J5.9 EVALUATING DESIGNS FOR FUEL MANAGEMENT PROJECTS: APPLICATION OF A MULTI-ATTRIBUTE FRAMEWORK

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1. INTRODUCTION

As federal land management agencies move into the 21st Century, one of the most challenging issues they face is the management of fuels to achieve ecological objectives and to influence the potential for catastrophic and uncharacteristic wildfires. At a broad policy level, a number of frameworks exist that provide guidance to local units about the desired future condition of forest ecologies as well as the potential role that fire can play in achieving and maintaining those conditions. However, local units often have to consider other objectives in the design of fuel management projects. For example, local community social values and economic objectives could be considered as part of project design. Likewise, fuel management must also take account of the escape risk associated with fuel management plans that incorporate prescribed fire as a fuel management tool.

This project takes the perspective that the development of fuel management projects inherently involves a set of *design decisions* that ideally address a wide range of objectives expressed as evaluation criteria. In this conceptualization, a given fuel management project is one of several alternative project designs that meet design criteria to a differing degree than others. These criteria can include ecological, economic (including cost), social, and risk-related criteria (such as risk of prescribed fire escape). The optimum project is the one that best reflects the value tradeoffs associated with the various design criteria, taking into consideration the relative weight or priority the project designer gives to the criteria.

Fuels management is often viewed from the “plan” or “project” perspective. Indeed, fuels management planning involves the definition of a specific project in terms of its objectives and its attendant risks. However, a question that often emerges with respect to such plans is “How good is this plan?” or “How good is this set of plans?” From a managerial perspective a fuels manager may also assess the performance of a fuels management program by evaluating an overall collection or set of projects. Such an evaluation could achieve several ends including (a) how well one plan potentially performs with respect to another, (b) how well the overall set of plans meets a broad set of objectives, and (c) where, within the landscape of a broad set of objectives, new plans may need to be developed. At this level of decision-making, a fuel management program is represented as a portfolio of plans, each of which is evaluable in terms of their objectives (benefits) and risks.

The purpose of this paper is to present a conceptual overview of the project and to illustrate the approach taken to facilitate evaluation of alternative fuel management project designs using a visualization approach based on multiattribute modeling.

2. CHALLENGES IN FUEL MANAGEMENT PROJECT DESIGN

Our research views fuel management project development as a set of sequential steps that begins with the evaluation of alternative fuel management project designs. From this perspective, only project designs that do well at meeting these (sometimes) competing objectives

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are worthy of further consideration and perhaps development as part of a NEPA process.

Many of the difficulties associated with implementing fuel management projects are attributable to "upstream" difficulties that local units face in the earlier stages of project/program design. This can come about from a variety of causes. First, too much weight may be given to ecological or fire-related criteria (e.g., internal agency priorities) in choosing which of several projects to develop, and insufficient weight may be given to social or non-agency priorities. Projects that suffer from these difficulties are more likely to do poorly in terms of social response.

From a cost efficiency standpoint, those projects should be submitted to the NEPA process that should have a relatively high likelihood of success, where success includes implementation. Projects that have a high potential to meet, for example, ecological criteria but that cannot be executed or implemented because of a failure to meet social criteria represent an opportunity loss with respect to other projects that may have done less well in terms of ecological objectives, but have had a higher likelihood of being implemented. Also to be considered is the cost of the NEPA process itself: although these costs are not typically considered as part of the direct cost of fuel management projects, NEPA planning costs can be considerable and the use of NEPA planning resources needs to be considered carefully and in light of their effectiveness.

Improving the process of fuel management project design requires methods that can help structure complex problems, including those that involve multiple stewardship objectives and that may span ownership boundaries. In addition, fuel management itself benefits from improved documentation that substantiates not only the legal requirements of a project, but also its broader rationale. Improved methods for *visualizing* and *communicating* the rationale for fuel management project designs increases their potential for implementation.

