Yellowstone Science

volume 17 • number 2 • 2009

9TH Biennial Scientific Conference

The '88 Fires: Yellowstone and Beyond

NPS/JEFF HENRY

Where Were You?

Last summer marked the 20th anniversary of the 1988 fires in Yellowstone and the northern Rocky Mountains. The 1988 fires have been described as being instrumental in the public's understanding of the role of fire in ecosystems, history-making, and career-building. In September 2008, in commemoration of those fires, the National Park Service (NPS), the International Association of Wildland Fire (IAWF), and a consortium of partners hosted *The '88 Fires: Yellowstone and Beyond* conference, which served as the 9th Biennial Scientific Conference on the Greater Yellowstone Ecosystem, in Jackson Hole, Wyoming.

This issue of *Yellowstone Science* features articles based on many of the plenary talks given during the conference. The speakers remind us that we are still learning from those fires as we look toward future changes in fire management and climate. For many people who were involved with the fires in some way, there is also a very personal connection, a story or a memory, that those fires recall. The "I Was There" button pictured above was handed out and worn during the conference by those whose lives and careers are tied to the fires.

Tall Timbers Research Station is publishing the conference proceedings, which is anticipated to be available online by October 2009 at the Tall Timbers, NPS, and IAWF websites: www.talltimbers.org, www.nps.gov/yell, and www.iawfonline.org.

The Greater Yellowstone Ecosystem biennial scientific conference series was initiated in 1991 to encourage awareness and application of wide-ranging scientific work on the region's natural and cultural resources. These conferences, with the active involvement of professional societies and other institutions, provide a much-needed forum for sharing knowledge among hundreds of researchers, park managers, and the general public. The next conference will take place in fall 2010, and themes are currently being discussed.

We hope you enjoy the issue.

YELLOWSTONE SCIENCE

a quarterly devoted to
natural and cultural resources

volume 17 • number 2 • 2009

TAMI BLACKFORD
Editor

MARY ANN FRANKE
Associate Editor

JANINE WALLER
EMILY YOST
Graphic Designers
Assistant Editors

VIRGINIA WARNER
Assistant Editor

ARTCRAFT PRINTERS, INC.
Bozeman, Montana
Printer

Yellowstone Science is published quarterly. Support for *Yellowstone Science* is provided by the Yellowstone Association, a non-profit educational organization dedicated to serving the park and its visitors. For more information about the association, including membership, or to donate to the production of *Yellowstone Science*, visit www.yellowstoneassociation.org or write: Yellowstone Association, PO Box 117, Yellowstone National Park, WY 82190.

For back issues of *Yellowstone Science*, please see www.nps.gov/yell/planyourvisit/yellsciweb.htm.

Submissions are welcome from all investigators conducting formal research in the Yellowstone area. To submit proposals for articles, to subscribe, or to send a letter to the editor, please write to the following address: Editor, *Yellowstone Science*, PO Box 168, Yellowstone National Park, WY 82190. You may also email: Tami_Blackford@nps.gov.

Yellowstone Science is printed on recycled paper with a soy-based ink.

On the cover:
Detailed satellite image of the Yellowstone Lake area September 7, 1988. *NPS photo.*
On this page: Smoke from the North Fork fire in Gibbon Canyon.
Photo by Jennifer J. Whipple.

FEATURES

DEPARTMENTS

News & Notes

Commission Charting Vision for Future of National Parks

The National Parks Second Century Commission conducted its third of five meetings January 27–29, 2009, at Yellowstone National Park. Chaired by former Senators J. Bennett Johnston, Jr. (D-LA) and Howard H. Baker, Jr. (R-TN), the commission's goal is to chart a vision for the parks' second century of service to the nation. Nearly 30 national leaders and experts with a broad range of experience participate in the bipartisan group, including scientists, historians, conservationists, academics, business leaders, policy experts, and retired National Park Service executives. The commission is being convened and funded by a grant from the non-profit National Parks Conservation Association (NPCA). The NPCA is independent of the National Park Service or any other government organizations.

"We are very pleased and honored to be hosting the commission in Yellowstone National Park," said Superintendent Suzanne Lewis. "Yellowstone National Park has been and remains the inspiration for so many who are interested in and dedicated to the preservation of our nation's public lands."

The Second Century Commission functions through six committees which address the various roles and responsibilities of the National Park Service that extend beyond park boundaries.

The commission held five meetings at national parks. They first met in August 2008 at Santa Monica Mountains National Recreation Area in California, and then in October 2008 at Lowell National Historical Park in Massachusetts. After the Yellowstone meeting in January, the commission met at Gettysburg National Military Park in Pennsylvania in March and at Great Smoky Mountains National Park in Tennessee in June. At each meeting, the commission heard from a range of subject matter experts and park managers. They also heard from the general public over the course of their yearlong effort. In fall 2009, the commission will issue a final report, outlining a vision for the role of national parks in society, the role of the National Park Service as stewards of the national parks, and an action plan for achieving that vision.

A list of the commission members, their biographies, and the agenda for the Yellowstone meeting are available at www.VisionfortheParks.org.

New Ken Burns Documentary *The National Parks: America's Best Idea*

The first session of the Second Century Commission's meeting in Yellowstone featured a preview and discussion about Ken Burns's latest documentary, *The National Parks: America's Best Idea*. PBS will show the documentary in six parts over 12 hours beginning September 27, 2009. Co-produced with Burns's longtime colleague, Dayton Duncan, who wrote the script, *The National Parks* is the story of a radical idea that is as uniquely American as baseball: that the most special places in the nation should be preserved, not for royalty or the rich, but for everyone. The series is a history of the national parks and National Park Service (NPS), and is a history of ideas and individuals.

Filmed over the course of more than six years in some of nature's most spectacular locales, the documentary is nonetheless a story of people from every conceivable background—rich and poor; famous and unknown; soldiers and scientists; natives and newcomers; idealists, artists, and entrepreneurs; people who were willing to devote themselves to saving some precious portion of the land they loved, and in doing so reminded their fellow citizens of the full meaning of democracy. It is a story of struggle and conflict, high ideals and crass opportunism, stirring adventure and enduring inspiration—set against breathtaking backdrops.

Burns called it the most transformative project he has undertaken, and he considers it his best work. He also expressed the hope that his work might add to the Second Century Commission's deliberations by imparting a clearer view of how to go forward. Duncan added that, as the filmmakers for this series, they hoped that people would come away from the stories with several basic ideas. The first is that the parks belong to them; the parks are the Declaration of Independence writ large on the landscape. The second idea, inspired by early NPS biologist George Melendez Wright, is that the parks represent a great treasure of diversity. Third, the parks face challenges and conundrums, but good people have always come forward to find solutions. Quoting Wright, Duncan said, "Save what you can and protect what you save."

NPS/JIM PEACO

Passing of Richard T. Gale

Richard T. Gale, retired National Park Service (NPS) chief of fire operations and a ranger with more than 40 years of field experience, died unexpectedly of a heart attack at his home in Boise, ID, on Friday, March 27, 2009.

Mr. Gale began his career in 1958 as a fire control aid at Lava Beds National Monument, rising to serve at the National Interagency Fire Center as NPS chief of fire operations prior to becoming the deputy chief ranger for the NPS. He also served on national Type 1 incident management and area command teams for 27 years (1971–1997).

One of his most memorable assignments was serving for seven weeks as area commander for the Greater Yellowstone Area fires in 1988. During that assignment he supervised 13 teams with a total of 9,550 personnel.

In addition to his fire assignments and qualifications, Mr. Gale served as search commander on several large-scale search missions, and was one of the first law enforcement specialists in the NPS, serving in that capacity at Lake Mead National Recreation Area from 1969 to 1973. He was also a founding member of the Association of National Park Rangers from 1977 until his death. He served as president of the association from 1988 to 1994.

In May 1994, President Clinton presented the first Harry Yount Lifetime Achievement Award to him at a ceremony in the White House. Mr. Gale also received the Department of the Interior's Meritorious and Distinguished Service Awards.

Edward O. Wilson Biodiversity Technology Pioneer Awards

The first Edward O. Wilson Biodiversity Technology Pioneer Awards were given on April 9, 2009, at a dinner presented by the American Computer Museum and Montana State University. Dr. Edward O. Wilson presented the awards to four individuals whose scientific discoveries have made profound contributions to the preservation of biodiversity on Earth.

Popularly known as the "Father of Biodiversity," Dr. Wilson is the Pellegrino University Research Professor in Entomology for the Department of Organismic and Evolutionary Biology at Harvard University. Dr. Wilson has made seminal discoveries in the scientific study of ants, including hundreds of new species during his lifelong fascination with biodiversity. He is the author of two Pulitzer Prize-winning books, *On Human Nature* (1978) and *The Ants* (1990, with Bert Hölldobler), as well as many other ground-breaking works. He has received numerous awards, including the National Medal of Science and 32 honorary doctorate degrees.

The award winners for 2009 are:

- Dr. Ignacio Rodriguez-Iturbe, professor of Civil and Environmental Engineering, Princeton University, for exemplary engineering work with ecohydrology.
- Dr. Steve Running, professor and director of the Numerical Terradynamic Simulation Group, College of Forestry and Conservation, University of

NPS

Standing left to right: Michael Soulé, E.O. Wilson, David Ward, Steve Running, Ignacio Rodriguez-Iturbe. *In front:* Tom Olliff, Yellowstone's Chief of Resources, and George Keremedjiev at Nymph Creek near Norris Geyser Basin.

Montana, Missoula, for pioneering scientific work with climatology, global warming, and other aspects of atmospheric science
- Dr. Michael Soulé, professor emeritus of Environmental Studies, University of California, Santa Cruz, founder and president of the Society for Conservation Biology and The Wildlands Project, for exemplary scientific and public outreach work.
- Dr. David Ward, professor of Microbial Ecology, Montana State University, Bozeman, for scientific work with thermal/hot spring microbial diversity, ecology, and evolution.

On April 10, 2009, Dr. David Ward led a field trip for Dr. Wilson, the awardees, and guests into Yellowstone National Park. Dr. Ward led a discussion of thermophilic microbial diversity and ecosystems at Mammoth Hot Springs and Nymph Creek and the group visited the proposed National Ecological Observatory Network's Northern Yellowstone Core Wildland Site to discuss continental-scale ecological monitoring.

Dr. Wilson will be returning to Bozeman on October 6–8, 2010, for the next awards ceremony, at which time he will be 81 years old. For more information on the Edward O. Wilson Biodiversity Technology Awards, visit www.eowilsonawards.org.

Northern Yellowstone Elk 2008–09 Winter Count

The Northern Yellowstone Cooperative Wildlife Working Group conducted its annual winter survey of the northern Yellowstone elk population during good survey conditions on January 30 and February 9, 2009. Approximately one half of the total 7,109 elk counted from airplanes were located within Yellowstone National Park; the other half were north of the park. This herd winters between the park's northeast entrance and Dome Mountain/Dailey Lake in Paradise Valley.

This year's count was lower than the 9,545 elk counted in winter 2005, but slightly higher than the 6,279–6,738 counts during the three previous winters. The slight increase "may reflect favorable counting conditions, a reduction in the hunter harvest of antler-less elk, and a reduction in wolf predation owing to a fairly large decrease in wolf numbers during the summer of 2008," according to park biologist P.J. White.

The working group will continue to monitor trends of the northern Yellowstone elk population and evaluate the relative contribution of various components of mortality, including predation, environmental factors, and hunting.

Accident Claims Life Of Infamous Yellowstone Elk

A well-known bull elk in Mammoth Hot Springs died as the result of an accident on February 8, 2009. The animal, known as "Number 6" due to his numbered orange and black ear tag, was found dead in Gardiner, Montana.

Montana Fish, Wildlife and Parks staff believe the bull tripped while trying to cross a fence and somersaulted onto his back, where he was pinned between rocks with his antlers beneath him and suffocated.

The results of a necropsy indicated that the bull was at least 15 years old and weighed 725 pounds. Elk have an average life span of 13–18 years, with bulls typically topping the scales at 700 pounds. His rack, although diminished in size from previous years, still gross scored an impressive 356 5/8 on the Boone and Crockett scale. At his peak, the animal would have been considered a "trophy" by elk hunters.

Large bulls venture into Mammoth Hot Springs each fall to compete for the attention of cow elk during the mating season (rut). Number 6 had his antlers removed in August 2004 and again in August 2005 in an effort to reduce the danger he posed to park visitors during the rut.

YS

J. WALLER

Each fall, several bull elk and large groups of cow elk congregate in Mammoth Hot Springs for their mating season.

Opening Remarks

Suzanne Lewis, Superintendent, Yellowstone National Park
September 22, 2008

Good morning and welcome to Jackson to commemorate, consider, argue about, and—perhaps most important of all—learn from the fires of 1988. Those historic fires and their biological, social, economic, and political aftermath have become one of the great modern case studies in our on-the-job training as public land managers. I'm sure we're all eager to hear the latest scientific insights as you reminisce about that remarkable summer.

We must begin, however, by remembering. And when we remember the Yellowstone fires of 1988, there are two names we must never forget: Donald Kuykendall and Edward Hutton, both of whom died in the aftermath of the fires. Pilot Don Kuykendall's fire-crew transport plane crashed on September 11, 1988, while returning to Jackson, and Bureau of Land Management firefighter Ed Hutton was killed on October 11 by a falling tree during a post-fire mop-up of the Clover-Mist Fire on the Shoshone National Forest.

I ask you all to join with me in a moment of silence for these men; and for all the other firefighters who have given the last full measure since 1988; and, indeed, for all of our 1988 friends and co-workers who have passed away since that momentous summer of fire.

Thank you.

I have two very vivid memories associated with the fires of 1988, the first comes from having been in Yellowstone in late May/early June of 1988—visiting for the first time since childhood but feeling much of the same joy and splendor that I remembered from the late 1960s. My second memory is shared with most Americans, as we watched the 1988 fires on the nightly news just weeks after I had returned from visiting the park. Many of you here remember the powerful public reaction to the fires, and the stirring national debate that followed that incredible fire season. The diversity of opinions, the heat of the conversations, and the intensity of scientific scrutiny all contributed to a reshaping of public land management. This may be the foremost legacy of the 1988 fire season in the American West.

But in this neighborhood, what the post-fire excitement also reminded us was how passionate Americans are about the Yellowstone country. Thirteen years after the fires, when I became superintendent of Yellowstone National Park, I immediately encountered the vital legacy of the fires of 1988.

In 1988, America was not ready for landscape-scale fire. We didn't know how to talk about it. We didn't know how to model and predict it. Our science was beginning to hint at the possibilities and significance of such fires, but our management policies were simply not designed to anticipate the hard reality of big fire when it came roaring over the hill.

