Economic Costs Of Fire-Suppression Forces

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ABSTRACT—A procedure to estimate costs of fire management inputs for presuppression and large fire suppression found significant hourly cost differences by deployment status among 12 units—ranging from small engines to 20-person handcrews—in three western states and three USDA Forest Service regions. Estimated suppression costs were 32 to 138 percent higher than current planning figures. Overhead, training, facilities, and equipment were major sources of cost variation. Fiscal 1981 hourly suppression costs ranged from $40 for small engines on standby in the Forest Service's Southwestern Region to $595 for a 20-person handcrew in the Pacific Northwest Region during large fire suppression.

Fire protection agencies emphasize economic efficiency. The USDA Forest Service revised its policy in 1978 to require that fire management programs be cost-effective and compatible with land-management objectives. In 1981, that policy was amended further to include criteria for evaluating economic efficiency of fire-suppression programs (USDA Forest Service 1981). Analysis requires complete and accurate cost estimates for all components of fire management.

Few authors in the field of fire management have emphasized costs of specific components. Sparhawk (1925) called for record-keeping to itemize and segregate these costs, but he looked only at direct costs of primary protection and suppression. Gale (1977) suggested modifications of the Forest Service's 5100-29 individual fire report form to record costs. He recognized five fire management activities that could be assigned a cost: fire prevention, fuel modification, fire detection, presuppression, and fire suppression. The first four categories reflect Sparhawk's primary category. Marty and Barney (1981) designed a tabular format for reporting expenditures.

We developed a technique for estimating costs. Our model identifies and measures component costs of fire management inputs (FMI), units used directly in fireline production during initial attack or suppression. We concentrated on only two of Gale's fire management activities—presuppression and large fire suppression—but the methodology is applicable to other activities.

The technique was designed to estimate costs for fire planning models, such as the Fire Economics Evaluation System (FEES) being developed by the Forest Service (Mills and Bratten 1982). Our model can be adapted for developing operational budgets or estimating trespass fire costs, where the Forest Service charges for suppressing a forest fire caused by a private party.

The model has four objectives: (1) identify budget costs that contribute to funding or support of specific FMIs; (2) estimate and incorporate otherwise unaccounted but legitimate costs of using FMIs; (3) convert fixed costs of an FMI to a variable per-hour basis (for evaluating incremental fire management programs); and (4) display variable costs in distinct categories that reflect how or when FMIs are used (for example, in the planned availability of FMIs throughout a fire season or on a specific fire during either normal or overtime hours).

The model estimates opportunity costs of capital (opportunities foregone because resources are tied up in firefighting equipment or facilities). It distributes costs of overhead and facilities—costs ignored in normal fire management accounting but necessary for long-term planning and optimal efficiency. González-Cabán (1983) offers an example of hourly cost estimates for use in long-term fire management analysis.

Compiling the Data Base

Data collection.— Basic data came from questionnaires sent to agency fire planners at state or Forest Service regional levels. Planners documented fiscal, management, equipment, and agency operations. A standard format and followup interview ensured uniformity of data. Interviews required two days for each organization; the database can include up to 1,000 separate entries.

Cost allocation.— Marty and Barney (1981) indicated that allocation was most problematic in expenditures serving multiple agencies. Shared costs for FMIs are less critical because component costs are assigned to a typical unit regardless of the funding source.

We apportioned fixed costs to FMIs based on expected overhead services. In long-term planning, fixed overhead costs would change with size and composition of the organization. Administration is a function of size with cost allocated uniformly over all employees. The overhead charge will vary, then, between FMIs with different crew sizes.

Person-years were used as the basis for allocation on the assumption that costs expand linearly. When the fire force grows, its per-capita overhead grows in direct proportion. An economies-of-scale hypothesis in per-capita overhead costs was tested and rejected for the six organizations studied (even though person-years worked during 1981 ranged from 76 to 5,113 and presuppression budgets ranged from $2.4 million to $90.2 million). Size did not increase efficiency.

Seasonal, annual, or other organizational fixed costs are allocated for FMIs in proportion to the number of hours such units are available during a normal fire season, because actual fire use of an FMI is unknown during planning. Historical costs, useful for analyzing FMI effectiveness and loca-

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tion, ignore the insurance function of standing fire organizations. They also overstate hourly costs of planning for FMI use during various deployments.

