Introduction

Fiscal year (FY) 1994 was a banner year for wildfire in our nation's forests and rangelands. During that year the expenditures for USDA Forest Service fire management reached a record-breaking total of nearly $1 billion, and other agencies saw similar increases. Because of these soaring expenditures and recommendations to address them from the Strategic Assessment of Fire Management Report (USDA Forest Service 1995b), the Fire Economics Assessment Team (FEAT) was chartered in 1995 by Forest Service's Fire and Aviation Management (F&AM) Staff in Washington, D.C. FEAT was to review current Forest Service fire management expenditures and their trends, and identify opportunities to control or reduce them. To accomplish this, FEAT identified expenditures and trends, causal factors driving them, projected future developments, and suggested changes to reduce future expenditures. FEAT's report was submitted to the Forest Service in September 1995 (Bell and others 1995).

This paper summarizes the FEAT Report's fire expenditure data and related analyses, which have been updated to include the 1995 fire season; describes procedures used to obtain data, presents summaries of the expenditures and their trends; and discusses some implications for fire management.

Methods

The assessment of fire-related expenditures focused on expenditures controlled by the USDA Forest Service's Fire and Aviation Management (F&AM) Staff. These expenditures, however, understate the total fire-related expenditures on National Forests for two reasons. First, F&AM is not the only unit within the Forest Service performing fire-related activities. For example, fuels reduction is conducted by timber management units on National Forests using brush-disposal funds collected from timber sales. Second, agencies other than the Forest Service fight fires on National Forests, for which partial or no reimbursement is made. For example, when military personnel fight fire on National Forests, the Forest Service reimburses for expenditures above basic expenses only. When a U.S. Department of the Interior (USDI) agency, such as the Bureau of Land Management, fights fire on National Forests, funds are not transferred. Similarly, funds are not transferred when Forest Service personnel fight fire on USDI lands.

Thus, in light of these caveats, we focused on four types of fire expenditure information: overall fire expenditures, fire suppression expenditures, an incident commander survey, and fuels management expenditures.

Overall Fire Expenditures

Fire expenditure information was developed for F&AM forest fire protection and fire suppression activities. Fiscal years (FY) were analyzed over time (1970-95) and space (Forest Service regions) in both nominal and 1995 real dollars. The current Federal fiscal year begins October 1 and ends the following September 30. For example, FY 1994 ran from October 1, 1993 to September 30, 1994. During the early 1970's, the Federal fiscal year ran from July 1 to the following June 30. The last such year was FY 1976 which ended on June 30, 1976. FY 1977 began the current system, starting on October 1, 1976. The 3-month period of July 1, 1976, to September 30, 1976, is referred to as the "transition quarter" and does not belong to any fiscal year.

Data Collection and Structure

Information about fire expenditures came from several sources, but all basically derived from the official Forest Service accounting record, the Statement of Obligations. Information for FY 1970-82 was provided mainly through the Forest Service Fiscal and Accounting Services (FAS) staff (Washington, D.C.), by accessing and copying original archived records. Information from those records were transferred to spreadsheets by Intermountain Research Station (INT) personnel. In many cases, records thought to exist (e.g., archived computer tapes at the National Finance Center in New Orleans, Louisiana) did not. In addition to obtaining the missing information for FY 1970-82, records for FY 1983-88 were obtained by contacting regional-level fiscal personnel. FY 1989-95 information was provided electronically by the F&AM staff, with the assistance of the Fiscal and Accounting Management unit of the Intermountain Region. Database query macros were developed to access the Forest Service's Central Accounting Data Inquiry (CADI) database. Electronic file information was converted to a spreadsheet format for our use.

The format of fire expenditure records has changed over time. Expenditure categories (currently referred to as work activities) became more detailed. Budget accounts (currently referred to as fund codes) varied between 1- and 2-year appropriations, controlled by F&AM or Timber Management. General Administration expenditures were included in fire-related appropriations in some years and separated in others. Nevertheless, this study always focused on two broad appropriations: forest fire protection and fighting forest fires.

These and other changes in the accounting system required us to develop a set of conversions (between fund codes and work activities) to ensure uniformity and consistency from year to year *(table 1)*. Specifically, personnel from INT and WO-F&AM developed conversions for FY 1994-95; WO-F&AM did FY 1989-93; and INT, WO-FAS, and the Northern Region Administration unit did FY 1970-88. Because the content and specificity of work activities changed over time, they were aggregated into broad categories:

- Forest fire protection (FFP)
  - — Presuppression
  - — Fuels improvement
  - — Other
- Fighting forest fires (FFF)
  - — Suppression
  - — Rehabilitation
  - — Severity
  - — Economic efficiency
  - — Other

For example, the fund code pertaining to fire protection was 002P&M in FY 1970 (then referred to as appropriation codes) and 701FP in FY 1987 *(table 1)*. Similarly, work activity codes 101 and 102 contained presuppression expenditures in FY 1970 (then referred to as major functions), as did codes 102 and 111 in FY 1987. However, the broad categories developed to aggregate work activity data did not always exist: Economic Efficiency began with FY 1993; Severity began with FY 1987; Rehabilitation began with FY 1977; and Fuels Improvement was distinguished from general presuppression expenditures in FY 1977 *(table 1)*.

Missing Data and Verification

Accounting records were not always complete and attempts to fill in the gaps with other data sources were not always successful. As a result, some missing fire expenditure data were estimated by INT personnel. The data verification process provided some values for missing data.

Table 1—***Fund codes and work activity codes for classes of fire expenditures, in FY 1970-1995***

	Forest fire protection (FFP)				Fighting forest fires (FFF)					
		Work activity classes				Work activity classes				
Fiscal year	Fund codes	Presuppression	Fuels	Other	Fund codes	Suppression	Rehabilitation	Severity	Econonic efficiency	Other
1970	002P&M	101, 102		312, 313, 320	003FFF	101, 102, 103				312, 313
1971	102P&M	101, 102		312, 313, 320	103FFF	101, 102, 103				312, 313
1972	202P&M	101, 102		312, 313, 320	203FFF	101, 102, 103				312, 313
1973	302P&M	101, 102		312, 313, 320	303FFF	101, 102, 103				312, 313
1974	402P&M	101, 102		312, 313, 320	403FFF	101, 102, 103				312, 313, 315
1975	502P&M	101, 102		312, 313, 320	503FFF	101, 102, 103				312, 313, 315
1976	602	101, 102		312, 313, 320	603	101, 102, 103				312, 313, 315, 180
1976TQ[1]	102	101, 102		312, 313, 320	103	101, 102, 103				312, 313, 315, 180
1977	701	111 to 114, 116, 920s, 930s	115	312, 313, 180, 173, 960+	703	102, 111 to 116	094			312, 313, 180
1978	801	111 to 114, 116, 920s, 930s	115	312 ,313, 180, 173, 960+	803	102, 111 to 116	094			312, 313, 180
1979	901FM	102, 110 to 114, 116, 920s, 930s	115	311 to 313, 316, 180, 173, 960+	903FFF	102, 110 to 116	094			312, 313, 316, 180
1980	001FFP	102, 111 to 114	115	311 to 313, 316	003FFF	102	092			312, 313, 316
1981	101FFP	102, 111 to 114	115	311 to 313, 316	103FFF	102	092			312, 313, 316
1982	201FFP	102, 111 to 114	115	311 to 313, 316	203FFF	102	092			312, 313, 316
1983	301FP	102, 111 to 114	115	311 to 313, 316	303FFF	102	092			312, 313, 316
1984	401FP	102, 111 to 114	115	311 to 313, 316	403FFF	102	092			312, 313, 316
1985	501FP	102, 111 to 114	115	311 to 313, 316	503FFF	102	092			312, 313, 316
1986	601FP	102, 111 to 114	115	311 to 313, 316	603FFF	102	092			312, 313, 316
1987	701FP	102, 111	115	311, 312, 313	703FFF	102	092	111		312, 313, 316
1988	8NFAF	PF11s, PF12	PF2s	ETs, GMs, MLs, PLs, TSs	8NFFF8	PF12s	FWs	PF11s		ATs, TSs
					8NFFF9	PF12s	FWs	PF11s		ATs, TSs
1989	9NFAF	PF11s, PF12	PF2s	ETs, GMs, MLs, PLs, TSs	9NFFF9	PF12s	FWs	PF11s		ATs, TSs
					9NFFF0	PF12s	FWs	PF11s		ATs, TSs
1990	0NFAF	PF11s, PF12	PF2s	Others	0FFFS0	PF12	FWs, ATs, LTs	PF11s		Others
	0FFFP	PF11s, PF12	PF2s	Others	0FFFS	PF12	FWs, ATs, LTs	PF11s		Others
1991	FFFP	PF11s, PF12	PF2s	Others	FFFS	PF12	FWs, ATs, LTs	PF11s		Others
1992	FFFP	PF11s, PF12	PF2s	Others	FFFS	PF12	FWs, ATs, LTs	PF11s		Others
					EFFS	PF12	FWs, ATs, LTs	PF11s		Others
1993	FFFP	PF11s, PF12	PF2s	Others	EFFS	PF12	FWs, ATs, LTs	PF11s	PF114	Others
1994	FFFP	PF11s, PF12	PF2s	Others	EFFS	PF12	FWs, ATs, LTs	PF11s	PF114	Others
1995	FFFP	PF11s, PF12	PF2s	Others	EFFS	PF12	FWs, ATs, LTs	PF11s, PF115	PF114	Others

[1]TQ=transition quarter

Verification—Fire expenditure data were verified by cross-checking for consistency and patterns with both internal and external sources. Internally, statement-of-obligation records came in two formats: fund code by work activity (Forest Service accounting report BUDG4V-3) showing a fund code check-total; and work activity by fund code (Forest Service accounting report BUDG4V-5) without fund code check-total. If work activity information was missing, it was treated as missing data, and regional personnel (both fiscal and fire) were contacted to secure needed records. External verification came from a variety of sources, records, and reports.

Missing Data—Even after extensive efforts to obtain all needed data, some data could not be obtained. We were able to obtain virtually all data for the Northern Region (Region-1), Rocky Mountain Region (R-2), and the Southwest Region (R-3), and most data for the Intermountain Region (R-4), Pacific Northwest Region (R-6), Southern Region (R-8), Eastern Region (R-9), and the Alaska Region (R-10). The Pacific Southwest Region (R-5) and the Washington Office (R-13) had the most missing data, but R-13 was the worst. Missing data were developed by using three methods. First, some missing values were deduced, as when the preceding and succeeding values for a particular work activity were zero. Second, some fund code totals (e.g., R-5 firefighting in FY 1980) were estimated by assuming the same pattern of change as in adjacent regions (e.g., R-3, R-4, and R-6 for missing R-5 values), or by assuming a percentage share for the missing year (e.g., R-6 fire protection expenditures in FY 1981 and FY 1982 were assumed to be 6 percent of the national total, because they were that in FY 1980 and FY 1983). Third, in some cases all data were known, except for the missing observation; in that case, the missing observation was specified as the residual. This approach was used extensively for the Washington Office, for which there was virtually no expenditure information from FY 1980 through FY 1988.

