OVERVIEW OF THE ANALYTIC HIERARCHY PROCESS (AHP) AS A METHOD TO IMPROVE DECISION-MAKING WITHIN THE U.S. FOREST SERVICE PLANNING MODEL

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ABSTRACT

The widespread application of multi-criteria decision-making methods to environmental and natural resource management indicates that their use is well aligned to advance the multiple objective and participatory nature of the forest planning process. Specifically, the Analytic Hierarchy Process (AHP) is a systematic multi-criteria decision-making approach which uses a hierarchically structure to deconstruct a decision into an overall goal, criteria, and alternatives. AHP has the ability to integrate individual preferences with factual information to arrive at the "best" solution for the current decision situation. Because of AHP's flexible structure and strong communication and educational components, AHP has the potential to enhance natural resource management decisions in the planning process. By means of a literature search, this paper explores the feasibility in terms of benefits and limitations of AHP, as well as opportunities for the application of AHP as a decision-making support tool within Forest Service project-level planning. However, due to the varied nature of project-level planning projects, specific opportunities and guidelines for incorporating AHP into the Forest Service planning process could not be clearly defined.

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INTRODUCTION

Forest management projects are often large and complex involving the multiple use management of lands, multidisciplinary collaboration, competing priorities, difficulty in placing economic values on ecosystem functions, uncertainty from incomplete knowledge, and the participatory nature of the planning process (Ananda and Herath, 2003). Land management decisions frequently embody both positive and negative impacts and the majority of land management actions undertaken by federal agencies are subject to public participation in the planning process as well as public scrutiny and the litigation and appeals process. While compliance with the National Environmental Policy Act (NEPA) improves the transparency of the planning process, additional techniques could be utilized to further improve understanding of decision problems and enhance participation in the process.

As Ananda and Herath (2009) explain, "planning requires a multi-objective approach and analytical methods that examine tradeoffs, consider multiple political, economic, environmental, and social dimensions, reduce conflicts, in an optimizing framework" (p. 2535). Improvements to the decision-making process can be made through the application of a multi-criteria decision-making approach that integrates decision-makers preferences as well as objective information. While the U.S. Forest Service uses a formal framework for planning and implementing forest management actions, the Analytic Hierarchy Process (AHP) could strengthen that approach to better align decisions with organizational objectives and stakeholder values. Mendoza and Sprouse (1989) recognized "the potential of AHP as a framework for planning in the National Forest

System” and suggested further investigation was warranted (p. 491). Peterson and Schmoldt (1999) identified the need for formal decision support tools that aid in producing rational, justifiable, repeatable, and transparent solutions in natural resource planning. Furthermore, AHP is a systematic approach that takes a quantitative perspective and has the ability to incorporate qualitative data (e.g. resource specialists' preferences and public values) into the decision-making process. AHP provides a logical framework to investigate the benefits and trade-offs of alternatives to arrive at the “best” solution for the situation at hand. The ability of AHP to combine objective and subjective information under one decision problem framework makes it powerful tool to apply to the land management planning process.

Multi-criteria decision-making methods have been successfully applied to forestry and environmental decisions over the last 30 years and their use has grown over the last decade (Diaz-Balteiro and Romero, 2008; Ananda and Herath, 2009; Huang et al., 2011). As a result, further investigation into the subject is validated because decision-making methods can increase the overall understanding of the decision problem, provide an opportunity for interactive participation in the decision-making process and reduce potential conflict and in theory, subsequent litigation.

METHODS

A literature review was completed regarding the feasibility and opportunities for incorporating AHP into the Forest Service planning model. The literature for this paper was comprised of books, peer-reviewed articles, and grey literature sources. Legal mandates were identified through the Council on Environmental Quality (CEQ), Forest Service policy documents, and the National Environmental Policy Act (NEPA) regulations and peer-reviewed journal articles. The literature search involved a combination of the keywords including: forest planning/management, environmental planning/management, natural resource planning/management, NEPA, Forest Service, public involvement and participation, stakeholder involvement and participation, multi-criteria decision-making, multi-attribute decision-making, multi-criteria decision analysis, and AHP. The literature review revealed opportunities for implementation of AHP within the planning process, considerations, strengths and potential shortcomings of the method, and recommendations for implementation.

REVIEW OF LITERATURE

This chapter reviews literature by professionals in the field of environmental decision-making regarding the planning process and the use of the Analytic Hierarchy Process (AHP) and effort was placed in identifying specific opportunities incorporating AHP into the Forest Service Planning Model. Supporting evidence will be presented for the eight main areas of focus for this project including: (1) introduction to the Forest Service; (2) overview of the planning process; (3) theory and methodology of multi-criteria decision analysis (MCDA) and the AHP; (4) existing applications of the AHP and applications within environmental decision-making; (5) benefits of AHP in reference to the Forest Service planning model; (6) limitations of AHP and hurdles to utilizing AHP in the Forest Service planning model; (7) consideration and best management practices for utilizing AHP in reference to the Forest Service planning model; (8) specific examples of where AHP can be applied in the Forest Service planning model at the project-scale. In total, 49 documents were reviewed and the central topic or topics of each document are summarized in Table 1 and Appendix A.

Table 1. Summary table of main topics in literature review.

	AHP[1]	Multi-criteria decision-making / Multi-criteria decision analysis[2]	NEPA/ Environmental Impact Assessment	Internal &/or External Stakeholders Participation	Environmental Planning/ Management	U.S. Forest Service
# of documents reviewed covering specified topics	18	17	18	19	34	12
% of total documents reviewed covering specified topics	37%	35%	37%	39%	69%	24%
TOTAL NUMBER OF DOCUMENTS REVIEWED: 49						

Notes: [1] AHP refers to papers using AHP or AHP hybrid as the main methodology; [2] Multi-criteria decision-making/Multi-criteria decision analysis refers papers where AHP is not the main methodology or where multiple techniques are considered

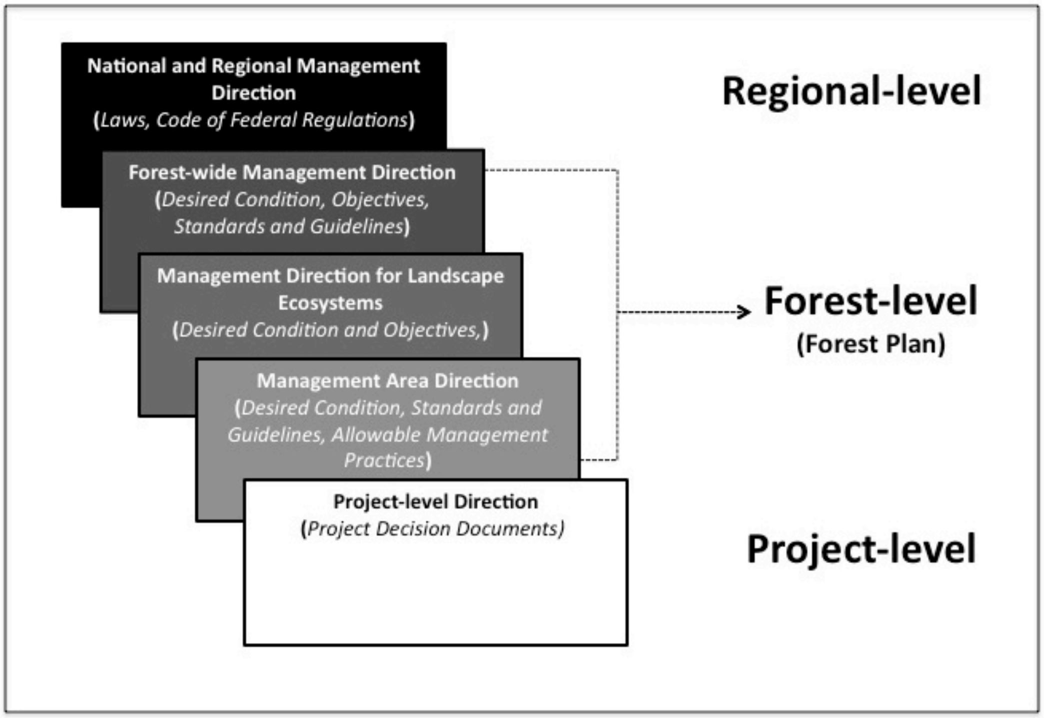
(1) Introduction to the Forest Service

The U.S. Forest Service was established by Congress in 1905 and is situated within the Department of Agriculture. The Forest Service has a multiple use mission in sustaining the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. The agency guides the management of 155 forests, 20 grasslands, and one prairie in the National Forest System.

