Chapter 18

Past Developments and Future Directions for the AHP in Natural Resources

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Abstract: The analytic hierarchy process (AHP) possesses certain characteristics that make it a useful tool for natural resource decision making. The AHP's capabilities include: participatory decision making, problem structuring and alternative development, group facilitation, consensus building, fairness, qualitative and quantitative information, conflict resolution, decision support, and preferences structuring. For each of these facilities, we describe how it is reflected in land management and then illustrate how it is addressed by the AHP. Based on this analysis and on the preceding chapters of the book, we offer some suggestions for extending the AHP in new directions, e.g. peer-to\ peer networking, site-specific management, forest management planning, statistical analyses, and software enhancements. The ability of the AHP to incorporate the human dimension (subjective preference) and to aid group decisions of choice are seen as the method's most noteworthy features.

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1. INTRODUCTION

In chapter 1, we briefly outlined the nature of natural resource management in the context of ecosystem management—the current paradigm for land stewardship. Natural resource management, by and large, entails making choices among alternative courses of action, or more specifically, decisions about alternative management regimes. Making these decisions is problematic largely because of the decision environment's inherent complexity. Examples of these complications include: (1) multiplicity of management objectives, (2) involvement of several beneficiaries, or stakeholders, with their own demands (agendas) and concerns (belief systems), and (3) uncertainty emanating from a general lack of knowledge about the dynamic processes and relationships involving different ecosystem components. The argument presented earlier is that, in light of these underlying complexities, decision support tools are needed as instruments to make rational, carefully reasoned, and justifiable decisions in natural resource management.

The preceding chapters provide an overview of the analytic hierarchy process (AHP) and its broad application across a variety of natural resource and environmental problems. Those authors demonstrated the use of the AHP with other analytical tools (e.g., mathematical programming), for group and participatory decision making, as part of other decision methods (e.g., SWOT, SMART), and with extensions (e.g., fuzzy sets, GIS). In almost all chapters, a real-world example was also provided. While land management typically involves selecting among a relatively small set of possible alternatives, executing one of those alternatives is often irreversible and can have dramatic impacts. One of the general observations that should be taken away from those chapters is that even though the choice set is small, selecting the best one may be a very complex, and risky, decision. Yet, current decision methods often lack the necessary flexibility and sophistication to make a good choice and to support that choice later on.

This chapter has two general purposes. First, it briefly reviews some of the important functions of decision methods, particularly the AHP. This review, however, will put less emphasis on technical issues. The chapters contained in this book offer excellent expositions on both the technical aspects of the method, and the novel approaches used to apply the method to different problem situations. Second, based on this functionality analysis and on the innovative applications of, and extensions to, the AHP appearing in the contributed chapters of this text, we offer some suggestions for possible future directions for the AHP. We consider AHP enhancements as both new application options and as extensions to the AHP methodology itself.

2. AHP CAPABILITIES

Some of the desirable capabilities of the AHP have already been described, albeit obliquely, by the earlier chapters. The purpose of this section is to explicate and amplify those roles and to establish the enormous potential of the AHP. Hence, the presentation that follows describes these capabilities focusing on specific attributes that are compatible with distinctive characteristics of management issues in natural resources and the environment.

2.1 Participatory Decision Making

Natural resource management has become an arena for public involvement characterized by a dizzying array of stakeholder interests, both public and private. More and more, these interest groups demand a voice, both in policy making and management decisions. Increasingly, these groups have become more informed, better organized, assertive, and aggressive in their demands to be involved, not only as sources of information, but as active partners in decision making. For a natural resource management strategy to have any chance of success under these circumstances, it must adopt a genuine participatory approach, where each interest group has active involvement, with their voices heard and their input accommodated in the decision-making process.