3. A MULTIATTRIBUTE MODEL FOR FUEL MANAGEMENT PROJECT DESIGN

Multi-attribute decision modeling is a prescriptive approach for dealing with complex decision problems (e.g., von Winterfeldt & Edwards, 1986; Edwards & Barron, 1994). Its structure and logic has been applied in the context of wildland fire. For example, Wildland Fire Situation Analysis (WFSA), a process used by the wildland fire community to structure and evaluate alternative fire management strategies as part of fire management decision making, uses a multi-attribute approach that takes into consideration a range of evaluation criteria, including safety, economic, environmental and social. Objectives are developed for each relevant value category and assigned a priority rating. Alternative fire management strategies are scored in terms of the multi-attribute model to produce a multi-attribute score (probability weighted) that reflects the relative "goodness" or quality of each alternative with respect to achieving the objectives in the multi-attribute model.

This project migrates the general structure of the WFSA process to provide an architecture for evaluating alternative fuel management project designs. The use of the term "designs" in this context is deliberate and is intended to distinguish between the design of a fuel management project and other "downstream" elements, such as the NEPA process and the fuel management plan itself (e.g., Prescribed Fire Plan). Thus, the process for which we are developing support is undertaken early in the fuel management cycle, and has as its goal the modeling of a broad fuel management context such that design alternatives can be evaluated in advance of submitting them to the NEPA process where significantly greater costs are incurred.

An approach to accomplish this objective involves the development of a model for evaluating alternative fuel management project designs based on a multi-attribute framework that represents design criteria in terms of an attribute structure. The attribute structure represents a *decomposition* of design criteria into measurable objectives that provide a basis for evaluating alternative project designs. The structural features of the framework permit the representation and visual display of projects that includes prioritization of objectives and tradeoffs. The framework provides the basis for development of a software decision support tool to aid in fuels management program design. A conceptual model of the aid is shown in Figure 1.

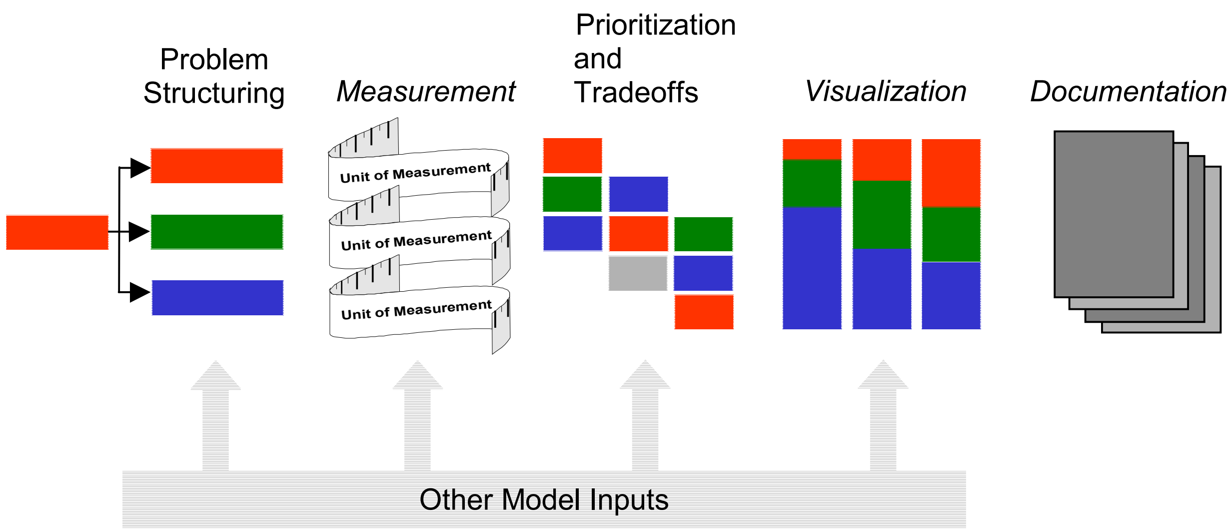

Figure 1. Model overview.

3.1 *Problem Structuring and Dimensions of Value: An Example from the Sierra Nevada Framework*

To illustrate the essential concepts of our approach, we begin with an example using the Sierra Nevada Framework (2001).