(2) Overview of the planning process

Forest Service planning scales

Management direction or guidance for managing resources and uses on National Forest System land occurs on a variety of levels (Figure 1). Rauscher et al. (2000) identifies three scales for National Forest planning including regional assessment scale, forest-level scale, and the project-level scale. At the forest-level scale, the National Forest's Land and Resource Management Plan (i.e. Forest Plan) is strategic and programmatic in nature and is required under the National Forest Management Act (16 USC § 1600). At this level, the Forest Plan identifies goals, desired conditions, objectives, standards, and guidelines that guide project-level (i.e. site-level) planning (Figure 2). The Forest Plan, like many land management plans and multi-criteria decisions, places emphasis on biological, social, and economic goals (USDA, 2004; Diaz Balteiro and Romero, 2008). Implementing the Forest Plan means developing and implementing site-level management projects that help accomplish and move towards desired conditions established in the Forest Plan (USDA, 2004). Project-level planning, also referred to as site-level planning, is tactical as well as location specific. Desired conditions, objectives, standards, and guidelines outlined at the Forest-level (i.e. Forest Plan) provide the management direction and context for project-level proposals (USDA, 2004). Project-level planning supports the goals identified in programmatic Forest Plan and the Forest Plan anchors project-level planning. Project-level planning requires significantly more detail and data than strategic forest-level planning. At the project-level, environmental impact analysis (EIS), environmental analysis (EA), and categorical exclusions (CE) are often initiated as a result of the planning and decision-making process. Project-level planning starts with considering how a site-specific project contributes or could contribute to the Forest-wide desired conditions, goals, and objectives and this often forms the purpose and need for site-specific projects (USDA, 2004). Project-level planning often include large-scale vegetation management projects; however projects may also include habitat enhancement and restoration, hazardous fuel treatments, prescribed burning, trail and road construction, or mineral projects, amongst others. Frequently, the purpose of a vegetation management project encompasses other resources areas like watershed and wildlife improvement projects. In project-level planning for vegetation management, the primary unit is a forest stand and the proposal consists of a collection of stand-specific treatments. The aim of project-level planning for vegetation management is to find a treatment schedule for each forest stand that is optimal for the project area as a whole and that results in the optimal realization of the standards, objectives, guidelines and desired conditions outlined in the Forest Plan.



GOALS → broad statements of the Forest's overall purpose

DESIRED CONDITIONS → descriptions of how the Forest should look and function in the future if the Forest Plan is successfully implemented

OBJECTIVES → measurable actions taken within a specific timeframe that contribute to reaching Forest-wide desired conditions

STANDARDS → required limits to activities and are designed to achieve desired conditions and objectives

GUIDELINES → preferable courses of action that may be used to reach desired conditions and objectives

Figure 2. Terms used in Forest-level planning. (Source: Superior National Forest Land & Resource Management Plan; USDA, 2004).

The role NEPA in the planning process

The passage of National Environmental Policy Act (NEPA) in 1969 established the first formal Environmental Impact Assessment (EIA) system (Cashmore, 2004). NEPA provides the foundation for the majority of land management actions proposed by federal agencies and established the Council on Environmental Quality (CEQ) which monitors federal actions, provides overall guidance, and tracks trends and resources. NEPA is a comprehensive national environmental policy and requires federal agencies to: (1) use a systematic interdisciplinary approach in planning and decision-making; (2) consider the environment impact of proposed actions; (3) identify adverse environmental effects that cannot be avoided should the proposal be implemented; (4) consider alternative to the proposed actions; (5) consider the relationship between local short-term uses of the human environment and maintenance and enhancement of long-term productivity; (6) identify any irreversible and irretrievable commitments of resources (Sec. 102 [42 USC § 4332]). NEPA is initiated when an action proposed by a federal agency may result in environmental consequences or impacts. Within the Forest Service, the mandates of NEPA are considered in conjunction with planning guidance provided by the Forest Service. Compliance with NEPA involves the administration of the appropriate environmental analysis procedure (i.e. Environmental Impact Statement, Environmental Assessment, or Categorical Exclusion) for a specific proposal. NEPA also requires that the proposal is developed in consultation with other appropriate agencies (e.g. county, state, tribal, etc.) and disclosed to the public (Sec. 102 [42 USC § 4332]).

Within federal agencies, the planning process starts when a project of resource management activity is proposed. There are two ways that a project may be initiated. Often projects are initiated by the Forest Service to implement some aspect of the Forest Plan; however, a project may also be proposed by an outside entity that wants to utilize or occupy Forest Service lands for a specific purpose (e.g. mineral exploration). When the process is initiated, the responsible official, usually the local district ranger or forest supervisor, appoints and assembles an interdisciplinary (ID) team. The ID team, made up of specialists from various resource areas, is integral to proposal development, environmental review and analysis of potential effects, and project implementation. Taking into account all the federal agencies, the Forest Service prepares the greatest number of Environmental Impact Statements under NEPA (Broussard and Whitaker, 2009). Stern et al. (2009) found that ID teams involved in the Forest Service planning had varying opinions on what defined success in the NEPA process; however success was often defined factors such as a lack of litigation, advancing the proposed project towards implementation, recognizing and addressing public concerns, educating decision-makers, improving the quality of final decisions, and reducing conflict. Litigation regarding Forest Service land management decisions is most commonly associated with timber harvesting (Broussard and Whitaker, 2009) and based on NEPA (Keele et al., 2006).

The Forest Service uses scoping and public comment periods for both EA and EIS to gather public input (Stern and Mortimer, 2009). Scoping is described as “an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to proposed actions” (40 CFR 1501.7). The administrative stages for including the public in Forest Service project-level activities include three stages: (1) scoping stage which includes the release of the agency proposed action and followed by a 30-day public comment period; (2) public release of EA or draft environmental impact statement followed by a 30-day public comment period for EAs or a 45-day public comment period for EISs; (3) public release of a Decision Notice (DN for EAs) or a Record of Decision (ROD for EISs) followed by a 45-day public appeal period (Scardina et al., 2007).

A goal of NEPA is to improve public involvement in the planning phase. One of the greatest strengths of NEPA is that NEPA allows for an open decision process through public acknowledgement of potential environmental consequences (Canter and Clark, 1997). Typically, the issue of public involvement is approached through public comment periods. The Forest Service implements a consultative public input model in which the public is given opportunities to submit input and challenge decisions on procedural grounds; however, the final decision-making authority is retained by the agency (Germain et al., 2001; MacGregor and Seesholtz, 2008; Stern et al., 2009).

Many land management decisions are made at the ranger district (i.e. district) level of the Forest Service. Ranger districts are sub-units of national forests and a district ranger who acts as the responsible official and holds the decision-making authority in project-level planning at his/her respective ranger district. The number of ranger districts agency-wide exceeds 600 (Scardina et al., 2007). The Forest Service planning model is outlined in Figure 3 and an overview of a generalized model for the NEPA process for an environmental impact statement (EIS) or environmental assessment (EA) is outlined in Figure 4.

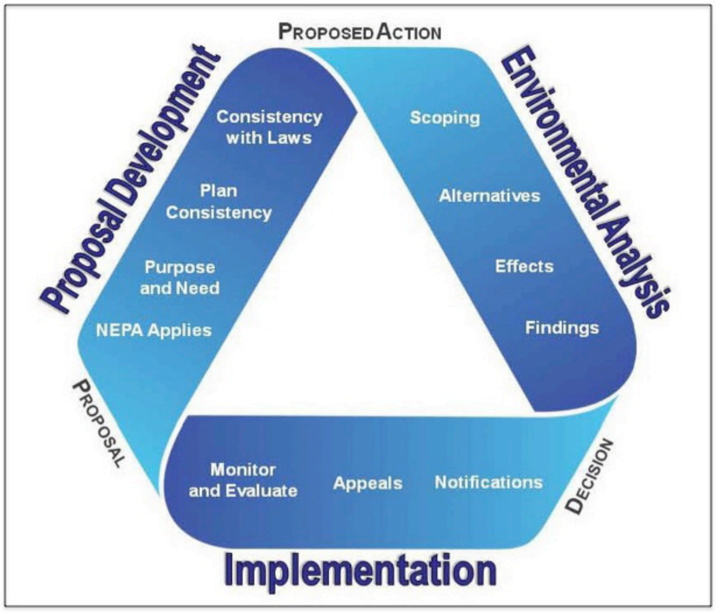


Figure 3. U.S. Forest Service Planning Model. (Source: USDA).

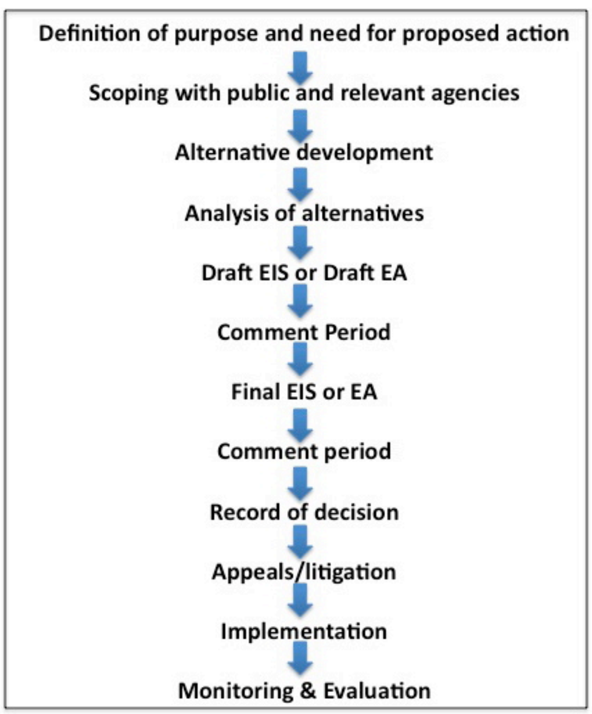


Figure 4. Generalized NEPA Planning Model. (Source: Adapted from Stern and Mortimer, 2009).

