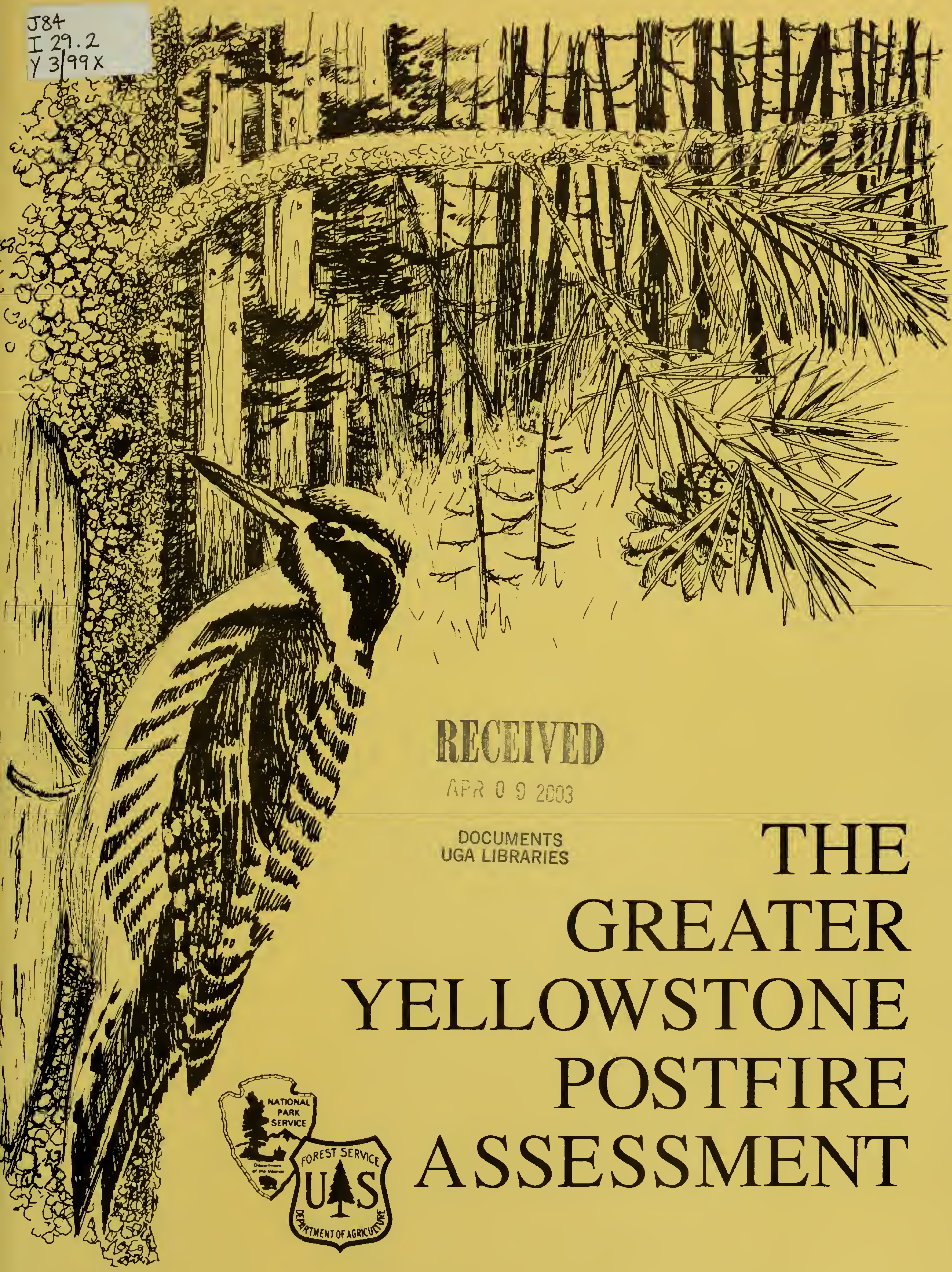

THE GREATER YELLOWSTONE POSTFIRE ASSESSMENT

NATIONAL PARK SERVICE
FOREST SERVICE
DEPARTMENT OF AGRICULTURE

THE
GREATER
YELLOWSTONE
POSTFIRE ASSESSMENT

THE GREATER YELLOWSTONE POSTFIRE ASSESSMENT

A Cooperative Project
of the

GREATER YELLOWSTONE COORDINATING COMMITTEE

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Rocky Mountain Region

Regional Forester,USFS
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Bridger-Teton National Forest

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Presents

THE GREATER YELLOWSTONE POSTFIRE ASSESSMENT

Prepared by

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National Forests

and

Grand Teton Yellowstone
National Parks

Published March 1989

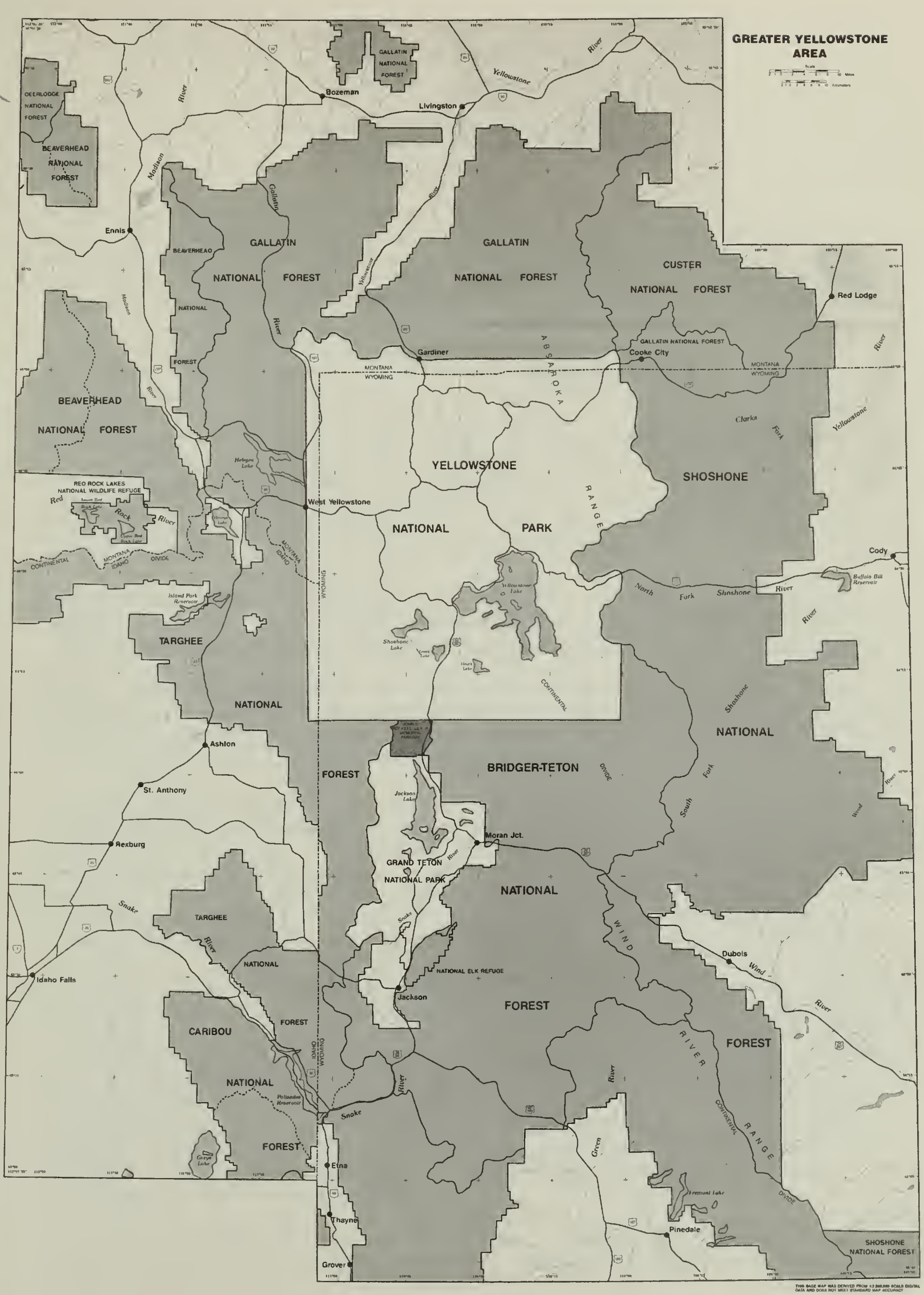
THE GYA AND THE GYCC

The Greater Yellowstone Area (GYA) is made up of parts of six National Forests and two National Parks. The contiguous portions of these parks and Forests encompass roughly 11.7 million acres of federal reservations, plus state lands, National Wildlife Refuges, unreserved public domain (Bureau of Land Management), and other lands. This huge area lies within three states - Montana, Idaho, and Wyoming - and includes all or parts of 12 counties.

In the early 1960's Forest and park managers recognized the need for coordination in managing Forests and parks in the GYA. The Greater Yellowstone Coordinating Committee (GYCC), born of that need, consists of the following:

- Regional Foresters of Forest Service Northern, Intermountain, and Rocky Mountain Regions
- Regional Director of the National Park Service, Rocky Mountain Region
- Superintendents of the Grand Teton and Yellowstone National Parks
- Forest Supervisors of the Beaverhead, Custer, Gallatin, Shoshone, Targhee, and Bridger-Teton National Forests

These park and Forest managers have met regularly over the past three decades to coordinate management and public services. More formalization of this coordination was prompted by congressional oversight hearings in October 1985. The GYCC met six times this past summer and fall to coordinate fire suppression and rehabilitation activities.


GREATER YELLOWSTONE AREA
GALLATIN NATIONAL FOREST
DEERLODGE NATIONAL FOREST
BEAVERHEAD NATIONAL FOREST
Bozeman
Livingston
Yellowstone
River
Madison
Gallatin
Ennis
BEAVERHEAD NATIONAL FOREST
GALLATIN NATIONAL FOREST
CUSTER NATIONAL FOREST
Red Lodge
GALLATIN NATIONAL FOREST
Gardiner
Cooke City
MONTANA
WYOMING
ABSAROKA RANGE
BEAVERHEAD NATIONAL FOREST
Clarks Fork
YELLOWSTONE NATIONAL PARK
SHOSHONE
RED ROCK LAKES NATIONAL WILDLIFE REFUGE
Red Rock River
West Yellowstone
Hebgen Lake
CONTINENTAL DIVIDE
MONTANA IDAHO
Cody
North Fork Shoshone River
Buffalo Bill Reservoir
Island Park Reservoir
Yellowstone Lake
Shoshone Lake
TARGHEE NATIONAL FOREST
CONTINENTAL
Shoshone
NATIONAL
Ashton
BRIDGER-TETON
DIVIDE
St. Anthony
Jackson Lake
South Fork
Rexburg
Moran Jct.
GRAND TETON NATIONAL PARK
NATIONAL
Snake
TARGHEE River
WIND RIVER RANGE
Dubois
Wind River
NATIONAL ELK REFUGE
Idaho Falls
Jackson
FOREST
CARIBOU NATIONAL FOREST
IDAHO WYOMING
FOREST
Palisades Reservoir
Snake River
Green River
CONTINENTAL DIVIDE
Grays Lake
Etna
Fremont Lake
Thayne
Pinedale
SHOSHONE NATIONAL FOREST
Grover
THIS BASE MAP WAS DERIVED FROM 1:2,000,000 SCALE DIGITAL DATA AND DOES NOT MEET STANDARD MAP ACCURACY

EXECUTIVE SUMMARY

Fifteen interagency teams were assembled by the Greater Yellowstone Coordinating Committee to collect and evaluate greater Yellowstone area postfire data. Initial assessments were conducted by scientists and specialists using the most complete and current data available. These assessments continue to be refined as new information becomes available.

Greater Yellowstone burned area survey. Color infrared photography was used to complete a systematic, consistent estimate of burned acreages, including burn intensity and soil heating. Results of this effort included a burned area map and statistical breakdowns of the extent, distribution, and intensity of the burned area. Initial assessments indicated that about 1.4 million acres in the GYA were affected by fire, approximately 988,925 acres of which were in Yellowstone Park (not including 2,700 acres in Grand Teton National Park) and 414,150 acres on Forest Service lands (excluding the Corral Creek, Hunter, and Fayette Fires). Future mapping efforts are planned to further refine these figures.

Remote Sensing. Various remote sensing resources were employed to gain an understanding of the scope and effects of the fires. These included LANDSAT imagery and a wide variety of aerial and ground-based photography.

Water. Threats to water resources or beneficial uses of the water were assessed to be insignificant. In instances where noticeable effects may occur, the effects will tend to be localized, low to moderate in magnitude, and limited to the first few years postfire.

Soil. At some sites, soil water repellency was altered slightly by the fires, although some degree of water repellency occurred naturally at all unburned sites tested. Changes in soil infiltration were small, though more sediment may be present in runoff from steeper slopes. These changes in soil properties should not significantly affect erosion potential in the GYA, with the exception of the Shoshone National Forest where burn intensities were higher and attendant potential for erosion is greater.

Air Quality. Monitoring was conducted at four GYA locations. Gardiner, Montana, experienced 19 days when particulate concentrations were over the ambient standard, Mammoth, Wyoming, experienced 7 days over standard, and West Yellowstone, Montana, experienced concentrations that were extremely high during the first week of September. No particulate concentrations exceeding the ambient standard in Cooke City, Montana. No appreciable amounts of hydrogen sulfide or sulfur dioxide were detected. Attempts to monitor carbon monoxide were unsuccessful due to equipment failures. Possible health effects may have occurred from benzo(a)pyrene exposure (a carcinogen found in wood smoke).

Fire and Plant Ecology. Once fires pass, plants respond soon afterwards by resprouting from underground parts or by dispersing seed. Lodgepole pine seed densities of 50,000 to 1,000,000 seeds per acre have been documented in GYA burn areas. Only in extremely limited areas (under fallen logs that burned for several hours) does soil heating kill all below-ground plant material. Within three years, forest floor cover should be equal in burned and unburned areas. Species diversity in burned areas will continue to increase over the next five years. Nutrients released from the ash should produce vigorous plant growth next year.

Timber. The 39,200 acres that burned on National Forest lands suitable for timber management represent about 2.2 percent of all GYA National Forest lands of this type. Artificial reforestation will be used in areas needing accelerated recovery efforts and in areas where timber production is a major management objective. Salvage harvests of fire-damaged timber are being considered where appropriate.

Range and Grasslands. Fire typically yields long-term gains in range productivity and health. Noxious weeds may establish where native vegetation has been disturbed by fire-suppression activities, which will lower range productivity. These disturbed areas hold the greatest threat for weed introduction, although because of the vast area involved, weed establishment may also be a possibility in burned areas.

Wildlife. Known fire-related mortalities included 335 elk, 36 mule deer, 12 moose, 6 black bear, 9 bison, and 5 young osprey. Other undocumented mortalities are certain to have occurred. No grizzly bears or other threatened or endangered species are known to have died. As a whole, these individual losses can be considered to be relatively minor when compared to the magnitude of long-term fire-related benefits. The fires are expected to dramatically improved habitat diversity and forage productivity. As a result of the fires, the GYA will be able to support a greater number of animals and wider variety of species.

Fisheries. Overall, potential impacts to fish and aquatic life were determined to be minimal and short-lived, and in many cases the fires may act to improve fish habitat and productivity.

Fire-suppression Effects. The effects of fire-suppression activities included not only the environmental impacts of actions taken to directly suppress fires but also the impacts associated with logistics and support functions, such as transporting, housing, and feeding firefighters. Most notable and detrimental are firelines, particularly those dug in once undisturbed wild areas. In the GYA, approximately 665 miles (164 acres) of handline and 137 miles (333 acres) of bulldozer line were constructed. Other effects included disturbances associated with off-road travel; structural protection; intensive aircraft use; helibase, camping, and staging activities; water and fire-retardant drops; and use of wetting and foaming agents.

Visual Resources. Wildfire is a natural occurrence in the GYA and its effects should be represented in the visual resources of the area. However, in many instances fire-suppression activities left human-made scars on the landscape that will endure for decades. Sensitive, uniform treatment of these impacts is essential to preserving forestwide and parkwide continuity. Visitor safety is an overriding concern in this treatment. Many burned areas can provide new educational and interpretive opportunities, and some views of scenic vistas have been improved, enhancing visitor experiences. These considerations and others have been inventoried and assessed.

Facilities. Considering the intensity and size of the fires, structural losses and damages were relatively light. Losses and damages in Yellowstone Park and Forest Service lands included cabins used by employees and guests, two backcountry cabins, and other miscellaneous outbuildings. Twenty-nine structures were lost in Yellowstone Park and six were damaged. On Forest Service lands, two structures were lost and one was damaged. Thirty-six private structures in the Crandall area were lost and five were damaged. Other losses included utility poles, signs, guardrails, bridges, water bars, picnic tables, and campsite improvements. Fire-killed trees in danger of falling in roadways, trails, and high-use areas present a safety risk. Some unburned developments and facilities were indirectly impacted by preventative fire-suppression activities.

Cultural resources. Partial inventories were conducted in many areas. There were no losses of individual historic buildings officially determined eligible to the National Register. Some structures or ruins that may have been eligible or that contributed to historic mining districts were damaged or destroyed. No known National Register archaeological sites were destroyed, but two known historic sites were damaged. Overall, historic structures in the GYA were well protected from fire. Additional inventory work may reveal other impacts as well as undiscovered sites obscured by vegetation before the fires.

Recreation. Compared to the past five summers, 8.8 percent fewer people visited Yellowstone Park during May through October 1988, overnight backcountry use was 28.7 percent lower, 17.4 percent fewer people used park campgrounds, and 14.5 percent fewer people used park lodging facilities. Facility and road closures in Yellowstone Park required travelers to alter itineraries. These closures (and those on Forest Service lands) undoubtedly affected travel throughout the GYA. Hunters in Wyoming were minimally impacted. The 1988 fires will provide numerous educational opportunities and may prove to be a significant visitor attraction in the following years.

Public Affairs. Between July 21 and September 21, 1988, the Yellowstone Park Public Affairs Office assisted over 3,000 media representatives. This tremendous influx of media correspondents greatly strained existing public affairs operations. More than 55 people were needed to accommodate this load. During the peak, over 200 representatives were assisted each day in Yellowstone Park alone. The Area Command Information Center was established to disseminate GYA fire information, relieving some of the media pressure. Media correspondents continued to return to Yellowstone Park conducting follow-up stories. More than 200 correspondents are expected to return this spring.

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INTRODUCTION

THE 1988 FIRES

The GYA fires of 1988 generated more national attention than any other event in the history of the area and involved the largest fire suppression effort ever undertaken in this country. By September 26, the perimeter of burns in the GYA was 1.4 million acres. Fifty fires had been ignited by lightning, of which eight were still considered alive, though after that date they made no more of the dramatic runs that had been seen during the summer, when thousands of acres of forest were eaten up in hours. All told there were 249 fires in the GYA in 1988. Eighty-one were suppressed at less than 10 acres. At the peak of fire fighting efforts, 9,500 firefighters (civilian and military), dozens of helicopters, and more than 100 fire trucks from many states were involved in a massive interagency struggle with the fires. The cost is now estimated at about $120 million.

Media attention, and to a great extent fire suppression efforts, concentrated on the protection of various developments in the park and communities nearby. The resultant media coverage was perhaps inevitably confused, as so many stories and issues were under attention at once that any brief report was almost certain to muddle them. A brief chronology of the major fires may help set the stage.

Major Fires

The huge North Fork Fire covered approximately 504,025 acres (including its administratively split branch the Wolf Lake Fire) was human-caused fire started on June 22 in Targhee National Forest just west of Yellowstone National Park (none of the human-caused fires in the GYA in 1988 originated as prescribed management-set fires; they were all accidental fires, fought from the outset). It quickly burned into the park and eventually threatened developments at Old Faithful, Madison Junction, Norris, Canyon Village, Mammoth Hot Springs (NPS headquarters), and Tower-Roosevelt, and the communities of West Yellowstone, and Gardiner, Montana.

The Shoshone Fire, a naturally caused fire, started in southern Yellowstone Park on June 23 where it was managed as a natural fire. It grew to an area of more than 24,000 acres before being administratively redefined as part of the Snake River Complex of fires, whose acreage covered about 172,025. By then it had threatened Grant Village, a park development on the shore of Yellowstone Lake.

The Storm Creek Fire, a lightning fire started on July 3 on the Custer National Forest north of Yellowstone Park, was at first managed as a prescribed natural fire under the terms of the national forest's management plan, but after two weeks was redefined as a "wildfire," that is a fire no longer within management prescriptions. It was then fought, but grew to about 95,000 acres and threatened the communities of Silver Gate and Cooke City, Montana.

The Clover-Mist Fire, started by lightning on July 9 in eastern Yellowstone Park, was originally managed as a prescribed natural fire under the terms of the park's fire management plan, then was fought. It grew to cover about 319,575 acres in the park and in Shoshone National Forest east of the park, and showed signs of threatening Silver Gate and Cooke City, then ran east and burned several structures in the Crandall/Squaw Creek area of Wyoming.

The Hellroaring Fire, a human-caused fire started on August 15 on Gallatin National Forest north of Yellowstone Park, eventually burned about 66,725 acres.

The Huck Fire, a human-caused fire originating on August 20 on the John D. Rockefeller Memorial Parkway between Yellowstone and Grand Teton National Parks, eventually grew to cover more than 106,000 acres before it was administratively redefined as part of the Huck-Mink Fire Complex, whose total acreage was about 227,525. It required the evacuation of Flagg Ranch, a development just south of Yellowstone Park.

Several smaller fires added to the total acreage. Merely that the Fan Fire, for example, which burned approximately 20,900 acres in Yellowstone Park, can be referred to as a "smaller" fire suggests the tremendous scale of this event.

Even the most casual reading of this summary of the major fires will reveal the extent to which this was an interagency emergency, as well as the extent to which the fires were managed under a variety of policies.

EFFECTS AND AFTEREFFECTS

Public interest in the GYA, especially in Yellowstone Park, following the fires has amounted to a heartwarming outpouring of sympathy and offers of support. Much of the help offered is inappropriate, such as pledges of nonnative seedlings from other parts of the country. National Park Service (NPS) and U.S. Forest Service (USFS) officials have established offices to deal with offers of assistance, and to channel them in meaningful directions.

This array of public interest, some informed and some not, points up the challenges faced by agencies in what is awkwardly called the "recovery" process. For the USFS lands where timber harvests or other commercial uses may prevail, there is indeed something to recover from. Active reseeding and revegetation may be useful in some places. For NPS lands where visitor facilities such as trails, picnic areas, or buildings were damaged recovery also seems an appropriate word. But for the large areas of wilderness burned by natural fires, recovery is by definition the job of nature. Rhetoricians even argue that it is inappropriate to describe a naturally burned forest as one in need of recovery at all; it is merely a forest in a different stage of its life, a stage through which it passed many times prehistorically, during previous fire cycles.

Recovery needs, that is actual physical work to be done, are indeed extensive in both Yellowstone Park and in surrounding national forests. In the GYA some 665 miles of hand-dug firelines had to be restored, to avoid erosion and incursions of exotic plants (nonnative weedy species) on exposed soils. About 137 miles of bulldozer lines (32 in Yellowstone Park) needed similar treatment. Dozens of camps, helicopter landing sites, and hundreds of smaller disturbances also needed to be repaired. In many instances, the efforts of fighting the fires created more enduring disruptions of settings than did the fires. Much of the work of restoring firelines and rehabilitating campsites was accomplished before winter snows came, but much remains to be done. Discussions of recommended or completed rehabilitation efforts will not appear in this document, but in many cases such reports are available from individual agencies or units.

There is a widespread if informal feeling that the massive firefighting efforts probably did not significantly reduce the acreage burned, but there is also consensus that firefighters' efforts to protect property and human life were remarkably successful. Firefighting activities resulted in many minor injuries to personnel and one fatality was reported: a firefighter was killed by a falling tree in Wyoming.

Opportunity

Promoters of travel to the region are emphasizing the singular opportunity the fires present; only once in several generations can visitors view such a huge ecological unit "starting over" this way. This opportunity has also been recognized by the scientific community.

Postfire research opportunities abound in the GYA, and scientific research will certainly burgeon. Scholarly interest in the GYA fires has been enormous, and hundreds of researchers from many disciplines have expressed interest or submitted proposals for research projects. Yellowstone Park currently hosts some 200 government and independent researchers from many disciplines each year. Yellowstone Park Chief of Research John D. Varley estimates that number may increase by 50 percent.

But ultimately, the finest opportunity is the resource's. The biotic communities of the GYA have just received a dynamic jolt of historic dimensions, and all the members of those communities will be doing all that evolution will allow to take advantage of the new order. For nature, opportunity rarely has knocked so loudly in the GYA.

THE GREATER YELLOWSTONE AREA POSTFIRE ASSESSMENT

At the direction of the Greater Yellowstone Coordinating Committee, an intensive postfire assessment effort was launched. Fifteen interagency teams were assembled to collect and evaluate greater Yellowstone area postfire data. The findings and conclusions of those teams are presented here. These initial assessments represent the professional opinions and evaluations of skilled scientists and specialists using the most complete and current data available. In the spring, once additional postfire data can be gathered, some estimates and assessments may change slightly; therefore, all figures should be considered to be provisional. In some instances the potential aftereffects cannot be fully known for some years, if at all.

This unified effort reflects the growing spirit of cooperation which the GYCC encourages and fosters. The fires highlighted both the new strengths and remaining weaknesses of interagency cooperation. In reflecting on postfire effects one thing cannot be overlooked; in no small way, this event brought the agencies of the GYA still closer together, and the GYA will be the ultimate beneficiary.

SECTION 1

GREATER YELLOWSTONE BURNED AREA SURVEY

GREATER YELLOWSTONE BURNED AREA SURVEY

In early September, the Burned Area Survey Team was assembled to determine how much burned, how hot the fires burned and, within fire perimeters, what portion of the mosaic was unburned. This interagency team of soil scientists, vegetation specialists, and support personnel from the National Park Service, U.S. Forest Service, National Aeronautics and Space Administration, and Montana State University worked to provide an initial assessment of the extent, distribution, and intensity of the burned areas in the GYA. This is a summary of the results of the Burned Area Survey completed in November 1988. Maps, supporting data, and other additional information are available from the Burned Area Survey Team, P.O. Box 168, Yellowstone National Park, Wyoming 82190.

Objectives

The project objective was to produce a map that represented a systematic, consistent estimate of the burned acreages within the affected part of the GYA, including burn intensities and soil heating. The project lasted three and a half weeks. The study area included Yellowstone Park and the contiguous National Forest and National Park lands. This area covers about 4 million acres. The Fayette, Corral Creek, and Hunter fires were not mapped. Although these fires are locally significant, they cover a relatively small portion of the total burned area (about 47,000 acres), and they were too widely separated to be included considering photographic coverage and the tight time constraints of the project.

Methods

To ensure a uniform estimate, consistent methods were used across the entire burned area. A minimum map unit size of 200 acres was selected. This size allowed rapid mapping from aerial photography while providing a level of detail adequate for resource assessment and planning. This was a reconnaissance-level survey. Its products were not intended for use in site-specific planning. The acreages given should be regarded as maximums since the 200-acre map units all contain a certain amount of unburned area.

Color infrared photography at a nominal scale of 1:63,360 was selected. Three photographic overflights were needed to provide coverage. Despite this, the photographs of some areas were still too smoky or cloudy to be interpreted (these include a small part of the Targhee National Forest and the North Fork of the Shoshone River). Burned acreages in these areas were estimated.

A team of ten scientists experienced in the interpretation of aerial photography, soil surveys, and vegetation mapping used standard soil and vegetation mapping techniques to delineate areas by intensity of burn,

PRELIMINARY SURVEY OF BURNED AREAS: YELLOWSTONE NATIONAL PARK AND ADJOINING NATIONAL FORESTS

GREATER YELLOWSTONE POST-FIRE RESOURCE ASSESSMENT COMMITTEE, BURNED AREA SURVEY TEAM

OCTOBER, 1988
(Burned areas as of Sept. 15, 1988)

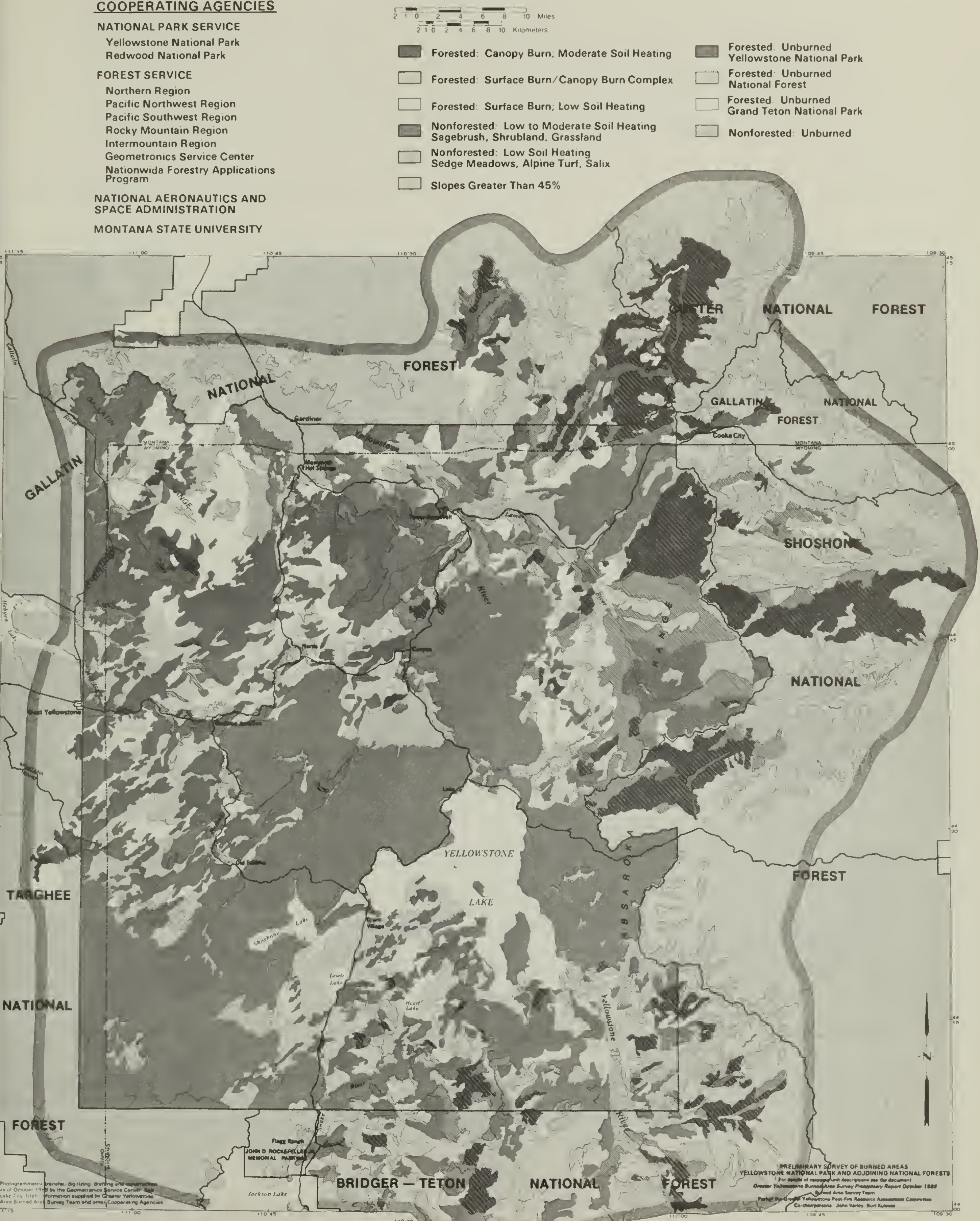
COOPERATING AGENCIES

NATIONAL PARK SERVICE
- Yellowstone National Park
- Redwood National Park

FOREST SERVICE
- Northern Region
- Pacific Northwest Region
- Pacific Southwest Region
- Rocky Mountain Region
- Intermountain Region
- Geometronics Service Center
- Nationwida Forestry Applications Program

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MONTANA STATE UNIVERSITY



degree of soil heating, and type of vegetation burned. Extensive supporting ground investigations were conducted to verify interpretations of photographic "signatures." Over 3,000 sites were investigated. Helicopters were used to reach some sites when necessary. Sample sites were randomly selected throughout the study area. Interpreted photographs were sent to the Forest Service Geometronics Service Center for stereoplotting, digitization, polygon analysis, cartography, and map production.

Results

The map depicts the distribution and character of the burned areas as of September 15, 1988. The following is a general description of the map units found in the legend.

Forested: Canopy burn; Moderate soil heating

> The forest overstory has burned. No unburned duff or litter remains on the forest floor. Soil is charred as deep as 5 cm. Up to 2 percent of this map unit could have charring from 6-10 cm deep. These more deeply burned soils may have tan or reddish surface layers and occur only where large logs have burned on the surface. On the Shoshone National Forest, up to 15 percent of the area mapped as this type could have char depths greater than 10 cm.

Forested: Surface burn/Canopy burn complex

> This is a mosaic of canopy and surface burns. Each type of burn covers between 30 and 70 percent of the map unit, averaging a 50 percent split. It is mapped as a mosaic because the components are too intertwined to separate at this scale of mapping.

Forested: Surface burn; Low soil heating

> Burning in this unit is largely confined to surface vegetation. Generally, the tree canopy is not burned. Most needle litter is absent, but most duff remains. Soil heating is not significant. Up to 15 percent of this unit can be unburned.

Nonforested: Low to moderate soil heating (sagebrush, shrubland, grassland)

> Most of this unit is grassland or sagebrush with small inclusions of aspen. Soil charring averages 2 cm where fuels are concentrated. This unit contains a mosaic of 75 percent burned and 25 percent unburned areas.

Nonforested: Low soil heating (sedge meadows, alpine turf, willows)

> This unit is generally found at higher elevations. Soil heating is low (less than 0.5 cm charring). This unit contains a complex mosaic of 75 percent burned and 25 percent unburned areas.

Soil heating classes were developed from Forest Service sources, research results, and consultations with Forest soil scientists. They relate to erosion and revegetation potential. "Low" soil heating intensity does not significantly affect soil erosion or revegetation. "Moderate" soil heating intensity affects erosion and revegetation to some extent. Erosion potential on steep slopes may be increased somewhat because of the absence of litter and organic matter just below the surface. Reemergence of shrubs, grasses, and forbs will occur rapidly from deeper plant parts. However, revegetation of moderately burned areas will take one to two years longer than areas with low-intensity burns because surface roots, seeds, and grasses have been lost in the surface layer.

Note that no "High" or "Severe" classes are given in the above map unit descriptions. These classes comprise such a small part of the burned area that they are not extensive enough to warrant inclusion in this map.

"High" soil heating is defined as having charring depths greater than 10 cm. Often there will be a surface layer of light reddish soil that has had all organic material volatilized and iron compounds oxidized. This class is rare in the burned area.

"Severe" soil heating is characterized by deep char, but also recrystallization or "baking" of soil materials. The soil is hardened. Erosion potential can significantly change, and almost all roots and rhizomes are killed. This class occurs only in unusual fuel load situations and is much less than one-tenth of 1 percent of the burned area.

Previous estimates of burned area have been based on burn "perimeter" or the line drawn around the extreme edge of the fires. This map depicts burned "area," which is only the area that has actually burned, disregarding previously drawn, sometimes arbitrary "perimeters." Since many acres within fire "perimeters" are not burned, the area estimates generated by this map are more accurate than earlier estimates.

Comparisons to perimeter acreage are also given. The perimeters used here are more exact than those given previously since they were generated from this map rather than from previous fire maps, which were delineated without the benefit of aerial photography.

In the future, more detailed mapping will resolve the total burned area further; some reductions of the total acreage figures are probable. At this scale of mapping, detailed delineation of the burn patchwork is not possible; thus, all numbers resulting from this first mapping effort should be regarded as maximum possible acreages and percentages. As much as 15 percent of the area counted as "burned" may not actually be affected by fire.

The following tables and charts display the burned area acreages by canopy burn, surface burn, and nonforested burn classes. Each chart is followed by its source tables. These figures have been calculated from the areas in each map unit. For example, since the Forested canopy/Surface complex averages 50 percent of each class, the total area in this map unit is apportioned accordingly into the canopy and surface burn classes.

Variations in Burned Acreage Estimates

At first there was much confusion and misinformation regarding fire acreages. Daily reports gave rough estimates of the perimeters of the burns, emphasizing that as much as half of the area within the perimeter was not burned (media reports typically quoted only the larger number). By late September, these rough estimates said that 1.6 million acres had been included within fire perimeters, 1.1 million of which was within Yellowstone Park. First estimates of actual burned acreage within fire perimeters in the park were arrived at by seat-of-the-pants guesstimates by skilled observers in helicopters. The figure they gave was 440,000. Then in late October the first round of infrared (IR) aerial reconnaissance mapping was completed by the Burned Area Survey Team (BAST). The BAST estimated a total burned acreage in the GYA of 1.4 million acres and within the park of 989,000 acres. Then in early December an EROS satellite image analysis of the burns estimated a burn acreage of 706,000 acres in Yellowstone. These numbers, all derived by respected means, differ so widely that they caused further confusion.

Differences in methods explain much of the discrepancies. For example, the resolution of the aerial mapping of October is 200 acre units, but included extensive field verifications of mapped data. Fires frequently burn in a "mosaic" pattern that creates a variety of shapes and sizes of new wildlife and plant habitats, and quite often the "jigsaw puzzle" is composed of very small pieces, each only a few acres in size. The EROS imagery, on the other hand, is measuring units of burnt or nonburnt land as small as 30 meters on a side but is still preliminary information with little supporting field verifications.

