Session III

Approaches to Fire Planning in Different Agencies

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The National Fire Management Analysis System (NFMAS) Past 2000: A New Horizon[1]

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Abstract

Wildland fire suppression policy in the USDA Forest Service has evolved over the years from forceful attempts to control all wildland fires at the smallest possible size to consideration of other land management and economic factors during suppression decision making. In 1978, working under congressional direction, the Forest Service started using and developing computer-based models to represent the benefits and costs of budget requests. Over time, the National Fire Management Analysis System (NFMAS) was implemented as the primary fire planning system in several Federal and State agencies. The NFMAS is a tool used by managers to evaluate alternative fire management programs against such things as land management objetives, program budget level, and dispatch strategies. In order to meet future information requirements, the NFMAS will need reengineering and enhancement in several areas. Scientists, software engineers, agency personnel, and others need to work together so the next generation NFMAS meets the needs of the user community, managers, and agency administrators.

The National Fire Management Analysis System (NFMAS) provides the basis for planning and budgeting of the USDA Forest Service Fire and Aviation Management program. By using the NFMAS, long range budget requests are prepared at the National Forest, Regional, and National organizational levels. Current year allocation is based upon those requests and available appropriation. The NFMAS is a fundamental tool to show Congress and the Office of Management and Budget (OMB) the value of financing the Fire and Aviation Management program. In recent years, several refinements to the original NFMAS have been developed. They improve the ability of the model to reflect and project Fire and Aviation Management program needs and outcomes.

This paper provides a brief history of the NFMAS, outlines the current status of the NFMAS, and discusses future enhancements that might be incorporated into the fire planning system.

A Brief History of Forest Service Fire Policy and Fire Planning Systems

Since the early years of this century, the USDA Forest Service has protected the lands it manages from undue damage by wildfire. Over the decades, a variety of criteria and philosophies has been used to identify the most appropriate kind and use of wildfire suppression resources (personnel and equipment).

One of the earliest measures of efficiency produced the "10 a.m. Fire Control Policy." This policy called for "fast, energetic, and thorough suppression of all fires in all locations, during possibly dangerous fire weather.... Failing in this effort, the attack each succeeding day will be planned and executed with the aim, without reservation, of obtaining control before 10 o'clock of the next morning" (Silcox 1935, p. 1).

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[1]An abbreviated version of this paper was presented at the Symposium on Fire Economics, Planning, and Policy: Bottom Lines, April 5-9, 1999, San Diego, California.

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This policy was grounded in the philosophy that all fires represented a threat of unacceptable damage and that it was more cost-effective to aggressively suppress wildfires at a small size than to allow them to get larger and then try to extinguish them.

In 1971 the Forest Service adamantly reaffirmed the 10 a.m. Fire Control Policy but recognized that conditions and situations varied across the country. There was also a prediction of a time "when a more flexible approach should be considered. It is anticipated that fire planning, fully supported by dependable data and knowledge, will permit suppression goals based on local judgements and decisions" (USDA Forest Service 1971, p. 1).

The next year, in the process known as "1972 fire planning," the agency specified that fire planning must provide a level of protection necessary for successful management of natural resources and to improve and protect air, water, soil, and visual quality. It stated that this must be done at the least cost commensurate with values protected. Preparedness forces were to be developed and financed at a level sufficient to manage fire problems encountered 90 to 97 percent of the time, as measured by the National Fire Danger Rating System (NFDRS) burning index. This signaled a substantial departure from the single minded mandate of "thorough suppression of all fires in all locations."

By 1975, the escalating cost of Forest Service fire management programs, without apparent commensurate reductions in suppression costs and resource damage, had caught the attention of the OMB. The next year, the Chief of the Forest Service requested that fire planning methods be reviewed, with special attention given to preparedness effectiveness. The ensuing study concluded that "the fire planning procedures appeared to be basically sound and rational" (USDA Forest Service 1976). It recommended:

- Setting fire control objectives based on output targets from the Resource Planning Act (RPA) and land and resource land management plans.
- Adjusting initial attack organizations based on planned fire prevention efforts.
- Projecting acres burned based on local fuels, weather and topography, and calibrating it according to local experience.
- Utilizing mathematical regression analysis to evaluate protection costs and results (Ellis 1969).
- Evaluating the Fire Operational Characteristics Using Simulation (FOCUS) model for expressing the effectiveness of preparedness expenditures, including the potential damages and benefits from wildfire, and the organization that can meet objectives at the least cost.
- Indicating the most cost effective, "mix of presuppression activities."
- Conducting economic efficiency analysis at a Regional level aggregating upward to produce a national evaluation.