Fire Suppression Expenditures

The original purpose of this part of the study was to develop a predictive model of fire suppression expenditures, based on fire-specific characteristics (the independent variables) and fire expenditures (the dependent variable). Fire-specific characteristics were to be obtained from the National Fire Management Information System (NFMIS) database and fire expenditures were to come from the specialized fire portion of the CADI database (CADI-Fire). But during this study, we discovered that fire acreage information contained in NFMIS included all acres in the fire, not just the National Forest acres. However, the expenditures contained in CADI-Fire (and NFMIS as well) are Forest Service expenditures only, excluding expenditures of other assisting agencies. In other words, whenever agencies other than the Forest Service fought a fire, Forest Service records understated total fire-related expenditures, which is the typical situation in larger fires. This is a seemingly insurmountable problem: the expenditures do not correspond to the acres. Thus, because fire size (acres) is a critical variable, the predictive model was abandoned. Nevertheless, we determined the magnitude of detailed Forest Service expenditures in several categories of fires relating to fire size and fuel type.

Sampling—Ultimately, expenditure information for sampled fires must come from the CADI-Fire database, which uses project codes (P-codes) as a primary fire identifier. CADI-Fire contains expenditure information, but no information about fire characteristics; NFMIS contains that information. Not all fires are assigned P-codes (especially the smaller fires), and not all fires contained in the NFMIS database have P-codes recorded. After an evaluation of the information available in the CADI-Fire and NFMIS databases, we decided to restrict the data to medium (100-999 acres) and large (1,000+ acres) fires occurring in FY 1993 and FY 1994, and to aggregate them into two classes of fuels: grass/brush and wood/slash. The

NFMIS administrator (Portland, Oregon) provided the sampling frame of all applicable fires. INT personnel selected a sample size of 202 fires, which would be distributed among regions, size class, and fuel type in proportion to their frequency. Forest Service regions were aggregated into three categories: East (R-8 and R-9), Interior West (R-1, R-2, R-3, and R-4), and Pacific West (R-5, R-6, and R-10). Information for the sampling frame was entered into a Minitab worksheet and the random sample procedure was used to select the fires sampled.

The NFMIS database indicated that 612 large and medium grass/brush and wood/slashfires occurred during FY 1993-94. From that total, we selected an initial sample of 202 fires, in which large fires were sampled at a higher rate (63 percent) than were medium fires (19 percent) because large fires were believed to be far more expensive. Ultimately, fires without P-codes assigned and fires with duplicated P-codes reduced the total sample size to 171 fires.

Data Collection—The list of sampled fires was communicated electronically to the CADI-Fire administrator (Ogden, Utah) and R-4 fiscal personnel who prepared needed database queries to access the CADI-Fire database. Queries were designed to be compatible with those developed in the Overall Fire Expenditure phase, insofar as fire suppression expenditures were aggregated into three classes of budget object code (BOC): personnel (salary and travel), supplies and equipment, and others. Query results were maintained in an electronic format.

Incident Commander Survey

The survey of incident commanders (IC's) was intended to measure the role of selected factors (e.g., wildland/urban interface) in increasing fire suppression expenditures. The survey was restricted to individual IC's for a sample of large fires occurring during the FY 1994 fire season.

Questionnaire—A brief questionnaire was developed and reviewed by FEAT personnel. Ultimately consisting of 34 factors (topics or issues), each was rated on a five-category scale ranging from very unimportant to very important. Respondent IC's were asked to indicate the response category that best described each factor's role in increasing fire suppression expenditures. Respondents were instructed to restrict attention to a specific fire (for which they were the incident commander) and were reminded to consider the full range of categories on the response scale.

Sampling—Fires sampled for the IC survey were limited to the large, FY 1994 fires sampled for the fire expenditure portion of this study, 102 fires in total. Wilderness fires (that had no incident commander), mislabeled fires (i.e., small fires labeled as large), and so on, reduced the initial sample such that 84 fires were used for the IC survey. Regional fire intelligence officers were contacted regarding identity and location of the IC(s) for each fire. Electronic mail addresses, surface mail addresses, or other information was provided. In many cases, several fires had the same IC, and in some cases, a single fire (typically a multiple-fire complex) had several IC's.

Data Collection—On May 15, 1995, questionnaires were sent, either via electronic or surface mail. Respondents were given almost 3 weeks to respond. After the deadline, a reminder note was sent, along with a new deadline. A second reminder note was sent on June 8, with an immediate-response deadline and another copy of the questionnaire. In total, 103 questionnaires were sent and 98 were returned, for a 95 percent response rate.

Data Analysis—Data from returned questionnaires were entered into a spreadsheet for analysis. Descriptive statistics were developed for each topic/issue, including the range, median, arithmetic mean, and total score. Topic importance was based on the median rating, with the mean score used to break ties.

Fuels Management Expenditures

Data on fuels management expenditures were obtained from Forest Service accounting records by using a process similar to that used for other fire expenditures. Several fund codes were used, including appropriated fuels management funds (FFFP), brush disposal funds (BDBD), Knutson-Vandenburg funds (KV), and funds from benefiting functions such as wildlife, timber management, threatened and endangered species, recreation, and others. Fuels management was not a designated work activity before FY 1977; it had been previously under either timber management or fire presuppression dollars.

The current Forest Service accounting structure allows for more than 20 different work activity codes to be recorded under fuels-related fund codes. But only a subset (the PF-2's) pertain to on-the-ground applications of fuel treatment, and only a subset of those concern prescribed burning. Fuel treatment (including prescribed burning) expenditures are recorded under work activity codes for activity fuels reduction (PF-25) and natural fuels treatments (PF-24), including management-ignited (PF-242) and prescribed natural fire (PF-241). We could not determine whether fuel treatment expenditures were for burning or some other method of fuel reduction. Therefore, expenditure data are most useful for comparing overall funding trends, shifts in expenditures among work activities, and expenditure shifts among Forest Service regions for the FFFP fund code. Detailed FFFP fuels expenditure data were available for FY 1987-95 and BDBD expenditure data for FY 1991-95.

Forest Service Management Attainment Reports (MAR) were used to isolate the number of acres reported in fuel management activity. Appropriated fuel treatment (MAR code 16.2) and brush disposal fuel treatment (MAR code 16.3) are summarized in the regional MAR data and represent our best estimate of natural fuels (MAR code 16.2) and activity fuels (MAR code 16.3) accomplishments. We used the MAR category "final accomplishments" rather than targeted or projected accomplishments. Reporting conventions vary somewhat by region and forest, and apparently some acres treated for multiple purposes (e.g., reforestation and fuels reduction) were double-counted in the MAR framework. In addition, about half of the natural fuels burning in the Southern Region was not captured under either of these MAR codes, presumably because the primary purpose of the burning was not fuel reduction.

Results: Fire-Related Expenditures

Fire-related expenditures in FY 1994 prompted concern that led to this study. FY 1994 did not have the highest number of fires, nor were the most acres burned. Over the FY 1970-95 period, the highest number of fires occurred in FY 1970, with more than 15,000 ignitions; FY 1994 ranks fifth, with 13,575 fires *(fig. 1)*. The most acres (more than 2.7 million) burned in FY 1988; FY 1994 ranks second, with about one-half as many acres. However, FY 1994 ranks first in expense; it was the most expensive year on record, exceeding the previous record (FY 1988) by 56.9 percent.

Overall Fire Expenditures

Fire-related expenditures refer to payments made by F&AM for goods and services to protect forests from fires and fight forest fires. Fire expenditures were acquired from central accounting records storage, fiscal management personnel from each of the regions, and the current accounting database. We distinguish between expenditures and costs. Economic cost is a more comprehensive term, generally held to be what is forgone to secure something, including opportunity and social costs. For example, some might argue that loss of biological diversity or air pollution are fire-related costs. Fire-related expenditures simply refer to direct, financial outlays.

General Expenditures

Our assessment of fire-related expenditures covers the time period FY 1970-95 and becomes more detailed approaching FY 1995. Over this period, the Forest Service spent about $7.9 billion on fire-related activities. F&AM expenditures amounting to $61 million in FY 1970 rose to almost $1 billion by FY 1994, a sixteenfold increase *(fig. 2)*. Using the average of FY 1970-74 to represent FY 1970 and the average of FY 1991-95 to represent FY 1995, fire-related expenditures rose at an average rate of 15.5 percent annually. The infamous 1988 fire season was expensive ($606 million), but not nearly as expensive as FY 1994, with a record of $951 million *(fig. 2)*.

Measuring total fire-related expenditures in 1995 dollars adjusts for inflation, thus holding the purchasing power of money constant at 1995 levels *(fig. 2)*. In

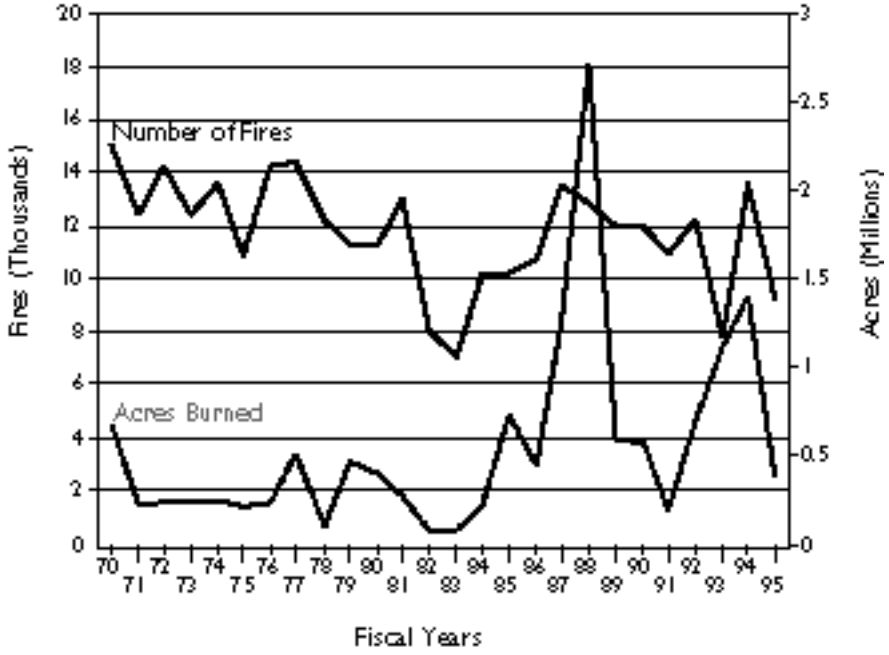


Figure 1—Number of fires and acres burned, FY 1970-95, by year.

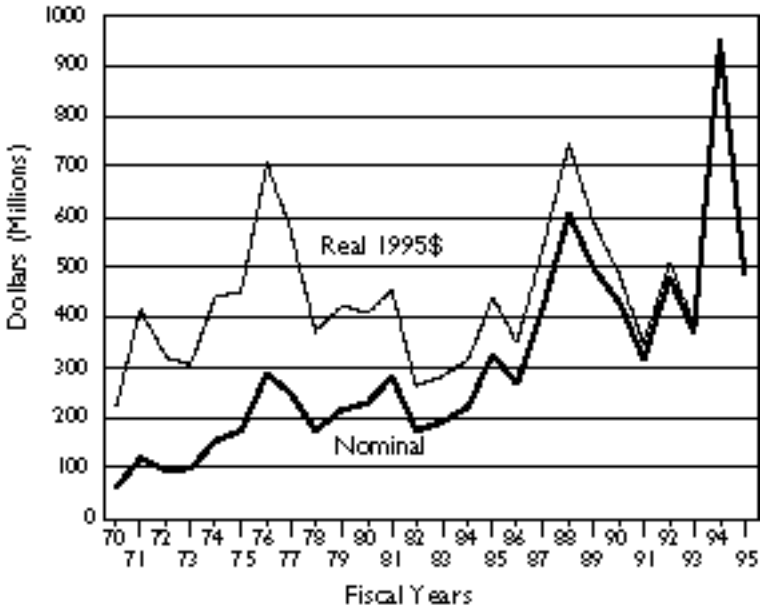


Figure 2—Total fire-related expenditures, FY 1970-95, by year.

constant dollars, FY 1994 was still the record year, followed by FY 1988 at $747 million and FY 1976 (a 15-month year) at $704 million. Though highly erratic, real, total fire-related expenditures from FY 1970-95 showed a statistically significant ($p = 0.05$) increase, primarily because of the influence of FY 1994. On the basis of constant 1995 dollars, about $11.8 billion were spent on fire-related activities for FY 1970-95, an amount 50 percent greater than measured in current-year dollars. However, real, fire-related expenditures rose at an average annual rate of only 2.3 percent. With FY 1994 removed from the time-series of real, total expenditures, the linear trend is not statistically significant ($p = 0.20$).

