

# Prescribed Burning Costs: Trends and Influences in the National Forest System<sup>1</sup>

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## Abstract

*The results of a survey from 1985 to 1994 of the USDA Forest Service's National Forest System prescribed burning activity and costs are examined. Fuels management officers from 95 National Forests reported costs and acreage burned for 4 types of prescribed fire, including slash reduction, management-ignited fires, prescribed natural fires, and brush, grass, and rangeland burns, and rated the relative importance of 9 resource enhancement targets and 12 factors influencing burning costs. Substantial differences were found in per acre costs and cost variability by burn type, National Forest Regions, and resource target mix. Planning costs were estimated to be about 25 percent of total costs in most regions. Unit size, labor availability, escape fire safeguards, and environmental restrictions were the most important cost influences, but these varied by region. Data limitations suggest the need for a uniform, comprehensive system of data collection on prescribed burning activity and costs.*

Recent analyses of fire policy have called for increased prescribed burning to enhance fire-dependent ecosystems and commercial forests and to prevent future wildfire damage (Bell and others 1995, Mutch 1994, USDA Forest Service 1994, USDI 1995). The USDA Forest Service has set a goal of burning 3 million acres per year by the year 2005 (Bell and others 1995). Achieving this goal requires an understanding of the costs of burning options. The costs and the risks imposed by burning options must be balanced against their ecological and risk reduction benefits.

This paper summarizes findings on costs and cost influences extracted from a survey conducted to characterize and quantify prescribed burning activity in the Forest Service's National Forest System from 1985 through 1994 (Cleaves and others [In press]). This survey was a comprehensive assessment of prescribed burning activity levels, resource target mixes, barriers to increased use of burning, costs, and cost influences. It attempted to interpret the physical, social, legal, economic, and managerial factors that shape the burning programs on National Forests. A brief summary of the activity and resource target mix results is provided to help explain cost differences among regions and burning types.

## Methods

Analyses were based on responses to a questionnaire mailed to National Forest district and forest-level fuels management officers (FMO's) in December 1995. The questionnaire asked for estimates for the following variables for the period 1985-1994: annual acres burned, number of burns and cost for four burn types--slash reduction, management-ignited burns in natural fuels, prescribed natural fires, and brush and range burns; major resource benefits targeted in the burning program; and historic trends and future expectations in burned acreage by type of burn. Fuels managers ranked the importance of the selected resource targets and cost influences on a scale of 0 to 5 with 5 being most important.

We received completed surveys from 95 of the 114 National Forests contacted, which represented about 85 percent of the National Forest acreage, excluding Alaska. We aggregated forest-level estimates into regional totals and averages and compared burn sizes, costs, trends, and other parameters across National Forest Regions.

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The respondents provided average, highest, and lowest cost estimates, and apportioned those costs into planning and project categories. Project costs included: preparing the burn site, ignition and maintenance, mop up, post-fire monitoring, contractor or cooperator costs, and other related activities. Planning costs included burn plan preparation; National Environmental Policy Act (NEPA) compliance and public involvement, project planning, and appeals; post-fire evaluation of effects; smoke management; interdisciplinary teamwork; and general overhead. Cost estimates were summarized and compared across burn types, Regions, and other parameters.

To confirm overall trends and evaluate data quality, we compared our estimates with data from Forest Service obligations records for fiscal years 1980 through 1995 (Bell and others 1995, Cleaves and others 1997, Schuster and others 1997). In those reports, per-acre expenditures were calculated for each Region from the obligations data. This data provided detailed funding information about fuels treated with appropriated fuels funds (FFFP), brush disposal (BDBD), Knutson Vandenberg (CWKV), and contributed or volunteer (cooperative) work (CWCW). Prescribed burning funded by benefiting Forest Service programs, such as wildlife, timber management, threatened and endangered species, recreation, range, and others, is often recorded under more general activity codes.