In 1978 Congress directed the Forest Service to conduct a formal cost-benefit analysis to support the fiscal year 1980 budget request. The next year, a computerized tool called FOCUS was used to analyze several years of historic fires on six National Forests to provide budget planning guidance. FOCUS provided information on wildfire suppression efficiency but could not be used for development of a national fire management budget. However, on the strength of that analysis, Congress increased the 1980 budget for fire management, but directed that any further increases would be withheld pending findings of a more comprehensive cost-benefit study.

A more comprehensive study was conducted in 1980 by using a different set of computerized tools to analyze 10-year fire distributions on 41 National Forests, representing different vegetation, resources, fire behavior conditions, and fire budget levels (USDA Forest Service 1980a, USDA Forest Service 1980b).

Preparedness budget needs for the entire National Forest System were extrapolated from these sample data and used to generate the 1981 budget request. Congress expressed support for the analysis results and urged full implementation of the analysis process the next year. The Chief mandated the use of economic efficiency as the principle measure for appropriate budget levels and directed the Washington Office to use this prototype analysis for national budget preparation in the future.

The 1980 Fire Management Budget Analysis compared alternative fire program mixes, then identified the preferred mix as that which satisfied land management objectives at the lowest cost plus net value change in natural resources as the result of wildfire. Although useful in describing fiscal efficiency at the national level, important cost centers (facilities, airtankers, smokejumpers, Regional offices, and the National Office) were not analyzed. These cost centers were added in after the analysis to derive the national budget level. Neither the database, the evaluation process, nor the outputs were sufficiently accurate or precise for direct comparison between Regions or individual National Forests. This was primarily due to inadequacies in the database rather than deficiencies in the analytical process (USDA Forest Service 1980b).

The 1980 analysis recognized that natural resource value changes did not drive program efficiency determination. The change in natural resource value represented smaller amounts than either preparedness or suppression costs. The analysis showed that net value change was primarily the result of losses to the timber resource, followed distantly by destruction of improvements. The greatest benefits were to commercial livestock forage, wildlife habitat, and usable water yield. Although the analysis did not specifically evaluate fuel treatment investments, it did conclude that in certain site specific and limited vegetation complexes, larger fuel treatment programs may be effective in reducing wildfire suppression costs. The analysis concluded that the greatest opportunity for cost reduction exists where high fire occurrence rates and high resource values coincide.

Despite the incomplete nature of the 1980 analysis, it was sufficient to demonstrate a fully reliable process for describing economically efficient fire management program benefits. This was the beginning of the current NFMAS.

The National Fire Management Analysis System (NFMAS)

In 1925, W. N. Sparhawk laid the early foundation for the NFMAS. He searched unsuccessfully for a scientific method and formula to determine fire protection budget levels for the National Forests. Through his work, he established the basic efficiency principles and cost plus net value change graph that are familiar to fire planners today. His study sought efficiency based on least protection costs plus losses incurred by wildfire. Consequently, it ignored what was known about the beneficial effects of some wildfires. His model tended to overestimate damages (Gorte and Gorte 1979, Teeter 1983).

The NFMAS refines Sparhawk's approach and estimates the most cost efficient fire management program mix, as indicated by the lowest sum of costs plus net value change, which meets resource management objectives and provides the necessary level of protection to life, property, and resources. Costs are both preparedness and suppression. Net value change considers the benefits and damages of wildfire on both natural resources (market and non-market values) and improvements. The NFMAS rejects former physical indicators or decision criteria, such as acres burned and the 10 a.m. control policy.

