

INFLUENCES ON PRESCRIBED BURNING ACTIVITY IN THE NATIONAL FOREST SYSTEM

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ABSTRACT

The results of a survey concerning National Forest System prescribed burning activity and costs from 1985–1994 are examined. Ninety-five (83%) of 114 National Forests responded. Number of hectares burned and costs for conducting burns are reported for 4 types of prescribed fire: slash reduction; management-ignited fires; prescribed natural fires; and brush, grass, and rangeland burns. Anticipated burning levels over the 1995–2003 period and burning levels needed to achieve desired management goals on National Forest System lands are also presented. Survey rankings are presented for 9 resource enhancement targets and 14 potential barriers to increased burning.

keywords: ecosystem management, environmental laws, hazard reduction, management-ignited fire, National Forests, prescribed natural fire.

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INTRODUCTION

Recent analyses of fire policy have called for increased prescribed burning to enhance fire-dependent ecosystems and commercial forests and to prevent wildfire damage (Mutch 1994, U.S. Department of Agriculture (USDA) Forest Service, Western Forest Health Initiative, unpublished report, 1994, Bell et al. 1995, U.S. Department of the Interior/USDA 1995). The USDA Forest Service has set a goal of burning 1.2 million hectares (3 million acres) per year by the year 2005 (Bell et al. 1995). Wise allocation of prescribed burning resources to achieve such a goal requires a solid baseline assessment of current activity and an understanding of barriers to implementing burning programs. Despite its ecological benefits, prescribed burning is being increasingly scrutinized and regulated as a source of air pollution (Sandberg et al. 1978), traffic hazards (Mobley 1990), and escaped wildfires (Mobley 1985, Hoover 1989, Craig 1990, Cleaves and Haines 1997).

This report summarizes the results of a survey conducted to (1) quantify prescribed burning activity in the National Forest System, and (2) identify resource targets and barriers to increased burning. There has been no comprehensive assessment of the amount of prescribed burning; only recently have Forest Service administrative units begun to consolidate their estimates of prescribed burning needs. This information, as well as a characterization of the physical, social, legal, economic, and managerial factors that shape the

burning programs on National Forests, is needed to effectively develop expanded burning programs.

METHODS

Analysis of prescribed burning activity levels, resource targets, constraints, and costs was based on responses to a questionnaire mailed to National Forest fuels-management officers in December 1995. The questionnaire asked for estimates for the following variables for the period 1985–1994: (1) annual acres burned, number of burns and cost for 4 burn types—slash reduction, management-ignited burns in natural fuels, prescribed natural fires, and brush and range burns; (2) major resource benefits targeted in the forest-level burning program; (3) historic trends and future expectations in burned acreage by type of burn; (4) barriers to expanding the use of prescribed burning; and (5) annual acreage of prescribed burning needed to achieve resource management goals. Fuels managers expressed expectations for future activity as subjective likelihood distributions. They rated the relative importance of resource targets and barriers on a Likert preference scale of 0–5 (5 was “most important”).

We surveyed all 114 administrative National Forests listed in the agency directory for 1995. Some of these units were consolidations of ≥ 2 forests previously administered as individual units. We received completed surveys from 95 of the 114 national forests contacted (83%), accounting for 85% of the National Forest hectares, excluding Alaska. Estimates at the forest level were aggregated into regional and national