Stakeholder Involvement

According to Lahdelma et al. (2000) stakeholders include the all the various individuals associated with the planning and decision process and stakeholders could be categorized into two groups, standard stakeholders and interest groups. Lahdelma et al. (2000) identify standard stakeholders as the individuals responsible for leading and managing the process. Within the Forest Service examples of standard stakeholders would include the responsible official, the environmental coordinator, and ID team. Interest groups typically include political parties, civic organizations, or residents of the affected area (Lahdelma et al., 2000). Within the Forest Service planning process, examples of interest groups would be other government agencies, private landowners, general and organizations with a specific purpose (e.g. environmental advocacy groups, timber groups, etc.). For the purpose of this paper stakeholders will be used to define all parties involved in the decision-making process and will be differentiated by internal stakeholders (i.e. standard stakeholders) and external stakeholders (i.e. interest groups).

It is often necessary in the planning process to combine professional judgments of internal stakeholders and personal value judgments of internal and external stakeholders. Professional judgments are made when expert knowledge (e.g. specialized training and experience) qualifies an individual to predict with some degree of certainty, the result of a proposed action or to reach a conclusion based on an interpretation of facts; whereas, personal value judgments are made about the value of something relative of other things. Generating suitable alternatives by an ID team is an example of when professional judgment is used in planning process. In the planning process, individuals have different opinions on relative values and importance of information and risk. External stakeholder involvement is an example of when personal value judgments can be used to augment professional judgments to increase acceptance of the planning and decision-making process.

Theory of the Environmental Impact Assessment (EIA) and the planning process

Two distinct and overlapping paradigms result from philosophical beliefs regarding the role of science within the EIA system (i.e. NEPA planning process): (1) EIA as applied science and (2) EIA as civic science (Cashmore, 2004). Cashmore (2004) identified a series of five models that result from the relationship between the role science and EIA on this continuum between the two paradigms. Specifically, the paradigm of EIA as applied science relies wholly on fact and objectivity and encompasses two models, the analytical science model and environmental design model; whereas, EIA as civic process recognizes the importance of political and social aspects in policy and decision-making (Cashmore, 2004). Three models are included in EIA as civic process paradigm: the information provision model, the participation model, and the environmental governance model (Cashmore, 2004).

There is considerable flexibility in the discretion of how public involvement is carried out within agencies like the Forest Service (Stern et al., 2009). How public involvement is perceived by agency personnel tasked with carrying out the planning process, influences how it is administered and what is acceptable (Predmore et al., 2011). Agency personnel views of public involvement, whether as a procedural requirement of NEPA and a hoop to jump through or as an opportunity to influence public views or to educate the public, can drive the quality of stakeholder participation in the process (Predmore et al., 2011).

MacGregor and Seesholtz (2008) question whether agencies use NEPA solely as an environmental disclosure process, or conversely, whether NEPA is utilized as a decision-making process for project design and development. Scardina et al. (2007) revealed that interactive discussion or two-way communication (i.e. face-to-face or verbal) between the Forest Service and the public was clearly lacking at the pre-decisional stages and suggest the agency would benefit from increasing opportunities for public participation at the pre-decisional stages. Focus should be placed on increasing the Forest Service's understanding of how public involvement methods and timing can provide the greatest benefit to the general public (Scardina et al., 2007).

Depending on how the consultative public input strategy is applied to the planning process, the Forest Service planning model aligns most closely with the information provision model and the participation model as described by Cashmore (2004). Both the information provision model and the participation model are included within the civic science paradigm; however, stakeholder participation is more restrictive in the information provision model as opposed to the participation model (Cashmore, 2004). The information provision model is described as systematic, comprehensive, quantitative, and informative with the process being primarily analytical and having limited opportunities for stakeholder participation (Cashmore, 2004). In the information provision model, the subjective nature of development planning is acknowledged and confronted, but not embraced, and stakeholder involvement is often restricted to (one-way) consultation (Cashmore, 2004).

The participation model recognizes the legitimate role for including both objective fact and subjective values; thus integrating social rationality and scientific rationality

(Cashmore, 2004). The participation model emphasizes inclusion, deliberation, quantification, qualification, and prediction and calls for open and early participation of stakeholders (Cashmore, 2004). The need for increased stakeholder participation is driven by two main factors in the participation model: (1) the belief that the environmental decision-making needs to be more transparent and responsive, and (2) the need to embrace societal priorities and values (Cashmore, 2004). If the overall goal of the Forest Service planning model is to work towards the participation model identified by Cashmore (2004) then utilizing multi-criteria decision-making methods, such as AHP, can improve the decision-making process.

(3) Theory and methodology of multi-criteria decision analysis and the AHP

The purpose of multi-criteria decision-making methods is to facilitate decisions with competing management objectives or goals. As Herath and Prato (2006) point out that as decision complexity increases, it becomes increasingly more difficult for decision makers to identify a single management alternative that optimizes all decision criteria. Multi-criteria decision analysis (MCDA) involves the application of theoretical approaches to multiple criteria in complex decision-making environments with the purpose of overcoming the limitation of intuitive and ad-hoc decision-making and the observed inability of people to effectively evaluate multiple inputs of seemingly contradictory information (Kiker et al., 2005). Multi-criteria decision-making methods provide a framework for gathering, saving, and processing all applicable information for a decision problem (Lahdelma et al., 2000) and can assist decision-makers in answering complex problems in a technically valid and convenient manner (Huang et al., 2011). An advantage of MCDA is in addition to quantitative information, subjective judgments or preferences of individual or group decision-makers can be obtained, quantified, and included in the decision-making process (Kiker et al., 2005). The various MCDA techniques differ by how the data is mathematically processed to reach a solution to the decision problem (Lahdelma et al., 2000).

Two subdivisions of multi-criteria decision-making models exist: (1) multiple objective decision-making models (MODM) and (2) multiple attribute decision-making models (MADM) (de Steiger et al., 2003). The main difference between MODM and MADM concerns the number of alternatives in the decision problem. MODM is used when an infinite number of alternatives exist and MADM is used when a finite number of alternatives exist (Mendoza and Martins, 2006). AHP and multi-attribute utility theory (MAUT) are examples of MADM and linear, goal, and integer programming are examples of MODM (de Stieger et al., 2003).

Ananda and Herath, (2009) affirm that multi-criteria decision-making methods are well suited to address forest management and planning problems. The most commonly used multi-criteria techniques include AHP, MAUT, outranking theory and goal programming (Ananda and Herath, 2003). In general, AHP is a more user-friendly method than MAUT because the technique used to obtain required information from participants is less complicated (Ananda and Herath, 2009). Huang et al. (2011) found that from 2000 to 2009, AHP and its extension, the Analytic Network Process (ANP) constituted 48% of the 312 papers utilizing MCDA methods in the environmental field and has been the dominant choice of the MCDA techniques available.

AHP, developed by Saaty (1980), provides an analytical decision-making framework to quantify and document preference-based solutions through a hierarchical approach where the importance or preferences of the decision elements are compared in a pair-wise manner with regard to the component preceding them in the hierarchy. AHP is grounded in the belief that people are more capable of making comparative judgments than absolute judgments (Kiker et al., 2005). Within the AHP framework, decision problems are deconstructed into a hierarchy of a goal, criteria, and alternatives (Figure 5). AHP uses a ratio-scale of importance for a group of decision components (e.g. overall goal, criteria, and alternatives) where judgments are expressed as ratios on the scale (Saaty, 1980). Schmoldt and Peterson (2001a) explain that in a standard AHP exercise, elements in the framework are compared pair-wise with respect to each element in the level above, and priority values are calculated down the hierarchy to alternatives at the bottom-most level (Schmoldt and Peterson, 2001a).

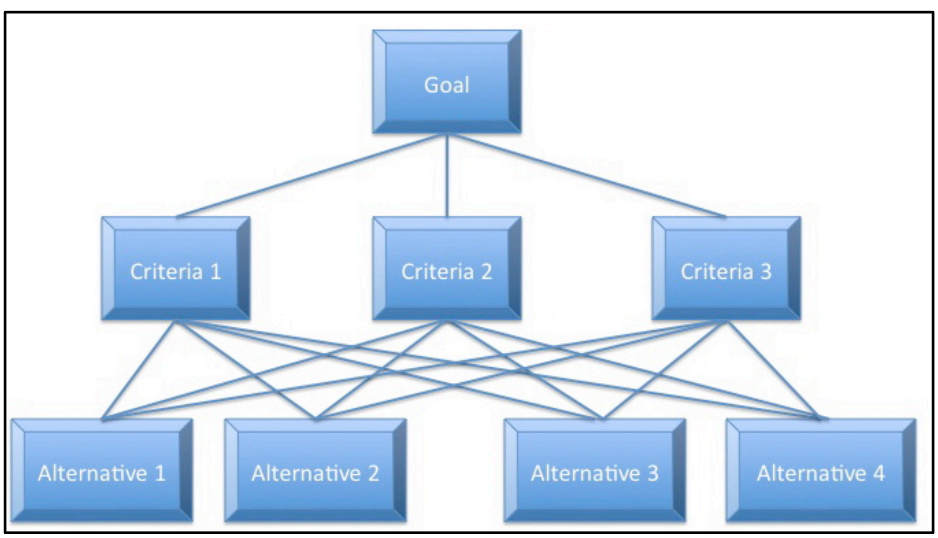


Figure 5. AHP basic hierarchy framework.