Individual voting, or solicitation, of expert judgments via pair-wise comparisons is a feature of the AHP that is a good match for including multiple stakeholders. Each participant group can voice and record their own opinions in a hierarchy. Those voices can be treated equally or they can be weighted by importance, experience, prominence, or any other characteristic that distinguishes the individual groups. Furthermore, because a hierarchy is a recursive structure of sub-hierarchies, each group's judgments can become part of the overall decision process by affording each group their own sub-hierarchy. Within their sub-hierarchy, each group can formulate the decision problem in the way that makes the most sense to them. Because the overall hierarchy provides a record of participatory inclusion, it is readily apparent how stakeholders are incorporated into, and influence, the decision process. The explicitness of this process makes it much harder for groups to claim exclusion, "We weren't listened to," or for decision makers to falsely claim, "We included stakeholder input into our decision." The AHP doesn't force participatory decision making, but it facilitates it and records to what extent it was applied.

Several scenarios for conducting this multi-group process using the AHP were suggested in Schmoldt *et al.* (1995). These included: (1) each group formulates their own AHP decision hierarchy separately, (2) all groups together create a single hierarchy in a plenary session, or (3) each group creates a sub-hierarchy, which decision makers use as part of their overall decision hierarchy. In addition, groups' hierarchies can be pre-structured by top-level decision makers, with each group providing judgments only. Then, judgments can be obtained without face-to-face meetings, but by the use of mail surveys (q.v., Smith *et al.* 1995). By avoiding face-to-face meetings in this way, it is possible to mitigate many negative aspects of group dynamics. This last approach can be criticized for allowing decision makers to constrain stakeholder input, but it is still much better than allowing no input at all. These decision makers' overall hierarchy should still indicate how stakeholder input was eventually used in their final decision—which is the important thing.

In Finland, use of the AHP in participatory natural resource decision making has attracted a lot of attention, especially within the forestry sector. With state-owned forests in Finland covering one-third of all forest land, AHP principles have been widely applied in participatory strategic forest planning (Kangas 1999). However, the first participatory applications were carried out in nature conservation planning (Kangas 1994). The AHP has also been used in forest policy analysis at the province level (e.g., Kajala 1996). Recently, the AHP has mainly been used interactively in participatory decision support processes (Pykäläinen *et al*. 1999). Interactive use of the AHP has been found to be an effective teaching and learning tool that highlights the complexity of decision situations to participants and helps them understand existing trade-offs, as well as, competing interests. When integrated into the more general context of a participatory planning framework, an interactive AHP serves as a powerful means for successful conflict management.

2.2 Conflict Resolution

This is perhaps the most common issue in the natural resource management arena. Disagreements are most likely to arise among participants because of differences of opinions on substantive issues. Environmental problems, in particular, are traditionally delicate issues where deeply rooted beliefs and principles may stand in the way of achieving group consensus. Finding a responsible and perceptive way to resolve these differences or conflicts may ultimately determine the success or failure of management actions.

Saaty and Alexander (1989) describe some case studies showing the adaptability of the AHP for resolving conflicts, including political conflicts. In their text, different political conflicts were simulated using the AHP in order to understand conflicts better and to find ways to negotiate through them. The AHP was used as a tool to structure the different conflicts using their vital elements such as: the problem (level 1), parties in the conflict (level 2), objectives for each party (level 3), and basic political structures (level 4). Actions and judgments of the different actors were then simulated following a forward and backward process. The forward process is a generally descriptive process that identifies most likely outcomes given the influence of different parties. The backward process identifies desired outcomes and the necessary actions in terms of the hierarchy to achieve desired results. These case studies illustrate how the combination of these two processes applied in an AHP simulation environment can yield negotiable results.

Mendoza and Prabhu (2000) have also shown how a team of experts can be used to arrive at a collective decision with respect to assessing sustainability of forests. Inevitably, evaluating forest sustainability is a complex process, one that must involve experts from different disciplines. Due to the inherent complexity of the factors affecting sustainability, it is natural that assessments and professional views among experts also vary. In this study, the authors analysed different sets of indicators of forest sustainability proposed by the expert team. For some of these indicators, there were disagreements among experts as to their importance. Using the AHP, compromise sets were generated according to the relative weights of all indicators. The calculated relative weights served as objective measures by which indicators were prioritised. Hence, potential conflicts were avoided by using objective measures of relative importance that were calculated as a collective decision of all experts involved in the assessment.

