ALLOCATING FUELS BUDGETS TO U.S. FOREST SERVICE REGIONS AND NATIONAL FORESTS: AN INTEGRATED APPLICATION OF LOGIC AND AHP MODELS[1]

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Abstract: There has been dissatisfaction with the USDA Forest Service (FS) process for allocating budgets for hazardous fuels reduction, including a common perception that the agency does not provide funding to the right geographic priorities. Key criticism includes lack of a transparent and repeatable process for budget allocation. The FS Washington Office, seeking to address these concerns, funded development of a prototype decision-support application that was tested for the 2007 budget process. The prototype was developed with the Ecosystem Management Decision-Support (EMDS) system, which provides a general solution framework for integrated landscape analysis and planning in a GIS environment. In the EMDS solution, a logic-based model evaluates wildfire potential at the scale of Forests and Regions, and a decision model, based on the analytic hierarchy process, assists with developing priorities at each scale. The decision model incorporates summary information from the logic-based analysis as well as additional logistical considerations such as efficiency and efficacy of fuels treatment, potential threats to people, etc. We present results of the prototype application for the 2007 budget allocation process, demonstrating how the application satisfies the key requirements for a transparent and repeatable process, and discuss longer-term development of a more comprehensive decision-support application.

Keywords: forest fuels, budget allocation, logic model, decision model

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1. Introduction

There has been dissatisfaction, both internally and externally, with the process used by the US Department of Agriculture Forest Service (hereafter, Forest Service) for allocating budgets for hazardous fuels reduction, resulting in the common perception that the agency does not prioritize and allocate funding according to the most critical needs (for example, Office of the Inspector General Draft Report - Healthy Forests Initiative Audit No. 08601-6-At). Key criticisms of the process include lack of a transparent and repeatable process for budget allocation, and lack of a standardized system for characterizing fire danger and associated socio-economic values at risk. The Fire and Aviation Management Staff of the Forest Service Washington Office, seeking to address these concerns, funded development of a prototype decision-support application that was tested for the 2007 federal fiscal year. Initial results of the prototype are presented in this paper.

2. Methods

The prototype application was developed with the Ecosystem Management Decision-Support (EMDS) system, which provides a general framework for integrated landscape analysis and planning in a GIS environment (Reynolds et al., 2003). EMDS provides decision support for landscape-level analyses through logic and decision engines integrated with the ArcGIS® geographic information system (GIS, Environmental Systems Research Institute[2], Redlands, CA). The NetWeaver® logic engine (Rules of Thumb, Inc., North East, PA) evaluates landscape data against a formal logic specification (e.g., a knowledge base in the strict sense of Holsapple and Whinston, 1996) designed in the NetWeaver Developer System (Miller and Saunders, 2002) to derive logic-based interpretations of ecosystem conditions such as forest fuels condition. The decision engine evaluates NetWeaver outcomes, and data related to feasibility and efficacy of land management actions, against a decision model for prioritizing landscape features built with its development system, Criterium DecisionPlus® (CDP, InfoHarvest, Seattle, WA). CDP models (InfoHarvest, 1996) implement the Analytical Hierarchy Process (AHP; Saaty, 1992), the Simple Multi-attribute Rating Technique (SMART; Kamenetzky, 1982), or a combination of the AHP and SMART methods.

In EMDS, a logic-based model was applied to data for evaluating wildland fire potential (Table 1) and was summarized to National Forests. Forest results were then summarized to Forest Service Regions as area-weighted averages of Forest-scale results.

A decision model, based on the AHP (Saaty, 1992), was developed with the Priority Analyst component of EMDS to assist with establishing priorities for allocating the national fuel budget among Regions. The decision model (Fig. 1) incorporated summary information from the logic-based analysis of wildfire potential as well as additional logistical considerations (Table 2) such as the potential consequences of wildfire, efficiency of fuel treatment, and opportunities for fuel treatment to address other concerns.

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

Table 1. Data sources for evaluating wildfire potential.

Datum	Source
Crownfire potential	FSL[a]
Length of fire season	FSL
Number of large fires	BLM[b]
Problem fire days	FSL
Surface fire potential	FSL
Total fire starts	BLM

[a]Missoula Fire Sciences Laboratory, Missoula, MT.
[b]Bureau of Land Management, Boise, ID.