Fire management inputs.— The model converts data into estimates of total economic cost for standard FMIs, representing a typical fire organization. FMIs can be redefined to accommodate specific agency needs. State fire organizations, in California and Montana for example, staff their helitacks with four firefighters, while the Forest Service's Northern Region uses two, and all others have three. The Pacific Northwest Region staffs large engines with five people, the Northwestern Region uses one, California uses three, and the rest use two. These differences weakened comparability of costs but made estimates more useful to organizations.

Cost components.— Costs for each FMI are grouped into nine mutually exclusive categories:

1. Implements and durable supplies
2. Team members' pay
3. On-fire supervision
4. Subsistence
5. Training
6. Training for specialized FMIs
7. Overhead
8. Equipment
9. Facilities.

Pay and training are directly related to personnel. The rest can be called support components with costs incurred to deploy an FMI on the fireline. The model separates costs from similar collection sources into subroutines for allocation and adjustment to hourly rates. Subtotals are combined in an hourly rate. The cost computation procedure and the algorithm are detailed by González-Cabán et al. (1984) and McKetta et al. (1981).

Estimating Costs

Table 1 presents data used to evaluate the methodology for cost collection and estimation. Three Forest Service regions and three state fire management organizations were selected to test the model over a range of budgets, areas protected, and organizational structures.

Table 1. Presuppression budgets in 1981 for fire organizations tested.

Organization	Presuppression budget, 1981	Protection area	Presuppression budget
	Million $	*Million ac.*	*$/ac.*
USDA Forest Service regions			
Northern (R-1)	14.5	28.0	0.52
Southwestern (R-3)	23.8	22.0	1.08
Pacific Northwest (R-6)	29.0	27.0	1.07
States			
California	90.2	33.0	2.73
Oregon	13.7	15.7	.87
Montana	2.4	41.2	.06

Cost differences among organizations.— Application of the model showed significant cost differences. Within the Forest Service, the Pacific Northwest Region costs were consistently high and the Southwestern Region low. Costs for state organizations did not follow a pattern. *Table 2* shows cost differences for four sample FMIs. The deployments represented are, on the average, the cheapest (availability or standby) and the most costly (large fire suppression). The difference in cost between state organizations and Forest Service regions for Category I handcrews is caused by prisoners' labor used in state crews.

Costs by component.— For each of the four FMIs, pay and overhead were consistently the largest contributors to total hourly cost *(fig. 1)*. Their combined proportion was generally greater than 50 percent and, in two cases, more than 70 percent of total cost. Estimates that ignore overhead understate the cost of maintaining and using initial attack and suppression units. In labor-intensive FMIs (such as handcrews), basic training and facilities are also significant. In capital-intensive FMIs (such as engines), equipment replaces basic training as a dominant cost.

Overhead was the primary source of cost variations. Pay for a Forest Service 20-person Category I handcrew, for example, ranges from $143 to $149, but overhead varies from $84 to $145. Facilities and training also account for cost differences. State hourly costs have a higher percentage in overhead than do Forest Service costs. The Forest Service's average overhead for availability status was 37 percent for the Category I handcrew. The corresponding state overhead contribution was 43 percent. Variations in FMI composition and the time base used for depreciation also caused differences.

Table 2. FMI hourly costs in 1981 for fire organizations tested.

Deployment status and FMI type	Forest Service regions			State fire organizations		
	Northern	Southwestern	Pacific NW	CA	OR	MT
	Dollars					
Availability (presuppression)						
Category I crew	296	251	351	25*	26*	n.a.
Helitack	73*	78	94	88*	97	83*
Engine (med.)	45	41	61	51*	73	70
Bulldozer (med.)	57	87	74*	31	72	90
Large fires (suppression)						
Category I crew	442	396	505	188*	334*	n.a.
Helitack	93*	102	119	100*	100	89*
Engine (med.)	93	76	126	79*	91	92
Bulldozer (med.)	101	119	150*	71	102	94

NOTE: FMI = fire management inputs.   ** = nonstandard FMI composition.*   *n.a. = not applicable.*

Deployment status variations — Transportation of personnel and equipment adds considerably to the hourly cost of FMIs during travel status. Hazard pay adjustment, subsistence, and on-fire supervision contributed to cost differences by deployment status for all organizations. The Northern Region cost pattern, representative of the entire sample, is shown in *table 3*. The Northern Region cost of a Category I handcrew on travel status (including transportation costs) is 25.7 percent higher than on availability status. Small fire suppression is 21.6 percent higher, and large fire suppression is 49.3 percent higher. Overtime (not shown here) also has a large impact on hourly costs.