The basic steps of the AHP involve identifying the objective or goal of the decision problem, determining the criteria for evaluating the alternatives, and selecting the alternatives to be compared. Forman and Gass (2001) described the AHP by its three primary functions: (1) structuring complexity (i.e. decomposing or deconstructing the decision problem into an overall objective, criteria, and alternatives), (2) measuring on a ratio scale (i.e. pair-wise comparisons elicited from the decision maker which are then used to calculate priorities of the criteria and alternatives in the hierarchy), and (3) synthesizing the preference scores to determine relative ranking of alternatives (or the "best" alternative).

Structuring the hierarchy is unarguably the most important step in the process since it defines the framework, influences how it is carried out, and influences the ability of respondents to accurately express value judgments (Kangas, 1994; Marttunen and Hämäläinen, 1995). To make value judgments useful, the structuring of the decision problem must be understandable and pair-wise comparisons must be meaningful (Kangas, 1994). Lahdelma et al. (2000) advised the development of the criteria should follow certain guidelines established by Kenney and Raiffa (1976) including completeness, operationality, nonredundancy, and minimality. The activity of structuring the hierarchy is based the decision-maker's experience and knowledge about the decision problem (Zhu and Dale, 2001).

As a multi-criteria decision model, AHP supports the selection of a single optimal decision option from a range of alternatives or can facilitate the ranking (e.g. prioritization) of alternatives. To arrive at the "best" solution for the decision problem, decision makers are asked to estimate the relative importance of elements within the decision problem. Specifically, the decision maker will evaluate the criteria in pair-wise manner with regard to the component preceding them in the hierarchy and with respect to the goal or objective of the decision problem. The pair-wise comparisons are completed in terms of which element (e.g. criteria and alternatives) dominates the other. The decision makers use a 9-point scale (Saaty, 2000) (Table 3) to indicate intensity of preference of one element over another and value judgments can be given verbally, graphically, or numerically; however if acquired responses are given verbally or graphically, the responses will be transformed into numerical values. Within Saaty's ratio scale for pair-wise comparisons, a value of one indicates that the two criteria being considered are equal in importance or preference in respect to each other while a value of nine represent extreme preference or importance of the criteria over the other criteria it is being compared to. The pair-wise judgment becomes a fraction when an element is regarded less favorably than the element it is being compared to (Zhu and Dale, 2001). The ratio scale measures elicited in the pair-wise comparisons will then be synthesized for first the criteria and then the alternatives using either Saaty's eigenvector technique or regression methods (Ananda and Herath, 2003). A summary of AHP's theoretical foundations can be found in Ananda and Herath (2009).

Table 2. Saaty's Ratio Scale for Pair-wise Comparisons.

Numerical Rating	Ratio Scale Used in Pair-wise Comparisons
1	Equal Importance/Preference
2	Equal to Moderate Importance/Preference
3	Moderate Importance/Preference
4	Moderate to Strong Importance/Preference
5	Strong Importance/Preference
6	Strong to Very Strong Importance/Preference
7	Very Strong Importance/Preference
8	Very Strong to Extreme Importance/Preference
9	Extreme Importance/Preference

Many applications of AHP have involved stakeholders (Zhu and Dale, 2001). The goal of utilizing AHP in planning activities can be to improve public involvement and acceptance of land management plans or the planning process itself. When incorporating groups with homogeneous preferences (e.g. stakeholder groups) into the decision-making process, AHP has the ability to weight all groups input equally or place unequal weights on group input (Schmoldt et al., 2001a; Ananda and Herath, 2003). However, it must be determined if the group decision situation involves a small group with homogenous preferences or a larger group with non-homogenous preferences since that determines the mathematically approach to group synthesis (Saaty, 2000; Mau-Crimmins, 2005). For example with small homogeneous groups, a single group judgment for each comparison can be obtained through geometrically averaging individual judgments of the group (Schmoldt and Peterson, 2001a). If consistency or homogeneity is lacking, geometric means may result in ranking reversals and eigen-value computation is the preferred approach (Saaty, 2000). Open source and propriety software packages exist to facilitate AHP. For example, Expert Choice® (http://www.expertchoice.com) uses the eigenvector technique and can be used to facilitate the structuring of the decision elements, measure the criteria and alternatives using pair-wise comparisons, synthesize criteria and subjective inputs, and provide the sensitivity analysis (Ngai and Chan, 2005). The sensitivity analysis provides an explanation of how the alternatives were prioritized relative to other alternatives with respect to each element in each level (Ananda and Herath, 2003).

The advantages of AHP over other MCDA techniques are that it is flexible, the structure is intuitive to decision makers, and it has the ability to check for inconsistencies in judgments (Saaty, 2000). Mau-Crimmins et al. (2005) found that the relative to an ad-hoc process, the AHP forced the study's decision-makers to more carefully and systematically consider the choice options and decision criteria. Schmoldt and Peterson (2001a) concluded that due to the complexity of natural resource management decisions decision support tools, such as AHP, are necessary to make logical and justifiable decisions in natural resource management. Utilizing AHP in planning would aim to improve public involvement and acceptance of land management plans or the planning process itself by including relevant subjective and technical information. This is reflective of the Marttunen and Hämäläinen (1995) application of AHP and the Simple Multi-attribute Rating Technique (SMART) to two water development projects to identify the preferred alternative(s) to satisfy environmental, social, technical and economical standards. Public participation is seen as a vital component in legitimizing planning decisions (Herath and Prato, 2006) and AHP can be applied to help facilitate this.

(4) Existing applications of the AHP and applications within environmental decision-making

The simplicity, flexibility, and power of AHP have resulted in its broad application across many disciplines and the capabilities of multi-criteria decision-making are well documented in the literature (de Steiguer et al., 2003; Ananda and Herath, 2009). AHP applications have been used for **choice decisions** (selection of single alternative from a set of alternatives under consideration), **prioritization** (determining relative importance of a set of alternatives, as opposed to the selection of a single alternative), **resource allocation** (assessing relative effectiveness of resources toward the organization's mission or purpose to better allocate funds), **benchmarking** (ability to make comparisons with high performing organizations), **quality management** (ability to assess the quantitative and qualitative factors such as leadership, process management, strategic planning, etc.), **public policy**, and **strategic planning** (Forman and Gass, 2001). AHP is the most widely applied of the MCDA methods and AHP dominates the application areas of natural resource management, stakeholder participation, and environmental impact assessment to name a few (Huang et al., 2011). Zhu and Dale (2001) identify potential application areas in natural resource management to include: (1) evaluation of policy alternatives; (2) identification of desired environmental outcomes; (3) prioritization and selection of project outcomes; (4) social and environmental impact assessment; (5) land use allocation; (6) site selection; and (7) conflict resolution.

Schmoldt et al. (2001) presented a collection of examples in the field of natural resource management and forest planning including the use of the AHP in multiple objective linear programming, multi-criteria forestry decision-making, national park planning, combining goal programming with the AHP, restoration of salmon habitat, biodiversity assessments for conservation, participatory planning, and spatial (GIS) decision-making.

Since then the growth and application of AHP has continued (Huang et al., 2011). In terms of forest and natural resource planning, applications of AHP are many and varied and have included the use of AHP for wildlife management (Moseley et al., 2009), inclusion of stakeholder and public opinion into forest planning and site selection (Ananda and Herath, 2003; Mau-Cummins et al., 2005), and hybrid approaches such as AHP-heuristic optimization for the scheduled maintenance of forest roads (Coulter et al., 2006). More recently, multi-criteria decision-making has used in conjunction with Geographic Information Systems (GIS) to accommodate land use planning decisions and to enhance NEPA (Stich and Holland, 2011).

(5) Benefits of AHP in reference to the Forest Service Planning Model

AHP is a versatile tool that if effectively incorporated into the Forest Service planning process, AHP holds the potential to advance the stakeholder participation within the consultative public input model (Germain, 2001) and within the participation model of the civic science paradigm (Cashmore, 2004). Through the integration of multi-criteria decision-making methods, such as AHP, a greater degree of reality as well as increased responsiveness and transparency can advance the decision-making and planning process (Ananda and Herath, 2009). AHP is valuable to the planning process because 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" (Schmoldt et al., 2001, pg. 289). Also important to the planning process is multi-criteria decision-making methods ability to deal with complex value issues with varying degrees of uncertainty, risk, and planning horizons (Ananda and Herath, 2009).

Increased understanding of the decision problem by all stakeholders is a benefit of adopting an MCDA approach (Lahdelma et al., 2000). AHP is visually based technique and has a strong education component that eases communication and understanding of the decision problem (Zhu and Dale, 2001). Marttunen and Hämäläinen (1995), found that clear problem definition associated with the AHP framework enhanced communication and understanding of problem and Mau-Crimmins et al. (2005) found that the AHP method of decomposing complex issues into the hierarchical framework can facilitate improved understanding of the decision problem.