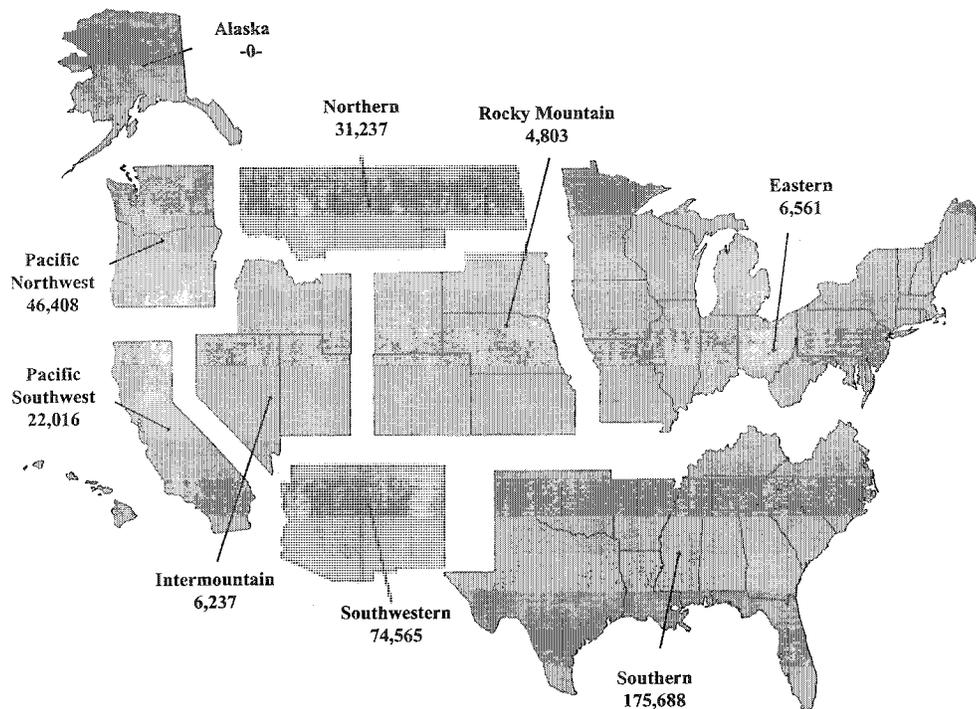


Fig. 1. Annual prescribed burning (hectares) by National Forest Service Region (1985-1994). Average annual totals include only those Forests responding to the survey.

totals. Average burn sizes, costs, trends, and other parameters were compared across regions, but no statistical analysis of significance was performed. We report totals and averages of the estimates we received in returned survey forms. We did not extrapolate results the entire National Forest System because the non-responding forests were not randomly distributed across the Forest Service regions.

RESULTS

Activity Levels

The total annual prescribed burned area in the responding National Forests averaged 367,516 hectares (908,120 acres). The Southern Region reported the highest annual average burned area at 175,688 hectares (434,119 acres); the Southwestern Region was next

highest, followed by the Pacific Northwest, Northern, Pacific Southwest, Eastern, Intermountain, and Rocky Mountain regions (Figure 1).

The total area was not evenly distributed across burn types (Table 1). Management-ignited prescribed fires accounted for the largest area, or 62.2%. This total was followed by slash-reduction (25.3%), brush and rangeland (8.3%), and prescribed natural fire (4.2%). Most of the management-ignited area (87.6%) was reported in the Southern and Southwestern regions. Most of the slash-burning area (70.7%) was reported in the Pacific Northwest, Southwestern, and Northern regions; the majority of brush and rangeland burning (62.7%) was conducted in the Southwestern and Pacific Southwest regions.

Overall, the responding forests conducted an average of 6,763 burns per year of which 75% were slash reduction, 20% management-ignited burns, and the re-

Table 1. Average annual hectares burned by National Forest System Region and burn type (1985-1994)^a. (1 hectare = 2.47 acres.)

Region (Response/Surveyed)	Slash Reduction	Management- Ignited	Prescribed Natural Fires	Brush, Range, and Grassland	All Types
Northern (12/13)	14,588	3,545	11,309	1,796	31,237
Rocky Mountain (8/10)	1,202	1,449	0	2,152	4,803
Southwestern (11/11)	19,151	37,784	2,383	15,248	74,565
Intermountain (8/15)	1,625	1,710	882	2,020	6,237
Pacific Southwest (15/18)	12,027	5,656	493	3,839	22,016
Pacific Northwest (18/19)	32,100	12,505	6	1,797	46,408
Southern (13/13)	10,973	162,425	0	2,290	175,688
Eastern (10/15)	1,467	3,547	232	1,315	6,561
Total (95/114)	93,134	228,620	15,305	30,457	367,516

^a Totals reported include only those National Forests responding to the survey. Some rounding error occurred in conversion from acres to hectares.

mainder, prescribed natural fires and brush and range fires. Accordingly, regions with significant slash-burning areas 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 in the responding forests was 54 hectares (134 acres). This average varied from 17 hectares (42 acres) in the Pacific Southwest Region to 185 hectares (458 acres) in the Southern Region. Like the Southern Region, the Southwestern Region conducted very large burns, with an average size of 179 hectares (441 acres). All the other regions averaged <36 hectares (90 acres).

