United States
Department of
Agriculture

Forest Service

**Pacific Southwest
Forest and Range
Experiment Station**

Research Paper
PSW-171

Costs of Fire Suppression Forces Based On Cost-Aggregation Approach

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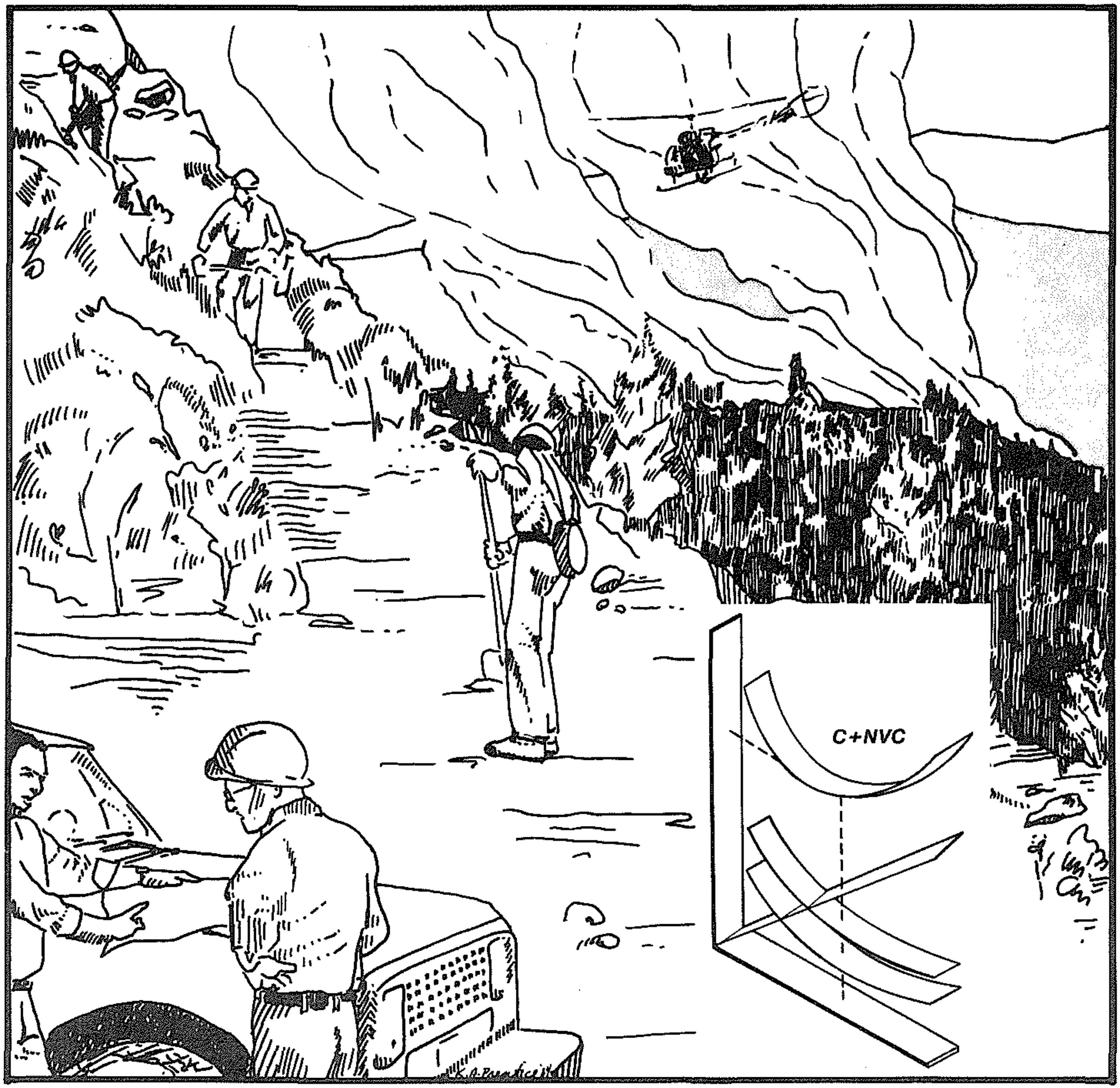

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González-Cabán, Armando; McKetta, Charles W.; Mills, Thomas J. **Costs of fire suppression forces based on cost-aggregation approach.** Res. Paper PSW-171. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1984. 16 p.

A cost-aggregation approach has been developed for determining the cost of Fire Management Inputs (FMIs)—the direct fireline production units (personnel and equipment) used in initial attack and large-fire suppression activities. All components contributing to an FMI are identified, computed, and summed to estimate hourly costs. This approach can be applied to any FMI by any organization with fire protection responsibility. Significant cost differences were found not only among the three State fire organizations studied, but among the three administrative regions within the Forest Service. Hourly suppression cost estimates ranged from $40 per hour for a small engine and 2-person crew in the Southwestern Region to $595 per hour for a 20-person Category II crew in the Pacific Northwest Region. The overhead, basic training, facilities, and equipment cost components were responsible for most of the cost variations.

Retrieval Terms: fire management costs, economic costs, fire economics, suppression costs, Fire Economics Evaluation System (FEES)

Publisher

Pacific Southwest Forest and Range Experiment Station
P.O. Box 245, Berkeley, California 94701

July 1984

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CONTENTS

IN BRIEF

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Retrieval Terms: fire management costs, economic costs, fire economics, suppression costs, Fire Economics Evaluation System (FEES)

Current cost estimates available for long-term planning of fire management do not provide accurate information nor are they in a form suitable for use in the Forest Service's Fire Economics Evaluation System (FEES) now under development. The FEES simulation model is being designed to analyze the economic efficiency necessary to meet the requirements of the new fire management policy adopted in 1981. That policy includes an economic efficiency criterion for evaluating fire suppression activities. In response to this directive a procedure was developed to estimate the economic cost of Fire Management Inputs (FMIs)—the direct fireline production units used in initial attack and large-fire suppression. The procedure was evaluated in three Regions of the Forest Service, U.S. Department of Agriculture, and three State forestry agencies. The three Regions were: Northern (Region 1) (Montana and northern Idaho), Southwestern (Region 3) (Arizona and New Mexico), and Pacific Northwest (Region 6) (Oregon and Washington). The three State agencies were the California Department of Forestry (CDF), Oregon Department of Forestry (ODF), and Montana Division of Forestry (MDF). The procedure uses a cost-aggregation approach in which all the components contributing to the cost of an FMI are identified, computed, and summed to estimate the FMI total economic cost on an hourly basis. This approach can be applied to any FMI by any organization with fire protection responsibility.

Nine cost components were identified for each of the FMIs: implements and durable supplies, FMI team members' pay, on-fire supervision, subsistence, training, special training for specialized FMIs, overhead, equipment, and facilities. Each of these components was estimated for 12 standardized FMIs identified in the study ranging from Category I handcrews through smokejumpers to engines and bulldozers and their attached personnel.

Attempts to standardize the cost component categories and FMI type and structure to represent a typical fire organization were not totally successful because real differences among organizations led to slightly different FMI compositions. California and Montana fire organizations, for example, staffed their helitack teams with four persons, rather than three, as did the Forest Service's Pacific Northwest and Southwestern Regions, and Oregon, or two, as did the Northern Region. Differences among organizations also existed in their tour-of-duty hours and the length of time used in their depreciation method. All organizations studied used a straight-line depreciation method.

The cost estimates varied significantly for each FMI among organizations. Forest Service Pacific Northwest Region costs were consistently higher than those of the Northern and Southwestern Regions. At the State level no organization showed cost estimates consistently higher than any other.

Within organizations, Forest Service FMI cost estimates ranged from $595 per hour for a 20-person Category II handcrew in the Pacific Northwest Region to as little as $40 per hour for a small-engine 2-person FMI in the Southwestern Region. State FMI cost estimates showed the same kind of variation. The pay and overhead cost components' (the general continuing costs involved in running a business) contribution to total hourly cost was consistently the most significant in all FMIs. Their combined total was always more than 50 percent, and usually more than 70 percent of total FMI cost.

The primary source of the FMI cost differences among Forest Service Regions and State agencies resulted from the overhead cost component even more than from pay differences. Facilities, basic training, and equipment cost components are also responsible for part of the cost differences among Forest Service Regions and State organizations. Other significant factors contributing to the FMI cost differences were variations in FMI composition and staffing, and variations in the length of time used in their depreciation method.

Differences in the economic cost of the FMI among the various categories of deployment status, that is, availability, travel to fire, suppression on small fires, and suppression on large fires were significant. Transportation and equipment costs added considerably to the total hourly cost of the FMI teams during travel status. The hazard-pay adjustment, subsistence, and on-fire supervision costs charged when an FMI was on a fire contributed considerably to the cost differences by deployment status.

The unit cost estimates from this procedure are higher than figures sometimes used for long-term planning purposes but must be compared cautiously. Various studies have differing objectives and were done for different base years. The estimates may differ further in how the fixed costs (costs that do not necessarily increase or decrease as the total volume of production increases or decreases) are allocated among FMIs, by FMI configuration, and by differences in what costs were included in the various cost estimation procedures.

The differences in the FMI economic cost estimates among Forest Service Regions and State fire organizations, and the differences in deployment status have implications for long-term planning and current management decisions. First, previous uses of nationwide cost averages across broad geographical areas and the various fire activity deployment status mask important and real economic cost differences. Second, suppression cost per acre burned will increase substantially as size of the suppression organization increases for a given burned area. Third, during planning of dispatching procedures extra attention should be given to increments in cost beyond the availability status; the extra cost to use an FMI is substantial, even after it has been paid to have it available.

Since 1975, the Forest Service, U.S. Department of Agriculture, and other agencies with fire protection responsibilities have increased their emphasis on analyzing the economic efficiency of fire management programs. Ever-growing budgets without discernible benefits prompted the U.S. Office of Management and Budget (OMB) (Gale 1977), and the U.S. Senate Appropriations Committee to ask the Forest Service to evaluate the costs and benefits of fire management practices (U.S. Senate 1978). State agencies have been faced with similar requests from State legislatures.

In response to the questions raised, the Forest Service made several major changes in its fire management policy. By 1978, fire management policy was revised to require that fire management programs be cost-effective and compatible with land management objectives. In 1981, that policy was amended further to include an economic efficiency criterion for evaluating fire suppression activities: "... suppression actions which result in the lowest cost plus net value change, having a reasonable probability of success, and providing for personal stafety should be selected" (U.S. Dep. Agric., Forest Service 1981). The evaluation of this type of analysis is described by Gorte and Gorte (1979) and its use is becoming more common (Bellinger and others 1983). To implement this type of policy change, fire managers need cost estimates for the economic analysis required in long-term planning.