Sierra Nevada Framework. The Sierra Nevada Framework is a broad, overarching amendment to the forest plans of a number of forests and parks along the Sierra Nevada mountain range. The units involved range from the Sequoia NF in the south to the Lassen NF in the north. In addition to guidance on species issues, the Framework directs that "A strategic approach for locating fuel treatments across broad landscapes will be adopted. The treatments are linked to support one another on the landscape so that wildland fire behavior spread and intensity are reduced. (p. 5)" This direction with regard to fire and fuels sets fire behavior as the measurable objective for fuels treatments. Further direction with regard to prescribed fire and mechanical treatment is also given. With the SNF, the preferred fuels treatment is prescribed fire, but this can be modified to include mechanical treatment under special circumstances, particularly when fuels treatment is done in habitation areas of sensitive species and/or when PF has high risk of escape or high cost. The time frame for accomplishing the fuel treatment in this decision is between 20 and 25 years.

Economic Impacts – Federal. In addition to the direction and criteria provided by the Sierra Nevada Framework are other criteria associated with economic impacts to Federal resources. Suppression costs are included here as well as potential damages to federal properties from wildfire.

Economic Impacts – Local Community. This category of issues include various economic impacts to communities. In this case, water issues are important. Also, local employment is an issue particularly as fuel treatment projects provide employment to local contractors, which translates into Basic Effective Income (BEI) for the community.

Social Impacts & Concerns (non-economic). A major area of concern in this district is Native American uses of aboriginal lands that are now part of the ranger district. Also, traditional uses of plant materials is an issue. This generally category of concerns, however, can be very large and in the time we were afforded for discussion we were not able to elicit all of the possibilities.