Figure 3 shows the historical level of nominal expenditures in forest fire protection (FFP) and fighting forest fires (FFF), as well as FFP expenditures in constant dollars. Generally, protection-related activities include actions taken before a fire is fought as a wildfire. Because Severity expenditures in FY 1987-95 and Economic Efficiency expenditures in FY 1993-95 were intended to supplement Presuppression expenditures, they were added to FFP totals and subtracted from FFF totals.

FY 1994 was the record year for both nominal FFP expenditures ($266 million) and FFF expenditures ($685 million) *(fig. 3)*. Over the entire FY 1970-95 period, FFP expenditures accounted for about $3.7 billion (47.6 percent of the total) while FFF accounted for $4.1 billion (52.4 percent of the total). However, FFP expenditures have increased faster than those for FFF. During the early years (FY 1970-74), FFP expenditures averaged about $35.2 million (33.0 percent) annually, and FFF expenditures averaged about $71.4 million (67.0 percent) annually. In recent years (FY 1991-95), FFP expenditures averaged $246.5 million (47.4 percent) annually, and FFF averaged $273.9 million (52.6 percent) annually.

FFP expenditures in constant, 1995 dollars generally rose throughout the 1970's, peaked in the late 1970's, and showed a statistically nonsignificant ($p = 0.17$) decline since FY 1977, despite recent increases *(fig. 3)*. In constant, 1995 dollars, FFP expenditures accounted for 82.3 percent of all fire-related expenditures in FY 1978, only 28.0 percent in FY 1994, but rose to 60.2 percent in FY 1995. FFF expenditures are not shown in constant, 1995 dollars because they so erratic. Even with FY 1988 and FY 1994 included, the linear trend in real, FFF expenditures over the FY 1970-95 period is not statistically significant ($p = 0.40$).

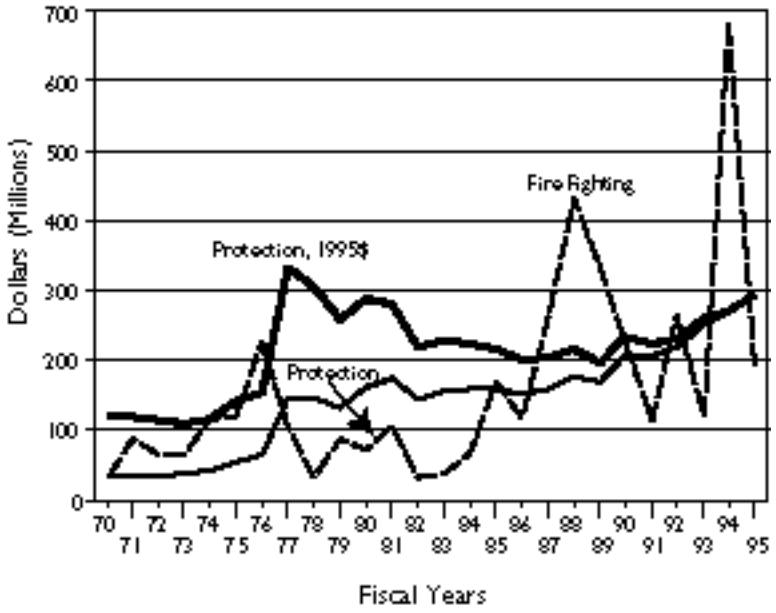


Figure 3—Fire protection and fire-fighting expenditures, FY 1970-95, by year. Protection includes and Fire Fighting excludes Economic Efficiency and Severity.

Fire-related expenditures are not distributed uniformly across the country. To display these data, Forest Service regions were aggregated into the Interior West (R-1, R-2, R-3, and R-4), the Pacific West (R-5, R-6, and R-10), the East (R-8 and R-9), and WO+ [R-13 (the Washington Office) plus other units, e.g., Experiment Stations]. WO+ expenditures include expenses of operating the WO staff, funding research (Missoula, Montana, and Riverside, California) and development (Missoula, Montana, and San Dimas, California) projects, operating the National Advanced Resource and Technology Center (Marana, Arizona) for advanced fire management training, and supporting the Forest Service portion of the National Interagency Fire Center (Boise, Idaho) that provides national contracts for air tankers, helicopters, etc.

During the FY 1970-95 period, the Pacific West accounted for almost half (49.6 percent) of all fire-related expenditures *(fig. 4)*. The East accounted for the least (8.0 percent) while the Interior West (32.4 percent) and the WO+ (10.0 percent) constituted the mid-range. Additionally, just as overall fire-related expenditures increased substantially between FY 1970-74 and FY 1991-95, region expenditures also increased. For example, fire-related expenditures in the Pacific West averaged $53.3 million annually during FY 1970-74, but rose to $248.8 million annually during FY 1991-95, an average 14.7 percent annual increase. The Interior West and East displayed similar growth rates, 13.3 percent and 15.6 percent, respectively. But the highest increases in fire-related expenditures occurred in the WO+ region: 5.8 percent of all expenditures during FY 1970-74, but rising to 12.0 percent by FY 1991-95; this doubling represents an average growth of 36.7 percent annually.

Clearly, the increase in fire-related expenditures was not uniform within fire activities nor among regions *(table 2)*. Overall, annual average expenditures increased by $197 million per year. The overall expenditure changes in R-5 alone accounted for about one-third of all changes. Overall, annual FFF expenditure increased by $122 million, representing more than half (61.7 percent) of all changes. Within FFF, expenditure increases by R-5 accounted for about one-third of all FFF increases and one-fifth of the overall total change. FFF increases by R-5 were followed closely by increases in the WO+ region (23.0 percent of total). More than one-third of FFP increases were accounted for by R-5, which also

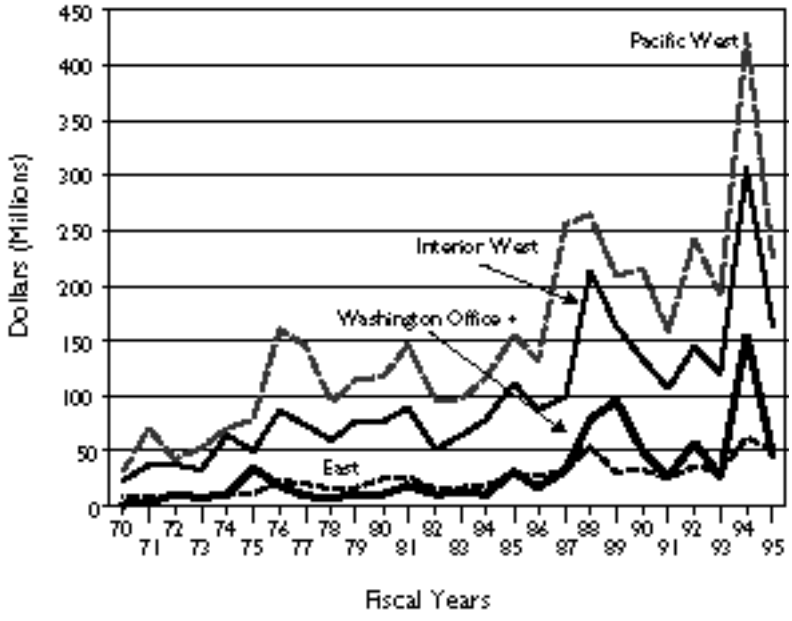


Figure 4—Regional fire-related expenditures, FY 1970-95, by year.

Table 2–*Total and percentage distribution of annual forest fire protection (FFP) and fighting forest fires (FFF) expenditure changes (1995 dollars), FY 1970-74 relative to FY 1991-95.*

Forest Service region	Expenditure change			Percent distribution		
	FFP	FFF	Total	FFP	FFF	Total
1	$4,368,556	$7,405,640	$11,774,196	2.22	3.76	5.97
2	1,048,424	2,327,214	3,375,638	0.53	1.18	1.71
3	11,120,507	(3,096,944)	8,023,562	5.64	-1.57	4.07
4	5,419,943	21,701,514	27,121,456	2.75	11.01	13.76
5	25,381,642	38,923,201	64,304,843	12.87	19.74	32.62
6	14,626,952	5,711,209	20,338,162	7.42	2.90	10.32
7	2,479,637	10,207,233	12,686,869	1.26	5.18	6.43
8	(797,574)	3,330,754	2,533,180	-0.40	1.69	1.28
10	218,101	1,592,143	1,810,245	0.11	0.81	0.92
WO+	11,567,624	33,620,973	45,188,598	5.87	17.05	22.92
Total	**$75,433,813**	**$121,722,937**	**$197,156,750**	**38.26**	**61.74**	**100.00**

accounted for 13.0 percent of the total increase. Average annual FFF expenditures in R-3 actually decreased, as did FFP expenditures in R-9.

Fund Code and Work Activity Classes

Accounting records for fire-related expenditures were organized at three levels. The broadest level corresponded to Congressional appropriations; this level identified the *source* of funds and was referred to as "fund codes" (or previously as "appropriation codes"), such as FFP and FFF. Fire-related expenditures were made for a specific purpose, such as fire detection. These *purposes* were referred to as "work activities" (or previously as "major functions"). Hundreds of work activities have been described and codified in Forest Service manuals. Work activity codes were not designed for the exclusive use of any particular functional area within the Forest Service. For example, both F&AM and Timber Management may use the work activity code pertaining to fuels improvement activities. The most specific level of expenditure information is the budget object code (BOC). BOC's refer to the *kind* of expenditure, such as personnel compensation. There are hundreds of BOC's organized in numerical codes and listed in the Forest Service Manual. Fire-related expenditures are specified by BOC (kind), associated with a work activity (purpose), and charged to a fund code (source).

Work activities were aggregated within the major fund codes because they are easier to assess if combined and so that changes in the definitions of work activities (as the accounting system evolves to meet the need for more- or less-detailed information) remain within an aggregate. For instance, FFP included Presuppression (the aggregate) expenditures for preventing, detecting, dispatching, planning, training, overhead, and staffing the initial attack organization (individual work activities). The initial attack organization includes recruiting, hiring, training, personnel compensation, equipment, and other such resources. Fuels improvement refers to actions that reduce fire hazard, such as prescribed burning. FFF includes Suppression expenditures such as those incurred after a natural fire has been declared a "wildfire" (burning out of prescription), or when Presuppression funds are inadequate for initial attack. Emergency fire Rehabilitation expenditures prevent additional damage resulting from suppression actions by performing activities such as repairing trails and fences, water-barring fire lines, and repairing drainage ditches. Severity

expenditures are emergency presuppression actions needed because of higher-than-average fire danger and potential fire severity. Economic efficiency expenditures are used to provide non-emergency presuppression capability, resulting from an imbalance between FFP and FFF appropriations. The "Other" categories consist of work activities that did not clearly fit other categories, such as PL-132 Law Enforcement.