Fire economic studies have addressed fire damage appraisal but few authors have emphasized specific costs for fire management optimization. Sparhawk (1925) called for record-keeping that kept these costs itemized and distinct, but looked only at direct costs of primary protection and suppression. Gale (1977) suggested modification of the USDA Forest Service 5100-29 fire report form to record costs as suppression activity accounts. He recognized five fire management activities and associated costs: fire prevention, fuel modification, fire detection, presuppression activities, and fire suppression. The first four categories reflect Sparhawk's primary protection category. Marty and Barney (1981) designed such a tabular format for expenditure reporting.

Current cost estimates available for long-term planning purposes do not provide accurate economic cost estimates, nor are they constructed in a form suitable for use in the Fire Economics Evaluation System (FEES) (Mills and Bratten 1982). The FEES simulation model is being designed to perform the economic efficiency analysis necessary to meet the requirements established in the new fire management policy.

We developed a cost estimation technique to provide updated and compatible fire management costs for the economic efficiency analysis required in long-term planning. Our cost technique concentrates on only two of the five fire management activities recognized by Gale: initial attack (presuppression) and suppression. Prevention, fuel modification, and detection costs were studied separately. The procedure identifies and aggregates, on an hourly basis, all the component costs of fire management inputs (FMIs), which are direct fireline production units used in initial attack or suppression.

This computational method includes items such as opportunity cost of capital and distribution of overhead and facilities costs to the production units, which are not included in standard budget procedures used at the Federal and State levels, but are necessary considerations for long-term planning and optimization. It does not provide managers, therefore, with data directly usable in their budgetary process. These items are also not included in the current National Fire Management Analysis System used for long-term planning purposes by the Forest Service (U.S. Dep. Agric., Forest Service 1982).

Although developed principally for long-term planning use in the FEES simulation model, the cost components aggregation approach provides sufficient flexibility to be used in other contexts. Cost components not relevant for current operating budget determination such as facilities and overhead costs, for example, can be eliminated from the computation. The numbers resulting can be used in budget development, trespass fire cost estimates, and mutual assistance protection programs' cost determination. An example of how hourly cost estimates can be used in long-term fire management analysis is discussed by González-Cabán (1983).

We included general system costs such as general administration and overhead identified by Davis (1974), but ignored indirect costs of fire pointed out by Zivnuska (1968) and Sutherland (1973) such as watershed damage and forest closure. They are not active costs of FMI activity and are considered part of the net value changes during optimization analysis.

The cost estimation procedure has four basic objectives: (1) to identify appropriate budgetary costs that contribute to the funding or support of specific FMIs and establish a pattern for allocation of aggregated costs; (2) to estimate and incorporate otherwise unaccounted costs that are legitimate economic costs of using the FMIs; (3) to convert fixed costs of an FMI into variable cost rates to facilitate increment evaluation of fire management organizations for long-term planning purposes; and (4) to display the variable costs in distinct categories on a per hour basis to reflect how or when the FMIs are used; for example, the planned availability of FMIs throughout a fire season, or their use on fire during either normal or overtime hours. Availability costs are incurred regardless of whether the FMIs are used during their availability period, except as adjusted for nonfire uses of personnel during availability status.

This paper describes the approach to determining hourly costs for fireline production units—termed Fire Management Inputs (FMIs)—used in initial attack or suppression actions. Application of this approach in collecting and analyzing cost data from fire protection agencies in three Forest Service Regions and in three States is reported.

METHODS

Cost Allocation Procedures

Cost allocation is a problem. Marty and Barney's (1981) cost list indicates a problem in allocation of shared resources, expenditures serving multiple agencies. Martin (1968) also found this problem between the private and public sector in Louisiana while evaluating fire taxes. He suggested that the number of fire origins and the benefits from timber should be the basis for cost sharing rather than the western acreage allocation formulas. Shared costs in FMIs are a minor problem as component costs are assigned to a typical unit regardless of the budgetary function or funding source.

The cost allocation problem addressed by Streeby (1973) was one of allocation between fire management functions. Sackett and others (1967) faced a similar cost allocation in assigning expenditures to particular fires. Expenditures for prevention, capital outlay, training, and detection, were allocated arbitrarily in proportion to acreages protected. Standby and maintenance expenditures were allocated in proportion to number of fires. Sensitivity analysis revealed that the method of allocation was not critical.

Our method for allocating fixed costs is also arbitrary but we found that it may have crucial effects on cost magnitudes. The methods used here link an FMI to its expected use of the items that make up the fixed cost. These costs are constant on a year-by-year basis, but are variable from year-to-year. In a long-term planning context, therefore, fixed costs are more appropriately referred to as long-term variable costs. The overhead cost, for example, is assumed to be a function of fire organization size so it is allocated in proportion to the number of personnel supported by overhead. This means that the FMI overhead charge varies by team personnel size rather than by being equally distributed between FMIs.

Seasonal or annual expenditures and fixed costs that serve large numbers of fire personnel are allocated to the FMIs in proportion to the total number of available person-hours in a season rather than hours they may actually be deployed on fire. The rationale for this allocation is that the actual use of an FMI during subsequent fire seasons is not known at the time the cost is incurred. The organizational necessity of maintaining a certain number of FMIs is determined on the basis of sufficient availability to encompass probable use. Costs allocated on the basis of actual use ignore the insurance function of standing fire organizations. Seasonal, annual, and multiyear costs are allocated to a per hour basis to reflect FMI availability costs.

When supplies, durable goods (such as equipment and facilities), overhead, or other fixed annual expenditures are associated only with the fire initial attack or suppression organization, the cost estimation technique presumes that they serve a function that occurs only during the active fire season. The resultant fixed cost is allocated to an hourly rate on the basis of fire season length. The fire season is defined by the length of time that a fire organization is at 80 percent or more of its peak presuppression strength. If the durable goods are used by nonfire functions at other times of the year, the portion of the total cost allocated to the fire program is a function of its proportional use.

Some fixed costs for the fire organization are spread over the employees served by those expenditures. A central fire cache, for example, is assumed to service all fire personnel equally. The cache costs are allocated over the annual average number of person-years worked directly in fire management, including all regular and temporary personnel in the costed unit. If the number of person-years is not known, it can be approximated from the wages expended and the average hourly wage rate.

When number of person-years is used as the basis for allocation, it is implicitly assumed that costs expand linearly for these components. As the fire force grows, its otherwise fixed overhead would have to grow in direct proportion. This is a simplistic assumption, but only slight evidence supports the hypothesis for economies-of-scale in the overhead function in those areas tested.

Another basic design criterion of the cost procedure is that all costs be allocated to the FMIs on a per hour cost basis to facilitate the economic efficiency evaluation. This is straightforward for hourly costs, such as pay, and for daily costs, such as subsistence costs, once an average day length is assigned. Costs that are incurred once during a season, such as training costs, are allocated on the basis of the number of hours in the fire season.

Allocation of durable items that last several fire seasons, such as equipment or facilities, requires additional data. The annual amortized cost is computed after considering initial cost, salvage cost, useful life, and discount rate. Cost annualization assumes uniform year-to-year use of the durable cost components. The annual equivalent cost is then allocated to an hourly basis, just as season costs are.

Designing Fire Management Inputs

We used a cost-aggregation approach to construct unit cost estimates from basic agency records. This approach required the identification of individual cost components of each FMI, such as supplies, pay, and training. The total fire season cost of each component was estimated and the costs summed to yield a total cost for the FMI. The season total cost was then divided by the number of hours in the season to yield a corresponding hourly cost. The costs of all components necessary to place the FMI on the fireline were included in the calculation.

The first FMI cost estimates were hand-computed to test the procedure in selected fire management organizations. The cost procedure converted an extensive and diverse economic database into cost estimates. FMI composition varied within and among fire management organizations. The variability in cost components and FMI composition made the cost-aggregation approach tedious and expensive in repetitive use when redesigned specifically for each agency. In addition, the lack of a systematic approach resulted in double-counting of some cost components while ignoring others.

The problem was solved by standardizing FMI cost component categories and the data collection procedures so that the same procedures could be applied to any fire organization. The questionnaire[1] used to collect all data included sample data for the Forest Service's Northern Region. The type and structure

[1]A copy of the questionnaire is available upon request to Armando González-Cabán, Pacific Southwest Forest and Range Experiment Station, 4955 Canyon Crest Drive, Riverside, Calif., 92507.

of the FMI team units were standardized to represent a typical fire organization for FEES simulations, but the cost collection method and computerized procedure allow FMI team unit redefinition to accommodate the specific needs of different agencies. The uniformity introduced by the standardization of cost components and procedures permits the use of computer software that streamlines the conversion of a bulky database into large numbers of FMI cost estimates at low cost.

Twelve standardized FMIs were designed for this cost study and were selected on the basis of similarity of costs and fireline production rates (Haven and others 1982):

Unit	Type
1	Category I crew
2	Category II crew
3	Category III crew
4	Project crew
5	Helitack
6	Smokejumper
7	Engine—small
8	Engine—medium
9	Engine—large
10	Bulldozer—small
11	Bulldozer—medium
12	Bulldozer—large

Six of the 12 FMIs were handcrew types, including helitack and smokejumper teams that perform handcrew duties on the fire, but whose form of transportation required specialized training costs as well as specialized transportation costs. Another three FMIs were water delivery systems and personnel combinations. The last three FMIs were personnel and bulldozer combinations. Standard FMI types included regular firefighting forces, hire-as-needed administratively determined (AD) crews, and nonfire agency personnel (*table 1*).

Category I handcrews are fully funded out of fire program dollars for the entire fire season. There are two kinds of Category II handcrews; one is composed of agency regular personnel, such as timber sale administration personnel, who occasionally are organized into a 20-person crew for fire suppression. Another is composed of temporary personnel hired as needed. For clarity purposes, we will refer to the agency regular personnel as Category II crew and the hire-as-needed personnel Category III crew. The two-person project crew is composed of personnel hired to perform nonfire work, but who occasionally assist in initial attack. A timber stand improvement crew is an example. All the engines, FMIs 7 to 9, are water delivery and personnel combinations and are treated as fully fire-program funded. All bulldozer combinations, FMIs 10 to 12, have personnel treated as fully fire-program funded.

We computed hourly costs separately for each of these five fire duty statuses:

1. Crew available for assignment
2. Crew on regular time on a small fire (less than 10 acres [4.047 ha])
3. Crew on overtime on a small fire
4. Crew on regular time on a large fire
5. Crew on overtime on a large fire.

During availability, the FMIs are paid at their regular pay rate. When sent to small fires during their tour-of-duty, the FMIs receive a hazard-pay premium, above and beyond their regular pay until the date the fire is controlled, but receive no subsistence or on-fire supervision. That is, no management team is sent to supervise or direct the fire suppression operations. When on small fires during overtime hours, the FMIs draw not only a hazard-pay premium but an overtime premium as well. They may occasionally receive subsistence, but for our purposes, during small-fire activities, they will not receive subsistence.

While on large fires during regular tour-of-duty, the FMI s receive a hazard-pay premium, until the date the fire is controlled, and also extra on-fire supervision and subsistence. During overtime on large fires, they receive a hazard-pay premium, an overtime premium, and extra on-fire supervision and subsistence. Fire duty status causes significant differences between each of the hourly cost categories (*tables 2-4*).