## Results

### **Background Findings**

#### **Activity Levels**

The total annual prescribed burned area in the responding National Forests averaged 908,120 acres. The Southern Region (Region 8) reported the highest annual average burned area at 434,119 acres. The Southwestern Region (Region 3; 184,248 acres) was next highest, followed by the Pacific Northwest (Region 6; 114,674 acres), Northern (Region 1; 77,186 acres), Pacific Southwest (Region 5; 54,401 acres), Eastern (Region 9; 16,213 acres), Intermountain (Region 4; 15,412 acres), and Rocky Mountain (Region 2; 11,867 acres).

Management-ignited prescribed fires accounted for the largest acreage burned, totaling 62.2 percent of the system total. This was followed by slash reduction (25.3 percent), brush and rangeland (8.3 percent), and prescribed natural fire (4.2 percent). Most of the management-ignited acreage (87.6 percent) was reported in the Southern and Southwestern Regions. Most of the slash burning acreage (70.7 percent) was reported in the Pacific Northwest, Southwestern, and Northern Regions. The majority of brush and rangeland burning (62.7 percent) was conducted in the Southwestern and Pacific Southwest Regions.

Overall, the responding forests conducted an average of 6,763 burns per year in which 75 percent were slash reduction burns and 20 percent management-ignited burns in natural fuels. Accordingly, Regions with significant slash burning acreages reported the highest number of burns. The Pacific Northwest Region was the highest at 1,816 burns per year, followed by the Northern Region (1,727), the Pacific Southwest (1,281), and Southern Region (947).

The average burn size was 134 acres. This varied from 42 acres in the Pacific Southwest Region to 458 acres in the Southern Region. The Southern and Southwestern Regions conducted the largest burns with average sizes of 458 and 441 acres, respectively. All the other Regions averaged less than 90 acres.

The largest burns were for prescribed natural fires (620 acres); the smallest for slash burns (45 acres). Management-ignited burns were the second largest (411 acres) followed by brush and range burns (306 acres). This relationship of relative sizes of burn types was similar for most Regions.

Respondents reported whether annual burning activity had increased, decreased, or remained constant over the period 1985-1994. The slash burn acreage had decreased in more forests (60 percent) than any other burn type

because of reductions in timber harvests. Management-ignited burning had increased in 76 percent of the responding forests, because of increasing fuel treatment budgets and greater emphasis on the use of prescribed fire for silviculture, ecosystem, and wildlife purposes. Prescribed natural fire levels had remained fairly constant except for a large increase in the Southwestern Region. Brush and rangeland burns had either remained stable or increased, particularly in the Southwestern and Intermountain Regions.

## Resource Target Mixes

Respondents rated the relative importance of nine resource targets for prescribed burning on a scale of 0 to 5. The highest rated resource target was hazard reduction (4.21), followed by ecosystem fire reintroduction (3.65), game habitat (3.15), reforestation (2.85), nongame habitat (2.37), vegetation control (2.26), threatened and endangered species (2.15), insect and disease protection (1.71), and grazing (1.70).

Mixes of objectives varied by region. Hazard reduction was the most highly rated objective except in the Rocky Mountain, Southern, and Eastern Regions. In the Rocky Mountain and Southern Regions, fire reintroduction and threatened and endangered species management, respectively, ranked slightly higher than hazard reduction. In the Eastern Region, four resource objectives were ranked higher than hazard reduction with game species management ranking the most important. Fire reintroduction was the second most important objective in the Northern, Southwestern, Intermountain, and Pacific Southwest Regions. Reforestation and non-game species management were second in the Pacific Northwest and Eastern Regions, respectively. Reforestation or game species management was the third most important resource objective in most Regions.

## Per Acre Costs

Slash reduction burning had the highest estimated cost per acre (\$167.04) in six of the eight Regions (*table 1*). Prescribed natural fire (PNF) was the second highest, averaging \$103.68. The variability in (PNF) ranking was high, ranging from least expensive in some Regions to the most costly in others. Management-ignited burns averaged \$78.13 per acre and brush, range, and grassland burns were the least costly, averaging \$57.09.