Overall expenditures (nominal dollars) were tallied for the FFP and FFF fund codes and the aggregates of work activities within each *(table 3)*. Some codes were not functional for all years in the study. For example, Severity begins in FY 1987, but did not exist in prior years. Expenditures in constant, 1995 dollars were also tallied *(table 4)* and can be used to assess changes in "real" fire-related expenditures.

Forest Fire Protection—During the FY 1991-95 time period, Presuppression (including Severity and Economic Efficiency) dominated FFP expenditures; Presuppression activities accounted for 86.5 percent of all FFP expenditures, and Fuels Improvement accounted for 4.5 percent *(fig. 5)*. Average annual Presuppression expenditures over this period were $213.2 million while Fuels Improvement averaged $11.2 million. Though nominal Presuppression expenditures have been increasing, the real value of both Presuppression and Fuels Improvement has been decreasing over the past decade *(table 4)*. Even with the addition of Severity and Economic Efficiency, which causes the real value of FFP expenditures to increase in FY 1991-95, there has been a statistically non-significant linear decrease in both overall FFP ($p = 0.17$) and Presuppression ($p = 0.36$) expenditures from FY 1977 to FY 1995. Real Fuels Improvement expenditures, which generally account for the difference between FFP and Presuppression expenditures, showed a statistically significant ($p = 0.00$) linear decline over that time period.

The most notable aspect of Presuppression (including Severity and Economic Efficiency) expenditures are the sharp increases in FY 1977. This increase reflects increased fire presuppression appropriations after the large fires of 1967, 1970, and 1972, and the 1972 fire re-planning effort that recommended increased presuppression resources. In FY 1972, the "10:00 a.m." policy was replaced by a policy of "appropriate suppression response" for escaped fires and start of a planning standard of a 10-acre average fire size. In FY 1978, the appropriate suppression discretion was extended to initial attack. Expenditure increases were probably caused by pre-attack planning.

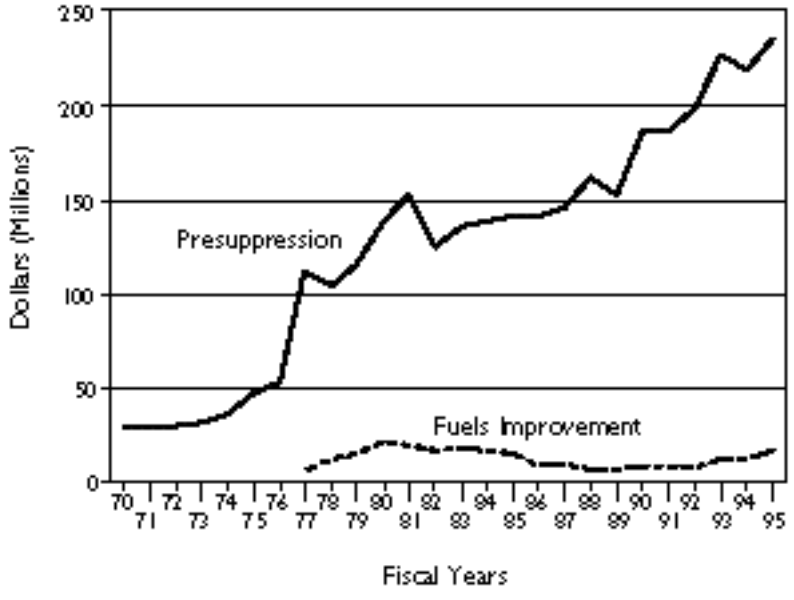


Figure 5—Fire protection expenditures, FY 1970-95, by year. Presuppression includes Economic Efficiency and Severity.

Table 3—*Forest Service fire protection (FFP) and fire fighting (FFF) expenditures, FY 1970-95, by work activity class of expenditure*

Fiscal year	Forest fire protection (FFP)				Fighting forest fires (FFF)						
	Presuppression	Fuels	Other	FFP total	Suppression	Rehabilitation	Severity	Economic efficiency	Other	FFF total	Total
1970	$28,234,106	—[1]	$4,445,903	$32,680,009	$27,425,705	—	—	—	$1,047,642	$28,473,346	$61,153,355
1971	30,139,322	—	4,473,166	34,612,488	82,929,089	—	—	—	2,388,901	85,317,990	119,930,478
1972	30,194,836	—	3,600,472	33,795,307	60,508,114	—	—	—	3,011,878	63,519,992	97,315,300
1973	31,618,290	—	3,531,627	35,149,917	62,141,570	—	—	—	2,039,041	64,180,611	99,330,528
1974	35,864,090	—	3,920,551	39,784,641	110,053,738	—	—	—	5,304,559	115,358,298	155,142,939
1975	47,020,132	—	7,038,127	54,058,259	114,479,335	—	—	—	4,327,533	118,806,868	172,865,127
1976	38,354,111	—	7,607,043	45,961,154	150,803,587	—	—	—	2,846,854	153,650,440	199,611,595
1976TQ[2]	13,781,468	—	2,393,159	16,174,628	70,200,929	—	—	—	1,637,354	71,838,283	88,012,911
1977	111,254,555	$5,368,327	27,638,582	144,261,463	95,435,588	$695,522	—	—	7,153,621	103,284,730	247,546,194
1978	104,541,207	11,528,545	27,951,880	144,021,631	27,683,921	630,858	—	—	2,757,934	31,072,712	175,094,344
1979	115,288,501	14,666,134	1,892,465	131,847,100	80,339,053	315,594	—	—	4,876,425	85,531,072	217,378,172
1980	138,338,458	21,088,634	1,701,487	161,128,578	63,375,264	1,365,721	—	—	4,448,703	69,189,688	230,318,266
1981	151,709,352	19,549,933	1,706,274	172,965,559	97,822,618	1,233,216	—	—	7,097,326	106,153,161	279,118,720
1982	124,894,897	16,297,431	1,697,601	142,889,929	27,158,985	102,785	—	—	2,563,927	29,825,697	172,715,626
1983	135,081,899	17,833,106	1,842,345	154,757,350	31,803,617	126,220	—	—	3,371,171	35,301,008	190,058,358
1984	139,024,025	17,180,623	1,609,182	157,813,830	62,011,053	215,743	—	—	4,037,359	66,264,155	224,077,985
1985	141,477,807	15,030,631	1,809,327	158,317,765	160,473,143	1,018,2521	—	—	5,208,929	166,700,324	325,018,090
1986	140,804,355	8,545,330	1,646,807	150,996,491	110,252,540	1,371,391	—	—	3,726,411	115,350,342	266,346,834
1987	145,674,975	9,499,856	1,637,070	156,811,902	252,402,013	622,714	$631,523	—	7,163,465	260,819,714	417,631,616
1988	150,798,495	6,685,323	6,404,090	163,887,908	413,603,414	5,021,616	10,995,388	—	12,937,987	442,558,406	606,446,315
1989	144,755,945	6,522,766	7,816,133	159,094,843	317,762,959	6,628,811	7,280,089.	—	7,933,617	339,605,476	498,700,319
1990	158,824,765	7,887,609	10,107,657	176,820,031	219,750,976	2,409,328	27,342	—	4,145,530	25,3647,506	430,467,537
1991	162,674,056	7,835,434	11,409,651	181,919,141	109,938,530	1,072,363	23,408,706	—	1,330,183	135,749,784	317,668,925
1992	169,620,330	7,451,460	11,453,032	188,524,822	254,825,229	1,903,222	29,160,878	—	4,947,494	290,836,823	479,361,645
1993	164,620,006	12,362,925	11,981,434	188,964,364	108,512,905	7,524,319	3,400,296	$58,713,435	1,945,496	180,096,452	369,060,817
1994	141,293,264	11,465,698	35,816,289	188,575,251	667,557,238	9,505,075	6,225,922	71,624,390	7,613,072	762,525,698	951,100,949
1995	105,486,062	16,643,994	39,829,271	161,959,327	167,660,724	12,768,948	4,778,848	125,058,586	12,364,110	322,631,218	484,590,545

[1]Work activity class did not exist.
[2]TQ=transition quarter

Table 4—*Forest Service fire protection (FFP) and fire fighting (FFF) expenditures (1995 dollars), FY 1970-95, by work activity class ofexpenditure*

Fiscal year	Forest fire protection (FFP)				Fighting forest fires (FFF)						
	Presuppression	Fuels	Other	FFP total	Suppression	Rehabilitation	Severity	Economic efficiency	Other	FFF total	Total
1970	$102,669,477	—[1]	$16,166,919	$118,836,395	$99,729,835	—	—	—	$3,809,606	$103,539,441	$222,375,837
1971	103,984,722	—	15,433,027	119,417,749	286,116,533	—	—	—	8,242,031	294,358,564	413,776,313
1972	99,611,829	—	11,877,846	111,489,674	199,614,398	—	—	—	9,936,092	209,550,490	321,040,164
1973	97,993,731	—	10,945,478	108,939,209	192,593,728	—	—	—	6,319,546	198,913,274	307,852,483
1974	102,240,614	—	11,176,625	113,417,239	313,738,942	—	—	—	15,122,129	328,861,072	442,278,311
1975	122,328,798	—	18,310,575	140,639,373	297,832,417	—	—	—	11,258,622	309,091,040	449,730,412
1976	93,868,570	—	18,617,620	112,486,190	369,079,523	—	—	—	6,967,444	376,046,967	488,533,157
1976TQ[2]	33,729,024	—	5,857,063	39,586,087	171,811,069	—	—	—	4,007,292	175,818,360	215,404,448
1977	254,751,037	$12,292,413	63,286,914	330,330,364	218,528,716	$1,592,608	—	—	16,380,384	236,501,708	566,832,072
1978	221,911,683	24,471,869	59,334,007	305,717,559	58,765,205	1,339,134	—	—	5,854,320	65,958,660	371,676,219
1979	225,296,613	28,660,537	3,698,252	257,655,402	156,998,454	616,733	—	—	9,529,502	167,144,690	424,800,092
1980	246,964,053	37,647,770	3,037,521	287,649,344	11,3138,547	2,438,108	—	—	7,941,896	123,518,551	411,167,895
1981	246,119,101	31,715,988	2,768,100	280,603,189	158,698,291	2,000,655	—	—	11,514,039	172,212,986	452,816,174
1982	190,770,248	24,893,451	2,592,994	218,256,693	41,483,891	156,999	—	—	3,916,260	45,557,151	263,813,844
1983	198,285,357	26,177,036	2,704,360	227,166,753	46,684,208	185,277	—	—	4,948,507	51,817,993	278,984,746
1984	195,550,276	24,166,151	2,263,465	221,979,892	87,224,339	303,462	—	—	5,678,923	93,206,724	315,186,616
1985	191,834,315	20,380,517	2,453,324	214,668,156	217,590,702	1,380,681	—	—	7,062,955	226,034,338	440,702,494
1986	185,995,432	11,287,949	2,175,349	199,458,730	145,638,029	1,811,538	—	—	4,922,401	152,371,969	351,830,699
1987	186,463,969	12,159,816	2,095,449	200,719,234	323,074,576	797,073	$808,350	—	9,169,235	333,849,234	534,568,468
1988	185,776,780	8,236,009	7,889,544	201,902,332	509,540,299	6,186,399	13,545,811	—	15,939,002	545,211,511	747,113,843
1989	170,771,990	7,695,060	9,220,875	187,687,925	374,872,431	7,820,164	8,588,493	—	9,359,475	400,640,562	588,328,487
1990	179,431,332	8,910,980	11,419,065	199,761,376	248,262,356	2,721,924	30,889,092	—	4,683,388	286,556,759	486,318,136
1991	177,060,197	8,528,363	12,418,668	198,007,228	119,660,985	1,167,198	25,478,865	—	1,447,818	147,754,867	345,762,095
1992	179,581,491	7,889,057	12,125,625	199,596,173	269,790,151	2,014,991	30,873,387	—	5,238,041	307,916,570	507,512,743
1993	170,618,306	12,813,396	12,418,004	195,849,705	11,2466,816	7,798,484	3,524,194	$60,852,792	2,016,385	186,658,671	382,508,377
1994	143,422,187	11,638,457	36,355,948	191,416,591	677,615,595	9,648,292	6319,730	72,703,585,	7,727,782	774,014,983	965,431,574
1995	105,486,062	16,643,994	39,829,271	161,959,327	167,660,724	12,768,948	4,778,848	125,058,587	12,364,110	322,631,218	484,590,545