Those of you who were here that year were confronted with unprecedented circumstances, both in the fires and in the political turmoil they engendered. You faced those challenges with extraordinary professionalism, wisdom, and tenacity. Since 1988, you have given America the tools to handle immense fire and the language we need to discuss it rationally. All of us who love these wild lands and our beautiful communities owe you a lifetime of thanks.

Because of the fires of 1988, you were also confronted with an unparalleled scientific opportunity, and I am confident that this conference will prove that you have taken full advantage of that opportunity. It has been said that the fires of 1988 rewrote the textbooks on fire and reshaped the fire management community. Thanks to your leadership, that process is still underway.

Since 1988, I have been one of many managers to take full

advantage of your work—first when I managed the Moose Fire as the superintendent of Glacier National Park in 2000, and since then in 19 different fires in Yellowstone. We have benefited from the lessons of 1988 in so many ways. Our understanding of fire behavior has grown by leaps and bounds, moving from paper-based nomograms to complex fire behavior models that incorporate crown fire, drought, and probability functions to predict fire size and spread. We apply these lessons in the many fuel reduction projects that we continue to complete.

And thanks to you, we are fostering a finer public awareness of how wildland fire works, so that tomorrow's citizens, especially the young ones, know fire for its whole reality—not just its immense power, but also for its ecological, cultural, and even aesthetic benefits.

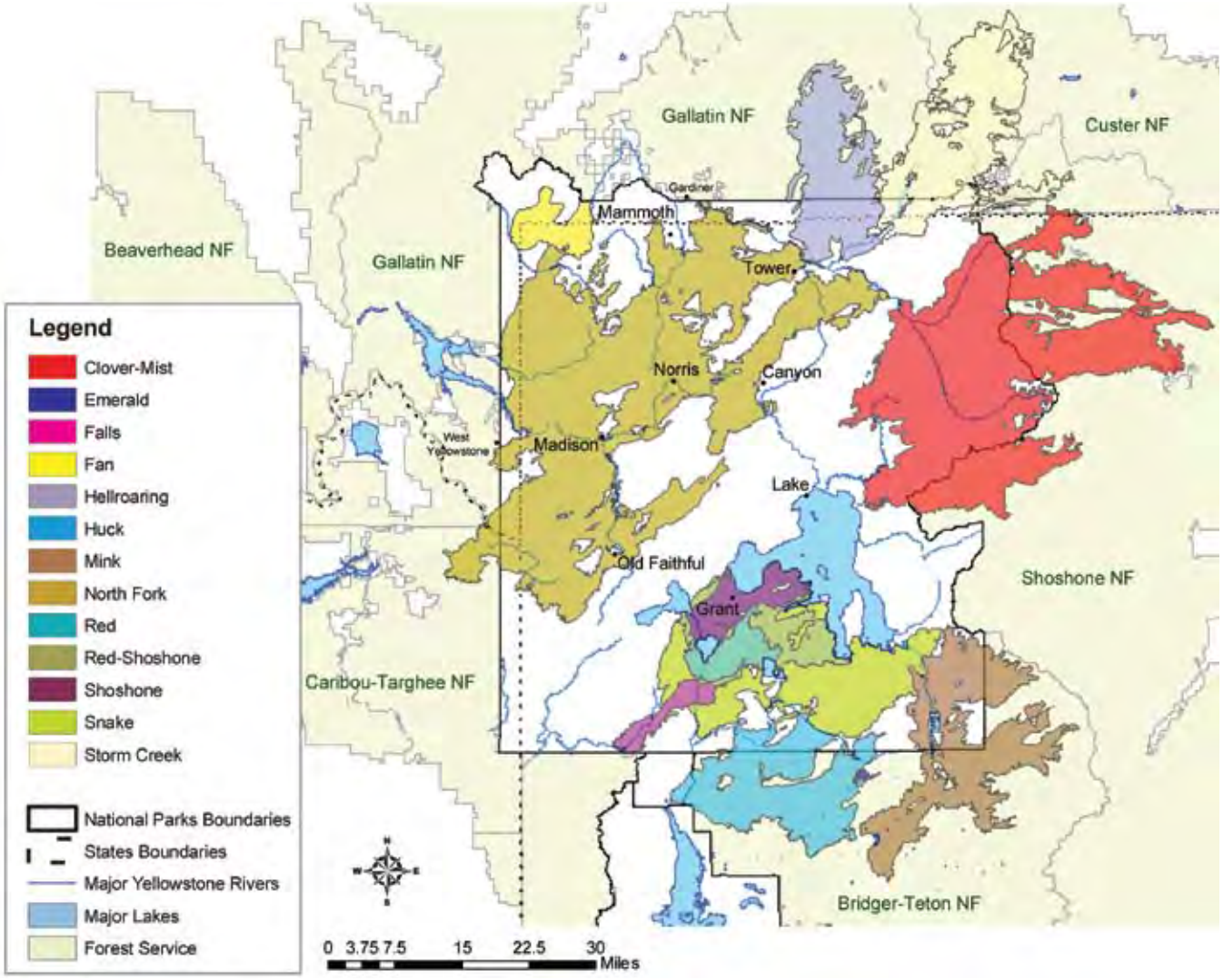
It's time to get this very exciting conference underway, so I will leave you with this thought. Historian Paul Schullery has described the essence of Yellowstone's place in the American fire culture this way:

> *When Captain Moses Harris of the First Cavalry arrived in Yellowstone in August, 1886, to take command of the park, one of the first duties he assigned his men was the fighting of a fire south of Mammoth Hot Springs. That act of expediency was, by all accounts, the very first involvement of the federal government in fire fighting on public lands, and the soldiers were frequently called upon to fight fires over the next 32 years. From that modest beginning grew a vast, multi-agency, high-technology fire-fighting bureaucracy employing many thousands of people—the world's largest and most expert firefighting team, a century deep in experience, training, and wisdom. And in 1988, they all came home.*

In that spirit, ladies and gentlemen, speaking on behalf of all of us in the National Park Service, it is my pleasure to welcome you home again. Thank you.

YS

This map shows the final perimeter of the major fires that burned in Yellowstone National Park in 1988. Several of these fires either began on or expanded to adjacent public and private lands in the surrounding area.



COURTESY OF THE AUTHOR

I Was There

Bob Barbee, Superintendent of Yellowstone National Park during the 1988 fires

Bob Barbee *was the superintendent of Yellowstone National Park from 1983 to 1994. Following a stint in the U.S. Army and earning a BS and a MS in Natural Resource Management from Colorado State University, he began his career in the National Park Service as a seasonal ranger in Rocky Mountain National Park, then worked in Yosemite National Park, Big Bend National Park, and Point Reyes National Seashore. In addition to his 11 years at Yellowstone, he served as superintendent of Cape Lookout and Cape Hatteras national seashores, and Hawaii Volcanoes and Redwood national parks, and as director of the Alaska Region before retiring from the National Park Service in 2000.*

The great Yellowstone fires of 1988 were one of the epic events of my life—vast, complicated, and confusing. The fires were character-building and humbling experiences for many of us involved and they served as a catalyst for the fire community to refocus on fundamental questions regarding the role of fire in natural systems. Hundreds of articles and books have been written in an attempt to depict that summer, each with a different perspective. About 25,000 individuals contributed to the management efforts as the fires grew in intensity and area over the course of the summer. Each of those individuals has a story and I offer my perspective and lessons learned from the '88 fires.

In his excellent book, *Fire in America: A Cultural History of Wildland and Rural Fire*, Steve Pyne noted that "fire is among the oldest words of any language." He also said, "Man's relationship with fire has always been ambivalent." E. B. Comeric, a familiar name in applied fire ecology, made an excellent summation of the role of fire on our planet: "The earth, born in fire, baptized in lighting, since before life's beginning, has been and is a fire planet." Fire has shaped the Yellowstone landscape since the retreat of the glacial ice masses. The vegetative ensemble in the Greater Yellowstone Ecosystem is a result of regular patterns of fire behavior. Because of studies of Yellowstone's subalpine forests conducted in the early 1980s by Bill Romme, park managers knew that Yellowstone was visited by great fires in 1705 and 1850.

Despite knowledge that a great fire was possible, the Yellowstone fire program became routine in the years prior to 1988. Between 1972 and 1988, there were 140 small fires in the park averaging about 250 acres per fire. Year-to-year weather patterns were similar between 1982 and 1988: mild winters with about 60% of normal snowpack and above average spring precipitation. Summers were cool and moist with 200% of normal precipitation. If area land managers had any expectations about the 1988 fire season weather, they were for conditions similar to the previous six years. The Greater Yellowstone Coordinating Committee (GYCC) met regularly in the 1980s. We were a collegial bunch, got along well, and had a lot of issues: grizzly bear recovery, outfitter policy, and cross-boundary communications. Fire, however, was simply not in our scope. We believed our protocols were in place if asked about fire. The subtle differences of suppress, confine, contain, control—that semantic swamp that fire managers have to lead agencies and the public through—were not part of the GYCC manager's working vocabulary. Neither were energy release components, escaped fire situation analyses, decision trees, nor flame length-height ratios.

During the summer of 1988, there were routine, small fires underway in Yellowstone. I recall our Chief Ranger Dan Sholly announcing at a staff meeting, "We have a couple of fires going. We might even get some acreage this summer." We had the expectation and the hope that we would get a little acreage out of the fires at the time, but we were not hoping for quite that much. Nineteen eighty-eight proved to be different. The June rains which ended previous fire seasons did not come. A series of high pressure systems developed cold, dry fronts, frequently with lightning. Forest fuels dried out and single-digit relative humidity was frequent. And then there was the choreographer, the wind. Hot dry winds became more frequent and the ingredients were in place for the perfect storm, though we did not realize that early on.

Yellowstone's fire policy at the time had been in place since 1972. It was referred to as "natural" fire management. This policy allowed some lightning-caused fires to burn, but recognized the ongoing impacts of human activities such as accidental ignitions and the need to control fires that threatened human life or property. In mid-July, the USDA Forest Service announced it would not "accept" a fire on the Targhee National Forest to the southwest, meaning the fire would have to be controlled

Media and the '88 Yellowstone Fires

Joan Anzelmo
Yellowstone Public Affairs Officer during the 1988 fires

Those of us involved in the historic 1988 fire season grew quickly over that summer. I had the benefit of working for Bob and in Yellowstone for a number of years prior to 1988, which gave me an edge. Though I did not know much about fire, I knew Yellowstone and the resource issues. I recall driving Dunraven Pass my first summer in Yellowstone with Superintendent John Townsley, Bob's predecessor. As he pointed out vast areas of Yellowstone, John said, "Mark my words, this is all going to burn someday and it's going to burn really, really big." Certainly, John's prediction came true!

Yellowstone was in the news long before the fires of '88 came. We had quite a public affairs infrastructure and had established good working relationships with local reporters. My philosophy toward the media was to be open and accessible, to make sure that we provided the public with information. It was not the trend at the time, but Bob supported providing access to the media.

I operated the same way I always operated when the '88 season arrived: I listened to Bob and then went out there and just told the truth. I answered the questions as fast as they came. The local reporters, who had frequently covered fires in past years, already knew the language. But by the middle of July, we had reporters from every media outlet in the U.S. as well as many from around the world. We had about 2,000 news media just that summer and they all came back in force the following year. Prescribed natural fire policy was in place at the time. That is an awkward term for main-stream America. Instead, we used the casual terms of "let burn policy" or "let burn fires." Looking back, I would have stricken the words "let burn" from our vocabulary. Instead, we would have talked about new fire ignition, monitoring, and managing and all the terminology that we use today in a much more proper way.

I also would have changed how we visually presented fires to the public. I have often thought how foolish we were to show maps with giant black blotches almost like amoebas growing each day and eating up Yellowstone National Park. Of course the public would be shocked by this pristine place seemingly getting gobbled up by fire.

I was not surprised that the news media increased their coverage of the fires proportionate to the growth and complexity of the fires themselves. Yellowstone National Park became "the story" of the summer. The world's first national park was on fire and it did not matter how much information we put out to try and give a truer picture of what was happening. The story was going to be told the way the masses of media chose to tell it: Yellowstone was burning up and being devastated. Fortunately we got a "do over" in 1989 and we were able to more thoroughly tell the story. Bob went on a world tour that year with tourism industry officials to let them know Yellowstone was alive and well.

I learned so much over the summer of '88 and have gone on to apply those lessons in all of my subsequent jobs. I would like to share the "end-of-summer" letter from Bob to Yellowstone seasonal employees. The summer was far from over on August 23, but Bob wrote:

> *In spite of the tedium and inconvenience that accompanies living with forest fires, we are experiencing a renewal that will only improve the health of Yellowstone in the long run. We are temporary stewards here, if we can stand back and see Yellowstone from the perspective of its long past and even longer future, we should be able to face our continuing challenges with resolve and optimism.*
>
> *Thank you again for your support and dedication.*

YS

CHRISTOPHER TOMLINSON, GRAND JUNCTION, CO

Joan Anzelmo is currently the superintendent of Colorado National Monument.

before it reached the forest. The park announced that all new fires in Yellowstone, including "natural" fires not caused by humans, would be suppressed unless they were ignited by lightning and were adjacent to existing fires. This also applied to the Storm Creek Fire on the Gallatin National Forest and the Mink Creek Fire on the Bridger-Teton National Forest. From there on, every fire and every ignition was treated as wildfire, or fire that threatens human life or property, and there were increasing ignitions. The complexity of the fires in the park and the surrounding forests resulted in the establishment of a Unified Area Command. The first order of business was for the professionals to explain to all of us managers what an Area Command was. Though some folks knew about it, the rest of us found out in a hurry. [A Unified Area Command oversees the management of multiple fires being handled by separate incident teams across multiple jurisdictions.]

In the course of that summer there were 26 Incident Command Teams, Type 1 and Type 2, that transitioned in and out of the park. Some of them came twice. As conditions worsened, there were endless VIP briefings for members of Congress, their staffers, state and local officials, and so on. Secretary of the Interior Don Hodel visited Yellowstone twice. He was a quick study and he supported his troops 100%. We owe him an enduring debt of gratitude.

The national media went into a frenzy and outdid themselves searching for high drama in the Yellowstone fires and described them with high octane hyperbole: "Nature gone mad." "The visitation of a capricious and a vindictive god." "The government land managers have pursued a flawed policy and rode it to Hell"—that was not what I wanted to see when I picked up the newspaper. But there were exceptions and particularly fine local reporting, including that by Rocky Barker of the *Idaho Falls Post Register*. Joan Anzelmo was the Yellowstone Public Affairs Officer at the time and I've asked her to tell the story of the 1988 media in her own words (see sidebar). She is a woman of unequalled talent and deftly managed the media from beginning to end.

