this value is then used in NetWeaver® calculations of the truth of "information" in combination with the computed truth values of "scientific info," "info dispersal," and "access to info." The responses inputted into these data links can result from knowledge obtained from various sources including survey or interview data. Important considerations about the choice of a data source are discussed later.

The second example pathway ultimately ends in the proposition that considering spiritual values in the natural resource decisionmaking process is important (fig. 4). Again, the knowledge base begins with the proposition about social acceptability, but in this example, the pathway splits into fairness principles rather than effectiveness principles. The overwhelming importance of considering fairness principles in the decisionmaking process is repeatedly demonstrated: 11 citations, including Brockner and others (1997), Knopp and Caldbeck (1990), and Leventhal (1980), are documented in NetWeaver® forming the basis for including fairness principles into the knowledge base.

Based on the literature, fairness principles were further divided into four categories: public trust in the agency, use of public input, the public as a full member of the decisionmaking process, and the existence of alternative decisions. To understand the need for considering spiritual values, the pathway will refer only to the items considered under use of public input. Although many agencies have public participation processes in place, studies suggest that the public participation processes of agencies are more show than substance and that agencies frequently are using the participation process to show the public the advantages of a previously made decision (Fortmann and Fairfax 1991). The belief that public input is disregarded has angered the public, contributing to public distrust of agencies. Thus, the need for agencies to consider public input is critical to public acceptance of the decisionmaking process (Lauber and Knuth 1997, Webler and Tuler 2000).

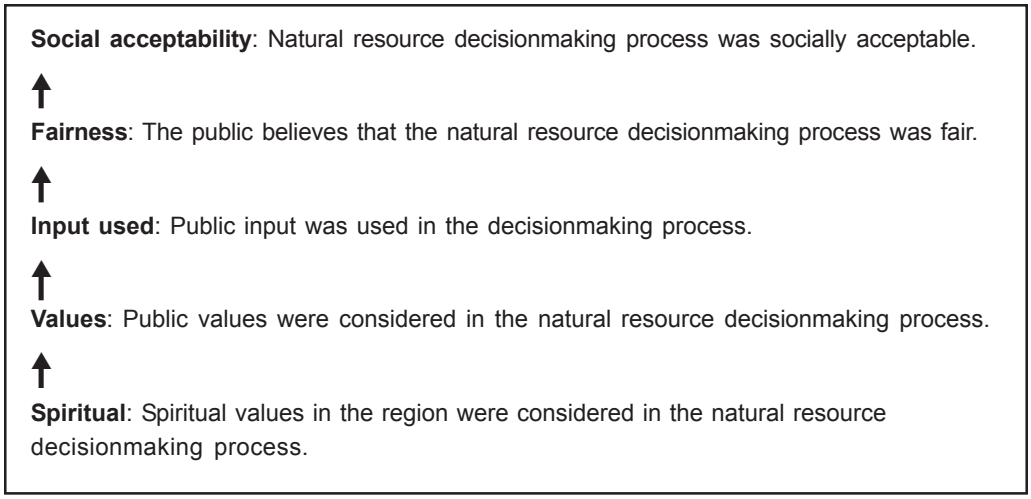


Figure 4—Pathway of the importance of considering "spiritual" values for social acceptability of natural resource decisionmaking. Comments contain the more complete definition of the proposition that is described by the short titles used in NetWeaver®.

Under the "input used" category, the hierarchy splits into a description of three subheadings: context, experiential knowledge, and public values. Following the pathway depicted in figure 4, we will now consider public values. Many research studies either indicate the importance of understanding public values for forest management (Shannon 1987, Stankey and Clark 1992) or examine environmental values in general (Inglehart 1990, Steel and others 1994a). Under the data link for values, factors were subdivided according to Stankey and Clark's (1992) discussion of the varying forms of values including commodity, amenity, environmental quality, ecological, public use values, and spiritual values. In addition to these, values for security and health were included to cover a more specific range of possible values.