[1]Work activity class did not exist.
[2]TQ=transition quarter

Expenditure information for Fuels Improvement begins in FY 1977. But that does not mean activities to improve fuels did not occur before FY 1977. Rather, before FY 1977 all FFP-related expenditures were controlled by timber management staffs, not by F&AM Staffs. Because timber management staffs also conduct fuels improvement activities not related to fire protection (e.g., slash reduction in timber sales), the accounting system could not distinguish between timber-related fuels improvement from fire-related fuels improvement. (In FY 1977, FFP appropriations came under the control of F&AM.) During FY 1977-81, Fuels Improvement expenditures averaged $14.4 million annually; during FY 1991-95 expenditures averaged $11.1 million annually. This difference represents an annual average decrease of 1.3 percent in nominal dollars, and a 3.2 percent annual decrease in constant, 1995 dollars.

Though labeled "presuppression," some expenditures contained in Presuppression are actually for suppressing forest fires. For example, the work activity covering fire suppression (PF12) constituted 2.2 percent of the Presuppression expenditures for the period FY 1991-95. This situation results from fiscal and accounting conventions. Fire suppression activities are charged to Presuppression for the base salary (the first 8 hours) of FFP-funded, initial-attack personnel. Overtime, hazard pay, and any other expenses not included in the FFP budget are charged to Suppression in the FFF budget. Additionally, if FFP-funded presuppression personnel are replaced at their home unit by backup personnel, backup personnel expenses are charged to Presuppression and all personnel expenses for the original presuppression personnel are charged to FFF-Suppression.

Fighting Forest Fires—Expenditures related to FFF are more difficult to evaluate at the level of work activity aggregates than were FFP expenditures because only one aggregate, Suppression, has existed over the entire FY 1970-95 time period. Rehabilitation was formally recognized in FY 1977; Severity began in FY 1987, and Economic Efficiency began in FY 1993. In the case of Rehabilitation, work activity 094 did not exist before FY 1977, so any rehabilitation work was charged to another code. Work activity 111, used to measure Severity, existed before FY 1987, but could not be used with FFF appropriations. And PF114, used for Economic Efficiency, existed in FY 1991, but was rarely used until FY 1993 when it was designated for use with Economic Efficiency.

Since FY 1970, Suppression has accounted for 95.6 percent of all FFF (excluding Severity and Economic Efficiency) expenditures, and 50.1 percent of all fire-related expenditures *(fig. 6, table 3)*. Using annual average expenditures during FY 1970-74 to represent FY 1970 and FY 1991-95 to represent FY 1995, Suppression expenditures grew at an average annual rate of 11.4 percent. During the FY 1991-95 period, Suppression accounted for 95.6 percent of FFF expenditures (excluding Severity and Economic Efficiency) and 50.3 percent of all fire-related expenditures. In contrast, Rehabilitation accounted for a scant 1.3 percent of the total. Suppression expenditures peaked in FY 1994 and Rehabilitation expenditures in FY 1995.

Suppression expenditures should be interpreted cautiously. There is a statistically significant ($p = 0.00$) positive linear trend in the (nominal) Suppression expenditures *(fig. 6)*. However, in constant, 1995 dollars, we found no statistically significant ($p = 0.36$) trend. In fact, except for FY 1988 and FY 1994, real Suppression expenditures vary quite closely around the mean of $230 million (1995 dollars) *(table 4)*.

Non-F&AM Fire-Related Expenditures—Because F&AM was not the only functional unit with fire-related expenditures, our assessment was probably understated, especially for FFP activities. Although a thorough evaluation of non-F&AM fire-related expenditures is beyond the scope of this study, expenditure data from R-1 provide some insight. In FY 1990 and FY 1993 about

31.5 percent of the main forest protection expenditures (the PF1s and PF2 work activities) were accounted for by non-F&AM units:

	Protection Expenditures
F&AM	$26,919,000
Non-F&AM	12,369,000
TOTAL	$39,288,000

Seven non-F&AM fund codes were used, including Brush Disposal (BDBD), Knutson-Vandenberg (CWKV), Cooperative Work (CWFS), Recreation Management (NFRN), Wildlife Habitat Operations and Improvement (NFWF), Anadromous Fish (NFAFO), and Restoration of Improvements (RIRI). In total, Brush Disposal accounted for 99.3 percent of all non-F&AM expenditures.

Fire Suppression Expenditures

To this point, we have focused on fire-related expenditures in terms of fund codes and aggregates of work activities. We now turn to a more in-depth look at the most expensive of all work activity aggregates, fire Suppression, and shift our focus to expenditures in budget object codes. We used two samples of fires. One sample consisted of 171 large and medium fires, randomly selected from the FY 1993-94 fire seasons. The other sample contained 20 very expensive fires from the FY 1994 fire season which were examined in detail. Data on individual fire characteristics (size, fuels, etc.) were obtained from the Individual Fire Report (Forest Service form SF 5100-29) database. Expenditure data on individual fires were obtained from the CADI-Fire database.

Types of Expenditures

Fire suppression expenditures for fires studied were identified through a series of queries in the Forest Service's accounting system database. In the 171-fire sample, budget object codes were aggregated into five categories. In the 20-fire sample, expenditures were aggregated into 47 more specific categories. The number of budget object categories is important to database queries because of complexity; the 47-category query is far more complex than the five-category query. In addition, because database queries for the 171-fire sample and the 20-

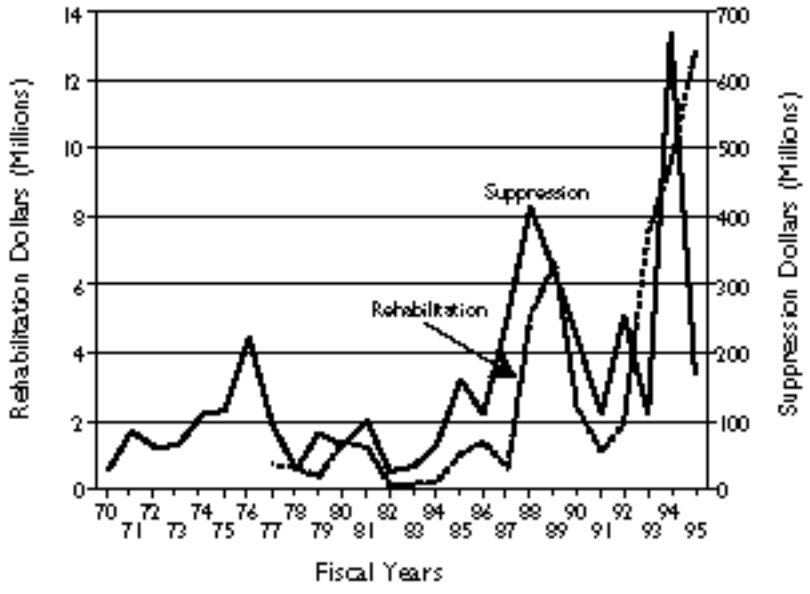
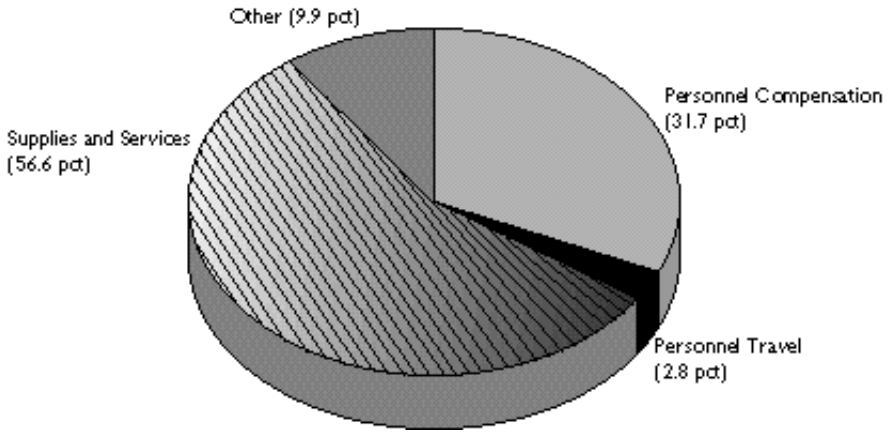


Figure 6—Fire-fighting expenditures, FY 1970-95, by year.

Figure 7—Distribution of FFF suppression costs for 171



fire sample focused on FFF-suppression expenditures exclusively and FFP-suppression expenditures were not assessed, our results somewhat understate the actual magnitude of suppression expenditures.

171 Fires—In our study of 171 fires, the original fifth category included aviation services, contracts, and fuel. But in the course of our study, we found numerous coding errors and inconsistencies such that aviation-related expenditures had to be aggregated into Supplies and Services *(fig. 7)*. Therefore, more than half (55.6 percent) of all fire suppression expenditures were for Supplies and Services. This includes aviation expenditures, along with purchase of equipment, food-supply contracts, and so on. The second most important category was Personnel Compensation, constituting 31.7 percent of fire suppression expenditures on large fires. If Personnel Travel (per diem, lodging, and so on) were added to Personnel Compensation, personnel-related expenditures would amount to more than one-third of the fire suppression expenditures. The Other category, about 10 percent of suppression expenditures, included insurance claims and interest payments.

The 171-fire sample was also divided into major components on the basis of fire size and fuel type. We developed expenditure data for Supplies and Services, Personnel Compensation, Personnel Travel, and Other for large (1,000 acres and more) and medium-sized (100-999 acres) grass/brush and woods/slash fires. Those four individual patterns of expenditures did not differ from the pattern shown in *figure 7*.

20 Fires—The 20 very expensive fires in FY 1994 consisted of the five most expensive fires from Forest Service regions R-1, R-3, R-4, and R-6. Results from the 20-fire sample were very compatible with those from the 171-fire sample *(table 5)*. For example, Personnel Compensation (Budget Code 1100) plus Personnel Benefits (Budget Code 1200) for the 20-fire sample totalled 28 percent of the expenditures, as compared to 31.7 percent from the 171-fire sample. Premium Overtime (Budget Code 1170) pay and pay to Casual Employees (Budget Code 1193) account for 21 of the total 28 percent for Personnel Compensation; full-time employees account for only 4 percent *(table 5)*. Similarly, Contractual Services-Other (Budget Code 2540) accounts for about 86 percent (49 of the 57 percent) of total expenditures accounted for by Other Services (Budget Code 2500). Combined, expenditures for those contractual services and the two types of personnel amount to 79 percent of fire suppression expenditures.