Also, the helicopter guesstimates, flown in smoky conditions, were rough counts only of burnt forests, while the Burned Area Survey Team were also able to measure ground fires under green forest canopies; of the 1.4 million acres reported by this IR aerial survey, 473,800 was ground fire under forest canopy, and another 80,075 was meadow or sage/grassland. No doubt upcoming surveys will also differ, and no doubt further public confusion will result. The BAST figures presented in this document are considered the most reliable and accurate to date.

BURNED AREA ACREAGES

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Abbreviations

YNP = Yellowstone National Park

GTNP = Grand Teton National Park

BTNF = Bridger-Teton National Forest

CNF = Custer National Forest

GNF = Gallatin National Forest

SNF = Shoshone National Forest

TNF = Targhee National Forest

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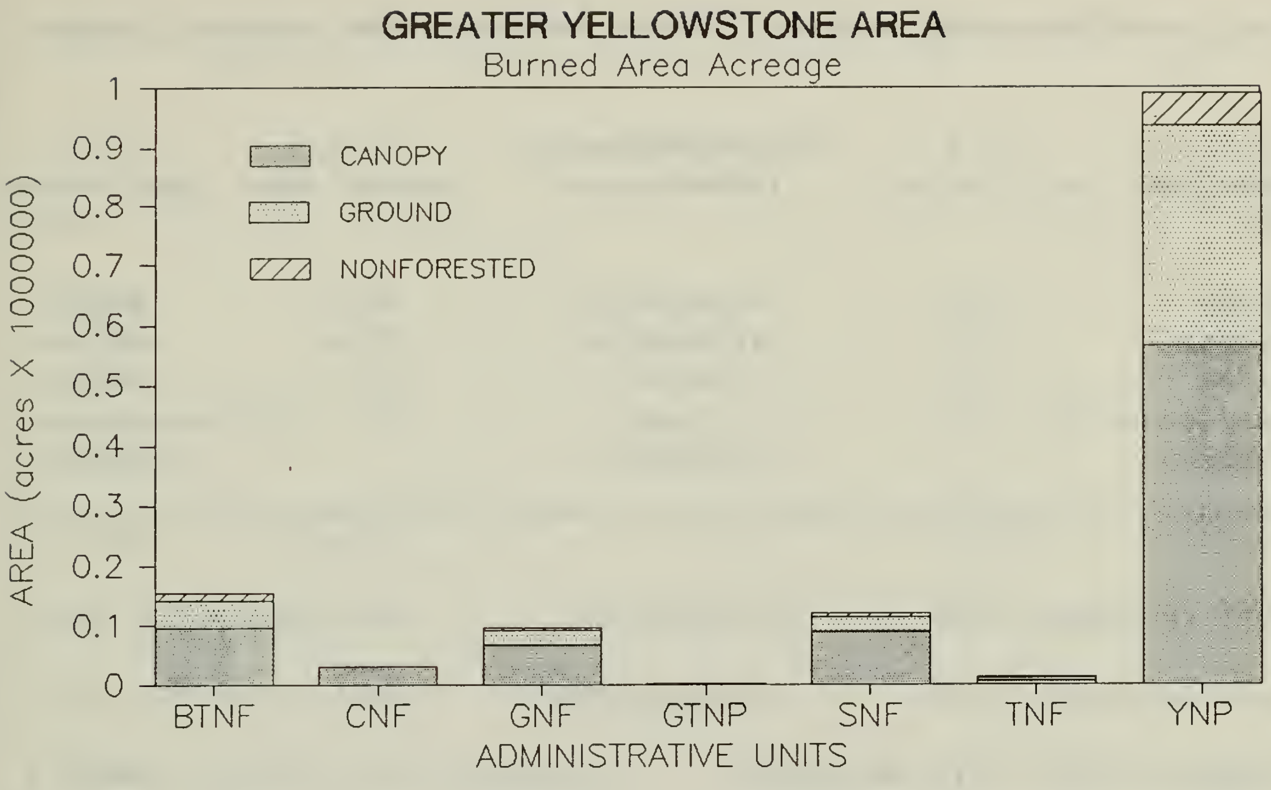


Figure 1. Burned Area Acreage in the Greater Yellowstone Area by Administrative Unit.
* These figures are preliminary and should be considered maximums. Future mapping will further refine these estimates.

TABLE 1. BURNED AREA ACREAGES WITHIN GREATER YELLOWSTONE AREA

Burn Type	Burned Area (acres)	% of Burned Area	% of Perimeter Area
Canopy	851900.0	60.6	53.6
Surface	473800.0	33.7	29.8
Meadow	46550.0	3.3	2.9
Sage/Grassland	33525.0	2.4	2.1
Unburned	182725.0		11.5
		100.0	100.0
Total in Burned Area	1405775.0		
Total Perimeter Area	1588600.0		
% Burned within fire perimeter			88.5

TABLE 2. BURNED AREA ACREAGES WITHIN BRIDGER TETON NATIONAL FOREST

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	97900.0	62.1	54.6
Surface	46700.0	29.6	26.1
Meadow	13050.0	8.3	7.3
Sage/Grassland	0.0	0.0	0.0
Unburned	21550.0		12.0
		100.0	100.0
Total in Burned Area	157650.0		
Total Perimeter Area	179200.0		
% Burned within fire perimeter			88.0

TABLE 3. BURNED AREA ACREAGES WITHIN CUSTER NATIONAL FOREST

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	29400.0	95.8	95.1
Surface	1300.0	4.2	4.2
Meadow	0.0	0.0	0.0
Sage/Grassland	0.0	0.0	0.0
Unburned	200.0		0.6
		100.0	100.0
Total in Burned Area	30700.0		
Total Perimeter Area	30900.0		
% Burned within fire perimeter			99.4

TABLE 4. BURNED AREA ACREAGES WITHIN GALLATIN NATIONAL FOREST

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	66000.0	68.9	64.2
Surface	24300.0	25.5	23.7
Meadow	5400.0	5.6	5.3
Sage/Grassland	0.0	0.0	0.0
Unburned	7000.0		6.8
		100.0	100.0
Total in Burned Area	95700.0		
Total Perimeter Area	102800.0		
% Burned within fire perimeter			93.2

TABLE 5. BURNED AREA ACREAGES WITHIN GRAND TETON NATIONAL PARK

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	1900.0	70.4	70.4
Surface	800.0	29.6	29.6
Meadow	0.0	0.0	0.0
Sage/Grassland	0.0	0.0	0.0
Unburned	0.0		0.0
		100.0	100.0
Total in Burned Area	2700.00		
Total Perimeter Area	2700.00		
% Burned within fire perimeter			100.0

TABLE 6. BURNED AREA ACREAGES WITHIN SHOSHONE NATIONAL FOREST

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	89000.0	74.9	55.2
Surface	22300.0	18.8	13.8
Meadow	3000.0	2.5	1.9
Sage/Grassland	4500.0	3.8	2.8
Unburned	42500.0		26.3
		100.0	100.0
Total in Burned Area	118800.0		
Total Perimeter Area	161300.0		
% Burned within fire perimeter			73.7

TABLE 7. BURNED AREA ACREAGES WITHIN TARGHEE NATIONAL FOREST

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	5350.0	47.3	47.3
Surface	5950.0	52.7	52.7
Meadow	0.0	0.0	0.0
Sage/Grassland	0.0	0.0	0.0
Unburned	0.0	0.0	0.0
		100.0	100.0
Total in Burned Area	11300.0		
Total Perimeter Area	11300.0		
% Burned within fire perimeter			100.0

TABLE 8. BURNED AREA ACREAGES WITHIN YELLOWSTONE NATIONAL PARK (FIRE PERIMETER BASIS)

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	562350.0	56.9	51.1
Surface	372350.0	37.7	33.8
Meadow	25200.0	2.5	2.3
Sage/Grassland	29025.0	2.9	2.6
Unburned	111475.0		10.1
		100.0	100.0
Total in Burned Area	988925.0		
Total Perimeter Area	1100400.0		
% Burned within fire perimeter			89.9

TABLE 9. BURNED AREA ACREAGES WITHIN YELLOWSTONE N.P. (TOTAL AREA)

Burn Type	Burned Area (acres)	% of Burned Area	% of YNP Area
Canopy	562350.0	56.9	25.3
Surface	372350.0	37.7	16.8
Meadow	25200.0	2.5	1.1
Sage/Grassland	29025.0	2.9	1.3
Unburned	1232875.0		55.5
		100.0	100.0
Total in Burned Area	988925.0		
Total Park Area	2221800.0		
% Burned of Total YNP Area			44.5

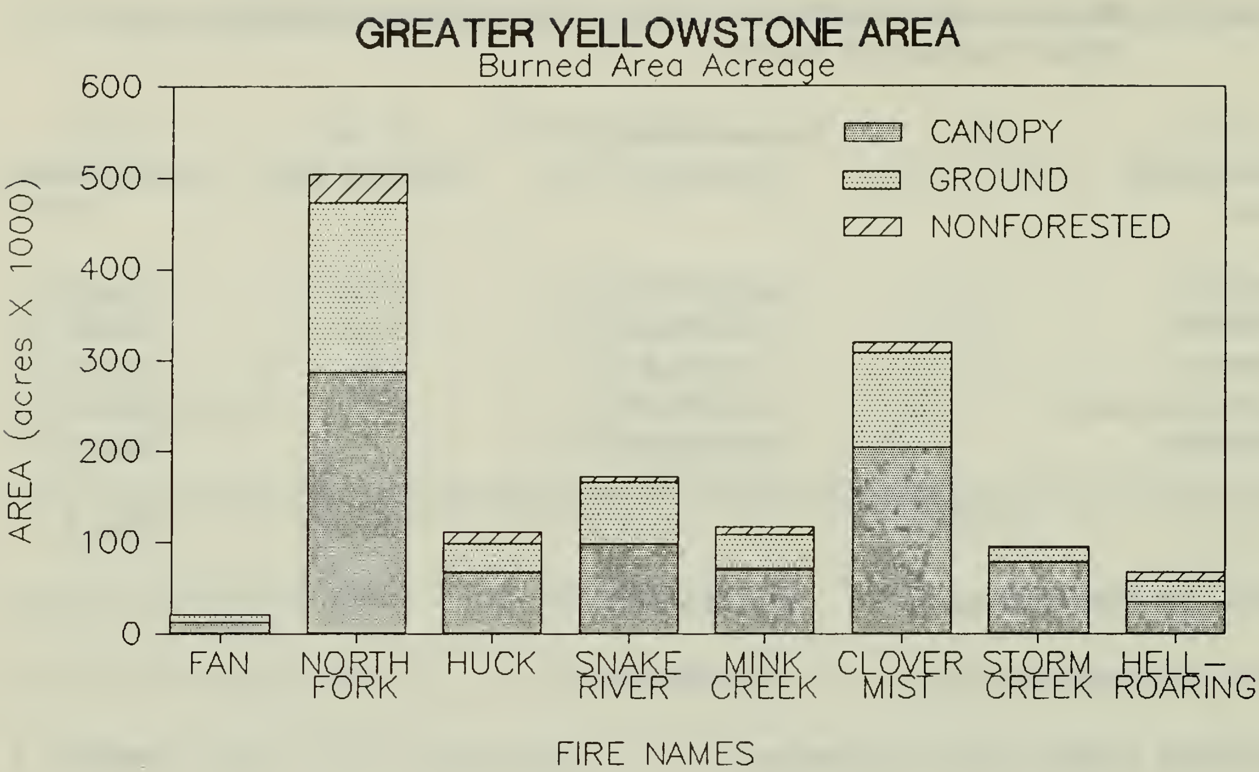


Figure 2. Burned area acreage in the Greater Yellowstone Area by Fire. *These figures are preliminary and should be considered maximums. Future mapping will further refine these estimates.

TABLE 10. BURNED AREA ACREAGE WITHIN THE GREATER YELLOWSTONE AREA BY ADMINISTRATIVE UNIT *

				UNIT				
FIRE	GTNP	YNP	BTNF	CNF	GNF	SNF	TNF	TOTAL
Clover Mist		200775				118800		319575
Fan		20900						20900
Hellroaring		19625			47100			66725
Huck	2700	25625	82875					111200
Mink Creek		41550	74775					116325
North Fork		490225			2500		11300	504025
Snake River		172025						172025
Storm Creek		18200		30700	46100			95000
TOTAL	2700	988925	157650	30700	95700	118800	11300	1405775

*excludes Fayette, Hunter, and Corral Creek fires.

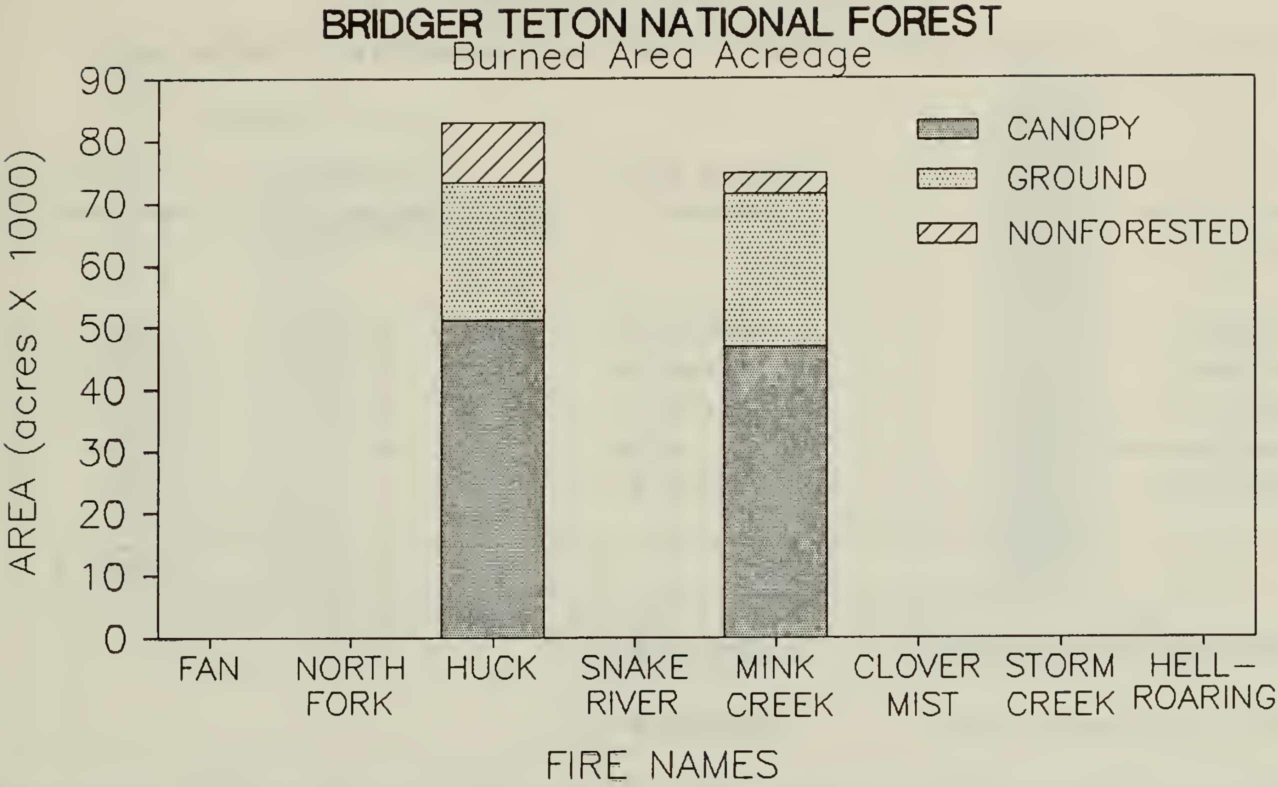


Figure 3. Burned Area Acreage in the Bridger Teton National Forest.
* These figures are preliminary and should be considered maximums. Future mapping will further refine these estimates.

TABLE 11. BURNED AREA ACREAGES FOR HUCK FIRE WITHIN BTNF

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	51200.0	61.8	52.3
Surface	22000.0	26.5	22.5
Meadow	9675.0	11.7	9.9
Sage/Grassland	0.0	0.0	0.0
Unburned	15025.0		15.3
		100.0	100.0
Total in Burned Area	82875.0		
Total Perimeter Area	97900.0		
% Burned within fire perimeter			84.7

TABLE 12. BURNED AREA ACREAGES FOR MINK CREEK FIRE WITHIN BTNF

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	46700.0	62.5	57.4
Surface	24700.0	33.0	30.4
Meadow	3375.0	4.5	4.2
Sage/Grassland	0.0	0.0	0.0
Unburned	6525.0		8.0
		100.0	100.0
Total in Burned Area	74775.0		
Total Perimeter Area	81300.0		
% Burned within fire perimeter			92.0

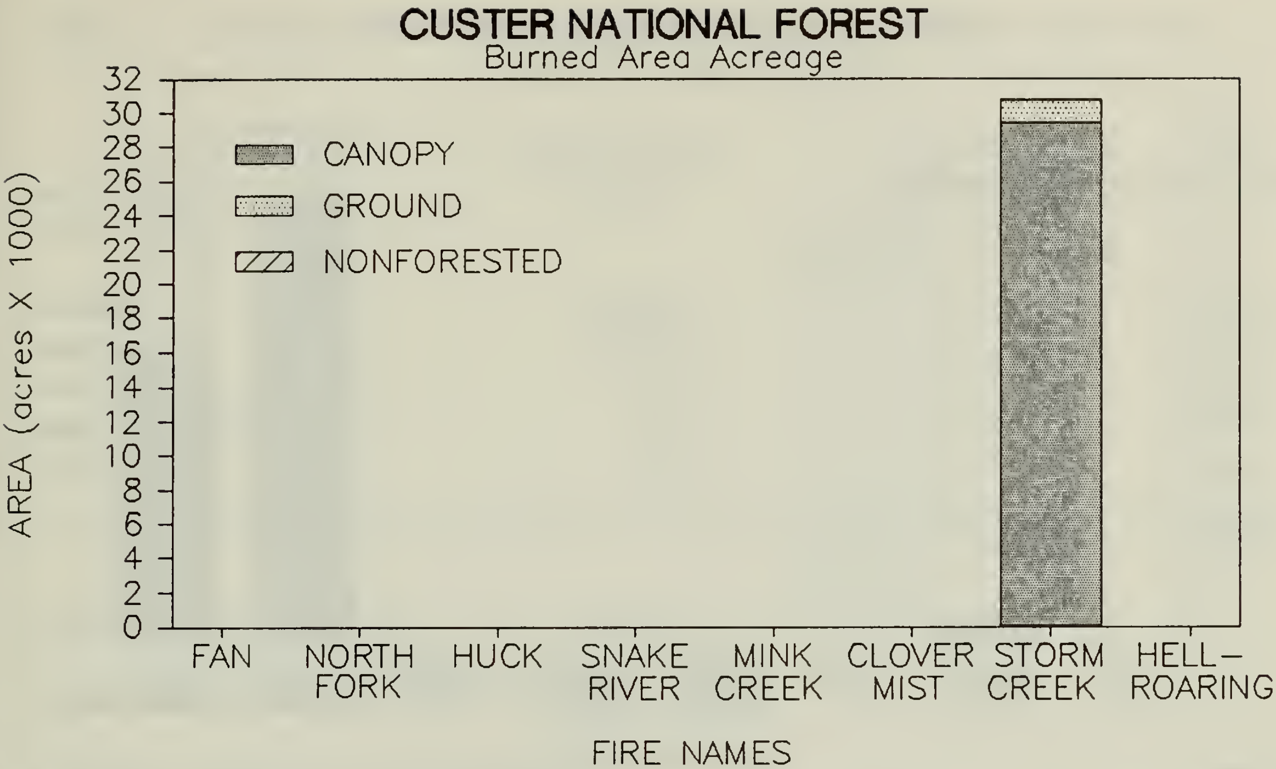


Figure 4. Burned area acreage in Custer National Forest
*These figures are preliminary and should be considered maximums. Future mapping will further refine these estimates.

TABLE 13. BURNED AREA ACREAGES FOR STORM CREEK FIRE WITHIN CNF

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	29400.0	95.8	95.1
Surface	1300.0	4.2	4.2
Meadow	0.0	0.0	0.0
Sage/Grassland	0.0	0.0	0.0
Unburned	200.0		0.6
		100.0	100.0
Total in Burned Area	30700.0		
Total Perimeter Area	30900.0		
% Burned within fire perimeter			99.4

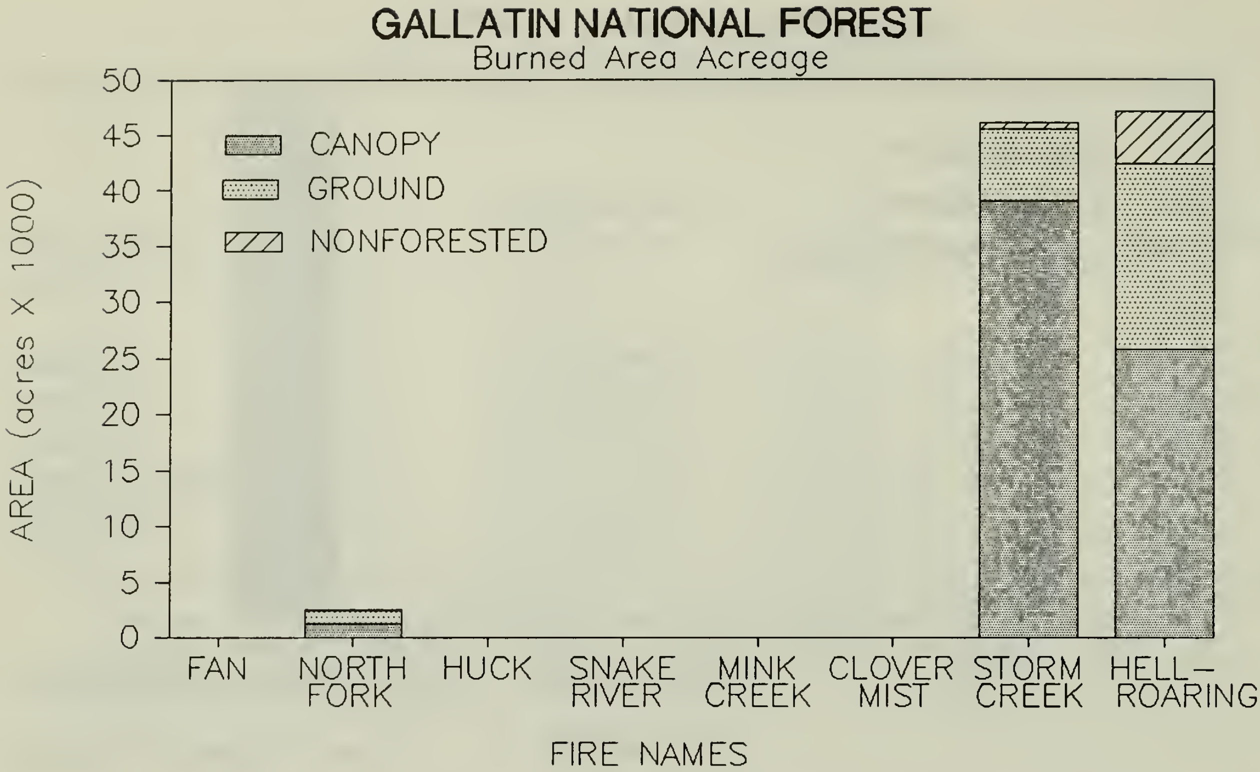


Figure 5. Burned Area Acreage in the Gallatin National Forest
*These figures are preliminary and should be considered maximums. Future mapping will further refine these estimates.

TABLE 14. BURNED AREA ACREAGES FOR HELLROARING FIRE WITHIN GNF

Burn Type	Burned Area (acres)	% of Burned Area	% of Perimeter Are
Canopy	25750.0	54.7	50.8
Surface	16550.0	35.1	32.6
Meadow	4800.0	10.2	9.5
Sage/Grassland	0.0	0.0	0.0
Unburned	3600.0		7.1
		100.0	100.0
Total in Burned Area	47100.0		
Total Perimeter Area	50700.0		
% Burned within fire perimeter			92.9

TABLE 15. BURNED AREA ACREAGES FOR NORTH FORK FIRE WITHIN GNF

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	1250.0	50.0	50.0
Surface	1250.0	50.0	50.0
Meadow	0.0	0.0	0.0
Sage/Grassland	0.0	0.0	0.0
Unburned	0.0	0.0	0.0
		100.0	100.0
Total in Burned Area	2500.0		
Total Perimeter Area	2500.0		
% Burned within fire perimeter			100.0

TABLE 16. BURNED AREA ACREAGES FOR STORM CREEK FIRE WITHIN GNF

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	39000.0	84.6	78.8
Surface	6500.0	14.1	13.1
Meadow	600.0	1.3	1.2
Sage/Grassland	0.0	0.0	0.0
Unburned	3400.0		6.9
		100.0	100.0
Total in Burned Area	46100.0		
Total Perimeter Area	49500.0		
% Burned within fire perimeter			93.1

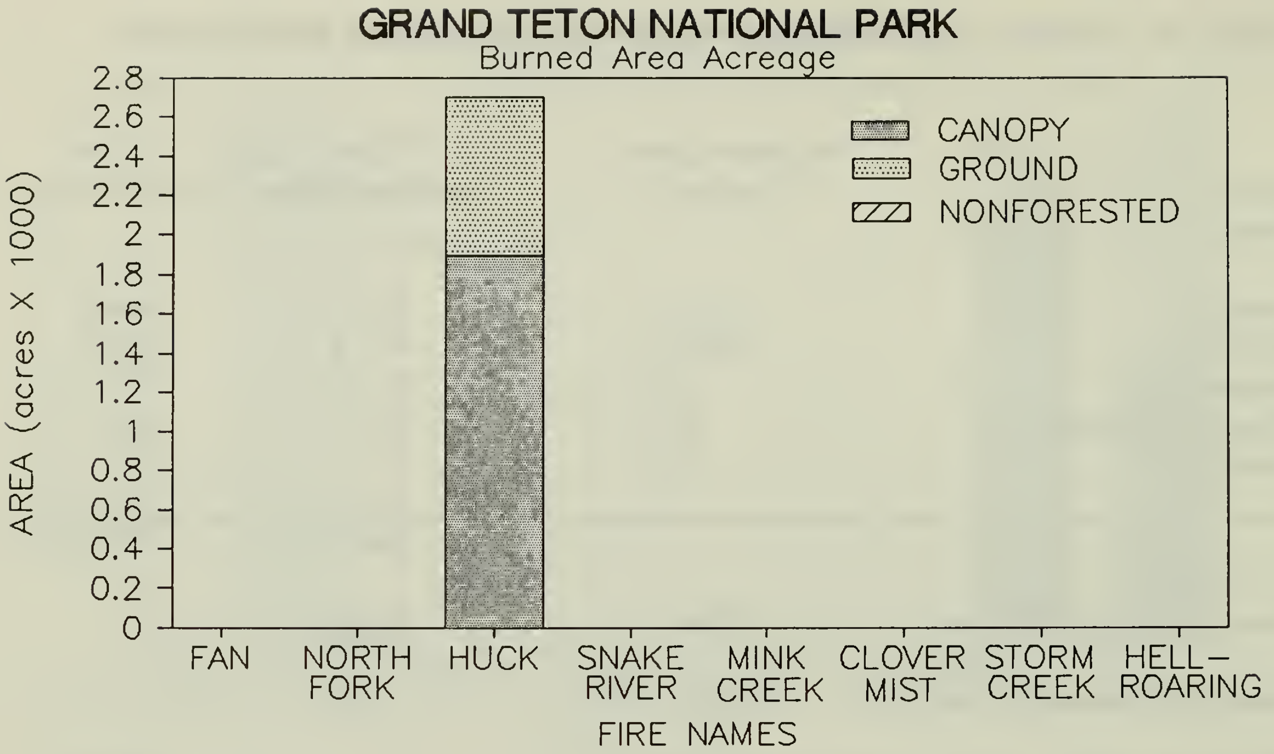


Figure 6. Burned Area Acreage in Grand Teton National Park.
* These figures are preliminary and should be considered maximums. Future mapping will further refine these estimates.

TABLE 17. BURNED AREA ACREAGES FOR HUCK FIRE WITHIN GTNP

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	1900.0	70.4	70.4
Surface	800.0	29.6	29.6
Meadow	0.0	0.0	0.0
Sage/Grassland	0.0	0.0	0.0
Unburned	0.0	0.0	0.0
		100.0	100.0
Total in Burned Area	2700.0		
Total Perimeter Area	2700.0		
% Burned within fire perimeter			100.0

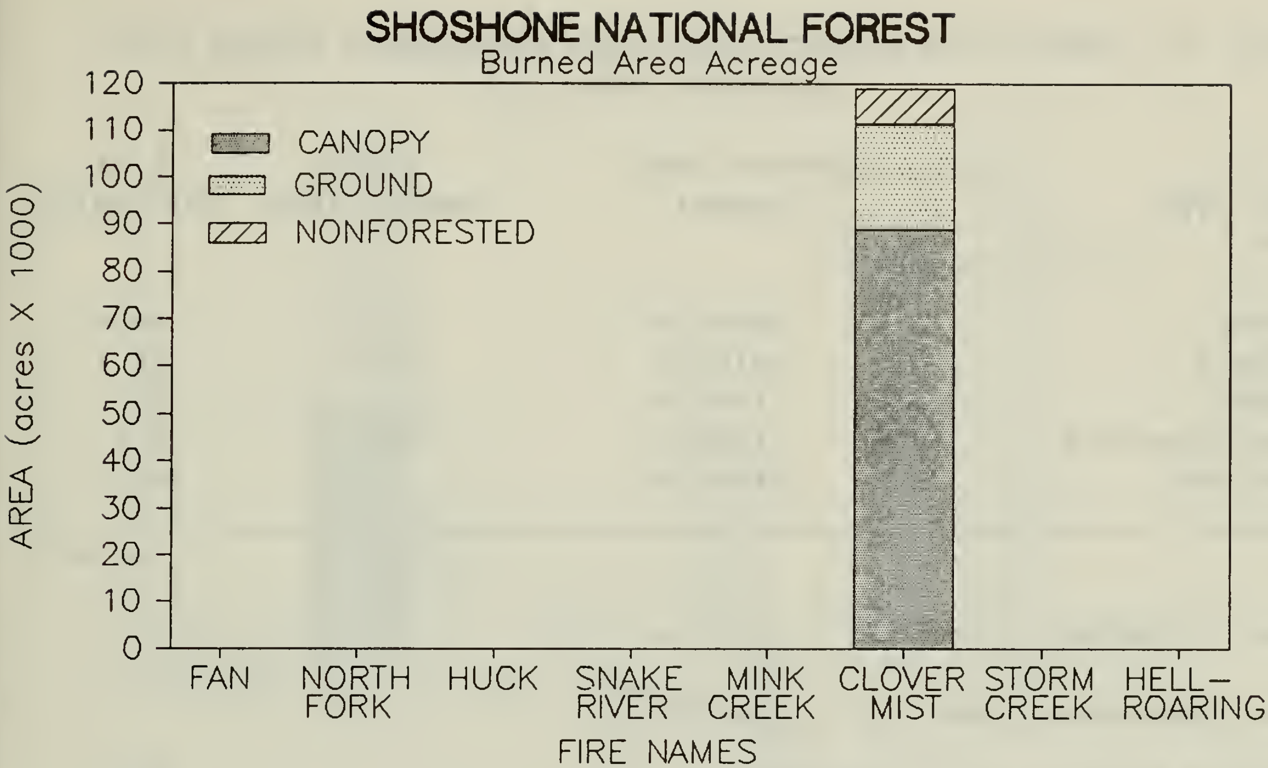


Figure 7. Burned Area Acreage in Shoshone National Forest.
* These figures are preliminary and should be considered maximums. Future mapping will further refine these estimates.

TABLE 18. BURNED AREA ACREAGES FOR CLOVER MIST FIRE WITHIN SNF

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	89000.0	74.9	55.7
Surface	22300.0	18.8	14.0
Meadow	3000.0	2.5	1.9
Sage/Grassland	4500.0	3.8	2.8
Unburned	40900.0		25.6
		100.00	100.00
Total in Burned Area	118800.0		
Total Perimeter Area	157900.0		
% Burned within fire perimeter			74.4

TABLE 19. BURNED AREA ACREAGES FOR CLOVER MIST FIRE WITHIN SNF (NORTHERN PART)

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	56700.0	71.5	49.6
Surface	16100.0	20.3	14.1
Meadow	1950.0	2.5	1.7
Sage/Grassland	4500.0	5.7	3.9
Unburned	34950.0		30.6
		100.00	100.00
Total in Burned Area	79250.0		
Total Perimeter Area	114200.0		
% Burned within fire perimeter			69.4

TABLE 20. BURNED AREA ACREAGES FOR CLOVER MIST FIRE WITHIN SNF (SOUTHERN PART)

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	32300.0	81.7	72.3
Surface	6200.0	15.7	13.9
Meadow	1050.0	2.7	2.3
Sage/Grassland	0.0	0.0	0.0
Unburned	5150.0		11.5
		100.00	100.00
Total in Burned Area	39550.0		
Total Perimeter Area	44700.0		
% Burned within fire perimeter			88.5

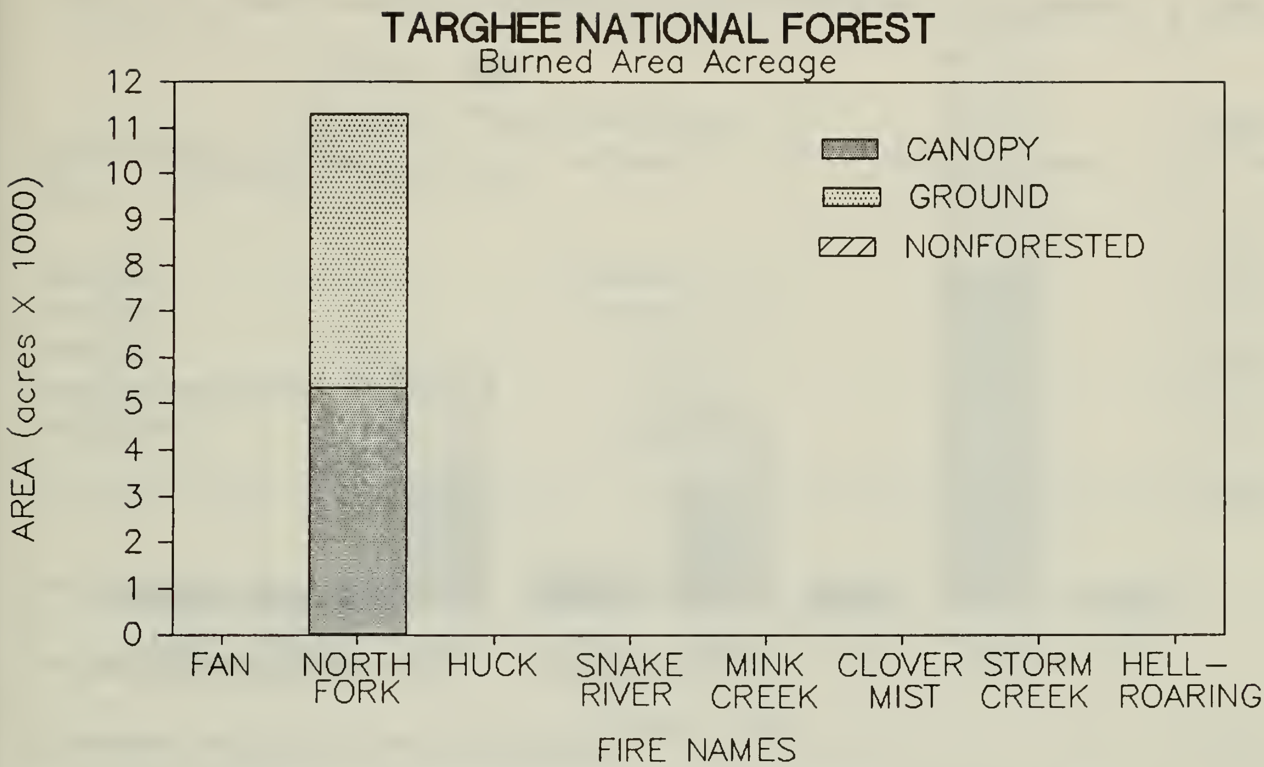


Figure 8. Burned Area Acreage in Targhee National Forest.
* These figures are preliminary and should be considered maximums. Future mapping will further refine these estimates.