2.3 Problem Structuring and Alternative Development

Many natural resource problems are shrouded with uncertainty because of a general lack of information or insufficient knowledge. Management objectives, for example, are not always known or, in some cases they are obscured and can only be elicited through prior analysis. Some aspects of the problem may also be undisclosed or not readily identifiable, although they may be articulated in qualitative terms. Hence, even before performing any analysis, problem conceptualisation and formulation need to be performed to gain a better understanding into the nature of a problem.

The decompositional and hierarchical features of the AHP offer a convenient platform for doing preliminary analysis. As shown in Chapter 1, the elements of a problem can be decomposed into manageable elements with decreasing levels of uncertainty or ambiguity. Decomposing a complex problem into a hierarchy of elements enables and conditions analysis where it is most appropriate. In the chapter by Mendoza and Prabhu (chapter 8), the problem of assessing forest sustainability illustrates hierarchy development. There, sustainability is decomposed into analytical constructs: from general principles to more tangible and measurable verifiers and parameters. Analyses were performed at each level independently but were linked and cumulated at higher levels in the hierarchy. In the chapter by Schmoldt and Peterson (chapter 7), fire modelling research issues are subdivided into *key questions*—and further into *responses* to those questions—within each of four research topic areas. Each topic area was assigned to a separate and independent workgroup, whose results were then aggregated by a research program manager at the highest level. Hence, decisions and judgments can be made at each level (or sub-hierarchy) of an AHP hierarchy, and finally, aggregated to produce impacts higher in the hierarchy.

SWOT analysis, a widely applied tool in strategic decision planning, offers one way to systematically approach a decision situation. However, SWOT provides no means to analytically determine the importance of factors or to assess the match between SWOT factors and decision alternatives. In, so called, A'WOT analysis (chapter 12), the AHP and its eigenvalue calculation framework are integrated with SWOT analysis. The AHP combined with SWOT yields analytically determined priorities for the factors included in SWOT analysis and makes them commensurable. In addition, decision alternatives can be evaluated with respect to each SWOT factor by applying the AHP (Pesonen *et al*. 2001). So, SWOT provides the basic frame within which to perform an analysis of the decision situation, and the AHP assists in carrying out SWOT analysis and in making more effective use of SWOT to develop alternative strategies and prioritise them.

In many cases, components of natural resource management problems are not known a priori; hence, they may have to be unveiled concurrently with analysis. The hierarchy offers a transparent framework where elements can be included or excluded interactively, and at any level in the hierarchy. Initially, decision makers may start with only a few elements (e.g., management options for a given objective). Then, with careful analysis, other elements may be added to progressively expand the scope of analysis. This is generally a better approach to complex natural resource problems, rather than starting too broad with limited knowledge of the elements or controllable actions. Iterative hierarchy development, analysis, and evaluation enable decision makers to create a dynamic decision process that can evolve over time and readily incorporates new information and knowledge as it becomes available.

2.4 Group Facilitation and Consensus Building

Because most natural resource management must take place in an environment conducive for public involvement and active participation, issues related to group dynamics, meeting facilitation, and consensus building have gained prominence (Schmoldt and Peterson 2000). Effective management has essentially become an exercise highly dependent on the ability to manage group interactions and to accommodate multiple inputs efficiently. The underlying goal is to manage or facilitate group interactions so that in the end some level of acceptable compromise can be achieved, unless consensus can be reached—the latter being a very rare event because of the diverse set of interests and concerns that characterize many natural resource problems.

The AHP, with its consistency measures, offers a pragmatic way to facilitate group decisions so that choices can be progressively and systematically steered toward an acceptable compromise. Consistency indices and consistency ratios can serve as guides to help direct the decision process towards better collective choices. The opportunity provided by the AHP for each participant to provide their input, and because these inputs are treated by the AHP in a manner transparent to the participants, it increases the likelihood that results of the analysis will be acceptable to all. This democratic process imparts ownership of any decision to the group as a whole.

The model described in Mendoza and Prabhu (1999) illustrates these points. In this model, experts were guided by the consistency index values to provide more consistent pair-wise comparisons of both the *indicators* and *verifiers* of sustainable forest management. Following an iterative process guided by the AHP's consistency indices, each expert (or forest sustainability assessor) was able to make more informed judgments leading to more consistent estimates of the relative importance of each sustainability indicator and verifier.