To simplify the analysis and application of the hourly cost estimates, we derived a weighted hourly cost for small-fire suppression and a weighted hourly cost for large-fire suppression. An average percent use of the FMIs on overtime as against regular time during five fire seasons was estimated. The average percent was used to weight the corresponding regular time and overtime rates together. With the same approach, we computed a weighted travel cost for all FMIs.

Table 1—*Composition of 12 standardized units of Fire Management Inputs*

Unit	Type	Composition		Firefighters
		Persons	Equipment	
1	Category I crew	20	Handtools	Regular
2	Category II crew	20	Handtools	Nonfire funded, FS regular
3	Category III crew	20	Handtools	Hired as needed
4	Project crew	2	Handtools	Nonfire funded, FS regular
5	Helitack	2	Handtools	Regular
6	Smokejumper	2	Handtools	Regular
7	Engine—small	2	Handtools, 250-gal tank	Regular
8	Engine—medium	3	Handtools, 500-gal tank	Regular
9	Engine—large	3	Handtools, 1000-gal tank	Regular
10	Bulldozer—small	2	Light bulldozer	Regular
11	Bulldozer—medium	2	Medium bulldozer	Regular
12	Bulldozer—large	2	Heavy bulldozer	Regular

During the fire season, when there are no on-going fires or the fire danger rating is low, the fire-funded FMIs are generally used to do nonfire work. Nonfire suppression work is any work not directly related to suppression of wildfires or escape prescribed burns—maintenance or building trails, prescribed fire burns, maintenance of campground or campground buildings, or other. Time spent cleaning barracks while waiting to go on a fire is considered fire time. Only the time devoted to actual fire standby or fire activities should be charged as an economic cost to the fire function, regardless of budgetary source. The cost of the average percent time devoted to nonfire suppression activities, therefore, is subtracted from the pay component of the total hourly availability cost. If 10 percent of a Category I crew fire season total time is devoted to prescribed burning or any other nonfire suppression related activity, such as campground maintenance or building of trails, for example, only 90 percent of the pay component is charged as part of the availability cost.

The fire management program in most agencies is built to accommodate the use of nonfire-funded personnel. An economic availability cost is charged for FMI personnel who are not nonfire-funded but who occasionally do fire work during the fire season. The facilities and program management overhead, for example, are used by the additional personnel. The cost for these FMIs is computed in proportion to the average use of the nonfire-funded FMIs during the fire season. If a two-person timber improvement project crew typically spends 10 percent of its time on fire duty during the fire season,

Table 2—*Hourly cost (excluding that of transport delivery and retrieval) of Fire Management Inputs available for assignment, by Forest Service Regions and State forestry agencies, Fiscal Year 1981*

Fire Management Input	Forest Service regions			State forestry agencies		
	Northern	Southwestern	Pacific Northwest	California	Oregon	Montana
			Dollars/hour			
Category I	296	251	351	[1]26	[2]26	—
Category II	35	—	65	[3]35	[4]17	—
Category III	24	[2] 62	—	[5] 7	27	43
Project crew	4	4	7	—	—	—
Helitack	[6] 73	78	94	[7]88	97	[7]83
Smokejumper	39	37	48	—	—	—
Engine—small	30	26	38	[8]41	48	47
Engine—medium	45	41	61	[7]51	73	70
Engine—large	32	[9] 18	[10] 96	[8]41	84	52
Bulldozer—small	49	35	[8] 70	31	53	70
Bulldozer—medium	57	87	[8] 74	31	72	90
Bulldozer—large	—	—	—	—	86	—

[1]Crew of 16 persons, nonfire funded.
[2]Crew of 19 persons, nonfire funded.
[3]Crew of 16 persons, nonfire funded.
[4]Crew of 21 persons, nonfire funded.
[5]Crew of 17 persons, nonfire funded.
[6]Crew of 2 persons.
[7]Crew of 4 persons.
[8]Crew of 3 persons.
[9]Crew of 1 person.
[10]Crew of 5 persons.

Table 3—*Hourly suppression cost (excluding that of transport delivery and retrieval) of Fire Management Inputs on small fires, by Forest Service regions and State forestry agencies, Fiscal Year 1981*

Fire Management Input	Forest Service regions			State forestry agencies		
	Northern	Southwestern	Pacific Northwest	California	Oregon	Montana
			Dollars/hour			
Category I	360	315	418	[1]137	[2]256	—
Category II	411	—	503	[3]178	[4]163	—
Category III	271	[2]220	—	[5]156	266	410
Project crew	42	36	56	—	—	—
Helitack	[6] 82	87	83	[7] 89	100	[7] 87
Smokejumper	47	45	56	—	—	—
Engine—small	39	34	47	[8] 49	50	60
Engine—medium	60	56	93	[7] 61	76	86
Engine—large	45	[9] 25	[10]133	[8] 51	85	77
Bulldozer—small	62	47	[8]100	45	66	70
Bulldozer—medium	78	104	[8]103	52	94	90
Bulldozer—large	—	—	—	—	—	—

[1]Crew of 16 persons, nonfire funded.
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[8]Crew of 3 persons.
[9]Crew of 1 person.
[10]Crew of 5 persons.

for example, 10 percent of its hourly pay is tallied as an availability charge to the fire function. The percent of time that fire-funded FMIs devote to nonfirefighting activities, and percent of time that nonfire-funded FMIs devote to firefighting activities, is estimated by the fire planner or another qualified person using a 5- to 10-year average for all the organizations surveyed. The percentage charged is different for each organization.

Identifying Cost Components

The costs for each FMI are grouped into nine standard components during data collection. We designed these so as to be able to group costs that came from similar sources and were allocated and aggregated in the same way. The components and their subclasses also serve as a checklist to eliminate double-counting and the overlooking of cost components.

The nine cost components are:

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

The objective is to allocate all component costs required to place an FMI on a fire, and then to sum them into a single hourly cost rate. The FMI cost rate can be compared directly with the fireline production rate of an FMI in the analysis of the economic efficiency of alternative fire management programs. To accomplish this, the cost for facilities, overhead, and on-fire supervision are allocated to specific FMIs. These costs are not direct operating costs of the FMI team unit, but are costs that must be incurred to place an FMI on the fireline.

Identifying all cost components provides flexibility to the economic cost procedure discussed here. Although long-term planning is the primary use of the procedure, for example, some cost components not relevant for current operating budgets, such as facilities or overhead, can be eliminated from the computation. These results can be used for purposes such as budgeting, trespass fire-cost estimates, and mutual assistance protection program cost determination.

Implements and Durable Supplies

The implements and durable supplies assigned to an FMI can be categorized into items carried by each individual, such as fire-resistant clothing and a hard hat, and those assigned to the team as a whole, such as a chain saw. Most of these items have a multiyear service life. The purchase cost and service life of each item is applied to a straight-line amortization calculation to yield an annual cost. Salvage value is assumed to be zero. It is tempting to devote a great deal of time to estimating these costs because they are a visible budget item for which there is close accountability. They make a very small contribution to total hourly costs, however.

FMI Team Members' Pay

This component includes the base hourly salary paid to the FMI's team members. All fire management input teams have a personnel and equipment structure. Although this team structure is fixed for the FEES model, it may be specified by the user by size and wage grades. The pay component can be computed from either of two different pay scales: employees who are regular members of the fire management organization for most of the fire season; temporary personnel who are hired only for a particular fire.

Table 4—*Hourly suppression cost (excluding that of transport delivery and retrieval) of Fire Management Inputs on large fires, by Forest Service regions and State forestry agencies, Fiscal Year 1981*

Fire Management Input	Forest Service regions			State forestry agencies		
	Northern	Southwestern	Pacific Northwest	California	Oregon	Montana
			Dollars/hour			
Category I	442	396	505	[1]188	[2]334	—
Category II	486	—	595	[3]229	[4]250	—
Category III	372	[2]317	—	[5]210	326	473
Project crew	48	39	66	—	—	—
Helitack	[6] 93	102	119	[7]100	100	[7,8]89
Smokejumper	62	60	70	—	—	—
Engine—small	46	40	53	[9] 63	62	61
Engine—medium	93	76	126	[7] 79	91	92
Engine—large	72	[10] 36	[11]176	[9] 66	97	81
Bulldozer—small	85	63	[9]142	65	75	91
Bulldozer—medium	101	119	[9]150	71	102	94
Bulldozer—large	—	—	—	—	126	—

[1]Crew of 16 persons, nonfire funded.
[2]Crew of 19 persons, nonfire funded.
[3]Crew of 16 persons, nonfire funded.
[4]Crew of 21 persons, nonfire funded.
[5]Crew of 17 persons, nonfire funded.
[6]Crew of 2 persons.
[7]Crew of 4 persons.
[8]Does not include equipment cost.
[9]Crew of 3 persons.
[10]Crew of 1 person.
[11]Crew of 17 persons.

In computing the total direct labor costs of an FMI, two types of adjustments are applied to the base hourly salary. The first type of adjustment is for benefits. These benefits are prorated over all the expected work hours in a fire season to reflect the average adjustment as a percentage of the base hourly salary. Annual and sick leave accrual in Federal agencies, for example, are equivalent to a 10 percent increase in the hourly wage paid. This percentage is applied to the appropriate base hourly salary to estimate the entire economic cost of personnel on duty.

The other type of pay adjustment is for special duties, such as overtime or a hazard-duty differential paid when personnel are actually engaged in firefighting or other special missions. This adjustment is applied to the base hourly salary during all hours worked on a calendar day when the special duties are performed.

Supervisory Factor for FMIs

Each FMI is usually linked to its own first-level supervision when assigned to a fire. These division and sector bosses are included in FMI cost estimations as direct costs required to place the FMI on the fireline. A Category II AD crew, for example, may have a full-time liaison officer, 33 percent of a sector boss, and 11 percent of a division boss assigned to it, depending on fire size. If it is common in an agency for FMIs to work independently, without first-level supervision, this category may be ignored—except that the team foreman or crew boss is automatically counted as an integral member of an FMI.

Supervisory personnel are only included in FMI hourly cost estimates when the FMI is engaged in active fire duty. When available, supervisors usually function as fire program staff officers so they are charged as part of the program management overhead. The cost of overhead teams, supervisory and support personnel required for large-fire suppression efforts, are above and beyond this supervision component. Those costs are estimated in a separate large-fire overhead team cost computation.

Daily Subsistence and Per Diem Surplus

Similar to the supervision cost, the cost of food and other consumable supplies is included only when the FMI is enroute to or on a large fire. FMIs are considered self-sufficient when on availability or fighting small fires. The cost of daily consumable items, such as short-lived personal gear supplied by the organization (paper sleeping bags, soap, prorated radio batteries, and other), are most readily estimated on a cost per person per day basis. The cost estimation technique assumes that this cost is allocated on the basis of a standard 8-hour day.