TABLE 21. BURNED AREA ACREAGES FOR NORTH FORK FIRE WITHIN TNF

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	5350.0	47.3	47.3
Surface	5950.0	52.7	52.7
Meadow	0.0	0.0	0.0
Sage/Grassland	0.0	0.0	0.0
Unburned	0.0	0.0	0.0
		100.00	100.00
Total in Burned Area	11300.0		
Total Perimeter Area	11300.0		
% Burned within fire perimeter			100.0

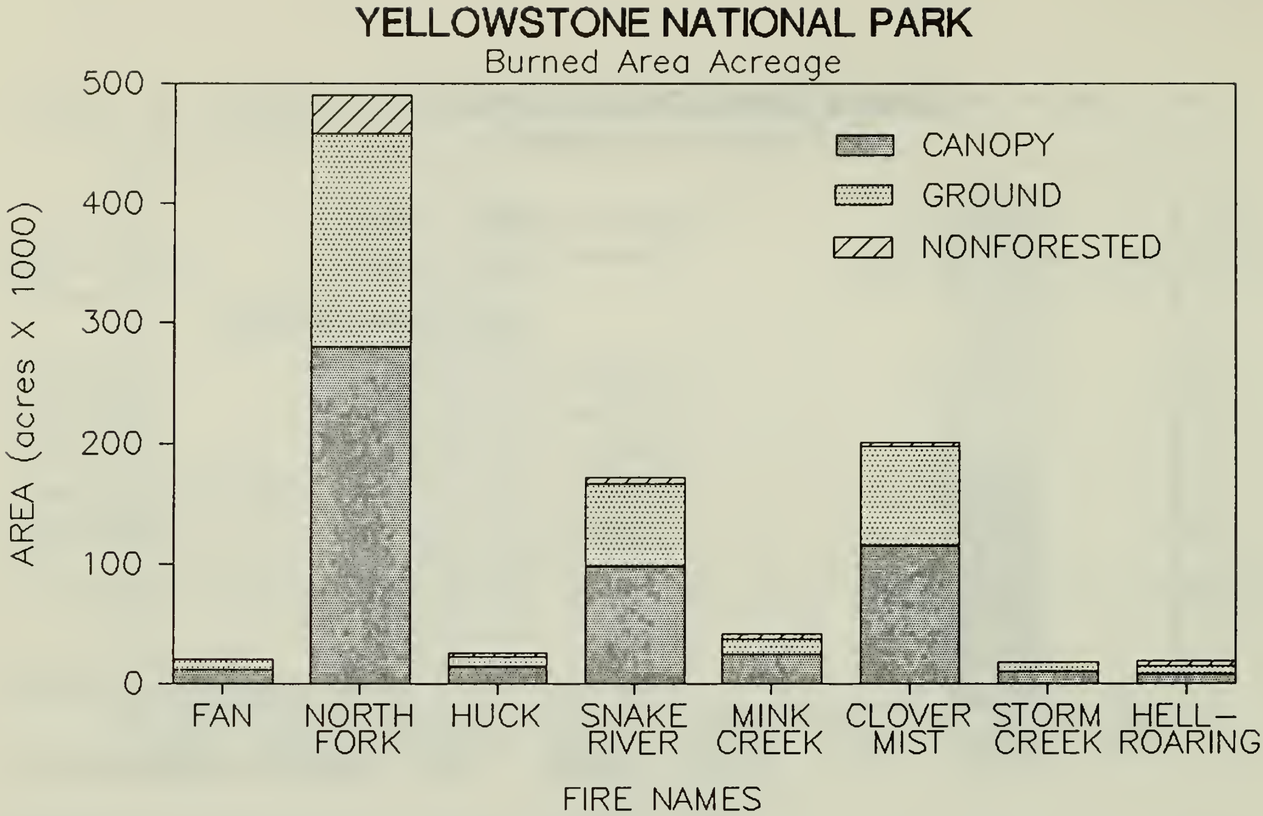


Figure 9. Burned Area Acreage in Yellowstone National Park.
* These figures are preliminary and should be considered maximums. Future mapping will further refine these estimates.

TABLE 22. BURNED AREA ACREAGES FOR CLOVER MIST FIRE WITHIN YNP

Burn Type	Burned Area (acres)	% of Burned Area	% of Perimeter Are
Canopy	115150.0	57.4	52.4
Surface	81950.0	40.8	37.3
Meadow	2850.0	1.4	1.3
Sage/Grassland	825.0	0.4	0.4
Unburned	19125.0		8.7
		100.00	100.00
Total in Burned Area	200775.0		
Total Perimeter Area	219900.0		
% Burned within fire perimeter			91.3

TABLE 23. BURNED AREA ACREAGES WITHIN FAN FIRE PERIMETER IN YNP

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	11550.0	55.3	54.2
Surface	9350.0	44.7	43.9
Meadow	0.0	0.0	0.0
Sage/Grassland	0.0	0.0	0.0
Unburned	400.0		1.9
		100.00	100.00
Total in Burned Area	20900.0		
Total Perimeter Area	21300.0		
% Burned within fire perimeter			98.1

TABLE 24. BURNED AREA ACREAGES FOR HELLROARING FIRE WITHIN YNP

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	8200.0	41.8	35.5
Surface	6700.0	34.1	29.0
Meadow	1050.0	5.4	4.5
Sage/Grassland	3675.0	18.7	15.9
Unburned	3475.0		15.0
		100.00	100.00
Total in Burned Area	19625.0		
Total Perimeter Area	23100.0		
% Burned within fire perimeter			85.0

TABLE 25. BURNED AREA ACREAGES FOR HUCK FIRE WITHIN YNP

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	14250.0	55.6	47.5
Surface	7850.0	30.6	26.2
Meadow	3525.0	13.8	11.8
Sage/Grassland	0.0	0.0	0.0
Unburned	4375.0		14.6
		100.00	100.00
Total in Burned Area	25625.0		
Total Perimeter Area	30000.0		
% Burned within fire perimeter			85.4

TABLE 26. BURNED AREA ACREAGES FOR MINK CREEK FIRE WITHIN YNP

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	24250.0	58.4	52.2
Surface	13250.0	31.9	28.5
Meadow	4050.0	9.7	8.7
Sage/Grassland	0.0	0.0	0.0
Unburned	4950.0		10.6
		100.00	100.00
Total in Burned Area	41550.0		
Total Perimeter Area	46500.0		
% Burned within fire perimeter			89.4

TABLE 27. BURNED AREA ACREAGES FOR NORTH FORK FIRE WITHIN YNP

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	280100.0	57.1	50.3
Surface	178400.0	36.4	32.1
Meadow	7200.0	1.5	1.3
Sage/Grassland	24525.0	5.0	4.4
Unburned	66175.0		11.9
		100.00	100.00
Total in Burned Area	490225.0		
Total Perimeter Area	556400.0		
% Burned within fire perimeter			88.1

TABLE 28. BURNED AREA ACREAGES FOR SNAKE RIVER COMPLEX WITHIN YNP

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	98150.0	57.1	51.8
Surface	67950.0	39.5	35.8
Meadow	5925.0	3.4	3.1
Sage/Grassland	0.0	0.0	0.0
Unburned	17575.0		9.3
		100.00	100.00
Total in Burned Area	172025.0		
Total Perimeter Area	189600.0		
% Burned within fire perimeter			90.7

TABLE 29. BURNED AREA ACREAGES FOR STORM CREEK FIRE WITHIN YNP

Burn Type Area	Burned Area (acres)	% of Burned Area	% of Perimeter
Canopy	10700.0	58.8	48.9
Surface	6900.0	37.9	31.5
Meadow	600.0	3.3	2.7
Sage/Grassland	0.0	0.0	0.0
Unburned	3700.0		16.9
		100.00	100.00
Total in Burned Area	18200.0		
Total Perimeter Area	21900.0		
% Burned within fire perimeter			83.1

SECTION 2

NATURAL

RESOURCE

ASSESSMENTS

REMOTE SENSING RESOURCES

As the fires increased in size, managers struggled to find a means of accurately assessing the scope and effects of the fires. Ultimately, remote sensing (primarily aerial photography and satellite imagery) provided the tools to accurately assess the scale and dimensions of the burned area and, thereby, provided the basis for postfire resource evaluations and recovery efforts. Remote sensing also provided a means for the public to view and understand the extent and effects of the fires in the GYA. Satellite imagery, aerial photography, and ground-based photography were used extensively in the mapping of burn intensity and extent.

The most pressing remote sensing need was for color infrared (IR) vertical aerial photography to produce the preliminary burned area map of the GYA described in the "Greater Yellowstone Burned Area Survey" section. This imagery was used in recovery efforts as well as resource evaluations. Satellite imagery was used in assessments of broad areas. Though resolution was lower than that of aerial photography, with adequate ground truthing accurate results can be obtained.

The following is a list of available remote sensing resources.

1. Satellite imagery

	Date		
LANDSAT	July 22, 1988	Bands 7,4,3	Clear conditions
	September 8, 1988	Bands 7,4,3	Smoke and clouds
	October 2, 1988	Bands 7,4,3	Clear conditions

2. Aerial photography (by NASA/ARC)

	Date	Scale	
U-2 High-altitude	September 15, 1988	1:60,000	Color IR
	October 6, 1988	1:30,000	Color IR
	October 6, 1988	1:60,000	Color IR

3. Aerial photography (by Mark Hurd, Inc.)

October 7 and 8, 1988	1:24,000	Color IR
October 7 and 8, 1988	1:60,000	Color IR

4. Aerial Photography   Oblique color

5. Aerial Photography   35 mm slides (partial coverage)

6. Ground-based photography of fires, effects, and suppression activities was conducted by individual administrative units.

7. Numerous other aerial photography products were authorized by administrative units. Products include both true color and color IR photography at both high and low altitude. Areas covered by these flights range from portions of an individual fire to the entire GYA. Areas include:

Administrative Unit		Scale	Fire
Custer National Forest	True color	1:16,000	Storm Creek
Gallatin National Forest	True color	1:16,000	Hellroaring
Targhee and Gallatin National Forests	True color	1:16,000	Dry Fork

WATER

The 1988 fires burned portions of all the major drainages of the GYA. An interagency team of hydrologists was assembled from the State of Montana and the Northern Region of the Forest Service to prepare an initial assessment of the effects of the 1988 fires on the greater Yellowstone area hydrologic systems. This report is a summary of that hydrologic assessment, performed in November 1988. Supporting data and other additional information are available from the Greater Yellowstone Area Postfire Assessment Committee.

INTRODUCTION

Large fires can significantly effect the hydrologic responses of drainage systems in an area. Fire has the potential to change the quantity and timing of water yields as well as and the physical and chemical properties of water.

Fire acts to reduce transpiration and interception rates by removing vegetation. This can affect the quantity of water produced by a drainage. In addition, extreme soil heating and drying may result in temporarily hydrophobic soils which resist water infiltration and, therefore, cause increased water yields. Combinations of these two conditions over a large percentage of a drainage may result in abnormally large water yields in a short period of time, especially during periods of high intensity precipitation or rapid snowmelt, which could result in flooding conditions.

Reduced tree cover affects the timing of peak flows by reducing snowpack shading. The magnitude of the effect depends on the proportion of the drainage burned, and the effect is most pronounced on south and west aspects at mid to low elevations. Generally, the snowpack begins to melt earlier in the spring in a burned area. However, air temperature is the primary determinant of initial snowpack melting; therefore, the early onset of melt due to a fire is frequently lost in natural variation.

Fire is less likely to affect late summer low flows in a stream system. The reduced transpiration of water by vegetation results in slight increases in late season flows for a few years until vegetation reestablishes. The late season flows gradually taper off until trees grow to the point where they are consuming as much water as the trees killed by the fire. The primary determinant of low flow volumes is the amount of precipitation an area has received in any given year. Observed low flow rates following a major fire will be more a reflection of prior precipitation amounts than an effect of the fire.

As a result of increased water yield and decreased resistance to soil erosion, higher-than-normal stream turbidity and sediment levels in fire areas can be common. The magnitude of the increase depends on the acreage burned, the intensity of the fire, and the natural resistance of the soil to erosion. The occurrence of mass-gravity movements (such as slumps and debris avalanches) may increase following a fire, which could also result in increased delivery of sediment to the stream system.

Pool formation and bedload gravel and sand movement are greatly influenced by trees that have fallen into and across smaller stream channels. The number of fallen trees in a stream channel is termed the Large Organic Debris (LOD) load. Fires have the potential to effect the LOD load in several ways. Most commonly, some of the fire-killed trees along the streambank will fall into the stream and add to the LOD load. The fallen trees form more pools and continue to retard the movement of gravels and sands out the system. If the fire burns with high intensity in riparian areas, the prefire LOD may be consumed. This may result in increased bedload movement and pool filling following the fire. Usually, however, fire-killed trees on stream banks will fall into stream channels to replace those consumed by fire. In the long-term, as the fire-killed trees in the stream decompose, there are no longer mature trees on the stream banks to fall into the streams to replace the decomposing ones. Increased bedload movement may continue until trees in the fire area become large enough to assume the role as LOD and provide regulation and structure in the stream system.

The introduction of ash and charred wood into the streams during and after a fire can result in short-term changes in water chemistry. Increases in pH (i.e., less acidity) and nutrients (primarily nitrates) will occur for a short period following fire. Other possible changes depend on the natural chemical constituents of the water and their reaction with ash and sediments introduced as a result of the fire.

OBJECTIVES

With the potential effects in mind, several objectives were established:

-- Assess potential for localized and downstream flooding resulting from the fires in virtually all of the watersheds in the area.

-- Predict changes of the annual supply volume and timing of peak water yields in various mainstem watersheds as a result of the fires.

-- Determine changes in late summer low flows as a result of the fires.

-- Determine local and downstream changes in sediment loads and turbidity levels in streams within the fire area.

-- Determine effects of changes in LOD loads on stream morphology, stability, and fish habitat.

-- Determine effects of ash and organics on the chemical composition (metals, nutrients, and pH) of area waters.

METHODS

The team assessment began with a field survey of the GYA conducted October 16-22, 1988, primarily through aerial and ground reconnaissance. The professional opinions of the team members presented in this report are based on prefire information. The size of the burned area and the short time available to conduct the assessment did not allow for extensive postfire studies. The report contains estimates of short- and long-term hydrologic effects of the fires relating to water yield and supply, flood potential, and changes in channel systems and physical and chemical water quality.

Estimates of burned area by drainage were taken from the "Preliminary Survey of Burned Area of Yellowstone National Park and Adjoining National Forests" completed by the Burned Area Survey Team.

ASSESSMENT RESULTS

Water Yield and Water Supply

Local Flood Potential

The possibilities for increased flood potential are greatest in the upper subdrainages of the Lamar River, Crandall Creek, and North Fork Shoshone River drainages. These subdrainages are characterized by steep slopes (greater than 45 percent), shallow soils, unstable geology (volcanics and volcanic sediments), and intense summer thunderstorms. The highest flow peaks occur during late spring and early summer snowmelt, a time when the streams also produce most of their total water volume. Streamflow response to precipitation is rapid. Fire can affect the hydrologic regime through the removal of canopy cover, but the primary controls are snow accumulation and melt rates. In many of these subdrainages, tree canopy cover was sparse before the fire, and even the total removal of trees will not increase the peak runoff from snowmelt or rainfall. The snow accumulation and melt sequence will most often be the major determinant of flood potential. The melt sequence is temperature- and wind-controlled, and in an average spring, even with an above-normal snowpack, gradually increasing temperatures will allow the streams to follow their normal runoff patterns. Higher melt rates are possible and floods may arise when snowmelt is delayed well into late June by prolonged cold spring weather. In this case the climatic factors become dominant, and increases in available water as a result of the fire will be insignificant in relation to the total amount available for streamflow.

Summer thunderstorms provide another instance where flooding may occur, especially in the high, quick-responding, subbasins in the Absaroka Range. Soils in burned areas may have reduced infiltration and storage capacities. Water will be routed more rapidly and in larger amounts to the streams, producing higher peaks than prefire conditions.

Watershed recovery will vary depending on location. In high-elevation areas where vegetation plays a small role in peak flow attenuation, hydrologic recovery will be relatively fast. In timber areas, the length of the growing season, and hence elevation, is the major determinant of vegetative recovery.

It is unlikely that fire will affect local flood flows in basins other than those in the Absaroka Range. In the Madison, upper Yellowstone, and Snake River systems, basin morphology reduces the likelihood of high peak flows and floods. Slopes are generally less steep, valley bottoms wider, and stream gradients lower. Despite the fact that steep slopes have proportionally less burned area than more gradual slopes, the overall result is that even though water yield will increase somewhat because there is less vegetation, the duration of greatest streamflow is lengthened by basin morphology. Flood peaks are better regulated, and flooding is less likely.

Approximately half of the Slough Creek drainage was affected by fire. Some subdrainages were almost totally burned while others were largely untouched. Slough Creek itself has a low-gradient channel and lies in a wide valley bottom. Many large point bars and some mid-channel bars indicate that sediment loads are naturally high, and some shifting of the channel is fairly common. Increased water yields from the most heavily burned subdrainages will likely be absorbed by the floodplain and should not appreciably increase in-channel erosion or lead to changes in channel morphology.

Downstream Flood Potential

There is only a remote chance that flood peaks will be affected at locations where damage to structures and property might result. Twenty-nine percent of the Yellowstone Basin above Gardiner, Montana, and 14 percent of the Yellowstone Basin above Livingston, Montana, have been classified as being in the most severe burn categories. Even though the upper Yellowstone watershed produces most of the water that flows by Livingston (80 percent), it is unlikely that any water yield increases from fire effects would be large enough to be measurable at either location. Additionally, the Yellowstone River is well entrenched in a confined channel for much of the distance to Livingston, and any minor increases in peak flows as a result of fire effects would not change the relationship of the river and its channel.

Water Supply

In general, water supply will probably increase as a result of the fire. Some water that was formerly transpired will become additional streamflow principally where large portions of the tree canopy within a drainage have burned. However, the increases will be hidden in the natural variability of the hydrologic system, and any increases will be difficult to verify. This effect will be smallest where vegetation used the least amount of water prefire (upper Lamar River, Crandall Creek, North Fork Shoshone River, Clarks Fork Yellowstone River, upper Slough Creek, and upper Hellroaring Creek). Where upper portions of watersheds were heavily forested (Lava Creek, Tower Creek, and Blacktail Deer Creek) the effect will be greater. The lower portions of most basins were either lightly burned or in a grass/shrub complex. The effect in those areas will be slight at best and will be short-lived due to rapid vegetative recovery. As with flood peaks, the fire-affected basins with low relief (Madison River, Gardner River, Yellowstone River above Yellowstone Lake, and Lewis River) will have any increases masked and moderated by longer routing times and broad floodplains.

Low Flows

Low flows should increase slightly in most small streams with large burned areas. This response is attributable to reduced transpiration and perhaps delayed snowmelt. In a few low-elevation streams, large fire-affected areas may advance snowmelt, which could conceivably reduce late summer flows. In any case, the fire effect on low flows would not be significant or measurable.

Summary

The 1988 wildfires in the GYA will probably not have a great affect on water yield. The areas where increases in flooding are possible (subdrainages in the Absaroka Range) are already characterized by high, flashy flood peaks. The vegetation in most of this area did not attenuate flood peak a great deal before the fire, so removal of the vegetation will have a minimal effect. However, it is likely that small increases in peak flows will occur in these drainages for a number of years. Annual increases in total water yield and low flows will occur in drainages as a result of the fire, but these changes will not be measurable.

Sediment, Debris, Turbidity, and Water Temperature

Sediment Yields

Fire can potentially affect the production and delivery of sediment to and through aquatic systems. The removal of live vegetation from mountain slopes can have many effects which include: a) reducing the erosion buffer against intense rain and running water, b) reducing precipitation and snowmelt infiltration thus increasing the chances of water running on the soil surface, c) altering flow regimes in streams to the extent that greater flows scour or erode the channel, d) reducing the soil-stabilizing function of dense root systems leading to potential mass failure, and e) reducing the general channelization of snow avalanche by widening "normal" paths and entraining new materials. The probability of changes in avalanche recurrence, magnitude, and duration is site-dependent. The response of a particular site or system is a function not only of vegetation but of morphology, climate and weather, soils, stream type, and history.

The potentially adverse effects of increased sediment loads in and downstream of the GYA as a result of the fires are generally related to a) reduction of the quality of fish habitat from the accumulation of fine sediments deposited in spawning and wintering habitat, and b) alteration of stream morphology that might reduce or degrade habitat (i.e., pool filling, increased width/depth ratios, bank or bed scour, increased local water velocity).

The potential for increased sediment loading appears to be confined to several small (third order and less) streams in the basins of the upper Lamar River, the upper Yellowstone River, Clarks Fork Yellowstone River, and North Fork Shoshone River basins. Susceptible watersheds have a major portion of the drainages characterized by steep and erosive slopes with continuous moderate to severe consumption of most of the timber. Cache Creek, Crandall Creek, and North Fork Shoshone River are the most significantly affected. However, those watersheds have very high natural sediment levels. The channels are depositational, being composed of recent glacial-period outwash and seasonal (and more mobile) snow-avalanche debris. These channels are not supply-limited. Sediment loads are essentially a function of the energy from spring snowmelt and intense summer thunderstorm-induced runoff, not the amount of sediment supplied to the stream.

It is conceivable that sediment delivery in the headwater streams will be increased for several decades primarily due to reduced channelization of frequent natural snow avalanche activity. In addition, the extent of the slides may increase since the loss of ground cover and stabilizing trees will result in sympathetic releases (slides caused by movement in adjacent areas) in areas that infrequently failed prior to the fire.

The morphology and biota in these watersheds have developed and adapted to the frequent high natural sediment concentrations. Development and adaptation have focused around unstable and constantly changing bed structure. The direct or indirect effects on water resources as a result of the fires will likely be marginal and undetectable when the extent and natural variability of these systems is taken into account.

The adverse effects on instream water resources will be influenced by weather patterns for the next few years. Rapid regrowth and regeneration should restabilize the soils and slopes. Thunderstorms and snowmelt (especially if prolonged and widespread in the next two years) will produce noticeably accelerated sediment loading with the potential to temporarily affect instream water resources. These conditions do occur in the GYA; however, the probability of occurrences over a large area are limited in the next two years.

Sediment loading in Slough Creek as a result of the fire will be a function of the frequency and intensity of storms that occur in the drainage in the next three to five years. Subdrainages that have been heavily burned will likely supply increased fines until vegetative recovery takes place, but it is doubtful that a measurable increase at the mouth of Slough Creek will result.

Cumulative responses in mainstem rivers downstream of the GYA as a result of localized changes in small upstream watersheds is expected to be unmeasureable relative to the natural variability. If cumulative responses exist at all they will be diluted to the point where they would not likely affect instream water resources. If a major climatic event should occur in the near future, downstream sediment effects will be extreme, regardless of the fires.

Debris Loading

Natural instream debris is an important and necessary component of streams and aquatic habitat. Fire can potentially affect the production and delivery of large organic debris (such as logs) to and through water systems. Snags and deadfall will eventually fall into stream channels and draws. Usually debris accumulations are beneficial in dissipating energy, providing stability, and providing aquatic habitat. Fish migration barriers and erosive currents may occur where local accumulations are excessive. There is potential for sediment and debris buildup in steep channels, and the buildup could fail resulting in catastrophic stream torrents. Excessive accumulations are infrequent and are often short-lived. The most likely channels for excess debris accumulation are those where heavily timbered slopes burned severely and continuously within 100-200 feet of an adjacent stream or draw. Excessive debris loading in response to the fires was not determined to be significant in the GYA.

Changes in Turbidity

Turbidity is the visual character of the water that is often related to the concentration of suspended material in the water. It is not necessarily directly related to or strongly correlated to suspended sediment. Turbidity is easily observed and measured; and therefore, it is often an indirect indicator of "clean water" to the casual observer and sometimes to regulatory agencies. Turbid water is not uncommon following high-intensity storms or even moderate precipitation events in the Yellowstone, Clarks Fork Yellowstone, and North Fork Shoshone Rivers.

Until vegetative cover is reestablish within two to three years in severely burned watersheds, turbid water may result from some less intense storms. In the Yellowstone and North Fork Shoshone Rivers, turbidity will likely be measurably greater (although not noticeably greater to the casual observer) for several years. Turbidity in these waters under certain runoff events is not unusual. The Hydrology Team observed that Crandall Creek, Jones Creek, and North Fork Shoshone River were noticeably turbid following a light precipitation and snowmelt event. This condition was observed in both burned and <u>completely unburned tributaries</u>.

Water Temperature

In some circumstances following wildfire, particularly when large expanses of riparian vegetation are consumed, the temperature regime of streams can be altered. A general increase of normal maximum summer temperatures or an increase in the diurnal (daily) fluctuations of water temperatures typically occurs, both of which can stress fisheries and other aquatic life if it exceeds a threshold. Lower winter minimum temperatures can also occur which, in conjunction with the loss of thermal cover, may permit or accelerate icing. Icing in winter rearing habitat can degrade the habitat by loss of volume. In addition, the breakup of several kinds of ice can cause considerable bank and bed scour resulting in sedimentation, habitat degradation, and damage to instream structures.

High water temperatures are not usually a significant problem in the GYA. Summertime temperatures are typically well below the thresholds for most fish species in their summer habitats. The team did not find any evidence that winter icing was a significant problem. Although large areas of streamside vegetation have been consumed, it is unlikely that this will exaggerate water temperature extremes or fluctuations to within critical thresholds due to several conditions:

-- The difference between the threshold and natural maximum temperatures is generally too great to expect critical changes to occur.

-- The streams in the GYA are typically too wide to permit the streamside vegetation does not influence the cumulative downstream water temperature significantly.

-- In narrower upstream tributaries of the northeast portion of the GYA, topographic shading is a dominant process.

-- Water temperatures in the Madison River, Gardner River, and parts of the Yellowstone River, are influenced by thermal features in their watersheds.

The team concluded that water temperature changes were not likely to produce significant effects.

Water Chemistry

Slight changes in water chemistry are expected to occur as surface and ground water respond to fire induced changes in the watershed. Increased concentrations of dissolved metals and nutrients (nitrate and phosphate) are of interest in the Madison drainage. Increased alkalinity and higher pH (less acidity) should occur in all watersheds affected by the fires.

Ash and charcoal are expected to produce a measurable but short-term increase in pH and alkalinity in all extensively burned watersheds during the first few snowmelt and storm runoff peaks. An increase in pH should not significantly affect dissolved metal concentrations in surface or ground water because most metals are less soluble as pH increases. Most salmonid fisheries can tolerate the expected short-term alkalinity and pH increases.

Nutrient availability is expected to increase for a short time or until erosion-preventive ground cover is reestablished in most burned watersheds. Biologically available nitrate and phosphate, which indirectly affect algal growth and dissolved oxygen in streams, are of interest in the geothermally-fed, nutrient-rich Madison River drainage. Watersheds outside the Madison drainage are of lesser concern due to fewer geothermal springs, dilution by fresh water, and adequate buffering. Nitrates are generally mobile in surface and ground water and do not readily adhere to sediments. Phosphates are less mobile and readily adhere to sediments. Overland flow and sediment loading may increase available phosphate in some streams. However, nutrients from the burned areas are not expected to significantly load the system over presently available nutrient levels.

Blue-green algae blooms occur frequently in the Grayling Arm of Hebgen Reservoir. The timing of these blooms is apparently controlled by temperature; and the magnitude of the blooms by phosphorus concentrations. For unknown reasons, these blooms are sometimes toxic. There will be slight temporary increases in phosphorus loads due to the burn in the headwaters of Cougar, Grayling, and Duck Creeks, the major tributaries to the Grayling Arm. The increases in in-lake phosphorus concentrations are not expected to cause increases in the frequency or duration of the toxic blooms. The phosphorus increases may cause slight increases in the magnitude of the blooms until ground cover is reestablished in these drainages.

Nutrient loading to streams is unlikely to cause measurable changes in stream biota. Because of the cool temperatures and reaeration in turbulent mountain streams, it is very unlikely that there will be any significant reduction in dissolved oxygen in GYA streams.

Because arsenic is readily absorbed onto particulate matter, it is unlikely that there will be any increases in arsenic concentration. In fact, if the suspended sediment in streams increases as expected, it is possible that the concentration of arsenic will be lower than normal in streams leaving the GYA.

CONCLUSIONS

Although vast expanses, and in some cases large proportions, of the GYA were involved in the wildfires of 1988, the potential for radical changes or serious threats to the water resources or beneficial uses of the water were assessed to not be significant. Emergency watershed rehabilitation measures planned and established by the several management agencies in the GYA appear to be adequate to control, to the extent that they can be effectively controlled, the critical local erosion and streambank stabilization responses caused directly by the fires. Beyond that, the expected responses are anticipated to be within the normal range of variability of the water resource systems and will be subject primarily to the climatic patterns in the next few years.

In the instances where noticeable effects of the fire on water resources do occur, they will tend to be local in nature, low to moderate in magnitude, and limited to the first few years following the fires. Cumulative effects in the large rivers will be rare, if they exist at all. Downstream effects outside the GYA are not likely to occur in any case.

SOIL

INTRODUCTION

The spectacular appearance of the 1988 fires caused many to grow concerned about the immense amount of heat being generated. This heat primarily rose skyward, but some entered the soil, especially where woody debris had contact with the ground. The most important influences of soil heating are soil charring (fire-blackened soil) and changes in infiltration potential and soil hydrophobicity (water repellency). The depth and degree of these effects influence erosion potential and revegetation time. This report is an initial evaluation of soil heating effects in the GYA. It was produced by a team of soils and vegetation specialists working in Yellowstone Park and surrounding Forests.

The vast majority of soils in the affected part of the GYA were only moderately to lightly heated and have very shallow char depths. Revegetation potential in these areas is relatively unaffected by the fires. For more information on the acreages and distribution of various burn intensities and soil heating effects in the GYA, refer to the "Greater Yellowstone Burned Area Survey" section of this report.

The soil heating effects of fire may act to slow the rate at which water percolates into the soil, which in turn may affect runoff. An increase in hydrophobicity reduces water infiltration and modifies the rate of evaporation from soils.

Even without heating, soils have hydrophobic properties. The primary sources of this hydrophobicity are organic compounds produced by vegetation and microbial processes. These nonpolar organic compounds naturally repel the strongly polar water molecule as oil does water. Fire produces or alters hydrophobicity when organic materials in the litter and surface soil are oxidized by heat. The resulting gases condense on cooler soil particles lower in the profile. The movement and chemical alteration of these hydrocarbons may change the soil's hydrophobicity.

The degree of hydrophobicity is determined by a combination of temperature and time. Hydrophobicity can increase, decrease, or remain unaltered depending on how hot the fire gets and how long it remains at a particular temperature. Overall effects are dependent upon the characteristics of the original soil environment.

METHODS

The effects of the 1988 fires on soil hydrophobicity and infiltration were examined using two different approaches, simulating rainfall and timing water/ethanol solution penetration. Three sites were chosen to represent three major soil parent materials and textures found in the GYA. Sampling was done in both burned and unburned locations at each site. The first site was located in a forested area that had experienced moderate soil heating. Soils at this site were formed in glacial till derived from tertiary andesitetic volcanics with silt loam textures. The second forested site also had experienced moderate soil heating and had soils formed in Pleistocene tuff with sandy loam textures. The third was a grassland site with low to moderate soil heating located on Pleistocene glacial till deposits with loam soil textures.

Rainfall Simulation Test

The first study employed a portable rainfall device which simulated a 127 mm/hr (5 in/hr) intensity storm. Infiltration rates were measured, and sediment yield was calculated from runoff. Soil samples were taken for a variety of lab analyses. Field observations included soil water repellency tests where penetration times were recorded for water dropped onto various soils (water drop penetration time). At this time, only infiltration rate and field observation data are available.

In this study a degree of hydrophobicity was observed in all study plots, burned and unburned, except for one unburned range plot. The forest soils were generally more water-repellent than the range soils. Water repellency at the forested andesitetic and grassland sites did not vary significantly between the unburned and burned areas. At the rhyolitic site, hydrophobicity in the unburned and lighter-intensity burned areas were not noticeably different, but hydrophobicity was present to a greater depth in the higher-intensity burned areas.

This study suggested that water infiltration rates at all three areas were primarily affected by natural soil hydrophobicity. It appeared that unburned and lightly charred litter had a higher water-holding capacity than more intensely burned areas. Although the infiltration rates in this study were not altered by fire, the erosion environment in areas where the litter layer was completely reduced to ash may have been altered.

Water/Ethanol Drop Penetration Test

The second study involved testing water repellency with a water/ethanol drop method. The hydrophobicity of a soil may be estimated by placing drops of a graduated series of ethanol solutions (a nonpolar solvent) of known concentration on the soil. A hydrophobicity index was determined by dividing water drop penetration time by the liquid surface tension of the ethanol solution that immediately penetrated the soil surface. Tests were performed on the surface, at 2 cm, and at 5 cm.

At the forested andesitetic site, comparisons using this hydrophobicity index showed no difference between the burned and unburned test areas. At the rhyolitic tuff site, the surface soils of the burned areas were more hydrophobic than those of the unburned areas. At the grassland site, increased soil hydrophobicity in the burned areas was noticeable at the surface and at a 2 cm depth.

CONCLUSION

These preliminary studies demonstrated that some degree of water repellency occurs naturally at all the sites involved, and in some cases, soil water repellency was altered by the fires. The effects of hydrophobicity are not severe and will probably not significantly affect erosion potential. These results can be extrapolated to most of the affected GYA, with the exception of part of the Shoshone National Forest, where burn intensities were higher with attendant increase in char depth and reduction in infiltration.

AIR QUALITY

AIR QUALITY MONITORING

On July 26, 1988, the Montana Department of Health and Environmental Sciences' (DHES) Air Quality Bureau received a copy of a petition from 330 upper Yellowstone valley residents to the Superintendent of Yellowstone National Park stating their concerns about the forest fires. One of their concerns was air quality. They noted that smoke accumulations were heavy and visibility was regularly limited to less than a mile. Previously, the DHES and Yellowstone Park headquarters had received calls and letters voicing concerns about the potential health impacts of the smoke in Gardiner.

In early August, the U.S. Forest Service (USFS) asked DHES to monitor the air quality in the Gardiner area. The DHES installed a high volume air sampler (hi-vol) on August 11 at the Gardiner Ranger Station. USFS personnel were trained as operators and daily 24-hour sampling was initiated. The filters were mailed to Helena where they were instantly weighed and the results phoned to the ranger station to be posted there and at the Gardiner post office. Costs of the monitoring equipment were paid by Yellowstone Park.

At the request of Yellowstone Park officials and in response to concerns from local citizens there, a hi-vol sampler was borrowed from Yellowstone County and installed at Cooke City on August 23 by the DHES. The sampler was located at the USFS ranger station, and USFS personnel were trained as operators. However, soon after the sampler was installed, Cooke City was evacuated. As a consequence of the move and some operator problems, the sampler was abandoned at this time, and no data was collected until later in September when the instrument was reinstalled in the park near the Northeast Entrance station.

As the fires continued to grow and smoke became an increasing problem in Gardiner, the DHES was contacted on August 19 by the Gardiner Superintendent of Schools. He was concerned about health risks associated with football practice and other outdoor activities during bad air quality conditions. He knew about the hi-vol readings at the Gardiner Ranger Station and was concerned that the data was two to three days old (at best). Since some days had better air quality than others and since the air would clear up during some periods of a day, he was interested in an instantaneous or real-time monitoring device so the school could schedule outdoor activities during periods of good air quality. To satisfy this need, on August 23 DHES installed a nephelometer (an instrument for measuring air quality) at the high school. The nephelometer measured visibility which could be correlated to inhalable particulate levels.

Yellowstone officials also contacted Wyoming air quality personnel and discussed monitoring options. Wyoming air quality staff were satisfied with Montana DHES' involvement and were not a significant participant thereafter since most areas impacted were Montana communities.

There was a two-to-three-day lag time between the time the filters were mailed to Helena and the time the results were received in Gardiner. The DHES sought a means to speed up the turnaround, given the magnitude of the concentrations. Early nephelometer data and the 24-hour TSP (total suspended particulates) data indicated particulate concentrations that could be causing health effects. DHES had a scale available with the accuracy necessary to weigh the hi-vol filters; it was taken to the Gardiner Ranger Station on August 26, and an operator was trained in its use. The scale allowed the filters to be weighed on-site. The weight was then called in to the DHES in Helena where the concentration could be determined. The result was then phoned back to the ranger station. Twelve-hour sampling from 8:00 a.m. to 8:00 p.m. and 8:00 p.m. to 8:00 a.m. was also initiated. In this way the public was advised of current air quality within one hour after the sample was taken.

Yellowstone also requested assistance from National Park Service (NPS) air quality personnel from their Denver office. Denver redirected an air quality contractor to assist in installing, training, and monitoring park devices. NPS efforts were coordinated with the Montana DHES. In addition to TSP and PM-10 instrumentation (equipment that collected 10-micron or smaller particles, those determined to be most detrimental to health), a number of other suspect pollutants were monitored including hydrogen sulfide (H_2S), sulfur dioxide (SO_2), carbon monoxide (CO), and benzo(a)pyrene (BaP) (a carcinogen contained in wood smoke).

The H_2S and SO_2 monitoring were conducted from September 1-6, 1988. No appreciable amounts were detected and the monitoring was stopped. The contractor also installed a hi-vol sampler in the West Yellowstone area as agreed upon by Denver air quality, the park, and DHES. Trained park personnel operated the instrument. Attempts to measure carbon monoxide concentrations, a by-product of incomplete combustion, were unsuccessful for any length of time. An instantaneous reading of 5 ppm (parts per million) of CO was found on September 4 using an Ecolyzer. However, the Ecolyzer failed as did a continuous CO monitor loaned to the park by DHES.

EPA (the Environmental Protection Agency) analyzed some of the filters for BaP at the request of Denver air quality. Those results indicated that some health effects could have occurred.

In addition to the DHES TSP monitoring activity, the Park Service secured two PM-10 monitors from EPA and installed one in West Yellowstone and the other in Mammoth. PM-10 concentrations in the thousand-microgram-per-cubic-meter range were measured in West Yellowstone during 12-hour periods on September 3 and 4 before the equipment broke down. The Mammoth PM-10 continued to operate although flow rates dropped drastically during the sampling run. Because of the extremely high concentrations reported, all sites were operated for continuous 12-hour periods. On September 14, additional hi-vols were taken to the park to make 12-hour sampling easier for the operators and so 6-hour sampling could be initiated if the necessity arose.

News releases were issued regularly by DHES to inform the public of the particulate concentrations and to issue health advisories. The following advisories were issued:

-- Eliminate all strenuous outdoor activities.