Table 5—*Distribution of fire suppression costs from 20 large fires, in 1994, by budget object code*

Budget code	Description	Suppression cost	Percent cost
100	Operating Income	$(24,049)	-0
200	Inter-Office/Region	(1,131,451)	-1
1100	Personnel Compensation	61,786,386	28
1101	Full-time	8,168,546	4
1121	Full-time temporary	2,537,886	1
1165	Hazard pay differential	3,213,158	1
1170	Premium overtime non-wage board	24,017,015	11
1193	Casual employees	21,885,434	10
	All other	1,964,347	0
1200	Personnel Benefits	3,579,865	2
1400	Commissary Deductions	(142,393)	-0
2100	Travel/Transport People	7,590,302	3
2111	Common carrier-domestic	3,365,029	2
2131	Per diem allowance-domestic	925,708	0
2160	Vehicular transport	2,926,440	1
	All other	373,125	0
2200	Transportation of Things	4,755,124	2
2220	All other transportation of things	1,602,629	1
2231	Truck rental-commercial	3,074,249	1
	All other	78,248	0
2300	Rent, Communications & Utility	6,720,104	3
2320	Communication services	183,077	0
2360	Rent equipment	4,813,616	2
	All other	1,723,411	1
2400	Printing/Reproduction	38,180	0
2500	Other Services	125,506,086	57
2513	WCF Equipment & FOR[1]	1,259,696	1
2540	Contractual services-other	107,145,285	49
2541	Flying contracts	3,870,056	2
2550	Agreements	3,417,727	2
2570	Misc. services	2,142,008	1
2576	Medical and dental care	590,785	0
	All other	7,080,529	3
2600	Supplies	9,234,668	4
2610	Supplies-energy	174,447	0
2614	Gasoline	627,891	0
2615	Diesel	396,717	0
2616	Aviation fuel	680,689	0
2670	Supplies/materials	7,125,225	3
2680	GSA-Fedstrip supply[2]	179,051	0
	All other	50,648	0
3100	Equipment	220,250	0
3200	Land & Structures	4,276	0
4100	Grants, Subsidies, & Contribution	969,070	0
4200	Insurance Claims & Indemnities	375,489	0
4300	Interest & Dividends	13,904	0
4400	Refunds	18,440	0
	Total	$219,514,251	100

[1]WCF=working capital fund; FOR=fixed overhead rate.
[2]GSA=General Services Administration.

Expenditures Per Acre

We were also interested in understanding the relationship between fire suppression expenses and fire-specific characteristics, especially fire size. The idea was to obtain expenditure information from the accounting system (CADI-Fire) and fire-specific information from the National Interagency Fire Management Integrated Database (NIFMID), but the two systems are not completely compatible. Specifically, information on fire size from NIFMID includes all fire acreage, National Forest and any other lands within the fire's boundary. On the other hand, expenditure information from the accounting system pertains to the Forest Service expenses only. Therefore, the expenditure information available must equal or understate the true expenditures incurred in suppressing fires.

The Forest Service incurred an average expense of $267 per acre of fire to suppress large- and medium-sized fires in FY 1993-94 *(table 6)*. Suppression expenditures (per acre) for fires occurring in woods/slash fuels are about two-thirds more expensive than fires in grass/brush. Similarly, suppression expenditures (per acre) for large fires are only about one-fourth those of medium ones. Does this mean that large fires and woods/slash fires are less expensive to the Forest Service? Yes. Does it mean that those fires are less expensive, overall, to suppress? Possibly not. Certainly, conventional wisdom attributes those decreases to "economies of scale," that decreasing expenditures per acre result from spreading fixed suppression expenditures over a larger acreage base. But other factors might also affect expenditures for large fires: as fires become larger, other agencies become increasingly involved and there may be little or no payment of suppression funds to those agencies; and because fire size is measured on the basis of a gross perimeter, as fires become larger, increasing amounts of unburned lands are included in the calculation of the fire's acreage. Both factors tend to make large fires seem less expensive to suppress on a per-acre basis.

One of the purposes for our analysis of per-acre fire expenditures was to assess the quality of suppression expenditure estimates contained in the NIFMID database. These estimates are widely regarded as unreliable. However, the correlation between uncorrected, NIFMID-based expenditures and those from the accounting system is 0.85, a surprisingly high level. A comparison of estimates of per-acre suppression expenditures on the 171 fires from the CADI-Fire accounting system with two NIFMID-based shows:

Database	*Per acre*
CADI-Fire	$267.08
NIFMID, uncorrected	$296.97
NIFMID, corrected	$294.84

The uncorrected NIFMID estimate is 11.2 percent higher than the accounting system's estimate, partially because it does not correct for duplicated or corrupted records associated with fires that are part of a "complex" of fires. After that correction was made, NIFMID produced an estimate that was 10.4 percent

Table 6—*Forest Service suppression expenditures per acre, by size class and fuel type, FY 1993-94*

Size class	Fuel type		
	Grass/brush	Woods/slash	Total
Medium	$1005.67	$1027.38	$1,014.50
Large	154.35	302.08	251.44
Total	$184.11	$311.35	$267.08

higher than the accounting system estimate. Because fire expenditures continue to be added to the accounting system database but not to NIFMID, per-acre expenditure estimates can only converge over time. Note, however, that although the per-acre expenditure estimates shown above are reasonably close, none deal with the understatement problem discussed earlier.

Expenditure-Increasing Factors

What causes fire suppression expenses to increase? An understanding of these causes may be key to identifying policies and procedures aimed at reducing or controlling fire suppression expenditures. We addressed this problem through a questionnaire administered to incident commanders (IC's), the persons in overall control of suppression activities on fires. We surveyed the IC's from 84 (the large FY 1994 fires) of the 171 fires selected in the detailed expenditure analyses. Respondents rated 34 topics or issues in terms of their role in increasing suppression expenses on the fire(s) for which they were responsible. The rank of each issue was determined on the basis of median rating, and mean ratings were used to break ties.

Data were grouped in one of three sets of rankings: overall, those for the seven most expensive fires, and those for the seven least expensive fires *(table 7)*. Only two overall issues had a median rating of "very important" (rating of 5) in increasing suppression expenditures: Weather During Fire and Access. Only two issues had a median rating of "moderately unimportant" (rating of 2): Air Quality Standards and Protecting Livestock. None of the issues received an overall rating of "very unimportant" (rating of 1). Twelve issues received an overall rating of "moderately important" (rating of 4) and 17 issues received a neutral rating of 3. Except for Weather During Fire, every issue received the full range of ratings, from "very unimportant" to "very important." The lowest rating given to Weather During Fire was "moderately unimportant."

Issues should be evaluated both in terms of their influence on fire suppression expenditures, and in terms of the ability of the Forest Service to influence outcomes. For example, Weather During Fire is clearly the most important issue studied, but it cannot be influenced by Forest Service actions. On the other hand, while the Forest Service can influence Forecasting/Decision Tools, that issue has only a neutral effect on suppression expenditures.

The overall ranking pertains to all 84 fires studied. Do these rankings change when only the most or least expensive of those fires are considered? Weather During Fire was the most highly rated issue with both the seven most expensive fires and the seven least expensive fires *(table 7)*. Beyond that similarity, differences are substantial. For the most expensive fires, Threatened and Endangered Species Standards, Protecting Structures, and Water Quality Standards were more important than in the overall ratings. For the least expensive fires, Protecting Lives and Fire Suppression Standards were more important than in the overall ratings.

We found differences in individual issues, but they do not illuminate patterns of response *(table 7)*. Issues with a common theme were also grouped and arranged in order of importance *(table 8)*. The first two groupings deal with fire-specific circumstances, and both have a very important effect on suppression expenses. They differ in that the Forest Service has some ability to influence Access/Fuel, but it cannot affect Weather/Terrain. Similarly, the Firefighter, Interface, and Availability groupings had a moderately important effect on suppression expenditures and can be influenced by the Forest Service. The Resource Availability grouping is distinct from those of quantity and quality of firefighting resources; the availability of those resources when they are needed has a moderately important effect on suppression expenses. All other groupings had a neutral effect on increasing suppression expenditures.

Table 7— ***Importance of issues and topics in increasing fire suppression costs for large 1994 fires.***

	Overall			Seven most expensive fires			Seven least expensive fires		
Topic or issue	Rank	Median	Mean	Rank	Median	Mean	Rank	Median	Mean
Weather during fire	1	5	4.53	1	5	4.80	1	5	4.86
Access	2	5	4.10	2	5	4.70	4	5	4.57
Terrain	3	4	4.18	3	5	4.65	9	4	4.14
Protecting lives	4	4	4.10	10	4	3.85	1	5	4.86
Line-officer direction	5	4	3.82	11	4	3.8	20	3	3.43
Firefighter availability	6	4	3.80	6	4	3.95	5	5	4.43
Fire suppression standards	7	4	3.79	14	4	3.65	3	5	4.71
Fuel loadings	8	4	3.76	8	4	3.9	20	3	3.43
Firefighter quality	9	4	3.70	12	4	3.75	9	4	4.14
Firefighter quantity	9	4	3.70	8	4	3.90	19	3	3.86
Protecting structures	11	4	3.69	5	4	4.00	24	3	2.86
Support personnel availability	12	4	3.54	21	3	3.00	17	4	3.29
Wildland/urban interface	13	4	3.45	12	4	3.75	34	1	2.43
Publicity/notoriety	14	4	3.35	17	3	3.25	18	4	3.14
Recreational/esthetic values	15	4	3.30	19	3	3.05	12	4	3.86
Equipment availability	16	3	3.52	23	3	2.95	5	5	4.43
T&E species standards[1]	17	3	3.48	4	5	4.50	7	5	4.14
Communications	18	3	3.43	27	3	2.80	13	4	3.71
Previous decisions	19	3	3.38	16	3	3.45	32	3	2.43
Equipment quantity	19	3	3.38	24	3	2.85	9	4	4.14
Equipment quality	21	3	3.33	19	3	3.05	22	3	3.29
Ecosystem values	22	3	3.27	15	3	3.60	28	3	2.57
Support personnel quantity	22	3	3.27	24	3	2.85	27	3	2.71
Support personnel quality	24	3	3.22	29	3	2.60	24	3	2.86
Water quality standards	25	3	3.18	6	4	3.95	13	4	3.71
OSHA standards[2]	26	3	3.17	27	3	2.80	8	5	3.86
Forecasting/decision tools	27	3	3.04	21	3	3.00	24	3	2.86
Cultural/historic values	28	3	3.00	18	3	3.15	16	4	3.57
Penalty for failure	29	3	2.90	30	2	2.35	28	3	2.57
Wilderness values	30	3	2.80	24	3	2.85	23	3	3.00
Timber values	31	3	2.58	31	2	2.20	32	3	2.43
Rewards for success	32	3	2.36	34	1	1.70	28	3	2.57
Air quality standards	33	2	2.36	32	2	1.80	13	4	3.71
Protecting livestock	34	2	2.27	33	1	1.75	28	3	2.57

[1]T&E=threatened and endangered.
[2]OSHA=Occupational Safety and Health Administration.