## Variation in Reported Costs

Differences between costs of different burn types reflect differences in blends of resource objectives, burning conditions, site characteristics, and management policies. Differences between slash and management-burn costs were greatest in the Pacific Northwest Region (\$334.02 - \$77.55 = \$256.47) and the Pacific Southwest Region (\$344.46 - \$223.38 = \$121.08), and were the lowest in the Southern Regions (\$42.34 - \$22.80 = \$19.54) and the Rocky Mountains (\$61.06 - \$58.24 = \$2.82). In the Northeastern Region, management-ignited burns were more expensive than slash burns by \$18.07 per acre.

There were distinctive differences within burn types. Slash burning ranged from an overall "lowest" of \$68.24 to an overall "highest" of \$330.72. The range (estimates of highest minus lowest) varied from \$594.40 per acre in the Northern Region to \$31.25 in Southern Region. The widest ranges for management-ignited prescribed burns were reported in the Northern Region (\$437.11 - \$37.56 = \$399.55) and the Pacific Southwest Region (\$356.98 - \$93.56 = \$263.42). The smallest range was reported in the Southern Region (\$30.73 - \$16.02 = \$14.71). The Rocky Mountain, Southwestern, and Intermountain Regions had similar ranges of about \$81 between the estimated highest and lowest costs. This variation reflects a wide range of site characteristics, post-harvest conditions, and multiple objectives among Forest Service harvesting and salvage units.

**Table 1**—Mean estimated average cost per acre and planning cost percentage for prescribed burning, in 1994 dollars, by National Forest System Region and burn type (1985-1994).

Region (Response/ surveyed)	Slash reduction		Management- ignited		Prescribed natural fires		Brush, range, and grassland		All types	
	\$ / Acre	Pct. in planning	\$ / Acre	Pct. in planning	\$ / Acre	Pct. in planning	\$ / Acre	Pct. in planning	\$ / Acre	Pct. in planning
1(12/13)	173.67	20.3	121.00	30.6	121.21	4.1	57.09	44.4	118.24	21.7
2(8/10)	61.06	15.6	58.24	19.0	-	-	38.81	30.0	38.53	20.4
3(11/11)	77.05	11.4	38.85	29.5	7.67	52.2	37.30	30.1	40.22	22.1
4(8/15)	81.34	16.0	34.88	24.9	133.50	5.6	19.83	37.8	67.39	13.6
5(15/18)	344.46	16.2	223.38	44.3	270.00	-	174.47	22.0	253.08	19.1
6(18/19)	334.02	19.3	77.55	42.5	85.97	35.1	55.82	48.2	138.34	27.9
8(13/13)	42.34	29.2	22.80	29.1	10.70	15.9	29.37	37.4	26.30	30.1
9(10/15)	45.60	21.9	63.67	20.1	22.00	22.7	29.38	10.6	40.16	19.3
<b>Total</b> (95/114)	<b>167.04</b>	<b>18.9</b>	<b>78.13</b>	<b>34.4</b>	<b>103.68</b>	<b>10.5</b>	<b>57.09</b>	<b>30.3</b>	<b>101.48</b>	<b>21.3</b>

Management-ignited prescribed burns were responsible for more acres burned than any other. Their cost would, therefore, drive any weighted-average regional or national estimate. The mean cost, \$78.13 per acre, was calculated from a regional mean of \$22.80 per acre in the Southern Region to \$223.38 per acre in the Pacific Southwest Region. The range between highest and lowest and the range across regional averages was much smaller than for either slash-burning or prescribed natural fires.

Prescribed natural fire (PNF) had the widest range in cost. However, because most Regions do not have an active PNF program, these estimates may not be reliable. They are based on 61 fires per year in which 2 Regions did not report any PNF's. The range in PNF costs varied from \$375.75 in the Northern Region to \$2.10 in the Southern Region. In Pacific Southwest Region, reports of the "average" and "lowest" estimates were the same in most forests.

Brush and rangeland burning costs varied from \$19.83 in the Intermountain Region to \$174.47 in the Pacific Southwest Region. The intra-Region ranges were the smallest of any burn type, except in the Pacific Southwest Region.