AHP provides a record of the rationale for key decisions, captures knowledge, values, and preferences to facilitate learning (Peterson and Schmoldt, 1999; Schmoldt and Peterson, 2000). AHP can be used as a tool to gather and capture information about internal and external stakeholder's perceptions regarding a decision problem. An advantage of AHP is that it can accommodate various forms of data and does not require one standard unit of data (Paulu, 2009) and can combine social and technical components of planning. Information regarding the stakeholder preferences could then be delivered to the responsible official (i.e. district ranger, forest supervisor, etc.) and factored into the planning decision. Although the Forest Service planning model remains a consultative public involvement model, a benefit of this approach is that it can improve two-way communication to interactively involve the public and other external audiences in the decision-making process. In addition, AHP can create a sense of local ownership in the final decision (Zhu and Dale, 2001) and Marttunen and Hämäläinen (1995) found that AHP increased trust in the decision result because the structuring of the decision problem was comprehensible, rational, and straightforward.

Within the federal government, there is a need for agencies to more effectively document the decision-making process and AHP is an analytical decision-making technique to provide better accountability within an organization and to the public (Peterson and Schmoldt, 1999). AHP can be used as a way to create a paper trail and record both internal and external stakeholder views into a formal decision-making structure. Complex multi-criteria decisions are common to natural resource management and AHP can be extended to help in both strategic and implementation planning levels (Peterson and Schmoldt, 1999).

To better meet the needs of the decision situation, AHP can be combined with other MCDA, decision-making, and strategic planning techniques to strengthen the decision-making approach (Kangas et al., 2003). Schmoldt et al. (2001) explain, that a successful hybrid approach mitigates the limitations of one method by utilizing the strengths of other methods. AHP can be used in combination with extensions or hybrid methods (e.g. GIS, ANP, A'WOT, etc.) and literature shows an increasing trend towards using hybrid methods (Ananda and Herath, 2009). For example, the hybrid technique of AHP combined with SWOT (acronym standing for Strengths, Weaknesses, Opportunities, and Threats) resulted in a hybrid method termed A'WOT. Kangas et al. (2003) provides the basic methodology for carrying out A'WOT. Further information on hybrid approaches can be found in multiple criteria decision-making reviews by Diaz- Balterio et al. (2008) and Ananda and Herath (2009).

The use of commercial software programs can yield an interactive and practical way of working with external or internal audiences in eliciting their value based preferences and priorities and have been found to be an effective educational tool in highlighting the complexity of decision situations (Schmoldt et al. 2001). AHP software can facilitate discussion and real-time projection of results to an entire audience so the process is transparent (Schmoldt and Peterson, 2001a). The following functions are typically facilitated with AHP software programs: problem structuring; comparison assessment (i.e. pairwise comparisons); synthesis (i.e. calculation of global and local weights); and sensitivity analysis (i.e. inconsistency measure of judgments) with the outcome being an overall priority or weigh for each alternative. The use of AHP software buffers the user from the mathematical computations of the process so that AHP can be applied effectively without the necessarily understanding all the technical aspects (Peterson and Schmoldt, 1999). Potential benefits of using AHP and associated software programs involve enhanced transparency and a greater sense that external opinions are being documented and considered in the process, improved communication that reduces the ambiguity of the decision problem and proposal, enhanced trust in the agency, and limiting conflict by facilitating communication between external stakeholders (Ananda and Herath, 2003). Additionally, AHP has the potential to improve an agency's standing with the public and enhancing the public's perception of federal agencies can include benefits such as avoiding litigation and increasing job satisfaction of agency personnel by making the agency's work more pleasurable (Stern and Mortimer, 2009).

In terms of participatory decision-making, natural resource decisions are subjected to a variety of stakeholders' agendas making it difficult to reach consensus or a state of satisfied acceptance, thus AHP could assist in understanding differences in preferences and provide a structured method for managing information (Schmoldt and Peterson, 2001a). Marttunen and Hämäläinen (1995) found evidence that MCDA can improve stakeholders' participation in the planning process and offers an organized way of dealing with conflicting viewpoints. Lahdelma et al. (2000) reported that multi-criteria decision-making approaches increase communication between different stakeholders and facilitates a focused discussion of appropriate topics. Zhu and Dale (2001) found that AHP provides an orderly way of investigating relevant issues and minimizing conflicts. AHP assists in clearer communication of the decision situation and therefore, in theory, less misunderstanding. Compared to ad-hoc methods, MCDA methods often generate a higher degree of agreement on the problem definition and therefore, proposed alternatives have an increased likelihood of satisfying all participants (Linkov et al., 2006). Participants in decision-making process utilizing AHP found that AHP was easy to understand and helpful in clarifying the issues and furthermore, the technique forced them to approach the decision problem from an expanded perspective (Marttunen and Hämäläinen, 1995).

Specifically to address criticisms of an inadequate participatory approach for stakeholder involvement, Ananda and Herath (2003) applied AHP within the context of the Australian Regional Forest Agreement (RFA) Program to examine feasibility and scope of AHP to a hypothetical forest planning situation and evaluated the usefulness of AHP as a decision support tool in regional forest planning. Ananda and Herath (2003) developed five hypothetical management plans for evaluation using AHP. Their decision model included four levels. Level 1, at the top of the hierarchy, the objective was to identify the management plan with the maximum overall utility. Level 2 included the stakeholder groups. Level 3 consisted of the decision criteria. At the bottom of the hierarchy was Level 4 that consisted of the five alternative forest management plan options. Based on the hypothetical exercise, Ananda and Herath (2003) found the advantages of AHP to include its helpfulness in constructing and evaluating options, ability to highlight value tradeoffs in a useful way, ability to provide credibility and transparency in decision-making, having educational value, and the capability of ranking alternative options (e.g. second best solutions or compromises that be identified). Ananda and Herath (2003) concluded that the use of the AHP along with other conventional public consultation procedures can form an effective tool in participatory decision-making in complex decision situations such as regional forest planning.

Specific circumstances surrounding decision situations may provide opportunities where AHP could benefit the planning process. For example, under certain circumstances responsible officials in the Forest Service may choose to tackle relatively high-risk NEPA projects (MacGregor and Seesholtz, 2008). MacGregor and Seesholtz (2008) outline three management strategies for high-risk projects: (1) thorough consideration of project definition and scope; (2) increased communication with agency personnel to clarify a project's high-risk nature and to boost internal ownership for the range of prospective NEPA-related outcomes; (3) increased interaction and communication with internal and external stakeholders. AHP could facilitate these strategies to aid in clear communication and transparency of the project, gather and document perceptions of the internal and external stakeholders, and support the development and implementation of an appropriate management response. Another potential benefit of utilizing AHP is in maintaining staff morale through the inclusion and consideration of the ID team's professional and personal value judgments regarding the proposal.

(6) Limitations of AHP and hurdles to utilizing AHP in the Forest Service Planning Model

Like any other MCDA technique, AHP has inherent weaknesses. Structuring the decision hierarchy is a critical and difficult step (Kangas et al., 2003). Because the hierarchy structure of the decision problem strongly influences the results of AHP, care must be taken to adequately frame of the decision problem and generate thoughtful criteria and alternatives for respondents to accurately express value judgments (Kangas, 2004; Marttunen and Hämäläinen, 1995). Benke et al. (2011) warned of linguistic ambiguity and imprecision that could be associated with the wording in the decision problem. To support accuracy of results and decrease uncertainty or error associated with the final priority ranking achieved through AHP, special consideration should be dedicated to wording and content of elements or expressions used in the decision-making framework (Benke et al., 2011).

Other criticisms of AHP include the AHP hierarchy approach can oversimplify the decision problem (Marttunen and Hämäläinen, 1995) and Linkov et al. (2006) warned, the results achieved in pair-wise comparisons have been criticized for not reflecting participant's true preferences. Benke et al. (2011) highlighted the issue of validation of the AHP for risk assessment models since there is no independent scale of measurement for assigning weights. Furthermore, mathematical procedures associated with AHP can lead to illogical results (Linkov et al., 2006). While the flexibility of AHP allows for hierarchy modifications, rank reversal is a phenomenon that result when the addition of another alternative alters the ranking of the alternatives determined by AHP (Ramanthan, 2001).

Limitations of using AHP for public involvement must also be acknowledged. Lahdelma et al. (2000) presented a variety of reasons in which obtaining any preference information from stakeholders may be unmanageable or impossible to obtain. Ananda and Herath (2009) cautioned that AHP is unable to accommodate a large number of participants and that general public involvement in AHP was limited to one application. Although not an inherent limitation of AHP itself, but rather the Forest Service planning model is the limited inclusion of external stakeholders based on traditional public involvement techniques. Lahdelma et al. (2000) recognized that, in general, stakeholder involvement efforts often only reach external stakeholders have underlying motives for participating and personal interests in the result of the decision problem (Lahdelma et al., 2000). Opponents usually make up the majority of participants (Lahdelma et al., 2000); thus it is possible that with incorporating stakeholders, conflict resolution will not be achieved and extreme alternatives with conflicting objectives will be preferred over more intermediate options (Ananda and Herath, 2009).