Although we believe spiritual values are important to consider in the decisionmaking process, we found little research incorporating these values into the public participation process. In contrast, research on other public values for natural resources, such as scenic beauty, is extensive (Benson and Ullrich 1981, Brunson and Reiter 1996, Ribe 1999). The variation in the number of research studies conducted on a topic is often useful for establishing future research priorities. Although it is possible that the lack of research studies on spiritual values indicates a lack of importance for consideration, it is more likely that researchers have simply chosen to focus on public values, such as scenic beauty, which are perhaps less complicated to study. The problems associated with a lack of research studies are, of course, external to the use of NetWeaver®; the knowledge base system is simply one place in which this operational difficulty reveals itself.

**Confidence**—As noted in the contrasting examples of two different pathways of the knowledge base, our confidence behind the inclusion of each proposition differs widely. Whereas some factors in the knowledge base are well grounded in the peer-reviewed literature, others are not. This lack of research is not meant to imply that the factor is less important as an impact on the main proposition; it simply means that additional research is needed.

In addition, although research studies were typically consistent in their findings, occasionally we discovered that different research studies revealed conflicting findings about the importance of a particular factor for social acceptability. For example, findings from research studies disagree on the importance of demographic characteristics, such as the age, race, household income, or gender of people, in how people form judgments. Although several studies report that gender influences a person's level of environmental concern (Barke and others 1997, Bord and O'Conner 1997, Davidson and Freudenburg 1996), other studies show mixed results (Stern and Dietz 1994, Stern and others 1993), and still other studies determine no relation between gender and environmental concern (Jones and Dunlap 1992, Kanagy and others 1994, Krause 1993).

Even when a review of the literature revealed contradictory findings about a topic, that item was still placed in the hierarchy. In these rare instances, we documented both contrasting viewpoints (literature references that justified entering a factor into the knowledge base and those that suggested the factor was not important for social acceptability). For future projects, it may be useful to consider incorporating some indices that represent the consistency of the research findings among the various research studies used to justify placing an item into the social acceptability knowledge base.

## Social Issues of Concern

Through our literature review and subsequent creation of a knowledge base prototype of social acceptability for forest management planning, we discovered some concerns that need addressing before determining the suitability of knowledge bases in forest management. This section describes four main issues of concern that resulted from our analysis of using a knowledge base modeling approach for understanding social acceptability. Note that these four areas are inherent and fundamental issues that confront the planning process. They are not unique to a knowledge base modeling approach as outlined here. In the following discussion, each issue is accompanied by the rationale underlying its impact on planning, followed by a set of future research recommendations.

### Issue 1

Natural resource agencies focus more on the social acceptability of their decisions than the acceptability of their decisionmaking processes.

**Rationale**—Too often, management agencies focus on the public's acceptance of their decision without fully comprehending that the attempt of an agency to achieve public acceptance of natural resource policy is inherently a question of process rather than outcomes. Wondolleck (1988) discussed how decisionmakers often start out addressing the wrong questions, which makes it difficult to generate conflict-free management decisions. She asserts that decisionmakers should not ask themselves "What decision should we make?" or "What is the proper allocation of resources in this situation?" but rather "How should we make such a complex, difficult, and controversial decision?"

Once decisionmakers are focused on the ramifications of the decisionmaking process, Wondolleck (1985, 1988) suggests that other, more pertinent questions will arise naturally such as "What information do we need, where can we get the information needed, who should be involved, what problems are we likely to encounter and how might we overcome them?" Wondolleck (1985) states that a focus on process is especially critical when the decisions are "complex and value laden and when there are

limits to technical expertise in reaching solutions" that are typically found in natural resource controversies. In brief, studies suggest that when socially acceptable processes are achieved, socially acceptable decisions will naturally follow (Shindler and others 1999). For this reason, the social acceptability knowledge base was designed around a question of process, "Was the decisionmaking process of the agency socially acceptable" rather than outcomes, "Did the agency create a socially acceptable decision?"