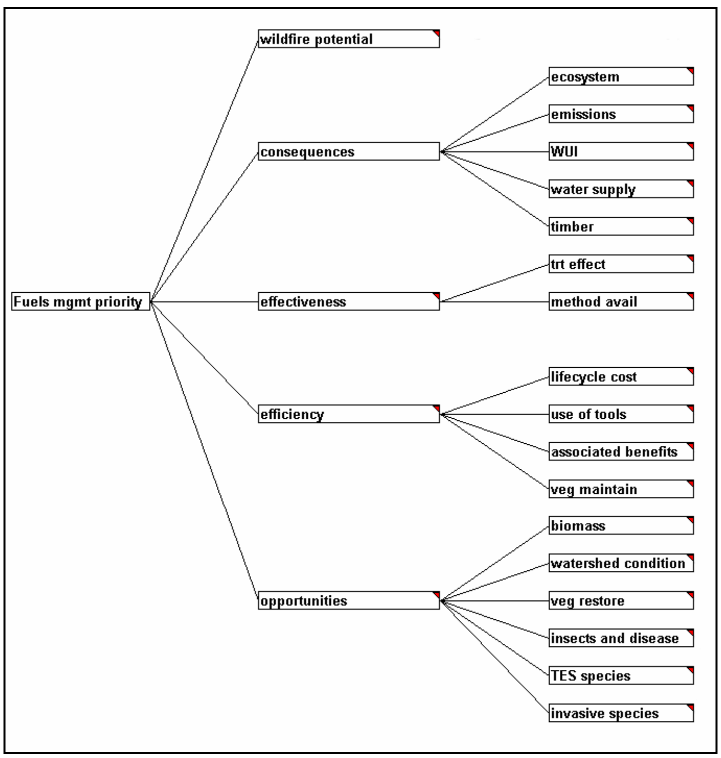

Figure 1. Decision model to allocate the national fuel budget among Forest Service Regions.

Table 2. Data sources for decision model to allocate national fuel budget to Regions.

Datum	Source
Associated benefits	Missing[a]
Biomass opportunity	RSAC[a]
Ecosystem health	FSL[c]
Emissions	FSL
Insects and disease	FHP[d]
Invasive species	RPA[e]
Legislative tools	WO[f]
Life cycle cost	Missing
Methods available	WO
Threatened & endangered spp	TNC[g]
Timber values	WO
Treatment effectiveness	Missing
Vegetation maintenance	FSL
Vegetation restoration	FSL
Water supply	EPA[h]
Watershed condition	WO
Wildland-urban interface	UW[i]

[a]Not used in current model.
[b]Remote Sensing Applications Center (USFS)
[c]Missoula Fire Sciences Laboratory
[d]Forest Health and Protection (USFS)
[e]Resources Planning Act Assessment (USFS)
[f]USDA Forest Service, Washington Office
[g]The Nature Conservancy
[h]Environmental Protection Agency
[i]University of Wisconsin, Silvis Lab.

3. Results and discussion

Results of the Forest-scale assessment of wildfire potential are illustrated for the western US (Fig. 2). The map has been symbolized as relative potential, based on 5 equal-interval classes, to better depict variation among Forests. Wildfire potential and priorities for budget allocation are summarized by Region (Table 3). Most priority scores are tightly clustered in the range of 0.35 to 0.45, but Regions 8 and 1 scored higher (Table 3), based primarily on higher contributions (Fig. 1) from consequences, effectiveness, and efficiency in the case of Region 8, and wildfire potential and opportunity in the case of Region 1. The priority scores should be regarded as preliminary because they are only intended to provide the starting point for deliberations on budget allocation, rather than an ultimate answer, which is the purview of the national leadership of the agency.

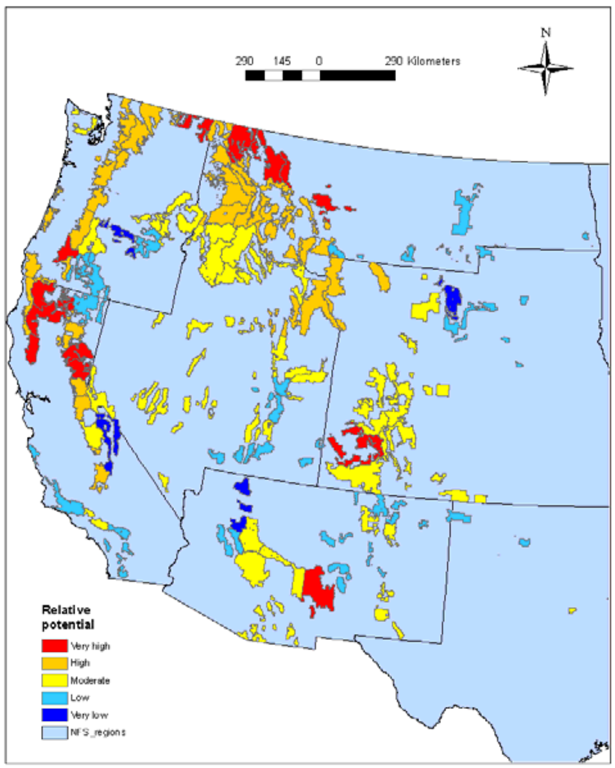

Figure 2. Relative wildfire potential in National Forests of the western US.