The onslaught of media and parade of VIPs were new to the National Park Service. Among them was presidential candidate Michael Dukakis, who came with a planeload of reporters after Black Saturday, August 20. I met him in West Yellowstone and in a moment of chitchat, I finally asked, "Why are you here?" He replied, "Well, I'm not here to hassle you." I was grateful for that. He said, "The reason I'm here is that you're the only game in town. There's nothing else going on and this is my way of demonstrating support for the West." We held a press conference with him at Madison Junction. I introduced him to the crowd, which included 200 reporters. Sam Donaldson was in the audience and quizzed Dukakis about his views on gun control. It was kind of an out-of-body experience—the questions were completely irrelevant to the chaos of Black Saturday.

There are several observations and lessons learned from the 1988 Yellowstone fires that I would like to share, which continue to be relevant and influence park managers. First, the reactions to the fires reaffirmed that our political leaders reflect the passions of their constituents, and at the time their constituents were anguished. When Wyoming Senator Malcolm Wallop had to land his plane on instruments in Sheridan, Wyoming, because of the smoke, he was anguished.

We learned the importance of excellent communications with the public, the media, and our neighbors during that summer. Excellent communications with the public yields good results, especially when you are winning. When you are losing, their effectiveness is more problematic. As Joan Anzelmo alludes to, policy took on a life of its own. There was great confusion among the media and public caused by the origins of some of the fires that met the fire policy definition of a prescribed natural fire. The confusion was aided and abetted by the media. The media also coined "let it burn," which became a term that we lived with.

We learned that it is easy to send mixed signals to the public. Bill Mott, director of the National Park Service at the time, tried to offer reassurance in discussing the natural and positive role of fire. This was while there were nearly 10,000 individuals working in multiple complexes on the fires, desperately trying to get them under control and we were spending millions of dollars on suppression. Mott's well-intended comments were viewed by political leaders as celebrating the fire that we were vigorously trying to get under control. The message at the time should have been to compliment and encourage the brave firefighters. We had the next 50 years to put a happy-face ecology story on the fires. I spoke with Mott about this and said, "People are confused, let's not worry about how good the fire is ultimately and talk about what we are trying to do now. We can get to the good of the fire later."

We also learned that there would be no shortage of pundits and Monday morning quarterbacks. There were thoughtful and serious reviews, and there were also those who seemed

NPS, YELL-185379

Bill Mott, director of the National Park Service, helped put out a small fire near the Thorofare Ranger Station during a visit to the park in summer 1988.

Advice for Young Fire Professionals

Bob Barbee

NPS/JIM PEACO

Democratic presidential candidate Michael Dukakis and Superintendent Bob Barbee at a press conference in 1988.

I WAS A YOUNG GUY when new fire management and policy was emerging, but I recall that there were disagreements within the National Park Service about the notion of bringing fire onto the land. I was sent to graduate school with the idea that I would return to the Service and implement the recommendations of what is now known as the "Leopold Report." This report outlined a strategy to put the management of the national parks on an ecological basis. I expected the notions that we were bringing to the table to be embraced, not discouraged, but I was not necessarily greeted with open arms when I arrived at Yosemite after graduate school.

Harold Biswell—one of the fathers of modern fire ecology, and a really wonderful guy—was a professor at Berkeley, but he also was a showman. He and I would put on little press conferences at Yosemite for the media. We would start little fires and put our hands underneath the pine needles to show that the fire was not scorching or sterilizing the earth. In addition to the technical knowledge, we must consider the value of public relations. The technical part is often the easy part; it is selling the program with humor and sincerity that is at least half the effort. Developing some salesmanship skills helps carry your program forward.

For believers in this fire program and those who are up-and-coming, remember that you have to go about your work patiently, even inch along. We build on the past. You have to realize that you are not always going to carry the day and that good data and plausible explanations do not necessarily yield understanding—people do not necessarily embrace things. It is a long, slow process and my counsel is persistence and patience.

Organizations are designed to police the status quo. Adventurism is not rewarded or encouraged because it rocks the boat. Neither are zealots embraced or welcomed. When you are pursuing programs that are new and somewhat innovative or are pushing the outer limits, you need to almost expect that there are going to be casualties. That is just a fact of life. Sometimes being watchful of adventurism means you go to the outside, bring experts and spokespeople in, and let some of the zealots do your work for you. Policy is never forever; it continues to evolve in the bureaucratic environment that we operate in, especially in the world of fire.

to specialize in coming out after the battle to bayonet the wounded. Fortunately there were not too many of those. We learned that nerves can become frayed and that once friendly neighbors can become anguished, even hostile.

We certainly learned that technology had its limits and that there will be fires in the forest and that they will burn at times no matter who does what, when, or how, just as they did in the big fires of 1910 in Idaho and western Montana and in the Great Black Dragon Fire of 1989 in which 18 million acres burned in Russia and China, destroying towns and killing many people. We continue to be reminded of this lesson as fires burn each year.

We learned that smoke is a depressant and we had a lot of it that summer. At its worst there was no wind, so there were no runs, which meant that the fire commanders did not know where the fire was for sure and they had to get their information from infrared flights. There were lots of technical challenges and, now, amusing recollections.

We learned the importance of maintaining a sense of humor—this does not mean that you are not taking things seriously. Here are a couple humorous moments from 1988. Paul Schullery, a historian, colleague, and friend, spoke of an acquaintance who remarked that she liked the burned areas because as she drove through the park they broke up the monotony of the beauty. I still puzzle about that. Hayes Kirby, a long-time resident of Cooke City, Montana, announced, "Ecology is dead in Yellowstone." He also announced that the entire park had been reseeded from an airplane at night so the forest would grow back. I remember one day I got on the phone with a man who was dead serious and said he had the solution: "Get a whole lot of water beds, fill them up, and load them up on one of those big airplanes. Then fly around and drop them on the fire and it will go out." I said, "Well, thank you very much, we hadn't thought of that."

The Yellowstone fires were certainly the character-building experience of a lifetime for a lot of us. They were a humbling experience and served as a catalyst to refocus on fundamental questions regarding the role of fire in natural systems and the conditions and limitations of its use. The '88 fires reaffirmed that nature is not always a gentle hostess, but she never fails to be an inspiring teacher. To this day I believe the Yellowstone fires of 1988 were unpredictable, unpreventable, uncontrollable and, finally, unimaginable.

YS

COURTESY OF THE AUTHOR

I Was There

Orville Daniels, Forest Supervisor of Lolo National Forest during the 1988 fires

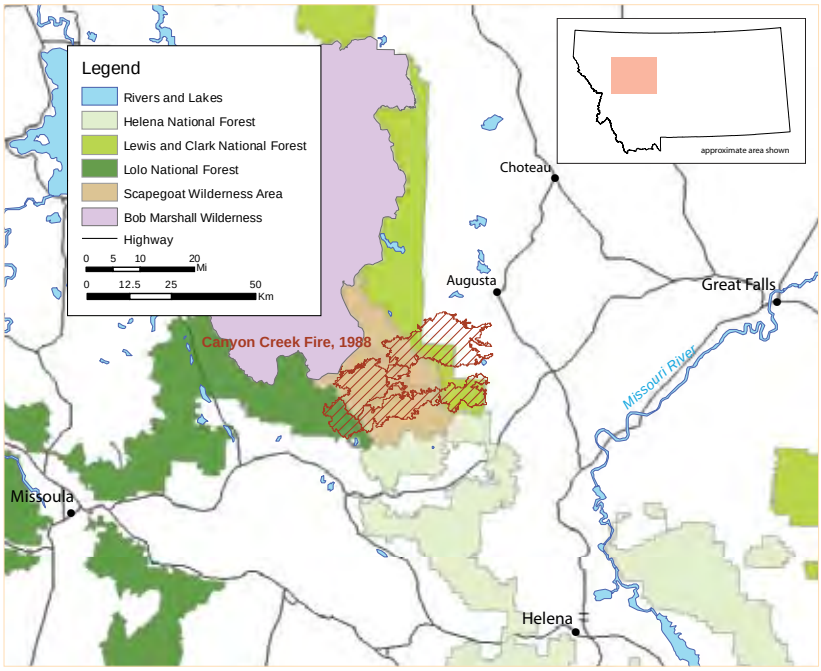
Orville Daniels *was a pioneer for prescribed natural fire in the USDA Forest Service. In 1988 he had the unique experience of being in charge of the Canyon Creek Fire in Montana, the fire no one heard about even though it burned nearly 250,000 acres, making it the largest prescribed natural fire on record. In 1957, after graduating as a forester from Colorado State University, Daniels began a 37-year career with the Forest Service as a field forester, district ranger, staff officer, director of the Job Corps Center, deputy forest supervisor, and as forest supervisor of the Bitterroot and Lolo national forests in Montana. In 1970, Daniels worked with others to prepare the first official prescribed wilderness fire program in the Forest Service. Since his retirement from the Forest Service, Daniels has been a trainer and consultant for the Forest Service, the National Park Service, the Bureau of Land Management, and a variety of private organizations dealing with strategic planning and organizational effectiveness.*

The steering committee gave me a lot of latitude in what I could say here. They said, "You were there." I was there not only in 1988, though that was the defining moment that changed a lot for me, but I was there early in the 1970s. I have a long history as an observer of fire management, sometimes as a participant, but mostly an observer. It is an important story. I hope there are some congressional staffers in the audience or others who are involved in policy that are trying to learn from this and if there are not, I would like to charge all of you to make sure that we get the message through to those people. I would like to talk a little about the fire community. We have done some wonderful work in the past, but there is still a lot to be done and a lot to learn. I am glad to see some folks here who still have a quite a bit of color in their hair and will stand up here 20 years from now talking about what we have learned.

I want to talk about Canyon Creek and share some experiences with you, but I want to go beyond that. I want to look at a little bit of the history of fire management in the federal agencies because there are some lessons to be learned there. I also want to talk about what has happened since '88, where I see the future going, and the challenges that we face.

I want to talk about those 18 years between the time I got started in fire management and '88 because it has some lessons for the fire community. In the 1970s, the National Park Service had the Leopold Report, a wonderful piece of work that got the agency started in restoring fire as a native ecological process to the landscape. The Forest Service started to emulate what the National Park Service was doing with fire management—and this is the story I would like to give to the folks who are going to be here 20 years from now. Scientists from all of the agencies and from Canada put together a working group to push the Leopold concept in the all of the federal land management agencies. Agency officials sanctioned the meetings, but the support was so low that the meetings did not have agendas because they did not want folks to know they were going to talk about fire management and putting fire back on the land. Bud Moore, who is the godfather of fire management in the Forest Service, came to Region 1 as the director of fire management with the sole intent of trying to get fire back on the landscape. After he got the job, he told his boss that he was going to do that. His boss said, "That's fine, but if it fails I will not support you and I will not say I knew you were going to do it."

My first fire was in '73. It was a pretty good fire—two or three thousand acres. It was the first in the Forest Service system to be approved by a line officer and conducted in the open instead of in the closet, which was how some had been done before. Those were tough times, folks. The first national fire management conference in 1973 was held in Missoula, Montana. Only 24 people showed up. They got in three vans to take their field trip. Only 24 people really had the vision, four of whom are here today and still involved in fire management. There were only 44 people in attendance the next year. The lesson here for future generations is that *a small group of people can make a big difference if they are dedicated and have persistence*. The folks who had that vision and worked toward it are unsung heroes. They changed the bureaucracy and by 1988 we changed the nation's perspective on fire. We are going to need



The final perimeter of the Canyon Creek Fire in western Montana, 1988.

that kind of dedication for the future. It takes persistence and patience—that is a message for folks just getting in the game.

Until 1988 there had not been much fire in the Northern Region. The 5,000 acres that burned at Charlotte Peak in 1985 were not enough. We just could not get the forest to burn. But by '88, we had 350 fires under our belt, just as Yellowstone had fires. Many of them were under prescription and we only had trouble with a couple of them. We thought we knew what we were doing; we thought we had the knowledge. On June 25, 1988, we had a fire start in the Bob Marshall Wilderness Complex—the Scapegoat Wilderness—and the ranger put it under prescription, meaning it was permitted to burn. I did the next prescription, for the Canyon Creek Fire, so I was personally responsible for everything that happened as a result of it. By the middle of July, under our plan, we had to reassess anything that started before July and decide whether or not to keep it under prescription. The Canyon Creek Fire was rather slow to start and did not burn very much at the beginning. I was hopeful that we would have a few acres burn—that we would get enough to begin to show what could happen in the Bob Marshall Complex with fire.

Then on July 25, almost 10,000 acres burned on the Canyon Creek Fire in an afternoon. I was driving down the street in Missoula because a forest supervisor, like a park superintendent, has lots to do and cannot just focus on fire activities, which I would have loved to have been able to do. I looked to the northwest and there was a cumulus cloud out of my windshield. "That's strange," I thought. I looked all around the horizon and there were no other clouds. I said, "Hooray! It must be burning." And it did—it burned 10,000 acres and I was happy. It burned a mosaic, which we hoped for. Not all of the area burned and it looked good. But, as in Yellowstone and the rest of the West, even though we thought the drought was over, the season-ending event never occurred. In northwest Montana, we can *promise* you that it will rain during Fair Week in Missoula, which is usually the second week of August. In fact, it did for 23 out of 25 years. But we never had that middle of the summer rain that year. So the fires continued to burn.

We managed the Canyon Creek Fire for 65 days before it escaped prescription and went onto private land. At that point we put it in suppression mode. It was still functioning fairly well until September 6.

Let me share my perspective with you: I was responsible for this fire and going to the daily briefings and it was beginning to make me nervous. Then the meteorologists said to me, "There's a jet stream coming at a low elevation in the Rocky Mountains." This was 48 hours before it hit. I asked, "Where is it going to hit and when?" The reply? "We don't know." I asked, "When are you going to know?" The meteorologists said, "When the weather balloons in Spokane tell us that the winds are up there." "And can you predict where it'll hit?" I asked. "Not even then." So here I am with 60,000 acres of fire, the Yellowstone fires to the south, and all of the other fire going on in the West, and we did not even know where the jet stream was going to hit. Imagine the feeling of that. Every 12 hours I would go back and get a briefing and they still did not know. On September 6 at about sunset, the meteorologists said, "It's coming your way." The lookouts in Idaho were beginning to pick up the wind. It was coming our way. But we still did not know whether it would hit Canyon Creek or Gates Park or Yellowstone. We figured it was probably headed toward Canyon Creek, but we knew it might veer a little.

So what do you do when the meteorologists give that projection at night and you have all those firefighters out there? At the time under suppression, we had people all out in front of it on another forest, though I did not have responsibility for them. So I drank a beer and went home and went to sleep. But I ordered a helicopter first, because I figured I would have to take a helicopter the next day and go out and see where the fire was, because it was not going to be where we wanted it to be.