Table 8—*Importance of groups of issues and topics in increasing fire suppression costs for large 1994 fires.*

	Original ratings			Grouping ratings	
Topic or issue	Rank	Median	Mean	Mean	Rating
Weather during fire	1	5	4.53	4.36	Very important
Terrain	3	4	4.18	4.36	
Access	2	5	4.10	3.93	Very important
Fuel loadings	8	4	3.80	3.93	
Firefighter availability	6	4	3.796	3.73	Moderately important
Firefighter quantity	9	4	3.70	3.73	
Firefighter quality	9	4	3.70	3.73	
Protecting lives	4	4	4.10	3.65	Moderately important
Protecting structures	11	4	3.69	3.65	
Wildland/urban interface	13	4	3.45	3.65	
Publicity/notoriety	14	4	3.35	3.65	
Firefighter availability	6	4	3.80	3.62	Moderately important
Equipment availability	16	3	3.52	3.62	
Support personnel availability	12	4	3.54	3.62	
Line-officer direction	5	4	3.82	3.42	Neutral
Communications	18	3	3.43	3.42	
Previous decisions	19	3	3.38	3.42	
Forecasting/decision tools	27	3	3.04	3.42	
Equipment availability	16	3	3.52	3.41	Neutral
Equipment quantity	19	3	3.38	3.41	
Equipment quality	21	3	3.33	3.41	
Support personnel availability	12	4	3.54	3.34	Neutral
Support personnel quantity	22	3	3.27	3.34	
Support personnel quality	24	3	3.22	3.34	
Fire suppression standards	7	4	3.79	3.20	Neutral
T&E species standards[1]	17	3	3.48	3.20	
Water quality standards	25	3	3.18	3.20	
OSHA standards[2]	26	3	3.17	3.20	
Air quality standards	33	2	2.36	3.20	
Recreational/esthetic values	15	4	3.30	2.87	Neutral
Ecosystem values	22	3	3.27	2.87	
Cultural/historic values	28	3	3.00	2.87	
Wilderness values	30	3	2.80	2.87	
Timber values	31	3	2.57	2.87	
Protecting livestock	34	2	2.27	2.87	
Penalty for failure	29	3	2.90	2.63	Neutral
Rewards for success	32	3	2.36	2.63	

[1]T&E=threatened and endangered.
[2]OSHA=Occupational Safety and Health Administration.

Fuels Management Expenditures

Concerns about ecosystem health have focused attention on fuels accumulation and the resulting hazard of catastrophic fires, especially in the western U.S. The costly 1994 fire season seemed to confirm these concerns and increased the demand for additional fuel treatments, which divide into two classes: **natural fuel treatment** refers to treating combustible wildland vegetation, either through prescribed natural fire or management-ignited prescribed fire; and **activity fuel treatment** refers to treating fuels resulting from management activities, such as timber harvest or road construction. Fuel treatments are funded in four ways: appropriated FFP funds are generally used for natural fuel treatments; brush disposal deposits (BD) resulting from timber sales are mainly used for activity fuel treatments; Knutson-Vandenberg (KV) funds from timber sales are also mainly used for activity fuel treatments; and other funds (e.g., wildlife or range) are used to accomplish specific management goals.

Comprehensive information on the extent and expense of fuel treatment does not exist. But available data for FY 1987-95 suggest that nearly 1 million acres of National Forest fuels are treated annually. About 70 percent of the fuel treatment acreage (about 673 thousand acres) is funded by either appropriated, FFP fuels improvement funds for natural fuel treatment or BD funds for activity fuels treatment. Although natural fuel treatment corresponds to use of prescribed fire, activity fuels treatment can involve chemical and mechanical treatments in addition to prescribed fire. The remaining 291,000 acres (about 30 percent) consist mainly of prescribed burning in R-8, funded by KV funds, timber management, or other resource functions, such as wildlife, range, and threatened and endangered species.

FFP expenditures for fuels management peaked in 1980 at $37.7 million (1995 dollars) *(table 4)*. Expenditures then dropped steadily until FY 1989 and increased steadily since FY 1992, with a sharp upturn in FY 1995. In 1995 dollars, FY 1995 expenditures were 29 percent higher that FY 1994, but still less than half of the FY 1980 level. R-5 accounted for the largest percentage increase, about 41 percent over FY 1994. Most regions experienced about a 30 percent increase in FFP funding, except for R-2 (14.6 percent) and R-10 (37 percent decrease). The acreage treated with FFP funds in FY 1995 was the highest recorded during the FY 1987-95 period. More than $16.6 million was expended for fuel treatment on 457,922 acres. Expenditures for BD-funded fuel treatment are not available.

Most fuels management is conducted with either appropriated FFP fuels improvement funds or with BD funds. An average of nearly 673,000 acres were treated annually from FY 1987-95, 53.6 percent from FFP funds and 46.4 percent from BD funds *(fig. 8)*. Acres shown in *figure 8* represent about 71 percent of the total acreage treated and 91 percent of the total expenditures on fuel treatment and prescribed burning in the National Forest System. Despite 3 consecutive years (FY 1992-94) of lower accomplishments (by about 100,000 acres), the total acreage of fuel treatment funded under these funds has remained relatively steady, with a coefficient of variation of less than 10 percent. The major trend has been the shift from BD to FFP-appropriated funding. The acreage treated with FFP-appropriated funds held steady through the late-1980's and almost doubled from FY 1992 to FY 1995. Appropriated fuels treatment averaged 360,779 acres annually. The acres treated with BD funds decreased from 351,697 acres in FY 1987 to 172,367 acres in FY 1995. As a percent of the total, BD-funded acres peaked in FY 1990 (57 percent) and decreased to 23 percent by FY 1995.

Because of reductions in Forest Service timber harvests, continued decreases in BD and KV funding of fuel treatments are probable. However, reduced harvests will also mean less need for slash reduction and site preparation burning, the types of activities most commonly funded by BD. Fuel treatment acreage in the western Forest Service regions (R-1 through R-6) is likely to shift

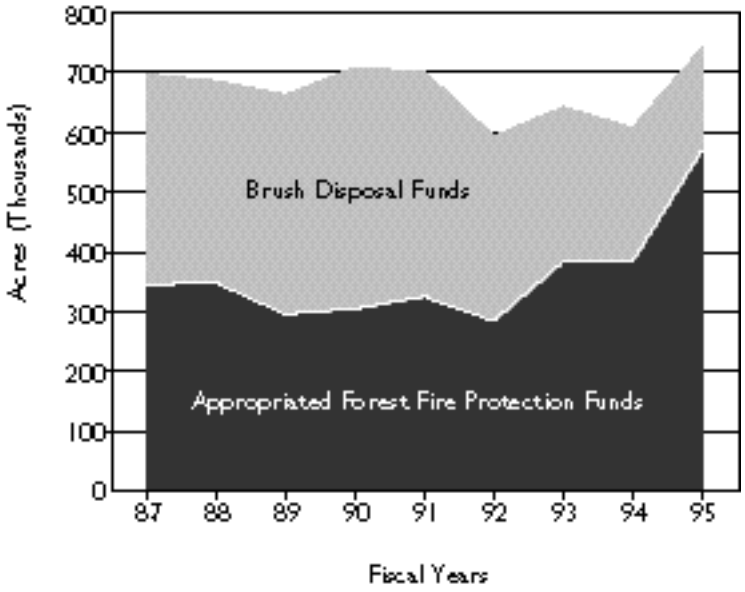


Figure 8—Acres treated for fuel management, FY 1987-95, by year.

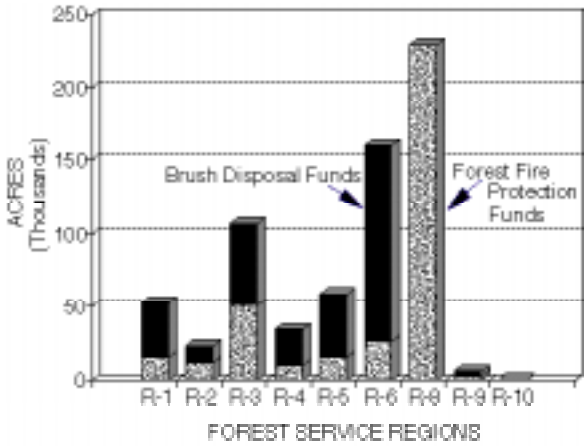


Figure 9—Average annual fuel management acres, FY 1987-95, by region.

more toward natural fuels treatment to achieve ecosystem management and forest health goals; benefitting functions may have to bear a larger part of the funding. More than half of the prescribed burning in the R-8 (not reflected in *fig. 8*) is funded through KV, an arrangement that may change as harvests in that region shift downward under new forest land management plans and the new red-cockaded woodpecker recovery plan.

The number of acres treated and the split between FFP-funded and BD-funded varies widely between regions *(fig. 9)*. Though the R-8 averages nearly 0.25 million acres annually, R-10 averages just a few thousand acres annually. R-8 treats the most acres, generally by underburning on gentle terrain in southern pine timber types. Forest Service records show prescribed burning on National Forests in R-8 average about 500,000 acres annually. Because FFP-funded acres *(fig. 8)* average about 229,536 acres and R-8 has no BD funding for fuel treatment, the remaining 270,000 acres of annual burning is funded through wildlife, threatened and endangered species, timber management/reforestation, recreation, range, and other accounts. An analysis of R-8 burning records for the period FY 1985-93 showed that 43 percent of the acres burned (about 215,000 acres per year) were primarily fuel-reduction burns. The next primary purpose was wildlife (30 percent), followed by control of undesirable species and range improvement (both at 8 percent), site preparation (5 percent), threatened and

endangered species (4 percent), pre-marking for timber sales (1 percent), and brown spot disease control (1 percent).

BD funds account for most of the fuel treatments in regions outside R-8 *(fig. 9)*. In Regions 1–6, fuel treatments (FY 1987-95) averaged 450,000 acres per year, with 70 percent (315,000 acres) accomplished from BD funds. Ninety-nine percent of the BD-funded fuel treatment is conducted in Regions 1–6 with R-6 accounting for 43 percent and R-3 for 18 percent. Regions 1–6 accomplished about 130,000 acres of FFP-funded treatment, with 40 percent accomplished by R-3. KV funds, cooperative funds, and other funding sources account for relatively little fuel treatment in western regions. As the amount of BD-funded fuel treatment decreases, these regions may have to compensate with FFP or other funds to meet natural fuels and ecosystem management burning objectives. Competition between regions for FFP and other funds may intensify.

R-6 has traditionally treated more acres than any other western region, about 84 percent (159,000 acres annually) with BD funds. R-6's fuel treatment program peaked in FY 1990 at 176,352 acres, and decreased to 103,178 acres in FY 1995. The percentage of BD-funded treatment has decreased from 86 percent in FY 1987 to 64 percent in FY 1995. R-3 has treated more FFP-funded acres than any western region, about 51,000 acres annually. About 47 percent of R-3 treatment acreage is FFP-funded.

FFP expenditures per acre treated vary widely between regions *(fig. 10)* (BD expenditures were not available.) Although R-10 had the highest per acre expenditure ($381 per acre) in 1995 constant dollars, it treated very few acres. At $130 per acre, R-5 was next highest and treated a substantial number of acres. R-2, R-4, R-6, and R-9 have similar expenditures, averaging between $47 and $71 per acre. R-1's per-acre expenditures were third highest, averaging $85 per acre. R-8 and R-3 have the lowest per acre expenditures, $13 and $23 per acre respectively, presumably because more of their burning program is conducted through underburning in lighter natural fuels.

Year-to-year variation in expenditures per acre is also quite high in some regions. For examples, R-1, R-5, R-6, and R-9 actually spent fewer FFP dollars per acre in FY 1994 than they did in earlier years. Variation in per-acre expenditures can be measured by the ratio of the variance of the annual estimates to their mean. This variation ranged from 54 percent in R-6 to 33 percent in R-2 and R-8.

