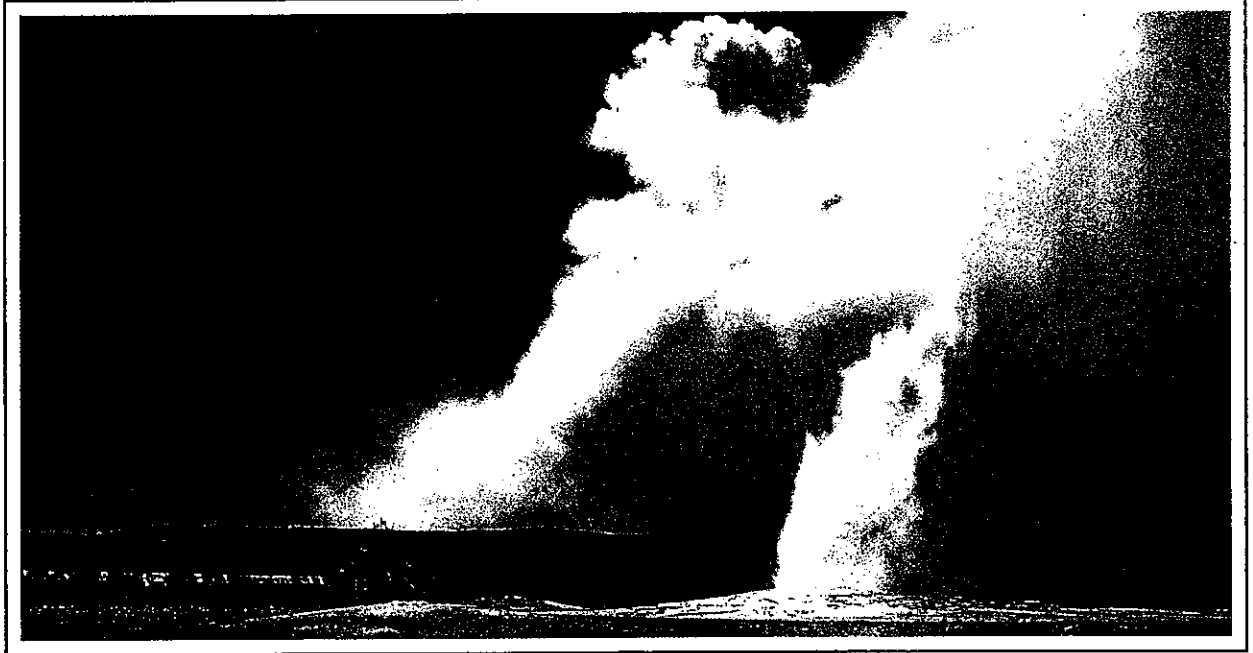


# Effects of the 1988 fires

*How accurate were the predictions, and what next?*

Jim Peaco/NPS



by  
**Dennis H. Knight**

*On September 19-21, Yellowstone hosted the Second Biennial Scientific Conference on the Greater Yellowstone Ecosystem. Entitled "The Ecological Implications of Fire in Greater Yellowstone," the conference featured more than 60 papers and posters in two intensive days (see page 20 of this issue for more on the conference events). Dennis Knight, of the University of Wyoming, served as conference summarizer, and has allowed us to publish his observations here.*

*With our encouragement, Dennis has taken the generalist's view of the conference findings. Rather than discuss the work of specific investigators, he has synthesized the many types of work being done into an overview that concentrates on the general directions of fire research in the Yellowstone area. Ed.*

During and after the 1988 fires, there were many predictions on how greater Yellowstone area (GYA) ecosystems would be affected. Some were based on research that had been done previously; others stemmed more from anecdotal evidence or untested hypotheses. Five years later, 225 scientists and managers from six federal agencies, six state agencies, and 24 colleges and universities gathered in Mammoth to compare the results of their research. Like the fires themselves, the meeting was historic. As Superintendent Bob Barbee observed, "The opportunity to learn did not go to waste." Numerous reports are now being written that will affect management and research in the future. Some of the highlights are presented in this summary.

## **Vegetation Change**

The paleoecologists at the conference described fire frequency and veg-

etation changes as far back as 10,000 years ago. At that time, Engelmann spruce was beginning to invade the tundra vegetation that had predominated over GYA landscapes since the retreat of the glaciers. A spruce-dominated woodland apparently persisted for many centuries. However, with continued warming and drying, forests of lodgepole pine and Douglas-fir became more common throughout the area. About 5,000 years ago a cooling trend began, and predictably, Engelmann spruce and subalpine fir became more abundant. Douglas-fir now persists only at the lowest elevations.

Prior to 1988, ecologists had learned that fires in stands of Douglas-fir occurred on average every 20-50 years, depending on location, and that stands dominated by lodgepole pine, Engelmann spruce, and subalpine fir burned every 200-300 years. All available evidence now suggests that, prior to 1988, the most extensive fires occurred 285 years previously, in about 1703. Lake-bottom sediments, with layers of charcoal, indicate that the length of time between fires was shorter about 8,000 years ago when the climate was drier. Even then, however, the GYA must have been a "non-equilibrium landscape" characterized by large-scale fires that burned large areas. Notably, such fires burn unevenly. Data presented at the conference indicates that 75 percent of the land area that was subjected to crown fire in 1988 is within 200 m of a less severely burned or unburned patch (50 percent was within 50 m).