Initial Attack Assessment and the NFMAS Model

There are numerous components to the NFMAS model. In general, it is based on historic fire occurrence, fire behavior, alternative initial attack organizations, and

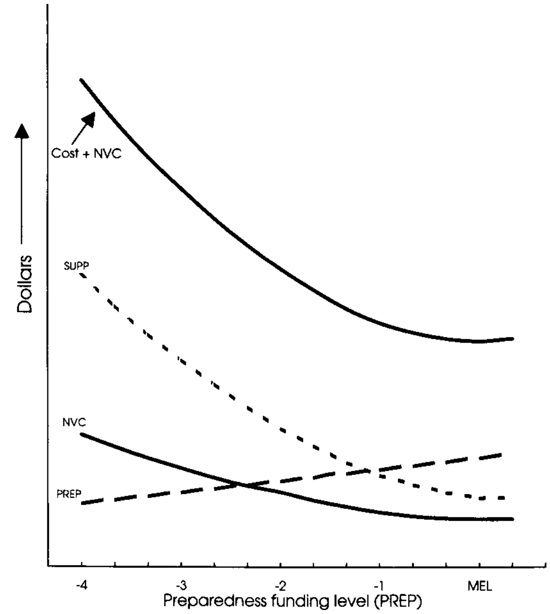

Figure 1

National fire management and analysis system (NFMAS) and cost plus net value change (C+NVC) chart: relationship between preparedness (PREP), suppression operations (SUPP), and net value change (NVC).

results of simulated fires that are captured or escape initial attack. The Interagency Initial Attack Assessment (IIAA) model within the NFMAS tests alternative initial attack organizations and dispatch strategies against wildfire conditions found on the planning unit (typically a National Forest).

The IIAA provides a simulation of wildland fire initial attack response and applies a measure of economic efficiency to each response. The key concept in the fire planning process is that there are numerous alternatives to organizing, deploying, and using initial attack forces, but only one "most efficient level" (MEL). MEL describes the one mix of initial attack organization (engine crews, hand crews, smokejumpers, helicopters, and retardant use) and the one dispatch philosophy (how and when particular firefighting resources are used during initial attack) that minimizes the predicted aggregate cost of providing the initial attack organization (preparedness) plus the cost of wildland fire suppression plus the value of natural resources due to wildland fire. This sum is more commonly referred to as "cost plus net value change" (C+NVC). Fire planners systematically define alternative initial attack organizations and dispatch strategies and test them in the IIAA to find the most economically efficient staffing and dispatch philosophy.

A guiding principle in fire planning and the C+NVC concept is that there is a point at which additional expenditures in preparedness do not return a net savings in suppression expenditures plus natural resource loss *(fig. 1)*. C+NVC is composed of three elements: The cost of supplying an initial attack organization (preparedness - PREP, *fig. 1*); the cost of wildland fire suppression (suppression - SUPP, *fig. 1*); and the value of natural resources lost due to wildland fire (NVC - NVC, *fig. 1*). The MEL occurs where the aggregate of these cost elements is minimized.

If a unit finances a small initial attack organization (point -4, *fig. 1*), some number of fires will escape initial attack. These escaped fires will grow in size, damage natural resources, and have high suppression costs. As the unit adds firefighters and the preparedness budget grows (points - 3, -2, and -1, *fig. 1*), the number of escaped fires should decrease. This will lead to fewer acres burned, a lesser amount of natural resource damage, and reduced suppression cost. The relationship of reductions in natural resource damage and suppression costs in respect to increases in preparedness expenditures continues until a point where the efficiency of the initial attack organization is maximized (point MEL, *fig. 1*). Adding any more to the preparedness budget will not return an equal savings in resource loss averted plus suppression costs. Thus, at some point, no matter how much additional is spent on preparedness, some fires are going to escape, grow large, and have a large suppression cost. It makes no economic sense to plan for these occurrences and maintain large preparedness organizations in the hope that every fire can be caught during initial attack.

The IIAA does a credible job of representing the results of alternative initial attack organizations. As a "marginal analysis" tool it estimates the magnitude of changes in outputs, specifically costs and losses, resulting from a known change in the inputs (Gorte and Gorte 1979, Teeter 1983).

The model is currently plagued by these weaknesses:

- Defining adequate overhead support cost information.
- Incorporating subjective non-market resource values (Hurd 1987).
- Recognizing the costs of social and political pressure.
- Adapting to small or low fire occurrence databases.
- Evaluation of prevention and fuel treatment programs.
- Evaluating fire season severity from one year to the next (Chase 1991).

Efforts are underway to address these deficiencies.

The Future of the NFMAS

Numerous enhancements and new functionality have been identified that will increase the effectiveness of the NFMAS as a planning tool and prepare the way for a replacement system.

Initial Attack Assessment

Input and output units are limited to U.S. units. A metric version would help planners in other countries.

The user guide and system technical documentation are written in English. It may be beneficial to translate these documents into other languages.