Kangas *et al*. (1998) used a traditional consensus building process, the Delphi technique, to quantify expert knowledge on forest biodiversity. To reduce bias, several independent experts carried out the required AHP pair-wise comparisons in a case study experiment. Variance components modelling was used to estimate judgment changes over three Delphi rounds for eleven experts. In this way, uncertainties in expert judgments elicited by pair-wise comparisons could be analytically studied, and the consistency of judgments could be improved during the process. It turned out that the judgments converged to some extent, while, in one case, an increase in shared inconsistency among judges was also detected. Variation between individuals decreased for all comparisons during the Delphi process.

Experiences by others (Peterson *et al.* 1994, Schmoldt *et al.* 1998), suggest that group participants seem to enjoy the search for consensus using the AHP and treat it somewhat like a game. Judgments offered by group members can be interleaved with feedback on group consistency—similar in some ways to the Delphi process noted above. There is no absolute requirement that consensus eventually arises, however; because, in the end, group judgments can be average to arrive at a group decision.

2.5 Fairness

The issue of fairness often surfaces in many group or participatory decision-making situations. The crux of the issue centres on the extent to which opinions of each participant are heard and considered as part of the decision process. In a democratic process, all opinions are weighted equally—one person, one vote. Realistically, however, some participants are more informed or are better positioned—either by skill, experience, or training—to provide better decisions. In such situation, the decision maker must decide whether to ascribe more importance to these "better" prepared participants, or to treat all participants equally regardless of expertise, experience, knowledge, or other extra-ordinary skills. The AHP is flexible enough to handle both situations. Because a "good" decision is an intellective choice and not a democratic (or majority or average) opinion, often it is preferable to treat individual opinions differentially. In this case, the AHP's aggregation procedure can assign different weights to each participant to reflect their varying degrees of expertise.

It should not necessarily be assumed, however, that knowledge in a field is coincident with analytical skill in that same field. Schmoldt and Peterson (2000) found that some group members, who were well respected and very knowledgeable in their field—and were instrumental in issue clarification and in AHP hierarchy development within their group—were, nevertheless, not as skilled at setting priorities (by making paired comparisons). It may be that the extensive knowledge possessed by those individuals enables them to see all sides of each issue so thoroughly that it clouds their ability to make critical comparisons and preferential choices. This suggests that *fairness* might best be achieved by allowing each participant to contribute in a way—which may not necessarily be voting or judging—that best utilizes their individual talents for the group's overall decision-making benefit.

2.6 Qualitative and Quantitative Variables

Informed decisions, whether they relate to common daily-life issues or to complex problems like natural resource management, rely on information which can be quantitative or qualitative. In general, better decisions are achieved not because of the abundance of data or information, but rather because of how well the information, qualitative or quantitative, is used. The AHP inherently uses mixed data. When quantitative data are available, and especially when the decision elements are not shrouded with ambiguity, pair-wise comparisons can become very precise. However, when quantitative data is inadequate, or in some cases nonexistent, participants may have to rely on intuition to make their judgements. These insights may be based on specialized experience or on general knowledge of known relationships among the decision elements.

Even in the presence of quantitative data, decision makers may wish to use subjective judgment to evaluate (or qualify) those numbers. Data-based numbers often imply a "counting" scale, which suggests that 100 of something is twice as good as (or twice as bad as, in other cases) 50 of the same thing. That sort of scaling may not necessarily reflect the inherent utility or value of those data, or the decision maker's preference. For example, the number of taxa present in a particular trophic level might be used to assess biodiversity—but 20 taxa present might, in reality, indicate that biodiversity is not much better than when 10 taxa are present. By using paired comparisons, the decision maker can create a preference scale for taxa counts. Similarly, one can also create mathematical relationships, e.g. using a logarithmic scale, but paired-comparison ratio scales are much easier for most decision makers to formulate and understand. In this same way, Saaty's chapter (chapter 2) describes how the 1-to-9 scale of the AHP can be extended to a 1-to-∞ scale, thereby expanding the realm of things that are commensurate.