When the FMIs are on a fire, only the per diem costs in excess of the amount charged to the firefighter for food, shelter, and other daily consumables are included in the economic cost. Charging the entire per diem paid would double-count some elements.

FMI Annual and Specialty Training

All firefighters require some form of initial and recurrent fire training. Though training costs are actually fixed, they are allocated over the fire season or multiples of fire seasons, as a contribution to hourly cost.

Two types of training are recognized: annual and specialty. An annual training course in basic firefighting skills and fire behavior is given each FMI. Because training is a prerequisite for the use of any firefighter, the salary during personnnel training is a legitimate cost of that training in addition to associated costs of travel, instructor salary, and training aids. Training expenditures are computed on a per training class basis and then allocated per person back to the FMI.

Some FMIs require additional specialty training. For example, helitack teams' training in helicopter use and rappelling is assumed to be taken by all helitack team members annually. Smokejumper training is another form of specialized training. Initial parachute training is required for all new recruits. The cost of both the initial training and refresher training sessions are amortized over the average service life of a smokejumper and then converted to an hourly rate.

Administrative Overhead

Two types of aggregated overhead costs are identified in the FMI cost estimation procedure: administrative and fire management. Administrative costs are charged for services, such as fiscal and personnel management. Such expenditures are usually budgeted to fire by a proration formula unique to the agency. The indirect overhead costs of general administration are usually a line item in organizational budgets and are used directly for all levels of the organization. The cost estimation procedure assumes that the general administration formula correctly reflects the proportional support given by various administrative services to the fire program. Just as with previous fixed cost, the cost procedure allocates this administrative overhead cost in equal proportions to each person in the fire management organization.

The other overhead costs are the total annual expenditures of the year-round permanent fire management organization, including fire management directors, fire staff, fire control officers, dispatchers, and clerical staff whose salary and operating funds originate in the fire management program. Expenditures for any FMI are deleted from the program management overhead to avoid double-counting. Time spent by fire control staff as division or sector bosses, for example, was excluded from this program management overhead because it was already included in the supervisory component. Similarly, the total program budget is divided between the several fire program activities—fuel management, prevention, detection, initial attack, and aviation—and the nonfire activities performed by fire staff. Some fire staff have responsibility for nonfire activities such as safety or recreation. Only the percentage assigned to initial attack and aviation are included in the program management overhead for these initial attack suppression FMIs.

The administrative overhead cost component is a relatively large contribution to the total cost of most FMIs but is one of the most difficult to estimate accurately. Formulas for allocation of general administration charges, for example, often vary from agency to agency according to different management philosophies that may not really reflect varying degrees of administrative support to the fire program.

Similarly, the fire program overhead is seldom recorded in the manner that is needed for this economic cost computation procedure. The "program management" line item in most accounting budgets, for example, usually considerably underestimates the program management overhead derived here by adding up the salary and the operating expenses of all fire program personnel who support the FMI teams. This is a primary example of the difference between economic costs used in long-term analyses of fire program planning and those used in budgets, which are designed to ensure accountability.

Capital Equipment

All equipment that is an integral part of the FMI and operated by the team in an initial attack or suppression mode is included in the equipment cost component. In general, fixed operating rates and mileage-use rates are converted to an hourly variable cost. All equipment rates excluded operator cost because the operator wages are calculated in the FMI pay component. When fire engines are used in suppression activities, they are assumed to move at an average speed of 5 miles per hour. This is changed to a dollar per hour rate to account for the mileage charges incurred by such a unit. If the agency surveyed uses a direct dollar per hour rate, then this rate is used directly.

One of two calculation procedures for equipment cost is used, depending on whether the equipment is rented or owned. If the fire equipment is rented or contracted, the rental cost for equipment in transit or in place, rather than in fire use, is converted to hourly terms and charged as an availability cost. The operating rate of equipment actually working in a fire suppression task is charged as a fire suppression cost. The operating rate is usually higher than availability cost because of the variable costs of fuel, higher insurance costs, and above average wear-and-tear in fire-related operations.

If the equipment is owned, an equivalent cost is calculated from fleet equipment operating costs. The annual fixed ownership cost of equipment includes items such as depreciation, differential replacement, administrative and management costs, insurance, and capital costs. It represents the cost of the availability of the equipment. The fixed ownership annual cost is allocated to an hourly charge on the basis of fire season length. The use rate, which is added for use on fire suppression, is the sum of costs that vary on a mileage or hourly basis, such as operating costs, fuel, lubrication, and maintenance (U.S. Dep. Agric., Forest Service 1980). Mileage rates are converted to hourly rates on the basis of average vehicle speed on typical system roads.

Estimates of transportation cost for equipment used in wildfire initial attack and large-fire suppression activities have also been developed. Seven different classes of transportation methods, divided into air and ground transport, and currently recognized are these:

Table 5—*Average hourly cost of transportation equipment used in initial attack and large-fire suppression activities, Fiscal Year 1981*

Equipment	Fixed cost	Variable cost	Total
		Dollars/hour	
Air tanker—fixed wing:			
Small (1128 gal)	60	813	873
Medium (1917 gal)	57	1110	1167
Large (2356 gal)	134	1302	1436
Air tanker—rotary wing:			
Small (110 gal)	66	328	394
Medium (450 gal)	224	811	1035
Large (900 gal)	24	1811	1835
Air transport—fixed wing:			
Small (8 passengers)	23	248	271
Medium (12 passengers)	126	376	502
Large (40 passengers)	118	994	1112
Air tansport—rotary wing:			
Small (3 passengers)	81	304	385
Medium (6 passengers)	289	443	732
Large (20 passengers)	103	1708	1811
Truck, tractor, and trailer:			
Small (30,000 pounds GVW[1])	25	19	44
Medium (60,000 pounds GVW)	30	24	54
Large (90,000 pounds GVW)	35	24	59
Truck, stake-side:			
Small (30,000 pounds GVW)	9	22	31
Medium (60,000 pounds GVW)	9	26	35
Large (90,000 pounds GVW)	10	30	40
Bus, passenger:			
Small (10 passengers)	16	17	33
Medium (20 passengers)	18	18	36
Large (33 passengers)	23	18	41

[1]Gross vehicle weight.

Air transport

1. Tanker—fixed wing
2. Tanker—rotary wing
3. Transport—fixed wing
4. Transport—rotary wing

Ground transport

5. Truck—tractor and trailer
6. Bus—passenger
7. Truck—stake-side

Each class of equipment is further divided into three different sizes—small, medium, and large. Because the resultant cost estimate is designed for general use in FEES simulation, no specific equipment identification is necessary (*table 5*). Users, however, could select either an average of vehicles in their own size categories or a representative vehicle for each.

Permanent Facilities

The annual cost of the numerous permanent facilities that house the FMIs and the fire program management staff are included in the facility cost component. The facility cost component is composed of an annual capital cost charge, a facility operating cost, and a maintenance cost. The maintenance and operating costs are sometimes already included in the general administration overhead charge so care is taken to avoid double-counting. If maintenance and operating costs are not already included there, they can be readily estimated from budget data.

The annual capital cost is equal to the rental rate for rented facilities and approximated by equivalent rental rates for agency-owned facilities. Equivalent rental rates are used for owned facilities because it is recognized that all facilities have an alternative use value even if their original capital cost is sunk. This treatment of facilities is conceptually parallel with the treatment of equipment costs that have multiyear service. The regional offices of the General Service Administration (GSA) are ready sources for the equivalent rental rates once the square footage and character of the facility is provided by the fire program agency.

The total cost of the facilities only partially occupied by fire program personnel or equipment is prorated to the fire program in relation to the area of proportional use. The facility costs of fire program management are allocated across all FMIs in proportion to the number of personnel in the FMIs. Specialized facilities, such as helitack bases, are allocated only to the FMIs who use them.

Collecting Cost Data

To collect cost data, we relied on written questionnaires and personal interviews. We first telephoned the agency fire planner, explained the purpose of the study, and then mailed copies of the questionnaire. The planner contacted the specialists best qualified to provide the needed information.

A week after the initial telephone call, we conducted the personal interview during which the data were collected. The interview enabled us to clarify the data required, and resolve any differences in interpretation of different accounting and budgeting systems, and in the FMI structure. Each interview took about 2 days. Although we pared the database down to as few items as possible, as many as 1000 separate entries were required for some organizations.

Sources sometimes lacked ready access to the required data. Cost studies of operational fire programs appear to have been done infrequently or are unrecorded. Most sources, however, are familiar with accounting and budgeting costs and can provide data with adequate precision.

To handle large amounts of data as efficiently as possible, we computerized the procedure, thereby easing the efforts at data revision (McKetta and others 1981). With the questionnaire and computer software available, the data for an agency can be evaluated in about 1 person-week.

We tested the cost-aggregation approach by collecting data in three Forest Service Regions and three State fire protection agencies (*table 6*). They were selected to cover a range of presuppression programs in which size varied both in total dollars or acres protected, and in intensity of protection, as reflected in the presuppression budget expended per acre protected. The organizations studied were also selected to evaluate the approach at different organizational levels.

The six organizations in which the data were collected were:

Forest Service:

Northern Region (Region 1, made up of Montana and northern Idaho)

Southwestern Region (Region 3, made up of Arizona and New Mexico)

Pacific Northwest Region (Region 6, made up of Oregon and Washington)

State agencies:

California Department of Forestry

Oregon Department of Forestry

Montana Division of Forestry

We attempted to standardize the cost component categories and the FMI type and structure to represent a typical fire organization. This objective was not fully accomplished be-

Table 6—*Forest Service regions and State forestry agencies in which the cost estimation procedure was applied*

Region or agency	Presuppression budget in 1981[1]	Protection area	Presuppression budget per acre
	Million dollars	*Million acres*	*Dollars/acre*
Forest Service:			
Northern Region (Region 1, made up of Montana and northern Idaho)	14.5	28.0	0.52
Southwestern Region (Region 3, made up of Arizona and New Mexico)	23.8	22.0	1.08
Pacific Northwest Region (Region 6, made up of Oregon and Washington)	29.0	27.0	1.07
State agencies:			
California Department of Forestry	90.2	33.0	2.73
Oregon Department of Forestry	13.7	15.7	.87
Montana Division of Forestry	2.4	41.2	.06

[1]Total Forest Service, U.S. Department of Agriculture, presuppression budget in Fiscal Year 1981 was $142,000,000.

cause real differences among organizations led to slightly different FMI compositions. The California Department of Forestry (CDF), for example, uses a 24 hour per day tour-of-duty during their fire season, just as does a city fire department. The other organizations use an 8 hour per day tour-of-duty. This difference biases CDF estimates downward relative to all other estimates. Also, the staffing level of some FMIs varied. California and Montana fire organizations, for example, staffed their helitack teams with four persons, rather than three as did Oregon and the Pacific Northwest and Southwestern Regions, or two as did the Northern Region. The Pacific Northwest Region staffed its large engine with five persons, the Southwestern Region used one, CDF used three, and Montana, Oregon, and the Northern Region used two persons. Although uniformity was introduced by standardizing the cost component categories and procedure application, the cost collection procedure and software allowed these variations to accommodate the specific needs of different organizations. The implication, however, is that the per unit cost results are not strictly comparable.