The largest burns were for prescribed natural fires (averaging 251 hectares [620 acres]) and smallest for slash burns (averaging 18 hectares [45 acres]). Management-ignited burns were the second largest (averaging 166 hectares [411 acres]) followed by brush and range burns (124 hectares [306 acres]). This relationship of relative sizes of burn types held for most regions.

Desired Burning Levels

Estimates of burning levels desired to achieve forest land management, fire protection, and other goals totaled 821,592 hectares (2,030,155 acres) per year, more than twice the average annual burn area reported for 1985–1994. The Southern and Southwestern Regions accounted for more than half of the area gap (51%) between the estimates of actual and desired burning levels. These two regions already have the largest burning programs. The gap relative to current burning levels was measured as the area reported for the survey period (1985–1994) as a percent of the desired (for the period 1995–2003). This percentage varied greatly. The Intermountain (15%), Rocky Mountain (16%), Pacific Southwest (22%), and Northeast (31%) regions were relatively far from their desired levels. The Pacific Northwest (47%), Southwestern (45%), and Southern (55%) regions had more modest gaps, and the Northern Region (69%) was relatively close.

Resource Target Mixes

Respondents rated the importance of 9 resource targets in their prescribed burning on a scale of 0–5. Based on these ratings, the highest ranked resource target was hazard reduction (4.21), followed by ecosystem fire reintroduction (3.65), game habitat (3.15), reforestation (2.85), non-game habitat (2.37), vegetation control (2.26), threatened and endangered species (2.15), insect and disease protection (1.71), and grazing (1.70).

In regional rankings, hazard reduction was the most highly rated objective except in the Rocky Mountain, Southern, and Eastern regions. The most important objective in the Rocky Mountain Region was fire reintroduction; in the Southern Region, threatened and endangered species management. In the Eastern Re-

gion, 4 resource objectives were rated higher than hazard reduction, with game species management rated the most important.

Fire reintroduction was the second most important objective in the Northern, Southwestern, Intermountain, and Pacific Southwest regions. In the Rocky Mountain and Southern regions the second-ranked objective was hazard reduction. 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.

Past Trends in Burning Activity

Respondents were asked to judge whether annual burning activity had increased, decreased, or remained constant from 1985–1994 for each of the 4 burn types. The slash burn area had decreased in more forests (60%) than had any other burn type because of reductions in timber harvests. Management-ignited burning had increased in 76% 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 in 62% of the forests reporting, except for a large increase in the Southwestern Region. Brush and rangeland burns had either increased or remained stable in most forests; the greatest increases were in the Southwestern and Intermountain regions.

Expected Trends in Burning Activity

Respondents were asked to estimate the likelihood of possible directions in burning activity over the next 10 years by distributing 100 likelihood points across 3 possible trends: “increase,” “decrease,” or “same” for each of the burn types. These responses acted as subjective probability distributions for expected trend direction, not to be confused with ratings for importance scale used with burn barriers and cost factors reported below.

The mean response for all burn types was 57 points to increase, 15 points to decrease, and 28 to stay the same. The strongest expectations for increasing activity were in the Rocky Mountain, Southwestern, Intermountain, and Northern regions. Likelihood averages for an increasing trend in management-ignited burns, prescribed natural fires, and brush and rangeland burns were 79, 66, and 51 points, respectively. The likelihood of increasing slash burning averaged only 31 points.

Regional expectations were very similar. Regional averages for increases in slash-reduction burning were <50 likelihood points. Conversely, regional averages for increasing management-ignited burns were >50 points in all regions, ranging from 67.5 in the Pacific Northwest Region to 96.9 in the Rocky Mountain Region. Similar but less dramatic increases for prescribed natural fire were anticipated; the Pacific Southwest and Eastern regions reported <50 points, (48.3 and 30.7, respectively) for expected increases. The likelihood of

Table 2. Mean ratings of importance for 14 barriers to expanding the use of prescribed burning, by National Forest System Region (1985-1994)^a.