### **Cost Components**

The largest portion of total costs (79 percent) for all burn types, was accounted for in actual project costs (*table 1*). Planning cost accounted for 21 percent of the mean, ranging from 11 percent for prescribed natural fires to 34 percent for management burns. The planning percentage was highest for PNF fires in the Southwestern Region (52 percent) and lowest for brush and range burns in the Northeastern Region (11 percent) and slash burns in the Southwestern Region (11 percent). Planning percentages were highest in the Southern (30 percent) and Pacific Northwest (28 percent) Regions and the lowest in the Intermountain (14 percent) and Pacific Southwest (19 percent).

### **Total Cost of the Burning Program**

To estimate the total annual cost of the burning program in the responding forests, we multiplied treatment acres reported from each Region and burn type by mean per-acre costs. The total cost for burning the 908,180 acres per year was \$76.9 million (*table 2*), most of which was incurred by the Pacific Northwest Region (38 percent) and the Pacific Southwest Region (20 percent).

Most of the estimated cost was for slash burns (63 percent) and management-ignited burns (26 percent). Slash reduction costs in the Pacific Northwest represented more than one-half of the total cost for this type and more than one-third of the total cost for all types. The costs for prescribed natural fires and brush, range, and grassland burns were roughly even, each representing about 5 percent of the total.

### **Cost Factors**

Fuels managers considered various factors to be important determinants of per-acre costs (*table 3*). In all Regions, unit size and the cost and availability of labor were the two most highly rated factors. Overall, safeguards to minimize escaped fires and compliance with environmental laws and regulations ranked third and fourth. Environmental laws received 3.0 and higher ratings in six of the eight Regions and was among the top four in the Northern, Southwestern, Pacific Southwest, Pacific Northwest, and Southern Regions. Escape safeguards received 3.0 and higher ratings in six Regions and was among the top four factors in the Northern, Intermountain, Pacific Southwest, and Northeastern Regions.

Two factors---availability of liability insurance and agency policies about risk-taking---received low ratings in all Regions. Satisfying multiple objectives, burn-unit shape, risks of liability, and residential development were also not highly rated overall but were each among the four most highly rated factors in at least one Region.

**Table 2**—Estimated total annual costs, in 1994 thousands of dollars, for prescribed burning activity on 95 responding forests, based on acreage and mean cost estimates, by National Forest System Region and burn type (1985-1994).

Region (Response/surveyed)	Slash reduction	Management- ignited	Prescribed natural fires	Brush, range, and grassland	All Types
1(12/13)	\$6,260	\$1,060	\$3,387	\$253	\$10,960
2(8/10)	181	209	-	206	596
3(11/11)	3,646	3,627	45	1,406	8,724
4(8/15)	327	147	291	99	864
5(15/18)	10,237	3,122	329	1,655	15,343
6(18/19)	26,495	2,396	1	248	29,140
8(13/13)	1,148	9,151	-	166	10,465
9(10/15)	165	558	13	96	832
<b>Total</b>	<b>\$48,459</b>	<b>\$20,270</b>	<b>\$4,066</b>	<b>\$4,129</b>	<b>\$76,924</b>

**Table 3**—Mean ratings of importance for 12 influences on the costs of prescribed burning, by National Forest System Regions (1985-1994) <sup>1</sup>