The field of procedural justice has contributed to our understanding of how decision processes become socially acceptable. Arising from the study of social psychology, procedural justice theories examine the effect of decisionmaking processes on public judgments of decision outcomes. A central premise is that public satisfaction derives from the process by which decisions are made as much as it comes from the outcome itself (Lawrence and others 1997). For instance, when judging the acceptability of an outcome, people take into consideration their perception about the fairness of the procedures that ultimately produced an outcome. Findings from conflict management research suggest that the public is more likely to accept an unfavorable outcome if they believe that the decisionmaking process was fair (Knopp and Caldbeck 1990). In the context of public land management, a major component of an acceptable decision process is the extent to which the public believes that the process itself was acceptable.

Many researchers have examined procedural criteria for developing socially acceptable policies. Procedural issues that influence public satisfaction include opportunity to participate (Smith and McDonough 2001, Tuler and Webler 1999); power to influence process and outcomes (Tuler and Webler 1999); having multiple methods of public participation (Blahna and Yonts-Shepard 1989, Smith and McDonough 2001); equal access to reliable information (Shindler and Neburka 1997, Smith and McDonough 2001); forming interpersonal relations between citizens and agency members (Lauber and Knuth 1997, Webler and Tuler 2000); and so forth. To encourage managers to use procedural variables when designing their decisionmaking processes, these concepts were incorporated into the knowledge base for social acceptability. Emphasizing these concepts in their decisionmaking processes gives agencies a better prospect of generating socially acceptable policies.

Since Thibaut and Walker (1975) first developed early theories of procedural justice, many studies have lent support to the premise that an acceptable process yields an acceptable decision (Lind and Tyler 1988). Of particular interest is the notion that the importance of procedures on public approval are greatest when the outcome is perceived as unfavorable. In short, when outcomes are favorable to public opinion, people do not need to judge the perceived fairness of a decision process. In contrast, when outcomes are unfavorable, people use their judgments about how the procedure was conducted to arrive at an overall judgment of acceptability (Brockner and Wiesenfeld 1996).

Studies on trust also have produced similar findings. Brockner and others (1997) discovered that when outcomes were favorable, people did not need to invoke judgments about the trustworthiness of decisionmakers. When outcomes were unfavorable, however, the people's degree of support for the organization's decision was based on their level of trust in that organization. We also noted that trust is, in part, determined by the procedural fairness of the process and concluded that managers perceived as trustworthy can maintain at least temporary support in the face of undesirable outcomes. Mayer and others

(1995) argued that attending to procedural issues is essential for building public trust.

Studies of the judicial system provide another perspective on the issue of process versus outcome. Procedural fairness affects public acceptance of the decisions of an authority by influencing the public perceptions of the legitimacy of their authority. In an examination of United States Supreme Court decisions, Tyler and Rasinski (1991) found that the legitimacy of the court's rulings was based on the perception that the court makes fair decisions and not on public agreement with the substance of the actual decision. These findings suggest a chain reaction of public opinion about decisions. By following fair procedures, the court is viewed as more legitimate, and because the court is viewed as legitimate, the public is more likely to accept their decisions even when these decisions may conflict with the public's own point of view. Natural resource agencies seem to have lost this legitimacy with much of the public and, consequently, have increasingly had their decisions called into question (Wondolleck 1988).

Although public participation processes are widely and routinely used by natural resource agencies, public dissatisfaction with both the procedure and the outcomes still result. Agencies are often confronted with allegations that their public participation processes are undertaken simply to fulfill legal requirements when, in reality, the decisions have already been made (Benfield 1985). Such situations have resulted in increased public dissatisfaction, distrust of agencies, and increased conflict over public land management decisions. To generate natural resource policies that are socially acceptable, agencies must address process factors that help achieve more positive public judgments of their decisionmaking processes as well as outcomes. For NetWeaver®, however, it is important to consider how well these factors can be operationalized in the social acceptability knowledge base. This concept is discussed in greater detail under "Issue 3."

**Recommendations**—

- Continue to develop an awareness within all levels of the agency about the importance of decision processes on public judgments of acceptability as opposed to decision outcomes
- Improve strategies for including broad public interests at the beginning of decisionmaking processes
- Continue to study the strengths and shortcomings of agency decisionmaking processes to refine protocols and improve agency implementation of the techniques

**Issue 2**

The NetWeaver® knowledge base system allows managers or other users to adjust the knowledge base design for a specific context. Unless the modifications are well documented, however, this flexibility can potentially reduce the transparency of the process by which the knowledge base evaluates agency decisionmaking.