	Northern	Rocky Mountain	South-Western	Inter-Mountain	Pacific S.W.	Pacific N.W.	Southern	Eastern	All Regions
No. responding/No. Surveyed	12/13	8/10	11/11	8/15	15/18	18/19	13/13	10/15	95/114
Social									
Public opinion	4.42	3.20	3.09	3.36	2.50	3.47	3.33	2.40	3.25
Residential	2.67	2.50	3.36	3.45	2.79	1.68	3.05	2.30	2.69
Economic									
Planning costs	3.83	3.00	3.27	3.00	4.00	3.26	2.67	3.60	3.29
Funding	3.50	3.23	3.45	3.27	4.64	3.63	3.67	3.60	3.66
Alternatives	1.33	1.60	1.91	2.09	2.14	2.21	1.10	2.60	1.82
Legal									
Regulations	3.58	3.83	4.36	3.73	3.64	3.89	4.19	2.90	3.82
Laws	3.75	2.30	3.91	3.09	3.36	3.37	2.29	2.20	3.02
Liability	3.33	3.30	2.82	3.45	3.00	2.79	3.62	3.30	3.20
Insurance	0.36	0.50	0.70	1.33	0.54	0.63	0.42	0.44	0.57
Administrative									
Mgt. Policy	2.58	2.80	2.18	3.09	2.57	2.53	2.33	2.60	2.56
Personnel	3.17	3.93	2.91	3.45	3.64	2.78	3.95	3.90	3.46
Technical									
Fuel loadings	3.42	3.10	3.73	3.45	3.07	2.83	1.90	1.70	2.82
Narrow window	3.08	3.04	3.00	4.18	3.29	3.22	3.71	4.40	3.48
Uncertainty	1.25	1.22	0.45	1.18	1.36	1.61	0.86	2.00	1.23

^a Rating scale: 0 = no importance. 5 = highest importance.

increasing brush, grass, and rangeland burning was also ≥ 50 points in all regions except the Pacific Southwest and Southern regions, which averaged 39.9 and 32.7, respectively.

Barriers to Burning

Respondents rated 14 factors on a 6-point scale of "importance" for their influence as barriers to expanding the use of prescribed burning (Table 2). Rating options varied from 0 for "no importance" to 5 being of "highest importance." The survey was worded to elicit relative influences on additional burning accomplishments, distinguished, if appropriate, from influences on past or current burning activity. The barriers were categorized as social, economic, legal, administrative, and technical.

Air quality and smoke management regulations received the highest mean rating (3.82); only in the Eastern Region did "regulations" receive a mean rating < 3.0 . Lack of adequate funding was the second most important barrier, with an overall mean of 3.66 and a mean rating of ≥ 3.0 in each region. Also highly rated were: personnel, referring to shortages of qualified personnel; narrow window, referring to the prescription window for conducting burns; planning costs; public opinion; liability, referring to smoke intrusion and escaped fires; and laws, referring to environmental and other laws (exclusive of smoke management).

Barriers with low ratings in all regions included: (1) alternatives to prescribed burning, (2) uncertainty about burning as an effective fuels-management practice, and (3) the availability of insurance. Excluding these 3 factors, the range of ratings was fairly narrow; the mean rating of each of the remaining 11 barriers

fell between 2.5 and 3.8. Although the range of ratings was greater within the individual regions, the clustering of importance for several factors was found in all regions. The distribution of factors within 1 point of the highest-ranked barrier ranged from 4 in the Eastern Region to 8 in the Rocky Mountain and Intermountain regions.

In individual regions, the highest-rated barriers were: (1) air quality regulations in the Southwestern, Pacific Northwest, and Southern regions, (2) narrow prescription window in the Rocky Mountain and Eastern regions, (3) public opinion in the Northern region, (4) personnel limitations in the Intermountain region, and (5) funding in the Pacific Southwest. Funding and air quality regulations were among the 4 most highly rated barriers in 7 of the 8 regions; personnel was among the top 4 in 5 regions. Public opinion and planning costs were each highly ranked in 4 regions.

The most important economic factors were funding availability and planning costs. Of the legal barriers, smoke management and air quality regulations were more important than either environmental laws or liability from smoke intrusion or escaped fires. In the administrative category, personnel availability was by far more important than administrative policy toward taking risks. Of the technical barriers, the available burning window was generally more important than fuel loading. In the Southwestern Region, fuel loading was a more important barrier than the prescription window.