Overhead cost was one of the most difficult components of the fire management program to estimate. Only the cost of the time that the year-round permanent fire personnel spent in the actual planning and overall supervision of the initial attack and large-fire organization was charged as program overhead. This was an arbitrary rule for the allocation of fixed costs, but we think it best represents the real cost to the initial attack and large-fire suppression functions. The allocation of overhead costs was crucial because it is one of the main differences between fire organizations. Different allocation rules produce different results.

RESULTS AND DISCUSSION

The cost estimates varied significantly for each fire management input among organizations. Hourly suppression cost estimates ranged from $40 per hour for a small engine 2-person FMI in the Southwestern Region to $595 per hour for a 20-person Category II crew in the Pacific Northwest region while on large-fire suppression actions. Cost estimates for state FMI suppression ranged from $65 per hour for a light bulldozer in California to $473 per hour for a 20-person Category II crew in Montana during large-fire suppression actions. This variation, combined with the FMI's fireline productivity, has implications for the purchase of FMIs. The technical limitations on use, program flexibility to budgetary changes, and arrival times to fires also influence decisions to purchase FMIs.

Cost Differences Between Components

Calculation of cost by component was not only a convenient way to collect data, but it also proved a convenient aid to the analysis of results. The pay and overhead contribution to total hourly cost was consistently the most significant in all FMIs. Their combined total contribution was always more than 50 percent, and usually more than 70 percent of the total FMI cost. The relative importance of the cost components for the Forest Service, and State organizations for two different FMIs—a 20-person Category I handcrew for the Forest Service and Category II for the State, and a medium engine—is demonstrated (*figs. 1-4*). In all labor-intensive FMIs, such as handcrews, pay, overhead, basic training, and facilities are the most significant components. In those capital intensive FMIs, like a medium engine, equipment replaces basic training as one of the most relevant cost components. Average hourly unit costs were broken down into cost components (*tables 7-9*).

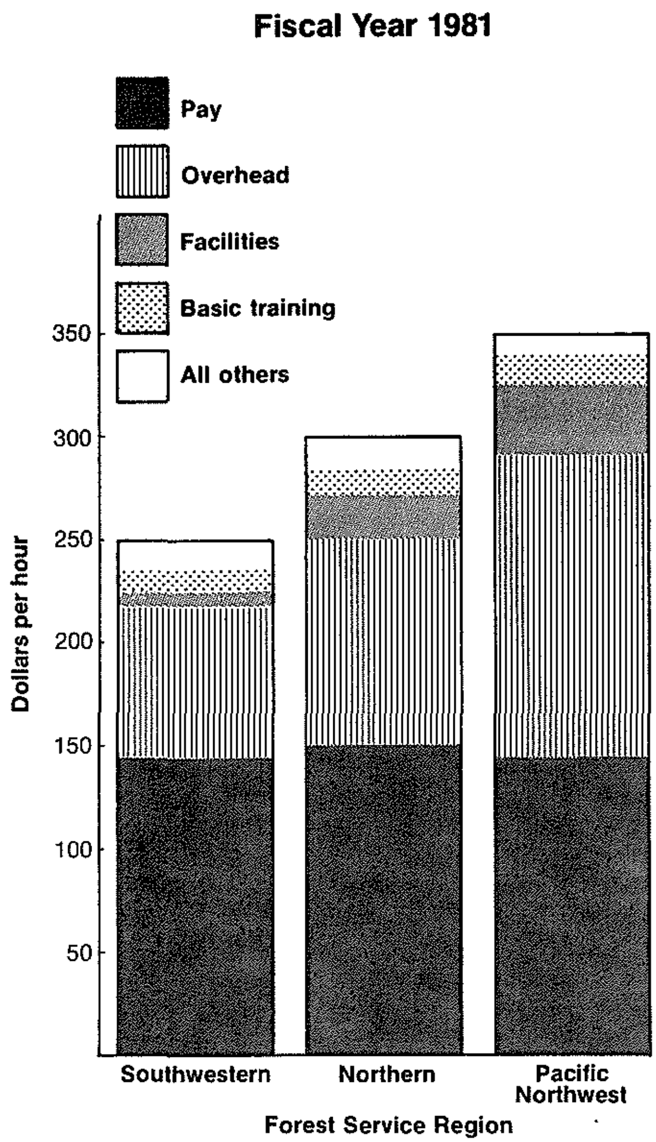

Figure 1—Contribution of Category I crew cost components to total hourly cost during availability for fire assignments, in Forest Service's Northern, Southwestern, and Pacific Northwest Regions.

Cost Differences Between Organizations

The FMI's per unit hourly cost estimates among the various fire organizations differed signficantly. Among Forest Service Regions, the Pacific Northwest's Region cost estimates were consistently higher than those of the Northern Region, and Northern Region cost estimates were consistently higher than those of the Southwestern Region. A 20-person Category I handcrew hourly cost estimate during availability status in the Pacific Northwest Region, for example, was $351 as against $296 (16 percent less) in the Northern Region, and $251 (28 percent less) in the Southwestern Region. The cost estimate of a medium engine was also higher in the Pacific Northwest Region than in the Northern and Southwestern Regions: $63 in the Pacific Northwest Region as against $45 (29 percent less) in the Northern Region and $42 (33 percent less) in the Southwestern Region. The same general cost differences persisted for all FMIs studied (*tables 2-4*).

The primary source of the FMI's cost differences among Forest Service regional organizations was the overhead cost component more than the pay differences. The pay component of a 20-person Category I handcrew, for example, varied from $149 in the Northern Region to $144 in the Pacific Northwest Region and $143 in the Southwestern Region (*fig. 1*). The overhead component, however, varied from a low of $84 in the Southwestern Region, to $100 in the Northern Region, and $145 in the Northern and Pacific Northwest Regions. Facilities and basic training were also responsible for part of the cost differences among regions. The same cost contribution pattern

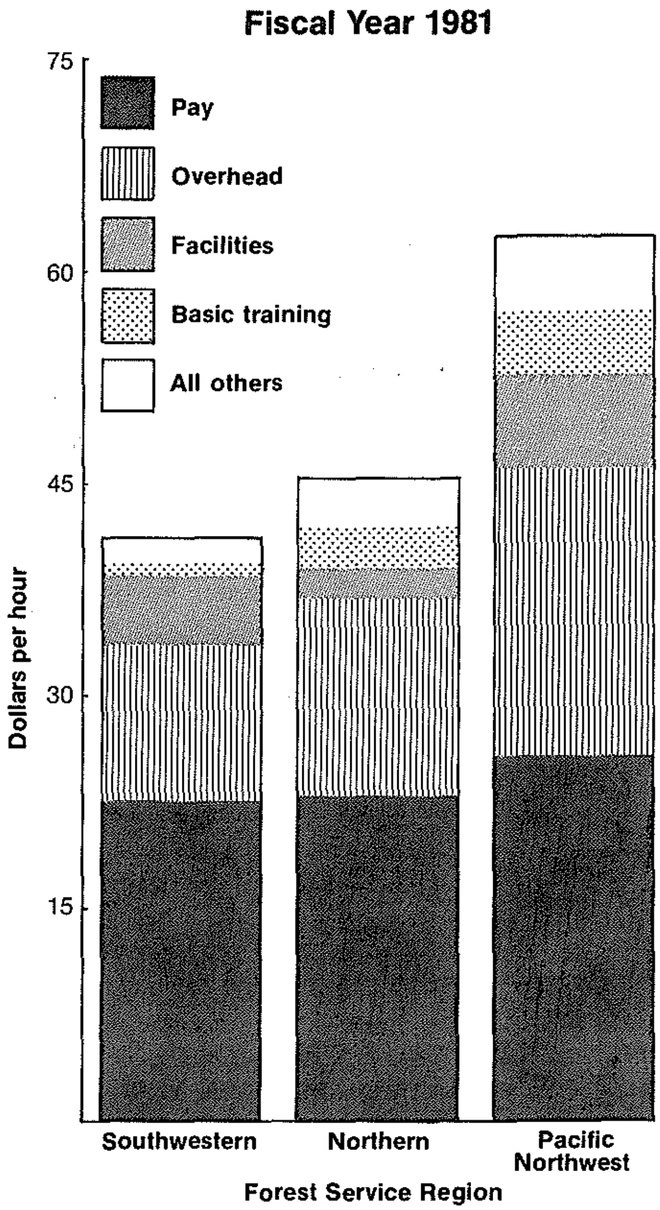

Figure 2—Contribution of medium engine team cost components to total hourly cost during availability for fire assignments, in Forest Service's Northern, Southwestern, and Pacific Northwest Regions.

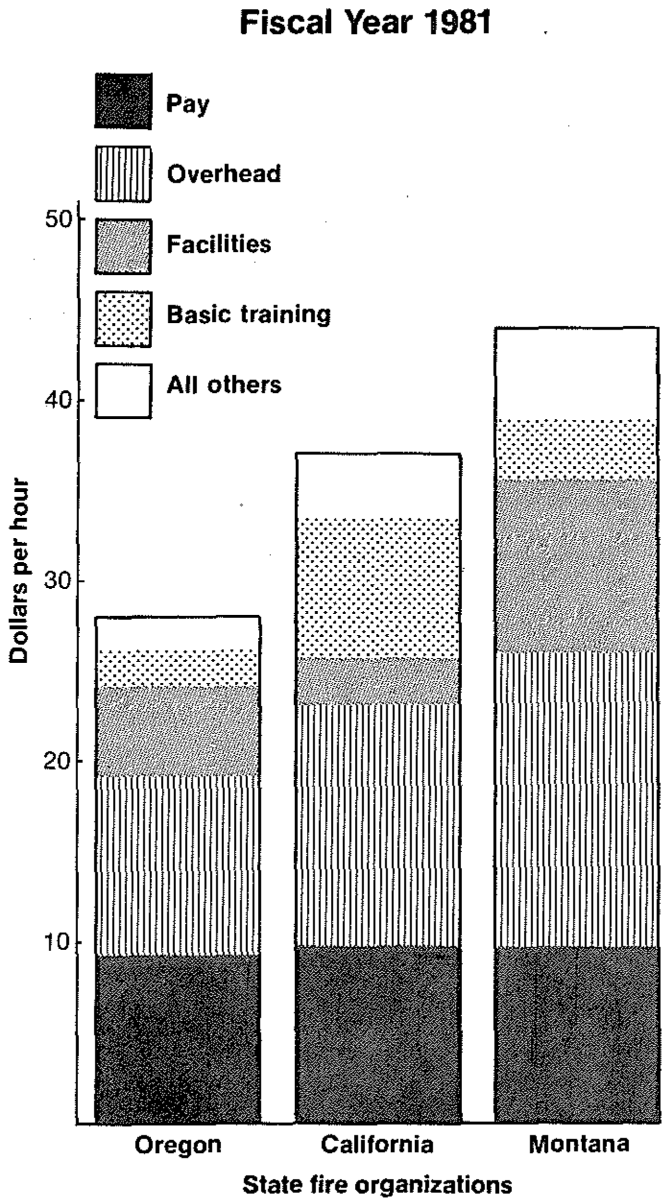

Figure 3—Contribution of Category II crew cost components to total hourly cost during availability for California, Oregon, and Montana fire agencies.

was repeated in the cost estimates for a medium engine (*fig. 2* and *tables 7-9*). Although the pay differences were higher than in the Category I handcrew, the overhead costs component contributed the most to the hourly cost differences. Equipment and facility differences were other contributing variables.