The smoke in Yellowstone was typical fan-shaped, gradient wind-slope. Canyon Creek had a tightly constricted smoke pattern, an effect of the jet stream. The jet stream did hit us and 180,000 acres burned in 16 hours. It was the fastest spread of fire in coniferous forests on the North American continent at the time. The stories from the people that were in front of the fire and in the fire are impressive.

It was wonderful to hear about Bob Barbee's experience

in Yellowstone because my experience was similar, with the exceptions of dealing with the media and the ability to suppress with big forces. Thank goodness for Yellowstone from my standpoint, because it kept the pressure off of me. All of the war stories that managers from Yellowstone tell about the media and suppression action did not occur on the Canyon Creek Fire. For one thing, Yellowstone had all the resources and even when we wanted to suppress the fires we could not because we did not have the resources. That was okay—the resources should have been at Yellowstone.

We both thought the summer would be different, but it was not. Nineteen eighty-eight was humbling. Bob used the words and I will use them. I think it was the most humbling experience of my career and if I had much arrogance about my knowledge of fire going into it, I lost it very quickly. In 1988, we promised people that the Canyon Creek Fire would not come out of the wilderness, but it did. We had some large fire experiences before 1988, but we did not necessarily learn the lessons from those fires. I hope we have all lost that arrogance, because we still have a lot to learn.

I think the '88 fires were appropriate in both Canyon Creek and Yellowstone. I am glad they happened. Large parks and large wilderness areas should be the benchmarks from which we learn how nature functions; they are critical parts of that business. In many ways, Bob and I fulfilled a role that was essential. We were able to try some fire management ideas because we had large land masses. In 1988, 775,000 acres burned in Montana outside of Yellowstone. There were 37 fires. That had not happened since 1910 or 1919. It was a year of awesome proportions all over the West.

Canyon Creek was a defining moment of my life. Every year for 15 years after the fire I presented my experiences from '88 at the National Advanced Resource Technology Center (NARTC), a national training center in Phoenix and Tucson, Arizona. I showed a video about the history of fire in the area through '88. In 1989, the Forest Service made this video available for free rental in Montana stores so people could try to understand what was happening. We used the Canyon Creek Fire as a case study to train line officers, park superintendents, forest supervisors, and others at NARTC. I relived this fire to help others learn from my experience.

Something that Bob exhibited and I tried to exhibit during these events is that if you are leading one of these efforts, the main thing you must do is not panic. When nature takes over, follow that old edict in *The Hitchhiker's Guide to the Galaxy*, "Don't Panic!" That is a phrase we all should know. If we play with fire and these things happen, for goodness sake's *don't panic*, keep your balance. Realize, as the folks in Yellowstone did, that it is not the time to try and sell your fire philosophy. It is time to talk about the crisis you have, because that is what the people want to hear. You can still think to yourself that the program is good and the forest will come back, but that is not what you should be talking about. You should be dealing with the emotions of the people. Don't panic. That is a great lesson we can learn from these events.

After 1988, we put in a drought index, we put in risk assessment, we put a maximum perimeter on fires, and we said we have to make an analysis of the availability of equipment. We asked ourselves, do we have suppression capabilities? Are we exceeding our suppression capabilities? If you do, start putting out the fire as best you can, but do not go beyond that.

The lesson here for future generations is that a small group of people can make a big difference if they are dedicated and have persistence.

We learned that we seriously underestimated the fire history of the Canyon Creek country. We did not expect that the fire would burn so much acreage—we thought the previous fires had burned in matrices, but they did not. Our prescriptions and our plans were the best we could do. Some really good people worked on them with a lot of heart and a lot of dedication. After the fire we dug deeper into the fire history. There was a similar fire in 1899 and it almost burned up the two towns that we almost burned up, Choteau and Augusta. That country burns fast only when it is ripe to burn and then it burns big. We had not fully understood that.

We did not understand our ecosystem well enough. The people who surveyed what is now the Bob Marshall noted that the area was 60% burned non-timber and shrub fields and another 30% was in recovery from burns. At the time we had our plan in 1988, the Bob Marshall was mostly tree covered. The lesson from this is: *do your fire history*. We have changed the landscape of the Canyon Creek area in the past century or so. It is not springing back after fires. There have been a couple of fires in the same area and we believe it will not come back to lodgepole and trees and alpine fir. It will be a shrub field. We are reestablishing the pattern that was there before recorded history, so to speak.

Nature gave us a glimpse into the future with the fires of 1988, particularly in Yellowstone. After '88, fire management changed and we had an idea that this country would burn big, bright, and hot, and it did. The Forest Service, particularly Region 1, had a couple of programs that continued over the years. The Selway-Bitterroot prescribed natural fire program kept natural fire on the landscape starting in 1973 through today. When the fires of 2000 hit the Bitterroot, the fires in the Selway did not come out of the wilderness because previous fires had burned a matrix and managers had already treated the fuels through natural fires. I am not sure we have

assimilated that lesson from those experiences yet. We have had re-burns and can now study what happens. These studies show we are going to a vegetative condition that has not existed for a long time.

I hope we have learned that we cannot trust politicians; they will hang you out to dry. They do not care about fire management on the land, they care about the next election. It is as true today as it was in '73 and '88. Our program is still fragile. A reminder of this is the Cerro Grande Fire of 2000, which was started by the National Park Service as a prescribed fire in Bandelier National Monument and eventually burned 47,000 acres of public and private land, including 18,000 acres of Los Alamos, New Mexico. The Secretary of the Interior wanted a scapegoat to be held responsible for the 235 houses burned and the National Park Service lost one of the best fire management teams they had. The board of review, which came much later after the scapegoating, said the team had a good plan, that they had followed it, and that it had been approved. I got the same board of review outcome for the Canyon Creek Fire and I survived. But that fire team took it because it was politically necessary to find a scapegoat. This is a legacy the fire community will face as you continue to put fire on the land. The community needs to be cohesive and stand shoulder to shoulder when these things happen. The fire community either hangs together or we hang separately; there is some interagency rivalry that we have to eliminate. The Cerro Grande Fire scapegoating really shook my confidence, almost as much as '88 did.

What will we talk about that we have learned at this conference 20 years from now? The fire management community is going to have to change. I believe we need new mechanisms to develop policy for wilderness and park fires and fires on the landscape. The way we have been setting fire policy is through politicians in the political system, bureaucratic folks, people in the agencies, and academia and research, but it is a fractured system if you want to set long-term strategy. The system is not geared for long-term strategy and we need some of that right now. I do not know what the answer is; I wish I did. Maybe we need new ways of setting land management policy for the nation—new ways that take strategy setting out of the system's political problems that we have in agencies and in academia. Agencies and academia have weaknesses when it comes to long-term strategy setting. Politicians by nature are concerned about their constituency and elections. I learned early to not fall on my sword. You have to be an idealist and know what is behind the question you have, but be pragmatic about it. If what you are doing is not working, back off and find another way. Keep your ideals, be persistent, but find a way to make it work. Otherwise you will be a casualty off on the side. If you become adventuresome, you will find that the system will increasingly discredit you. You have to stay within the system and make it work.

Agencies do not have time to fight budget problems. No one has done a full high-quality evaluation of the past effects of the fire programs in Region 1, including the Selway and the Bob Marshall. This is not being evaluated for its future importance because of money. We need to make sure we have learned those past lessons for the future, because they have basis. In spite of everything, I wonder if we need something nonpolitical that transcends time like the Federal Reserve System for resource management and land management policy in the country. I do not know what the solution is, but we need something better. We have to be patient enough and persistent with policy change to be effective. We have to be patient enough to understand the political scene we are working in and turn it in our favor. We have to know our own inner selves and what we believe as a fire community and be pushing it consistently. That is what the early fire people did. They would go any place in the nation where there was a criticism of a fire management program and try to set it straight. They did a marvelous job.

Fire managers have tried to look at our fire history and emulate it, though now we have complex, complicating factors—social, economic, and wildland-urban interface. Fire in wilderness and the big national parks has to be the benchmark for the rest of our forested landscape in the nation. We know that what we have done is good. There are more heroes in this room than I can shake a stick at. There are good suppression people, fire people, and policy makers. But I believe that the future we face means we have to adapt and change how we work. It is not going to be good enough to know how the ecosystem burned before we settled this country and try to emulate that. The conditions and fires that are coming and our solutions are going to be new. But, regardless of what you do, especially if you are just getting into the game, do not vilify the past. People in the past were doing the best with what they knew, just as you will.

There are more permanent changes on the landscape. No matter how global warming is caused, it is happening and the effects are beginning to show very quickly. Two degrees warming of the climate allows the mountain pine beetle to evolve into an organism unlike any organism we saw four or five years ago. We are going to face this. The fire community needs to be on the cutting edge of fire ecology and sell this knowledge to the people within our own agencies, in addition to the media and students. I believe that what we think within the fire community will eventually extend to the public. We need to be ahead of the game.

In summary, 1988 was a learning experience. I am happy for what we have learned from those experiences and for the wonderful work of the fire community. I am so proud to be a part of this management community. The distance we have covered is miraculous though I fear that the challenges of the future will make it hard for us to make the same kind of progress that we have made in the past if we do not have some systems kind of approach to help us with policy setting. Thank you very much.

YS


NPS

Science and the Media

John Varley, Chief of Research of Yellowstone National Park during the 1988 fires

John Varley *holds degrees in zoology and entomology from the University of Utah. In 2007, he was also awarded an honorary PhD of science by Montana State University. He spent the first 20 years of his career as a fisheries researcher and manager, including a nine-year assignment with the U.S. Fish and Wildlife Service's Fisheries Unit in Yellowstone National Park. Varley was one of the leading forces in the resurgence of Yellowstone fisheries in the 1970s. He served for ten years as chief of research in Yellowstone and is the author of dozens of scientific publications on fish, wildlife, and their management. In 1993, he was appointed the founding director of the Yellowstone Center for Resources, and was one of the principle architects for the restoration of wolves in Yellowstone. Varley was appointed the executive director of the Big Sky Institute at Montana State University in 2007.*

Roy Renkin, who is sitting up here, told me that I'm here because I was there. And when 20 years passes by—there are fewer of us here that were there. In 1988 when forest-consuming fires unparalleled in human memory were sweeping across Yellowstone National Park, television, radio, and print media, local and national politicians, and indeed the American public believed these fires were causing devastation on a scale never before seen, at least not by anyone then alive. The media might have given their story this way: "Yellowstone National Park died yesterday after a brief illness. According to reliable media reports, the cause of death was uncontrollable fire exacerbated by misguided federal policy." Now that was just for starters. The obituary went on: "according to business sources in Gardiner and West Yellowstone the death was entirely predictable because the National Park Service has been searching for a way to shut down Yellowstone's gateway communities for decades and they've finally done it." Well, I made that up. But this attitude on the part of the media, who were my heroes prior to 1988, gave me the essence of this talk. In the immortal words of Charles Dickens: "It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, … it was the spring of hope, it was the winter of despair.…" I couldn't construct a sentence that describes 1988 better than these words of Dickens. It describes my 1988 and my 1989 to a T.

In reality, that fateful year, there were two big megastories relating to the fires. One story spoke to the largest firefighting effort ever assembled up to that point. An extraordinary effort that ultimately involved some 25,000 fire fighters, an air force of hundreds, and cost $140 million. There are many people at this conference that can tell that story better than I can, and I will happily yield it to them. Except for maybe one short story:

In early September of 1988 the order came down to "prepare the defense of Mammoth Hot Springs"—meaning that they expected the North Fork fire to make a run on the little park headquarters town. At the time, I lived in an 80-year-old house on the periphery of Mammoth. It was of wood-frame construction and had a 35-year-old shake shingle roof. It goes without saying that I had a little concern about that house going up in flames. This caused me, at one point, to put a lawn sprinkler on the crest of the roof to start to try to waterlog those shake shingles. Being a good scientist, my first critical observation after turning the sprinkler on was to notice that there was no runoff from the shingles. Now I call that a clue. I marked the time I started the sprinkler and it took almost 30 minutes for the first drips to come off the eaves, and even then it was a slow drip... drip... drip. That worried me.

My colleagues in town gave me a lot of grief over that sprinkler; like I was some kind of hegemonist or maybe even a heretic. That concerned me too, until I realized that they were in houses with tile or metal roofs. So I kept sprinkling. Then a crew and pumper truck from the California Department of Forestry showed up and started laying hose all around my house. Now, I knew that these guys knew wildfire real good—better than real good. They actually made me nervous. I said

NPS, YELL-12810-34

More than 3,000 reporters visited Yellowstone in 1988.

to myself, "If they're laying hose all around my house, they must know something I don't know. They think it's gonna burn down." Kind of goofy thinking—but maybe not. Those Department of Forestry guys from California would sort of look out of the corner of their eyes at me and watch me teetering on top of that roof, moving the sprinkler around. They probably (correctly) concluded that I had higher odds of falling from that roof than it going up in flames. But they watched me for about 24 hours. They were very vigilant. They watched me precariously gamboling around that roof as I tried to soak each and every shingle. Finally, one time after I had successfully gotten off the roof and down the ladder, the whole crew approached me with serious looks. They said, "Mr. Varley, we are not going to let your house burn down." I paused to let that sink in and said, "Oh. Okay." Then I went and turned off the tap to the sprinkler.

And by golly, they didn't let my house burn down. Or any other house in Mammoth, for that matter. By September 10 the North Fork fire was indeed at Mammoth's doorstep. But on September 11 we got a pretty good rain and snow storm across the entire park, which pretty much stole all of the fire's energy and put the fire down for the year. Not out, but it never recovered from that rain and snow. By the night of September 11 that little frame house was cold enough to prompt me to fire up my wood stove. At the time I couldn't quit thinking of the irony of my previous few days and that bittersweet relationship we have with fire: one minute I was loading my cars with my most precious possessions in case I had to flee and just a little later I was lighting a fire in that same house to take the chill out of the air. That was certainly not the only irony of the summer, fall, or winter. I pondered greatly over one fact: How could it be that one quarter inch of rain and snow defeated those fires, when massive firefighting efforts could not? My own conclusion was then, and still is, that it might not be nice to fool with Mother Nature.