Costs

Because planning costs and funding were highly rated as barriers, we summarized the per-hectare (per-

acre) and total cost results by region and burn type. Slash-reduction burning had the highest estimated cost per hectare (\$412.59 [(\$167.04 per acre)] in 6 of the 8 regions. Prescribed natural fire was the second most costly type, averaging \$256.09 per hectare (\$103.68 per acre). However, the variability in prescribed natural fires across regions was large, ranging from the least expensive in some regions to the most costly type of burn in others. Management-ignited burns averaged \$192.98 per hectare (\$78.13 per acre). Brush, range, and grassland burns were the least costly, averaging \$141.01 per hectare (\$57.09 per acre).

The largest portion of average per-hectare costs (79%) for all burn types was accounted for in project costs (variable cost). Planning costs, including overhead and planning, accounted for 21% of total costs.

The total annual cost for the 95 responding forests on the 367,516 hectares (908,120 acres) burned was \$76.9 million. More than 97% of the costs were incurred in the Pacific Northwest, Pacific Southwest, Northern, Southern, and Southwestern Regions (37.9%, 19.9%, 14.4%, 13.6%, and 11.3%, respectively). Most of the costs were incurred for slash-reduction (63.0%) and management-ignited (26.4%) burns. Slash-reduction costs in the Pacific Northwest represented >33% of the total cost of burning for all burn types and >50% of the total cost for slash-reduction burns. Costs for prescribed natural fires and brush, range, and grassland burns were roughly even, each representing about 5.0% of the total costs for all burn types.

DISCUSSION

Activity Levels

The area annually burned has been increasing in most forests, especially for natural fuels burning, both management-ignited and prescribed natural fire. The future of the prescribed natural fire program remains uncertain, despite respondents' optimism. The use of prescribed natural fire is controversial and subject to conflicting political, physical, and managerial objectives.

Burning supports an expanding variety of resource objectives. Respondents said that the increasing emphasis on the broadly stated objectives of fire reintroduction and endangered species management is relatively new in the mix and serves to draw prescribed burning in as a more active component of integrated programs to sustain ecological conditions. The outlook for the Forest Service's prescribed burning program is closely intertwined with the future of other programs, such as wildlife, threatened and endangered species, range, and ecosystem management. Our survey did not allow us to determine how much fire reintroduction is valued as a unique objective under new policy needs versus a justification for meeting the traditional fuel reduction objectives.

Survey respondents confirmed the need for increased burning. No respondent indicated that burning should be lower than current levels. The level for the

period of our study is less than half the desired level, although the gap has narrowed with recent increases in appropriated funds and forest performance targets. Although respondents were optimistic about making major progress on these goals, the implementation barriers they rated could prove to constrain their actual accomplishments. Four of the regions have been burning at <30 percent of their desired levels.

One distinct trend mentioned by respondents is a shift from slash-reduction burns to natural fuels burns, resulting in fewer and larger burns. This trend could have positive implications for per-hectare burning costs, but could present problems in urban interface areas and sensitive species habitats and other protected areas. The bigger projects may have to be analyzed as environmental assessments or environmental impact statements under the National Environmental Policy Act (NEPA), which could open up burn decisions to close scrutiny by public groups and regulatory agencies. Heretofore, much of the burning has been conducted under NEPA categorical exclusions, which are easier to plan and implement during the narrow and unpredictable burning windows.

Barriers to Increased Burning

Barriers to increased burning consist chiefly of funding, labor availability, narrow burning windows, and smoke management restrictions. Although appropriated fuels funding has increased since 1995, labor availability for prescribed burning may become a limiting factor, especially with increasing competition from wildfire control.

The high rating of the smoke and air quality regulations was not surprising. The perceived importance of this barrier may be explained by 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 possibility of legal action by environmental groups or concerned citizens may also contribute to the high importance rating reported by some respondents.

There appear to be important concerns about potential restrictions around particulate matter (PM) nonattainment areas. Nonattainment status invokes planning and notification requirements through the state air quality agency. Several managers commented that their forests were in or near nonattainment areas. They expressed concern about proposed new U.S. Environmental Protection Agency (EPA) air quality standards and the implications of expanding human populations. Responses in our survey were based on the (then) current PM air quality standards; perhaps air quality laws would have been ranked even higher under the proposed stricter standards. Regions with many urban areas and rapidly expanding populations might be expected to have more new nonattainment areas and to face stronger barriers to achieving desired burning levels. This situation could be quite serious in the Rocky Mountain, Intermountain, and Pacific Southwest regions.