**Rationale**—One benefit of NetWeaver® is its ability to allow for user modification. Managers work in highly variable environments and might find that certain factors in the social acceptability knowledge base do, or do not, apply to their particular situation. For instance, managers operating the program can choose to exclude a particular factor for social acceptability from their knowledge base evaluation if they observe that the factor is

not an important consideration in their particular management situation. The flexibility and discretion to alter the knowledge base, however, also has the potential to inadvertently create a hidden process. Although NetWeaver's capacity for documentation is designed to ensure that the rationale behind changes to the knowledge base are documented, it does not ensure that the documentation will actually be completed. If the individual who amends the knowledge base does not take time to document how and why the knowledge base was altered, the knowledge base can become another case of "black box" decisionmaking.

In addition, the potential to make alterations to the knowledge base raises several questions. How will managers know when modifications are necessary? Who will make the changes for each management scenario? Do they have adequate understanding of the knowledge base to make changes? What criteria will guide such modifications?

Depending on the level and number of modifications made to the knowledge base, the program could generate diverse output values. Such concerns suggest that researchers and managers should be conservative in using the knowledge base to evaluate and compare decisionmaking in different contexts. Perhaps the most appropriate solution is for managers and scientists to avoid using the knowledge base to generate a numeric estimate of social acceptability relative to a specific decision process. Instead, the knowledge base should be used as a guide to the various factors that the research literature has found to influence social acceptability. This allows managers to review the social acceptability knowledge base to consider those factors most applicable to their situation and where they need the most improvement.

**Recommendations**—

- Recognize the caveats associated with having managers modify the knowledge base design
- Use the social acceptability knowledge base as a guide to understanding the factors influencing public acceptance of decisionmaking, not as a quantitative test of public acceptability

**Issue 3**

Natural resource management and science programs are dominated by the technical-rational paradigm; a model of thinking and acting that rests on a rational, scientifically based analytic process, which also acts to constrain incorporation of subjective, qualitative knowledge.

**Rationale**—Natural resource professions are grounded deeply in a model of thinking and decisionmaking that assumes resource management problems are technical. Whether the challenges facing the profession relate to questions of appropriate resource allocation (wilderness or development) or to management (clearcutting versus selective harvesting), they are defined as technical problems and, subsequently, technical processes and information are seen as the source of answers; as Hays (1959) notes "since resources [are] basically technical in nature . . . technicians, rather than legislators, should deal with them."

However, this technically-dominated model, grounded in science, quantification, and rationality, has become increasingly subject to criticism (Wondolleck 1988). There is growing concern that the model either fails to accommodate critical social information, because of the inability to quantify them or, equally problematic, artificially forces these measures into some quantitative expression that misrepresents and distorts them. For example, Socolow (1976) has discussed how the creation of what he calls "golden rules" and "golden numbers" (prescriptions or numbers that might have evolved in the most tentative or speculative manner, but which become virtually immutable constraints) operates to prevent the analyst from taking full advantage of the capabilities that a model, or tool, such as NetWeaver® originally offered. In either case, the sum result is that the social dimension is represented inadequately (a complex domain, such as trust, becomes reflected in some single digital representation) or missing altogether ("if we can't measure it, it must not exist").

The knowledge base system is constrained by a limitation it shares with many other decision-support models. Although this knowledge-based representation of acceptability is based on logic as opposed to mathematically-based models, NetWeaver® ultimately requires that numerical values be assigned within the hierarchy. For the social component, these measures typically are assigned and linked to a particular set of ordinal responses for each proposition. For instance, one lower order proposition states that public participation starts early in the decisionmaking process, before decisions are made. The four possible responses for answering the truth of this proposition include "very late, late, early, and very early" and are assigned values of -1, -.5, .5, and 1, respectively. When respondents do not know the answer to a question, they can choose "unknown," which is assigned a value of zero. In addition, respondents can choose to leave the question blank. In its calculations, NetWeaver® also assigns a zero to these missing values.