-- Stay indoors and limit outdoor ventilation (close windows and doors).

-- People experiencing respiratory or other health problems should use extreme care to limit exposure and may want to leave the area.

In order to predict fire activity and smoke impacts, the DHES staff performed daily meteorological forecasting. The DHES was concerned with the potential for continuous smoky conditions lasting several days and inversion conditions in the fall. The fires were mapped and weather data collected on a daily basis to anticipate where smoke impacts would occur and how long they would last.

On September 17, the Cooke City site was reinstalled by EPA personnel at the park entrance, and an NPS employee was trained as an operator. The fire activity that had caused the earlier evacuation had passed through Cooke City, but fire and smoke were still in the area.

EPA, the National Park Service, and the DHES cooperated in sending people to the park to do necessary equipment maintenance. All sites remained operational until October 18 at which time all equipment was removed except the PM-10 at Mammoth. The last sampling date for the Mammoth PM-10 was October 31, 1988.

MONITORING RESULTS

As discussed above, DHES was requested to monitor air quality at four locations (Gardiner, West Yellowstone, Cooke City, and Mammoth). The DHES first responded by deploying hi-vols which measure TSP (total suspended particulates). These devices were available because they had recently been retired from service due to a change in the particulate matter standard. Since July 1987 the federal and Montana ambient standards for particulate matter have been based on the collection of the smallest particles which are less than 10 microns in size (PM-10). The measurement of PM-10 samplers requires a different type of sampler with a size-selective inlet. DHES did not have any spare PM-10 samplers to use in the monitoring effort at Yellowstone Park; therefore, TSP samplers (hi-vols) were used.

The ambient air quality standards for PM-10 are 50 mg/m^3 (annual average) and 150 mg/m^3 (24-hour average). Since the DHES used a nonreferenced method which measured all particulate matter, a standard conversion factor of 0.8 times the TSP value was used to determine PM-10 concentrations. This value was then reported to the public and compared with the standards.

(The conversion factor was determined from an EPA report titled "Emission Factors for Particles from Prescribed Fires by Region in the United States.") Since a conversion factor was used and readings did not represent actual PM-10 readings, the results should be reviewed as trend information and not absolute quality-assured data.

In addition to DHES monitors, the EPA supplied some PM-10 monitors which were used at the Mammoth and West Yellowstone sites. Due to heavy loadings, the flow rates on these monitors dropped off considerably and results were suspect.

Over the monitoring period, Gardiner experienced 19 days when particulate concentrations were over the ambient standard. Two of those days were between 350 and 420 mg/m^3, which is the "alert" level (the first level of concern) under the DHES emergency episode plan, two were between 420 and 500 mg/m^3, the "warning" level, and two were over 600 mg/m^3, which is the "significant harm" level. Mammoth also showed high concentrations with seven days over the standard, one over 350 mg/m^3, two over 420 mg/m^3, and one over 600 mg/m^3. West Yellowstone experienced concentrations of particulate matter which were extremely high from September 3-6. On September 10 the concentrations started to drop and were low after September 18. There were no PM-10 (suspended particulate) concentrations exceeding the ambient standard measured in Cooke City.

The ambient air quality standard is based on a 24-hour average concentration. Even though the 24-hour averages did not show continuous exceedances, there were portions of almost every day when the air quality posed a significant health threat in all communities. A complete tabulation of the data from each site follows.

Gardiner Episode Monitoring

Date		TSP Lab Results
8/12	24-hour	147
8/13	24-hour	62
8/14	24-hour	81
8/15	24-hour	117
8/16	24-hour	148
8/18	24-hour	156
8/19	24-hour	162
8/22	24-hour	329
8/23	24-hour	260
8/24	14-hour	223

Went to weighing filters in the field

Date		TSP Lab Results (mg/m^3)	Field Results PM-10* (mg/m^3)
8/25	Day	322	293
	Night	256	207
8/26	Day	182	169
	Night	58	50
8/27	Day	63	53
	Night	114	89
8/28	Day	141	111
	Night	132	105
8/29	Day	324	259
	Night	284	227
8/30	Day	280	212
	Night	307	245
8/31	Day	68	58
	Night	94	109
9/01	Day	240	192
	Night	139	123
9/02	Day	317	270
	Night	114	97
9/03	Day	241	209
	Night	182	136
9/04	Day	391	306
	Night	456	415
9/05	Day	1011	716
	Night	295	240
9/06	Day	460	409
	Night	296	258
9/07	Day	215	175
	Night	130	118
9/08	Day	484	386
	Night	1254 4 hr	462
9/09	Day	427 7 hr	632
	Night	301	234
9/10	Day	799	659
	Night	48	50 snow

Date		TSP Lab Results (mg/m^3)	Field Results PM-10* (mg/m^3)
9/11	Day	31	37 snow
	Night	VOID	VOID
9/12	24-hour	88	62
9/13	24-hour	70	59
9/14	24-hour	209	164
9/15	24-hour	182	151
9/16	24-hour**	DID NOT RUN	
9/17		156	165
9/18		75	63
9/19		98	88
9/20		19	16
9/21		59	50
9/22		61	50
No longer doing weekend runs			
9/26		72	67
9/27		31	69
9/28		42	28
9/29		49	36
OPERATOR OUT OF OFFICE			
10/10			120
10/11			116
10/12			89
10/13			69

* This is based on using an 80% conversion factor for wood smoke on TSP values

**All samples are 24-hour from 9/16 on

Mammoth Episode Monitoring

Date		PM-10 (mg/m^3)	TSP (mg/m^3)
8/30	Night	51	75
8/31	Day	37	48
	Night	30	42
9/01	Day	150	176
	Night	61	78
9/02	Day	129	164
	Night	31	48
9/03	Day	103	137
	Night	162	185
9/04	Day	209	234
	Night	263	264
9/05	Day	663	697
9/06	Day	299	412
	Night	311	378
9/07	Night	68	96
9/08	Day	279	354
	Night	602	661
9/09	Morning	608	775
	Afternoon	62	162
	Night	281	484
9/10	Day	457*	1217
	Night		47
9/11	Night		8
9/12	Day		57
	Night		28
9/13	Day		41
	Night		176
9/14	Day	211	155
	Night	202	241
9/15	Day	122	137
9/16	24-hour**		168
9/17		82	133
9/18		44	57
9/19		33	71
9/20		16	22
9/21		32	53
9/22		23	39
9/23		19	40
9/24		22	51
9/25		28	67
9/26		36	60
9/27		19	NONE
9/28		22	25
9/29		22	32
9/30		24	32
10/01		25	51
10/02		29	40
10/03		23	35
10/04		38	51
10/05		49	63
10/06		50	64

Date	PM-10 (mg/m^3)	TSP (mg/m^3)
10/07	42	54
10/08	43	55
10/09	28	45
10/10	57	64
10/11	42	54
10/12	46	64
10/13	27	45
10/14	23	43
10/15	14	31
10/17	7	13***
10/18	16	
10/19	6	
10/20	13	
10/21	17	
10/24	10	
10/25	16	
10/26	13	
10/27	13	
10/28	18	
10/31	18****	

* Sampler blew over

** All samples are 24-hour from 9/16 on

*** Sampler removed

****Sampling discontinued

West Yellowstone Episode Monitoring

Date		PM-10 (mg/m^3)	TSP (mg/m^3)
9/01	Day	485	
	Night		82
9/02	Night		67
9/03	Day	1345	
	Night	1217	
9/04	Day	1030	
	Night	1211	
9/05	Day	*	688
	Night		167
9/06	Day		510
	36-hour		179
9/10	Day		280
	Night		65
9/11	Day		70
	Night		64
9/12	Day		134
	Night		58
9/13	Night		41
9/14	Day		45
	Night		36
9/15	Day		59
	Night		45
9/16	Day		70
	Night		54
9/17	Day		49
	Night		28
9/18	Day		9
	Night		18
9/19	Day		36
	Night		42
9/20	Day		13
	Night		13
9/21	Day		23
	Night		18
9/23	Day		24
	Night		28
9/24	Day		26
	Night		27
9/25	Day		32
	Night		26
9/26	Day		31
	Night		37
9/27	Day		47
9/29	Afternoon		30
	Night		15
9/30	Night		14
10/01	Day		21
	Night		12

Date		PM-10 (mg/m^3)	TSP (mg/m^3)
10/02	Day		20
	Night		19
10/03	24-hour		33
10/04	Day		44
10/05	Day		33
	Night		22
10/06	Day		36
	Night		43
10/07	Day		41
	Night		24
10/08	Day		38
	Night		30
10/09	Day		25
	Night		21
10/10	Day		33
	Night		41
10/11	Day		44
	Night		25
10/12	Day		47
	Night		25
10/13	Day		42
	Night		24
10/16	Day		30
	Night		22
10/17	Day		29
	Night		16

*Sampler broke

Cooke City Episode Monitoring
24-Hour Samples

Date	TSP (mg/m^3)
9/17	78
9/18	119
9/19	78
9/20	59
9/21	45
9/22	42
9/23	42
9/24	65
9/25	66
9/26	53
9/27	31
9/28	41
9/29	30
9/30	34
10/01	30
10/02	79
10/03	47
10/04	35
10/05	31
10/06	41
10/07	47
10/08	37
10/09	29
10/10	144
10/11	60
10/12	50
10/13	57
10/14	27
10/15	26
10/16	32

Benzo(a)pyrene (BaP) Analysis
Results

Site	Date	BaP (ng/m^3)
Gardiner TSP	8/12	4.52
	8/19	6.69
	8/29 am	5.82
	pm	1.03
	9/04 am	4.22
	pm	2.16
	9/05 am	6.00
	pm	1.72
West Yellowstone PM-10	9/03 am	7.93
	pm	2.28
	9/04 am	9.59
	pm	1.70
Mammoth TSP	9/05 pm	8.93
	9/07 am	3.35
Mammoth PM-10	9/05 pm	3.68
	9/07 am	9.03

FIRE AND PLANT ECOLOGY

POSTBURN RESPONSES OF VEGETATION IN THE GYA

Response to fires is immediate in both the forested and nonforested areas. Temperatures high enough to kill living plant tissue usually penetrate less than an inch into the soil even in areas of intense crown fire. Only under logs and deep litter accumulations where the fire burned for several hours does the lethal heat pulse penetrate very far into the soil. And even in these instances, the soil is not "sterile," a seed which drops on the soil will germinate. Where water is available in the soil, the plants immediately begin to regrow. In dry soils, the rhizomes, bulbs, root crowns, seeds, and other reproductive tissues must wait until soil moisture is restored. This moisture can come in the form of summer or fall rains but usually comes the following spring as the snow melts.

Within three years, the amount of ground covered by forest floor species is equal in burned and unburned forests. About 15 different species are present the first growing season, and this diversity increases to 20 to 30 species within the first five years.

Lodgepole pine begin to reestablish immediately after fires pass, dropping seeds from serotinous cones (that only open when heated as in a fire) and from mature cones of the year. Judging from intense crown fires of years past, lodgepole seeds should not be killed by the heat of the fires. Apparently the extremely high temperatures generated by gasses burning during crown fires do not last long enough to push lethal temperatures into the cone. Seed densities from 50,000 to 1,000,000 seeds per acre have been recorded already this year in burned areas in the GYA. Some of these seeds survive the seed predators and begin to grow immediately. They are subject to competition and do not do well in areas where dense herbaceous growth gets started. Within five years, lodgepole seedling densities often exceed 1,000 seedlings per acre. Engelmann spruce and subalpine fir may also sprout the first year but their seedlings are not nearly as numerous as those of the lodgepole.

The largest, most notable change in the grasslands and sagebrush steppes will be the vigorous response of the grass clumps next spring. Increased sunlight penetration will spur growth by warming the ground. Additional nutrients released from the ash will also produce more luxurious growth next year. Some sagebrush plants were killed as well as some of the grasses beneath them. These sites will be temporarily invaded by a number of weedy species but eventually will be taken over by new grass clumps and sagebrush seedlings. Sagebrush from neighboring stands will disperse seed into the burned areas, and within 20 to 30 years the sagebrush will be back to its original state.

Several hundred thousand acres of the GYA were changed from various seral stages to a very young successional stage, and the normal processes that have operated for thousands of years will move them slowly and inexorably into the succeeding stages.

TIMBER

This assessment pertains to burned areas occurring solely on Forest Service lands where timber harvests are carried out. In keeping with the legislative mandates of Yellowstone Park and wilderness areas, timber harvests are not conducted in these areas, and insect activity and lightning-caused fire are recognized as natural forces.

OVERVIEW

Approximately 416,850 acres of National Forest lands in the GYA have been affected by fire. Most of this area is immediately adjacent to Yellowstone National Park. National Forest areas within fire perimeters represent a small fraction (less than 6 percent) of all National Forest lands within the GYA.

Even those acres that actually burned present a mosaic of vegetative conditions and burn intensities. Portions of the burn were on nonforested land where recovery should be rapid, and within two years the result may actually be a net improvement in range conditions. However, these burned rangelands will offer less browse for this first winter. Other portions were essentially surface fires under standing trees. Here, depending upon fire intensity, mortality in the overstory trees may range widely. Other burned areas supported crown fires that blackened nearly all trees. Even in those areas of crown fires there are differences in intensity. Some crown fires moved through quickly and did not consume all forest floor litter or even consume all cones on standing trees. Other areas were subjected to more heating. In these areas the forest floor litter layer was totally consumed, some of the organic matter was burned out of the soil, and seed stored in serotinous cones on lodgepole pine trees may have been destroyed. A breakdown of burn intensities and vegetation burn types is in the "Greater Yellowstone Burned Area Survey" section of this report.

POTENTIAL IMPACTS

Insects

There is some uncertainty about whether insect-killed trees worsen fire conditions. Some contend that the fires on the east side of Yellowstone Park found a ready fuel source in the lodgepole pine that had been killed by mountain pine beetle over the last decade. Others point out that the fires burned through beetle-killed trees in a similar manner to those in living forests. But crown fires running into areas with many beetle-killed trees were observed to typically become ground fires, because there was less fuel in the canopy. Also, many crown burns occurred in areas not significantly affected by mountain pine beetle.

The last few years of drought, which contributed to erratic fire behavior, also have created large areas of stressed trees that are susceptible to bark beetle outbreaks. Trees damaged but not killed by fire may present a source for the build-up of bark beetle populations, but surges in beetle infestations appear to be driven and controlled more by drought than any other circumstances, such as the presence of fire-killed trees. These bark beetle populations could potentially then move out to attack other trees. Beetle infestations could increase in these situations.

Fuels

While the fires consumed large amounts of fuel that accumulated over past decades, there is still fuel available. In areas of light burns only fine aerial fuels were consumed and larger fuels remain. In areas of intense burns the fire-killed trees will eventually fall over, providing a source of large fuels for decades to come. History has shown that reburns can occur in the Northwest after large fires, although there is some question as to whether this will occur in the GYA since it has not in the past.

In lands administered by the Forest Service salvage harvests may be completed to reduce these fuels and create more fire-resistant forest stands. However, the vast majority of these fires were either within Yellowstone National Park or within Forest Service wilderness areas. Here, statute, policy, and public opinion preclude any large-scale harvest.

Research Natural Areas

A Research Natural Area (RNA) on the Island Park District of the Targhee National Forest is inside the burn perimeters of the North Fork Fire. Full analysis of the impact to this RNA is not complete. Approximately 500 acres are involved.

Timber Resources

About 39,200 acres burned on Forest Service lands that are classed as suitable for timber management. These lands represent only about 2.2 percent of all such lands available in the GYA. However, these effects vary greatly by National Forest, and on the Shoshone National Forest these fires will have an impact on timber management. The following table displays these facts.

National Forest	Suitable Timber Acres in Burn	% Total Forest Suitable Base Acres in Burn
Beaverhead	0	0
Gallatin	3,340	1.2
Custer	0	0
Shoshone	16,000	18.6
Bridger-Teton	0	0
Targhee	11,300	1.6

The 18.6 percent timber base loss on the Shoshone National Forest occurred on one District and will impact the local lumber mill, which employs 55 people. An analysis of these impacts is under way.

Salvage of fire-damaged timber is one option available to land managers interested in resource recovery. It is used not only to recover marketable timber that was lost in the fire, but can also be used to help mitigate visual impacts, damaged range, wildlife, and fish habitat, and reduce the risk of insect infestations or of additional fire. National Forest are evaluating salvage potential at this time. The following figures are preliminary and may change as more information becomes available, and as the Forests do further planning and analysis.

National Forest	Total Suitable Volume Lost MMBF	Estimated Volume Considered for Salvage MMBF	Salvage Volume as % of Forest Annual Harvest
Beaverhead	0	0	0
Gallatin	9.5	9	42.5
Custer	0	0	0
Shoshone	100	30	268
Bridger-Teton	0	0	0
Targhee	60	1.5	1.7

On the Shoshone National Forest, potential salvage represents over 2 1/2 times their normal annual harvest. Timber will only be in salvageable condition for about two years before it becomes so cracked and checked that it can no longer provide sawn products. The Gallatin National Forest is considering salvaging an additional 7.5 MMBF (million board feet) from its lands in the Storm Creek Fire near Cooke City. There are also about 1,600 acres of private lands within the burn in this area. These lands also have salvage potential. The Targhee National Forest is the only other area with potential for salvage activities. Here, only 1.5 MMBF are being considered for salvage, and the local markets are well able to handle this amount.

Artificial Reforestation

Because of short time constraints most Forests have developed only preliminary reforestation plans. Reforestation needs are expected to increase in the next few months as needs are identified. Currently, about 2,100 acres on the Gallatin National Forest near Cooke City and about 3,000 acres on the Targhee National Forest portion of the North Fork Fire have been identified as needing some artificial reforestation. Progress of salvage plans and availability of suitable planting stock will probably spread the tree planting effort over a two-to-four-year period. Total reforestation needs will be developed over a period of months as fire effects and resource needs are fully analyzed.

Natural Reforestation

Overall, we can expect significant natural reforestation. Lodgepole pine was a significant proportion of the tree canopy, even in areas that were not mapped as lodgepole pine cover types. Serotinous cones of lodgepole pine provide a readily available seed source. In these types of stands, large numbers of lodgepole pine seeds are now on the ground, and natural regeneration potential is high. Where the burn was spotty, and all the overstory was not killed, a seed source for other tree species also exists.

Many species of grasses, forbs, and shrubs will sprout back from root crowns and will actually be invigorated by low-intensity burns. Seeds from other species sprout regularly on burned duff or soil, adding to vegetative diversity in the years immediately following a burn.

On those limited areas where fire intensities were high the situation may be different. In those cover types where lodgepole pine was not present, intense canopy burns eliminated most tree seed. Natural regeneration times vary depending upon the size of the severely burned area, and the ability of tree seed to blow in from outside areas. If large drainages were completely consumed by very intense fires it may be many decades before forests naturally regenerate themselves. These areas are limited largely to parts of the Shoshone National Forest.

Though fire intensities were high in many areas, soil heating was generally low to moderate (see "Greater Yellowstone Burned Area Survey" section of this report) in the GYA. Revegetation will probably occur in the first three years. Seed densities of 50,000 to 1,000,000 seeds per acre have been recorded on the ground in burned areas.

Even where lodgepole was present, there are some limited areas where fire intensities may have been high enough to destroy serotinous cones. It is not known if there are significant amounts of this type.

In those few limited areas where soil heating was intense, sprouting grasses, forbs, and shrubs were eliminated. Understory vegetative succession depends upon seed sources outside the severely heated soil. Successional development of forests and forest understory vegetation on these areas will be slow and will differ significantly from areas of lower burn intensity. These sites represent less than one-tenth of 1 percent of the total burned areas.

CONCLUSION

In many instances, the actual effects of the fires on insect populations and vegetation cannot be predicted now and will not be known for some time. However, initial estimates of soil heating indicate that the vast majority of the burned areas in the GYA will revegetate naturally in one to three years. Mountain pine beetle infestations may occur in some areas. Artificial reforestation will be used in those areas needing accelerated recovery efforts and in areas where timber production is a major management objective. Salvage harvests are also a potential recovery tool where appropriate.

RANGE AND GRASSLANDS

This report was prepared by an interagency team of vegetation specialists from the National Park Service and Forest Service to provide an initial assessment of the extent of rangeland impacts resulting from the fires in Yellowstone National Park and adjoining National Forests. The GYA fires affected a variety of vegetation types. There were also impacts to structures on some National Forest rangelands with domesticated livestock allocations.

OBJECTIVES

The team attempted to estimate the degree that vegetative productivity will be altered by the fires and the duration of these effects. Additionally, damaged livestock management structures were inventoried and assessed and replacement costs were estimated.

RESULTS

Vegetation

The effect of fire on rangelands in the West can be characterized as short-term losses which usually become long-term gains in productivity and health of the range. Fire is a natural component of most grass and forested communities within the GYA, and it acts to stimulate growth if the soil heating intensity is not too great and provided there is sufficient moisture to support plant growth.

Within the GYA, soil heating intensities on grassland types were low to moderate. Soil heating was similar on forested ranges, except for small islands of higher intensity heating, such as under fallen trees. Therefore, there should be no long-term loss of vegetative productivity due to soil heating.

Fires were more likely to burn forested vegetation types, and the resulting mosaic of burned and unburned trees should provide improved foraging conditions for a variety of wild species as well as livestock. A significant gain in the productivity of herbaceous and shrub species can be expected in the lodgepole pine vegetation types, which have been returned to an earlier successional stage.

Burns within riparian (wetland) areas will probably result in increased growth of willows and aspen and provide forage in areas where previously overly mature vegetation discouraged foraging animals. This will result in increased grazing pressure from moose, elk, deer, and livestock and has the potential to pose significant management challenges in balancing use on Forest Service lands.

On the Shoshone National Forest, approximately 9,000 acres of rangeland will be deferred or rested from livestock grazing to provide the maximum period for vegetative recovery.

Noxious Weeds

An additional threat to long-term vegetative productivity is the introduction of noxious weeds, most notably leafy spurge and spotted knapweed, into disturbed areas. Areas where native vegetation was disturbed by fire-suppression activities (especially by machinery exposed to infested areas) provided the greatest potential for weed seed introduction. To quantify the risk of noxious weed spread, the following table was constructed. It lists the type and extent of surface disturbance in order of the greatest to least threat.

Type of Disturbance	Miles	Acres
Bulldozer Line	137.3	332.6
Camps, Staging Areas, etc.		254.7
Handline	665.8	164.0

Considering the 751 acres of mechanically disturbed areas plus the vast burned acreages, local land managers rated the overall probability of noxious weed invasions as follows:

High	78.1 acres
Medium	386.9 acres
Low	26,511.3 acres

The factor which may most significantly impact the recovery of the rangelands, forested and nonforest alike, will be moisture availability. The effects of drought extend beyond the year they were first experienced, and last year's areawide drought would have resulted in less vigorous vegetation growth in 1989 regardless of the fire activity. Under normal moisture conditions, the vegetation should have the opportunity to benefit from the stimulation of fire.

Structures

Because most of the fires occurred in National Parks or wilderness areas, the loss of range improvements was relatively low. The figures below summarize the losses:

Improvement	Quantity	Costs ($)*
Boundary fence (private)	2.0 miles	$ 5,000
Boundary fence (public)	1.0 miles	8,000
Interior fence (public)	18.3 miles	8,700
Herders cabin (public)	1 cabin	30,000
Stock driveway (public)	6.0 miles	4,000
TOTAL		$215,700

* Costs do not necessarily reflect total replacement cost, rather the cost to repair the improvement.

Administrative

As a result of the impact from the fires on National Forest grazing allotments, four Allotment Management Plans will require revision for a total estimated cost of $4,000.

WILDLIFE

FIRE-RELATED MORTALITY

Fire-killed ungulate (hooved mammal) surveys were conducted by the U.S. Forest Service (Gallatin and Bridger-Teton Forests), by Yellowstone National Park, and by the Wyoming Fish and Game Department (Cody and Jackson offices). The Yellowstone Park survey, the largest, involved 48 helicopter-hours, 431 miles of ground survey, and 91 person-days of effort. The Cody office of Wyoming Game and Fish mounted the second largest effort, amounting to several weeks of work by ground crews. The Jackson offices of the Wyoming Game and Fish Department and the U.S. Forest Service cooperated on a six-hour aerial survey of Gravel and Pacific Creeks and in a six person-day ground survey of the same areas.

In the GYA, total known fire-related mortalities were: 335 elk, 36 mule deer, 12 moose, 6 black bear, and 9 bison. A breakdown by fire is presented in Table 1. These figures are refinements of earlier totals and are almost certain to be revised in the future. Unquestionably, they are minimum figures. (Bird mortality also occurred and is discussed in later sections.) Nearly all of these animals were suspected to have died from extensive smoke inhalation as verified by smoke deposition in tracheas. Nearly all ungulates showed a remarkable ability to move and avoid actively burning flames. For the most affected species, elk, the known mortality was still only about 1 percent of the population present in any specific

Table 1. Fire-related Wildlife Mortality in the GYA

	Elk	Moose	Black Bear	Mule Deer	Bison
Outside Yellowstone Park					
Huck, Emerald, and Mink Fires	30	6	-	13	-
Clover-Mist Fire	53	3	4	17	-
Hellroaring Fire	6	1	2	2	-
Within Yellowstone Park					
Clover-Mist Fire	27	2	-	2	-
Red-Shoshone Fire	4	-	-	-	-
Fan Fire	1	-	-	-	-
North Fork Fire	214	-	-	2	9
Totals	335	12	6	36	9

An additional elk within Yellowstone and 1 moose and 1 black bear outside the park were destroyed because they were severely burned.

area. Mortality was concentrated where wide, rapidly moving fire fronts passed through elk range. The mortality that occurred near Gravel Creek resulted when wildlife were caught between two fires, a back fire and the Huck Fire. Ungulates easily avoided narrower or slower moving fronts. None of the 60 radiocollared elk in Yellowstone National Park died in the fires. No grizzly bear mortality was observed. Two areas known to contain additional mortality in Yellowstone National Park were not surveyed due to extensive grizzly scavenging activity. These two areas likely held additional dead elk. Extensive scavenging by ravens, coyotes, grizzlies, black bears, golden eagles, and bald eagles was observed on all fire-related carcasses. The Gallatin National Forest reported an increased susceptibility of moose to bear predation right after the fires.

THREATENED AND ENDANGERED SPECIES

Peregrine Falcon

The peregrine falcon is doing remarkably well in Yellowstone National Park in recent years thanks to a reintroduction program conducted by the Peregrine Fund (Boise, Idaho). There are currently three peregrine falcon nesting territories in Yellowstone, and a total of four peregrines fledged from these three wild sites. At another area, a pair of adults were observed occupying a cliff that had been the site of a peregrine hacking program in the past. A new peregrine hack site was established at another location in Yellowstone, and five peregrines fledged successfully. This new hack site lured in an adult, which did not seem to disturb the recently fledged peregrines.

The 1988 GYA fires had little affect on peregrine falcons in the areas where they are known to occur. However, a large section of the rugged Yellowstone backcountry has yet to be surveyed for peregrines. Since peregrines nest in cliffs and lay their eggs on fine gravel substrates, the fires will not effect their nesting sites. The habitat around two wild sites and two hack sites were influenced by the fires, but very little impact is expected from this perturbation. Overall, the peregrine falcon will benefit from the fires because they act to create meadow areas from once forested habitat. The end result is expected to be an increase in vegetative diversity which will in turn increase bird diversity and abundance and will, therefore, benefit peregrines, since they prey on small to medium sized birds.

Bald Eagle

There are currently 14 nesting territories in Yellowstone National Park that are being monitored on an annual basis. A total of 11 eaglets fledged from bald eagle nests in 1988. The fires had no influence on bald eagle fledging success, since the eaglets fledged before the fires entered these nesting territories.

The fires had a direct affect on six nesting territories in the GYA. Five nests in Yellowstone National Park were destroyed by fire. However, it should be noted that territory occupancy by adult bald eagle pairs, as documented during two aerial surveys conducted on October 27, 1988, and November 1, 1988, was quite high indicating little if any immediate displacement due to the fires. Bald eagles were also frequently observed capturing fleeing prey during the fires on their respective territories. The bald eagle nesting territories that were directly affected by fires are expected to change ever so slightly, since there will be little effect on the prey, and the mosaic burn patterns have left large live trees available for nesting. Once the bald eagle nesting sites are reestablished, bald eagle production is expected to be back to normal, but as always production will be highly influenced by weather. Intensive monitoring of these bald eagle nesting territories will be conducted.

Whooping Crane

The whooping cranes that are found in Yellowstone are a result of a cross-fostering experiment conducted by Dr. Rod Drewien at Grays Lake National Wildlife Refuge in Idaho. In the last few years two whooping cranes have been utilizing the open meadows of Yellowstone National Park. These two whooping cranes are not paired and, therefore, are solitary or accompanied by sandhill cranes. The two whooping cranes that frequent Yellowstone also utilize two entirely different areas of the park.

Only one of the whooping crane foraging areas was affected by the fires. This areas is located south of Yellowstone Lake. The whooping crane was observed on numerous occasions during and after the fires went through this area. During the fires, the whooping crane was observed hunting the fronts of the fires in the open meadows pursuing prey. After the fires burned through the meadows, the whooping crane frequented the blackened meadows in search of food. The 1988 GYA wildfires had very little affect on whooping cranes and, in fact, may have benefited this species by allowing food to be more readily available. Whooping cranes will be monitored actively in 1989 to determine if they still forage in these newly burned open meadows.

Grizzly Bears

Many research biologists now believe the effects of the fires will enhance areas utilized by grizzly bears by increasing the diversity of both plant and animal food sources available to the bear. Much needs to be learned, however, and no clear answers may be readily available for several years, although sightings were made of grizzly consumption of carcasses this fall.

In an effort to gain more information of future movements in burned areas, the Interagency Grizzly Bear Study Team will attempt to increase the sample of collared bears in the area of the Clover-Mist Fire. At present, 36 bears are collared in the GYA, but not all are in areas in or near the burns.

There were 19 sightings of female grizzlies with 40 cubs of the year in the GYA in 1988. None of these bears died as a result of the fires.

Concern has been expressed about the effects on whitebark pine, a fall food source. Less than 20 percent of the whitebark pine stands in and near the fire areas were affected. Impacts will not be known for several years.

SPECIES OF SPECIAL CONCERN

Trumpeter Swan and Common Loon

Most bird populations in Yellowstone are highly influenced by weather. The Yellowstone trumpeter swan and common loon populations were influenced more by the drought than by the fires. Even though the fires had little affect on the populations, lakes and ponds used by trumpeter swans and common loons are expected to benefit due to the fertilizing effects of the fires.

Osprey

The osprey population was influenced by fires. Seventeen percent of the osprey nesting territories were affected. Five osprey young were documented as having died in the wildfires; however, projected figures of known nest sites indicated that there is a chance that 17 young may have died. The overall prognosis for ospreys is good, however, since more dead trees will be available for nesting sites and since their food source (fish) has not been affected.

UNGULATES

Gallatin National Forest

About 67,000 acres of elk and mule deer summer range and an estimated 2,500 acres of elk winter range were affected by two fires, the Hellroaring and Storm Creek Fires. About 13,000 acres of moose summer range was affected and 18,000 acres of winter range. About 3,000 acres of year-round mountain goat habitat, about 1,000 acres of bighorn sheep winter range, and approximately 400 acres of summer range were affected by fire.

Long-term enhancement of elk and mule deer summer range is predicted. Moose winter habitat will likely be enhanced due to increased abundance, production, and quality of deciduous shrubs. Willow growth will likely increase in burned areas with resulting benefits to beaver and moose. There will likely be an increase in the sucker growth of aspen, which will benefit ungulates since this is a preferred browse species. Mountain goats may benefit from increased forage production, but about one-half of their burned habitat was old-growth forest where conifer cover is now reduced.

Beaverhead National Forest

About 2,860 acres of elk, mule deer, and bighorn sheep winter range were burned in the Corral Creek Fire. This amounts to only about 5 percent of the total winter range used by elk and deer. Effects will be minor. During the winter of 1988-89, elk and deer may use private lands more than in past winters.

Bridger-Teton National Forest

The Mink Creek, Emerald, and Huck Fires burned approximately 157,650 acres within the Bridger-Teton National Forest. Preliminary surveys indicated that high-intensity burns involved about 15 percent of the burned area, about 30 percent was moderate, and the remaining 55 percent was low-intensity burn. (These fire intensity terms are explained in the "Greater Yellowstone Burned Area Survey" section of this report.)

Ungulate winter ranges sustained very little impact. Most impacts affected late spring, summer, and fall ranges. Most burning was in lodgepole pine forests. Mountain meadows rarely burned, even though adjacent clumps, stringers, and islands of fir and spruce did burn. Improved forage conditions for elk are predicted.

Shoshone National Forest

The Clover-Mist fire burned an estimated 118,800 acres Moose will be positively affected by the fires since a number of riparian, willow, and aspen communities burned. Some dense cover adjacent to feeding sites was lost. Only one sheep winter range (Clarks Fork Sheep Herd Unit) and one moose winter range (Crandall Moose Herd Unit) lost more than 10 percent of its forage. Therefore, winter range impacts were relatively minor for the forest. Most impacts occurred in late spring, summer, and fall ranges. The long-term impacts on big game populations are expected to be positive.

Targhee National Forest

About 11,300 acres were affected by the North Fork Fire. The North Fork Fire burned about 450 acres of moose winter range. There should be some positive effects of increased forage, especially aspen and willow. There was also a loss of conifer cover, however, which will take 60-80 years to recover. About 2,400 acres of elk calving areas burned, and about 2,100 acres of summer range. Some elk security cover along migration routes was lost. A road closure (58 miles) was instituted in 1988 to mitigate the loss of security cover.

Yellowstone National Park

Elk

The drought of 1988 reduced forage production by 40 to 80 percent on various elk summer range sites and by about 22 percent on winter range sites. Approximate amounts of burned winter range for the following herds were: about 61 percent for the upper Yellowstone elk group, about

41 percent for the Madison-Firehole herd, about 34 percent for the northern herd within the park, and a trace of the Gallatin herd's range within the park. The extent of burning in the more critical foraging areas, however, was less. Fifty-five percent of the wet meadow/willow type burned in the upper Yellowstone, 27 percent of that type burned in the Madison-Firehole, and 9 percent of the dry grasslands on the northern range burned. Elk, however, also use forested areas in the late winter in all the winter range areas. Earlier, larger migrations and some winterkill are predicted for the winter of 1988-89 in these areas. As more precise burned area maps and data become available, this information will be refined.

Summer ranges burned very extensively, but approximate acreages were not calculated, as they were for the winter ranges. The majority of fire effects will be positive, including increased production of grasses, forbs, and shrubs; higher protein content in forages; lower fiber content; earlier spring green-up; and more diverse diets for elk. There would be some negative effects. Some conifer cover was lost, although burn mosaics will produce meadow areas in once dense forests, and conifer cover does not appear to be limiting anywhere. Much sagebrush was removed on the northern range. Elk eat a minor amount of sagebrush, and sagebrush may influence snow characteristics to benefit elk. Some sagebrush calving areas were burned. However, the loss of sagebrush represents a return to more natural conditions on the northern range.

Short-term fire-related displacements were observed in 14 radiocollared elk. Nine returned to use their normal summer ranges after the fire passed, but five were more permanently displaced. Eight elk returned to their winter ranges early, and five of those elk occupied summer ranges that did not burn. The early migration is therefore attributed more to the drought than to fires.

Bison

Drought was a major driving force for the fires of 1988. Many effects of drought and fire are not separable, so both are discussed.

Three bison (Bison bison) subpopulations inhabit the park according to winter range designations. These are the northern range (Lamar), Pelican, and Mary Mountain (Hayden Valley and the Firehole). Bison which winter on the northern range and in Pelican Valley mix considerably in summer, traditionally ranging across the Mirror Plateau and the Upper Lamar country. During the recent wet summers, they have made extensive and intensive use of the Lamar Valley bottoms. The Mary Mountain population summers mostly in Hayden Valley. More than half of this subpopulation begins the winter in Hayden Valley, but reverse this distribution later so that more than half to three-fourths finish the winter on the Firehole.

Bison use mostly open meadows, although forested areas, especially the edges, may be important when severe winters force them to scatter and utilize sites such as tree wells and obscure thermal areas where they do not usually forage. The following estimates of areas burned are for traditional bison use areas. On the northern winter range, the expanded bison use areas from Tower west through Blacktail are included. Areas outside park boundaries are not included because the State of Montana removes bison by use of permit hunters.

Effects on Bison Seasonal Ranges. Burns were visually estimated; detailed maps are not yet available.

Subpopulation:

Northern Range	In the absence of detailed maps of the winter range it has been estimated that roughly 40 percent of the traditional foraging areas were affected by fire. These include parts of the Lamar Valley south of the river and south of the road, the Tower area including Pleasant Valley, and the Hellroaring slopes above the flats. Foraging sites in the expanded winter range between Tower and Mammoth were mostly burned except in the general area of Oxbow-Geode Creek. Areas outside the park were unburned but are of little importance because the animals are not allowed to settle down and develop undisturbed patterns of use.
	The summer use areas for both the northern range and Pelican bison are mostly within fire perimeters.
Pelican	The winter range was largely unaffected by fire; perhaps 2 percent of the major meadow use areas burned. Sites important within forested areas were not burned.
Mary Mountain	Winter range in Hayden Valley was affected by fire along the north edge. An estimated 1 percent of areas important to bison burned.
	An estimated 10 percent of the winter range on the Firehole was affected by fire, mostly in the upper and lower geyser basins. In addition, interspersed forest areas burned; these have variable importance according to the kind of weather, and a percentage has not been assigned.
	Summer range is mostly in Hayden Valley and was little burned.