None of the cost estimates of the State fire organization was consistently higher than any of the cost estimates from other States. The hourly cost estimate of a Category II handcrew during availability, for example, was $43 in the Montana Division of Forestry, $36 in the California Department of Forestry, and $27 in the Oregon Department of Forestry. But the cost of a medium engine was $73 in Oregon, $70 in Montana, and $51 in California (*figs. 3, 4*). Again, the overhead and pay components contributed more than 50 percent of the total hourly cost in all FMIs, except in the medium engine team in Oregon where the equipment component was the greatest (*fig. 4*).

Other significant variables contributing to the FMI's cost differences were variations in FMI composition and staffing, and in length of time used in computing depreciation charges. California's 24 hour per day tour-of-duty, for example, resulted in a smaller pay and equipment cost component. The personnel pay and equipment depreciation was computed on a 24-hour basis, yielding a lower per hour cost estimate than would an 8 hour per day tour with depreciation. California's estimate could be computed on an 8 hour per day tour to increase comparability, but would not provide a realistic estimate for the California organization. Differences in staffing patterns— the number of personnel on an engine or in a helitack team—also accounted for real cost differences between organizations.

A higher percentage of the total State's per hour costs was overhead than was the situation for the Forest Service samples. The highest Forest Service overhead contribution to per hour cost during availability status, averaged across the three Regions, was 37 percent for a 20-person Category I handcrew. The corresponding State average overhead cost contribution for a similar handcrew during availability status was 43 percent (*tables 7-9*). Overhead cost compared with organization size, where size was represented by total labor hours, showed a weak correlation. This implies that no economies-of-scale exist in the fire protection organizations studied.

Cost by Deployment Status

The economic cost of the FMIs among the various categories of activity deployment status—availability, travel to fire, suppression on small fires, and suppression on large fires—differed significantly. Availability as used here is being available at the normal duty station. Hourly cost of a Category I handcrew at the Northern Region was $299 when on availability as against $347 on travel status to a fire, $330 during suppression activities of small fires, and $420 during suppression activities of large fires (*fig. 5*). The same cost pattern reappears for all FMIs (*fig. 6* and *table 10*). Deployment status is further compared: *table 2*— FMI hourly availability cost; *table 3*—FMI hourly suppression cost on small fires; *table 4*—FMI hourly suppression cost on large fires.

Transportation and equipment costs add considerably to the total hourly cost of the FMI teams during travel status. As examples, the hourly cost of a 30-passenger bus to transport a

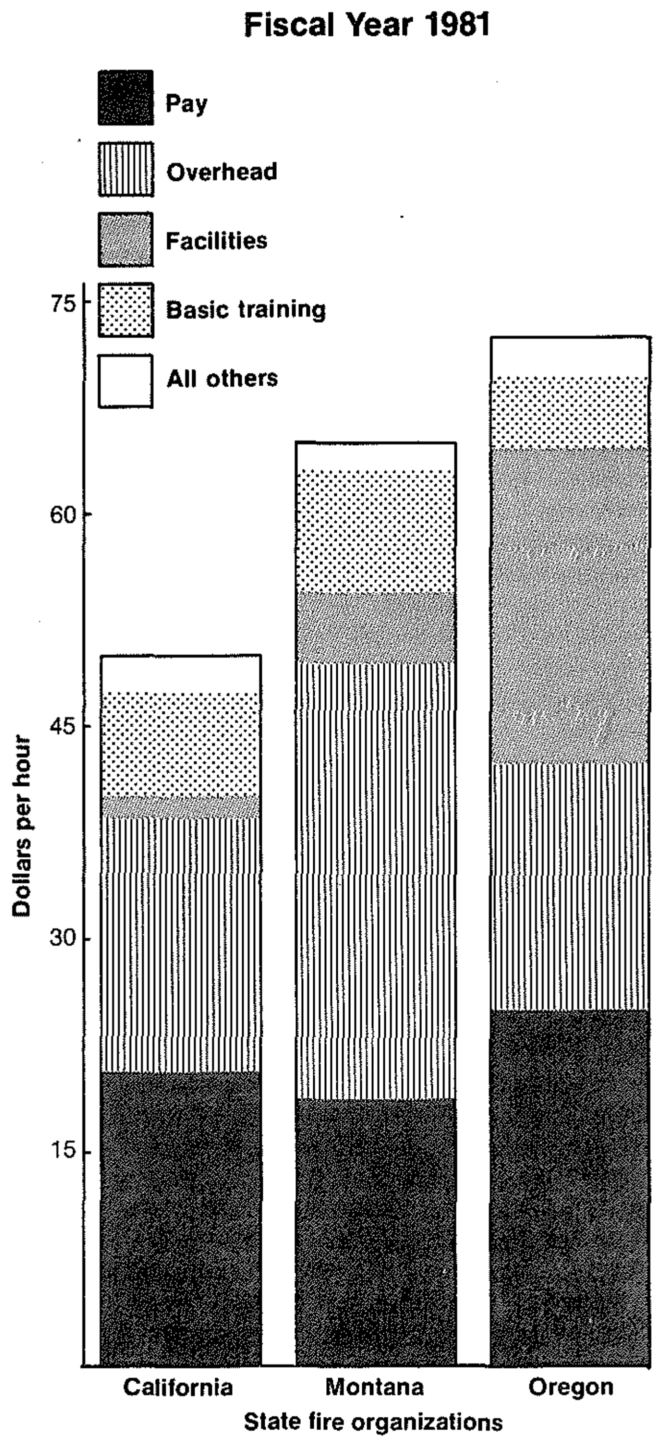

Figure 4—Contribution of medium engine cost components to total hourly cost during availability for California, Oregon, and Montana fire agencies. (California depreciates its equipment on a 24-h basis, which translates into a small equipment cost per hour.)

Table 7—*Combined average hourly cost of Fire Management Inputs in Forest Service Northern (R-1), Southwestern (R-3), and Pacific Northwest (R-6) Regions, by cost component (available for fire assignment), Fiscal Year 1981*

Fire Management Input	Supplies		Pay		Training		Special training		Overhead		Equipment		Facilities		Total	Stand. dev.
	Dollars/hour and pct															
	$	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	
Category I	6.85	2.29	145.38	48.62	10.71	3.58	[1]5.35	1.79	111.33	37.23	3.93	1.31	18.86	6.31	299	50
Category II	[1]7.29	14.58	[1]19.40	38.80	[1]16.72	33.44	[2]—	—	[1]5.36	10.72	[1] .17	.34	[1]1.21	2.42	50	22
Category III	[1]6.71	15.60	[1]17.11	39.79	[1]6.25	14.53	—	—	[1]11.45	26.63	[1] .51	1.19	[1] .72	1.67	43	24
Project crew	.70	14.00	2.03	40.66	1.29	25.87	—	—	.50	10.00	.07	1.40	.09	1.80	5	2
Helitack	1.00	1.22	19.79	24.13	1.47	1.79	1.34	14.78	14.78	18.02	40.05	49.39	2.51	3.06	82	11
Smokejumper	.98	2.39	17.90	43.66	1.20	2.93	2.50	6.09	10.97	26.76	5.66	13.80	1.88	4.59	41	6
Engine—small	.76	2.42	14.83	47.19	1.04	3.30	—	—	10.97	34.89	1.95	6.21	1.88	5.99	31	6
Engine—medium	1.78	3.62	22.16	44.98	1.55	3.14	.46	.94	16.45	33.39	4.04	8.19	2.83	5.74	49	11
Engine—large	1.75	3.62	20.53	42.43	1.73	3.58	1.25	2.58	16.83	34.79	3.60	7.43	3.52	7.28	48	42
Bulldozer—small	1.32	2.58	22.08	43.27	1.58	3.09	[2] .75	1.47	13.39	26.23	9.97	19.53	2.45	4.80	51	18
Bulldozer—medium	1.56	2.15	23.17	31.92	1.60	2.19	—	—	13.39	18.44	30.41	41.90	2.45	3.38	73	15
Bulldozer—large	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[1]Two observations. [2]No observations. [3]One observation.

Table 8—*Combined average hourly cost of Fire Management Inputs in Forest Service Northern (R-1), Southwestern (R-3), and Pacific Northwest Regions (R-6), by cost component during large fire suppression, Fiscal Year 1981*

Fire Management Input	Supplies		Pay		Supervision		Subsistence		Training		Special training		Overhead		Equipment		Facilities		Total	Stand. dev.
	Dollars/hour and pct																			
	$	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	
Category I	6.85	1.54	210.32	47.16	9.76	2.19	72.08	16.16	10.71	2.40	[1]5.35	1.20	109.67	24.59	7.02	1.57	18.86	4.22	446	56
Catetory II	[1]7.29	1.35	[1]284.09	52.51	[1]12.21	2.26	[1]67.63	12.50	[1]16.72	3.09	[2]—	—	[1]122.64	22.67	[1]3.55	.66	[1]26.48	4.89	541	75
Category III	6.71	1.95	129.57	37.67	36.70	10.67	61.07	7.75	6.25	1.82	—	—	89.78	26.09	3.00	.87	4.29	1.25	344	40
Project crew	.70	1.37	27.08	53.10	6.02	11.80	4.34	8.51	1.29	2.53	—	—	10.97	21.51	2.57	5.04	1.88	3.69	51	14
Helitack	1.00	.95	28.65	27.29	6.57	6.26	7.18	6.84	1.47	1.40	1.34	1.28	14.78	14.08	40.50	38.57	2.51	2.39	105	13
Smokejumper	.98	1.53	25.85	40.39	8.96	14.00	5.28	8.25	1.20	1.88	2.50	3.91	10.97	17.14	5.66	8.84	1.88	2.94	64	5
Engine—small	.76	1.64	21.46	46.32	—	—	6.21	13.40	1.04	2.24	—	—	10.97	23.68	3.77	8.14	1.88	4.06	46	15
Engine—medium	1.78	1.81	30.11	30.62	18.75	19.08	9.90	10.07	1.55	1.58	.46	.47	15.86	16.13	14.65	14.90	2.83	2.88	98	25
Engine—large	1.75	1.85	29.85	31.53	17.63	18.62	9.31	9.83	1.73	1.83	1.25	1.32	16.83	17.78	13.48	14.24	3.52	3.72	95	73
Bulldozer—small	1.32	1.42	29.74	31.98	18.86	18.13	8.28	8.91	1.58	1.70	[3] .75	.81	13.38	14.39	19.33	20.79	2.45	2.63	93	40
Bulldozer—medium	1.56	1.30	30.23	25.26	16.80	14.04	7.98	6.67	1.32	1.11	—	—	13.38	11.19	45.51	38.03	2.45	2.05	120	19
Bulldozer—large	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[1]Two observations. [2]No observations. [3]One observation.