Our survey asked whether the presence of special

Class I air quality protection areas—wilderness, parks, and other areas where the regulatory goal is zero reduction in air quality—had affected the burning program. Most respondents said that their programs had not been strongly affected because there was no slash or management-ignited burning in these areas—only prescribed natural fires, which are not subject to Class I restrictions. Much of the management burning on the fringes of Class I areas is done during the fall and early spring, when visitors' use of public wilderness areas and National Parks is lowest. The restriction most often mentioned was a narrowing of the prescription window near Class I areas in an attempt to find favorable wind directions. Some respondents feared greater complications in documenting possible Class I effects for NEPA as the size and total scale of management-ignited burning increased.

Limitations to the available burning windows are actually manifestations of weather and fuel conditions and the influence of air quality regulations on the ability to schedule burns. Depending on how the respondents viewed the relative importance of seasonal, time of day, and other scheduling rules related to air quality, the regulation factor could be strongly correlated with the responses on narrow burning windows.

Air quality regulations and environmental laws are treated as separate factors in this study. Respondents described how compliance with environmental laws can also add to the planning costs of burning, a highly rated factor (3.2). Open response comments about the importance of environmental laws shed some light on their role as constraints on burning activity. Often mentioned was environmental effects documentation required in burn planning under NEPA. Many managers considered these requirements excessive because the NEPA analysis requires levels of public involvement that can delay burn projects and cause them to miss prescription windows. Some managers foresee an increasing burden under NEPA because of the trend toward larger burns for ecosystem management and fuel reduction in natural fuels, requiring more elaborate NEPA analyses. However, there is little information about how many burns go through NEPA analysis or how much NEPA adds to the cost and complexity of burning.

Regulations for threatened and endangered species and water quality protection may also present constraints. Such standards include best management practices for fireline construction under the Clean Water Act and various protection measures for threatened and endangered species under the Endangered Species Act. Furthermore, under the National Forest Management Act, species viability provisions must be factored into the burn planning; burns with unacceptably high risks of escaping, or damaging species or habitats, may be postponed or canceled. It is unclear how these risks are accounted for in burn planning and decision making.

Snag retention standards have become an issue not only because snags must be afforded protection from fire damage, but also because they pose a hazard to the safety of fire crews and can serve as an ignition

source. Protecting a growing network of riparian reserves and archeological sites has also complicated burning programs.

Data Limitations

Survey responses reflect subjective judgments based on data from a variety of record-keeping systems. Data was not uniformly available for different resource targets, burn types, or regions. There is great variation among responses from national forests within some regions.

Many forests reported that data for some years were not available and that 1989 was a low year because many natural fuels programs—management-ignited and prescribed natural fires—were suspended because of the public uproar and policy reconsiderations following the Yellowstone National Park (Wyoming) fire. There are few guidelines for collecting or analyzing cost data since most prescribed fire receives funding from several sources. Our crude cost categorization did not allow managers to show different slash preparation and ignition methods, which may be important uses in future burning programs.

MANAGEMENT IMPLICATIONS

Prescribed burning is probably the most extensive planned disturbance activity in the National Forest System, a distinction formerly afforded to timber harvesting. To be a meaningful tool for ecosystem and fuels management and other objectives, prescribed burning must be conducted regularly and widely. Changes are occurring rapidly in the burning program; for example, fuels-management budgets have increased dramatically, from historic levels of about \$20 million to \$60 million in 1997. Forest Service fire managers are making progress on increasing the burning activity, but they are dealing with many new issues in the process.

Our comparisons should not be used to assert that one region is more efficient than another in its progress toward desired levels. Comparisons among regions should be made cautiously and only after extensive follow-up. Nor should broad overall targets for increased burning be set without understanding the unique blend of resource objectives and physical, cultural, political, and economic influences that comprise burning prospects in each forest and region. Understanding how those elements shape the feasibility and cost of burning is critical to improving the effectiveness of the burning program without creating unacceptable social and environmental costs.