When the respondents choose the answer that best reflects their opinion of the truth with regard to a proposition, NetWeaver® automatically assigns that response to a predetermined value, ranging from -1 to +1. The person's choice of categories to answer lower order propositions thereby determines the truth values of those propositions. Ordinal categories were assigned to the variables so that responses reflecting a low degree of truth are valued from -1 to 0 and responses reflecting a high degree of truth are valued from 0 to +1.

Although this method of assigning a value is simple because respondents select an answer from an ordinal scale as they would in a survey, the choice of the particular response—and thus the numerical value—involves a value judgment, reflecting the assumptions and biases of the respondent. Variations in the sources from which those values are obtained—whether resulting from a manager's opinion, a survey of the public, or from indepth interviews—can greatly alter the calculated truth value. It is important, therefore, to thoroughly consider who will comprise the sample of individuals that will select the responses in the knowledge base. To obtain valid responses, it is imperative that the sample be designed in a scientifically rigorous manner so that the respondents adequately represent the public.[5]

[5] For an indepth discussion of sampling methods in survey research, refer to Babbie (1995) and Hengry (1990).

The assumption that the sample of respondents represents the public is particularly critical because nearly all the propositions are set up to reflect a statement that the public believes to be true or false. Studies describing both agency and citizen perspectives on the same issue show that the level of truth for any particular item can differ widely between, as well as within, agency members and citizens. Shindler (1997) found that agency members tended to rate their performance in various areas more highly than did members of the public (see footnote 3). This trend held true even for many relatively "straightforward" characteristics. For example, when both agency members and citizens were asked whether they believed decisionmakers regularly attend and participate in public planning activities, 78 percent of the agency members surveyed agreed, whereas only 43 percent of the surveyed citizens agreed (see footnote 3). In addition, Vining and Ebreo (1991) noted that resource managers held a more traditional, commodity-oriented view toward resource use than did the public. If agency members, therefore, complete the responses in NetWeaver® to determine the social acceptability, they likely will obtain a truth value that differs from that of the public's.

However, even if members of the public are chosen to complete these responses in order to have the calculation of the knowledge base reflect public opinion, several issues need to be considered. Most importantly, who will represent "the public"? Can citizens who are involved in public participation processes represent the wider, nonparticipating public? Can interest groups represent the public? "Public opinion" is a generic term encompassing a variety of social values, beliefs, and attitudes. Opinions from a few respondents will not reflect the various opinions observed in the broader public. The generation of an "accurate" answer to the question of what constitutes social acceptability for the entire public is largely dependent on the representativeness of the respondents who input the data into the knowledge base. How will these respondents be chosen and how will their information be integrated to achieve a broader view of acceptability? Do agencies even want to know the acceptability of the larger society or only attentive publics? These questions need answering before a knowledge base system is used.

Because responses are required in many different areas within the hierarchy and because these choices influence the truth of the main proposition, NetWeaver®'s overall truth value will be highly variable depending on the person. Although the program has the ability to calculate a value for the level of acceptability of the proposed practice, its replicability and reliability are highly dependent on subjective answers. Because of this potential, it is especially important to document the proposed respondent, why responses were chosen, and any assumptions that underlie the analysis. Thus, we need to treat the output cautiously because it could differ greatly between different respondents.

Because of the limitations and the variability associated with using a knowledge base to generate a truth value for the main proposition, the utility of a knowledge base approach to predict or to analyze the social acceptability of a particular forest management decision-making process is sometimes limited. If, however, diverse publics independently obtain similar results from the acceptability of natural resource decisionmaking processes, it is a good indication of the validity of the data used within the knowledge base. In addition, NetWeaver® can help managers or researchers examine the alternative truth values derived from various sources (managers, attentive publics, etc.) to determine whether overall assessments of acceptability are sensitive to these different measures. If it is discovered that the social acceptability knowledge base is highly sensitive to diverse measures, then the need for an appropriate, valid data source is underscored.