Fire planners now must enter vast amounts of derived information in order to set up an analysis. It is desirable to produce a "minimum necessary information" module that will allow planners, without large fire and weather occurrence and historic fire fighting organization databases to run the IIAA.

There are many opportunities to increase the amount of automation that now occurs in the IIAA. Assuming the fears of overautomating the system are overcome, these procedures will reduce the amount of planning time and increase the amount of analysis time available to fire planners. The program can be restructured to allow the machinery to run many more simulations than the fire planner. Some cost data can be empirically derived. Model development can take place that will allow for "extended attack" simulation (simulations that look at 1-2 days rather than hours) and long range simulation (1 week or more).

Advanced simulation tools need to be incorporated into initial attack and other fire planning exercises (large fire suppression decisions, land management planning, fuel treatment, and wildfire suppression training). Numeric data must be able to be transformed into visual information (motion, color, and graphic) for ease of discussion, location of "critical" areas, predictions of future events, and depictions of events.

The current model is limited to simulating one fire at a time. In the western United States, lightning storms can cause numerous fires in a short amount of time. The IIAA can be modified to include queueing theory or service/ supply modeling techniques to indicate how organizations should respond to multiple fire events.

Better and more defensible information is needed regarding the valuation of non-market forest resources and the effect wildfire has on them. Currently, the IIAA does not do a good job of handling non-market wildfire effects. Better damage functions, defensible values for non-market resources, and critical thresholds for resource damage need definition in the present or future system.

Weather Analysis

Seasonal or yearly fire severity analysis needs to be more fully developed. Climatological predictions of fire severity may help planners shift preparedness forces to those areas likely to have increases in normal fire occurrence.

Climatological predictions can be applied to geographic information systems (GIS) based fire spread models to aid managers with suppression alternatives and subsequent suppression decisions. Longer range climatological information prediction systems will be an important part of future fire planning and simulation.

Fuel Treatment

Reducing the amount of dead woody material in forests should reduce the rate of spread and intensity of a wildland fire burning in that forest. This should lead to reductions in preparedness expenditures as any fire burning in treated forests is more easily controlled. A problem facing fire planners at this time is how much fuel treatment is economically defensible. Development work on an economic model that describes the trade-offs of fuel treatment expenditures versus preparedness expenditures is desirable. Work has started on numerous elements of this problem. Eventually, many of the projects will yield products that will be combined into one system that will help managers define the costs, benefits, trade offs, and value of fuel treatment.

Work is needed in the area of how various treatments (prescribed burning, handpiling, machinepiling) affect fuel models. Cost and effectiveness information of each treatment type will be needed to feed the fuel treatment model.

Work has been completed on a first generation system (FORBS). Future work will build upon this base and introduce more of the complexities surrounding fuel treatment decisions.

Wildland Fire Prevention Programs

If prevention programs are successful, the number of human caused fires should decline. This success should manifest itself in reductions in suppression expenditures and natural resource loss. A model (PWA2) has been developed to test this theory. Peer reviews and enhancement of this model will be made in the future.

Geographic Information Systems (GIS)

Forest vegetation growth and decay has a profound affect on predicted fire behavior and selection of areas for fuel treatment. GIS-based, graphic data displays of data allow better and more accurate communication between managers. A model that can predict future forest vegetation types across a GIS landscape will help managers decide where to place fuel treatment and land management emphasis.

GIS based systems will allow better simulations of initial attack, will help with Wildland Fire Situation Analysis projections of escaped fires, and will assist managers with land management planning decisions. Fire planning will eventually involve more robust simulation tools that will allow long range predictions of wildfire events, land management planning decisions, and fuel treatment decisions.

Visual displays of quantitative information will be an important part of future systems development. Visual simulations of real time and predicted events will aid decision makers and simplify presentations of decision alternatives.

Program Management

As initial attack organizations grow, questions arise about the appropriate level of "overhead" and support. Developing a system based on the concept of "what management and support structure is appropriate for this budget and preparedness force" is something that needs exploration. The U.S. Department of Interior uses a system called FIREPRO. A part of FIREPRO defines an overhead structure based on workload and program complexity. A project that looks at organization structure will have value in future fire planning systems.

Conclusion

The National Fire Management Analysis System (NFMAS) is working well, but it can be enhanced. New analysis products, the use of new technology, and software engineering will increase the effectiveness of the NFMAS to answer questions and plan for the future. Research scientists, software engineers, economists, academics, and agency personnel should be working together to build the next generation fire planning tool.