The other big megastory about the fires of '88 covered what was *really* happening to one of America's most beloved landscapes. Not in terms of close calls or heroism or attack strategies or retardant bombers, but what was *really* happening to the forests, meadows, shrublands, lakes and streams. What was really happening to the wildlife? What about those threatened grizzly bears and the bison, elk, trout, and all the other creatures? In other words, what was happening to the 99% of Yellowstone that was *not* human infrastructure? One reason it was the lesser told story in the media was that, frankly, most of the 3,000 reporters that cycled through Yellowstone in 1988 were only there today to find tomorrow's headlines, the more lurid, the better. Most reporters had no interest in scratching beneath the surface unless it fit their accepted story line. This is what Ohio State University journalism professor Conrad Smith called the "disaster-victim-villain" story line. Who were the players? The fires in the park were the disaster. The victims were the visiting public and the people in the gateway communities who were losing business. The villain role was played by none other than America's most popular federal bureau, the National Park Service and their villainous natural fire policy and program. The press subsequently named it the "Let It Burn" policy. I admit there was certain logic to the nickname. The way they played it, it made some sense. I mean, there were never-before-seen conflagrations in the mother park. That means somebody must have screwed up, doesn't it? The Park Service had allowed several fires in the early summer to be managed as natural fires. Surely, that must mean the natural fire policy was responsible for those huge conflagrations. A federal agency is in charge and everyone knows they can't do anything right. According to the media, it had everything we need for a good villain. During that summer, Yellowstone's superb public relations chief was Joan Anzelmo and, to me, she was a genius. She screened all of the reporters. Those that were hunting for the disaster-victim-villain story headlines, she sent this way or that, or over there. All of the reporters that I had to deal with

If reporters had emphasized the sciences of fire ecology, landscape ecology, conservation biology, plant and animal ecology, … millions of Americans could have been exposed to an ecological perspective that was new and completely foreign to most of them.

were those journalists who wondered out loud to her about "what might really be going on, what's this really doing to the park." The few environmental reporters sent to cover the story did a good job, as did the press from the regional media, but very few media organizations had environmental reporters in 1988. This included the big flagship newspapers like the *Wall Street Journal*, so they searched their ranks and found a reporter who had been fishing on a few occasions, and sent him. He was a nice guy. Clueless, but nice. And he eventually pieced together a fairly predictable story. His best line was "[the park is] a smoke-blackened ruin." A ruin! He should as well have stayed home and wrote about the swollen pink pork-belly futures or some such thing.

I showed no particular genius when talking with reporters or the public or state or federal policy makers. I merely told them science stories from the substantial body of work that many researchers had done on fire in our kind of ecosystem. There was a pretty good assemblage of research done in Yellowstone and Grand Teton and in the national forests surrounding the parks. Had the reporters done their homework, which I was under the mistaken impression was their job, then maybe they would not have been quite so clueless. If the reporters had emphasized the sciences of fire ecology, landscape ecology, conservation biology, plant and animal ecology, and long-fire return ecosystems (the category that Yellowstone's fires fall within), millions of Americans could have been exposed to an ecological perspective that was new and completely foreign to most of them. The fires were not destroying nature as the mainstream media were reporting. Instead, we proclaimed that the fires were doing the exact opposite. The fires were cleansing and renewing these ecosystems, assuring that this landscape would be perpetuated for centuries into the future. Not only was the concept foreign to most people, but it was also contrary to Smokey's long-time admonitions and contrary to Walt Disney's stories. Now those are formidable opponents.

According to noted historian and environmentalist Roderick Nash, Disney's animated film *Bambi* is "the most important document in American cultural history influencing the public attitudes about fire management policy." After the fires, I looked into that subject myself and read Felix Salten's original book, *Bambi: A Life in the Woods*. And Uncle Walt did not get the story line exactly straight. In fact, he got it backwards. Going public with the radical new story "Fire is Good" was viewed by many of my friends and colleagues as a risky gamble. Some of my reporter friends told me that it sounded like a concocted story that only the National Park Service could conjure up to justify what was going on. That view, when combined with the stupendous blazes, brave firefighters, angry lawmakers, an absolutely apoplectic tourism industry, plus the national media that universally covered it with the disaster-victim-villain plot line, caused the "Fire is Good" story to be viewed by many as not a very good fit. During the summer's fires and the following fall, telling the real story looked like a

NPS/JIM PEACO

John Varley (*right*) briefs President George H.W. Bush (*left*) on the Yellowstone fires in the spring of 1989.

mistake that had higher odds of leading to the gallows than to the medal ceremony. Media-savvy friends strongly advised me to take myself out of that game, arguing it was too complex to be telling two stories to the public at the same time. They (correctly) saw a disconnect in the logic between saying fires are good for the ecosystem while having the largest, most expensive fire fighting effort in the country's history still underway. They argued that there would come a time when the fires were out—*then* we could tell the "Fire is Good" story. At the time, this made sense to me and it came from people I believed in and respected. But I had doubts too. The national media was telling public untruths at worst, and were just deceptive at best. And they were getting away with it. The media would be long gone from Yellowstone when it came time to tell America the real story. Who would even be listening months after the fires were out? What possible good could we do then? Time for Charles Dickens again: "There is nothing so strong or safe in an emergency of life as the simple truth." In the end, my self-imposed embargo only lasted a few days. The national media were clearly winning the day with their untruths.

The big change in the outlook of my friends and colleagues might have occurred the night Dan Rather essentially announced Yellowstone's death and spoke its obituary. When that happened, everyone I knew wanted to counterattack. So much for the nuanced messaging stage of the '88 fires. Alastair Bath, a Canadian social researcher, was working in Yellowstone the summer and fall of 1988. I don't remember exactly what

his research topic was, I think it had to do with public attitudes about wildlife. But like Saul on the road to Damascus, he saw the light. He scrapped everything he had been doing up to that point and decided to find out what the public was really thinking about the fires. What a novel idea! By the time he hit the field in Yellowstone in 1989, Dr. Bath had had the entire winter to refine his public survey, and he was a glutton for work. Now, a word about polling here, quite unlike national polls which, if you follow those, have these magic equations or algorithms or whatever you want to call them, where they dial up a dozen people in one congressional district and 8 in another and 14 in a third and once they get 240 they make an estimate of what people think. Dr. Bath, did it the old fashioned way. By the end of 1989, he had surveyed roughly 4,000 people *at the entrance gates* to Yellowstone. This was *before* they had even seen any of the park's landscape. He interviewed another 4,000 people *after* they had viewed the "ruins" and were leaving the park. He collected an amazing sample size and it yielded results that you could take to the bank.

Unfortunately, the results came too late to make national news. But it was huge news to me. The American public was not duped by the media about the Yellowstone fires. To one degree or another, they apparently placed more faith in nature than in CBS. Around 80% of the people Bath surveyed *coming into* the park believed that fire was as important as sunshine, water, and soil in sustaining Yellowstone's landscape. I mean, those are the kinds of figures you think are cooked up. But they weren't cooked up—they were based on an extraordinary sample size. It might not have made the same news flash the Yellowstone fires made when they were raging, but it made an impression on me. I had wasted a lot of energy being angry at the news media. Oh, they were shallow, hateful, and they told untruths, to be sure. My error was in believing that they had powers over the American people that were much greater than they actually had. I underestimated the American public and I overestimated the media, which I regret.

In my diatribe about the national media, I would be remiss if I didn't add that there were some really good reporters on the scene too. They were mostly from the regional newspapers and I know a number of them are at this conference. People like Bob Ekey, Angus Thuermer, and Rocky Barker and then the feature story authors for magazines such as *Natural History, Smithsonian, Audubon,* and others wrote very accurate and really well-written stories about the fires. One of those regional newspaper reporters is Rocky Barker, who at the time was with the Idaho Falls newspaper and is now with the *Idaho Statesman* in Boise. Mr. Barker just published a book called *Scorched Earth: How the Fires of Yellowstone Changed America.* It's a fascinating take on what the '88 fires have meant to society in the last 20 years. Barker says that the fires started a public debate about firefighting and public land management that continues to this day. I agree with a lot of what he says in the book. He has done an excellent analysis. He now argues

JENNIFER J. WHIPPLE

Elk continue to graze as a lodgepole pine tree torches behind them on August 20, 1988, "Black Saturday," in Elk Park.

that the '88 fires were the signal fires for the frequent and large fires that we have seen all over the West since 1988, which are a harbinger of the long-term trend of warming and drying of the West. Could it be, possibly, that those fires are something that Mother Nature is telling us about the future of the West? The science I have read would seem to support that hypothesis. Of course, it doesn't hurt that it also agrees with my own biased views.

Two decades later, I believe that the '88 fires made a lasting change in the way that the media reports on fires. I still watch, read, and listen to the news, albeit with a more jaundiced and critical eye. They still go overboard with their hyperbole; they still favor crying homeowners who have lost their homes to a blaze somewhere in the West; and they tell the brave firefighter story accurately and fairly well. But this is significant: they also understand why, at certain times, fire bosses pull their fire fighters off the lines of the really big ones. I'm not sure that the reporters would've understood that reasoning in 1988. As Conrad Smith said: "In Chicago, when you call the fire department, you expect the fire to be out the next day." They still try to simplify and generalize and draw inappropriate conclusions about fire. And even though they still use words like "disaster" to describe a forest fire that burns only forest; the media has come to understand that in the vast majority of cases, nature doesn't destroy herself. I call that progress. I argue that the media, warts and all, has ultimately influenced the American public by making it a more informed body on these subjects.

In summary, I will quote Charles Dickens again: "…nature gives to every time and season some beauties of its own; and from morning to night, as from the cradle to the grave, it is but a succession of changes so gentle and easy that we can scarcely mark their progress." That, ladies and gentlemen, is how I feel about the last two decades. Thank you for your kind attention and your patience.

YS

Why Fire History Matters

Cathy Whitlock

COURTESY OF THE AUTHOR

Since 1988, fires in the American West have increased in size, frequency, and intensity, raising concerns about their cause. An analysis of recent fire data, for example, suggests that the average number of acres burned in the last 15 years is 670% higher than in the previous 15 years, and the likely explanation is warmer winters and earlier spring snowmelt (Westerling et al. 2006). Current climate projections suggest that this trend is likely to continue (IPCC 2007). To fully understand the role of climate, fuel conditions, and people in shaping fire regimes, and to adequately prepare for fires in the future, it is critical to look at the role of fires in the past.

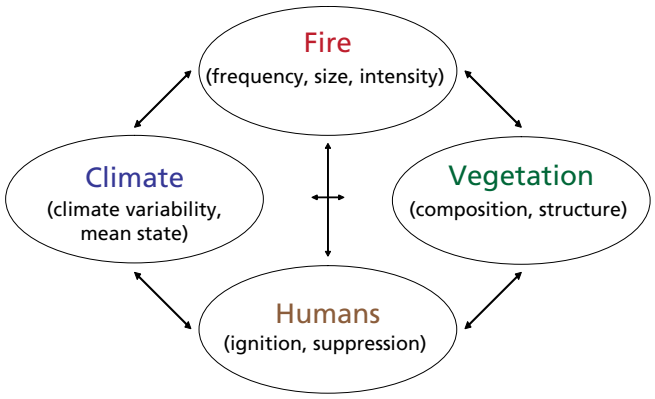
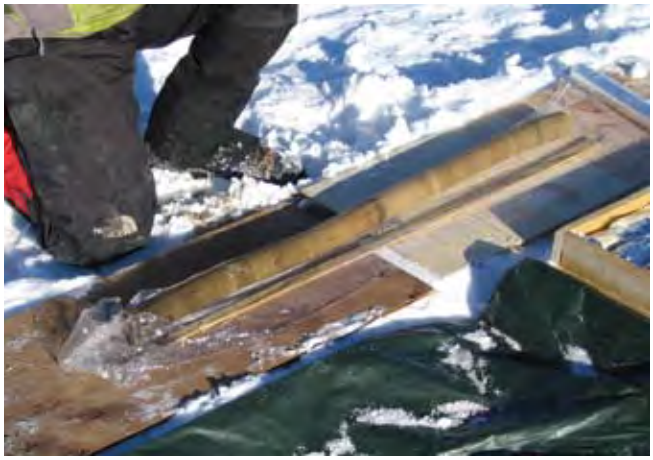


Figure 1. Fire occurrence is determined by climate, vegetation, and human activity, although the specific linkages and the feedbacks vary through time and space.

This perspective must extend back more than a few decades or centuries—it must encompass millennia in order to consider a broad range of possible climate conditions, vegetation types, and human activities (Whitlock 2004).

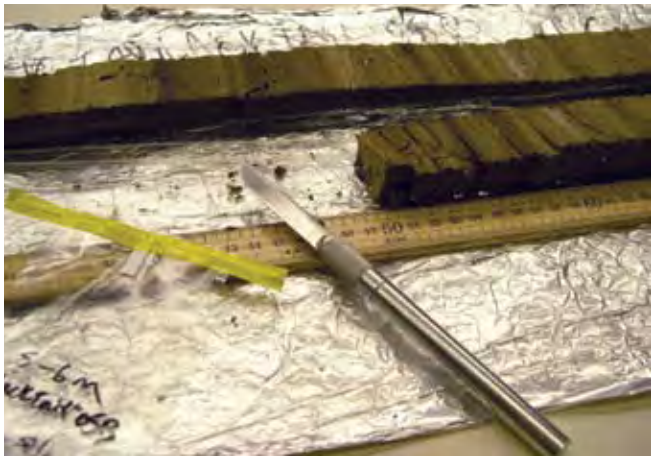
Fires are not a new phenomenon. As soon as Earth had sufficient oxygen (13–35%), fires shaped terrestrial vegetation. Scott and Glasspool (2006) suggest that the initial appearance of fires was closely associated with the evolution and diversification of upland plant communities. In Yellowstone, petrified sequoia trees that are 35 to 55 million years old have fire scars, suggesting they experienced surface fires much like modern sequoia forests. Charcoal records from lakes register numerous fires in the last 10,000 years and fire-scarred tree rings indicate fires throughout the region in recent centuries.

A long-term history of fire requires identifying the evidence of past fire as well as developing an understanding of the causes of fire over different temporal and spatial scales (Fig. 1). Vegetation, climate, and humans all play a role in shaping fire regimes, but their relative effects on fuels, weather, and ignitions have varied through time. Vegetation determines fuel levels and composition. Climate conditions, including temperature, moisture, pressure, and circulation features, influence the weather characteristics that lead to and support particular fire events, as well as the long-term characteristics that comprise fire regimes. Human activities like igniting, suppressing, and eliminating fires also shape the temporal and spatial scale of fire events and fire regimes, particularly in some regions.



J. FISHER

One section of the 6.2-m sediment core collected from Blacktail Pond in northern Yellowstone during winter 2006.



M. HUERTA

Sliced lengthwise, sediment cores reveal clear layers. Samples are taken from each layer for pollen and charcoal analyses.

Fire History

Most fire-history information comes from documentary evidence, tree-ring records, and lake sediment data. Fire scars on trees can pinpoint the year or season of a fire event, and provide precise information on where a fire occurred. Such fire histories records are available from most western forest types, and the approach is particularly powerful in low-elevation forests that experience frequent low-severity fires (Swetnam and Baisan 1996). It is less useful in describing the history of high-severity and infrequent fires that characterize high-elevation forests (Schoennagel et al. 2004). Information on high-severity fires comes from forest stand ages (Romme and Despain 1989) and from charcoal records in lake sediments. Charcoal records are temporally less precise and spatially less resolved than tree-ring records, but they have the advantage of extending the fire chronology back several thousand years.