	R-1 Northern	R-2 Rocky Mountain	R-3 South- western	R-4 Inter- mountain	R-5 Pacific Southwest	R-6 Pacific Northwest	R-8 Southern	R-9 Eastern	All regions
No. of forests reporting/ No. of forests surveyed	12/13	8/10	11/11	8/15	15/18	18/19	13/13	10/15	95/114
Physical									
Size of the unit	3.58	4.07	4.00	3.55	4.00	3.44	4.52	4.00	3.92
Shape of the unit	3.00	1.97	1.64	3.36	2.57	3.06	3.67	2.40	2.83
Legal									
Regulations	3.42	3.23	3.82	2.91	3.43	3.06	3.48	2.00	3.21
Inputs									
Labor	3.25	3.43	3.45	3.55	4.50	3.33	3.90	4.00	3.69
Insurance	0.40	0.67	1.11	1.00	0.50	0.56	0.32	0.00	0.53
Risk									
Liability	3.25	3.40	2.82	3.45	2.82	2.50	2.95	3.00	2.98
Residential	2.67	3.37	4.09	3.00	3.29	1.50	3.19	2.70	2.90
Crew safety	3.08	3.30	2.91	3.64	2.71	2.94	3.05	2.60	3.02
Weather	3.50	3.40	2.55	3.91	3.21	2.82	3.12	3.10	3.17
Management action									
Objectives	3.17	2.43	2.91	3.27	3.21	3.33	2.43	1.70	2.83
Risk-taking	2.92	1.93	1.64	3.18	2.64	2.72	2.33	2.80	2.53
Escape safeguards	3.58	3.04	2.73	4.00	3.50	2.94	3.19	3.60	3.30

<sup>1</sup> Rating scale: 0 = no importance, 5 = highest importance.

The ratings profiles across the major categories—physical, legal, inputs, risks, and management action—were similar across the Regions and skewed toward physical (primarily size), inputs (labor), legal, and management action (escape safeguards). The most drastic differences in regional responses were in the risk category. For example, in the Rocky Mountain Region, three of the risk factors were among the most highly rated, but in the Southern Region, no factor in this category was similarly rated.

## Discussion

### **Cost Estimates**

Per acre costs seemed to be most influenced by unit size, although many factors, including the objectives mix and risk profile, interact to determine the final cost. This is consistent with results found in other studies of prescribed burning costs (Bell and others 1995, Dubois and others 1995, González-Cabán and McKetta 1986, Rideout and Omi 1995, Vasievich 1981, Wood 1988). Our study and Cleaves and others (1997) indicate that per-acre expenditures for natural-fuels burning have been decreasing in most Regions. This is attributable to more active and larger-scale burning, a growing awareness of cost determinants, and active programs to implement cost controls. As slash burning is reduced, FMO's may have to contend less with unit sizes and shapes that have been determined by harvest unit standards and guides.

Responses to our questions about project and planning costs were remarkably uniform, hovering at about 22 percent of the total cost in all the Regions. Because our definition of planning cost included activities that would normally be fixed, increasing burn unit sizes may decrease the impacts of planning on per acre costs in the future, *ceteris paribus*.

The responses show that prescribed natural fire can be expensive and variable. Substantial cost is incurred in monitoring PNF's and maintaining sufficient standby personnel to respond quickly to changing burning conditions. Although such fires are typically large, they require major commitments of fire fighting resources during times of high demands for these resources.

### **Comparisons with Other Data**

Our total cost estimates were for the period 1985-1994. They do not reflect the cost of the burning program after 1994. Furthermore, they only show the costs of the 95 Forests that responded to the survey. We did not extrapolate to the entire National Forest System because we did not consider our nonresponses to be randomly distributed.

Our grand average for per acre cost is greater than inflation-adjusted expenditures from appropriated fuels (FFFP) and brush disposal (BDBD) funds for fiscal years 1980 through 1995 (Cleaves and others 1997, Schuster and others 1997). These are not directly comparable because these earlier reports were expenditure data, whereas ours were estimates from FMO's. However, some comparison highlights the complexities of accounting for and understanding burning costs.

For example, for the Management Attainment Report (MAR) Prescribed Fire (PF-2) class activity "natural fuels burning," which is analogous to Forest Service management-ignited burns, Cleaves and others (1997) and Schuster and others (1997) show expenditures of \$48.10 per acre. Our estimate was \$78.13. The proportional differences were similar for most Regions. Contrasts between these earlier reports and our estimates are as follows for each Region: Northern \$125.78 (\$121.00); Rocky Mountain \$80.06 (\$58.24); Southwestern \$31.28 (\$38.85); Intermountain \$101.39 (\$34.88); Pacific Southwest \$191.42 (\$223.38); Pacific Northwest \$192.72 (\$77.55); Southern \$10.97 (\$22.80); and Northeastern \$89.24 (\$63.67). The mean estimates in our survey were not weighted by acreage in burn types. Our rankings of regional averages were similar to those reported in the

earlier studies: the Northern, Pacific Southwest, and Pacific Northwest Regions were highest; the Rocky Mountain, Southwestern, and Southern Regions were the lowest.