The inherent difficulty of modeling social science information from a knowledge base is reflected in some additional concerns. First, although an attempt was made to be thorough, the knowledge base currently does not adequately represent the full complexity associated with the variables such as risk, that influence social acceptability. The prototype knowledge base, therefore, may need expanding to thoroughly capture the complexity surrounding the social variables. Because guidelines and standards do not currently exist for operationalizing these variables, the method of doing so will reflect the subjective judgment of the individual designing the knowledge base.

Second, the process of assigning an ordinal scale to the predetermined values of -1 to +1 poses some particular problems with regard to social data. Although this process is often relatively straightforward for most biological or economic data, the value assignments that NetWeaver® uses to determine the level of truth for a proposition in the social component is more subjective or arbitrary depending on the individual who assigns them. For example, although uncertainty and conflicting opinions exist in any research, most biologists can agree on a pH value fatal to fish. When designing a knowledge base to examine fish survival in a stream, biologists can use that pH value to determine the point at which the proposition (that the water quality is adequate for fish) becomes false.

In contrast, such complete agreement for the responses to the social acceptability component is rare. For instance, a social acceptability/knowledge base respondent is asked for information on whether or not the agency has had good prior working relations with a community. Because these opinions are more subjective than responses under the pH example, it is not possible to definitively state the point at which the statement is considered completely false, partially true, mostly true, and completely true as is currently arranged in the knowledge base. At best, several social scientists should review the knowledge base structure to reach some agreement on the responses used to reflect varying levels of truth for each proposition. They then could document their reasoning behind the assignment of particular responses to the -1 to +1 values used in NetWeaver® calculations.

A third concern is that the automatic assignment of zero to “unknown” results in a response in NetWeaver® where one cannot immediately distinguish between a missing answer and a “don’t know” answer. In addition, the automatic assignment of zero to “unknown” precludes the use of a five-point ordinal scale in which the zero would be assigned as “neutral.” This type of scale, typical in social science survey research, allows a respondent to choose an option that is midway between both extremes. In the case of the social acceptability knowledge base, it would allow the person to choose a response halfway between completely false and completely true. It is not clear to what degree this inability to choose “neutral” will prevent respondents from choosing an answer that best reflects their opinion.

As previously stated, this study was conducted under the assumption that forest management decisions need to be biologically, economically, and socially acceptable to achieve compatible and sustainable forest management decisions. Because there are many caveats associated with using NetWeaver® to analyze a numerical value for the social acceptability of a decisionmaking process, we believe that efforts to achieve compatibility by quantifying social acceptability by using a knowledge base modeling approach are too simplistic and ultimately will prove unsuccessful. This conclusion

generates further questions about compatibility. How should variables that are well represented within the knowledge base system (economic data) be integrated with variables that cannot be (social values)? The alternatives for integration range from excluding social data entirely to forcing social data into the model without consideration of the inherent difficulties in quantifying social information. Some variation between these two extremes is likely the most effective way of integrating the different disciplines studied under the compatibility initiative.

In summary, NetWeaver® should not be used to quantify social acceptability without being based on a sound sampling design and without consideration of the caveats associated with using a numerical value to represent a concept as complex as social acceptability. The knowledge base system, however, is useful as a framework for integrating biological, economic, and social components. As stated previously, a key benefit of a knowledge base is its formal representation of the complexity of the social acceptability concept. The process of constructing and reviewing the social acceptability knowledge base requires users to identify and organize the many factors that influence public judgments of acceptability. The conceptual framework for each component of the comp-atibility initiative is useful for researchers and managers for discussing integration of these different disciplines. In particular, the ability to visualize the social acceptability construct might prove especially useful for individuals who have difficulty working with social data. This process of attempting to integrate the social, economic, and biological knowledge bases could help provoke interesting and enlightening discussions about perceived links among the three different components. Some questions likely will be answered, whereas new ones arise as managers, scientists, and citizens collaborate to integrate these knowledge bases. This type of communication could prove effective for initiating the integration necessary to achieve compatible forest management decisions. In this way, the NetWeaver® knowledge base modeling approach might assist researchers, scientists, and citizens in creating compatible forest management decisions.

