Wildfire Initial Response Assessment System: A Tool for Fire Preparedness Planning[1]

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Abstract

Recent advances in operations research and computer technologies present new opportunities to improve preseason wildland fire planning tools. In this paper, we describe the Wildfire Initial Response Assessment System (WIRAS), a stochastic simulation model that incorporates many recent technical advances and is designed to closely represent the dynamics of fire occurrence and suppression. The computer simulation model provides fire managers a powerful tool to examine operational and performance characteristics of their initial attack capabilities for planning appropriate preseason protection organizations.

Introduction

The Forest Fire Laboratory in Riverside, California is engaged in the development of a new presuppression wildland fire planning model. This modeling effort builds on knowledge gained from previous developmental efforts (Bratten and others 1981; Fried and Gilless 1999; Martel and others 1984; McAlpine and Hirsch 1999; Wiitala 1998). The model, the Wildfire Initial Response Assessment System (WIRAS), incorporates many recent advances in operations research technologies and takes several new approaches to model design. The intent in building WIRAS was to closely represent the dynamics of fire occurrence and suppression resource deployment characteristic of many federal and state protection programs in the western United States. The close correspondence of the model to reality provides an effective decision support system to help fire managers and planners better determine the appropriate size, location, composition, and use of locally controlled initial attack programs as well as evaluate nationally shared aerial resource programs. This paper provides an overview of WIRAS.

Model Building Approach

Protected federal wildlands in the western United States is the environment for model development. The variability of the timing and intensity of fire workloads in this environment can have a profound effect on performances of different presuppression organizations. Given this variability as well as other operational and environmental

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uncertainties, we selected discrete-event, stochastic simulation as an appropriate modeling methodology to design WIRAS. We adopted a process-oriented approach (Law and Kelton 1991) in using an enhanced variant of the discrete-event simulation language General Purpose Simulation System (Henriksen and Crain 1989) to build the model.

Model Structure

WIRAS distinguishes itself from other models with the ability to plan both local and national fire preparedness programs. It also pioneers the ability to conduct local planning within the context of the national fire environment. This embedded planning approach allows fire planners to design a local initial attack program while taking into account their success in competing for nationally shared aerial resources.

From a process viewpoint, WIRAS simulates the deployment and retrieval of ground and aerial resources in response to a yearly time stream of fires unique in their fire behavior, location, and time of arrival *(fig. 1)*. Initially WIRAS dispatches local and nationally available suppression resources from their home bases to fires according to user-defined rules and with regard to deployment constraints. As is the case operationally, when the first resource arrives at the fire, the simulation model, based on observable fire behavior, reassesses staffing needs to either request additional suppression units or return some of those in transit to the fire. After a fire is contained or escapes the initial attack effort, the simulation model demobilizes initial attack suppression resources to their home bases for dispatch availability on a subsequent day. As an exception, WIRAS will redeploy ground resources to on-going understaffed fires the same day of demobilization if attack times are within reason.

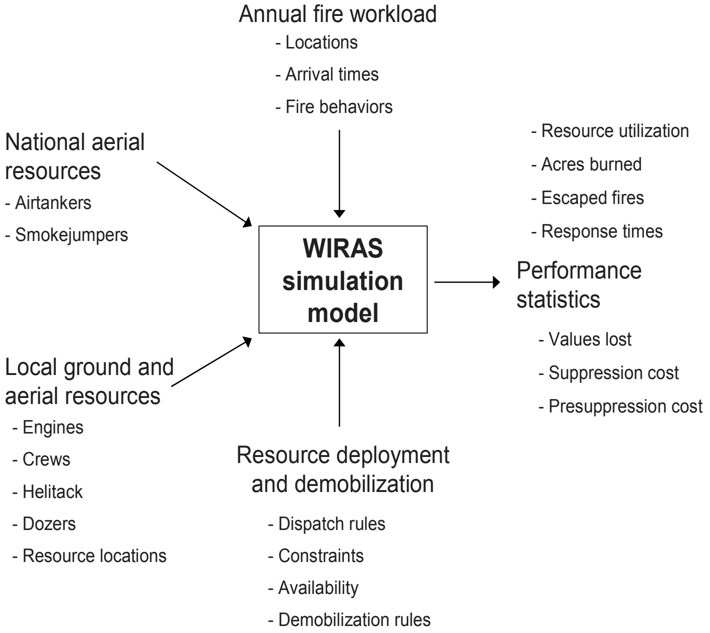

Figure 1—WIRAS overview.

Suppression Resources

WIRAS manages four classes of initial response resources. Three classes involve aerially delivered suppression capability: airtanker retardant delivery, smokejumpers, and helicopter delivered crews and water. The fourth class, ground resources, currently includes engines, crews, dozers, and water tenders. Each of the four suppression resource categories is modeled uniquely to capture important and disparate operational features (Wiitala 1998; Wiitala and Dammann 2003).