Table 3. FMI hourly costs by deployment status for USDA Forest Service, Northern Region in 1981.

FMI type	Deployment status				
		Suppression			
	Presuppression availability	Travel to fire	Small fire	Large fire	Planning Handbook*
	Dollars				
Category I crew	296	372	360	442	221
Helitack	73	234	82	93	34
Engine (med.)	45	82	60	93	34
Bulldozer (med.)	57	110	78	101	43

**Proration assumes 8-hour day.*

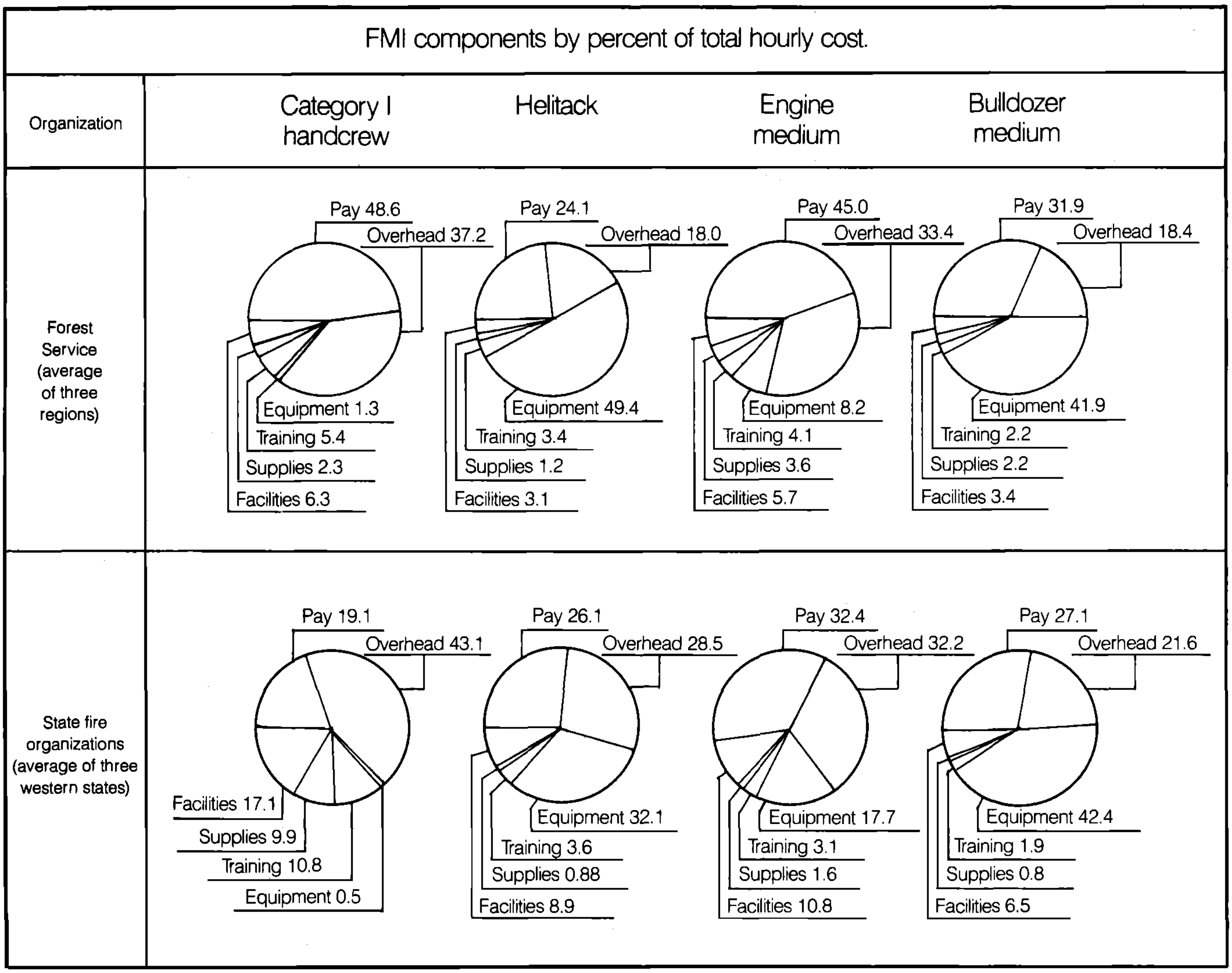

Figure 1. Comparison of component contributions to total hourly costs of forest management inputs (FMIs) during availablity status (presuppression). Percent totals will not equal 100 due to averaging of figures from three USDA Forest Service regions and three state fire organizations.

Comparison with other cost estimates.— Our estimates were higher than those often used for long-term planning. Northern Region costs (for an 8-hour day) were higher than costs in the *Fire Management Analysis and Planning Handbook* (USDA Forest Service 1982), shown in the last column of *table 3*. Cost differences are greatest for large fire deployment status. Cost estimates in the *National Interagency Reinforcement Crew Analysis and Action Plan* (USDA Forest Service 1979) were also lower than our estimates, although differences in crew configuration and pay grade schedules account for part of the difference.

Cost estimates from different studies are difficult to compare, as objectives were different. This study estimated total economic costs, which are more inclusive than budgetary costs. Estimates may also differ by allocation of fixed costs, FMI composition, and base year. The earlier studies were nationwide approximations, while our study considered six highly active western organizations.

Management Implications

Differences in FMI costs and the absence of economies of scale indicate variation in management strategies. Accurate cost estimation is necessary to express operational philosophies in economic terms and to test formally the efficiency of existing strategies in meeting fire management goals.

Our model—with cost-collection methodology and cost allocation and estimation algorithm—has proven flexible enough for use with most wildfire protection organizations. The software manipulates a large number of data entries efficiently, lowering the time demands for data input and manipulation and reducing costs of data revision and analysis. The cost estimates can be updated whenever organizational changes or annual reviews warrant refinement. A full cycle through the procedure from data collection to output analysis can be achieved in one analyst-week. For further information on the software, contact Armando González-Cabán, Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, Forest Fire Laboratory, 4955 Canyon Crest Drive, Riverside, CA 92507.