Another vital aspect of incorporating public involvement into multi-criteria decision-making is the public's understanding of the decision problem. Ananda and Herath (2003) acknowledged that AHP is only worthwhile if participants are able to provide credible responses to the questions posed. Implementation of decision methods must be clear and understandable to the public in order for them to be useful since AHP relies on the ability of the respondents to make qualitative distinctions between decision elements. Kangas et al. (2003) cautioned, that exercise of completing pair-wise comparisons could be a barrier for incorporating the public into the decision-making process due the difficulty involved in making pair-wise comparisons. Marttunen and Hämäläinen (1995) found that AHP was overly cumbersome and time consuming and the study noticed that participant motivation decreased in the process. The implementation of AHP requires the technical ability of staff to explain the AHP process and interpret the results to avoid a black-box scenario (Paulu, 2009).

Other potential obstacles to incorporating AHP into the planning process may result from existing attitudes regarding the role of public involvement in Forest Service's planning processes. Internal pushback and cynicism may be encountered regarding the appropriateness and usefulness of AHP in the planning process. For example, Stern and Mortimer (2009) found that none of the chief NEPA compliance officers from the Forest Service perceived public buy-in as an indicator of a successful NEPA process and instead identified a lack of litigation or appeals as an indicator of success. While the majority of NEPA compliance officers sampled in Stern and Mortimer (2009) felt that limiting public involvement to only disclosure and acceptance of public comments was not adequate public involvement; others viewed the purpose of public involvement to simply keep the public informed rather than actively involved. Furthermore, while there was consensus among all NEPA experts for early public engagement in the planning process; none of the respondents felt the public should play a leading role in driving the purpose and need of a proposal (Stern and Mortimer, 2009). Thus implementing AHP would require buy-in from the responsible official. A responsible official's view of decision-making and the NEPA process drives how the NEPA process proceeds and the approach taken (MacGregor and Seesholtz, 2008). With hundreds of ranger districts in the national forest system, at the agency scale there is bound to be inconsistency among responsible officials. Rangers and line officers who value EIA as a civic science (Cashmore, 2004) and who are skilled in an interactive management style would be more inclined to see the benefits of AHP, while others who view EIA as applied science (Cashmore, 2004) and view the NEPA process as a mechanism exclusively for public disclosure would quickly dismiss AHP as an unneeded step in the planning process.

(7) Consideration and best management practices for utilizing AHP in reference to the Forest Service Planning Model

Although AHP has major acknowledged limitations, Huang et al. (2011) hypothesized that the availability of proprietary software packages and engaged user groups have fueled its popularity. Best management practices and process considerations should be acknowledged to address shortcomings and hurdles of applying AHP to the planning process. Furthermore, AHP should not be used indiscriminately and may not be appropriate for every proposal or Forest Service planning situation. In general, AHP is appropriate for decision situations where ad-hoc decision-making is not sufficient, subjective judgments of alternatives are important to the decision-making process, and quantification of preferences is useful (Mau- Crimmins et al. 2005). Furthermore, Mau-Crimmins et al. (2005) suggest that AHP is likely to be helpful in decision problems with contentious aspects, which is often characteristic of the planning process.

Kangas et al. (2001) explain that, there is no one size fits all when it comes to the selection of a method or hybrid method. In determining the appropriateness of using AHP in the planning process, the circumstances of the decision situation and the process itself should be considered. Lahdelma et al. (2000) presented five requirements for selecting a “MCDA method to be used in public environmental problems” including: (1) “the method should be well defined and easy to understand, particularly regarding its central elements, such as modeling of criteria and definition of weights"; (2) "the technique must be able to support the summary number of DMs" (*decision-makers*); (3) "the method must be able to manage the necessary number of alternatives and criteria"; (4) "the method should be able to handle the inaccurate or uncertain criteria information"; (5) "due to time and money constraints, the need of preference information from the DMs (*decision-makers*) should be as small as possible" (p. 601). Likewise, Kangas and Kangas (2005) suggest choosing a MCDA approach that is easy to understand or one that participants are familiar with in order to focus on the comprehension of the decision problem. This selection approach holds true for hybrid approaches. Kangas et al. (2003) advise that it is best if there is a level of familiarity when using a combination of approaches and Kangas et al. (2001) explain that known methods in hybrid approaches can fuel new ideas in the planning process. By adhering to MCDA selection guidelines, this approach will also help in avoiding a black box scenario in that the process can be adequately explained to participants or readily understandable and to keep the focus on the decision problem rather than the process itself. While computer applications can shield the user from complex mathematical computations (Peterson and Schmoldt, 1999); Ananda and Herath (2009) warn against the indiscriminate applications of mathematical techniques and highlight the recent shift in using multiple MCDA approaches to the same decision situation to help empirically validate the decision outcome.

AHP be used to deal with common problems that include the need for "analyzing and structuring hierarchies in the decision-making process; setting and synthesizing priorities including consistency of the established priorities; conflict resolution; making group decisions and working toward consensus" (Mendoza and Sprouse, 1989, p. 490). When determining whether or not to apply AHP to a decision problem associated with the planning process, it may be helpful to consider the degree to which the public may view the proposed action as highly controversial. More controversial decision problems or high-risk NEPA project will be more aligned for AHP while the use of AHP may not be as useful in non-controversial or more routine decisions.

Rauscher et al. (2000) advise that the decision analysis process should explicitly recognize that there are limits on time, expertise, and economic resources. For example, funding and time constraints may preclude completing pair-wise comparisons with every potential decision-maker (Lahdelma et al., 2000). This is an important aspect to keep in mind when determining the appropriateness of how AHP will be implemented given staff and resources limitations since the possibility exists that incorporating AHP into the planning process may create a more onerous process and overwhelm agency staff.

The forest-planning environment is often associated with fuzziness, complexity, vagueness, ambiguity, and imprecision (Mendoza and Sprouse, 1989). AHP can enhance decision problem formulation and by organized, thoughtful, and systematic effort up-front (Schmoldt and Peterson, 2001a). Careful preparation and structuring of decision problem is important to improve reliability of results and success of the method (Ananda and Herath, 2003). How the hierarchy is structured will directly influence the outcome since it defines the framework of the analysis; thus structuring the hierarchy can be argued as the most important step in the process (Marttunen and Hämäläinen, 1995; Ananda and Herath, 2003; Ananda and Herath, 2009). In structuring the hierarchy, it is essential that elements in the lower level of the hierarchy be mutually exclusive and adequately represent the higher-level elements (Keeney, 1992).

When identifying criteria and developing the hierarchy it is important to create a balance between completeness and simplicity (Marttunen and Hämäläinen, 1995; Ananda and Herath, 2003); therefore, Keeney and Raiffa (1976) and Baker et al. (2001) recommended criteria should be non-redundant, limited in number, operational and meaningful, complete (include all goals), and have the ability to discriminate among the alternatives and to support the comparison of the performance of the alternatives (as cited in Lahdelma et al. 2000 and Fülöp, 2005). It is equally as important to limit number of alternatives and pair-wise comparisons because pair-wise comparisons become impractical with a large number of alternatives (Zhu and Dale, 2001). Ananda and Herath (2003) and Mau Crimmins et al. (2005) caution that if a large number of criteria to be considered or many levels included in the decision hierarchy then pair-wise comparisons will become tedious and time-consuming for the respondents. While the number of alternatives generated is highly dependent on the decision situation; Saaty (1980) recommends that 10 be the maximum number of alternatives to include in any application of AHP.

To be useful, the process needs to be an adequate vehicle for gathering input. Lahdelma et al. (2000) advises that all stakeholders should be identified at the onset of the planning process and the framework should establish who will participate, at what phase(s), and to what extent. In gathering input, it is an option within AHP to place different weights on group input; however the unequal weighting of stakeholder's input by an agency is likely not a best management practice in implementing AHP (Ananda and Herath, 2003) and could result in distrust of the process and the agency. Medoza and Martins (2006) identified three main aspects to consider in the decision process when incorporating group decision-making with MCDA methods: (1) the identification and selection of participants, (2) the distribution of information to facilitate participant's input; (3) the assemblage of individual preferences and decisions. When identifying or incorporating participants, it is important to keep in mind that AHP could get messy with large numbers of people or groups involved (Ananda and Herath, 2009). To avoid introducing bias in pair-wise comparisons, participant's ranking should be completely confidentially by each individual (Peterson and Schmoldt, 1999).

Mendoza and Sprouse (1989) highlight the significance of the consistency index obtained in AHP. The consistency index provides information on how consistent the pairwise comparison matrix is (Mendoza and Sprouse, 1989). Furthermore, Mendoza and Sprouse (1989) advise, "if the consistency index is beyond acceptable limits (e.g. greater than 10%), the decision maker(s) may seek additional information, encourage further dialogue and debate, and possible reexamine the data used in construction the matrix in order to improve consistency" (p. 501).

Lahdelma et al. (2000) instruct, the selection of a MCDA method should be supported by empirical applications; therefore, it is advisable to learn about how AHP will perform when applied to various decision situations in an internal setting before pursuing an external application of AHP. Ananda and Herath (2009) suggest advancements through empirical applications should be pursued to improve and ease the decision-making process. Ananda and Herath (2009) highlight the "need to refine decision criteria to reduce their vagueness, add clarity and limit analysis to a manageable set of attributes, to reduce tediousness in interview procedures and enhance the decision-makers grasp of the choices being made without obscuring important issues and value judgments" (p. 2543).