Program Performance Testing

WIRAS currently tests the performance of an initial attack organization against a set of historical fire seasons. Resource dispatching is controlled through a system of Boolean variables that mimics the rules and priorities governing an administrative unit's preplanned dispatch policies. The model is designed to favor dispatching quickest response, local ground resources provided they could be expected to reach a fire within a reasonable time; otherwise, the model attempts to dispatch aerially delivered firefighters. The first firefighters to arrive at a fire reassess the preplanned staffing needs for sufficiency and determine the need for retardant deliveries.

Several of the arguments in the Boolean variables reflect the types of information typically available to dispatchers in making deployment decisions. The simulation model maintains and updates state variables corresponding to these arguments. This system of Boolean variables is sufficiently flexible to permit planners to set, within the simulation model, the conditions for dispatching ground resources based on attack times, fire behavior potential, and protection objectives.

Travel Time Calculations

The WIRAS project is making a special effort to accurately model suppression resource response times. This is viewed as critical to the successful modeling of the initial attack system (Mees 1986). Total response time is composed of getaway, reloading, refueling, and travel time. Travel time is usually the largest component. For aircraft, distance between travel points and average airspeed are combined to calculate aircraft flight component of response time. For aerially delivered firefighters an additional amount of landing and walk time is included in total response time. In the case of airtankers, reloading and refueling times add to response times. Additionally, WIRAS models congestion at airtanker bases during periods of high fire activity which can lengthen response times when airtankers have to wait for available loading pits.

The project is making a major push to develop improved methods for estimating ground resource travel time which includes vehicle travel along a road network and off-road foot travel. The effort involves the development of a computationally efficient least-cost-path algorithm to quickly calculate travel times over a landscape (Hatfield and others, this proceedings). A study of ground resource travel times is underway to gather empirical information to validate the least-cost-path algorithm and quantify additional random travel time components (Wilson and Wiitala 2003). The simulation model presently integrates the travel time algorithm to calculate ground resource travel time from any ground resource location to any other location. The value of the algorithm in allowing WIRAS to mirror real operational practices is particularly apparent during a simulation when a ground resource in transit to a fire becomes available for diversion to another fire. At this point in the simulation, the least-cost-path algorithm can determine the resource's current location and calculate response times to all needy fires to decide the best plan for its redeployment.

Model Outputs

Discrete-event simulation models provide great capability to collect large amounts of information on system conditions and performance over the course of a simulation. WIRAS is no exception. Examples of average annual statistics collected by WIRAS include: acres burned by fire intensity for both contained and escaped fires, numbers of fires escaping initial response, volume of delivered retardant, flight hours for aerial resources, resource dispatch and arrival lists for each fire, and fire containment time and size distributions.

WIRAS also tracks annual dispatch frequency which is an important model output that can help planners evaluate suppression resource and base utilization to improve program performance and efficiency. Underutilized suppression resources are good candidates for relocation or elimination. Utilization statistics can help identify opportunities to close bases.

WIRAS also monitors a number of queues to help identify potential bottlenecks in various service delivery processes. For example, information on the frequency and length of time airtankers must wait for retardant reloading facilities allows planners to assess the need for and value of expanding or reducing airtanker base facilities.

Operational and performance statistics produced by WIRAS provide the basic building block to examine economic trade-offs between average annual fire suppression costs and natural resource loss and the budget cost of building alternative preseason suppression organizations *(fig. 2)*.

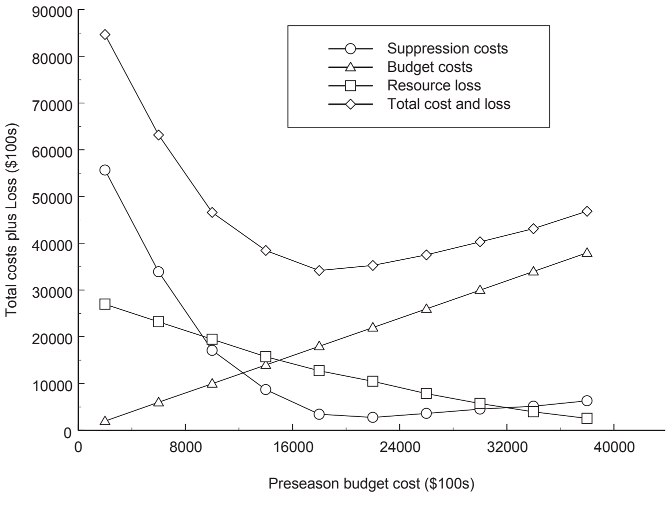

Figure 2—Economic tradeoffs associated with alternative presuppression budget levels.

Conclusions

Discrete event stochastic simulation provides a powerful operations research method for building decision support tools for planning highly complex initial attack service delivery systems. Taking a systems analysis perspective in the design of the WIRAS, the resulting initial attack simulation model can tackle a wide range of program and policy issues not previously addressable by other fire planning technologies. Not only can fire planners use WIRAS to determine the best program composition, they can also use it to improve their resource deployment and dispatch policies—locally, regionally, and nationally.

Acknowledgments

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