The component design of the procedure allows easy conversion for applications other than long-term planning. Some subset of the cost components, for example, could be used to negotiate mutual assistance contracts among organizations or to determine trespass fire costs. Caution must be used in these applications because the aggregation of cost components may still neglect unique or unusual costs, resulting in conservative cost estimates.

The trials reported here indicate that initial attack and suppression forces may be more costly than previously thought, especially in overhead, training, and facilities. Pay was not proportionately as important as expected. Conclusions about optimal FMI deployment should not be drawn from cost alone, however. Costs vary significantly and must be related to fireline productivity before one draws inferences on optimal purchases of FMIs. Technical limitations on FMI use, program flexibility and sensitivity to budgetary changes, and variations in travel times to fires will also influence the kind and number of FMIs purchased.

When compared with FMI production rates, arrival times, and resource values, these results have operational implications for selecting the optimal size and makeup of fire management organizations. Reduction in field personnel alone may be an overly simple and deceptive approach to fire budget cuts.

Differences in FMI costs among organizations and between deployments have implications for both long-term planning and operational decisions:

- Nationwide cost averages across broad geographical areas and between deployments mask important economic cost differences.
- Standing fire organizations are expensive, and the suppression cost per acre burned increases substantially as the size of the suppression organization rises.
- A large organization does not ensure efficiency. Economies of scale are apparently absent.
- The travel cost to fires is high. The trade-off remains undetermined between a more dispersed organization and a compact, mobile force.
- During dispatch planning procedures, attention should be given to cost increments beyond availability status; the extra cost to use FMIs is substantial, even when they are available.
- Cost-effectiveness should be an integral part of any fire management planning. ■

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