Although the decision model is relatively complex (Fig. 1), the logic model in this prototype is very simple, only constrained by the current lack of consistent national data. Hessburg et al. (2006) describe a far more comprehensive approach to evaluation of wildfire potential that can replace the current prototype version when data development for the national LANDFIRE program is completed in 2008.

The decision model for Regions is readily adapted to support allocating fuel budgets among Forests within a Region because most data employed in the decision model were initially obtained as summaries of Forest-scale information. Thus, a single modelling approach can be consistently applied across at least two spatial scales, and with additional modification, could perhaps be applied to still finer scales, such as assisting with allocations among Ranger Districts on individual Forests.

Only the most basic results from the analyses have been presented in this paper. However, managers using the application can view maps (similar to Fig. 2) for the evaluated state of all topics that enter into the logic. More importantly, considering the criticisms that motivated this EMDS solution, any map at any level in the logic evaluation can be interrogated by the user to display the logic that leads to the results of any part of an evaluation. Results of interrogations are shown in an intuitive graphic representation of the logic and its structure. The Priority Analyst component of EMDS similarly displays additional explanatory material such as how subcriteria at one level of the decision model contribute to their criterion score, robustness of model weights, and trade-offs among lowest level decision criteria.

Table 3. Regional summary of wildfire potential and budget priority.

Region	Wildfire potential[a]	Priority score[a]	Rank
1	0.56	0.45	2
2	0.59	0.40	4
3	0.61	0.37	6
4	0.44	0.41	3
5	0.52	0.39	5
6	0.48	0.39	5
8	0.47	0.57	1
9	0.45	0.41	3

[a]The scale of potential and priority is [0, 1], with a value of 1 indicating the maximum in each case.

Evaluation of treatment priorities related to wildfire potential is not necessarily limited to fuel and fire characteristics; it can also incorporate human impacts, and social or economic, or other value considerations. One such consideration, when evaluating the context of wildfire potential, may be the consequences of large, severe fires (Fig. 1). Readers might fairly ask, “Given that the logic model for wildfire potential and the decision model for treatment priorities share common data elements, why bother with two separate models?” First, and perhaps most obviously, the two models produce very different interpretations of the data (Table 3). The logic model is a relatively objective interpretation of wildfire potential, given that parameters used to interpret observations were derived from field data, and given that the logic is presented in a relatively pure form insofar as all topics are equally weighted. Although weights can easily be applied to topics in a logic model, they also add an additional level of subjectivity that is more effectively managed within the context of decision models, such as those based on the AHP that are more specifically designed to deal with such issues (Reynolds et al. 2003). Logic models also offer the opportunity to synthesize and summarize potentially complex information, thus simplifying the structure of a decision model. In this study, for example, the decision model used summarized information about the topics under wildfire potential that might otherwise have been difficult to adequately represent in an intrinsically linear decision model.

Finally, the two types of models are complementary in the sense that the logic model focuses on the question, “What have I got?”, whereas the decision model focuses on the question, “Now that I know what I have, what should I do about it?” Notice that logistical issues are not pertinent to the first question, but they may be extremely important for the second. An important consequence of separating the overall modeling problem into these two complementary phases is that each phase is rendered conceptually simpler. The logic model evaluates and keeps separate the status of the components of each ecological system under evaluation; in this case, the components of wildfire potential of planning units such as regions or National Forests. The decision model takes the ecological status of each ecosystem and places it in a social context that is designed to further inform a decision-making process. The decisions will be based only partially on information about ecological status. They will also be based on social context and associated human values. After priorities have been derived by the decision model concerning what to do about the existing wildfire potential, the decision-maker can look back at the decision and see the relative contributions of the ecological states and their social context(s) in the overall decision. This transparent model design and structure aids in decision explanation, and allows decision makers to consider, in the sense of scenario planning, the effects of alternative weightings of important decision criteria.

4. Conclusions

Over the past year, the modeling process and results have been vetted at several national fire conferences and workshops as well as reviewed by Congressional staff and oversight agencies of the US government such as the Office of the Inspector General and the Office of Management Budget. Despite some bumps and warts associated with currently limited data and limited development time, the overall process has been widely viewed as a successful proof of concept insofar as it demonstrated a rational, transparent approach to supporting budget decisions for allocation of fuel treatment funds.

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