During a fire, charred particles of wood, bark, and leaves are carried aloft. Some of these particles settle on the surface of lakes, sink, and are incorporated into the sediments. Over time, younger layers of sediment are deposited upon older ones, and the lake becomes progressively shallower as the basin fills. Sediment cores are taken with hand-operated drilling equipment that recovers a series of vertical cores through the sediment layers. The cores are brought back to the lab, sliced open, carefully described and sampled (Whitlock and Larsen 2001). The abundance and composition of charcoal particles in the cores reveal the history of past fires, but other components of the sediment are equally important for reconstructing fire history. For example, pollen grains buried in the sediments identify the plants that were growing near the lake in the past, and from this we can infer what the vegetation was like before and after a fire event. The chronology of fire events is established by a series of radiocarbon dates on plant remains in the core and the presence of volcanic ash layers of known age.

To reconstruct past fire history, it is necessary to know how far charcoal particles travel before falling to the ground and becoming incorporated in lake sediments. Simple modeling has shown that particles >100 microns largely settle within a few kilometers of the fire, whereas smaller particles can travel several kilometers before they are deposited (Clark 1988). Sophisticated modeling efforts and empirical studies help us interpret the charcoal record in terms of past area burned and the distance of fire from the lake, based on the abundance of charcoal particles of particular size (Higuera et al. 2007). We also calibrate charcoal data and refine our interpretations by comparing the age of charcoal-rich sediment layers (assumed to be fire events) with the age determined from tree-ring and documentary data (Millspaugh and Whitlock 1995; Whitlock and Millspaugh 1996).

Climate-Fire Linkages

Climate-fire linkages can be examined on several temporal and spatial scales, and the relationships can be complex. On short time scales, fire weather is important. The occurrence of lightning ignitions, relative humidity, temperature, and wind speed during particular days influences the scale and behavior of fires. On annual to decadal time scales, seasonal to annual periods of drought, snowpack variations, and their effects on fuel buildup are critical. On longer time scales, persistent patterns in atmospheric circulation have significant impact. For example, a strengthened northeastern Pacific subtropical high pressure system driven by higher-than-present summer insolation likely led to more frequent fires during the early-Holocene period, 11,000 to 7,000 years ago (Whitlock and Bartlein 2004).

In Yellowstone, Balling et al. (1992) showed that large fires of the last century were associated with exceptionally dry summers. These large-fire years are characterized by a persistent high-pressure system in the northeast Pacific in summer, which increased the vertical sinking air and reduced precipitation (Baker 2003; Bartlein, unpublished data). When calibrated

COURTESY OF THE AUTHOR

Cores from living trees provide one source of fire-history information. The fire-scarred tree-rings on Douglas-fir can be used to precisely date the year of a fire.

charcoal data are used to reconstruct area burned over the last 800 years, the 1988 Yellowstone fires are shown to be unusually large. Nonetheless, large fires in previous centuries are also associated with drought years, as revealed from a comparison of charcoal records with paleoclimate information obtained from tree-ring data (Higuera et al., unpublished data). A long-term fire history at Cygnet Lake in central Yellowstone helps us better understand the role of vegetation and climate on millennial time scales (Millspaugh et al. 2000). The vegetation history, inferred from the pollen record, shows that lodgepole pine (*Pinus contorta*) arrived about 11,000 years ago following a period of grass-steppe or tundra and has thrived in the nutrient-poor, rhyolitic soil to the present day. Unlike the vegetation, which has changed little in the last 11,000 years, the fire history, based on charcoal data, has varied considerably as a result of climate change. For example, fires were three times more frequent prior to 7,000 years ago, when summer drought was more intense than at present. In the last 7,000 years, and especially in the last 4,000 years, the climate has become cooler and wetter, and fires have become less frequent.

Paleoecologic studies suggest that different climate regimes within Yellowstone may account for geographic differences in fire history (Millspaugh et al. 2004). When the central and southern portions of the park experienced a high occurrence of fires in the early Holocene, the northern park had a lower occurrence. The opposite was true in the late Holocene. An analysis of long-term changes in July/January precipitation ratios (Whitlock and Bartlein 1993) puts Yellowstone at the boundary of two different precipitation regimes at present. One regime has more summer precipitation relative to winter precipitation, and the other has less. In the early Holocene, each precipitation regime was strengthened as a result of greater-than-present summer insolation (energy received from solar radiation): areas that are summer-dry today were drier then and areas that are summer-wet today were wetter. In the late Holocene, summer-dry regions became progressively wetter and summer-wet regions became drier. These variations in the timing of maximum summer precipitation may explain the long-term differences in fire history in the northern and southern/central parts of Yellowstone (Fig. 2).

Comparing long-term records of fire history at several sites across the northwestern U.S. shows some broad trends related to regional climate change. Most sites show that charcoal abundance was low at the end of the last glaciation, and rose steadily until charcoal levels decreased about 2,000 years ago. The initial period of low charcoal levels is associated with tundra vegetation, and fires were probably infrequent and small because of sparse fuel cover. The subsequent rise in charcoal levels was related to widespread warming in the Holocene and a shift in fuels as the vegetation changed from tundra to parkland and then forest (Marlon et al. 2006). At individual sites, local fire history is highly variable and reflects the interaction

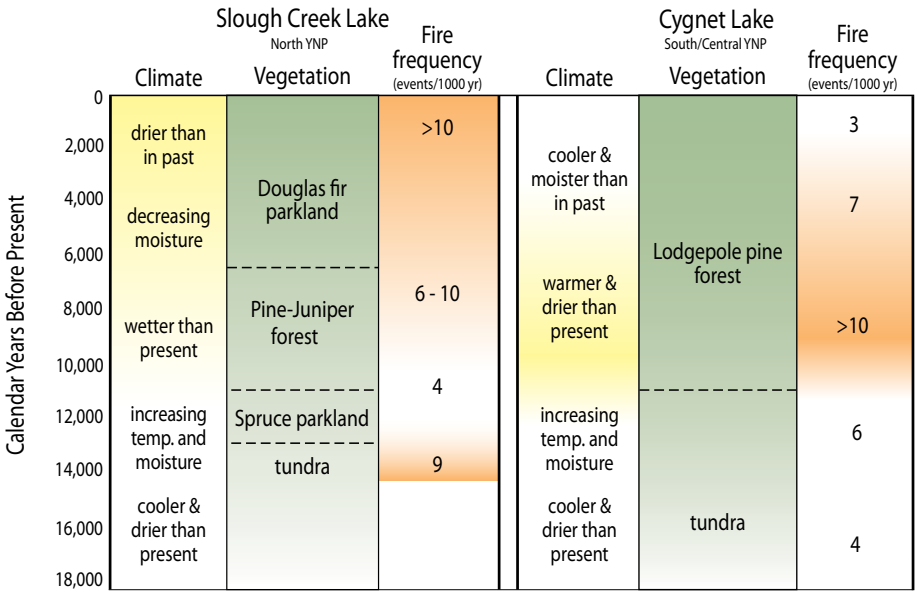
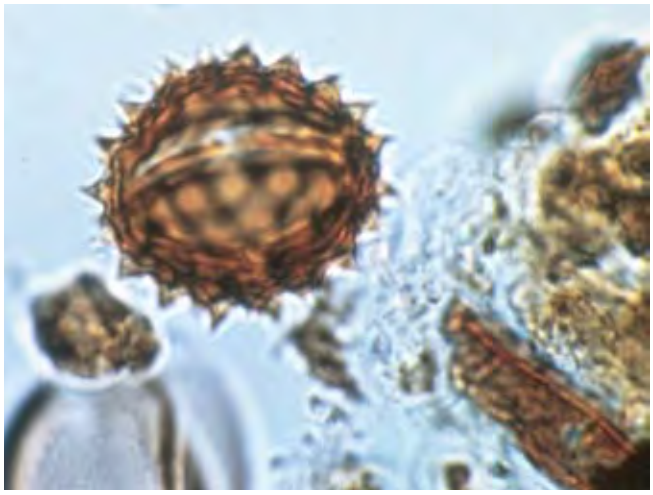


Figure 2. The climate, vegetation, and fire history at Slough Creek Lake and Cygnet Lake based on pollen and charcoal data. At Slough Creek Lake, fires have been most frequent in the last 7,000 years, with the development of Douglas-fir parkland. Fires were most frequent at Cygnet Lake 11,000–7,000 years ago with the first appearance of lodgepole pine forest (after Millspaugh et al. 2004).



R.J. NICKMANN

Ragweed (*Ambrosia*) pollen is identified by its distinctive architecture. This grain is about 25 microns in diameter.

of climate, fuels, and topography in specific locations. At larger scales, trends in fire activity over the last 4,000 years show regional patterns. For example, northern Yellowstone sites show an increase in fire frequency in the last 4,000 years, whereas the subalpine forests of the northern Rocky Mountains and central Yellowstone indicate decreased fire activity during that time. Some regions, like the Flathead Valley, record a history of very frequent fires, whereas the Oregon Coast Range has always had comparatively few fires (Whitlock et al. 2008).

Human Influence

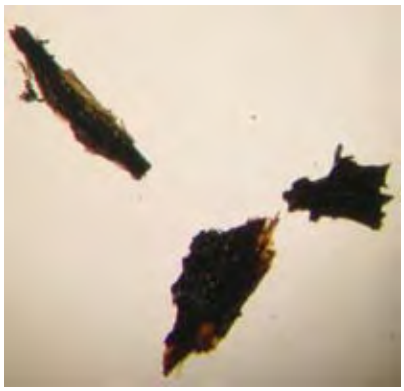
The role of native peoples, particularly Native Americans, in shaping prehistoric fire regimes is poorly known, and archeological evidence often provides little information as to how ancient peoples used fire. As a result, it is difficult to separate human from climate influences in shaping prehistoric fire regimes in the western U.S. where people have been on the landscape for thousands of years (Whitlock and Knox 2002). New Zealand, on the other hand, has an oceanic climate with little lightning, and natural fires were rare prior to the arrival of Māori peoples about 700 years ago (Ogden et al. 1997; Wilmshurst et al. 2008). Evolving in the absence of fire, most New Zealand tree species are not well-adapted to and lack traits to survive fire. About 40% of the forests across New Zealand were lost during a period of intense burning soon after Māori arrival, and much of the South Island of New Zealand was converted from forest to grass and shrubland at that time. This initial burning was followed by a second period of fires in the 1800s set by Europeans to extend and maintain grasslands (Ogden et al. 1997).

On New Zealand's South Island, sediment cores have been retrieved from small lakes that were remote from known settlements to examine the consequences of this initial burning period (McWethy et al., in press). The purpose of this examination is to determine whether the fires in such areas were the result of deliberate or accidental burning, and how these fires affected the watershed. Data show that the initial burning period lasted less than 100 years at most sites and may have consisted of only one or two fire episodes. These initial fires often led to massive erosion, loss of nutrients, and shifts in lake chemistry from acidic to alkaline. The research in New Zealand suggests that the consequences of anthropogenic burning in the absence of natural fires are sometimes profound and long-lived, especially in ecosystems that have little resilience to the appearance of new types of disturbance.

Global Patterns in Fire History

An international effort is underway to create a global paleofire database consisting of over 400 charcoal records from around the world. The first effort of the Global Paleofire Working Group was to describe the broad changes in fire activity since the last glaciation (Power et al. 2008). This paleofire database has also been examined for possible fire-climate-human linkages over the last 2,000 years (Marlon et. al 2008). A composite fire record was compared with trends in global population growth, atmospheric CO_2 records preserved in ice cores, and estimates of land-cover change for the same period. The levels of charcoal declined between 0 CE and 1750 CE, which was attributed to the effects of cooling in the late Holocene. This period was followed by increased charcoal levels between 1750 CE and 1870 CE, attributed to widespread forest clearance in the Americas, Europe, and Australia. Since 1870 CE, decreasing charcoal levels are explained by the elimination of fires due to fire suppression, forest clearance, and grazing. The decline appears at low and middle latitudes more strongly than at high latitudes. The study concluded that the impact of contemporary human activity has been to reduce biomass burning on a global scale (Marlon et al. 2008).

The federal government currently spends billions of dollars to prepare and respond to wildfires (U.S. Government Accountability Office 2007), in large part to protect homes built at the wildland-urban interface. Yet, biomass burning continues to increase, and projected changes in global and regional climate in the coming century are moving us into conditions that have little precedence in the recent past (IPCC 2007). For that reason,



T. MINCKLEY

Charcoal particles come from partially combusted wood, bark, and leaves.

insights from history have become essential information. From the past, we learn that large fires are a natural component of most forested ecosystems and occur during years of unusual drought. From a longer time perspective, history shows that large-scale changes in climate have led to major, sometimes rapid, reorganizations of vegetation and fire regime. Thus, the lessons we learn about ecosystem dynamics during times of past climate change are becoming ever more relevant as we try to prepare for the future.

YS

KELLY GORHAM/ MSU NEWS SERVICE

Paleoecologist **Cathy Whitlock** has been a professor of Earth Sciences at Montana State University since 2004. Her research focuses on the ecological consequences of past climate change and the long-term linkages between fire, vegetation, and climate. The Yellowstone fires of 1988 inspired her group to look closely at the layers of charcoal in lake sediments and consider their potential use as a record of past fire. Whitlock's current projects in fire history extend from the western U.S. to Patagonia and New Zealand. She has helped build a global network of paleofire researchers and is a member of the advisory board for NOAA's International Multiproxy Paleofire Database.

References

Baker, W.L. 2003. Fires and climate in forested landscapes in the U.S. Rocky Mountains. In *Fire and climatic change in temperate ecosystems of the western Americas*, eds. T.T. Veblen, W.L. Baker, G. Montenegro, and T.W. Swetnam, 120–157. New York: Springer.

Balling, Jr., R.C., G.A. Meyer, and S.G. Wells. 1992. Climate change in Yellowstone National Park: Is the drought-related risk of wildfires increasing? *Climatic Change* 22:35–45.

Clark, J.S. 1988. Particle motion and the theory of stratigraphic charcoal analysis: Source area, transport, deposition, and sampling. *Quaternary Research* 30(1): 67–80.

Higuera, P.E., M.E. Peters, L.B. Brubaker, and D.G. Gavin. 2007. Understanding the origin and analysis of sediment-charcoal records with a simulation model. *Quaternary Science Reviews* 26(13–14):790–1809.

[IPCC]. International Panel on Climate Change 2007. *Climate change 2007–Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the fourth assessment report of the IPCC*, eds. M.L. Parry, O.F. Canziana, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson. Cambridge: Cambridge University Press.