Known direct mortality totals nine; two separate bulls and some members of a mixed group including a bull calf, a young bull, an older bull, and four not characterized. Probably there were others in the group that escaped.

Elsewhere in this report effects of drought on the northern winter range and the summer range are characterized according to those measurements available. While only anecdotal observations are available to comment further, I would say the available measurements and assessment derived therefrom are a minimum and probably underestimate winter range effects by a considerable amount. Available measurements reflect the effects of precipitation that occurred in May and early June. Measurements were essentially unavailable for later season grasses such as timothy (Phleum pratense), and for the sedge (Carex sp.) swales and bottoms which are of particular importance to bison. The absence of later precipitation apparently had major effects. In 29 field seasons, Research Biologist Dr. Mary Meagher had never seen the Lamar areas, the Yellowstone River bottoms in Hayden Valley, nor the meadows of the Firehole look as they did in the late summer/fall of 1988. Dr. D. B. Houston concurred regarding the northern range, derived from his 10 years in Yellowstone Park as a Research Biologist during the 1970s. Dr. Phil Farnes of the Soil Conservation Service, long-time precipitation/weather/snowpack authority for this area, shared these perceptions. These observations would indicate that the drought effects on the several bison winter ranges greatly exceeded those of fire. Long term, fire is assumed to be beneficial through increased forage production and nutrient cycling.

In recent winters northern range bison have made large movements across the boundary near Gardiner, Montana. Major influences appeared to be use of the plowed road for travel, the gregariousness of bison, and acquired knowledge of new areas. On the west side of the park, the boundary problem occurs more in late winter. Population increases with mild winters and wet summers have intensified both boundary problems. This year, with drought and fire, major movements were predicted in September. A roughly average winter (as of February 1) will add additional impetus. The State of Montana will remove as many bison as feasible outside the park by permit hunting. Long-term data gathering relative to distribution, population, and ecological relationships will continue. The December 1, 1989, aerial survey showed a distribution and grouping more suggestive of a February survey as snow depths increase. This further indicated that the bison populations would be subjected to major stress this winter.

Recommendations were made to management proposing restriction of off-road recreational use on ungulate winter ranges.

Bighorn Sheep

Bighorn sheep (Ovis canadensis) on the northern winter range occupy more or less a continuum on the lower portions and more discrete pockets of suitable habitat east of Tower. These animals summer to the northeast and on Mt. Washburn. Summering bighorn also occur in the Gallatin Range (wintering mostly north of the Yellowstone boundary), along Yellowstone's eastern boundary (wintering in Wyoming), and as isolated summer occurrences (Mt. Sheridan). This discussion will address only the northern range, including those bighorn which summer in the Gallatin Mountain Range.

Most of the bighorn use sites in the Mt. Everts area were untouched. Some of the Specimen Ridge winter range burned. Summer range to the northeast was largely untouched; Mt. Washburn sheep use areas burned to some extent. Gallatin Range bighorn summer areas were little affected by fire except for Sepulcher Mountain. Travel routes were probably affected, particularly between the Mt. Everts area and Mt. Washburn. In general, drought impacts probably exceeded those of fire.

There was no known fire-related mortality of bighorn. However, indirect impacts due to disturbance appear to have occurred. The Eagle Creek and Mammoth helibases both utilized flight routes that put constant helicopter activity over bighorn use areas and travel routes. The Mammoth Area Ranger observed what appeared to be displacement of some bighorn rams, and the wintering distribution on the lower reaches is below typical. The wintering distribution probably is influenced by other factors, but the possible effects of disturbance cannot be dismissed.

Long term, the fires should benefit bighorn sheep. Comparative photographs spanning as much as 100 years indicate increased density of forest and some encroachment on open areas. Where fire occurred it may increase suitable bighorn range. Postfire nutrient and forage production increases may occur.

Summary

The carrying capacity of the park's ungulate ranges will be greatly enhanced by both the burning on summer and winter ranges. While some fire-related mortality was incurred, on a whole these are relatively minor losses when compared to the overall benefits these species will reap for several years.

OTHER MAMMALS

Mountain Lions

The activities of eight radiotagged mountain lions were monitored during and after the 1988 fire season in Yellowstone National Park. Movement patterns of five adult lions and two kittens suggested that they avoided areas with burns in progress, but continued to use them afterward where prey numbers and cover conditions were not greatly affected. Two adult lions and two kittens showed pronounced changes in their use of home ranges, possibly in response to fires. A comparison of home range use among three adult lions between winter 1987-88 and 1988-89 showed that each individual is presently using a different area, but differences in snow accumulations, temperature, drought, and distribution of prey animals could also account for the new patterns. Eleven percent of the radio-locations have occurred in burned habitats. Additionally, 11 percent of the prey killed by lions has been captured in burned areas. Additional data are necessary to fully evaluate the long-term impacts, if any, of the 1988 fires on this predator.

Coyotes

Short-term effects on small mammal populations (rodents, etc.), the coyote's prey, in environments characterized by heavy cover could possibly have short-term impacts on coyote populations. Coyotes are mobile and have a good sense of smell. Accordingly, coyotes are able to exploit carcasses effectively; therefore, coyotes generally benefit from situations like drought or fire. In the long term, grass production will be stimulated as a result of the fires. This should lead to an increase in small mammal populations. The long-term benefits to prey (small mammals) and carrion species (elk) will also translate into long-range benefits for coyotes.

Beaver

Beaver are a relatively stationary animal, and if an extensive burn occurs directly around their lodge or during a time when they are storing food for the winter, a fire could have an adverse impact on a specific population. These temporary effects should be far outweighed by the tremendous abundance of willow and aspen growth that will be stimulated by the fires.

BIRDS

Wildfires are instrumental in increasing vegetative diversity which will in turn increase and/or improve the diversity of birds in Yellowstone. The wildfires did not burn uniformly, they created a mosaic of different age and/or types of vegetation coupled with different fire intensities. Wind-driven wildfire skipped across the landscape burning at different intensities depending on the wind speed, humidity, fuel load, and time of day. Overall, this newly created vegetative mosaic is expected to yield a collective increase in Yellowstone's bird populations. The rare three-toed and black-backed woodpeckers, in particular, will benefit from the fires and there numbers will increase dramatically in burned areas for the next few years. These woodpeckers will follow the influx of beetles which laid eggs in charred and damaged trees.

Bird species occupying old-growth habitats are expected to decline in numbers to some degree as a result of the wildfires, these include such species as the sage thrasher, golden-crowned kinglet, Williamson's sapsucker, and the boreal owl. However, it should be noted these species will eventually return in larger numbers.

Several unique and interesting phenomena occurred as a direct result of the fire activity. An adult common loon was stranded on a dry sewage lagoon at Old Faithful. The loon apparently got confused and disoriented with the smoke and landed on the dry sewage lagoon mistaking it for water. The loon was stranded since loons require a sizable water runway in order to take off. The loon was eventually freed.

Perhaps the most impressive bird phenomenon associated with the 1988 Yellowstone wildfires was the raptor "feeding frenzy." Raptors have previously been observed hunting the front of wildfires (Centennial Valley, Montana), but raptor hunting observations of this magnitude and concentration are nearly unheard of. Raptors such as bald eagles, golden eagles, ospreys, peregrine falcons, prairie falcons, kestrels, Swainson's hawks, red-tailed hawks, northern harriers, goshawks, Cooper's hawks, sharp-shinned hawks, and even great gray owls were taking advantage of the fleeing and/or displaced prey. It was most impressive in the open meadows where the actions and interactions were more observable.

The gigantic columns of smoke acted as an advertisement luring resident and migrant raptors to the area. The most noteworthy observation was that of ferruginous hawks. Normally, ferruginous hawks are very rare in Yellowstone. On September 7, 1988, more than 40 ferruginous hawks were observed hunting the open meadows between Cascade Meadows and Hayden Valley. They were feeding mainly on two types of displaced prey, voles and pocket gophers. It was theorized that the ferruginous hawk, being an open-country/plains raptor, has evolved to associate wildfire with an plentiful food source. Lightning-caused plains fires are very common. The ferruginous hawks it seems, like many other raptors, were lured to the Yellowstone plateau in above average numbers due to the visual stimuli of the massive smoke columns.

The wildlife phenomenon did not just benefit raptors. Bird species, such as the common raven, whooping crane, sandhill crane, and great blue heron, were working the open meadows just in from of active fire fronts. Even more surprising were the birds that immediately began searching for food in the blackened forested areas. Red crossbills, pine siskins, Clark's nutcrackers, and pine grosbeaks utilized the newly blackened areas the most. They were feeding on the millions of seeds from serotinous lodgepole cones (cones that open only in response to intense heat, such as fire) and extracting the loose pine seeds.

Bird mortality did occur, but the degree of the overall mortality will never be known. There were observations of direct losses to fire, such as osprey chicks and a ruffed grouse nest containing eggs. There was mortality associated with smoke inhalation. Birds were disoriented and confused because of the smoke resulting in collision-related mortalities in the cases of a mallard and a Barrow's goldeneye. Displacement from home ranges and/or feeding areas as a result of the fires led to roadkills of the following species: common raven, great gray owl, ruffed grouse, and ferruginous hawk. There were unconfirmed reports of bird mortality of unknown cause (a great gray owl fledgling, a sandhill crane, a Hammond's flycatcher, an unidentified raptor, and a vesper sparrow). Individual birds may have been lost, but for most species, the vegetative changes are a blessing in disguise.

Once the fires past through an area, shoots of green grass started to come back, fire-released seeds dropped in the blackened areas, insect species lured by the fires appeared, and pocket gophers resumed their normal activities. Bird species, such as northern flickers, hairy woodpeckers, American robins, mountain bluebirds, Cassin's finches, great gray owls, and horned larks, were observed feeding on these readily available food sources after the fires went through their respective habitat types.

Yellowstone and the GYA will be better bird habitat and, therefore, a better place to view birds as a result of the 1988 fires. The area is now more open. There will be an increase in vegetative diversity which will in turn increase avian diversity. There will also be an overall increase in total numbers of birds. This situation will not last forever for that is the beauty of nature, but it will last for quite some time until a new natural event modifies the already existing complicated Yellowstone vegetation mosaic.

CLOSING REMARKS

The effects of fire on many wildlife species are not fully known. In these instances, the GYA fires have presented scientist with a great opportunity to study the responses and adaptations these species have developed towards fire. While limited fire-related mortalities did occur and species that prefer old-growth habitats may be displaced from burned areas, overall the fire-related benefits to wildlife will far out weigh the losses.

FISHERIES

Many large rivers and tributaries in Yellowstone National Park and five contiguous national forests were affected by the 1988 fires. Fisheries in these river systems are some of the best in the country, attracting many recreationists from across the nation. The Fisheries Assessment Team was assembled to evaluate potential fire-related impacts to the aquatic life of the GYA.

POTENTIAL POSTFIRE HYDROLOGIC CHANGES

Large forest fires can have notable effects on the fisheries of an affected watershed by changing the hydrology of the system. Water quality and quantity, timing and intensity of peak discharges, and alterations of the physical habitat can independently or synergistically influence the associated fish populations. Some of the more notable potential hydrologic changes are listed in this section. In some instances, these represent worst-case scenarios. There are three areas of particular concern:

1. Shorter but more intense peak flows can occur due to consumption of canopy cover within the drainage. Shading, snow interception, and evapotranspiration can be reduced causing snowmelt to occur within a shorter period of time.

2. Fire, especially if intense, can cause the soil to be hydrophobic. Without sufficient infiltration surface runoff increases, resulting in higher peak flows and introducing additional sediment into streams.

3. With the loss of side-slope vegetation, sediment is more prone to enter a stream system through overland flow, mass slope wasting, and increased avalanche activity. The loss of riparian (wetland) vegetation can increase instream sediment levels since the vegetation normally filters out sediments from flood and overland flows and stabilizes streambanks. Large woody debris trap existing sediment, and the loss of these materials can also contribute to instream sediment levels.

Changes in the hydrology of a drainage correspondingly affect the associated fish populations. More intense peak flows can damage the structure of a stream degrading fish habitat, especially if the streambanks themselves have been damaged by fire, previous overgrazing, timber harvesting, and/or heavy recreational use. Large introductions of sediment can devastate spawning and incubation activities, fill in needed pool habitat, and decrease or destroy instream food sources, such as macroinvertebrates.

Fire can destroy the large woody debris in streams. Not only does this release trapped sediments but also eliminates pools and flow diversity necessary for a healthy fish population. In addition, woody debris provides the basis for the biotic food chain needed for all aquatic life. If the trees along the streamside are also lost, local debris recruitment may not be available for several decades until streamside forests have been reestablished.

Conversely, fires could provide excess debris if dead trees along the stream fall into the water in large numbers over a short period of time. Fish migration and streambank degradation can result from this debris overloading.

Water temperature can be altered with the removal of overstream canopy. Water temperatures can increase in summer and decrease in winter encouraging lethal anchor ice problems.

Fire can directly kill fish by raising water temperatures during the fire to lethal levels. As water temperatures increase, fish can suffocate due to the decreased availability of oxygen. Ash and chemical changes can pose problems too, primarily by increasing pH and alkalinity and causing nutrient overloading. Many low-order streams do not have the buffering capability to offset these increases. Chemicals from fire suppression can also be harmful.

ASSESSMENT AND EVALUATION

The 1988 GYA fires burned portions of numerous drainages in Yellowstone National Park (YNP) and five contiguous national forests (NF). The following is a list of the major fires, the drainages burned, and the associated administrative unit(s):

Fire	Drainage(s)	Administrative Unit(s)
Fan	Gallatin River above Taylor Fork	Gallatin NF
North Fork	Madison River Gallatin River Henrys Fork River	Targhee NF Gallatin NF Yellowstone NP
Hellroaring/ Storm Creek	Yellowstone River Stillwater River	Gallatin NF Yellowstone NP Custer NF
Clover-Mist	North Fork Shoshone River Clarks Fork Yellowstone River Yellowstone River	Shoshone NF Yellowstone NP
Mink, Huck, and Emerald	Yellowstone River Snake River	Bridger-Teton NF Yellowstone NP

After evaluating the available data and the potential postfire hydrologic changes, the Fisheries Resources Assessment Team identified the following specific concerns. These concerns represent worst-case scenarios in some instances.

-- Flashier or more intense peak flows could damage the stability of the streams. This is especially likely where the riparian vegetation has been reduced due to fire or past management activities.

-- Increased sedimentation could decrease available spawning sites, impact fish egg incubation, reduce macroinvertebrate populations, and fill in valuable pool habitat.

-- Woody debris needed for pool habitat development, sediment traps, and the biotic aquatic food cycle could be reduced for several decades where streamside vegetation is totally consumed.

-- As fire-killed trees along streams fall into the water, the stream may become overloaded with large woody debris causing migration barriers and possible channel degradation.

-- Direct fish mortality may have occurred during the fire activity due to excessive heat and other related factors.

-- Stream temperatures may exceed tolerant levels during the summer and/or winter causing stress or mortality to fish and macroinvertebrates.

-- Water quality may be adversely affected due to fire-related increases in pH and alkalinity. Other water chemistry may be altered.

-- Impacts from the fires may reach larger, valuable, fishery rivers and reservoirs downstream.

IDENTIFIED FISHERY CONCERNS

Yellowstone National Park

The majority of the streams burned in the park were type A channels - those with narrow V-shaped valley morphology, steep gradients, and large boulder controls. There was some limited riparian damage in wider, low gradient, highly meandering streams (type-C channels), but most of these streams that were effected by fire retained their riparian vegetation. Fortunately, much of the type-C channel vegetation is composed of willow species which return quickly and vigorously following a burn event.

Shoshone National Forest

Two major drainages burned on the Shoshone National Forest, the North Fork Shoshone River and the Clarks Fork Yellowstone River. High-quality fisheries occur in these two rivers and their tributaries.

The North Fork Shoshone River is considered by Wyoming Game and Fish Department (WGFD) to be a valued trout fishery. This river supports significant populations of Yellowstone cutthroat trout and is the major spawning stream for important fish species that reside downstream in Buffalo Bill Reservoir. It is estimated the North Fork Shoshone River provides for 13,000 fishermen-days annually from Pahaska down to the reservoir. The reservoir itself offers about 27,000 annual fishermen-days. The reservoir's fishery is dependent on spawning success in the North Fork Shoshone River upstream. Eight tributaries and 15 miles of the river itself were affected by fire to varying degrees. Fire-related fish kills were found on the river, although the aquatic invertebrates appeared to be unaffected by the increase in water temperature, which apparently killed the fish. The upper reaches of this drainage were the most severely burned in the GYA. It is estimated that there will be a 20 percent increase over "normal flow" in the North Fork Shoshone River.

The Clarks Fork Yellowstone River is classified by WGFD as a "blue ribbon" trout stream. Crandall Creek, a major tributary, supports one of the few remaining populations of genetically pure Yellowstone cutthroat trout in the area. The Clarks Fork, as a whole, is estimated to provide in excess of 15,000 fishermen-days annually. At least 24 tributaries of the Clarks Fork were affected by fire, including Crandall Creek. Fire-related fish kills were also noted in Crandall Creek.

Gallatin National Forest

Portions of three major drainages, Slough, Hellroaring, and Buffalo Creeks, were burned on the Gallatin National Forest. These streams originate on the Forest and comprise part of the Yellowstone River drainage well within the Yellowstone Park boundary. The fish species found in these streams include the Yellowstone cutthroat, rainbow, cutthroat-rainbow hybrid, and brook trout. The fishing use is heavy, especially by Yellowstone Park visitors.

Of the three streams, Slough Creek has the highest fishery resource value (fishing use within the park is estimated to exceed 19,800 fishermen-days). Much of Slough Creek has steep gradients punctuated with a few scattered meadows.

Approximately half of the Slough Creek drainage was burned, some at a moderately intense level. Forest personnel predicted a 57 percent increase in sediment over natural until the watershed revegetates. This increase is expected to decrease fry production by 22 percent and juvenile rearing survival by 7 percent.

Hellroaring Creek supports approximately 450 fishermen-days per year within the park and yields very high angler satisfaction. For the most part, this stream is quite steep with a few isolated meadow areas. The fire burned approximately one-fourth of the drainage, with a resulting 27 percent increase of sediment predicted by Forest personnel. This increase in bedload sediment is expected to reduce fry production by 12 percent and juvenile rearing survival by 1 percent.

Buffalo Fork, a major tributary to Slough Creek, was burned over approximately half of its drainage. Although this is considered an important fishery, it is not easily accessible, therefore, fishing use is light. Forest staff predicted an 8 percent increase in sediment yield over prefire levels, which could decrease fry production by 8 percent and juvenile rearing survival by 1 percent.

Bridger-Teton National Forest

Tributaries of the Snake and Yellowstone Rivers and some of their tributaries were affected by the 1988 fires on the Bridger-Teton National Forest. Approximately 245 miles of streams both inside and outside fire perimeters are expected to be influenced by the fire activities. Although sedimentation, summer water temperature, nutrient levels, and peak flows will increase, impacts to fisheries are not expected to be significant as determined by Forest staff. Water quality changes should not significantly affect aquatic species. Nutrient input to streams and small lakes as a result of the fire may improve the aquatic insect species density and thus the fishery resource by providing increased food sources for fish populations. Increases in water temperatures in upper elevation streams may improve the aquatic habitat by raising temperatures to near optimum levels.

Observations by Forest personnel concluded that less than 5 percent of the streamside riparian vegetation burned. This vegetation should respond vigorously next spring as plant species are composed mostly of willow types and other fast-responding vegetation. Many of the streams within the burn area are contained in floodplains which will provide a buffer between the streams and the adjacent burned hillsides. The buffer vegetation should act to capture much of the sediment before it enters open water.

Long-term benefits to the aquatic habitat may outweigh negative impacts. Benefits may result from increased stream debris which could provide structural diversity, increase stream temperatures, and increase nutrient input. Short-term impacts to the aquatic resource can be expected from increased sedimentation to streams and lakes. A large flood event in the spring of 1989 through 1992 could trigger landslides and debris torrents which would create long-term impacts to the aquatic resource.

Targhee National Forest

On the Targhee National Forest several streams were affected by fire. These streams feed into Henrys Fork River, a "blue ribbon" trout stream, and Island Park Reservoir, a well used recreation area. These streams include Moose, Split, Thirsty, and Chick Creeks. Moose Creek supports spawning runs of kokanee salmon and rainbow and cutthroat trout. Split Creek provides for rainbow and cutthroat trout.

Forest evaluations indicated that the watershed as a whole would not be expected to produce significant amounts of erosion. Only a 5 percent degradation in fish habitat is anticipated from the fire activities.

An increase in shrubby vegetation may increase detritus input to streams. This coupled with an increase in solar radiation may increase food organisms for fish.

Custer National Forest

On the Custer National Forest, the Storm Creek Fire burned areas adjacent to the Stillwater River, a popular trout stream. Postfire evaluations by Forest personnel determined that impacts to water quality and fisheries from the burn would be insignificant, if noticeable at all. Soils are basically very thin or nonexistent in the burned area as bedrock material is dominant. Therefore, soil movement into the streams as a result of the fire is not expected.

DISCUSSION

The 1988 fires burned adjacent to and in many important fishery drainages within the GYA. It was the intent of the Fisheries Assessment Team to address the fire impacts that may occur to these fisheries.

After evaluating the information from many sources (the Forest's reports, the "Water Resources Assessment" section of this document, other available data and photographs, as well as consulting with Forest Service, Park Service, U.S. Fish and Wildlife Service, and fish and game personnel from Idaho, Wyoming, and Montana), it is the team's conclusion that fire impacts to fisheries will probably be insignificant and short term. The rationale for this conclusion is detailed in the following discussion. The initial statements outline potential concerns. They are followed by a discussion of the potential for these impacts.

More intense peak flows normally follow a fire event. These flows can add sediment to the streams and cause instream erosion.

The drainages within the GYA are inherently "flashy" in terms of fast peak runoff. Aspect, gradient, weather, and soils play a major role in spring runoff in this geographical area. It is expected that the fire impact will not significantly add to this natural hydrologic occurrence. Also the streams and associated biotic communities have adapted to and evolved with these high peak events.

Increased sediment in the streams generally follows fires as the soil-holding vegetation is often lost and tree canopy is not available to intercept the force of heavy precipitation on the exposed soils.

A large share of the fires burned at higher elevations where stream channels are steep and rocky. In these reaches, pools are more permanent as they are formed by boulders and readily flush. The soils on the higher elevation slopes are usually thin or composed of bedrock and should not produce much soil movement into the streams. The lower gradient streams are of a willow/sedge riparian component which recovers quickly following a burn. Many of these reaches, especially those in the park, survived the fire and will continue to filter sediment from surface runoff. It has been observed that many trees burned and fell perpendicular to the slopes. These trees should act as water bars and natural barriers to downslope soil movement. Rehabilitation efforts include an extensive seeding program on the forests to protect those barren slopes and exposed soils determined vulnerable to erosion. Further observations reveal that most of the streams in the GYA naturally experience significant bedload movement and any fire-related effects will probably be minor by comparison.

Woody debris needed for pool habitat and the aquatic nutrient base can significantly be reduced for several decades where streamside vegetation is lost.

A "boom and bust" cycle for large woody debris is common following a fire. Fortunately, most of the riparian conifers involved were lodgepole pine, a rather short-cycled seral tree. Lodgepole should reinvade these sites as some lodgepole seeds are fire-released, and the trees reach debris recruitment age in 50 to 75 years, more quickly than other conifer species such as cedar and spruce. Willow species should become established in many areas, and large debris resulting from the fire should be present in the stream system for some time. Debris recruitment will also be available from unburned reaches upstream.

Excessive woody debris from fire mortality can cause migration barriers to fish and encourage streambank erosion by choking the channels.

This may occur. Where management policies allow, monitoring programs should include debris jam management to detect and prevent debris overloading from occurring.

Direct fish mortality as a result of the fires was noted in several streams.

Electroshocking of these highly impacted reaches by state personnel showed some survival of fish. The fish populations should recover rather quickly through natural reproduction and recruitment from downstream migration. Fish stocking in selected areas could supplement recovery if deemed necessary by state fish personnel.

Water temperatures may exceed the lethal levels for fish due to loss of overhead canopy shading.

It is not expected that any increase in water temperature will adversely affect fish populations. A modest increase in summer stream temperatures should benefit fish populations by increasing biotic productivity. Anchor icing will probably increase due to colder streamside temperatures in winter. These could cause some mortalities to fish and aquatic invertebrates.

Water quality may be adversely affected due to fire-related increases in pH and alkalinity. Water chemistry may be altered.

A moderate increase in pH and alkalinity usually benefits the biotic productivity. However, in sterile-watered small streams where buffering is essentially ineffective, higher pH levels and increased alkalinity may pose problems to aquatic life. Fortunately, this usually occurs in low order streams where fish populations are small or nonexistent. Heavy metals and other chemicals released by a fire usually bond with the stream sediments and become basically inert if not excessive.

Impacts from the fires may reach the larger rivers and reservoirs downstream.

Increased sediment in downstream rivers will occur as the fire-affected streams flush the material. Hopefully, this material will be reduced by the revegetation of exposed soil and the trapping of sediments by large instream debris. It also should be diluted as it enters the larger river systems downstream. Reservoirs, such as Island Park and Buffalo Bill, will trap sediments preventing this material from continuing down beyond these structures. Unfortunately, the sediments will have a direct influence on the storage capacity and usable life span of these reservoirs.

Fishery habitat work in addition to the mitigation measures identified in this report do not seem feasible at this time. Sediment trap and pool structure construction was suggested, but the team felt they would only create short-termed benefits and would soon be buried to where they would lose their effectiveness. Stocking fish, another suggestion, might only be feasible where direct mortalities occurred. As indicated earlier it is expected that those die-off reaches will soon repopulate. Any other stocking would merely overwhelm the existing carrying capacity of a given stream reach.

Any changes in fishing use on the streams influenced by fire should be short termed. Unless fishery habitat in certain high-use areas is adversely altered, most changes in fishing use will probably occur as a result of changes in aesthetics or access rather than changes in fish populations. Generally, the first year following a fire, burned streamsides discourage fishing and camping due to ash, sharp debris, and the unpleasant appearance of the area. Once the area begins to green up, use increases. Contrarily, fishing access is increased where thick riparian vegetation has been burned or new roads have been developed.

CLOSING REMARKS

Numerous drainages that headwater the Yellowstone, Snake, Gallatin, Madison, Henrys Fork, Stillwater, North Fork Shoshone, and Clarks Fork Yellowstone Rivers were affected by the 1988 GYA fires. These rivers and many of their tributaries support valuable fisheries. Overall, the Fisheries Assessment Team has concluded that impacts to fisheries from the fires will be minimal and generally short termed. This conclusion has been drawn by considering basin hydrology, character of soils, and mitigation measures applied to the most severely impacted drainages.

FIRE-SUPPRESSION EFFECTS

The effects of fire suppression include not only the environmental impacts of actions taken to directly suppress fires but also the impacts associated with logistics and support functions, such as transporting, housing, and feeding firefighters. Some of these impacts can be mitigated, some cannot. This report summarizes the various suppression activities in the GYA and discusses some potential impacts.

DIRECT EFFECTS

Firelines dug in once undisturbed wild areas represent some of the most notable suppression impacts. There are about 665 miles (164 acres) of handline and 137 miles (333 acres) of bulldozer line in the GYA, including 32 miles of bulldozer line in Yellowstone National Park. These figures do not include firelines within burn perimeters that burned over.

Handline consists of a trench about two feet wide dug to mineral soil. Vegetation is also cleared about twelve to twenty feet beyond the line, and the line is usually reinforced by burnout. Burnout is the controlled burning of fuels between the fireline and flaming front. Once a line is dug, it is used a as walking trail for the duration of the fire. In addition to the principal line, there are generally many spot fires which are individually lined.

Bulldozer line is most destructive because it is wider, deeper, and straighter than handline. Bulldozer lines in the greater Yellowstone area are one and two blades wide (up to thirty feet). After being constructed, these lines were typically patrolled by hand crews and pumper trucks and were used as roads for pumper trucks and supply vehicles. Brush piled up alongside the line impedes wildlife movements, and the line forms an unnatural corridor for wildlife.

Fireline explosive (FLE) was used to construct fireline near West Yellowstone on the North Fork Fire. The effects of the concussion on wildlife is not known, but line constructed with FLE is usually less intrusive to the public than handline. However, vegetation effects are the same as handline.

The detrimental effects of firelines are both ecological and aesthetic. Firelines provide pathways for erosion. They form unnatural trails for wildlife or barriers to migration. The ecology of the line area is changed, as the critical topsoil is lost leaving infertile subsoil. Though revegetation will occur it will be delayed, and a different species mix will probably occupy the site for extended periods. Firelines appear distinctly unnatural. Cleared lines, topsoil bermes, and waterbars and other debris are obviously the result of man-caused activities, and these will persist for decades.

Water, delivered by pumper trucks and backpack pumps, was used to maintain line and mop-up or put out spot fires whenever possible, and in some cases, to construct wet line. Innumerable sumps and impoundments were constructed in streams to catch and hold water. Some gas and oil were spilled and riparian vegetation was trampled. Small streams and ponds were usually drawn down. Overall, the damages resulting from water operations were low.

Approximately 1.4 million gallons of retardant were dropped in Yellowstone Park alone. One load was accidentally dropped into the Little Firehole River on the North Fork Fire, and one load was accidentally dropped into Fan Creek on the Fan Fire. About one hundred dead fish were counted after each of these incidents. The effects were temporary. The ammonium phosphate based retardant will add to the nutrient load in the runoff; however, retardant covered vegetation is not usually severely damaged by chemical effects. There will be a temporary (one or two year) fertilizing effect on local vegetation. This may cause a temporary difference in character of annual leaf color, etc.

In addition to retardant, tons of wetting and foaming agents were used. These agents were applied by ground forces and helicopters. Chemicals used in these agents are of low toxicity. They are primarily soaps, and precipitation will remove them from the soil in one or two years.

An estimated 10 million gallons of water were dropped by helicopter. On the Fan Fire, 300,000 gallons were dropped in one day. Some ponds were drawn down noticeably, and stream and pond bottoms were disturbed.

There was considerable off-road travel, and many meadows have vehicle tracks. In the Canyon Village of Yellowstone, for example, area vehicle tracks have been found three miles from the nearest road. These scars will persist for one to twenty years, depending on precipitation and vegetation type. Scars in moist meadows may persist for decades.

Structural protection consisted of fuel reduction around buildings, primarily cutting trees and bulldozing fireline. Work was done around Mammoth Hot Springs, Cooke City, Canyon Village, West Yellowstone, Crandall Creek, Grant Village, Old Faithful, and numerous government and privately owned cabins. Impacts of these activities are more detrimental to the aesthetics than the ecology, since most of the areas were disturbed to some extent before the fires.

LOGISTICS EFFECTS

Over 18,000 hours of aircraft time were recorded in Yellowstone Park. During the period of intense fire suppression, there was no time or place in the GYA that an aircraft could not be heard. This caused significant irritation to visitors and certainly significant short-term impacts to wildlife. Each fire had several major helibases where cargo was loaded. Loading of personnel, fueling, repair, and maintenance occurred at these locations on a daily basis for a period of two or three months. In addition, there were approximately 150 backcountry helispots throughout the area. Some were preexisting meadows, while others were cut out from dense forest and were leveled to improve the landing site.

Horses were used extensively on the Fan and Hellroaring Fires. The strings deepened and widened trails, wore out water bars and bridge approaches, and probably spread noxious weeds. Trailheads and meadows were heavily grazed.

During the major fire activity, 108 large animals were known to have been killed by vehicles. This figure does not deviate significantly from road kill statistics of past summers. In this regards, it seems that the increase in vehicular activity due to suppression was somewhat compensated by the decrease in visitor activity, although much of the fire-related activity occurred in the early morning hours, a time usually relatively free of disturbance. Some animals were no doubt displaced by fire and fire suppression activity. Roadside use by animals appeared to increase notably. This could have been an effect of the drought, since most roads are in the moister riparian areas.

Camps

Each fire had one or more major camps. At one point (September 5, 1988), the total number of firefighters in the area approached 9,700, and more than 25,000 firefighters worked in the GYA over the course of the summer. In addition to the base camps, an estimated 100 spike and "coyote" camps (auxiliary backcountry camps used to quarter crews) were established. Sometimes camp areas are marked by trash, fire rings, firewood, human waste, and food. Camp activities probably displaced wildlife and dispersed a certain amount of garbage and human waste throughout the area. Numerous confrontations between humans and bears occurred on the Fan, North Fork, and Clover-Mist Fires. Future bear problems may occur due to habituation of bears to humans, human food, and garbage on the fireline and in the various fire camps.

Activities at fire camps, helibases, and staging areas left approximately 255 acres of bare or severely impacted ground throughout the area. Most of these areas will slowly revegetate to a natural appearance, except where vehicles were used.

SUMMARY

Suppression activities in general have significant effects only on a local level. However, because of the large extent of the fires of 1988, cumulative impacts may be noticeable. Wildlife, aesthetics, and soils may be affected.

SECTION 3

SOCIAL

RESOURCE

ASSESSMENTS

VISUAL RESOURCES

Historically, fire has played a major role in the development of the character of American landscapes. Many climax species have adapted to its influences. Wildfire, fire management, and fire suppression activities greatly affect the visual quality of landscapes, often times causing significant changes that remain visible for decades. The total exclusion of fire creates landscapes with less vegetative diversity. Management activities related to fire management such as fire lines, treatment of debris, and the use of prescribed fire can also severely change or degrade visual quality. If those activities are implemented with an understanding of the natural role and the historical effects of fire, the results can be visually pleasing or perhaps even enhancing.

Differences in land management policies impact the aesthetic treatment of ecological processes, and fire is no exception. For clarity, visual resources in Yellowstone National Park have been assessed separately from the surrounding Forests. The first section of the report will focus on the effects of the GYA fires on the visual resource on the National Forests surrounding Yellowstone National Park.

FOREST SERVICE AREAS

INTRODUCTION

Because Yellowstone National Park is of national and worldwide significance, the travel routes and campgrounds adjacent to the area are also of significant value. The fires have affected all three viewing zones (foreground, middleground, and background) as seen from those primary routes entering the park. In dealing with the vast acreages involved the numbers and sensitivities of travelers, and the need to address the most important areas for rehabilitation or recovery, it was necessary to focus this report solely on the foreground viewing zone of the primary access routes leading to Yellowstone National Park.

Planning and design for burned areas within the middleground and background viewing zones should be considered in future analyses or projects and should be consistent with the visual quality objectives set forth in the various forest plans. Planners must recognize that wildfire is a natural occurrence and that visual qualities are not necessarily degraded; but they are <u>different</u> and may possibly be enhanced over time as a direct result of the mosaic patterns of burned and unburned vegetation.

INVENTORY AND ASSESSMENT

Process

The following discussion outlines the process used to meet or exceed the objectives which will help in recovery or rehabilitation relating to aesthetics. The principle considerations were safety, enhancement, and wildlife. More specifically, the criteria for meeting those objectives are detailed in the following paragraphs.

Safety

Many trees adjacent to and alongside highways and roads have been damaged to the point that a slight wind may cause them to fall on the road or even travelers if the circumstances are right. These have come to be known as "hazard trees." Safety is the primary consideration throughout this assessment. Depending on the fire intensity, many trees may have to be removed, while in other areas just a few hazard trees may be removed. Highway maintenance is also a factor relating to this criteria. Properly managed roadside vegetation will result in less overall highway maintenance costs and better safety for drivers.

Enhancement

Some of the travel routes, specifically on the Gardiner District of the Gallatin National Forest, can be described as a tunnel situation. Vegetation grows to the very edge of the highway. In those same areas, fires have burned up to the roadside, and in many places, new opportunities exist to view scenic mountain backdrops from the highways. Enhancement is a critical concern, since driving for pleasure is one of the most popular forms of recreation. A mutually beneficial situation exists for both forest managers and visitors - that of managing the thick growths of lodgepole pine stands while creating views of scenic peaks.

Design for Wildlife

Research and experience have shown that roadsides are popular gathering areas for wildlife. When vegetation grows immediately adjacent to the roadside, the visibility of wildlife entering the travelway from the side is diminished. Additionally, lush fire-stimulated growth adjacent to roads will encourage roadside grazing, increasing the potential for collisions.

RATING GUIDE

What constitutes a change or an effect on the visual quality? Are the effects of fire the same along the roads throughout the GYA?

A common system or methodology was developed to assess the impacts on the wide variety of landscapes found throughout the GYA. The following table displays and assigns a score to the elements used to describe the effects of fire on the visual resource as seen in the foreground viewing zone from primary routes or use areas.

Visual/Fire Rating Guide
Foreground Distance Zone - Level 1 Routes and Use Areas

Element	Rating
Low to Moderate Burn Intensity	1
High Burn Intensity	2
Severe Burn Intensity	3
0-20% Slopes	1
21-35% Slopes	3
36% + Slopes	6
Dominant Fire Suppression Lines	3
Seen From Moving Viewpoint	1
Seen From Stationary Viewpoint	3
Inferior Viewing Position	1
Superior Viewing Position	3
Underburn Condition	1
Some Trees Scorched	2
Crownfire-blackened Trees	3

Summary of Rating Guide

In order to uniformly assess the effect of fire on the visual condition and to identify the priorities for rehabilitation, the following guidelines were established.

Priorities	
Low	0-6
Moderate	7-12
High	13 +

Thus, if a burned area contains the following rating elements: severe burn intensity on steep slopes, obvious firelines that can be seen from a turnout on the highway in a superior viewing position, and the vegetation is charred and blackened, then that area would receive a point value of 21 (high) and should be considered as a high priority for rehabilitation.