2.7 Decision Support

Typically, one views "decision support" as data, as information, and as tools to manipulate and analyse those data. Decision support, however, can also include decision procedures that provide some measure of assurance that all pertinent issues and information have been fairly addressed in decision making. Public planning and the management of public lands are being subjected to increasing levels of scrutiny. Appeals and litigation often delay the implementation of management projects that were conceived with great effort and expense. The complexity of management issues and the reality of limited budgets, make it imperative that land management organizations have rational, consistent, and defensible management systems.

The AHP provides the structure and rigor to support complex and controversial decision making through its hierarchical framework and ratio-scale priority assignment. When examining an AHP hierarchy, it is immediately apparent how a decision was reached. While that does not preclude other decision makers from arriving at a different decision using a different hierarchy and different judgments, at least there is no doubt as to how the original decision was formulated. The AHP removes the mystery, and hidden rationale, from the decision process, so disagreements can focus on the real issues involved, and not on any inadequacies of the process itself.

2.8 Structuring Preferences

Accurate and complete information is critical to good decision making in natural resources management, not unlike other fields of endeavour. But, it is not the decision maker's only source for decision support. Knowledge, in the form of past experiences, (in)formal training, and beliefs/ideologies, all contribute to the process. This knowledge appears as a preference structure—a very selective lens, through which the decision maker views the world and interprets what he or she sees. One of the AHP's strengths is how it facilitate expression of those preferences—initially, as a set of comparison judgments and, ultimately, as priority vectors. Furthermore, preferences become even more evident *and* explicit because the final priority vector is a cardinal scale, rather than a less-informative ordinal scale. This also means that these priorities can be included in more quantitative analyses, such as mathematical programming, which are exampled in chapters 4-6, and in statistical tests for differences (Smith *et al.* 1995, Schmoldt *et al.* 1998). Use of paired comparisons seems to many to be a very natural and easy-to-understand method for stating preferences (Peterson *et al.* 1994), especially when compared to some other methods (Bard 1992). Preference structures elicited by the AHP aid in choice selection, are useful in subsequent analyses, and offer a glimpse into the belief systems that govern a decision maker's world view.

3. FUTURE DIRECTIONS AND EXTENSIONS OF THE AHP

The compatibility between AHP functionality and the general attributes of land management and decision making, as described in the above section, strongly intimates the AHP's potential as a decision support tool. This has also been borne out by the various applications described in the preceding chapters. The following subsections introduce some possible future extensions of the method to make it more appealing to a wider audience and their decision-making needs.

3.1 Site-Specific Decision Making

Advances in spatial, electronic, and digital technologies (precision forestry), particularly geographic information systems (GISs), are enabling land managers to formulate activities that address the unique needs of individual sites. GISs offer an environment within which the AHP can easily interface to make analyses of natural resource and environmental systems more site-specific. Itami *et al.* (chapter 17), for example, describes a computer-assisted decision support system combining GIS with the AHP. Similar efforts integrating the AHP with spatial analysis include Jankowski (1995), Jankowski *et al.* (1997), and Eastman *et al.* (1998). Making natural resource decisions site-specific adds realism and practicality to these decisions. Moreover, because of the AHP's flexible analytical features, it can take advantage of these spatial technologies and serve as a useful link to bridge information gaps using expert opinions (Store and Kangas 2001). Strengthening this link will mutually enhance the applicability of the AHP as well as the utility of these spatial tools, which ultimately should enhance the acceptability and practicality of natural resource use decisions.

3.2 Peer-to-Peer Networking

More and more land management decisions are being made in a group context, which may include a broad spectrum of resource specialists or a diverse set of stakeholder organizations. In either case, there are logistic difficulties in organizing such group meetings around everyone's busy schedule, so that everyone is coincident in both space and time. Tele- and video-conferencing can address the spatial differences, but not the time differences. Everyone must still be available at an appointed time to participate in a conferencing call.