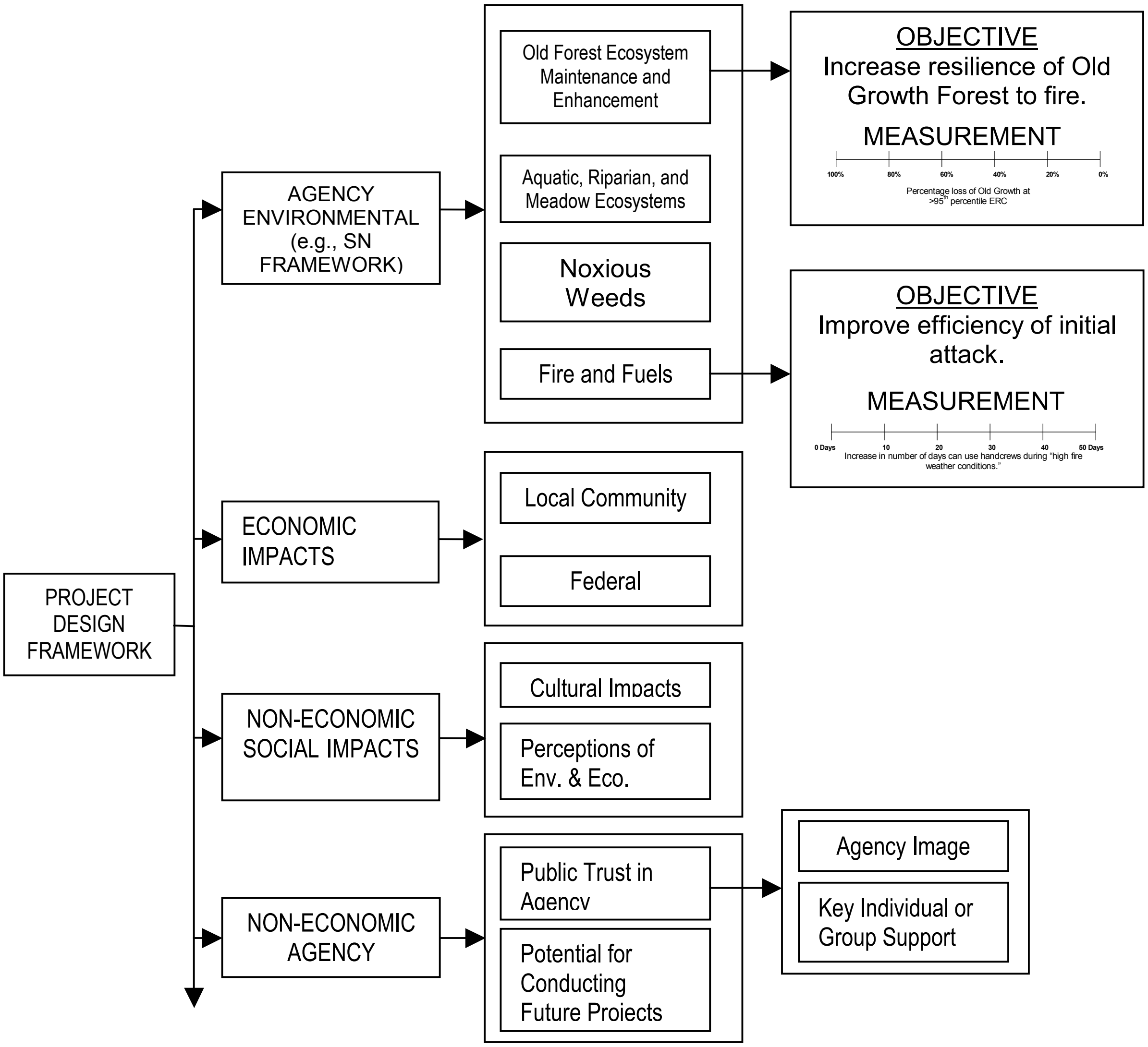

Figure 2. Partial Multiattribute Decision Topology

3.2 *A Multiattribute Decision Topology*

A key concept in the model shown in Figure 1 is the development of a multi-attribute decision topology that represent a decomposition of the fuel management context into a set of attributes, objectives, and methods of measurement or characterization. Figure 2 shows an example of a simplified version of a decision topology for a fuel management problem using some elements of the Sierra Nevada Framework.

In this model, project design is shown as four top-level attributes of value that are further decomposed into subcategories. Each subcategory is defined in terms of a measurable objective with an appropriate scale. As shown in the figure, some attributes can be decomposed further (e.g., public trust, agency image, etc.) to reach an objective measurement.

3.3 *Visual Evaluation of Projects*

To illustrate our approach, we show a hypothetical evaluation of fuel treatment projects using part of the framework shown in Figure 2: two of the projects are prescribed fire projects, and two are mechanical treatment.

Within type of treatment (e.g., PF vs. mechanical) the projects differ in scope and extensivity. At this level of the exercise, the goal was to illustrate how a portfolio of projects would map onto an evaluation framework

Figure 3 shows the placement of each of the four hypothetical projects as well as a “no-action” alternative onto the partial evaluation framework of Figure 2.

An interpretation of the visual representation shown in Figure 2 might go as follows: None of the hypothetical projects in the portfolio performed at the top end of the evaluation