Marlon, J.R., P.J. Bartlein, and C. Whitlock. 2006. Fire-fuel-climate linkages in the northwestern USA during the Holocene. *The Holocene* 16(8):1059–1071.

Marlon, J.R., P.J. Bartlein, C. Carcaillet, D.G. Gavin, S.P. Harrison, P.E. Higuera, F. Joos, M.J. Power, and I.C. Prentice. 2008. Climate and human influences on global biomass burning over the past two millennia. *Nature Geoscience* 1:697–702.

McWethy, D., C. Whitlock, J. Wilmshurst, M. McGlone, and X. Li. 2009. Rapid deforestation of temperate forests in South Island New Zealand by early Polynesian fires. *The Holocene*. In press

Millspaugh, S.H., C. Whitlock, and P.J. Bartlein. 2004. Postglacial fire, vegetation, and climate history of the Yellowstone-Lamar and Central Plateau provinces, Yellowstone National Park. In *After the fires: The ecology of change in Yellowstone National Park*, ed. L.L. Wallace, 10–28. New Haven: Yale University Press.

Millspaugh S.H., C. Whitlock, and P.J. Bartlein. 2000. Variations in fire frequency and climate over the past 17,000 years in central Yellowstone National Park. *Geology* 28(3):211–214,

Millspaugh, S.H., and C. Whitlock. 1995. A 750-year fire history based on lake sediment records in central Yellowstone National Park. *The Holocene* 5(3):283–292.

Ogden, J., M. Horrocks, J.G. Palmer, and R.A. Fordham. 1997. Structure and composition of the subalpine forest on Mount Hauhungatahi, North Island, New Zealand, during the Holocene. *The Holocene* 7(1):13–23.

Power, M.J., J. Marlon, P.J. Bartlein, S.P. Harrison, F.E. Mayle, A. Ballouche, R. Bradshaw, C. Carcaillet, C. Cordova, S. Mooney, P. Moreno, I.C. Prentice, K. Thonicke, W. Tinner, C. Whitlock, Y. Zhang, Y. Zhao, R.S. Anderson, R. Beer, H. Behling, C. Briles, K.J. Brown, A. Brunelle, M. Bush, P. Camill, G.Q. Chu, J. Clark, D. Colombaroli, S. Connor, M. Daniels, A.-L. Daniau, J. Dodson, E. Doughty, M.E. Edwards, W. Fisinger, D. Foster, J. Frechette, M.-J. Gaillard, G. Gil-Romera, D.G. Gavin, E. Gobet, S. Haberle, D.J. Hallett, P. Higuera, G. Hope, S. Horn, S. Impagliazzo, J. Inoue, P. Kaltenrieder, L. Kennedy, Z.C. Kong, C. Larsen, C.J. Long, J. Lynch, B. Lynch, M. McGlone, S. Meeks, S. Mensing, G. Meyer, T. Minckley, J. Mohr, D. Nelson, J. New, R. Newnham, R. Noti, W. Oswald, J. Pierce, P.J.H. Richard, C. Rowe, M.F. Sanchez Goñi, B.J. Shuman, H. Takahara, J. Toney, C. Turney, C. Umbanhower, M. Vandergoes, B. Vanniere, E. Vescovi, M. Walsh, X. Wang, N. Williams, J. Wilmshurst, and J.H. Zhang. 2008. Changes in fire regimes since the Last Glacial Maximum: An assessment based on a global synthesis and analysis of charcoal data. *Climate Dynamics* 30(7–8):887–907.

Romme, W.H., and D.G. Despain. 1989. Historical perspective on the Yellowstone fires of 1988. *BioScience* 39(10):695–699.

Schoennagel, T., T.T. Veblen, and W.H. Romme. 2004. The interaction of fire, fuels, and climate across Rocky Mountain forests. *BioScience* 54(7):661–676.

Scott, A.C., and I.J. Glasspool. 2006. The diversification of Paleozoic fire systems and fluctuations in atmospheric oxygen concentration. *Proceedings of the National Academy of Sciences* 103(29):10861–10865

Swetnam, T.W., and C.H. Baisin. 1996. Historical fire regime patterns in the southwestern United States since AD 1700. In *Fire effects in southwestern forests: Proceedings of the second La Mesa Fire Symposium, Los Alamos, New Mexico, March 29-31, 1994*, tech. ed. C.D. Allen, 11–32. Fort Collins (CO): USDA Forest Service Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-GTR-286.

U.S. Government Accountability Office. 2007. Wildland fire management: A cohesive strategy and clear cost-containment goals are needed for federal agencies to manage wildland fire activities effectively. Statement of Robin M. Nazzaro, director Natural Resources and Environment. GAO-07-1017T.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase western US forest wildfire activity. *Science* 313(5789):940–943.

Whitlock, C. 2004. Land management: Forests, fires, and climate. *Nature* 432:28–29.

Whitlock, C., and P.J. Bartlein. 1993. Spatial variations of Holocene climatic change in the Yellowstone region. *Quaternary Research* 39(2): 231–38.

Whitlock, C., and P.J. Bartlein. 2004. Holocene fire activity as a record of past environmental change. In *The Quaternary Period in the United States*, of *Developments in Quaternary Science, 1*, eds. A. Gillespie, S.C. Porter, and B.F. Atwater, 479–489. Elsevier.

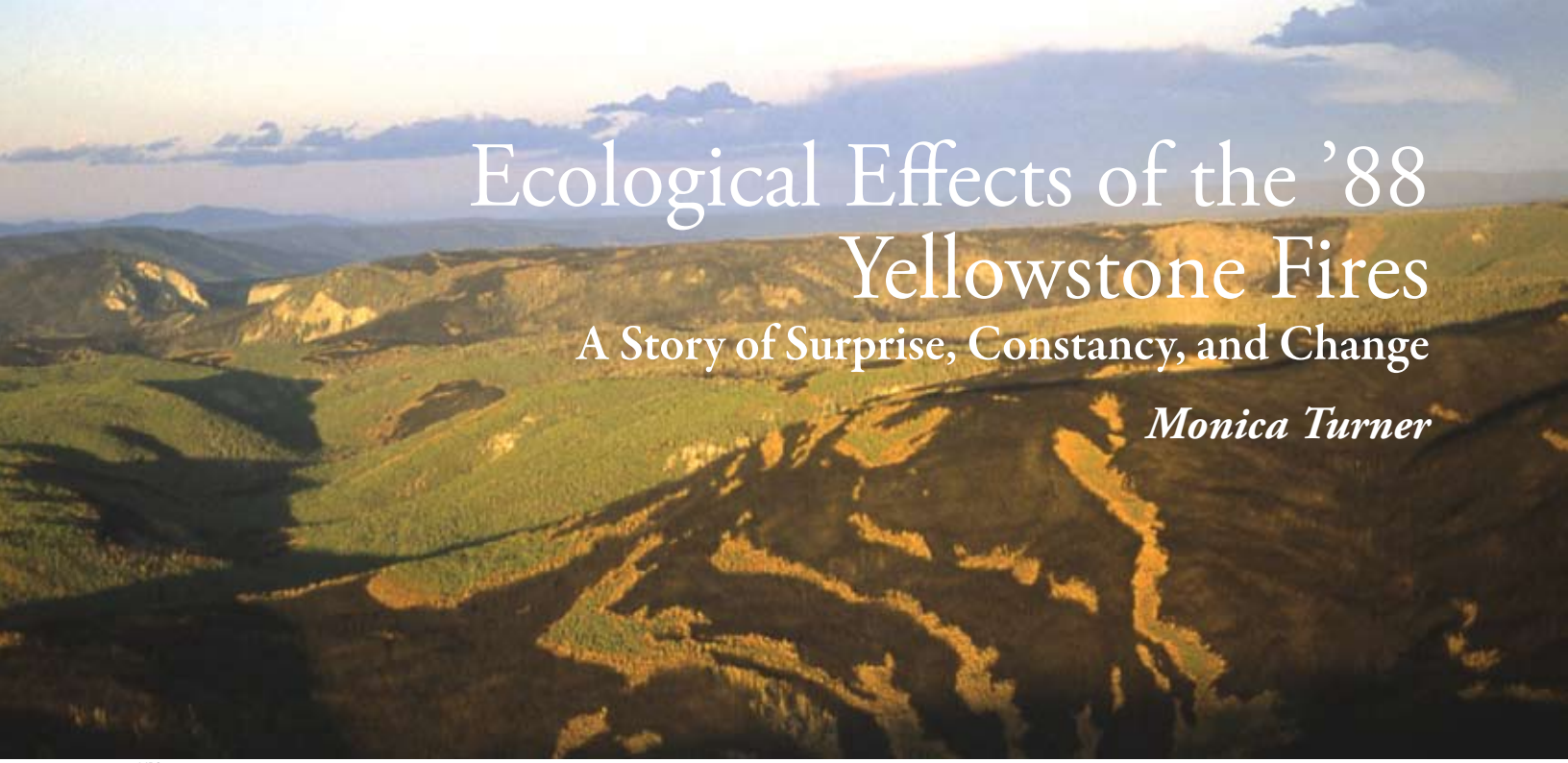
Whitlock, C., and C.S. Larsen. 2001. Charcoal as a fire proxy. In *Tracking environmental change using lake sediments, Volume 3: Terrestrial, algal, and siliceous indicators*, eds. J.P. Smol, H.J.B. Birks, and W.M. Last, 75–97. Dordrecht, Netherlands: Kluwer Academic Publishers.

Whitlock, C., and M.A. Knox. 2002. Prehistoric burning in the Pacific Northwest: Human versus climatic changes. In *Fire, Native Peoples, and the Natural Landscape*, ed. T.R. Vale, 195–231. Washington, D.C.: Island Press

Whitlock, C., and S.H. Millspaugh. 1996. Testing assumptions of fire-history studies: An examination of modern charcoal accumulation in Yellowstone National Park, USA. *The Holocene* 6(1):7–15.

Whitlock, C., J. Marlon, C. Briles, A. Brunelle, C. Long, and P.J. Bartlein. 2008. Long-term relations among fire, fuel, and climate in the northwestern U.S. based on lake-sediment studies. *International Journal of Wildfire Research* 17(1):72–83.

Wilmshurst, J.M., A.J. Anderson, T.F.G. Higham, and T.H. Worthy. 2008. Dating the late prehistoric dispersal of Polynesians to New Zealand using the commensal Pacific rat. *Proceedings of the National Academy of Sciences* 105(22): 7676–80.



Ecological Effects of the '88 Yellowstone Fires

A Story of Surprise, Constancy, and Change

Monica Turner

NPS

Yellowstone National Park is characterized by extensive subalpine forests dominated by lodgepole pine (*Pinus contorta* var. *latifolia*). Dendrochronology and paleoecological studies revealed a long history of fire in this landscape, with stand-replacing fires for lodgepole pine occurring at 100–300 year intervals since the last ice age (Romme 1982, Romme and Despain 1989, Millspaugh et al. 2000). Despite this history, the size and severity of the fires in 1988 surprised everyone, including regional managers and scientists. The 1988 fires presented an unprecedented opportunity to study the landscape-scale ecological effects of an infrequent natural disturbance—a large, severe fire in this case—in an ecological system minimally affected by humans.

The 1988 fires affected Yellowstone's forest communities, influencing patterns of succession, productivity, and nutrient cycling; native wildlife; and aquatic ecosystems in surprising ways. The 1988 fires were by no means an ecological catastrophe, and they have led to new insights about the nature, mechanisms, and importance of change.

Landscape Heterogeneity

Pre-fire heterogeneity—the variation in topography, fuels, and forest age—had little influence on the size and pattern of most of the burned areas. Climate, rather than fuels, was primarily responsible for the extent of the fires. The fires that burned early in the season did respond to successional stage and natural firebreaks, much as they had in previous dry years (Despain 1990). However, fires that burned later in the season were responsible for most of the area burned, and these fires showed little response to pre-fire landscape patterns (Turner et al. 1994; Turner and Romme 1994).

The 1988 fires did not homogenize the landscape, though many of us expected them to do so. Rather, the fires created spatially complex mosaics with patches of varying size, shape, and fire severity, as in the photo above. Of the areas affected by crown fire—where the fires consumed the needles of the trees and completely consumed the surface organic layer—50% was within 50 m of a green edge and 75% was within 200 m of a green edge (Turner et al. 1994).

Aquatic Ecosystems: Streams and Lakes

The 1988 fires did not cause lasting degeneration to aquatic ecosystems. During the early post-fire period, streams had warmer temperatures and elevated nitrate (NO_3^-) concentrations and showed greater temporal variability both within and among years (Gerla and Galloway 1998; Gresswall 1999; Minshall et al. 1997). More coarse wood, or fallen trees, was added as fire-killed trees began to fall (Zelt and Whol 2004). The macroinvertebrate communities shifted to more trophic generalists (Minshall et al. 1997). There was also greater sediment transport and cross-sectional stream power. Generally, the greatest changes observed were in low-order streams with steep gradients (Meyer et al. 1992; Legleiter et al. 2003).

Overall, there was minimal shift in water quality in Yellowstone and Lewis lakes, even though 25% of their watersheds burned. This minimal change is attributed, in part, to the mosaic effect, which moderates some of the effects of burning in larger watersheds. Inputs to the lakes may have also been diluted by the volume of water, which would moderate changes in water quality. Few changes or lasting effects were found in Yellowstone's lakes as a result of the fires (Lathrop 1994).

Forest Regeneration and Successional Dynamics

Natural processes rapidly restored native plant cover after the 1988 fires. This surprise was counter to hypotheses that succession would be very slow and would depend on long-distance dispersal of seeds from unburned forest. The fires were hot and intense, but even in crown fires the soil was charred to an average depth of only 14 mm (Turner et al. 1999). Thus, the roots and rhizomes of many plants survived, even though their aboveground leaves and stems had burned. In 1989, many herbs, graminoids, and shrubs resprouted from surviving underground plant parts. In 1990, those plants flowered profusely, and in 1991, a peak of seedling recruitment followed. Less flowering and seedling establishment has been observed since 1992, though both continue to occur. Thus, even in large burned areas, the understory vegetation was filled in by surviving individuals that flowered, set seed, and produced the seedlings. Dispersal from the unburned forest was less important than we had anticipated.

Though many of us expected an increase in invasive plant species like Canada thistle (*Cirsium arvense*) after the fires, nonnative plants did not take over within burned areas. Invasives were observed, but they were associated primarily with roads and trails. The rapid recovery of the native vegetation likely reduced the opportunities for nonnative species to expand. Invasive cover is on average less than 3% in the burned forests, and relatively few nonnative plants established successfully (Fig.1; Turner et al. 1997; Schoessow and Tinker, forthcoming).