An emerging new networking paradigm, peer-to-peer, is gaining popularity with certain applications, e.g., the sharing of computer processing time over the Internet to solve highly computational problems. This differs dramatically from the client-server protocols that we have become familiar with using the Internet, e.g., FTP, POP3, HTTP. In peer-to-peer networking there is a direct interchange of information between computers at many different locations, without any distinction between one computer providing services and one receiving those services. By combining peer-to-peer networking with AHP software designed to operate in this environment, decision makers working in different *locations* could contribute to an AHP decision process at different *times*. In such a scenario, several AHP decision hierarchies might be created and exist simultaneously, or there might be a single one that everyone is working on together. This type of computermediated work environment has been promoted in the literature on group-supported cooperative work (Engelbart and Lehtman 1988), wherein computerized documents and tools provide the foci and capabilities for multiple participants to author a common document collaboratively. A Java version of the AHP (Schmoldt and Lu, unpublished) already exists that runs on all computer platforms. There are plans to add a networking component, which would allow this type of distributed group decision making and relieve participants of the time and space constraints associated with most traditional group activities.

3.3 Extending and Embedding AHP Software

The immediately preceding section emphasized combining the AHP with a GIS. In fact, both chapters 16 and 17 describe using the AHP with such spatial tools. The opportunity also exists for *embedding* the AHP in other software tools. Because the AHP can be used to describe and analyse behavioural decision making, it can be viewed as a useful knowledge acquisition tool (Schmoldt 1998). It could be included as one of a suite of tools that aids the interview process. There are also many forest/ecosystem management software tools (e.g., NED, Twery *et al*. 2000) that could benefit from goal priority setting. For most land managers, all goals do not carry equal importance, so our management aids need to accommodate those preferences. AHP software itself can also be *extended* by some of the priority analysis methods proposed in chapter 15 (see below) and by the inclusion of uncertainty using SMART (chapter 13). While many software implementations of the AHP include some sensitivity analysis capability, they are quite limited. The use of TreeMaps (Asahi *et al*. 1995)—a multi-level analysis tool—significantly enhances a decision makers investigation of “what-if” scenarios. The Java version of the AHP mentioned above includes this TreeMaps feature. As useful as the AHP method is by itself, it is even more valuable when merged with other software or when its own implementations are extended in meaningful ways.

3.4 Forest Management Planning

Although the AHP has achieved good success in strategic natural resources planning, some problems have also been noticed. One drawback is that when ”alternatives” represent composite actions, scoring each alternative (even using absolute rating) can easily become a complex task. For example, in forest management planning—within an area consisting of possibly hundreds of forest stands each having several alternative treatment schedules—there are far too many possible forest plan alternatives (i.e., combinations of stand-wise schedules) to be evaluated and compared. In that kind of situation, the AHP alone is not enough; efficient optimisation algorithms are needed to analyse production possibilities, and to produce alternative strategies and compare them.

One possibility is to utilise a hybrid approach, combining the AHP and other decision support techniques. In a successful hybrid approach, shortcomings of one method can be mitigated by utilising the benefits of other methods. The HERO heuristic optimisation method is an example of a practical hybrid that makes use of the AHP and numerical optimisation (chapter 4). It is specially developed for tactical forest planning to analyse a great number of alternative management plans. One of the key ideas in HERO is to utilize principles of the AHP in the formulation of the optimisation problem in a manner more compliant with the objectives and preferences of the decision maker than is possible using mathematical programming alone. In addition, combined use of the AHP and goal programming has been proposed for similar purposes (chapter 6). Integrating the AHP into more process-oriented approaches, having their foundations in general decision theories has been found a promising approach for participatory decision-making processes. The combination of the AHP and Positional Analysis (chapter 9) is an example of hybrid methods usable in participatory planning. The hybrid method A'WOT (chapter 12) also represents an approach where the AHP is applied within a more general strategic management framework (SWOT).

There is still plenty room for advances in this area of methodological development work. Most likely, one of the main directions for AHP-related research in the future will focus on integrating ideas, techniques, and methods appearing in other theories of decision support.

3.5 Statistical Analysis within the AHP Framework

The lack of a sound statistical theory behind the AHP has also been seen as one of the drawbacks of the method (e.g., Alho *et al.* 1996). In practical applications, too, problems have arisen regarding use of the standard AHP, that can be alleviated by application of statistical methods. Perhaps, the two foremost problems in this sense are that the original comparison scale does not allow expression of any hesitation regarding comparisons, and that the AHP itself does not provide tools for a thorough analyses of the priorities, particularly the uncertainty inherent in the data. However, the basic idea of performing pairwise comparisons, as being a pedagogical and intuitive approach, has proved to be very practicable.