**Recommendations**—

- Create more interdisciplinary forums where scientists can convene to discuss links among social, biological, and economic data
- Develop integrated approaches and methods that include public acceptance of processes and outcomes

**Issue 4**

Our understanding of the social acceptability of decisionmaking processes is incomplete and needs further study.

**Rationale**—As noted in the findings, one benefit of a knowledge base modeling approach arises from the process of obtaining information and integrating it into the knowledge base structure. Because the knowledge base derives from a synthesis of previous research and experience, the creation of this framework has uncovered certain research subjects that are not well documented in the natural resource literature. Examining this research can generate questions to incorporate into future research programs. This study identified certain areas where more research is needed to provide greater utility for forest management planning. We have separated these research needs into three basic categories: important topics for social acceptability that need further study; topics already widely studied in other fields that need more research for natural resource management; and syntheses and recommendations for forest managers.

First, although extensive research exists for such areas as public values, institutional barriers, and trust between and among citizens and agency members, more research is necessary to identify ways of linking them with specific locations and contexts to ensure socially acceptable decisionmaking. For instance, although public values are often considered in the decisionmaking process (Stankey and Clark 1992), needed research on certain spiritual and public use values is lacking despite their importance to the social acceptability judgment process. Furthermore, although studies have identified institutional barriers within the USDA Forest Service and other government agencies that hamper the ability to conduct successful public participation processes (Brown and Harris 1992, Cortner and others 1996, Wondolleck and Yaffee 1994), more research is needed on overcoming those barriers. Lastly, research is also strongly needed on trust between and among citizens and agency members, which is critical to the formation of social acceptability judgments.

Second, although some areas of research are well documented in other fields, it is important to consider how well they apply to natural resource decisionmaking. Without research studies that bridge the gap between an issue and its utility in the field of natural resources, it is difficult to understand the value of those research findings within the context of natural resource decisionmaking. For example, because of their strong influence on social acceptability, issues such as risk and collaboration need to be increasingly applied to natural resource decisionmaking.

Finally, the ability to move from a research study to effective forest management planning is dependent on the extent to which findings are translated into actual recommendations and approaches that managers can use. For instance, although it is understood that public values are important in decisionmaking, questions exist as to how to incorporate these values into natural resource management. Should managers assume that these values will be considered by assuring that diverse groups of publics are engaged and heard in the decisionmaking process? Is there another method by which managers can be certain that these values will be considered even if a broad representation of publics are not involved in the decisionmaking process?

In addition, owing to their more ambiguous nature, certain factors necessary for social acceptability might prove more difficult to implement and institutionalize within the agency. For example, research shows that natural resource agencies should be open to change (Brown and Harris 1992), should not rely solely on technical expertise (Brunson 1992), and should understand that the public holds differing value systems than do agency members (Magill 1991, Steelman 1999). Even with this basic understanding, however, natural resource agencies might find it difficult to integrate these suggestions into their decisionmaking procedures. Research is needed therefore to understand the most effective methods of achieving these goals. Syntheses of existing research and studies of successful and unsuccessful cases, such as those by Shindler and others (see footnote 1) and Wondolleck and Yaffee (1994, 1997), might serve as two useful models to achieve these goals.

**Recommendations—**

- Develop studies to improve our understanding of:
  - Collaborative decisionmaking processes
  - Institutional barriers to effective, socially acceptable decisionmaking
  - Factors that influence the development of citizen-agency relations
  - Trust-building
  - How to incorporate values into decisionmaking
  - How context influences public beliefs and attitudes
  - Risk in forest management planning, including risk to future generations

## Conclusions

In this study, we have explored the benefits and the limitations of using knowledge bases for understanding social acceptability. This study contributes to the compatibility initiative by examining a knowledge base framework for understanding the social acceptability of decisionmaking processes. Through this process, we achieved further insight into the potential role of knowledge bases in addressing the notion of compatibility. We had two primary objectives:

1. To examine the ability of a knowledge base modeling approach to account for the factors influencing social acceptability of natural resource decisionmaking processes
2. To evaluate the suitability of this knowledge base modeling approach for forest management planning

Our review of the research literature on social acceptability and our attempts to integrate that information into a knowledge base system have given us an appreciation of the value of knowledge bases for the analysis of social data.