Estimates in our survey include planning costs paid with funds other than FFFP and BDBD, including general overhead or other program functions. Project costs include those paid with funds provided by wildlife, range, and other benefiting programs. For example, about 273,000 of the 434,119 acres burned per year in the Southern Region had been funded with Knutson-Vandenberg (KV) funds, timber management, wildlife, range, other resource programs, and volunteered resources. This represents an additional \$3 to \$4 million not reflected in the Southern Region's Fire and Aviation Management obligations records and the corresponding acreage not listed as fuel treatment in MAR reports. We were not able to determine the extent of non-FFFP and non-BDBD in the other Regions. However, by comparing our survey with Cleaves and others (1997), we can identify Regions and roughly estimate the non-fuels funded acreage being treated.

Cleaves and others (1997) reported average annual BDBD-funded acreage at 361,757, whereas our study reported 230,131. Most of this discrepancy resulted from nonresponse; in the Intermountain and Pacific Northwest Regions a total of eight forest FMO's did not respond to our survey. The FFFP-funded (natural fuels) acreage in Cleaves and others (1997) was 336,460; our estimate was 677,989. Most of the difference was in the Northern, Southwestern, and Southern regions. The excess in the Northern Region reflected the use of prescribed natural fire, a burn type not recorded in MAR's. The Southwestern Region excesses, which totaled about 94,000 acres per year, were brush and range fires (37,677 acres) and, presumably, other fire activities not funded under FFFP. In the Southern Region, where we recorded 196,434 acres more than Cleaves and others (1997), the discrepancy was primarily because of burning funded by other benefiting programs, primarily wildlife and threatened and endangered species.

Although the FMO response rate was low in the Intermountain Region, our acreage estimates were close to those of the earlier studies. Greater response to our survey would have substantially increased the estimate of acreage not funded by fuels appropriation and BDBD. Several of the non-responding National Forests have well-publicized, natural-fuels burning programs of tens of thousands of acres per year.

### ***Data Limitations***

Data on costs were scattered and of variable quality. Survey responses primarily reflect subjective judgments and quantified data from a variety of record-keeping systems. Furthermore, the data is difficult to compare without knowledge of specific mixes and burn execution factors. Some of the FMO comments on open-ended questions in Cleaves and others [In press] provide additional insight into data quality, burning activity, and costs.

Comparisons among Regions should only be considered after extensive follow-up. There is great variation among responses within some Regions. These data comparisons should not be used to assert that one Region is more efficient than another. Each Region has a unique blend of resource objectives and physical, cultural, political, and economic cost influences. Understanding how those elements shape the cost of burning is critical to improving cost effectiveness.

There is an apparent need for a uniform data collection system to track cost trends and compare cost effectiveness of different burning strategies. This could be useful in guiding the allocation of costs to benefiting programs and in predicting costs with burn unit and other parameters (González-Cabán and Bednar 1990, González-Cabán and McKetta 1986).

There were few guidelines for collecting or analyzing cost data in the period of our study. Most uses of prescribed fire receive funding from several sources,

making information retrieval and consolidation difficult, and comprehensive estimates problematic. We received estimates from a variety of sources: subjective estimates, project burn plans, fire planning work sheets, Ranger District records, and district- or forest-wide rules-of-thumb. Subjective estimates reflect many forms of judgmental bias.