Table 9—*Combined average hourly cost of Fire Management Inputs in California, Montana, and Oregon State agencies, by cost component (available for fire assignment), Fiscal Year 1981*

Fire Management Input	Supplies		Pay		Training		Special training		Overhead		Equipment		Facilities		Total	Stand. dev.
	Dollars/hour and pct															
	$	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	*Pct*	*$*	
Category I	[1]2.58	9.85	[1]5.00	19.07	[1]2.83	10.79	[2]—	—	[1]11.29	43.11	[3]0.13	0.50	[1]4.49	17.14	26	0.1
Category II	[1]2.58	9.92	[1]4.93	18.95	[1]2.09	8.04	—	—	[1]1.80	45.37	[3] .13	.50	[1]4.61	17.72	26	13
Category III	3.31	12.81	6.19	23.98	5.17	20.03	—	—	8.97	34.75	[3] .09	.35	2.17	8.41	26	18
Helitack	.80	0.89	23.58	26.49	1.21	1.36	10.30	11.57	25.76	28.94	29.04	32.63	8.01	9.00	89	17
Smokejumper	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Engine—small	.78	1.72	15.39	33.91	.93	2.04	.50	1.11	15.36	33.85	7.50	16.52	4.93	10.85	45	4
Engine—medium	1.01	1.57	20.92	32.35	1.30	2.02	.73	1.12	20.81	32.17	11.43	17.67	7.00	10.83	65	12
Engine—large	.90	1.53	15.34	26.04	.93	1.57	.58	.98	15.36	26.08	20.86	35.42	4.93	8.36	59	22
Bulldozer—small	.49	0.96	16.90	32.99	.86	1.67	.38	.74	13.87	27.07	14.71	28.72	4.15	8.10	51	20
Bulldozer—medium	.49	0.77	17.40	27.06	.87	1.35	.38	.58	13.87	21.57	27.26	42.41	4.15	6.46	64	24
Bulldozer—large	[4] .11	0.12	[4]20.69	24.04	[4] .65	.76	—	—	[4]11.88	13.81	[4]51.00	59.26	[4]1.73	2.01	86	—

[1]Two observations. [3]Does not include equipment for Montana State.
[2]No observations. [4]One observation.

Category I handcrew is $36, the total estimated cost of a medium-size helicopter is $732 per hour. Transportation cost estimates for different transportation methods vary (*table 5*). Hazard-pay adjustment, subsistence, and on-fire supervision costs charged when an FMI is on a fire contributed considerably to the cost differences by deployment status. The State organizations and Forest Service regions showed the same pattern of cost by deployment status (*figs. 7, 8*).

Comparison With Other Cost Estimates

These unit cost estimates are higher than figures sometimes used for long-term planning. The Northern Region FMI's daily costs (assuming an 8-hour day) were higher, for example, than costs proposed in the Fire Management Analysis and Planning Handbook (U.S. Dep. Agric., Forest Serv. 1982). The daily Category I handcrew cost during availability, for example, is $2368 by the method described here and $1765 in the Planning Handbook. The cost difference grows even larger during suppression on small fires and suppression on large-fire deployment status (*table 11*).

Comparability of the two estimates is difficult to assess. The estimates differ in how the fixed costs are allocated among FMIs, by the FMI's configuration, and by differences in which costs are included in the daily costs for the two procedures. Overhead costs that were allocated to the per hour cost of the line-building FMIs in the cost procedure provided here, for example, were charged elsewhere in the Planning Handbook Method (Lundeen 1983). The overhead cost computation itself may also be different.

Cost estimates in the National Interagency Reinforcement Crew and Analysis Plan (U.S. Dep. Agric., Forest Serv. 1979) show the same relative results. The cost estimates for compa-

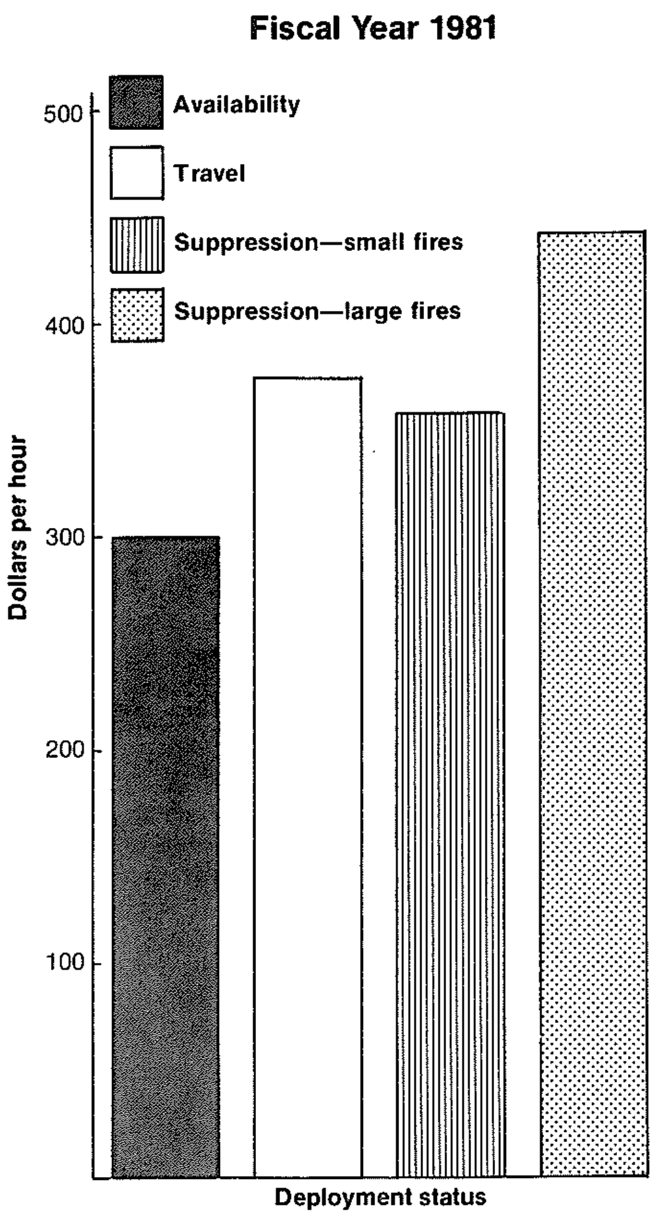

Figure 5—Category I crew cost by deployment status for the Forest Service's Northern Region.

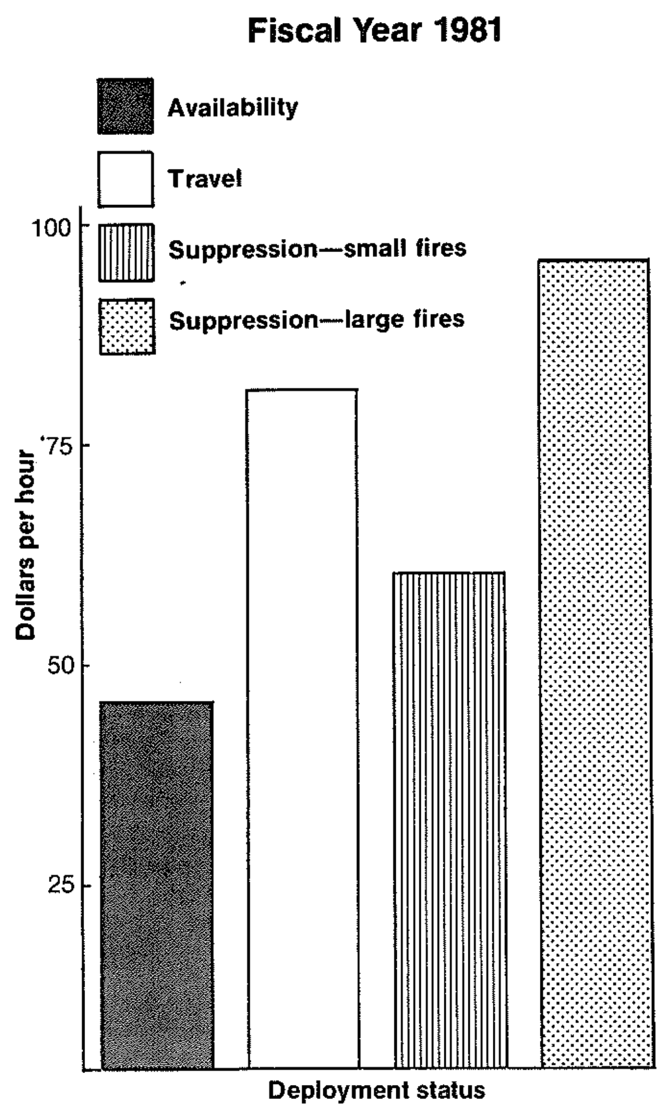

Figure 6—Medium engine team cost by deployment status for the Forest Service's Northern Region.

Table 10—*Hourly cost of Fire Management Inputs, including availability and travel costs, and suppression costs for small and large fires, in the Forest Service's Northern Region, Fiscal Year 1981*

Fire Management Input	Crew available for assignment	Weighted cost, travel to fire[1]	Weighted cost suppression of . . .		Weighted cost, travel as multiple of crew available	Cost as multiple of crew available for . . .	
			Small fires	Large fires		Small fires	Large fires
			Dollars/hour		—		
Category I	296	[2]372	360	422	1.26	1.21	1.49
Category II	[3] 35	[2]427	414	486	[4]	[4]	[4]
Category III	[3] 24	[2]284	271	372	[4]	[4]	[4]
Project Crew	[3] 4	33	42	48	[4]	[4]	[4]
Helitack	73	[5]234	82	93	3.23	1.11	1.27
Smokejumper	39	[6]109	47	62	2.79	1.21	1.56
Engine—small	30	51	39	46	1.73	1.23	1.47
Engine—medium	45	82	60	93	1.82	1.28	2.02
Engine—large	32	72	45	72	2.25	1.40	2.21
Bulldozer—small	49	95	62	85	1.95	1.27	1.76
Bulldozer—medium	57	110	78	101	1.92	1.36	1.77
Bulldozer—large	—	—	—	—	—	—	—

[1]Includes transportation to fire plus all other components. Percent regular time and percent overtime used as weights.

[2]Assumes transportation of entire crew in a 20-person bus.