References

Beasley, J. Lamar. [Memo to Regional Foresters]. 1985 Dec. 1 leaf. Located at: Fire and Aviation Management, Washington Office, USDA Forest Service.

Booher, Brian. 1996. **NFMAS planning course, student lesson plans**. Costa Mesa, CA: Bighorn Information Systems; 117 p.

Chase, R.A. 1991. **Incorporating seasonal severity into annual fire program planning**. In: 11th conference on fire and forest meteorology; 1991 April 16-19. Missoula, MT.

Ellis, T. 1969. **Multiple regression estimates of the effectiveness of national forest fire control expenditures: A PBS special study**. Unpublished manuscript on file with the Washington Office, Fire and Aviation Management, USDA Forest Service.

Gorte, J.K.; Gorte, R.W. 1979. **Application of economic techniques to fire management-a status review and evaluation.** Gen. Tech. Rep. GTR-INT-53. USDA Forest Service, Intermountain Research Station; 26 p.

Hurd, E.J. 1987. [Memo from State of Alaska Department of Natural Resources]. 1987 June 22. Located at: Fire and Aviation Management, Washington Office, USDA Forest Service.

McDonald, Robert J. [Memo to Fire Directors]. 1983, June. 1 leaf. Located at: Fire and Aviation Management, Washington Office, USDA Forest Service.

Schweitzer, D.L.; Anderson, E.V.; Mills, T.J. 1982. **Economic efficiency of fire management programs at six national forests.** Res. Paper PSW-157. Berkeley, CA: Pacific Southwest Forest and Experiment Station, USDA Forest Service; 29 p.

Silcox, F.A. 1935. [Memo to Regional Foresters]. 1935 May 25. Located at: Fire and Aviation Management, Washington Office, USDA Forest Service.

Simard, A.J. 1979. **A computer simulation model of forest fire suppression with air tankers.** Canadian Journal of Forest Research (3): 390-398.

Sparhawk, W.N. 1925. **The use of liability ratings in planning forest fire protection.** Journal of Agriculture Research 20(8).

Swanson, John. 1995. **The National Fire Management Analysis System (NFMAS): past, present, and future.** Unpublished manuscript on file with the Washington Office, USDA Forest Service; 6 p.

Teeter, L. 1983. **Providing for national interests: a perception of the federal role in state and private fire protection.** In: The National interest in Federal role in protection of State and private rural and wildlands from fire hazards conference; 1983 March 30-April 1; Fort Collins, CO: Colorado State University.

USDA Forest Service. 1971. **Report of the fire policy meeting, Denver, Colorado.** 1971May 12-14; Unpublished manuscript on file with Fire and Aviation Management, Washington Office, USDA Forest Service.

USDA Forest Service. 1976. **Evaluating national fire planning methods and measuring effectiveness of presuppression expenditures.** Unpublished manuscript on file with Fire and Aviation Management, Washington Office, USDA Forest Service.

USDA Forest Service. 1998. **FORBS - fuels out-year request and budget system, guide to users.** Available from USDA Forest Service, National Information Systems Support Group, National Interagency Fire Center.

USDA Forest Service. 1980a. **Fire management budget analysis, fiscal year 1980: preliminary report.** Unpublished manuscript on file with Fire and Aviation mangement, Washington Office, USDA Forest Service.

USDA Forest Service. 1980b. **National forest system fire management budget analysis: 1980, June.** Unpublished manuscript on file with Fire and Aviation Management, Washington Office, USDA Forerst Service.

USDA Forest Service. 1994. **Briefing paper #1: national aerial delivered firefighter study.** Unpublished manuscript on file with Fire and Aviation Management, Washington Office, USDA Forest Service.

USDA Forest Service and USDI. 1985. **National study of airtankers to support initial attack and large fire suppression: final report phase 1.** Unpublished manuscript on filewith Fire and Aviation Management, Washington Office, USDA Forest Service.

USDI National Park Service. 1997. **Overview of FIREPRO program planning and budget analysis.** Unpublished manuscript on file with the National Park Service, National Interagency Fire Center.

USDI and USDA. 1998. **Users guide - (PWA2) prevention workload analysis version 2**. Boise, ID: National Information Systems Support Group, National Interagency Fire Center. USDA Forest Service.