Already in the 1980's, de Jong (1984) and Crawford and Williams (1985) showed how pairwise comparison data could be analysed by using a regression model instead of the eigenvalue technique. In many cases, the two methods give similar numerical results, but one major difference is that the regression model enables an analysis of uncertainties. As an extension to the work of de Jong, Crawford and Williams (1985), and Alho *et al.* 1986), Alho and Kangas (1997) proposed a Bayesian approach to the regression model, which provides results that may be more easily understood by decision makers than *p*-values from classical hypothesis tests. Leskinen and Kangas (1998), in turn, showed how to analyse interval judgment data—instead of judgments given as a single number—in the Bayesian regression framework. Furthermore, Alho *et al.* (chapter 15) showed how the characteristics of the attributes being compared, or the background characteristics of the judges, could be incorporated into the regression model as explanatory variables. In Chapter 15, they also illustrated how the regression approach permits estimation of priorities based on fewer pairwise comparisons. This allows one to consider more decision elements than the standard AHP.

Using statistical analyses does not violate any principles of the AHP. Instead, they serve as additional tools for decision support carried out within the AHP framework. As such, they provide decision makers with greater information regarding their preferences and choices.

4. CONCLUSIONS

Technological advances continue to increase rapidly. Most notably, these are arriving in the form of new and innovative decision support tools. Similarly, improvements in data generation, storage, processing, and management are reducing information gaps and data needs. Finally, we are also realizing transformations to methodologies that address the human dimensions of resource management. This is the area within which the AHP fits, as it puts the decision maker at centre stage and allows him/her to effectively utilize the volumes of information generated by the other technologies. It provides a mechanism to organize and condense information so that it can articulate a choice in the mind’s eye of the decision maker.

In looking back at the many examples provided in the text, there are a surprising number that deal with decision making in a group setting. How readily the AHP accommodates group processes strongly argues for its use in a wide variety of applications. This is reflected in its value for participatory activities, fairness concerns, consensus building, and conflict resolution. The interdisciplinary nature of resource management issues and recent stakeholder inclusion in the decision process makes those AHP features most compelling.

As the AHP becomes as widely known as other multi-objective decision methods, it should gain more prominence in natural resource management applications. Decision makers, that we have introduced to the method, are very pleased with it and agree that it is a very useful tool. However, all such decision processes enjoy limited use in practice, seemingly for other reasons. While new analytical tools, e.g. GISs, and innovative data collection/storage methods are readily adopted by land management organizations, techniques for actually making decisions—choosing alternatives—are less easily accepted or used. Because the act of making a decision is inherently risky and error prone, many managers avoid the decision process or, at least, do not want the process laid open to examination and possible criticism. Consequently, the steps and rationale actually used in making choices are often confusing and shrouded in mystery. As noted elsewhere in the text, it then becomes difficult to justify decisions when they are scrutinized, which opens the door to contentious arguments and possible litigation. Therefore, what hinders the AHP's use most (and other decision methods, also) may be established procedures and protocols and institutional inertia, rather than any failings of the method's approach. By highlighting this final step of land management decision making (i.e., choice), we hope to encourage more regular and committed use of the available methods.

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Managing Forest Ecosystems

Volume 3

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Aims & Scope:

Well-managed forests and woodlands are a renewable resource, producing essential raw material with minimum waste and energy use. Rich in habitat and species diversity, forests may contribute to increased ecosystem stability. They can absorb the effects of unwanted deposition and other disturbances and protect neighbouring ecosystems by maintaining stable nutrient and energy cycles and by preventing soil degradation and erosion. They provide much-needed recreation and their continued existence contributes to stabilizing rural communities.

Forests are managed for timber production and species, habitat and process conservation. A subtle shift from *multiple-use management* to *ecosystems management* is being observed and the new ecological perspective of *multi-functional forest management* is based on the principles of ecosystem diversity, stability and elasticity, and the dynamic equilibrium of primary and secondary production.

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