Succession following the 1988 fires has been highly variable from one area to another. Lodgepole pine was a very successful pioneer species, as predicted, but the density of new seedlings in burned areas varies greatly (from nearly zero to over 100 seedlings per square meter!). Lodgepole pine seedling density is correlated with heat severity, the prefire abundance of serotinous cones, elevation, seed-bed characteristics, and postfire climatic conditions. Intense fires may burn most of the seeds contained within the serotinous cones, though the heat tolerance of the seeds appears to be considerable.

Generally, lodgepole pine seedlings were most dense where serotiny was high in the forest that burned; within any serotiny class, seedlings were more dense near the edges of burned areas where burn intensity was moderate. Engelmann spruce, subalpine fir, whitebark pine, and aspen can be early invaders along with the lodgepole pine in some areas. Regardless of species composition, new even-aged stands are developing. Tree age can vary greatly in these "even-aged stands," with the broadest range of ages occurring where, for whatever reason, the initial density of tree seedlings and other plants was sparse. Nevertheless, more than 75 percent of lodgepole pine seedlings present today in burned areas were established within the first two years after the fires.

One of the most surprising results of the 1988 fires has been a dramatic increase in the number of aspen seedlings. Abundant seed apparently was dispersed into the burned areas and soil moisture conditions apparently were favorable, probably because of the relatively moist year that followed the fires combined with less soil drying due to lower rates of transpiration. Aspen also are capable of root sprouting following fires. Higher densities of sprouts did occur in some burns, but notably, not in others. In all cases, the aspen continues to be heavily browsed by elk, causing some stands to persist only as shrubs.

It remains to be seen if new aspen

clones will develop because of the fires. Data presented at the conference suggest that most tree-sized aspen on the northern winter range in Yellowstone National Park developed between 1870 and 1890, a period when both elk and beaver populations might have been low because of intensive hunting and trapping. The cause of aspen and willow decline continues to be a controversial issue, with most of the evidence pointing to heavy browsing by elk. Elk browsing also may limit the establishment of new trees in burned Douglas-fir woodlands, but the magnitude of this effect has not been determined.

### Animal Populations

The effects of the 1988 fires on animals were as variable as the effects on plants. Generally, there was no observable adverse effect on the trumpeter swan, bald eagle, and peregrine falcon. The osprey, mountain bluebird, various species of woodpeckers, and the cavity-nesting Barrow's goldeneye and bufflehead appeared to benefit. The greatest diversity of bird species was observed where fires were of moderate intensity and resulted in a patchy mosaic of burned and unburned forest. Even woodpeckers were uncommon in large, severely burned forests. The Clark's nutcracker was observed caching whitebark pine seeds in burned areas.

Changes in insects and other terrestrial invertebrates depended on burn

*Renee Evanoff*



intensity. Predictably, significant declines in litter-dwelling species were noted when the forest floor burned. This was in contrast to reptiles and amphibians which typically burrow into the soil or which select moist habitats that would burn with less intensity. Some insects were favored by the fires, especially those that could invade fire-damaged but surviving trees.

Insect-caused mortality was higher after the fires on fire-damaged Douglas-fir, Engelmann spruce, and subalpine fir (due, respectively, to Douglas-fir beetles, spruce beetles, and wood borers). Some lodgepole pine mortality was caused by the pine engraver. The mountain pine beetle remains an important cause of lodgepole pine mortality in general in the west, but very little mortality in the GYA can be attributed to this beetle during the last five years.

The 1988 fires had a significant effect on some winter ranges. Burned forage, in combination with hunting pressure, low forage production during the dry summer, and a severe 1988-1989 winter, led to a 38-43 percent reduction in the northern Yellowstone elk herd. The scarcity of food during the winter appeared to force some elk to feed on the bark of lodgepole pine. Though conifer bark normally is viewed as low quality food, the heat of the fires may have volatilized some of the resinous compounds, thereby making it more palatable. Moreover, because of the nutrient-rich phloem layer, tree bark can be quite nutritious. By 1993 the elk populations throughout the park had essentially recovered. Burned areas were used more for grazing than unburned areas (regardless of the pattern of burning). New willow sprouts became an important food in burned riparian habitats.

With regard to other large mammals, pronghorn antelope have become more abundant since 1988, possibly because of more nonforested habitat at lower elevations. Moose, in contrast, may have declined in abundance because of less winter cover. Bison mortality ap-

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*Burned lodgepole pine bark was more palatable to elk, who consumed it in several locations following the fires.*

parently was affected more by severe weather conditions than by the fires. Grizzly bears have less whitebark pine seeds available to them, but close observations indicate that roots and rodent caches are being used more often. At this time it appears that the grizzly and black bear populations have been affected very little if at all.