INVENTORY AND ASSESSMENT

Hellroaring/Storm Creek Fire

"High" Zones

Highway 212 leads to the Northeast Entrance of Yellowstone Park. This route is heavily used year-round. In addition, this route is proposed as a Scenic Byway. By following the rating guide, fire patterns are obvious in the foreground. Approximately 1.4 miles of "high" rating and 0.5 miles of "moderate" rating occur along the stretch of highway between the Northeast Entrance and the Wyoming border. Table 1 shows a mile log rating by the various zones of effects due to fire and fire suppression activities. The area contains bulldozer lines, hazard trees, exposed stumps, and excess slash. Riparian (wetland) areas have lost much vegetation. Interpretive signs regarding the fires are needed at appropriate locations.

"Moderate" Zones

Approximately 0.5 miles of "moderate-rated" changes have occurred within the Gardiner District adjacent to Highway 212. The characteristics are periodic burned trees and brush, downed timber, hazard trees, stumps, and underburned conditions.

Table 1. Storm Creek Fire, Gallatin National Forest
Aesthetics/Fire Rating Table, Mile Log

West to East	High	Medium	Low
Yellowstone National Park to bulldozer line		0.1	
YNP bulldozer line to Silver Gate		100 ft	
Silver Gate to west side of Cooke City	0.1		
	0.2		
		0.2	
Wood sign at Cooke City to Daisy Pass Jct.	0.1		
Daisy Pass Junction to Soda Butte Junction	0.1		
Soda Butte Campground Jct. to Lulu Pass Jct.	0.2		
	0.1		
	0.2		
Lulu Pass Jct. to Colter Campground	0.15		
Colter Campground-Interior Roads	0.3		
Colter Campground to helibase	0.1	200 ft	
Colter Campground entrance to meadow	0.1		
Meadow to town of Cooke Pass		0.2	
Subtotal	1.65	0.5	

Bulldozer Lines

The wide bulldozer lines (72 feet) near the Yellowstone Park boundary adjacent to the highway are an unpleasant visual intrusion. The lines are very straight and bare and are very unnatural looking.

Colter Campground

The Storm Creek Fire wreacked extensive damage at the Colter Campground. Six camping units were destroyed and one toilet building burned. Much of the effects in the campground rate in the "high" range. Some campsites are no longer screened from each other, and burned trees present a hazard.

Clover-Mist Fire

Shoshone National Forest

The assessment of the Clover-Mist Fired is focused on the effects in the foreground zone of both State Highway 212 (Beartooth Highway) and 296 (Sunlight Basin Highway). Both of these routes were proposed as National Scenic Byways earlier this summer.

The effects on the Wapiti District are minor as the fire occurred within the boundaries of the wilderness and are not visible from high-use roads or developed recreation areas.

Approximately 0.2 miles of "high," 0.4 miles of "moderate," and 1.9 miles of "low" ratings occur along Highways 212 and 296. See Table 2 for mile logs and field notes. The area on the south side of Highway 296 between the Crandall Trailhead and the turnoff to the Crandall Ranger Station rated "high." Fire-related effects include hazard trees, exposed stumps, slash, and bulldozer line. Riparian areas have lost much of their vegetation. Interpretive signs would be appropriate at points overlooking burned areas.

North Fork Fire

Gallatin National Forest

The majority of the North Fork Fire occurred in Yellowstone National Park, but a minor portion impacted some backcountry parts of the Targhee National Forest. The changes induced by fire and related activities were minor in comparison to the impacts associated with the high-use roads and recreation areas.

Storm Creek Fire

Custer National Forest

The portions of the Storm Creek Fire which occurred on the Custer National Forest were totally within wilderness boundaries. The effects of the fire are not visible from high-use roads or developed recreation areas.

Table 2. Clover-Mist Fire, Shoshone National Forest
Aesthetics/Fire Rating Table, Mile Log

West to East	High	Medium	Low
40.4*			
Cooke Pass to Wyoming border no sign of fire; tunnel situation with a talus slope; few but brief glimpses of mountains	--	--	--
42.9			
Border to Fox Creek Campground no sign of fire in foreground; broad panoramic views available	--	--	--
48.3			
Fox Creek Campground to scenic overlook; no foreground views of fire; but do have background views on high ridges; need interpretive sign	--	--	--
52.2			
Scenic overlook to Highway 296 to burn area in foreground			0.2
Under burn and scorched Douglas fir			0.7
54.1			
To Hunter Peak Campground			0.1
55.8			
Private land		0.2	
56.9			
North Crandall Trailhead to ranger station turnoff	0.2	0.1	
58.8			
Clover-Mist Fire Camp to K-2 Ranch both sides of highway; rehab fireline on north side of road			0.2
59.5			
At turnout, tremendous interpretive opportunity, provide graphic interpretive sign			0.2
59.8 to 60.1			
North side		0.1	0.2
60.4			
Another interpretive opportunity no turnout exists will need to provide a turnout. Middleground view of fire.			0.3
65.8 to 66.1			
Grass - burnout. No restoration needed. End of foreground views of fire.	--	--	--
71.2			
Tremendous viewing opportunity. Panoramic views of limestone walls in middleground	0.2	0.4	
Subtotal	0.2	0.4	1.9

*Odometer reading to locate change of conditions

YELLOWSTONE NATIONAL PARK

INTRODUCTION

Visual elements in a park are important in helping visitors understand natural processes and their results. Through this, the complexity and beauty of the natural landscape are revealed. Often only the end results of natural processes are visible, which is why the 1988 fires are additionally important to park ecology and interpretation. These naturally occurring (and historic) processes should be reflected in the aesthetic composition of the landscape.

Many fires burned within Yellowstone Park during the summer and fall of 1988. Approximately 989,000 acres were burned. Visual resource affects (affects on scenery, vistas, etc.) were assessed two ways: 1) for the park as an entity, including facilities and service systems affected and 2) by fire (the North Fork, Clover-Mist, Snake River Complex, Huck, Mink, Storm Creek, Hellroaring, and Fan Fires).

It is important for visual continuity within the park that the various systems (i.e., road corridors, scenic drives, utility corridors, and facilities), picnic areas, campgrounds, and thermal areas be treated in a manner which reflects the park as a unified sequential experience; a progression within the natural system. Methodology and techniques should be consistent and sensitively implemented throughout the park.

INVENTORY AND ASSSESSMENT

All burned areas were assessed for fire suppression activities. These assessments were combined with information on soil-heating intensity and type of burn. Road corridors, scenic drives, utility corridors, picnic areas, developed areas, campgrounds, and thermal areas were then cross-referenced with this information. Field checking was also completed. Visual resource assessments included the evaluation of each area based upon the following factors:

-- Resource Impact
-- Visitor Safety
-- Interpretive Opportunity
-- Landscape Continuity

Resource Impact

Visual elements in the park focus on natural conditions. Although some feel that the effects of the fires were unpleasant, they are a part of Yellowstone and its naturally occurring cycles. They represent a natural process. Fire suppression and maintenance activities are not naturally found in the landscape, and it is the results and impacts of these activities which should be minimized. Visitors should see the resource, including natural processes and their effects, not the results of man's involvement.

Visitor Safety

Safety is a concern in areas impacted by fire and fire suppression activities. Concern increases where resources are actively used by visitors or where postfire visitor use may increase. Of the potential hazards in a burned area, hazard trees (fire-killed trees or trees with burned roots that could fall) are the most significant. Due to the characteristics of lodgepole forests, potential hazards existed prefire. These hazards have increased in some areas but not in others. Each area identified as a visitor use area in an affected zone has been evaluated for hazard trees. Trees were assessed for slope, degree of burn, size, openness of canopy, and root conditions.

Interpretive Opportunity

The visual resources of a park are valuable tools in educating the public about natural processes and features. This element is one of the primary reasons for the establishment of a national park.

Natural processes are often difficult to observe because they may occur over many decades. Wildfires as those witnessed in 1988 will not occur again for many lifetimes. Currently, visitors have an unprecedented opportunity to view the initial stage of an ongoing, long-term process. This is important in communicating the evolving perception of fire as a natural force in ecosystems. Where possible, visual resources should be used to present such interpretive opportunities to visitors.

Most visitors experience the park from an automobile. Sensitive treatment of visual resources along road corridors can enhance visitors' experiences in several ways. Generally, if the effects of natural processes are retained in places where visitors can interact with them safely, this will enhance visitors' experiences, particularly if they can view the effects in a holistic manner. Specifically in this case, vista selection, minimal removal of fire-affected vegetation from selected road corridors, sensitive use of techniques to minimize man-caused disturbances, and appropriate use of interpretive signing will enhance visitor experiences.

Landscape Continuity

Visitors traveling in the frontcountry (i.e., roadways, developed areas, etc.) within Yellowstone National Park experience a sequence of road corridors, developed areas, picnic areas, and thermal features. Treatment of burned areas within this framework must be compatible with the specific resource and the park as a unit. Rehabilitation and maintenance activities should be approached in a manner which reinforces parkwide continuity.

Activities such as removing hazard trees and exposed stumps, rehabilitating firelines, creating vistas, and adding interpretive signs should be accomplished using techniques that are similar parkwide. Certainly, resource variations should be addressed, but stump removal exemplifies an activity which greatly impacts visual resources and necessitates a parkwide standard.

VISUAL INVENTORY

Mapping was conducted on a parkwide basis for areas affected by burning. Burned frontcountry areas have been further assessed using the four criteria already addressed. The results have been mapped. Map 1 provides an overview. Road corridors, scenic drives, utility corridors, developed areas, picnic areas, and thermal features affected are indicated as well as burn intensity and type of impact (fire or fire suppression). Each incident was then assessed for proposed treatment. Most critical in the treatment for each situation is the removal of hazard trees. Specific recommendations for treatment are available from Yellowstone National Park, Division of Maintenance.

North Fork Fire

Acreages and statistics for the North Fork Fire and the Wolf Lake Fire have been combined since the two fires were separated for management purposes, were actually one fire. The perimeter of this fire, shown on Map 2, exaggerates the total acreage involved. Approximately 490,200 acres were actually affected by fire. Approximately 131 miles of road corridor were affected; of this distance, 57 miles will need rehabilitation work.

North Fork Fire - Road Corridors Affected

Road Segment	Affected (miles)
West Entrance-Madison	14
Madison-Old Faithful	16
Old Faithful-West Thumb	17
Madison-Norris	14
Norris-Canyon	12
Canyon-Tower	19
Norris-Mammoth	21
Mammoth-Tower	18

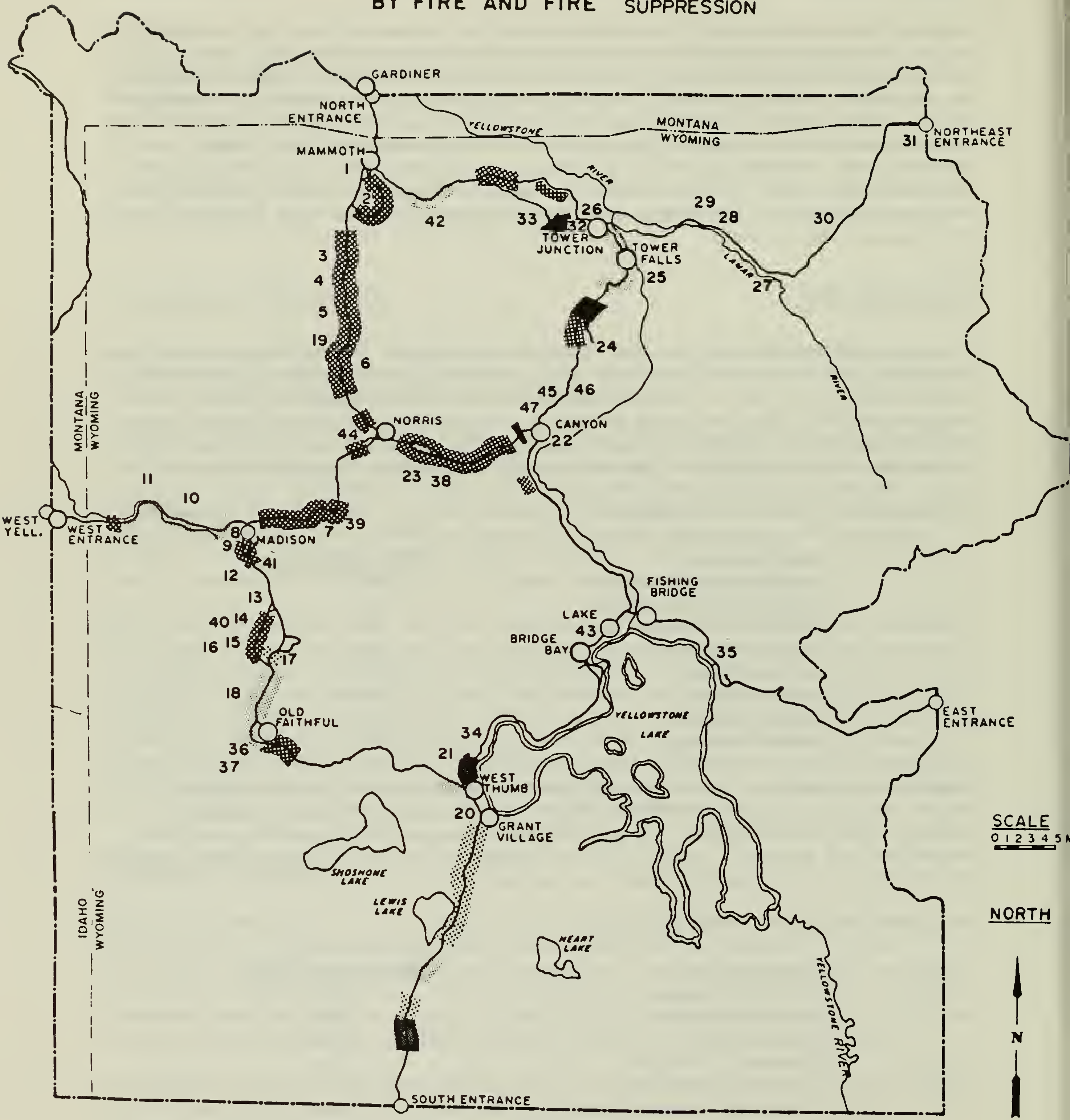
Impacts that need to be addressed along road corridors include hazard trees, exposed stumps, excessive slash (tree limbs and miscellaneous debris), and burned signs. Fire-related interpretive signs at selected locations are needed. Some vistas in areas of numerous hazard trees should be redirected for highest scenic potential.

North Fork Fire - Scenic Drives Affected

Scenic Drive	Affected (miles)
Firehole Canyon	2.3
Fountain Flats	5.5
Bunsen Peak	6.0
Blacktail Plateau	7.0
Virginia Cascades	2.7
Chittenden Road	0.4
Upper Terrace Loop	1.5
Petrified Tree	0.5

PARK WIDE

DEVELOPED AREAS AFFECTED BY FIRE AND FIRE SUPPRESSION



LEGEND

- YELLOWSTONE NATIONAL PARK BDY.
- 34 — SITE NO. & LOCATION
- FIRE PERIMETERS (UNSHADED AREA DESIGNATES FIRE)
- INTENSELY BURNED
- MODERATELY BURNED
- INTERMITTENT MOD./INT.
- INTERMITTENT MODERATE

SITE NAMES FOR PARK WIDE MAP OF DEVELOPED AREAS AFFECTED BY FIRE AND FIRE SUPPRESSION ACTIVITIES

Legend:

	Scenic Drives		Picnic Areas
	Utility Corridors		Thermal Features
	Campgrounds		Ranger Stations

SITE #:	SYMBOL:	SITE NAME:	SITE #:	SYMBOL:	SITE NAME:
1		Upper Terrace Drive	25		Tower Fall Campground
2		Bunsen Peak Road	26		Roosevelt Lodge
3		Indian Creek Campground	27		Lamar River Picnic Area
4		Superintendent's Campground	28		Buffalo Ranch
5		Apollinaris Spring Picnic Area	29		Slough Creek Campground
6		Roaring Mt. Thermal Feature	30		Pebble Creek Campground
7		Gibbon Falls Picnic Area	31		Northeast Entrance
8		Madison Campground	32		Petrified Tree Road
9		Madison Museum Picnic Area	33		Blacktail Plateau Drive
10		Madison River Picnic Area	34		Little Thumb Utility Line
11		Madison Range Overlook Picnic Area	35		Sedge Bay Picnic Area
12		Firehole Canyon Drive	36		Old Faithful Area Utility Line
13		Nez Perce Picnic Area	37		Black Sand Basin Utility Line
14		Fountain Flat Drive	38		Norris Area Utility Line/Substation
15		Goose Lake Picnic Area	39		Gibbon Falls Utility Line
16		Feather Lake Picnic Area	40		Fountain Flats Utility Line
17		Whiskey Flats Picnic Area	41		Madison Utility Line
18		Biscuit Basin Thermal Feature	42		Undine Falls Utility Trench
19		Beaver Lakes Picnic Area	43		Lake Utility Line
20		Grant Village/West Thumb	44		Norris Geyser Basin
21		Potts Hot Spring Basin	45		Dunraven Road Picnic Area
22		Canyon Village Campground	46		Dunraven Pass Picnic Area
23		Virginia Cascade Drive	47		Cascade Picnic Area
24		Chittenden Road			

Scenic drives differ from main road corridors in that vehicle use is much lower. Hazard trees pose a greater danger since visitors are more likely to stop and enter burned areas along these roads than the more heavily traveled, busier main roads. Picnic tables and guardrails have been burned in some areas. There are promising close-range interpretive opportunities in these areas. Other affects are similar to those already mentioned for main road corridors.

North Fork Fire - Utility Crossings (xing) and Corridors Affected

Area	Affected (miles)
Old Faithful (poles, xing)	1
Black Sand Basin (xing)	0.5
Fountain Flats Road (poles)	6
Norris (xing,substation)	1.5
Gibbon Falls (poles)	5
Madison (xing)	0.5
Undine Falls (trench)	2.5

The ground has been disrupted in many areas around utility poles, and vegetation has been disturbed by vehicles. Bulldozers were used around the Norris substation and the microwave tower. Soils were disturbed, and there are large areas of bare ground. Unnatural looking piles of materials exist. The Norris substation can be seen from the road. Screening (transplanted trees) is needed near corridor endings. Miles of utility poles have lost their vegetative screening and are visible from roads and viewing areas. New poles are particularly visible. Junction boxes have also been exposed.

North Fork Fire - Developed Areas Affected

Old Faithful (4 miles affected). Hazard trees present a danger. Stumps, slash, and obvious firelines detract from the aesthetics of the area.

Madison (5 miles affected). The Madison Campground and museum areas were used as fire camps. Soils were severely compacted, ground litter was displaced, and numerous footpaths crisscross the area.

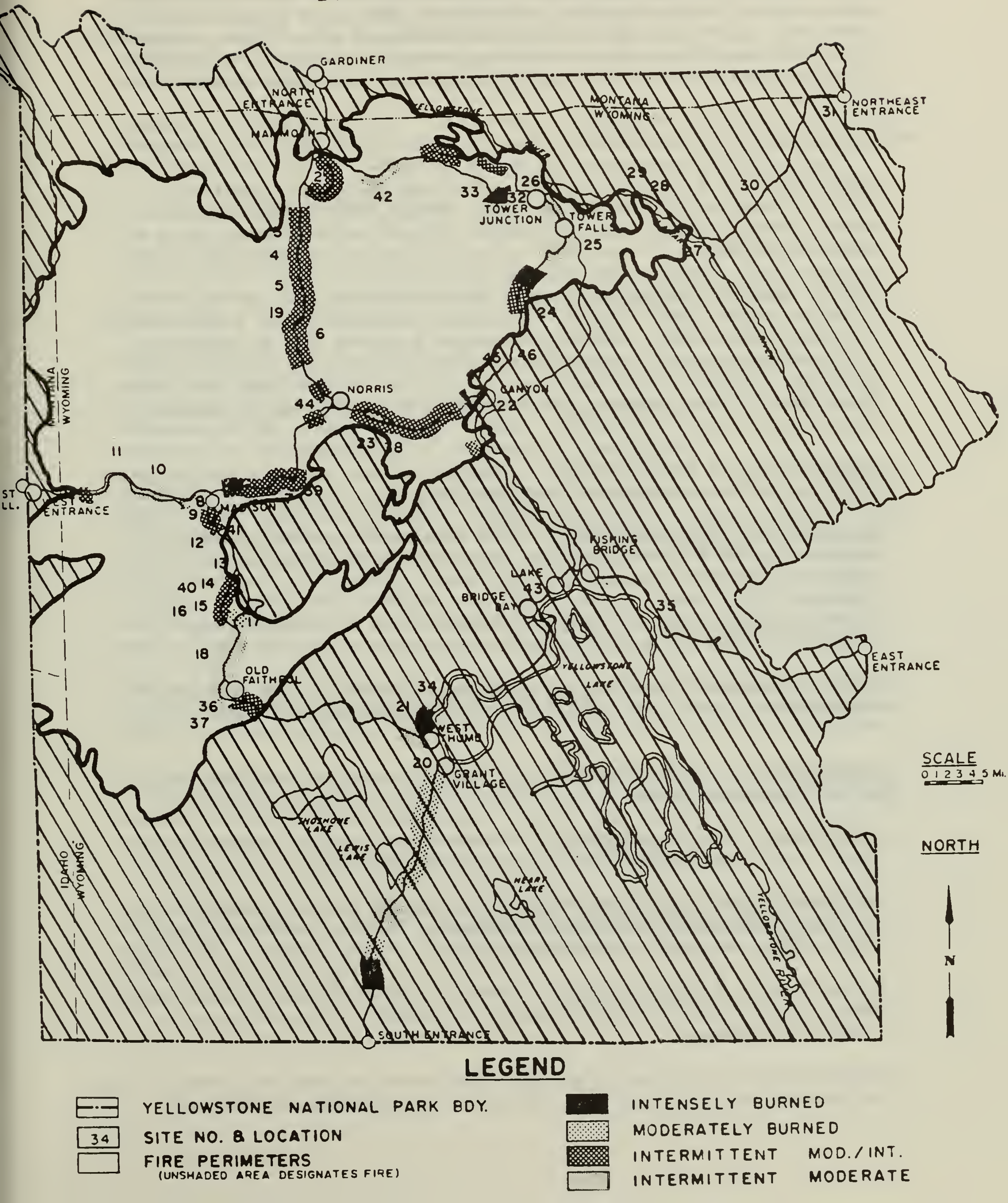
Indian Creek (4 miles affected). Impacts in the campground include hazard trees, exposed stumps, and slash. The "Superintendent's Campground" area was also impacted. Picnic tables, site markers, and signs were burned. Screening vegetation has been reduced in areas that were moderately impacted by fire.

Canyon (10 miles affected). Much debris covers the area. Asphalt was damaged, areas were disturbed and compacted. Visual impacts occurred in areas used as fire camp. Other impacts include hazard trees, stumps, and slash in burned areas. Firelines traverse the developed area. Off-road vehicle use has resulted in compacted, tracked areas.

NORTH FORK

DEVELOPED AREAS AFFECTED

BY FIRE AND FIRE SUPPRESSION



Tower (8 miles affected). In the campground, hazard trees, stumps, and slash can be found in areas impacted by fire. Steep areas within the campground may be susceptible to erosion. Some areas are severely compacted. Firelines exist within the developed area. Trees damaged by water gun spray in the Roosevelt Lodge area are visually unpleasing. Interpretive opportunities exist. Signs could be placed at scenic pullouts.

North Fork Fire - Picnic Areas Affected

Gibbon Falls (2.5 miles affected). The area was nearly completely burned. Impacts include hazard trees, stumps, and slash, and burnt picnic tables, bumper logs, and signs. Interpretive signing would be appropriate here.

Feather Lake (1.5 miles affected). This extensively burned area contains hazard trees, stumps, and slash. Picnic tables, toilet vaults, and signs were burnt. Erosion prevention measures will be necessary. Interpretive signing is essential here.

Goose Lake (2 miles affected). Conditions were the same as Feather Lake.

Whiskey Flats (1 mile affected). Impacts include hazard trees on the perimeter of area, exposed stumps, and slash.

Nez Perce (1.5 miles affected). This area sustained the impacts associated with helibase and fire camp activities including soil compaction and bare ground.

Firehole River (1 mile affected). Hazard trees and stumps exist. Interpretive signing would be appropriate.

Madison Range Overlook (2 miles affected). Conditions include hazard trees, stumps, and slash. Topsoil was disturbed and will need attention.

Madison River (1.5 miles affected). Impacts were the same as for Madison Range Overlook.

Beaver Lakes (2 miles affected). Uneven stumps, slash, and hazard trees, both green and charred, will require attention.

Apollinaris Spring (2 miles affected). Impacts include hazard trees, both green and charred, stumps, and slash. The vault toilets, now visible from the road, require screening.

Dunraven Road (1 mile affected). Impacts include hazard trees, exposed stumps, slash, and disturbed topsoil. An unburnt disturbed area is visually unpleasing.

Dunraven Pass (1.5 miles affected). This area was used for staging fire suppression activities but did not burn. It provides an excellent opportunity for interpretive signing from a vista which illustrates the effects of slope, watershed, and mature vegetation on fire behavior. Impacts to the area include hazard trees, stumps, slash, and disturbed topsoil. Access over erodable slopes should be restricted, and screening of disturbed, high-use areas would improve the area's appearance. Interpretive signing would be appropriate here.

Cascade (2 miles affected). This area was used for staging fire suppression activities but did not burn. Hazard trees, stumps, slash, disturbed topsoil, and unrehabilitated fireline exist in the area.

North Fork Fire - Thermal Features Affected

Roaring Mountain (0.5 mile affected). This area is now more open as a result of the fires. Visitors will be tempted to enter this dangerous thermal area. Signs indicating danger are required as well as obstructions to restrict access into the thermal area.

Upper Terraces (3 miles affected). Many fragile, dangerous thermal areas have been exposed by fire. Screening, where possible, and signs indicating the danger are necessary as are obstructions to restrict access into the thermal areas. Large, interpretive signs may be necessary at the beginning of the Terrace Loop Drive.

Norris Geyser Basin (4 miles affected). Roadside scenic vistas of the geyser basin have been opened. These enhance the visitor experience but should be monitored to determine if visitors are now using these areas as access points to the geyser basin. Since there are no pullouts in this location, no action is necessary at present. If future problems develop, signing and screening may be necessary. Sensitive, dangerous thermal areas adjacent to parking and trails are now visible and may need to be screened or signed.

Old Faithful Area (2 miles affected). Several small thermal areas near the development have been exposed. Most areas will need log bumpers to prevent vehicle access.

Black Sand Basin (1.5 miles affected). A thermal area near the parking is now exposed. Hazard trees exist, but once felled, they will restrict access to sensitive thermal areas. Stumps and excess debris also may mar the area. Restrictive signing may be necessary. Additional boardwalk access from the parking area may be necessary.

Biscuit Basin (1.5 miles affected). The thermal area and parking are now in plain view. Hazard trees near parking and boardwalks require attention. Access through fragile thermal areas must be restricted. Signs may be necessary.

Clover-Mist Fire

Shown on Map 3, the Clover-Mist Fire included approximately 200,775 acres of actual burn in Yellowstone Park. Due to its location and the type of suppression actions taken, impacts associated with the Clover-Mist Fire were much different and not as extensive as those of the North Fork Fire.

Clover-Mist Fire - Road Corridors Affected

Tower-Northeast Entrance (29 miles affected). Impacts to road corridors were minimal. Effects included hazard trees, uneven stumps, and slash. In some areas, bulldozer lines are visible from the road. Some scenic vistas are redirected towards these impacted areas.

No scenic drives were affected by the Clover-Mist fire.

Clover-Mist Fire - Utility Crossings (xing) and Corridors Affected

Lake developed area (4 miles affected). Fire suppression and fuel reduction (vegetation removal) activities exposed utility lines in the Lake area, although the area did not burn. Utility corridors are now visible and require attention.

Clover-Mist Fire - Developed Areas Affected

Tower (14 miles affected). Slough Creek and Pebble Creek Campgrounds were both used as base camps for fire suppression activities. Areas were compacted and disturbed. Slopes near streams may need erosion control. Many footpaths cross the area. Fireline was dug on the north side of Slough Creek.

Buffalo Ranch (2 miles affected). This area was used as a helibase. Impacts include discarded litter and disturbed ground.

Northeast Entrance (3 miles affected). Impacts include uneven stumps and slash and hazard trees near snow course station.

Fishing Bridge (2 miles affected). Hard-surfaced areas were used as a helibase. The area may need litter cleanup and some screening.

Clover-Mist Fire - Picnic Areas Affected

Lamar River (3 miles affected). Impacts associated with helibase operations include disturbed ground, footpaths in steep terrain, and bare areas.

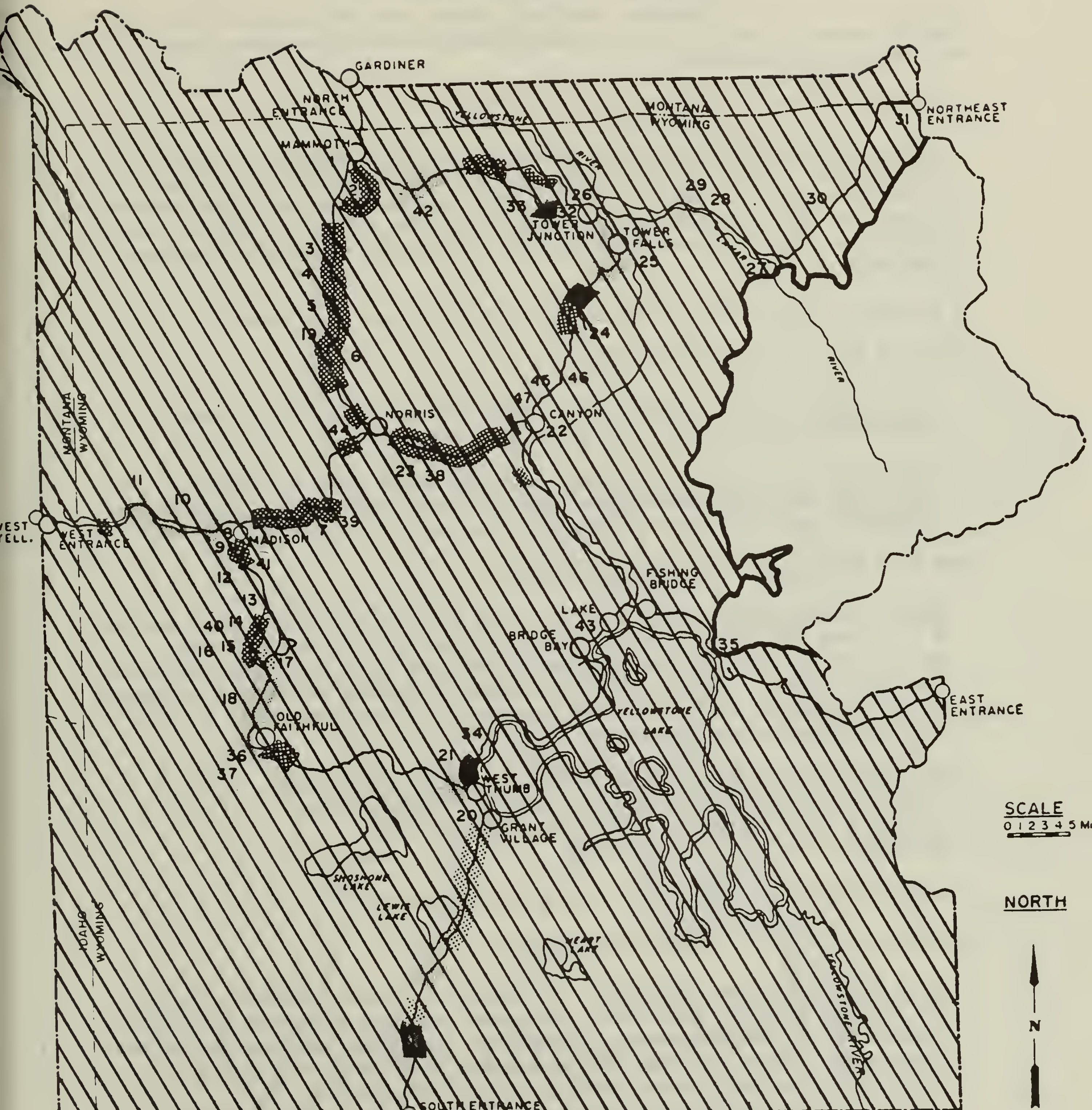
Sedge Bay (1 mile affected). Helibase activities have impacted this area. The area is visible from the main road, an undesirable situation.

No roadside thermal features were affected by the Clover-Mist Fire.

CLOVER-MIST

MAP 3

DEVELOPED AREAS AFFECTED BY FIRE AND FIRE SUPPRESSION



LEGEND

YELLOWSTONE NATIONAL PARK BDY.	INTENSELY BURNED
34 SITE NO. & LOCATION	MODERATELY BURNED
FIRE PERIMETERS (UNSHADED AREA DESIGNATES FIRE)	INTERMITTENT MOD./INT.
	INTERMITTENT MODERATE

Snake River Fire Complex

Composed of the Red, Shoshone, and Falls Fires, the Snake River Fire Complex, shown on Map 4, involved approximately 172,025 acres within Yellowstone National Park.

Snake River Fire Complex - Road Corridors Affected

Grant-South Entrance (22 miles affected) and West Thumb-Lake (20 miles affected). Impacts include hazard trees, uneven stumps, slash, and disturbed topsoil. Mechanized equipment was used on the South Entrance Road, and tracks from this vehicle are visible in places. Scenic vistas should be carefully assessed and views redirected as hazard trees are removed.

No scenic drives were affected by the Snake River Fire Complex.

Snake River Fire - Utility Corridors Affected

Little Thumb (3 miles affected). Fuel reduction and burning have exposed the utility lines along the road corridor.

Grant Village (2 miles affected). Utility poles have been exposed. Bulldozers were used around the Grant Village substation. Topsoil was disturbed, and the erosion potential has been artificially increased.

Snake River Fire Complex - Developed Areas Affected

Grant Village (6 miles affected). Grant Village Campground was used as a fire camp and also burned, as did sections of the developed area. Many hazard trees were removed, but others may need to be removed after the snow clears. Impacts include stumps, excessive slash, and disturbed areas denuded of topsoil. Steep areas will be susceptible to erosion and will require log water bars.

West Thumb (2 miles affected). There are hazard trees and uneven stumps in the area. Additional boardwalk through sensitive, high-visitor-use burned areas may be necessary. Interpretive signing would be appropriate here.

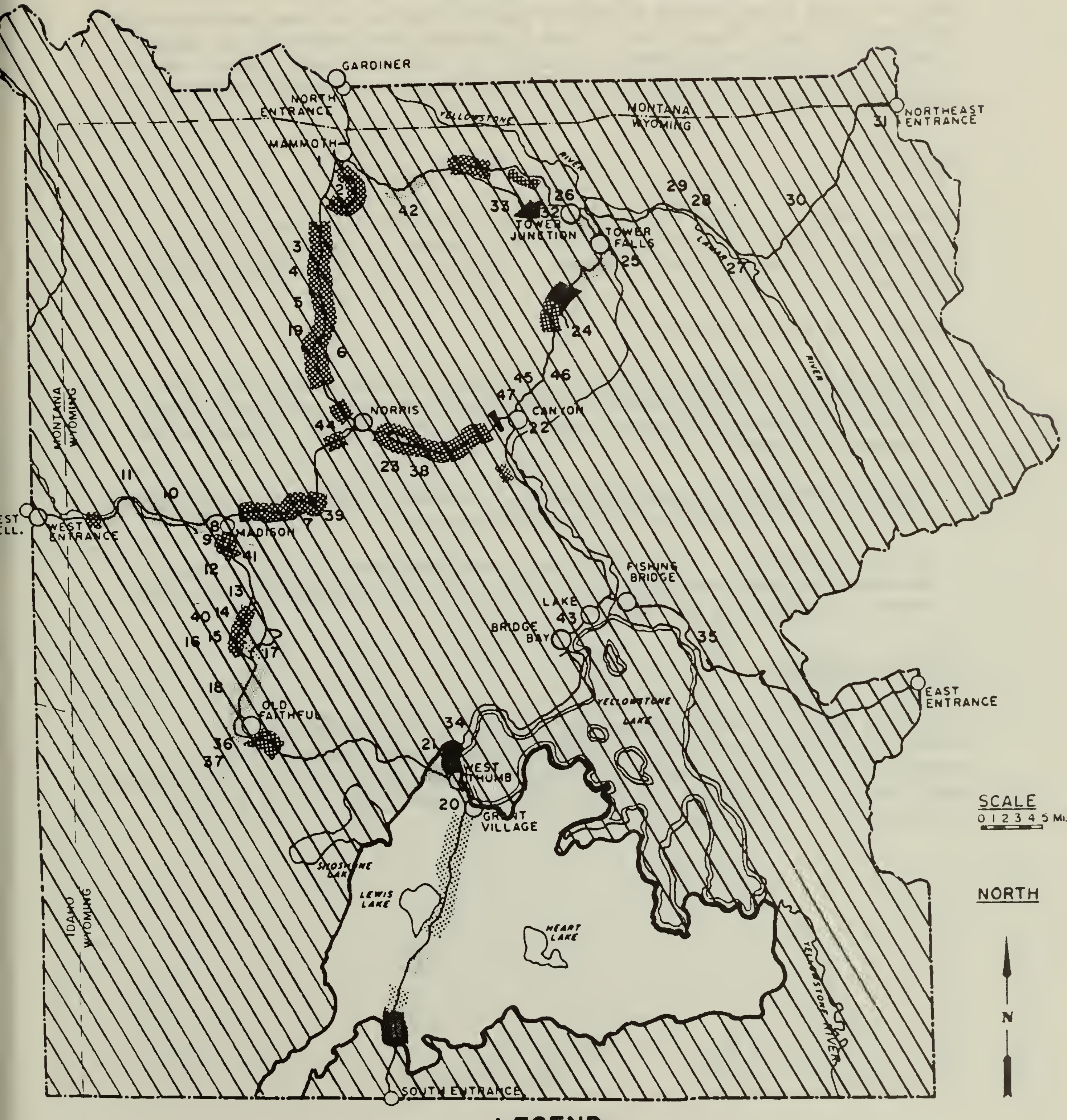
No picnic areas were affected by the Snake River Fire Complex.