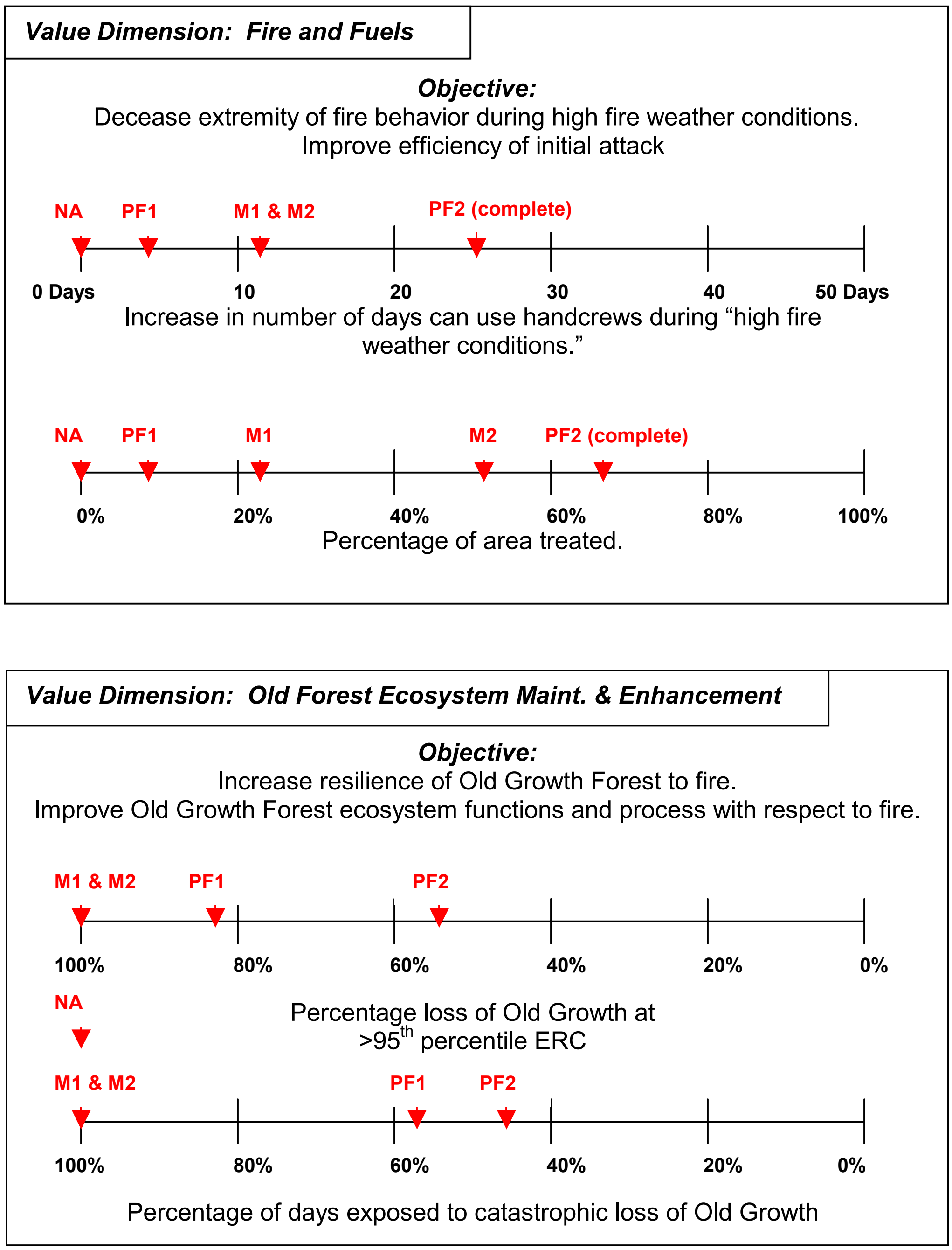

Figure 3. Visual presentation of hypothetical projects evaluated in terms of two value dimensions.

scales. However, one or more projects may have rated higher on scales not included in this analysis, particularly cost. Nonetheless, the results of the evaluation suggest that the portfolio of plans may need to include options that perform better on the dimensions included in the analysis, even if they may be more costly.

With regard to WUI protection, the M2 plan outperformed the M1 plan with respect to area treated, but in this preliminary evaluation the two plans were about equal in terms of their effects on fire behavior as measured by the number of days handcrews could be used during high fire weather conditions. Were these actual plans, this could suggest that the plans should be reviewed for cost efficiency. Alternatively, the plan that treats a greater area may accomplish other objectives not shown in the framework.

With regard to Old-growth protection, the difference in performance between PF1 and PF2 illustrates some of the challenges in developing appropriate measurement scales and suggests that multiple scales may be appropriate. PF2 marginally outperforms PF1 with respect to potential for catastrophic loss of old growth. However, in terms of percentage of old growth lost at high ERC (Energy Release Component) values, PF2 strongly dominates PF1. From the perspective of preventing catastrophic loss, both projects perform moderately and fuel managers who are sensitive to catastrophic loss may want to develop more effective plans in this regard. However, in terms of percentage of old growth lost at high ERC values, PF1 performs relatively poorly. Overall, PF2 provides moderate protection against catastrophic loss, as well as moderate losses overall.

We propose that the use of visual scales and problem representations both in the form of computer aids and as part of project documentation greatly facilitates not only the *internal* evaluation and communication of project goals and objectives, but also facilitates *external* communication with non-agency groups and individuals from whom project support is critical.

4.0 ACKNOWLEDGEMENTS

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