Lack of trained personnel and uncertainty about long-term funding are 2 constraints that will need to be addressed if progress on these goals is to continue. The narrow seasonal burning window makes it doubly important to have a well-prepared workforce to capture burning opportunities. Although funding constraints may have been partially removed, full accomplishments at desired levels would cost about \$150 million (1994 dollars) annually on the forests that responded

to our survey. Trends to larger fire sizes may allow fuels dollars to go further, but anticipated increases in environmental documentation and compliance may divert some of the funding to overhead and planning, leaving less to accomplish on-the-ground goals. The dollars formerly provided through brush disposal and reforestation trust funds are no longer available. Therefore, the funding burden will fall on appropriated fuels funding and funds provided by functions that benefit from burning activity, such as wildlife and range.

The trend to larger burns could also present unwanted effects and problems in successfully managing resources in the wildland-urban interface, sensitive species habitats, and other protected areas. It is perhaps ironic that burns designed to enhance ecosystem conditions and habitat for some species (e.g., red-cockaded woodpecker) could create hazards for other species (e.g., freshwater mussels and fish). Furthermore, we do not know how burning at larger scales will change the frequency and severity of escapes. Tripling or quadrupling the number of hectares burned could likewise increase the number of escapes and smoke intrusion incidents, especially if (1) the additional burning is more difficult than in the past, (2) the regions take more risks in pushing toward hectare performance targets, and (3) the skilled workforce is not available to manage these risks effectively.

Political realities may constrain the goals of increasing the annual burning program, depending on the region. Prescribed burning is a relatively new battleground for interest groups with potential for inciting new entrants concerned with visibility and human health hazards. The tradeoffs among different objectives will become more acute and contentious as interest groups debate and litigate burning projects. If vegetation manipulation must precede burning, as is the case on many hectares in the western regions, objections from traditional anti-harvest groups will be added to the dissonance. These and other concerns may require research on new ignition and fire management techniques for employing fire on larger scales in a variety of ecological systems while maintaining acceptable levels of escapes, smoke intrusions, and non-target fire damage.

The U.S. EPA's recent introduction of stronger particulate matter restrictions and visibility goals may prove to be an important limiting force not captured in our survey results. Our study's respondents assessed only a 60% likelihood of increasing burning under the (then) current PM standards. These same respondents might not be so optimistic today.

Expectations for the role of expanded prescribed natural fire need to be reexamined. Prescribed natural fire can be expensive, with costs that are much more variable than management-ignited burns. The popular notion that prescribed natural fires are extensively managed, inexpensive "let burn" wildfires is not consistent with our survey results. Substantial costs are incurred in monitoring these fires and maintaining sufficient standby personnel. Although such fires are typically large, their per-hectare costs are high and they

require major commitments of firefighting resources during times of high demand on firefighting resources.

The issue of who pays for burning will become more critical. A large portion of the current burning activity is paid for with non-fire funds, primarily wildlife and reforestation. Multiple objectives, tighter budgets, and severe reduction in timber harvest-based funding will lead to more complex and controversial cost allocation problems.

Besides a general agreement that hazard reduction is the key objective of burning, there are strong differences in regional resource objective mixes. A more sophisticated assessment of these mixes may be necessary to guide budget planning and implementation. Our survey uncovered emerging concerns about possible competition for funding between urban interface and ecosystem enhancement burning. Criteria for performance at the program and project levels may be needed to tie the multiple-objective nature of burn prescriptions to desired future conditions in forest plans. Ranges in performance and costs for burn types within forests could be built into flexible performance targets and cost-effectiveness standards.

Environmental regulations and NEPA as well as forest-level guidelines need to be further monitored for their influence on burning activities and costs. Some of our respondents said that the planning component of burn costs had been increasing because of analysis requirements under agency NEPA implementation guidelines, forest plan standards and guides, and environmental protection laws. Public involvement and analysis of effects may be more relevant and efficient at broader geographic scales. Efficiency may demand that planning for increased burning should take place during the Land Management Planning and watershed analysis processes, alleviating burdens and timing delays at the project execution level. Revisions in policies and regulations will have to consider the need to quickly capture fleeting prescription windows.

Tracking the prescribed burning program of the future will require regularly collected, comparable data on burning status and trends. A continuation beyond our 1994 survey would help establish trends and identify dynamics that will drive the success of the burning program. A comprehensive, uniform system of data collection on activity levels, costs, resource targets, and other elements could enhance burning programs and the further integration of land management planning and fire planning.

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