[3]Nonfire funded. Value represents an imputed cost to account for the availability of the nonfire FMI for fire use, derived in proportion of total use during fire season.

[4]Nonfire funded; comparisons, as a multiple of availability costs, therefore, are meaningless. See also footnote 3.

[5]Assumes use of small rotary-wing aircraft (3-person capacity), which ferries two helitack teams to fire. Flying cost prorated on a team/hour basis.

[6]Assumes use of small fixed-wing aircraft carrying four smokejumper teams at a time. Flying cost prorated on a team/hour basis.

Table 11—*Daily costs of Fire Management Inputs for the Forest Service's Northern Region, Fiscal Year 1981, compared with those of the Forest Service's Fire Management Analysis and Planning Handbook*

Fire Management Input	Handbook cost[1]	Crew available[2]		Northern Region costs Weighted cost, for suppression of . . .			
				Small fires		Large fires	
		Dollars/day	*Pct difference*	*Dollars/day*[2]	*Pct difference*	*Dollars/day*[2]	*Pct difference*
Category I	1765	2368	34	2880	63	3520	99
Category II	2660	[3] 192	(92)	2144	(5)	2976	32
Category III	2440	[3,4] 280	(89)	[3,4]3288	35	[3,4]3896	60
Bulldozer/plow units	[5] 340	[6] 457	34	622	83	810	138
Engine—small	[7] 270	[8] 244	(10)	311	15	364	34
Smokejumper (each)	130	156	20	188	45	248	91
Helitack (including personnel and equipment)	[9] 310	[10] 584	88	[11]1876	605	[11]1964	639
Airtankers	[12]1210	[13] 424	(65)	[14]9224	762	[12]9224	762

[1]No length period specified.

[2]Assumes 8-hour day; includes all appropriate overhead, hazard, and overtime charges during small and large fires.

[3]This FMI not maintained on standby during fire season. Only a proportion of standby cost assigned, on basis of proportion of use throughout season. Nonfire funded leads to misinterpretable entries.

[4]Forest Service regular nonfire-funded personnel.

[5]Bulldozer nor crew size specified

[6]Medium bulldozer equivalent to a D-6, with a two-person crew.

[7]No crew size specified.

[8]Includes two-person crew.

[9]Helicopter nor crew size specified.

[10]Small helicopter with capacity for three people; includes two-person helitack team.

[11]Assumes 8-hour flying time, including two-person helitack team. Cost prorated on a team/hour basis because two helitack teams ferried.

[12]No plane size specified.

[13]A 1900-gal tank capacity plane.

[14]Assumes 8-hour flying time.

rable handcrews were higher when the method described here was used. Differences in crew configuration and pay grade schedules account for part of the cost differences. The overhead cost computation and allocation may be other sources of differences.

The objectives of the various studies done are quite different. This study estimates total economic cost to the agency of placing an FMI on the fireline. The cost of fringe benefits offered to the employees, such as holidays, annual leave, and sick leave, therefore, are included, but are not included or registered elsewhere in the two other studies cited (U.S. Dep. Agric., Forest Serv. 1980; U.S. Dep. Agric., Forest Serv. 1979). The year of the database also varied among the studies. The crew need study was done in 1979, the Planning Handbook numbers are from 1980, and the data of this study are for fiscal year 1981. In addition, the earlier studies are nationwide approximations, while the current study is regionally specific for three western high fire-activity regions.

The resultant output of the cost-aggregation process is an estimate of the true economic cost of the various FMIs. The final costs may not be consistent with budget estimates because budget costs fail to include some items, such as the annual cost of facilities, or fail to allocate some costs to each FMI, such as fire program management overhead. As a result, these economic costs are usually higher than those with which fire program managers deal. Because the use of cost components as building blocks may ignore unique or unusual costs, the economic cost estimates may actually be conservative.

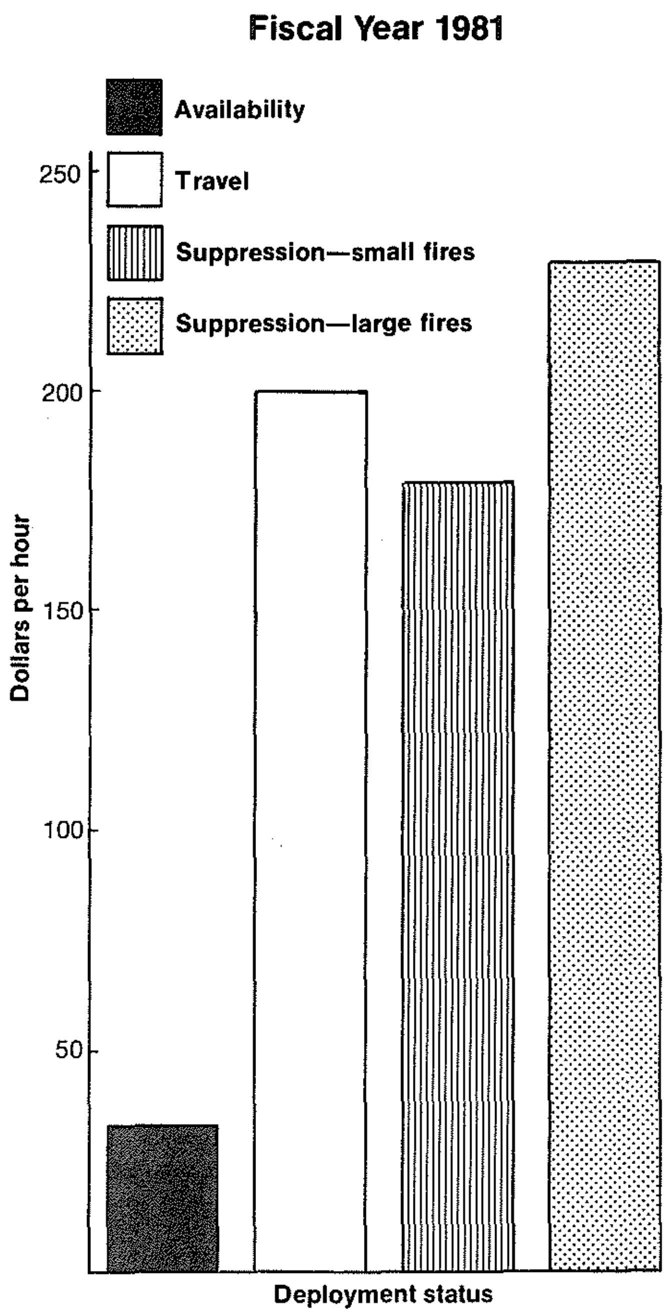

Figure 7—Category II crew cost by deployment status for the California Department of Forestry.

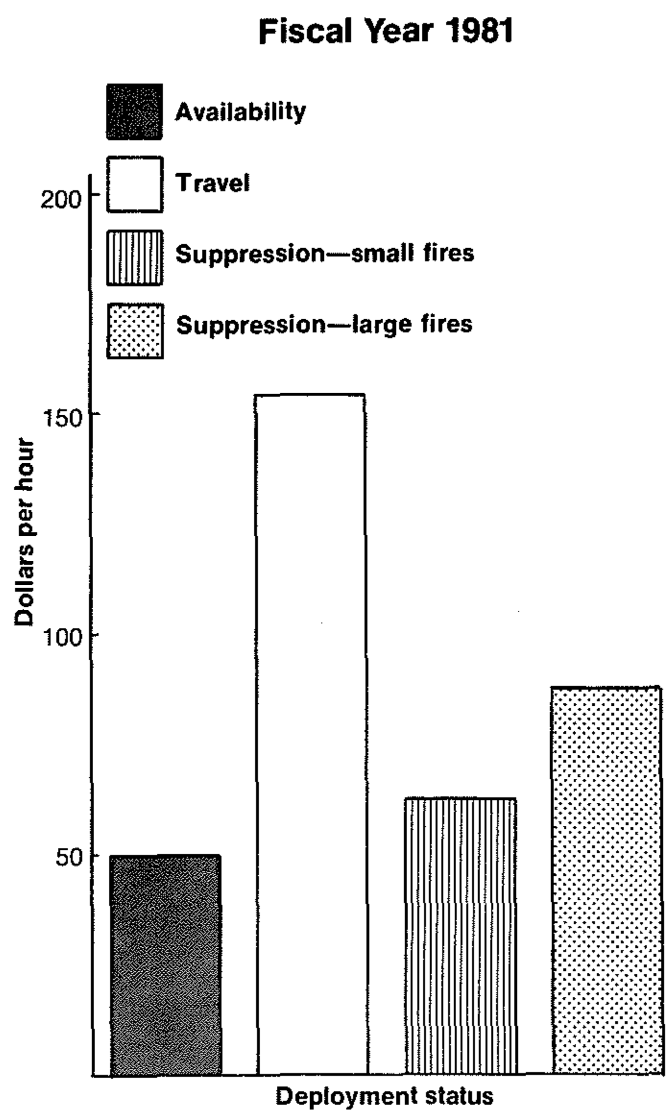

Figure 8—Medium engine team cost by deployment status for the California Department of Forestry.

CONCLUSIONS

With minimum effort, the cost estimates can be updated annually, or whenever organization changes warrant refinements. A full cycle through the procedure—from data collection through analysis of output— can be achieved with a person-week of work.

The cost computation algorithm is sufficiently generalized to be useful to any organization with fire protection responsibilities. Because total comparability between agencies is not possible, the cost collection method and computerized procedure were designed to have enough flexibilty to accommodate the specific needs of different organizations. Because of the procedures and the component nature of the cost, the results may be useful in 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.

The magnitude of the cost estimates of this example application are much higher than previously thought, especially the overhead, training, and facilities components. The pay component, although significant, was not as costly as expected. These results have operational implications during constrained budget situations. Sometimes reduction in field personnel is looked upon as the only solution to budget cuts, but this analysis reveals that approach to be only a partial simplistic solution.

This example application of the economic cost procedure also shows that the economic cost of the FMIs among the Forest Service regions and the State fire organizations differ significantly. Part of the cause lies in dissimilar staffing patterns, and in differences in tour-of-duty and length-of-time use in their depreciation schedules. Much of the difference, however, lies in real differences in the overhead, facilities, training, and pay cost components. The economic cost estimates also differ significantly among the different categories of fire activity deployment status; that is, availability, travel to fire, suppression on small fires, and suppression on large fires.

Differences in the FMI's economic cost estimates between Forest Service regions and State fire organizations, and differences between activity deployment status, have implications for both long-term planning and real-time management decisions. The use of nationwide cost averages across broad geographical areas and the various fire activity deployment status mask significant and real economic cost differences. The suppression cost per acre burned will increase substantially as the size of the suppression organization enlarges for a given burned area. The cost during travel status is high and fixed no matter how small the fires are contained; larger suppression organization will contain fires at a smaller size. During planning of the dispatching procedures, attention should be given to the increment in cost above the availability status—the extra cost to *use* an FMI is substantial, even after it has been paid to have the FMI available.

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