Our data collection process could be improved. Slash-burn cost estimates generally included the costs of machine or hand-piling and other preparation. Our crude categorization did not allow respondents to show different slash preparation and ignition methods, which may have been important sources of variation in the estimates. Also, there is some disagreement about what to include as "project" or "planning" costs, although most FMO's tried to conform to our categorizations. According to the respondents, planning cost estimates were less certain than estimates of project costs. Fire managers have less hands-on experience with overhead activity costs. Some admitted being very conservative in their estimates of this component, while others were as high as 70 percent. Some FMO's also said that the costs of planning were increasing because of requirements for comprehensive planning under NEPA, forest plan standards and guides, and environmental protection laws.

### ***Cost Influence Implications***

Several elements in our data suggest that burning costs could increase in the future. Cleaves and others [In press] reported that FMO's saw important barriers to increased burning in the form of funding availability, labor availability, and environmental restrictions. Despite fuels funding increases, labor availability may become critical, especially if an increasing wildfire control burden competes for trained labor.

The perceived importance of environmental restrictions was thought to be a reaction to a combination of factors: ambiguity in the application of regulatory standards; actual restrictions on burning practices; and reaction to the prospect of increasing regulations, the prospects of increased demands for NEPA environmental effects documentation, and potential legal actions. Many respondents felt that NEPA documentation and public scoping would delay burn projects and cause them to miss prescription windows. Some managers foresee an increasing NEPA burden because larger burns in natural fuels may require more elaborate analyses. There is little information about the current extent of NEPA analysis or how it adds to the cost and complexity of burning.

## **Conclusions**

Prescribed burning is probably the most extensive planned disturbance activity in the National Forest System, a distinction formerly afforded to timber harvesting. Because burning supports a variety of resource objectives, its outlook is closely intertwined with the future of other programs, such as wildlife, threatened and endangered species, range, and ecosystem management. Success in these programs depends on the cost effectiveness of the burning program.

Ambitious burning goals are being pursued. Forest Service fire managers are gradually increasing the use of prescribed fire while holding down costs. Their responses in this survey reveal an awareness of and sensitivity to cost and cost factors. Their efforts deserve support. Fuel management budgets have increased dramatically, from historic levels of about \$20 million to \$60 million in 1997, but they recognize that this does not reduce the need to be cost effective. To meet burning goals, difficult trade-offs among resource objectives and funding sources will be necessary.

A uniform data collection system is needed to track cost trends and compare cost effectiveness of different burning strategies. This could be useful in guiding the allocation of costs to benefiting resource programs and in predicting costs with burn unit and other parameters. This data could also be used to guide

additional investigation into the constraints to implementing burning programs and enhance the further integration of land management planning and fire planning.

This data system should include a set of accepted criteria for indicators of burning performance at the program and project levels. The multiple-objective nature of burn prescriptions demands that such criteria be tied to resource management measures used to characterize desired future conditions in Forest plans. Measures of variability both in activity and costs could provide valuable perspectives on program performance. Ranges in costs for burn types within Forests could be assimilated into flexible performance targets and cost-effectiveness standards.

Activity data should be collected to allow stratification by fuel type, habitat type, and other resource management land-area categories, for a variety of burn types. The categories in this survey were too coarse to fully explain variations in cost, although they provided better information than the MAR data.

Cost data should not neglect planning costs. FMO's said they had trouble estimating those costs and, as a result, gave them less attention in making project or program decisions.

It is important to understand the reasons for cost differences among Regions, organizational units, or burn types. The data in this study should not be used to assert that one Region is more efficient than another. Each Region has a unique blend of resource objectives and physical, cultural, political, and economic cost influences. Understanding how those elements shape the cost of burning is critical to improving cost effectiveness.

There is also a need to better understand how political, managerial, and other forces influence the fire manager's behavior and the costs of burning. A more complete research design could better assess the relative importance of these factors and how they influence decision processes. One such factor is the shortage of qualified personnel. The burning season's narrow window of opportunity makes it doubly important that managers have a well-trained and available workforce. The role of environmental regulations could be better understood by conducting an assessment of the effect of laws and forest-level standards and guides. These effects could be researched as opportunity costs, similar to studies of harvesting and silvicultural investments made to comply with water quality best management practices.

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