The overall average (nominal dollar) FFP expenditure per acre in FY 1995 was $35.83, compared to an average expenditure in FY 1987 of $31.08, reflecting only a small increase. However, in 1995 constant dollars, per acre expenditures actually decreased in that period. For example, R-1 decreased from $137 to $53 per acre; R-2

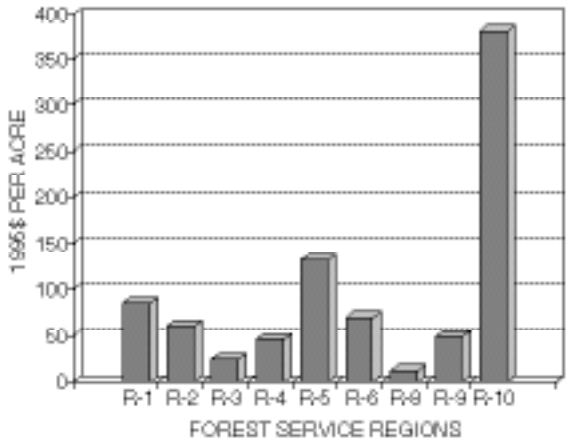


Figure 10—Average cost of FFP fuel treatment, FY 1987-95, by region.

from $90 to $58; R-5 from $128 to $116; R-6 from $91 to $71; and R-9 from $144 to $44 per acre. However, R-3 and R-8, which account for most of the FFP-funded treatment acres, have shown increases in constant dollar expenditures per acre. In 1995 dollars, R-3 expenditures increased from $17 per acre in FY 1987 to $20 in FY 1995; R-8 expenditures increased from $11 per acre to $15 in FY 1995. These data suggest that regions with the highest treatment activity are becoming more expensive, which will affect the amount of treatment that can be accomplished with limited budgets in the future. Factors accounting for increases in burning expenditures in R-8 include compliance with air quality regulations and the risk of liability for accidents, smoke intrusions, or escape fires (Cleaves and Haines 1995). Because of expenditure increases and budget reductions in public agencies, the more ambitious burning plans found in ecosystem assessments, forest plans, and species recovery plans may need to be re-evaluated.

Time-series trends that use per-acre expenditures should be interpreted cautiously. These numbers are single-year estimates and ratios of expended dollars to reported accomplishments. Changes in these ratios over time may reflect changes in the fuel treatment program's policy on burning in more natural fuels or conducting larger burns; changing ratios could also reflect year-to-year variations in accomplishment success.

Discussion

During our analysis of fire-related expenditures, a number of trends and concerns became apparent. These, combined with the other fire review recommendations, other policy directions, and Congress' desire to balance the national budget, have some important implications for fire management in the Forest Service.

Data Needs

Without reliable data, it is difficult to determine where and how expenditures can be reduced. The difficulty we had in assembling valid consistent data for this report highlights the need to improve existing reporting systems. Data had been lost or never gathered, too aggregated or of poor quality, and scattered or inconsistent over time. Other reports, such as the Strategic Assessment (USDA 1995b) and the Fire Management Policy Review (USDI/USDA 1995), have also noted this problem and include data management recommendations. In addition, as a result of these assessments, an interagency taskforce is being formed to address these needs. However, expenditure data may never be standardized among agencies because of their unique accounting systems. Furthermore, without additional resources and emphasis, data recording will always be the first action overlooked or postponed until later. Also, without some form of auditing, accuracy will always be suspect.

Long-Term Trends

The most obvious trend affecting expenditures is inflation. In recent years inflation has been about 3.6 percent per year (Council of Economic Advisors 1995). Although this rate may not seem high, the amount accumulates (more than 45 percent in the past decade). Thus, one of the major reasons fire management expenditures increased from $61 million in 1970 to $485 million in 1995 was inflation. Despite the fact that presuppression expenditures, net of inflation, were essentially level during this time period, we expect the inflation trend to continue increasing fire-related expenditures.

In addition, the incorporation of ecosystem management into fire planning is a long-term trend that has also increased expenditures. Pioneers viewed fire as a

tool for land clearing. But early forest protection efforts viewed wildfire as a hazard to the forests and grasslands so that excluding fire from wildlands became a goal of all land managers throughout most of this century. The policy of exclusion evolved to become an appreciation of the vital role of fire in maintaining some ecosystems. Some groups now blame many of our forest health problems and catastrophic wildfires on excessive exclusion of fire (Lyons 1994, Thomas 1994). As a result, the Forest Service has begun to emphasize fire use in wildland planning and is searching for ways to modify fire suppression activities in light of other values at risk. For example, the Los Padres National Forest employed up to 20 archeologists on a relatively small fire (Bell and others 1995); in our survey of incident commanders, protecting threatened and endangered species was considered the fourth-ranked cause of increased expenditures; and minimum impact suppression tactics (MIST) were thought to increase the likelihood of slopovers. The activities increase fire-related expenditures and will likely continue to increase expenditures as they become more prevalent.

Another trend involves increasing accumulation of wildland fuels. A number of reports (USDA Forest Service 1994, USDA Forest Service 1995b) have identified fuels buildup from the exclusion of fire as a major factor for the increase of the number and size of wildfires. This fuels buildup can only result in increased cost of fighting fires unless fuels are reduced. Unfortunately, fuel reduction is expensive. The fuels management appropriation has been only a small part of the overall fire budget. The sharp decline in BD and KV funding because of reduced harvests and the need to focus on more expensive treatments in the western regions will result in either dramatic increases in expenditures or dramatically reduced number of acres treated if current funding levels continue.

Rural urbanization, population growth, and the proliferation of structures in rural areas will also increase expenditures. As the Strategic Assessment (USDA 1995b) identified, the expanding population of the United States increasingly interfaces with wildlands that are subject to wildfires. Although this contact is particularly serious in the western regions, it is also a problem in some other parts of the country. Between 1970 and 1980 the population in rural counties increased by 23 percent (Bailey 1991). Human-caused fires in these areas are increasing and the property values at risk are becoming a dominant factor in fire suppression decisions. A larger portion of the Forest Service's fire protection resources are being used to protect life and property in the wildland-urban interface. Our survey of incident commanders revealed that factors associated with wildland urbanization are some of the most important contributors to fire suppression expenditures. Firefighting resources used to protect private property can dilute the ability to protect wildland resources or keep fires in prescription to accomplish ecosystem management objectives. Thus, either more damage will occur to the forest or total expenditures must be increased to accomplish both objectives.

And finally, global warming is another long-term trend that may affect expenditures. Although the preponderance of evidence seems to suggest that the climate is indeed warming, the rate at which it is happening and its effect on fire are unclear. Currently, extreme weather events seem to be commonplace, but it is debatable if this is a long-term trend or a climate aberration. In any case, our survey of incident commanders identified fire weather as the most important contributor to fire expenditures; unfavorable weather increases the expense of fire. Merely comparing a high and a low-expense fire-year ($66 million in FY 1984 to $763 million in FY 1994) shows that variations of an order of magnitude are possible. If this volatility continues or increases, fire managers can expect years with phenomenally higher expenses as well as perhaps irreversible human and natural resource losses.

Expenditure-Reducing Opportunities

Several reports contain more than 200 recommendations and action items oriented toward reducing fire management expenditures (Truesdale and others 1995, USDA Forest Service 1995a, USDA Forest Service 1995b, USDI/USDA 1995). Our investigation confirmed the value of many of these recommendations. Although we did not develop any new or unique approaches that were not already outlined in these reports, we have highlighted several that address the most compelling problems that surfaced in our expenditure analysis. Some important expenditure-related recommendations include:

- *Prescribed Burning*—Establish a landscape-scale prescribed burning program of 3 million acres annually by the year 2005. This program should be viewed as an investment. Though it would increase expenditures in the short-run, long-term costs along with resource and property damage should be reduced because of it. This program would represent a threefold to fourfold increase over present fuel treatment levels. Estimated expenses run to $200 million per year given current expenditures per acre. However, this level of funding is unlikely, given Congress' desire to balance the budget. Therefore, economic analysis must be used to allocate funding to treatment opportunities that are most efficient (USDA Forest Service 1995a).

- *Interface Partnerships*—Develop specific partnership agreements affecting the wildland-urban interface that clearly recognize the limited ability and responsibilities of the Forest Service to protect an expanding structures matrix. Our survey of incident commanders indicated that current local, State, and Federal arrangements significantly contribute to expense in the interface area. Agreement provisions and land use zoning laws, such as setbacks, access requirements, and smoke restrictions can influence the cost of fighting fires and danger to fire fighters and residents in urbanizing area (USDA Forest Service 1995a and 1995b, USDI/USDA 1995).

- *Tradeoffs*—Display the economic tradeoffs of a range of long-term fire protection strategies in National Forest land management plans. Desired future conditions for Forest management can have significant expenditure implications for fire management. These tradeoffs must be considered in the public involvement and decision-making process. Likewise, fuels and fire management strategies can strongly influence environmental conditions and the feasibility of reaching desired future conditions and forest plan direction (USDA Forest Service 1995a and 1995b, USDI/USDA 1995).

- *Escaped Fire Situation Analysis*—Improve the Escaped Fire Situation Analysis (EFSA) procedural standards and guidelines, streamline the process, and train fire managers in its use in real-time situations. The long-term effects of fire on ecosystems and the costs of alternative suppression strategies should be incorporated into EFSA's, and line officers should be trained to use EFSA to guide selection of suppression strategies. The strategy selected will determine the final fire size, effect on property and resources, the resulting cost, and other suppression criteria. The EFSA should be used as a backdrop for conducting reviews of fire decisions and creating a base of experience with which to train new incident commanders. Standards and review are necessary to reinforce efficient and informed decision-making, and to provide for national consistency (Park and Smart 1995).

- *Standards, Training, and Oversight*—Make high-cost decisions by those with substantial knowledge, skills, and abilities in fire management. Fire suppression decisions are subject to large over- or under-allocations of resources because firefighting resources must usually be ordered in big packages. This "lumpiness" makes suppression decisions vulnerable to overallocation to anticipate perceived risks. Better training and more qualifications could help reduce expenditures, according to the incident commanders we surveyed. In addition, although budget and purchasing specialists are assigned to many larger fires (those dealing with millions of dollars), a higher level of fiscal accountability is more generally needed to ensure cost-effective fire suppression (USDA Forest Service 1995a and 1995b, USDI/USDA 1995).

- *Reviews and Coaching*—Conduct performance reviews during fires and provide coaching for line officers. These reviews allow for mid-course corrections to more efficiently suppress large fires. Adopt an "adaptive management" strategy to fire suppression in areas and times where it is appropriate. The "Large Fire Cost Study" (Truesdale and others 1995) revealed that changes in fire suppression strategy made after the initial EFSA could have reduced final costs. Additionally, except for local reviews of individual fires, no studies have evaluated the costs and benefits of suppression tactics on large fires. Modeling or analysis techniques could be developed to identify cost-effective strategies and tactics and then be applied on a real-time basis to individual fires (Park and Smart 1995).

Fire protection and fire fighting are very expensive activities within the Forest Service. Some say that they are too expensive. A thorough understanding of fire-related expenditures and a thoughtful assessment of their causes and trends, as begun in this report, may be the first steps toward expenditure containment. Additionally, the recommendations discussed in this report should be implemented. This may take several years, and it is not clear whether these recommendations will be sufficient to offset the factors that will tend to increase expenditures. Time will tell, but they are a good place to start.

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