Snake River Fire Complex - Thermal Features Affected

Potts Basin (5 miles affected). A dangerous, fragile thermal area is now visible from the main road. The area requires screening and signs indicating the danger and the location of trails and parking in the West Thumb area. These problems can be reduced by constructing boardwalk, accessible from West Thumb, through some of the area.

SNAKE RIVER COMPLEX

DEVELOPED AREAS AFFECTED
BY FIRE AND FIRE SUPPRESSION



LEGEND

YELLOWSTONE NATIONAL PARK BDY.	INTENSELY BURNED
34 SITE NO. & LOCATION	MODERATELY BURNED
FIRE PERIMETERS (UNSHADED AREA DESIGNATES FIRE)	INTERMITTENT MOD./INT.
	INTERMITTENT MODERATE

Huck, Mink, Storm, And Hellroaring Fires

Most of these fires burned on Forest Service land or in the backcountry of Yellowstone Park. Maps 5, 6, 7, and 8 indicate the locations of these fires. No fire-related impacts occurred to road corridors, scenic drives, utility corridors, developed areas, picnic areas, or thermal features in Yellowstone Park.

Fan Fire

Shown on Map 9, the Fan Fire covered approximately 20,900 acres. Highway 191 within the park from West Yellowstone north was affected by fire and fire suppression activities. This was the only road corridor affected.

Fan Fire - Road Corridors Affected

<u>Highway 191 (20 miles affected)</u>. Impacts include hazard trees and uneven stumps. Fireline can be seen along the road corridor. Scenic vistas will be created where hazard trees are removed. Interpretive signing is needed.

<u>Bighorn Trailhead (3 miles affected)</u>. Helibase activities impacted this area. Nonnative weed control may be necessary.

No scenic drives, utility corridors, developed areas, picnic areas, or thermal features were impacted by fire or fire suppression activities associated with the Fan Fire.

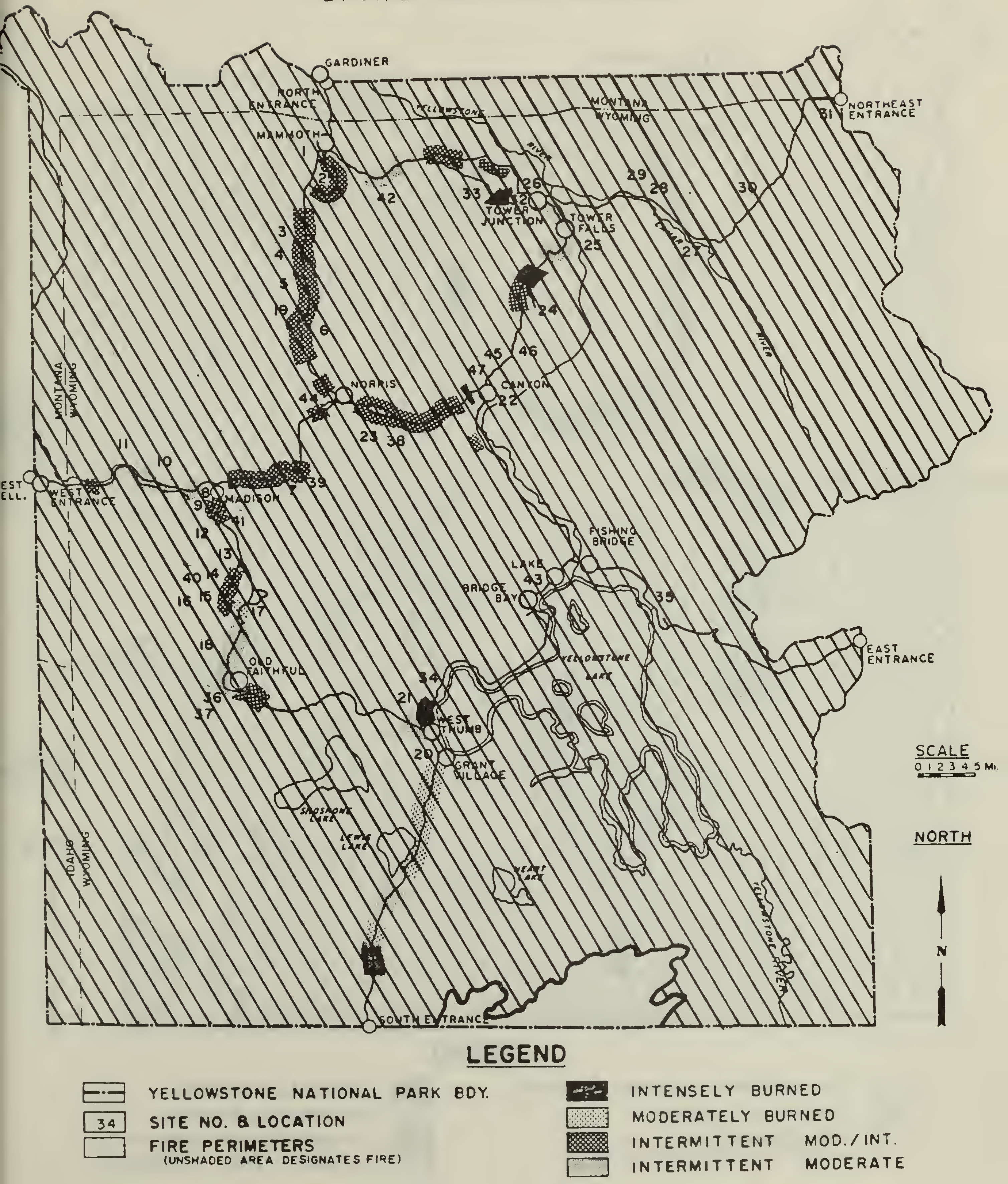
CLOSING COMMENTS

The fires have created a unique opportunity to understand natural processes. Their results will enhance visual resources and visitor experiences throughout the GYA. Fire is a part of the ecology of the area and, therefore, should be incorporated and represented in its visual resources.

MAP 5

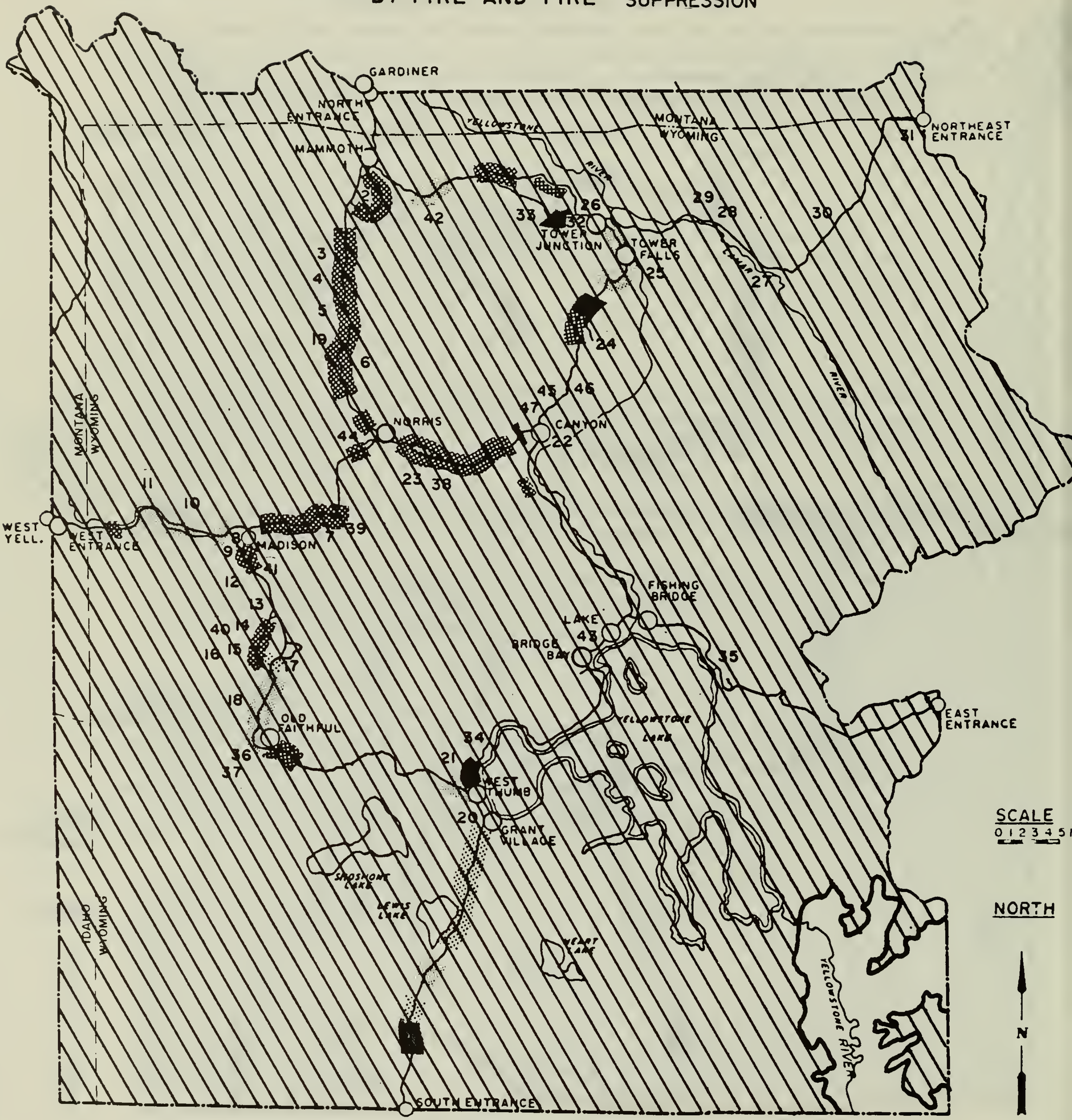
HUCK

DEVELOPED AREAS AFFECTED BY FIRE AND FIRE SUPPRESSION



MINK CREEK

DEVELOPED AREAS AFFECTED BY FIRE AND FIRE SUPPRESSION



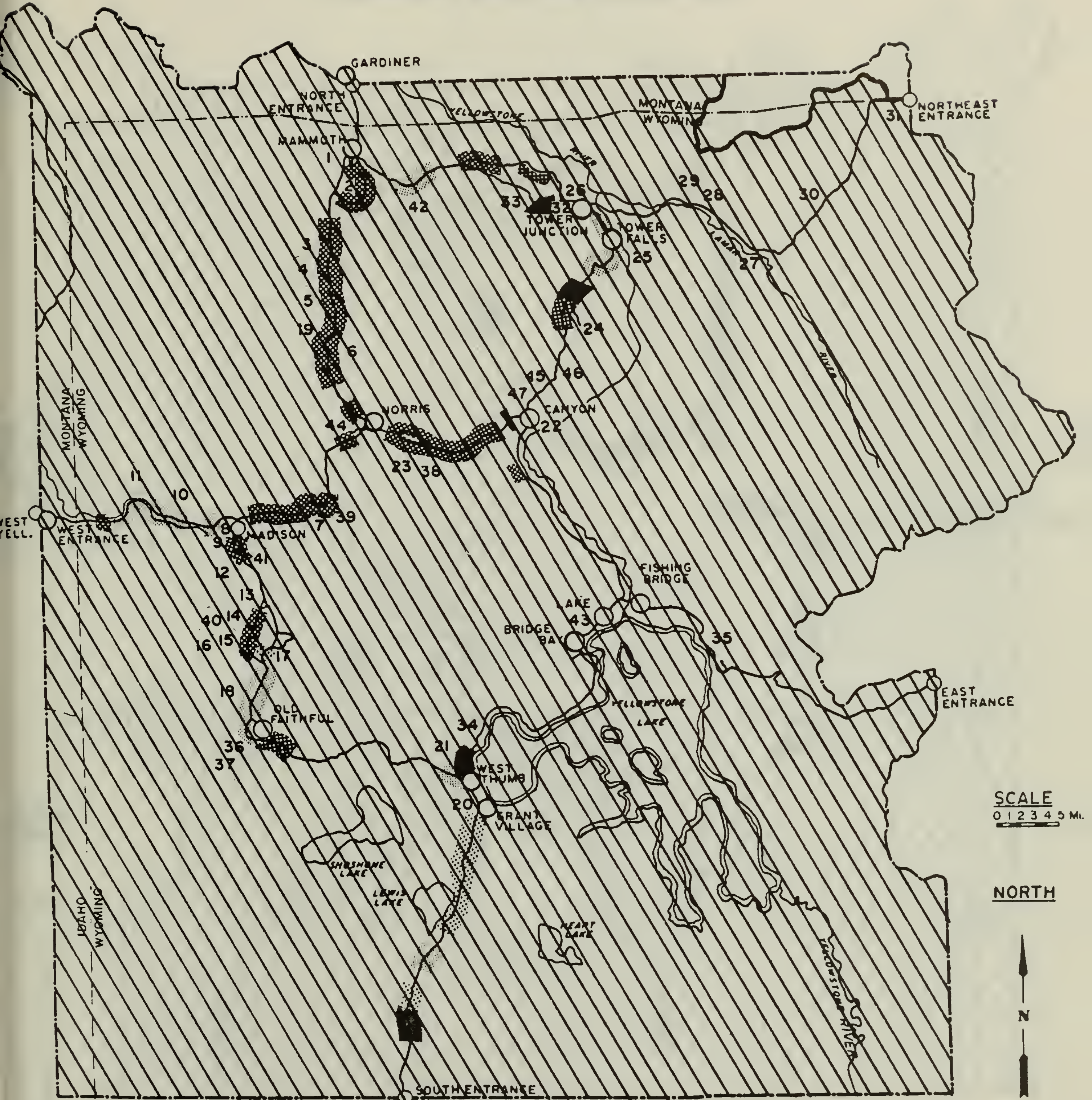
LEGEND

YELLOWSTONE NATIONAL PARK BDY.	INTENSELY BURNED
34 SITE NO. & LOCATION	MODERATELY BURNED
FIRE PERIMETERS (UNSHADED AREA DESIGNATES FIRE)	INTERMITTENT MOD./INT.
	INTERMITTENT MODERATE

MAP 7

STORM CREEK

DEVELOPED AREAS AFFECTED BY FIRE AND FIRE SUPPRESSION

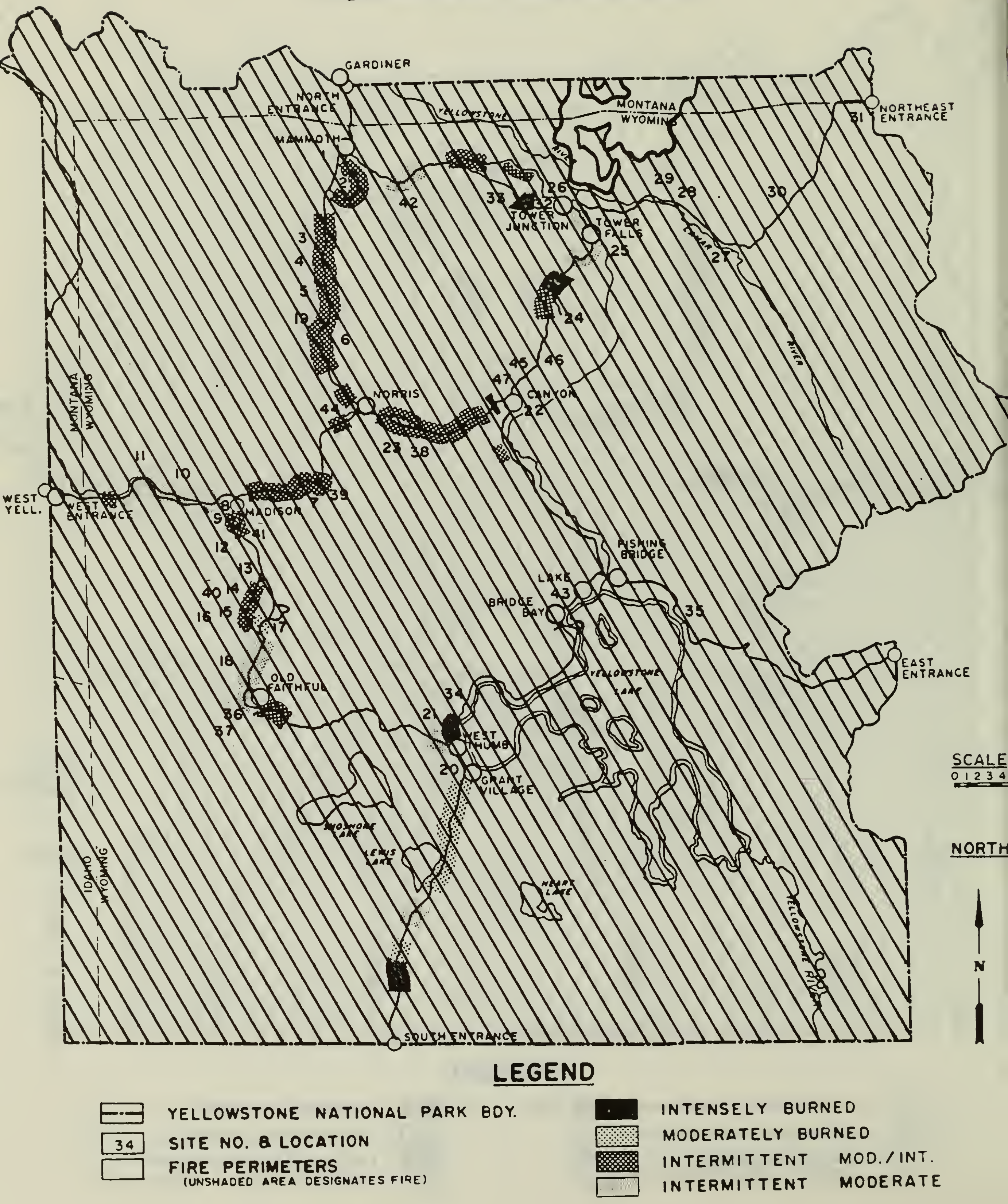


LEGEND

- YELLOWSTONE NATIONAL PARK BDY.
- 34 — SITE NO. & LOCATION
- FIRE PERIMETERS (UNSHADED AREA DESIGNATES FIRE)
- INTENSELY BURNED
- MODERATELY BURNED
- INTERMITTENT MOD./INT.
- INTERMITTENT MODERATE

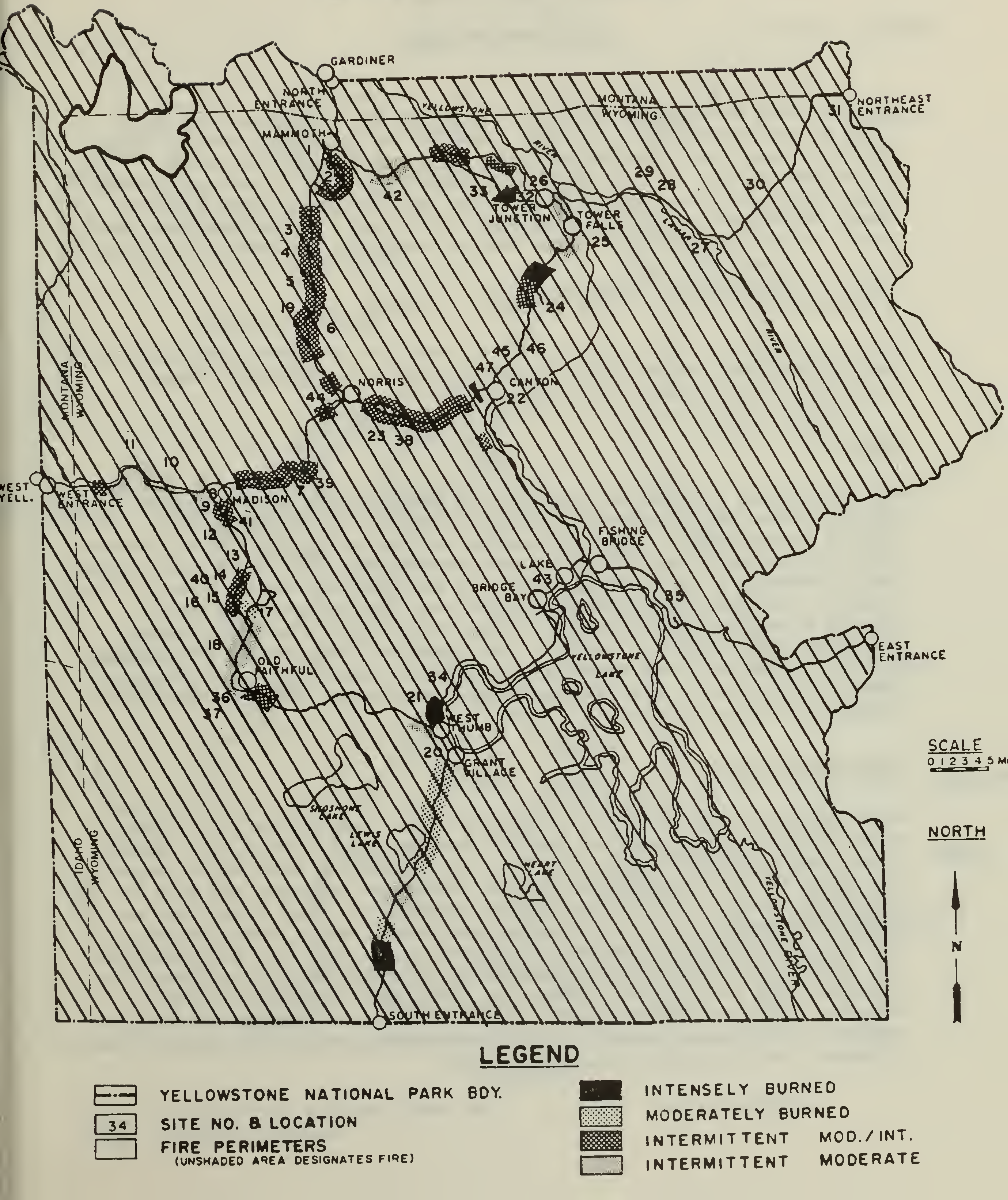
HELLROARING

DEVELOPED AREAS AFFECTED BY FIRE AND FIRE SUPPRESSION



FAN

DEVELOPED AREAS AFFECTED BY FIRE AND FIRE SUPPRESSION



FACILITIES

The GYA fires have had an effect on facilities and related service areas (such as trails) to the extent that a substantial amount of rehabilitation and restoration work is required. The fires and related suppression activities resulted in a twofold impact upon facilities. The most obvious impacts include direct damage to buildings and trails, but the long-term impact of destroying such structures as wooden water bars and bridges could result in substantial erosion and resource damage if they are not replaced.

YELLOWSTONE NATIONAL PARK

Facilities impacts were much the same on each fire although quantities and particulars, such as buildings, varied considerably. Commonly damaged elements are discussed in the following section.

Roads

One hundred and sixty-seven miles of road were affected by fire (see Map 1). There are substantial numbers of standing burned trees (over 50,000) that present a liability problem in terms of safety. These "hazard trees" (fire-killed trees or trees with burned roots that could fall) need to be removed and their stumps need to be flush-cut and ground down to preserve a more natural appearance. The road ditches have substantial amounts of ash and debris that will clog culverts and potentially cause floods and erosion if not removed. The slash left from hazard tree removal and the tracks left from suppression activities need to be raked out. Bumper logs, signs, posts, snow poles, and guardrails that were damaged or destroyed must be replaced.

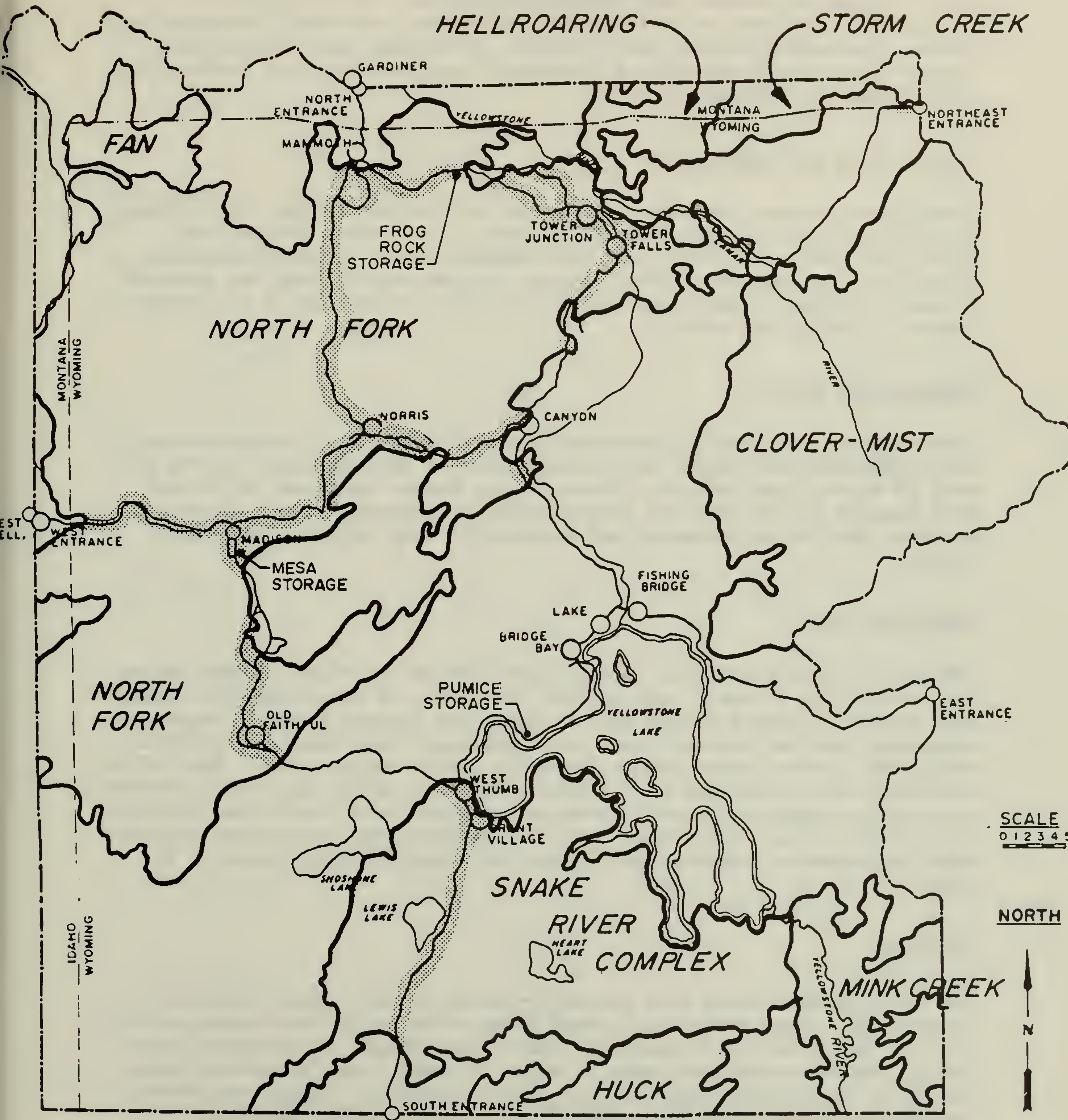
Backcountry Trails

Fire effects included 611.6 miles of backcountry trails (see Map 2) and 126 miles of boundary markers (see Map 3). Seventy-three bridges were damaged to the point that they need to be replaced. Virtually every wooden water bar within fire perimeters were heavily damaged or destroyed and must be replaced. A high potential for erosion exists until these water bars are replaced. Burned trees, both standing and downed, are a safety hazard. The hazard trees need to be dropped and the stumps flush-cut and blackened. All of the trails will require clearing of numerous fallen burnt trees - a situation that is expected to recur for some years. Most of the trail markers, signs, and boundary markers were destroyed or damaged and must be replaced. Backcountry campsites that were burned over must be repaired and relocated, and food poles must be replaced.

MAP I

PARK WIDE

ROADWAYS AFFECTED BY FIRE AND FIRE SUPPRESSION



LEGEND

- YELLOWSTONE NATIONAL PARK BDY.
- AFFECTED ROADWAYS
- FIRE PERIMETERS

Patrol Cabins

Twenty-six patrol cabins were protected from fire. This protection universally consisted of nailing fire shelters on the roofs, reducing fuels (trees, vegetation) around the building, and wetting the building down. Stumps need to be flush-cut and blackened, and the effects of nailing and water damage need to be repaired.

Picnic Areas and Campgrounds

Twenty-three picnic areas and campgrounds were either burned over, damaged by fire, or used extensively as fire camps. The tables, bumper logs, signs, and comfort stations that were damaged due to these actions need to be repaired or replaced. Other impacts include hazard trees and exposed stumps. Drainage ditches and culverts in these areas need to be cleaned to prevent flooding and erosion.

Frontcountry Trails

Approximately 29 miles of frontcountry (developed area or roadside) trails and boardwalks were burned over, damaged due to falling trees, or are in need of hazard tree removal. Posts, signs, bumper logs, and water bars were damaged and ditches and culverts must be cleaned of ash. Boardwalk sections need to be inspected and repaired if they suffered structural damage.

Developed Areas

Twelve developed areas were directly affected by the fires or were subject to preventative actions, such as fuel reduction. A large number of trees were removed, leaving behind downed timber and exposed stumps. Vegetative screening that was removed needs to be replaced, landscaped, or otherwise mitigated. Hazard trees pose a threat to safety and property. Many of the buildings were foamed and wetted down to such an extent that discoloration or exterior damage occurred. Painting and minor repairs will be required as a result. Signs and bumper logs were damaged, and every smoke detector must be checked or replaced due to the prolonged excessive exposure to smoke.

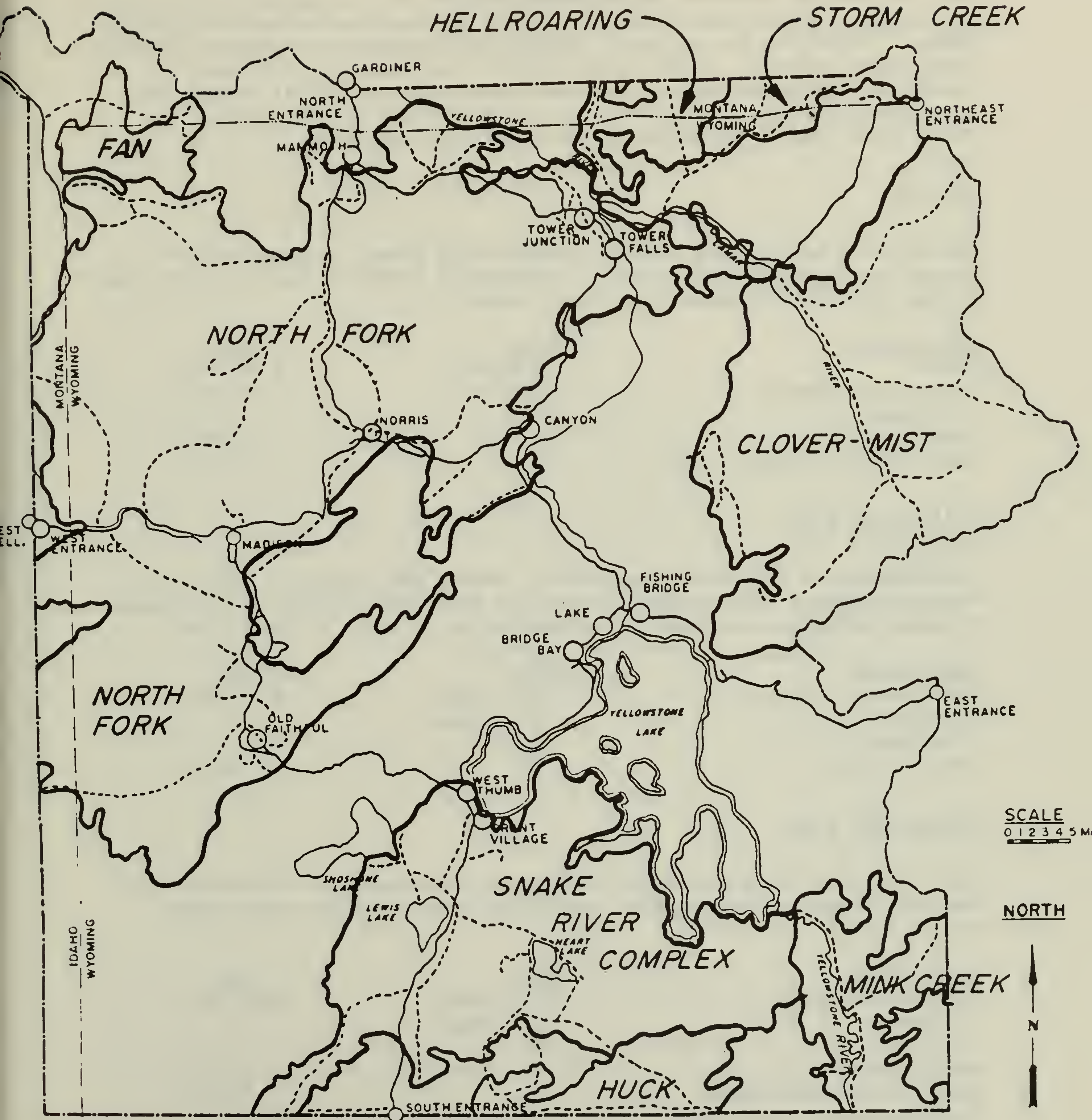
Utilities

The fires wreaked havoc with the above-ground utility lines, especially power lines. Over 10 miles of power lines, with up to four conductors per circuit, were destroyed along with almost 300 damaged or destroyed power poles. Hazard trees threatened 57 miles of power line. Lines and poles had to be replaced in order for the park to operate. Hazard tree debris and exposed stumps must be removed. Approximately eight telephone pedestals were destroyed and must be replaced.

MAP 2

PARK WIDE

TRAILS AFFECTED BY FIRE AND FIRE SUPPRESSION



LEGEND

YELLOWSTONE NATIONAL PARK BDY.

FIRE PERIMETERS

AFFECTED TRAILS

COMPILATION OF FACILITIES DAMAGE

The fire damages incurred can be summarized as cost of repair or replacement. These cost estimates include all costs associated with the damage. Costs are for one year, except for backcountry trails and roadside hazard tree removal. It will take $100,000 per year for five years to clear roadside hazard trees, while the large amount of trail damage and short working season result in a cost of $1,500,000 for two years. The costs shown include the total of these multiyear programs.

Fan Fire

The Fan Fire essentially burned in backcountry areas, and most of the damage was to backcountry trails. The notable exception was the total loss of the historic Sportsman Lake Patrol Cabin.

Description	Units	Cost
Roads	2 miles	$ 18,000
Backcountry Trails	12 miles	59,000
Bridges	10	
Patrol Cabins	1	1,000
Sportsman Lake Patrol Cabin	1	35,000

Hellroaring Fire

The Hellroaring Fire burned backcountry areas, and primarily trails and boundary markers were damaged, except for frontcountry support camp damage. No structural loss occurred in Yellowstone as a result of this fire.