Schmoldt and Peterson (2001a) advise that AHP can be applied in a workshop setting; however, to be successful, the objectives need to be clear and the process must be highly structured involving the assistance of trained facilitators. This in-house testing and evaluation of AHP to internal decision situations will be a critical step before introducing in a "real world" decision environment. It would be practical to start the learning process by applying AHP to a simple and straightforward decision situation to gain familiarity and confidence in structuring the decision problem and generating criteria and alternatives before tackling a more complex decision. Once comfortable with the AHP process then there is the possibility to combine it with other tools (e.g. GIS, A'WOT, ANP, etc.) or employ another method to validate results generated from AHP or move to a more complex decision situation. To help build a knowledge base regarding the feasibility of the future applications of AHP to varied decision problems, tracking of the process and decision situations will be essential to distinguish what elements (e.g. number of participants, type of decision situation, etc.) result in some efforts being more successful than others. During the in-house learning process, it is likely to become apparent if there is sufficient buy-in in implementing AHP to future planning decisions and if it is a practical method to invest agency funds and personnel time in mastering.

It is important to note that there can be various motivations behind and risk associated with project proposals. For example, projects may be selected and initiated for the purpose of improving community relations (MacGregor and Seesholtz, 2008). Projects of this nature can represent a symbolic rather than functional value and therefore, are good candidates for testing AHP in the planning process.

(8) Specific examples of where AHP can be applied in the Forest Service Planning Model at the project-level

Legislation and policy, scientific knowledge, funding and staffing, and public values, are all factors that influence the decision framework. Applying AHP to the planning environment would complement the mandates of NEPA and discourage predetermined decision-making. In effect, AHP supplements the planning process, but does not drive it and would be useful as another method to capture stakeholder values. Project-level planning involves a wide range of projects; however, no matter what the project is, for AHP to be effectively used, it is essential that the project be well understood and an extensive working knowledge of the decision problem exists.

Emphasis should be placed in identifying opportunities for using AHP to enhance stakeholder participation in the Forest Service's planning process since facilitating effective public involvement is a managerial challenge in meeting the requirements of NEPA (Stern and Mortimer, 2009). Emphasis should also be placed on examining how communication of NEPA documentation could be improved to enhance the agency's mission (MacGregor and Seesholtz, 2008). Given that the majority of the AHP applications have involved stakeholders (Zhu and Dale, 2001), the application of AHP to the planning process is logical choice. Furthermore, Mau-Crimmins et al. (2005) found that AHP does offer the potential to be used as a public participation tool in national forest planning decisions.

It may be necessary to split the planning and decision process into multiple phases due to the length and complexity of the planning process (Lahdelma et al., 2000). The Forest Service planning model has three major phases: (1) proposal development; (2)

environmental analysis; and (3) implementation (refer to Figure 1). Each major phase in the planning model can include sub-steps. Phase 1, proposal development is an information gathering stage and identifies a project's purpose and need. Phase 2, environmental analysis is an information analysis stage and includes alternative design; alternative analysis; and alternative evaluation, selection, and authorization. Phase 3, implementation includes project implementation and monitoring and evaluation.

AHP has the potential to be utilized at one or multiple phases of planning by both internal and external stakeholders. Opportunities for incorporating AHP into the planning process are varied and project dependent; however, a general framework for stakeholder participation has been proposed in Figure 6. Traditional public involvement practices and techniques used by federal agencies in the planning process to gather public input include public meetings, open houses, breakout sessions, site visits, and smaller, less formal meetings with specific constituencies (Stern and Mortimer, 2009). Traditional techniques best suited to supplement AHP for gathering information on public values would include: (1) breakout sessions following a public meeting; (2) a special, less formal meeting with specific stakeholders. The final selection of a technique used to gather input would be up to the discretion of the environmental planner or responsible official to best meet the needs to the decision situation. To obtain useful input, an overview of AHP methodology and the project proposal would need to be introduced to the decision-makers prior to asking participants to complete pairwise comparisons. Trained facilitators may be necessary to help guide the decision-makers through the process especially if input is gathered from members of the general public who have less familiarity with project details and application of AHP.

Table 3. Suggested opportunities for stakeholder participation within the Forest Service Planning Model.

	Phase 1: Proposal Development		Phase 2: Environmental Analysis				Phase 3: Implementa
	Define problem		*Develop and analyze problem & select preferred solution*				*Monitor and ev preferred sol*
	Identify project area, purpose, and need of action	Generate preference information regarding problem definition	Generate alternatives and criteria	Analyze alternatives	Evaluate alternatives / generate preference information	Choose final alternative	Determine mon prioritie
External Stakeholders		X			X		
Internal Stakeholders	X	X	X	X	X	X	X

If a large number of participants are expected to be involved in the planning process, it may be necessary to limit the number of participants or restrict participant input in some way. If needed, one possibility for limiting the number of participants would be to identify special interest groups and individuals that frequently engage in the local NEPA processes by reviewing public comments of prior projects specific to the National Forest and/or ranger district where the project is proposed. Regardless of the strategy used identify and involving participants, Lahdelma et al. (2000) stress the importance of identifying stakeholders early in the planning process.

Phase 1: Proposal Development

A sample of chief NEPA compliance officers from the National Park Service, Forest Service, Army Corps of Engineers, and Bureau of Land Management found that the most common response regarding the purpose of NEPA given by respondents was public disclosure and responses underscored process over outcome, especially concerning public involvement (Stern and Mortimer, 2009). This view of NEPA as vehicle for public disclosure rather than active public involvement in the process may result in NEPA taking on an adversarial nature rather than the public being seen as openly welcomed participants in the planning process (CEQ, 1997). Public dissatisfaction in the planning process may also be attributed to the fact that public involvement often occurs after key decisions have been made in management proposals (Herath and Prato, 2006). Public disclosure of a proposal is required only after the proposed action has been developed by the agency and the planning process enters the administrative stage known as "scoping." The scoping stage involves a public release of the proposed action followed by a 30-day comment period. The purpose of scoping is to provide the public with an opportunity to identify significant issues associated with the proposed action. MacGregor and Seesholtz (2008) suggest that early and extensive involvement of external stakeholders is a strategy for mitigating process risk in NEPA-related projects.

While external involvement prior to scoping is not mandated, engaging the public and stakeholders prior to the scoping stage in proposal development may be advantageous course of action in highly contentious projects. Lahdelma et al. (2000) suggest the probability of successful decision process is positively linked to communication with stakeholders from the beginning of the project. Fostering agreement among stakeholders by eliciting external concerns prior to scoping may improve public participation and increase trust in the agency and ownership in the proposed action (Ananda and Herath, 2003; Zhu and Dale, 2001; Marttunen and Hämäläinen, 1995).

It is in the proposal development phase that elements in the hierarchy will be identified. The development of criteria is context dependent and the identification of criteria is only possible once the perspectives of internal and external stakeholders are recognized (Lahdelma et al. 2000). Paulu (2009) incorporated AHP in the Forest Service planning process to address public concerns by including community concerns as a criteria in the hierarchy. During the proposal development stage, inquiry or decision-making techniques such as nominal group technique could be used to facilitate the solicitation of stakeholder perspectives. Lahdelma et al. (2000) advise that stakeholders should be asked to provide reasoning for their preferred alternative and this approach would help build a knowledge base of stakeholder perspectives. Stakeholder perspectives could then be used to develop as criteria and possibly alternatives in the AHP hierarchy and that can then be evaluated in the environmental analysis phase. While external input may not drive the purpose and intent of the proposed action, it does offers the public and stakeholders an opportunity to provide input at an early stage and increases the likelihood that solicited input will influence development of the proposed action.

Another application of AHP within the proposal development phase could be in the prioritization of project-related actions, such as the ranking of specific areas or selection of "best" location for habitat enhancement or restoration or trail projects. Coulter et al. (2006) used a combination of AHP and heuristics to set maintenance priorities for forest roads to assess the potential advantage gained from completing a particular maintenance project. Heuristic techniques rely on trial and error and experimentation to reach a conclusion (de Steiger et al., 2003). Mau-Crimmins et al. (2005) applied AHP to a fairly simple site selection decision (i.e. campsite placement) to test the potential of AHP as a means to improve public participation in national forest planning. Similar applications of AHP could be utilized at this phase to provide an opportunity for stakeholder involvement in proposal development.

Phase 2: Environmental Analysis

Phase 2, the environmental analysis includes alternative design; alternative analysis; and alternative evaluation, selection, and authorization. Significant issues identified in the public scoping stage will drive the development of additional alternatives. Alternative design and the subsequent analysis of alternatives is completed by specialists on the ID teams.

AHP provides the framework upon which the alternatives can be examined, evaluated, and synthesized by the decision-maker (Mendoza and Sprouse, 1989); thus after the analysis of alternatives is completed internally, the alternatives could be evaluated in respect to various criteria. For example, timber production, wildlife habitat, scenic improvements, public concerns, amongst other objective variables (i.e. criteria) could be considered in respect to the overall goal. Where applicable, results from the internal stakeholder (i.e. ID team) analyses could be incorporated into the hierarchy as quantitative data to help describe and distinguish amongst alternatives. Within each alternative, criteria could be expressed as acres, board feet or another appropriate measurement. The exercise of using AHP to rank preferred alternatives could carried out internally (i.e. ID team), externally (i.e. general public and stakeholder groups), or in combination. While external stakeholder input could be included in the hierarchy development, it is advisable that internal stakeholders take lead in defining the hierarchy (i.e. alternatives and criteria) based on professional judgment and increased understanding of the project, as illustrated in Paulu (2009). As such, external stakeholder participation would be restricted to providing preferences (i.e. personal value judgments) on elements in the predefined hierarchy.