### Aquatic Ecosystems

Popular hypotheses prior to 1988 were that large scale fires in the GYA would lead to the nutrient enrichment of aquatic ecosystems because of higher rates of nutrient leaching from watershed soils, and that fish productivity would increase because of the additional nutrients. Several studies found that the streamwater was enriched with nitrogen, and one study found some evidence for increased fish growth rates in rivers. However, after five years there was no evidence that the growth of cutthroat trout had changed appreciably in Yellowstone Lake. Investigators found great year-to-year variation in growth and suggested that fishing harvests and population year-class abundance probably had a more important effect than the fires.

High sediment loads were observed in the streams draining some burned watersheds, but usually only after heavy thunderstorms or during spring runoff. While some fish mortality was attributed to these episodes of erosion, no

significant effects on fish populations could be detected. Changes in other aquatic organisms, such as diatoms and benthic invertebrates, were observed in small streams, but there were no obvious effects on the organisms of the larger rivers. Streamflow increased in some watersheds due to less transpiration from vegetation, but abnormal flooding did not always occur.

Overall, the magnitude of the effects of fire on aquatic ecosystems appears to be dependent on channel gradient, the steepness of valley slopes, the amount of surface runoff, the percentage of the watershed that burned, the proportion of the riparian vegetation that burned, and the degree to which the upland and riparian vegetation has recovered. A wide range of these watershed conditions were available for study in the GYA.

### What next?

The papers presented at the conference indicate once again that ecosystems are highly variable from place to place and from one year to the next. For example, lodgepole pine was an early invader in many areas, as predicted, but not everywhere. Also, erosion was accelerated in some areas, but the amount of soil loss and subsequent sediment deposition in streams varied greatly from place to place, and in most cases was within the normal variation observed before the fires.

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*Fire conference participants at paper and poster sessions.*

Animal responses also were variable. This variability, occurring within a relatively small area (such as the Yellowstone landscape), provides excellent opportunities for scientists to improve their predictive abilities. Such high variability also suggests that caution should be used in making broad generalizations, whether for a national park, national forest, or an extensive mosaic of federal, state, and private lands. Nevertheless, predictions about fire behavior and the effects of fire can now be based on much more information than was available in 1988. This represents a significant scientific accomplishment.

There is still, however, much to be learned. Indeed, some of the spatial and temporal variability in the way ecosystems responded to the 1988 fires is puzzling. Explanations may be possible only with additional research on, for example, the effects of fire and other variables on microbial organisms in the soil, or trees other than lodgepole pine and aspen. Studies that focus on small scales, individual species, or specific ecosystem processes should be complemented with more holistic research at the scale of several watersheds or whole districts.

Scientists should also consider doing experiments with the young postfire ecosystems. For example, what would happen if dense stands of lodgepole pine saplings are killed by another fire (or some other mechanism) within 5-10 years after a stand-replacing fire in old-growth? If aspen are present, whether as root sprouts or young seedlings, the effect could be the rapid development of a new aspen grove where a pine stand might otherwise have occurred. Similarly, what would be the effect of reduced browsing on aspen and Douglas-fir adjacent to winter ranges? Additional fenced exclosures should be established to determine if (or where) the elk population is capable of preventing the reestablishment of the forests and savannas that were burned in 1988.

Other experiments could be done by fertilizing streams or lakes to simulate the effects of the fires, or by manipulating postfire riparian vegetation along portions of some streams. The knowledge gained thus far by taking advantage of the 1988 fires could be augmented greatly with carefully designed, more controlled experiments. Some would be appropriate for Yellowstone or Grand Teton National Parks; others might be acceptable only on adjacent national forest lands. The best science, pursued in as many directions as possible, should be encouraged so that there is more information available for evaluating the "natural regulation policy" and other management paradigms.

The value of long-term data for determining the effects of disturbances became eminently clear during the conference. The nature of mature ecosystems

depends to a large extent on the history of an area and what happens during the first few years after disturbances. Answers to numerous important questions would not have been possible without the long-term records of the U.S. Geological Survey, U.S. Fish and Wildlife Service, USDA Forest Service, Soil Conservation Service, and National Park Service. The magnitude of the 1988 fires, along with their value for understanding ecological phenomena beyond the boundaries of the GYA, mandate that long-term research and monitoring programs should be continued (including those initiated in 1989). Moreover, such data (including historic photographs) should be carefully archived and used more frequently.

The value of simulation modelling for understanding ecological interactions also was quite evident during the conference. Several models were described. Whether designed for large-scale questions and used in conjunction with satellite imagery and geographic information systems, or for small-scale questions pertaining to a specific process, the simulation approach to ecological research helps prevent scientists and managers from becoming too simplistic in the interpretation of their data.

A larger modelling effort is now called for, primarily because the value of an individual study is greatly enhanced when it is integrated with others. Simulation models also help in establishing research priorities. Developing defensible ecosystem models that are useful at the scale of landscapes is a significant challenge, but, with managers and scientists working together more closely than in the past, this goal should be possible. The payoffs will be substantial for education, new scientific methods, visitor satisfaction, the best possible stewardship for two of the world's favorite national parks, and improved ecosystem management throughout the region.

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