Description	Units	Cost
Backcountry Trails	26.4 miles	$129,500
Boundary	8 miles	
Bridges	11	
Patrol Cabins	1	1,000

Clover-Mist Fire

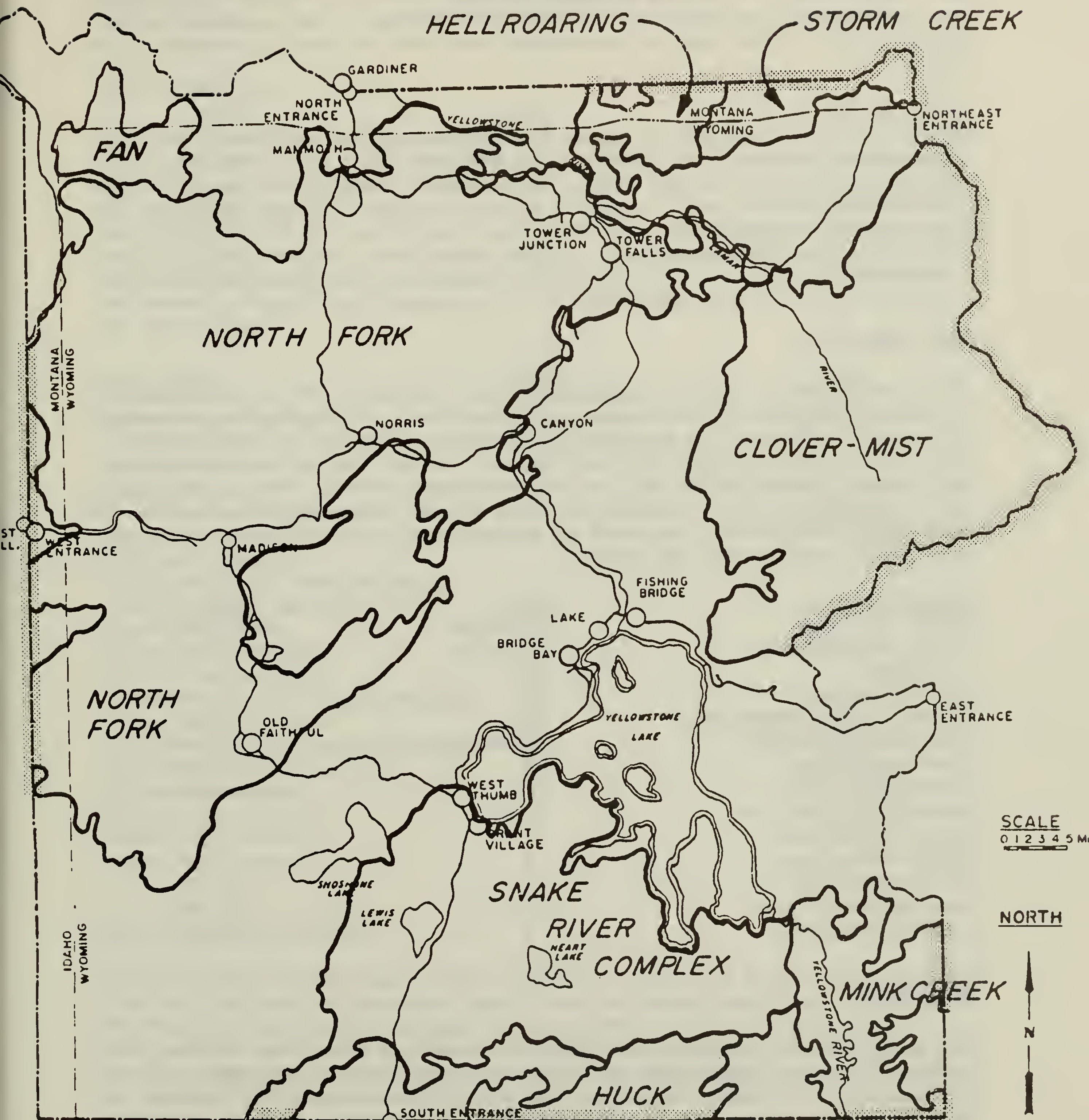
The Clover-Mist Fire burned in Yellowstone's backcountry. Structural facility losses or damages were limited to a snow course station near Parker Peak.

Description	Units	Cost
Backcountry Trails	92.4 miles	$453,500
Boundary	57 miles	
Bridges	10	
Patrol Cabins	5	5,000
Picnic Areas/Campgrounds	1	4,500
Developed Areas (Lake, East Entrance	2	101,000
Snow course	1	10,000

MAP 3

PARK WIDE

BOUNDARIES AFFECTED BY FIRE AND FIRE SUPPRESSION



LEGEND

YELLOWSTONE NATIONAL PARK BDY.

FIRE PERIMETERS

AFFECTED BOUNDARIES

Storm Creek Fire

The Storm Creek Fire burned in the northeast corner of the park, and except for its dramatic run north of the Northeast Entrance, was confined to the backcountry. No Yellowstone structures were lost or heavily damaged by the fire.

Description	Units	Cost
Roads	5 miles	$ 45,000
Backcountry Trails	16.8 miles	82,500
Boundary	17 miles	
Patrol Cabins	3	3,000
Picnic Areas/Campgrounds	2	8,500
Developed Areas (Northeast Entrance)	1	50,500

Wolf Lake Fire

The Wolf Lake Fire (part of the North Fork Fire split off for management purposes) damaged more areas than any other fire, although total structural losses were limited to a barn at Winter Creek, a ski hut at Undine Falls, and an old generator shed at Tower Falls. The ski hut and generator shed were nongovernment buildings, and no replacement cost is noted. The barn will not be replaced. In addition, some gauging stations were damaged, two television translators (operated by an employee group) were destroyed, and the Lupine snow course was damage.

Description	Units	Cost
Roads	92 miles	$826,500
Backcountry Trails	116 miles	569,000
Bridges	13	
Patrol Cabins	6	6,000
Picnic Areas/Campgrounds	10	43,500
Frontcountry Trails	14 miles	48,000
Developed Areas	4	201,500
Electrical Lines		600,000
Undine Falls Ski Hut	1	
Tower Falls Shed	1	
Winter Creek Barn	1	
TV Translators	1	15,000
Lupine Snow Course	1	15,000
Gauging Stations	1	50,000

Mink Fire

The Mink Fire crossed into Yellowstone's Thorofare area, deep in the backcountry. All damage was confined to nonpopulated areas. No significant structural damage occurred due to this fire in Yellowstone National Park.

Description	Units	Cost
Backcountry Trails	24 miles	$117,500
Boundary	13 miles	
Patrol Cabins	3	3,000

North Fork Fire

The North Fork Fire did more structural damage at Old Faithful than all of the other park fires combined. The fire entered Yellowstone's backcountry along its western boundary but eventually made its way up the west side of the park, and nearly crossed the north boundary. The fire melted the insulation off of a steel water tank at Madison, burned 19 buildings at Old Faithful, and damaged a half-dozen others. Power lines burned and reburned, and telephone pedestals were destroyed. All replacement costs are shown although the disposition of 13 buildings is not in the hands of the government.

Description	Units	Cost
Roads	45.5 miles	$408,500
Backcountry Trails	162 miles	794,500
Boundary	13 miles	
Bridges	13	
Patrol Cabins	3	3,000
Picnic Areas/Campgrounds	9	39,000
Frontcountry Trails	11	38,000
Developed Areas (Old Faithful, West Entrance, and Madison Junction)	3	151,000
Electrical Lines		600,000
Telephone Pedestals		25,000
Cabins Operated by a Concessionaire (nongovernment)	12	625,000
Garage Operated by a Concessionaire (nongovernment)	1	75,000
NPS Employee Housing Unit	1	49,000
NPS Storage Sheds	5	60,000
Madison Water Tank	1	73,000
Snow Course South of West Yellowstone		25,000

Snake River Fire Complex

The Snake River Fire Complex (Red, Shoshone, Huck, and Falls Fires) was the first to burn over a developed area. Four buildings were lost, although the four were slated for removal in late 1988 and were not protected against fire. No costs are shown for their replacement. One building was heavily damaged as a result of this fire. The only other building damaged was the "L" loop comfort station at Grant Village Campground which can be repaired. The fires burned an extensive area of the backcountry where the majority of the trails are in the high country. This fire was fought with many of Yellowstone's structural fire trucks, two of which were damaged beyond repair. The replacement costs of these vehicles are included here.

Description	Units		Cost
Roads	22.5	miles	$202,000
Backcountry Trails	162	miles	794,500
Boundary	18	miles	
Bridges	16		
Patrol Cabins	4		4,000
Picnic Areas/Campgrounds	1		4,500
Frontcountry Trails	4	miles	14,000
Developed Areas (Grant Village, South Entrance)	2		101,000
Electrical Lines			300,000
Outbuildings at West Thumb	4		
Damaged Comfort Station at Grant Village	1		15,000
Structural Fire Engines Damaged Beyond Repair	2		300,000

SYNOPSIS

Considering that the fires involved a large part of Yellowstone Park, structural losses and damages were extremely small. Damage done to backcountry trails was, however, quite extensive since sparks hitting wooden water bars appeared to have smoldered and damaged them, even when the area directly around them was not burnt. Water bar damage has the potential to allow water to flow unchecked along trails, providing artificial conduits that will promote erosion. Safety considerations along roads, trails, and in developed areas due to hazard trees are also extremely important. If these items can be successfully mitigated, damage to facilities can be held to a minimum.

NATIONAL FOREST SERVICE AREAS

Facilities damaged or lost on National Forest Service lands are summarized by area and fire in the following tables. Damages are represented in terms of cost. More specific break downs were not available at the time of printing.

Beaverhead National Forest

Corral Creek Fire

Description	Units		Cost	
Boundary Fence	3.5	miles	$ 3,500	private
Interior Fence	2.25	miles	5,500	
Bridge	1		500	private
Culvert	1		300	private
Trail Damage (drainage)	1	mile	200	

Gallatin National Forest

Hellroaring Fire

Description	Units	Cost
Trail Damage (repair and maintain)	60 miles	$160,000
Corral (Buffalo G.S.)	1	5,000
Bull Moose Cabin	1	45,000
Signs	2	200
Trail Corduroy	40	60,000
Benchmark Replacement	15	1,500
Campsite Food Pole Replacement	30	75,000
Hazard Tree Removal		3,000
Clear Stock Driveway	3 miles	2,000

Storm Creek Fire

Description	Units	Cost
Coulter Campground Damage		
Damaged Units	5	
Replace toilet	1	
Replace signs	3	$ 20,000
Hazard Tree Removal		3,000
Trail Damage	90 miles	242,000
Trail Corduroy	20	30,000
Road Damage	4 miles	32,000
Bridge Repair	1	500
Land Line Location/Posting	6 miles	10,000
Benchmark Remonumenting	25	2,500
Bearing Tree and Corner Identification	25	9,000
Campsite Food Pole Replacement	40	9,000
Corral Fence	1	5,000
Clear Stock Driveway	3	2,000
Internal Fence	2 miles	6,000

North Fork Fire

Description	Units	Cost
Snowmobile Trail Signs	300	$ 600
Snowmobile Trail Damage	1 mile	1,500
Culverts	2	200
Land Line Location	9 miles	15,000
Wildlife Water Guzzlers	4	6,000
Snowtel Site	1	7,600

Custer National Forest

Storm Creek Fire

Description	Units	Cost
Signs	5	$ 225
Bridges	2	14,350
Trail Damage	29 miles	10,000
Big Park Cabin (Debris Removal)	1	2,400

Shoshone National Forest

Clover-Mist Fire

Description	Units	Cost
Internal Fence	15 miles	$ 50,000
Corrals	3	20,000
Water Developments	5	15,000
Signs	20	5,000
Culvert	1	1,000
Trailhead Toilet and Ramp	1	10,000
Road Damage	91 miles	29,000
Pole Fence	1	
Land Line Location	25	
Destroyed Benchmarks and Corners	40	5,000
Trail Damage	110 miles	105,000

Bridger-Teton National Forest

Hunter Fire

Description	Units	Cost
Boundary Fence	2 miles	$ 3,000

Corral Creek Fire

Description	Units	Cost
Culvert	1	$ 2,500
Road Damage	60 miles	100,000
Trail Damage	3 miles	5,000

Fayette Lake Fire

Description	Units	Cost
Trail Damage	44 miles	40,000
Culvert	1	

Huck-Mink Fire

Description	Units	Cost
Trail Damage	153 miles	$ 75,000
Trail Corduroy	85 locations	15,000

Targhee National Forest

North Fork Fire

Description	Units	Cost
Signs	12	$ 1,200
Road Damage	60 miles	7,000
Snowmobile Trail	0.5 mile	5,000

Summary of Facilities Lost or Damaged on
National Forest Lands in the 1988 GYA Fires

Description	Units
Boundary Fence	5.5 miles
Interior Fence	19 miles
Bridges	4
Culverts	6
Trail Damage	490 miles
Road Damage	215 miles
Corrals	5
Structures	2
Signs	42
Snowmobile Signs/Reflectors	300
Trail Corduroy	145
Benchmark/Corners	80
Land Line Location/Posting	40 miles
Campsite Food Poles	70
Stock Driveways	6 miles
Toilets	2
Campground Units	5
Snowmobile Trail	2.5 miles
Wildlife Water Guzzlers	4
Snowtel Site	1
Water Developments	5

PRIVATE FACILITIES

Private structures were destroyed and damaged in the Crandall area including 17 mobile homes, 4 dwellings, a general store, and 12 garages and outbuildings.

CULTURAL RESOURCES

The greater Yellowstone area fires of 1988 have had an effect on cultural resources, specifically archaeological resources, historic sites, and historic buildings. At this time, it is too early to determine specific effects for the total burned area, but general statements can be made. Of the buildings affected by fire, no individual historic buildings officially determined eligible to the National Register were lost. Some structures or ruins that may have been eligible or that contributed to historic mining districts were damaged or destroyed. Because so much of the burned area is unsurveyed, we cannot know the extent of destruction or damage to archaeologic or historic sites. No known National Register archaeological sites were destroyed, and two known historic sites were damaged. It is possible that unidentified significant archaeological and historic sites were damaged or destroyed by fire or suppression activities.

DAMAGE TO HISTORIC STRUCTURES OR SITES

Unlike archaeological inventories, historic building inventories are generally complete. Those structures damaged or lost are identified below. Otherwise, no known historic structures were lost or damaged in the fires. Historic site inventories are generally incomplete.

Yellowstone National Park

Fan Fire. The historic Sportsman Lake backcountry patrol cabin, (National Register eligibility undetermined) was lost to fire.

Snake River Complex. Four buildings belonging to an old road camp at West Thumb were burned. These buildings were abandoned and scheduled for removal this fall. They may have been eligible to the National Register.

Wolf Lake Fire. Barronett's cabin ruins were damaged by fire. Other cultural materials were uncovered. This site is being nominated to the National Register.

North Fork Fire. Three buildings contributing to the Old Faithful National Register historic district were destroyed. These consisted of two employee lodging cabins and one concessionaire storage building. Seven more historic employee cabins were damaged. All of these structures were proposed for removal under the approved development concept plan for Old Faithful.

Gallatin National Forest

Storm Creek Fire. Several structures contributing to the New World historic mining district near Cooke City were burned, but this is not considered an adverse impact to the district.

Hellroaring Fire. The historic Bull Moose cabin used for administrative purposes and believed to be eligible to the National Register was destroyed. Two cabin ruins contributing to the Horseshoe mining district near Independence Peak were lost to fire. This is considered an irretrievable loss of information and an adverse impact to the district. Six cabins (an inholding) belonging to the Frenchy's Meadow historic district near Silver Tip Ranch were lost to fire.

Shoshone National Forest

Clover-Mist Fire. A historic site consisting of Bill Cody's carvings on a tree was damaged. Plans to further protect this site are under way.

Custer National Forest

Storm Creek Fire. The Big Park Cabin was lost to fire. The fires have revealed previously undiscovered evidence of a historic ranger station.

ASSESSMENT OF DAMAGES, FIRE EFFECTS, AND RESOURCE IMPLICATIONS

Overall, historic structures in the greater Yellowstone area were well protected from fire. This is particularly true in Yellowstone Park where protecting buildings was a priority. (Yellowstone has over 600 buildings eligible to the National Register; most are located in eight historic districts). Successful attempts were made in parks and forests to avoid known cultural sites during suppression activities. This was done in places like Silver Tip Ranch (Gallatin National Forest) and backcountry patrol cabins in Yellowstone National Park. Four National Historic Landmarks in Yellowstone were protected from fire. Methods used included watering down exteriors, covering roofs with fire shelters, and removing vegetation and other fuels from around buildings. Destruction of significant historic structures would have been an irreplaceable loss since policy does not recommend reconstruction of historic buildings once integrity is lost.

Specific facts about the effects of the fires on archaeological resources cannot be attained without additional selective, or in some cases, comprehensive inventories. Partial inventories were completed for park and forest lands before the fires occurred, and some were done after the fires had passed. These will continue in the following seasons, should funding permit. Many of the areas burned are unlikely to yield cultural sites because their rugged terrain or dense stands of lodgepole pine make them uninhabitable. Meadows, rivers, lakes, and stream shores have a much higher potential of yielding cultural materials or sites. These areas would be targeted for future inventory work.

Resources that could have been destroyed or damaged by fire include wickiups and other lodges; structures or sites associated with poaching, homesteading, farming, or mining; axe or rope markings on trees; wooden game traps; and materials that were culturally fire related but will now be confused with natural fire (hearths, charcoal). Some of these sites cannot be protected from future fire due to their location in extremely flammable timber stands. Camping, tool manufacturing, and other occupation sites consisting of lithic scatters (stone tools and chipping debris) are unlikely to be damaged by fire. Their visibility will be enhanced by the loss of vegetation. This exposure will greatly facilitate future identification of sites and materials missed in previous inventories. One nationally significant archaeological site, Obsidian Cliff, was approximately 85 percent burned. This will facilitate a site inventory scheduled for 1989. Surface obsidian fractured as a result of fire should not be confused with culturally broken rock.

By clearing vegetation and exposing previously unidentified sites, the fires have produced circumstances beneficial to archaeologic and historic artifact exploration. There is now a unique opportunity to locate and record these sites as well as study the effects of fire on cultural materials. An inventory of burned areas should occur in the next several summers to take advantage of this opportunity. Improved visibility of cultural materials will also make them more susceptible to vandalism.

Once cultural resources are lost they cannot be recovered or restored. They are irretrievable resources. Damage to cultural resources result in a loss of integrity, and the historic association cannot be replaced. Many areas of suppression activity (i.e., handlines, fire camps, bulldozer lines, helispots) have yet to be surveyed to determine what impact these activities had on archaeological materials. Mitigation is an alternative where fire or fire suppression activities have damaged a site. Where adverse effects have occurred, it may be possible to excavate, collect, study, and evaluate the site. Salvage archaeology will occur on National Forest lands where timber sales of burned material are planned. National Register buildings should be recorded according to HABS (Historic American Buildings Survey) standards to ensure documentation against future loss.

RECREATION

Throughout the GYA, recreationalists were impacted by fire activity or other effects of the drought. It is difficult to estimate the full scale of these impacts. While Yellowstone Park collects and maintains visitor use records on a regular basis, Forest Service units did not have the means in place to gather this type of information.

YELLOWSTONE NATIONAL PARK

Visitors to Yellowstone National Park were affected by numerous facility and road closures. Many services were also not available. Visitors wishing to stay overnight in the park had fewer choices due to campground and lodging closures. Many times road closures prevented them from reaching their intended destinations. These inconveniences altered visitor use patterns. Tables 1, 2, 3, and 4 recount the series of closures, openings, and reclosures that occurred. Short-duration closures were too frequent to included in the tables. Table 5 compares 1988 summer visitor use figures to the average of the past five summers. These statistics and charts summarize the overall fire-related effects on visitor use. Compared to past summers, 8.8 percent fewer people visited Yellowstone Park, overnight backcountry use dropped 28.7 percent, campground use was down 17.4 percent, and 14.5 percent fewer people used lodging facilities in the park.

Backcountry campers faced disappointment when many backcountry campsites and trails were closed. Closures started on a limited basis near the Fan and Red-Shoshone Fires in early July. By August 20 all backcountry campsites and most trails were closed parkwide with the exception of the Bechler area. Some backcountry areas remained closed after the fires were out because burned bridges and falling trees presented hazards. On countless occasions the Backcountry Office personnel diligently made adjustments in hikers' itineraries to accommodate their plans. Frequently backcountry staff monitored hikers' progress in the backcountry to ensure their safety and timely exit from areas of potential danger. Changes in backcountry use are detail in Table 5.

Visitors also encountered frustration when they were unable to follow through with their planned itineraries due to road closures. Entrance station personnel made every effort to inform visitors of the present and probable road closures. However, extreme weather and fire conditions made it impossible to predict road accessibility with any certainty from one hour to the next. Some visitors were required to travel in ranger-led convoys which experienced long delays. Other visitors were forced to change planned routes, sometimes adding many miles to their trip.

It was a difficult time for park personnel and visitors alike. But perhaps the realization that they witnessed a significant, rare, and dramatic ecological event will, in time, overshadow the frustrations and disappointments visitors experienced.

Table 1. Yellowstone Park Entrance Stations
Dates of Closure Due to Fires

Entrance Station	Day (hour) Closed	Interim Days (hours) Reopened	Interim Days (hours) Reclosed	Day (hour) Opened	Total Number of Days Closed*
North	9/10 (0700)			9/12 (1000)	2
Northeast	8/26 (1831)			8/26 (1900)	
	9/03 (1831)			9/16 (0800)	12
East	9/06 (2233)			9/12 (1000)	5
South	7/22 (1936)			7/22 (2044)	
	7/23 (1203)				
		7/31 (0900) -	7/31 (1431)		
		8/01 (0900) -	8/01 (1000)		
		8/02 (0900) -	8/02 (1300)		
		8/03 (0900) -	8/03 (1300)		
		8/03 (1800) -	8/03 (2100)		
		8/04 (0900) -	8/04 (2100)		
		8/05 (0900) -	8/05 (2100)		
		8/06 (0900) -	8/06 (2100)		
				8/07 (0900)	
	8/18 (2037)				
		8/19 (1130) -	8/19 (1247)		
		8/20 (0943) -	8/20 (1306)		
				9/01 (0800)	
	9/07 (1641)			9/12 (1000)	28
West	8/15 (1545)				
		8/16 (1200)			
			8/17 (1510)		
		8/17 (1820)			
			8/18 (1329)	8/18 (1555)	
	8/30 (1325)			8/30 (2130)	
	9/07 (1056)			9/07 (1837)	
	9/09 (2100)			9/10 (0600)	1

*Includes days with 8 or more hours closed between 6:00 a.m. and 10:00 p.m.

Table 2. Yellowstone Park Campgrounds
Dates of Closure Due to Fires

Campground	Day Closed	Day Opened	Total Number of Days Closed*
Mammoth	9/10	9/13	2
Tower	9/07	remained closed	11
Slough Creek	8/31	remained closed	60
Pebble Creek	8/16	8/31	
	9/01	remained closed	26
Indian Creek	9/07	remained closed	12
Norris	8/17	9/14	28
Madison	8/15	remained closed	77**
Canyon	8/24	remained closed	19
Fishing Bridge	9/06	closed on schedule	0
Bridge Bay	9/08	9/13	
	9/28	closed for season	5
Grant Village	7/23	8/12	
	8/20	9/28	56
Lewis Lake	7/22	8/13	
	8/20	9/01	
	9/09	9/17	63
Fishing Bridge R.V. Park	9/06	remained closed	5

*Based on scheduled closing dates for each campground
**If Madison reopened before 10/31, this number would have changed

Table 3. Yellowstone National Park Lodging
Dates of Closure Due to Fire

Facility	Date closed	Scheduled closing date	Total number of days closed*
Grant Village	7/23**		
re-opened 8/06	8/20**	9/19	43
Canyon	8/24**	8/29	5
Lake Hotel	8/28	9/18	21
Old Faithful Lodge	8/28	9/26	29
Roosevelt	8/29	9/06	8
Old Faithful Inn	9/07**	10/12	35
Old Faithful Snowlodge	9/07**	10/31	54
Lake Lodge	9/08	9/12	4
Mammoth	9/09**	9/18	9

*Based on scheduled closing date
**Closed after ordered evacuation

Table 4. YELLOWSTONE NATIONAL PARK

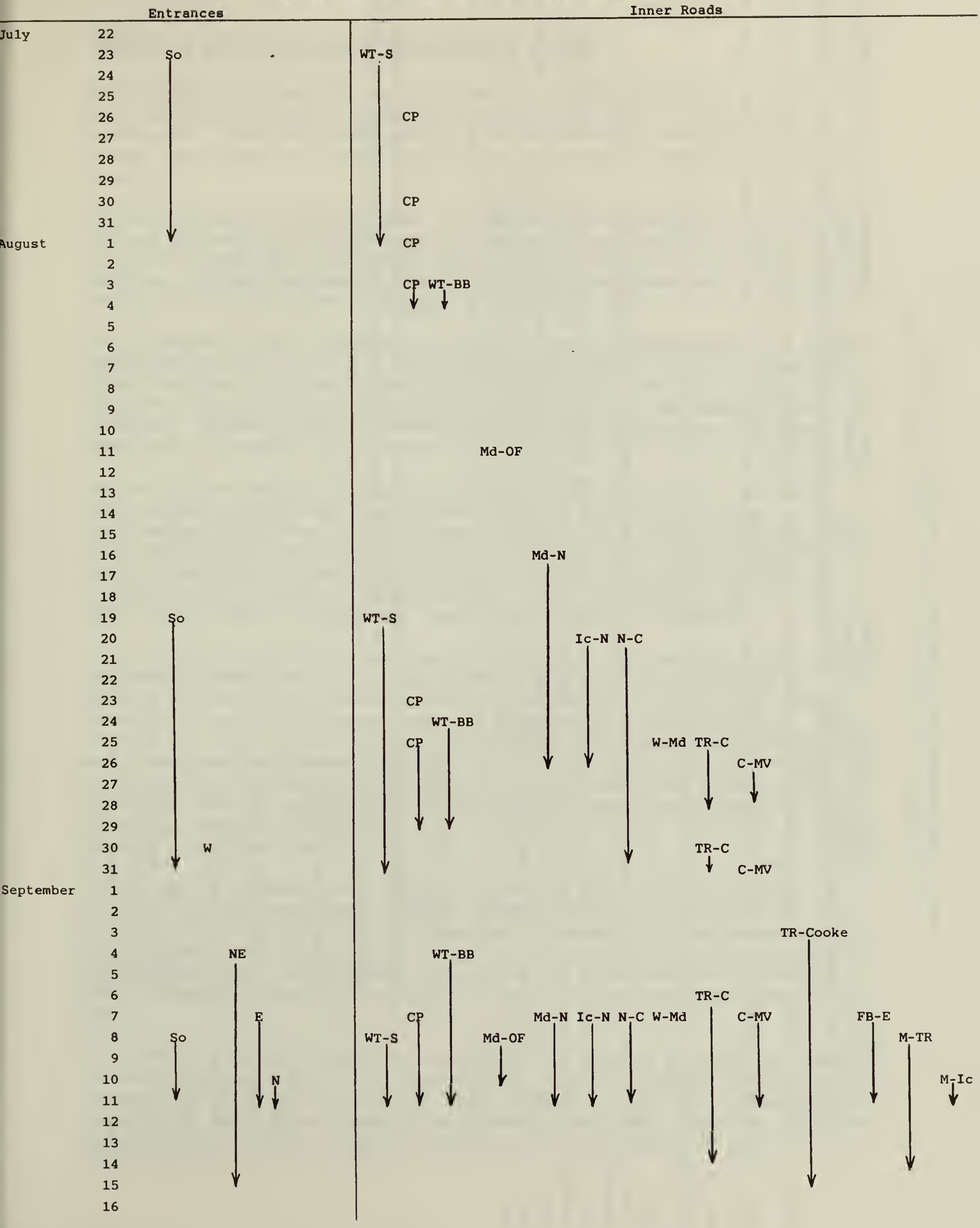
Closures due to fires July 22 through September 17, 1988*

*LL reopened September 17, 1988

All lodging remained closed

Table 4. YELLOWSTONE NATIONAL PARK

Closures due to fires July 22 through September 17, 1988*



*Only closures of eight or more hours between 6:00 a.m. and 10:00 p.m. have been used

Table 5. 1988 Visitation and Recreational Uses, Yellowstone National Park
Percent change between 1988 and five-year (1983-87) average, May-October

	May			June			July		
	1988	5-year average	% Change	1988	5-year average	% Change	1988	5-year average	% Change
Lodging	22,251	21,736	+2.4	142,117	121,905	+16.6	177,091	185,856	-4.7
Camping	27,611	17,406	+58.6	162,426	135,574	+19.8	220,558	235,794	-6.5
Overnight backcountry	1,083	607	+78.4	5,532	4,455	+24.2	11,146	11,743	-5.1
Total Visitation	178,447	152,750	+16.8	447,649	417,931	+7.1	641,752	681,737	-5.9
Entrances:									
North	31,161	34,480	-9.6	64,168	59,421	+8.0	100,373	90,549	+10.8
Northeast	5,923	4,224	+40.2	21,830	21,539	+1.4	35,482	40,336	-12.0
South	47,578	35,320	+34.7	140,288	123,246	+13.8	151,530	199,834	-24.2
West	56,125	51,683	+ 8.6	130,885	127,939	+2.3	229,106	215,169	+6.5
East	37,660	27,044	+39.3	90,478	85,786	+5.5	125,261	135,849	-7.8

	August			September			October		
	1988	5-year average	% Change	1988	5-year average	% Change	1988	5-year average	% Change
Lodging	138,442	170,853	-19.0	10,205	63,104	-83.8	0	9,462	-100.0
Camping	116,341	203,077	-42.7	12,967	67,365	-80.8	10,926	7,683	+42.2
Overnight backcountry	3,997	10,843	-63.1	132	3,601	-96.3	554	718	-22.9
Total Visitation	445,776	608,602	-26.8	180,742	309,938	-41.7	175,019	97,479	+79.5
Entrances:									
North	77,592	83,858	-7.5	41,161	51,363	-19.9	42,160	23,956	+76.0
Northeast	26,743	38,696	-30.9	7,170	16,414	-56.3	9,732	2,568	+279.0
South	93,526	172,455	-45.8	45,748	79,279	-42.3	37,483	20,522	+82.6
West	158,147	197,742	-20.0	59,854	105,897	-43.5	65,569	34,552	+89.8
East	89,768	115,850	-22.5	26,809	56,985	-53.0	20,075	15,881	+26.4

Six-Month Totals

	1988	5-year average	% Change
Lodging	490,106	572,916	-14.5
Camping	550,829	666,900	-17.4
Overnight backcountry	22,444	31,479	-28.7
Total Visitation	2,069,385	2,268,437	-8.8
Entrances:			
North	356,615	343,627	+3.8
Northeast	106,880	123,777	-13.7
South	516.153	630,656	-18.2
West	699,686	732,982	-4.5
East	390,051	437,395	-10.8

Overnight backcountry use figures are calculated by multiplying the number of people in a party by the number of nights they stayed in the backcountry. Other figures represent the actual number of people.

IMPACTS TO WILDLIFE-RELATED RECREATION IN WYOMING

The following information was assembled by the Wyoming Game and Fish Department and relates to Wyoming's wildlife resource and associated recreation. Additional information will be gathered throughout the winter months, and follow-up investigations and surveys will resume next field season.

Between September 1 and November 15, resident and nonresident hunters were advised of the status of hunting seasons and fire-related restrictions and closures through press briefings and a national toll-free telephone service. During that period, some 10,306 calls were received from in-state and out-of-state callers. Messages were updated daily.

Trailer-based hunter information field stations located along major travel routes provided fire-related information to hunters en route to hunting areas from early September through early November. During the peak of fire activity, approximately 2,500 hunters sought information through this resource. Regular department-operated hunter check stations also were important in disseminating information on the fire situation in Wyoming.

The short-term impacts to hunting during the 1988 season were minimal. Most of the impacts were simply inconveniences stemming from the uncertainty about what season changes, if any, would result from the fires. This apprehension was largely allayed through the toll-free telephone service and other informational outlets. No hunting season changes resulted from the fire. While localized access closures or use restrictions were in place, all seasons proceeded as scheduled.

No license fees were refunded, and surprisingly, the demand for such action was almost nonexistent. No adjustments were made for the holders of general elk and deer licenses, since the opportunity existed for those individuals to hunt in other areas not affected by access closures. The holders of limited quota archery elk licenses in hunting areas within Park and Teton Counties, where fires had shut off all access, were afforded the opportunity to exchange their licenses for an archery elk license leftover after the draw in another area, if they had not previously hunted on the original license. All totaled, only 14 archery hunters had their licenses changed to another hunting area.

Finally, only bighorn sheep license holders in hunt area #1 met the criteria for the department's policy on the return of limited-quota licenses which could not be used because the majority of the area occupied by the species was inaccessible by the midpoint of the season. A total of 13 residents and 4 nonresidents, out of 18 and 6 respectively, returned their unused licenses and will be entitled to a bighorn sheep license in 1989.

If tourism in general declines, nonconsumptive uses of wildlife in Wyoming (viewing, photographing, etc.) may decline as well, although Yellowstone's record-setting October visitation figures are encouraging. Furthermore, aggressive, coordinated promotion efforts by the travel industry may offset these short-term declines that might occur in the absence of such initiatives.

In the long term, wildlife viewing and photography opportunities will be enhanced in the affected areas because of increased openness and enhanced growth of palatable forage for large animals. Increased populations of big game also would increase nonconsumptive use opportunities.

CLOSING COMMENTS

The fires have already proven to be a major new attraction in the GYA, though it is unclear what effect they will have on overall visitation levels. Visitation last fall was up compared to past years, and Yellowstone Park visitation hit an all-time high for the month of October. Numerous new educational programs are currently being developed in Yellowstone to introduce the public to the great effects fires have had on the GYA. These programs will include new trails for adults and children in burned areas, a variety of multimedia presentations, and many publications. Thinning of the lodgepole will enable the public traveling by auto to more easily view the scenic beauty of the area and its wildlife.

PUBLIC AFFAIRS

The GYA fires of 1988 created a media event unequaled in the history of wildland fire. Between July 21 and September 21, 1988, more than 3,000 media representatives were assisted either in person or by phone interview in Yellowstone National Park. Every major newspaper in the United States, foreign correspondents, many major magazines, and all the major radio and television networks were represented. Since Yellowstone is well known, the park's Public Affairs staff even received information requests about fires burning outside the GYA. As of November 15, the park was still receiving 40-70 media and public information requests per day concerning the 1988 fires.

Due to Yellowstone's high visibility and the extreme competition for news in the media business, there were occasions when minor events were blown out of proportion. These occasions had the potential to cause conflict among the agencies managing the fires.

The Yellowstone Public Affairs Office (PAO) at park headquarters in Mammoth assumed the role of the central fire information office at the onset of the fire season on June 23, 1988, and continued this role throughout the entire fire season, assisting the media. During the early stages of the fire season, most of the media and public interest was local and regional and was handled by the park's existing two Information Officers.

The PAO responded daily to media inquiries, media visits, and public questions and concerns. As many as 5,000 visitors were personally assisted by personnel responding to incoming calls from the public. These calls varied from fire information to assistance with trip planning.

As the fire season continued and the situation grew increasingly more serious, the media interest greatly intensified. The PAO expanded hours and staff to meet the growing demand of media requests and public inquiries. The office operated from 6 a.m. to midnight, seven days a week. Other staff were brought on to serve as Information Officers in the Mammoth office to assist media. In addition, 41 other staff members were brought on to assist with visitor inquiries. During peak days, the Mammoth PAO assisted over 200 members of the media by telephone and in person each day.

As more Incident Command Posts were established, the PAO brought on other staff members to serve as Field Fire Information Officers. More than 15 National Park Service (NPS) employees were used in this capacity at the different incident locations. These staff were fire-qualified and also familiar with Yellowstone.

Area Command (AC) was established July 23 in West Yellowstone, Montana, and an information office was opened at AC headed by a U.S. Forest Service public affairs director and seven other information officers. The AC Information Office worked very closely with the Mammoth PAO and relied on

Mammoth to continue to serve as the primary information center. In early August, most of AC in West Yellowstone closed - including the information office - and Mammoth continued to serve as the primary fire information center. Later in August, AC reopened with an expanded information office. Once again the Mammoth PAO and AC Information Office worked together very closely. Initially, AC asked Mammoth to continue to serve as the primary central Fire Information Office. Later in August, AC assumed an increased central information role. In late September, AC and their Information Office once again closed. Mammoth again served as the primary information center for both current fire information and handled the tremendous amount of follow-up information requests. These requests have continued, with an average of 20 media representatives and filmers in the PAO daily throughout the fall. As many as 50-70 media inquiries or interviews have continued to be processed on a weekly basis. Throughout the winter an average of 5-10 media representatives have traveled back to the park weekly to research and prepare follow-up stories. More than 200 media representatives are anticipated to return to the park in April and May to continue postfire stories, documentaries, and videos.

In addition to the increased staffing of the Mammoth office, Yellowstone's Public Affairs staff soon recognized that they needed additional help. Their first request for assistance was to the NPS Fire Office in Boise on July 21. Once Area Command was established, the system worked well. Coordination with the park was good. When the Public Information section of AC was released during the first part of August, Yellowstone picked up most of the work load until AC Public Affairs Information section was reestablished a few days later. It was staffed by a Region-5 Information Team. The break in the Public Information section at AC created a tremendous duplication of effort until the Yellowstone and AC information personnel got coordinated. Once the coordination was in place again, it worked well. There were countless positive contacts with the media as well as the communities surrounding the park.

There was some uncertainty among Area and Incident Teams about how the Freedom of Information Act applies to fire records, especially while suppression efforts are in progress.

The NPS was organizationally unprepared at the park, Region, and Washington level to handle the media and information requests generated by this and the other fires. Part of the problem was that there are very few qualified Incident Information Officers in the NPS. Yellowstone management innovatively utilized personnel who were good communicators with some knowledge of fire suppression. The knowledge level varied from person to person, and this created some problems. A number of employees plan to attend Incident Information Training during the spring of 1989.

Overall, a very positive communication exchange occurred between the information offices, the media, and the public in spite of the problems that occurred. There have been numerous letters of commendation from the media and the public for the help they received covering the fires.

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Soils - Henry Shovic, Gallatin NF/Yellowstone NP

Air Quality - Jan Gillman, Montana Department of Health and Environmental Sciences; Stu Coleman, Yellowstone NP

Fire and Plant Ecology - Don Despain, Yellowstone NP

Timber - Art Zack, Panhandle NF

Range and Grasslands - Ron Klatt, San Juan NF; Susan Hayman, Custer NF

Wildlife - Frank Singer, Mary Meagher, Terry McEneaney, Yellowstone NP; Kerry Murphy, Wildlife Research Institute

Fisheries - John Lloyd, Sawtooth NF

Fire-Suppression Effects - Tim Hudson, Yellowstone NP

Visual Resources - Patrick Thomas, Flathead NF; Elanore Williams, Yellowstone NP

Facilities - Tim Hudson, Yellowstone NP

Cultural Resources - Sonya Capek, Yellowstone NP

Recreation use - Anita Varley, Yellowstone NP; Wyoming Fish and Game

Public Affairs - Amy Vanderbilt, Yellowstone NP