Mendoza and Sprouse (1989) used a two-stage approach that utilized different two methods at Phase 1 and Phase 2 in the forest planning process. First, to generate alternatives (i.e. Phase 1, Proposal Development) the authors used a fuzzy linear programming and then in the second step (i.e. Phase 2, Environmental Analysis), AHP was used to prioritize and evaluate alternatives (Mendoza and Sprouse, 1989). Specifically, Mendoza and Sprouse (1989) used AHP to prioritize forest management alternatives according to three criteria: (1) maximize economic return; (2) maximize wildlife habitat; (3) maximize recreation opportunity. More recently, Paulu (2009) used AHP to prioritize stand treatments according to four main criteria: (1) habitat improvement; (2) protection of forest health; (3) utilizing forest stewardship; (4) accommodating community concerns. Paulu (2009) used managers and specialists to create the hierarchy and then used public participation to develop the sub-criteria under the main criteria of "accommodating community concerns."

Once preferred alternative is selected and the draft EA or EIS is completed by the agency, a public comment period follows and the agency would provide responses to public comments received during the comment period. This would be followed by the public release of the Decision Notice or Record of Decision and followed by a 45-day appeal period. If no appeals are filed then the project enters the implementation phase soon thereafter.

Phase 3: Implementation

Adaptive management provides the base for the land management in the Forest Service. Rauscher et al. (2000) identified four activities critical to the feedback loop of adaptive management: planning, implementation, monitoring, and evaluation. Because adaptive management acknowledges incomplete knowledge of a system, MCDA approaches can be readily connected to the adaptive management paradigm (Linkov et al., 2006).

Monitoring and evaluation is critical to adaptive management and the Forest Service planning model. Implementation monitoring examines the question of: Did we do what we said we were going to do? In other words, "the result of the monitoring process is then used to evaluate whether the implementation of the selected alternative is actually changing the state of the forest so that the difference between the goal state and the actual current state of the forest ecosystem is being reduced" (Rauscher et al., 2000, p. 205). While some monitoring may be required as directed in the NEPA document (i.e. EA or EIS); a holistic approach to monitoring could be strategized and implemented. A framework for monitoring and evaluation could use AHP to prioritize monitoring and evaluation needs. This internal application of AHP would be completed as a Forest-wide exercise by including all project areas and ranger districts in the decision framework. AHP could then be used to allocate resources (e.g. funding, staff, etc.) to monitoring priorities. For example, the National Park Service's Inventory and Monitoring Program utilized AHP to rank monitoring projects in order to achieve the greatest return given budget and personnel limitations (Peterson and Schmoldt, 1999; Schmoldt and Peterson, 2001b).

Empirical Application of AHP at the Forest Level

Potential uses for AHP extend beyond the project-level to regional and forest-level planning scales. For example, Moseley et al. (2009) applied AHP at the forest-level, specifically at Monongahela National Forest, for the purpose of selecting management indicator species (MIS). MIS are used in the planning process as a way to assess impacts of forest management activities on Forest Service lands. MIS selection methods have been criticized for lacking scientific rigor and the objective of Moseley et al. (2009) was to apply AHP as a more thorough approach to MIS selection. Through the use of AHP, Moseley et al. (2009) considered the approach to be successful and criteria priorities and rankings for alternative MIS as comprehensive and defensible.

CONCLUSION

AHP holds the potential to improve decision-making and involvement in the Forest Service planning process; however, the decision situation at project-level planning scale is very project specific and consequently, the best approach for incorporating AHP into the planning process is very situation dependent. While I was not able to provide specific guidelines for applying AHP within the planning process, I was able to provide opportunities within the planning framework where AHP could engage external and internal stakeholders. Due to the varied nature of project level planning, opportunities for incorporating AHP in Forest Service planning model suggested in this review are speculative and not definitive. Theoretical developments have exceeded empirical applications of MCDA methods (Ananda and Herath, 2009); therefore, future efforts should focus on experimental and practical applications of utilizing AHP within the Forest Service planning model. In regards to successfully integrate AHP as a tool in the Forest Service planning model, I suggest the use of AHP should begin with simple internal stakeholder exercises to allow staff to gain familiarity with the technique. The next step in the learning process would be to apply AHP to decision problems with increasing complexity and in combination with other techniques. When internal stakeholders are comfortable with the use of AHP, opportunities to participate in the planning process using AHP should be extended to involve external stakeholders.

Determining how best to include external stakeholders through the use of AHP in the planning process is a strategic question yet to address and should be determined in reference to the environmental and situational context of the project at hand.

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APPENDIX A. Major topics of documents included in literature review.

Literature Reviewed	AHP	Multi-criteria decision-making / multi-criteria decision analysis	NEPA/ Environmental Impact Assessment	Internal &/or External Stakeholder Participation	Environmental Planning/ Management	U.S. Forest Service
Ananda, J. & Herath G. (2003).	X			X	X	
Ananda, J. & Herath G. (2009).		X			X	
Benke, K.K., Steel, J.L. & Weiss, J.E. (2011).		X			X	
Broussard, S.R. & Whitaker, B.D. (2009).			X			
Canter L. & Clark, R. (1997).			X			
Cashmore, M. (2004).			X			
Coulter, E.D., Sessions, J. & Wing, M.G. (2006).	X		X		X	
Council on Environmental Quality. (1997).			X			
de Steiguer, J.E., Liberti L., Schuler A., & Hansen B. (2003).		X			X	
Diaz-Balteiro, L. & Romero, C. (2008).		X			X	
Forman, E.H. & Gass, S.I. (2001).	X					
Freeman, J., Stern, M., Mortimer, M., Blahna, D., & Cerveny, L. (2011).			X	X		
Fülöp, J. (2005).		X				
Germain, R.H. Floyd D.W., & Stehman, S.V. (2001).			X	X	X	X
Herath, G. & Prato, T. (eds.). (2006).		X			X	
Huang, I.B. Keisler, J., & Linkov, I. (2011).		X			X	
Kangas, J. & Kangas, A. (2005).		X			X	
Kangas, J. (1994).	X			X	X	
Kangas, J., Kangas, A., Leskinen,, P., & Pykalainen, J. (2001).		X		X	X	
Kangas, J., Kurttila, M., Kajanus M., and Kangas, A. (2003).		X			X	
Keele, D.M, Malmsheimer R.W., Floyd, D.W. & Perez, J.E. (2006).			X			X
Keeney, R.L. & Raiffa, H. (1976).		X				
Kiker, G. A., Bridges, T. S., Varghese, A., Seager, T.P. & Linkov, I. (2005).		X			X	
Lahdelma, R., Salminen, P. & Hokkanen J. (2000).		X		X	X	
Linkov, I. Satterstrom, F.K., Kiker, G., Batchelor, C., Bridges, T., & Ferguson, E. (2006).		X			X	
Marttunen, M. & Hämäläinen, R.P. (1995).		X		X	X	
Mau-Cummins, T., de Steiguer, J.E. & Dennis, D. (2005).	X			X	X	
McGregor, D.G. and D.N. Seesholtz. (2008).			X			X
Mendoza, G.A. & Martins H. (2006).		X		X	X	
Mendoza, G.A. & Sprouse W. (1989).			X		X	X
Moseley, K.R., Ford, W.M., Edwards, J.W., & Strager M.P. (2009).	X				X	X
Ngai, E.W.T & Chan, E.W.C. (2005).	X					
Paulu, C.A. (2009).	X		X	X	X	X
Peterson D.L. & Schmoldt, D.L. (1999).	X			X	X	
Predmore, S.A., Stern, M.J., Mortimer, M.J., & Seesholtz, D.N. (2011).			X	X	X	
Ramanathan R. (2001).	X		X	X		
Rauscher, H.M, Lloyd F.T., Loftis D.L., & Twery, M.J. (2000).	X		X		X	X
Saaty, T.L. (1980).	X					
Saaty, T.L. (2000).	X					
Scardina, A.V., Mortimer, M.J. & Dudley, L. (2007).			X	X		X
Schmoldt D.L., Kangas, J., Mendoza, G.A., & Pesonen, M. (Eds.). (2001).	X				X	
Schmoldt, D.L., & Peterson, D.L. (2000).	X			X	X	
Schmoldt, D.L., & Peterson, D.L. (2001a).	X			X	X	
Schmoldt, D.L., & Peterson, D.L. (2001b).	X			X	X	
Stern, M.J, Blahna, D.J., Cerverny, L.K. & Mortimer, M.J. (2009).			X		X	X
Stern, M.J. & Mortimer, M.J. (2009).			X	X	X	X
Stich, B. & Holland, J.H. (2011).		X	X	X	X	X
USDA Forest Service. (2004).					X	X
Zhu, X. & Dale, A.P. (2001).	X				X	
Total Number of Papers (per category)	18	17	18	19	34	12