Through the creation of the social acceptability knowledge base, we have discovered that knowledge bases are an effective method of synthesizing and representing information. In particular, the knowledge base modeling approach holds considerable potential and value with regard to the ability to account for factors affecting social acceptability. The process of examining the literature, synthesizing major ideas, and arranging those ideas into the decision-support system is useful in clarifying the main concepts learned. The development of the knowledge base into a hierarchical structure helps to reveal the research gaps associated with particular topics or fields, providing insight into future research needs. This feature, in conjunction with the ability of NetWeaver® to compute the relative importance of missing data through knowledge of the location and frequency of the data in the hierarchy of the model allows researchers to prioritize the acquisition of new information.

In addition, NetWeaver® allows the user to document the assumptions and caveats that influence the knowledge base calculation. Managers can then review those assumptions to determine how well they apply to their own management issues and revise them accordingly. Thus, the creation of a knowledge base can be particularly valuable for forest management planning because it allows managers and scientists to obtain a better understanding of the factors that influence public acceptance of the decisionmaking process an agency.

On the other hand, certain issues were identified that hinder socially acceptable decisionmaking. For instance, as discussed in "Issue 4," our understanding of how social acceptability judgments are formed is limited. If we are not sufficiently aware of the processes through which these judgments are formed, we are limited in our attempts to adequately define and incorporate those factors into a knowledge base. We also caution against the use of a technical-rational model of thinking for examining social data and noted the potential for a knowledge base to become a "black box." Although these social issues of concern are not specific to knowledge bases, our ability to effectively use NetWeaver® to achieve socially acceptable decisionmaking is constrained by these problems.

Because of the limitations associated with the input of social data into the knowledge base, there are many caveats associated with using a knowledge base to produce a truth value for the proposition that a given decisionmaking process was socially acceptable. Although NetWeaver® allows for the documentation of key assumptions underlying the knowledge base structure, a central concern is that once a specific truth value is generated, it might prove difficult–despite the documentation–to remain aware of the limitations associated with its calculation and to prevent individuals and agencies from making inappropriate conclusions. Nevertheless, knowledge bases in which underlying assumptions are thoroughly documented and that contain data obtained from an appropriate sampling method are potentially effective for testing social acceptability. Critiquing the function of the model in case studies or grounded experiments could lead to more conclusive information about the effectiveness of using knowledge bases.

In summary, because of the caveats associated with using the social acceptability knowledge base as a predictive tool, we have some concerns about the ability of knowledge bases to help achieve compatibility through the use of their calculated truth value. The construction of the various knowledge bases, however, can provide a basis from which scientists of varying disciplines can conceptualize and discuss the links among social, economic, and biological knowledge. If knowledge bases are used as a method of discussing the compatibility between differing forest uses and values in this manner, they may prove useful for forest research and management.

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## Glossary

**Data link**—An elementary dependency network. A dependency network is an object that represents a proposition about a topic of interest in the problem domain for which the knowledge base is constructed.

**Knowledge base**—A formal logical representation of items of interest in a problem domain and their relations to one another. A body of knowledge organized within a formal syntactic and semantic framework that allows uses to make inferences about a problem.

**Metadatabase**—A database that provides specifications for interpreting information.

**NetWeaver®**—A knowledge base development system that provides a graphical environment to construct and evaluate knowledge bases. It is founded on the fact that many complex and qualitative issues cannot be described with mathematical equations. Instead, it uses a fuzzy logic model as opposed to a traditional rule-based model.

**Proposition**—A statement in terms of a truth to be demonstrated or the smallest unit of thought to which a measure of truth can be assigned.

**Prototype**—In this scenario, an initial representation of the social component of the knowledge base.

**Truth value**—A measure of the degree to which subordinate networks and data links support or refute the proposition of the main network.

The **Forest Service** of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.



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