Post-fire lodgepole pine establishment was abundant, widespread, and spatially variable. Lodgepole pine stand density varied widely across the burned landscape, and patterns established in 1989 or 1990 persist today and are likely to shape Yellowstone's forests for up to 200 years. In our studies of early post-fire succession, 200,000 lodgepole pine seedlings per hectare were recorded in one geographic location and very few in another area (Turner et al. 1997). This variation

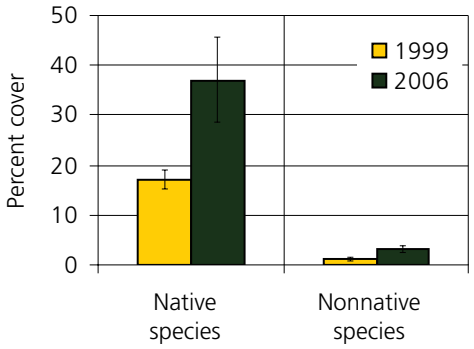


Figure 1. Nonnative plants did not take over within burned areas. Invasive cover is on average less than 3% in the burned forests (after Turner et al. 1997, 2003b; Schoessow and Tinker, forthcoming).

BILL ROMME

MONICA TURNER

Herbs, graminoids, and shrubs resprouted in 1989 and flowered profusely in 1990 (*above*). Seedling recruitment peaked in 1993. Less flowering and fewer seedlings have been observed since 1992 (*below*).

in lodgepole pine seedling densities was primarily related to pre-fire variation in serotiny (the production of serotinous, or closed cones, which release their seeds when heated). The presence of serotinous cones in lodgepole pine varies substantially across the Yellowstone landscape (Tinker et al. 1994), and high post-fire seedling densities were associated with areas of high pre-fire serotiny. For example, 65% of the canopy trees bore serotinous cones in the Cougar Creek area, the post-fire area in which more than 200,000 seedlings per hectare were recorded. About 10% of the pre-fire trees bore serotinous cones in the Old Faithful area, and less than 1% in the Yellowstone Lake area. Accordingly, post-fire pine seedling densities were lower in these regions (Turner et al. 1997). The variation in post-fire lodgepole pine densities was also related to variation in burn severity. In areas with severe surface fires (which were stand replacing, but the needles of the trees were not consumed by fire), pine seedling densities were greater than in similar areas of crown fire (Turner et al. 1997).

Variation in serotiny across the Yellowstone landscape is related to both elevation and stand age (Schoennagel et al. 2003). At high elevations (>2,300 m in Yellowstone), serotiny is low in both young and old lodgepole pine stands. The reconstruction

Past Change in Ecological and Human Communities as a Context for Fire Management

Andrew J. Hansen

Since 1890, the Greater Yellowstone Ecosystem (GYE) has experienced a period of rapid climate change that favors increased fire severity. Fuel loads are accumulating at lower forest treeline areas, possibly causing a shift to more severe fire. Biodiversity, wildland conversion, and fuel buildup concur in the same areas, presenting opportunities and constraints for fire management. These challenges will likely intensify over time and an examination of historical data on climate, tree cover, bird species richness, and land use can inform planning for future fire management.

A comparison of mean annual and monthly temperature and precipitation trends shows different patterns throughout the ecosystem. Mammoth Hot Springs is warming in summer and precipitation has decreased, whereas Moran in Grand Teton National Park is cooling in summer and precipitation has increased. Mammoth, Moran, and Yellowstone Lake monitoring sites all had warming winter temperatures which could lead to reduced snowpack and decreased runoff. This decrease in moisture could produce a longer drying season and an increase in fire activity or severity.

Comparative analysis was used to measure the rate of vegetation change in selected areas of the GYE. Some decrease in conifer cover since 1871 was attributed to the 1988 fires and logging, but a net increase was documented, primarily in Douglas-fir zones. Conifer cover increased fastest at lower forest treeline, on north-facing slopes, and near existing conifer. The increase is principally due to densification rather than areal expansion, suggesting possible changes in fuel load (Powell 2007). Coupled with a substantial decrease in fire frequency in these Douglas-fir zones over the past 150 years, high fuel availability is likely.

Further comparisons of vegetation indicated that 38% of plots demonstrated a loss of aspen since 1956 (Brown et al. 2006). Aspen growth rates are fastest on clay soils where summer precipitation is high and temperatures are warmer. These elements occur in biophysical settings that favor Douglas-fir growth—the lower forest ecotone. Data shows that aspen is not currently located in the habitats where it could grow fastest. It is possible that competition with Douglas-fir limits aspen distribution and partially explains the loss of aspen cover. Douglas-fir dominance in areas suitable for aspen growth could be broken by prescribed fire, thereby allowing for aspen regeneration at the lower forest treeline.

Across North America, bird species richness has been found to be associated with biophysical factors relating to primary productivity. Predicted hotspots for bird species richness in the GYE overlap with the lower Douglas-fir ecotone. Breeding bird survey data and bird point count data indicated that bird species richness decreased with disturbance (e.g., fire, flood, logging) in a lower productivity landscape but increased with disturbance in a high productivity landscape (McWethey et al. 2009). It may be that low productivity areas are slow to recover after a disturbance but high productivity areas recover rapidly, as many native species require periodic fire.

The history of land development in the GYE reflects the integration of factors like agricultural suitability, transportation, natural amenities, and past development (Gude et al. 2006). The number of rural homes in the GYE increased 108% between 1975

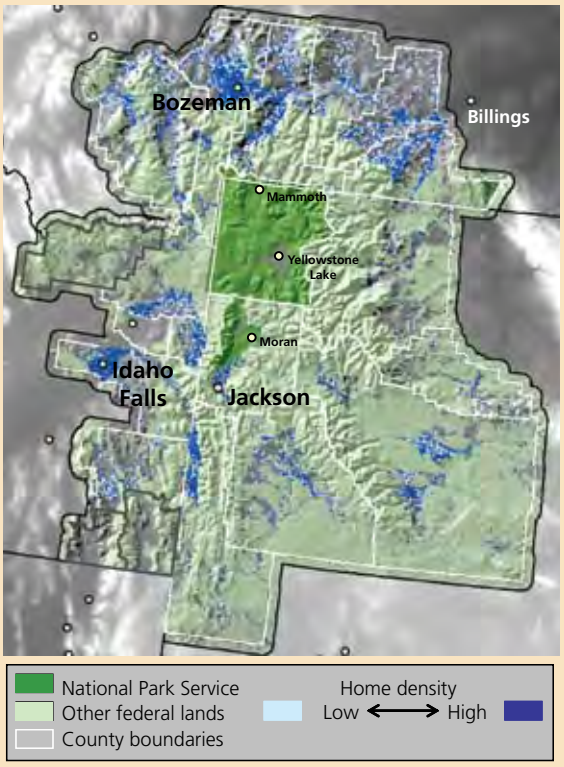


Figure 2. Distribution of rural homes in the greater Yellowstone area in 1999 based on county tax assessor records validated against aerial photographs (Gude et al. 2006).

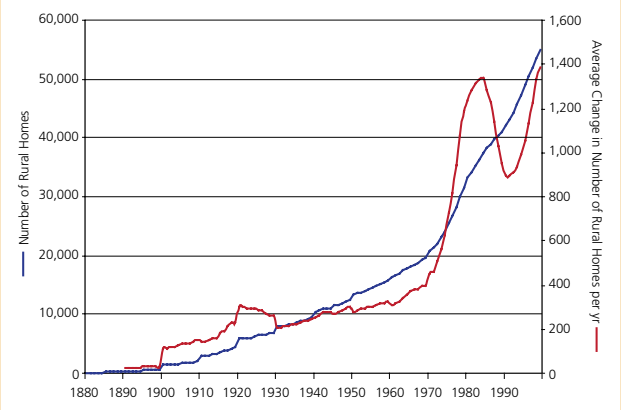


Figure 1. The number of rural homes in the Greater Yellowstone Ecosystem has dramatically increased.

and 1999 (Fig. 1), principally in agricultural valleys bordering public land. A population increase of 87% in the 20 counties of the GYE between 1970 and 2007 has spawned the conversion of 37% of the unprotected wildland in those counties to human use. These areas of development overlap with the hotspots of high species richness and the areas of increased fire intensity and fuel availability within the lower forest ecotone (Fig. 2).

With land use and climate changes on the horizon, the potential for challenges in the management of fire will likely increase. Convergence of such a variety of factors will likely force fire management strategies to be tailored to local conditions within regions and across the United States.

YS

Andrew J. Hansen is a professor in the ecology department and Director of the Landscape Biodiversity Lab at Montana State University. His research focuses on interactions among biodiversity, ecosystem processes, and land use, with an emphasis on landscape management. Recently he has focused on rates of land use change and consequences for protected areas such as Yellowstone National Park. Dr. Hansen is currently studying vulnerability of national parks to land use and climate change across the U.S. His work uses a combination of remote sensing, computer simulation, and field studies.

References

Brown K., A.J. Hansen, R.E. Keane, and L.J. Graumlich. 2006. Complex interactions shaping aspen dynamics in the Greater Yellowstone Ecosystem. *Landscape Ecology* 21:933–951.

Gude, P.H., A.J. Hansen, R. Rasker, and B. Maxwell. 2006. Rates and drivers of rural residential development in the Greater Yellowstone. *Landscape and Urban Planning* 77(1–2):131–151.

McWethy, D.B., A.J. Hansen, and J.P. Verschuyl. 2009. Edge effects for songbirds vary with forest productivity. *Forest Ecology and Management* 257(2):665–678

Powell, S.L., and A.J. Hansen. 2007. Conifer cover increase in the Greater Yellowstone Ecosystem: Frequency, rates, and spatial variation. *Ecosystems* 10(2):204–216.

of fire-return intervals showed that the high-elevation fire intervals were about 300 years, which is nearly at the end of the lifespan of lodgepole pine if it has not burned. At low elevations (<2,300 m in Yellowstone), serotiny is low in younger stands (<70 yrs) but quite high in older stands (>70 yrs). The fire interval for these lower elevations is approximately 180 years (Schoennagel et al. 2003); we think that the occurrence of serotiny is related to the fire-return interval and whether it will select for serotinous cones over the long term.

Our initial studies focused on three geographic locations of Yellowstone that were selected to replicate measurements of post-fire succession in burned forest patches that varied in size and fire severity. However, we did not know how representative our results were for the burned forest as a whole. Therefore, in 1999, we sampled forest structure and function in 90 plots (0.25 ha) distributed widely throughout the burned landscape. We found striking variation in the 1999 post-fire lodgepole pine sapling densities that spanned six orders of magnitude (range = 0–535,000/ha, mean = 29,380/ha, and median = 3,100/ha). Lodgepole pine sapling density was greater at lower elevations (r = -0.61), consistent with trends in serotiny. Approximately 20% of burned landscape had very dense stands of >20,000 saplings per hectare (Turner et al. 2004).

Young lodgepole pine trees were already producing cones within 15 years after fire. Cones were present in 10–80% of trees in stands (n = 16) that we sampled in 2003. Serotinous cones were infrequent, but observed in five stands (only at <2,200 m), consistent with expectations based on elevation; the presence of serotinous cones did not appear to be influenced by tree density. Considering the density of trees and the number of cones per tree, cone density was 4,000 to 4,000,000 per hectare within 15 years of the fires (Turner et al. 2007a).

The recruitment of new aspen genets after the 1988 fires was a surprise

JENNIFER J. WHIPPLE

Newly-opened serotinous lodgepole pinecones.

(Romme et al. 1997). The widespread establishment of seedling aspen—not root sprouts of existing clones of aspen—was observed only in burned forests and up to 15 km from mature aspen (Turner et al. 2003a). The mean height of seedlings in 2000 was approximately 30 cm. Tall aspen were occasionally recorded at higher elevations where lodgepole pine is less dense, and it appears that some new tree-sized stands may be developing. However, most seedlings have been browsed by elk, and even aspen seedlings that were protected from browsing have grown slowly (Romme et al. 2005).

Ecosystem Processes: Productivity, Nitrogen Cycling, Coarse Wood, Decomposition

Lodgepole pine stands are very productive, even in the generally infertile conditions of Yellowstone. Primary productivity recovered rapidly following the fires and remains high. Within 10 years of the fires, the aboveground net primary production was very high at the stand level. Generally, stands with more trees were more productive, although the productivity of individual trees declined in high-density stands. Stands are still in the biomass accumulation phase, which is likely to go on for a few more decades (Turner et al. 2004; Turner et al. 2009).

Chronosequence studies indicate that the legacy of the 1988 fires for ecosystem structure and function may persist for up to 200 years (Kashian et al. 2005a,

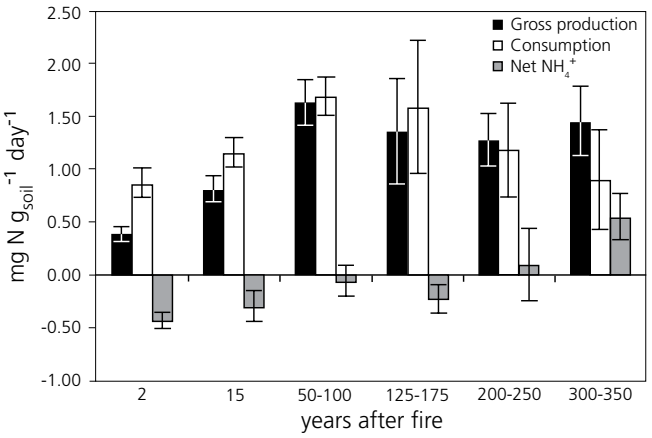


Figure 2. Gross production, consumption, and net ammonium after fire. Concentrations of nitrate and ammonium are elevated soon after fire, but soil microbes "consume" more nitrogen than they produce, creating a nitrogen "sink" (after Turner et al. 2007).

2005b; Smithwick et al. 2005a). Up to the 175-year stand age class, tree density will be relatively high and among-stand variability will be substantial. This among-stand spatial variation in stand structure (and function) will decline over time. Two mechanisms contribute toward convergence in structure and function: the dense stands will self-thin, and the sparse stands will fill in. At about the 200-year age class, the footprint of spatial variation in stand structure and function is no longer evident (Kashian et al. 2005a).

Soil nitrogen availability is often assumed to be limiting to the production of lodgepole pine forests in this area. However, there are surprisingly few empirical data on nitrogen dynamics following natural stand-replacing fires. Most research has been conducted on low-intensity surface fire and prescribed fire. Little is known about nitrogen dynamics after severe natural wildfire (Smithwick et al. 2005b). When organic matter is put into the soil, it decomposes and is mineralized to produce ammonium (NH_4^+) which is in turn nitrified to produce nitrate. Nitrate and ammonium are the inorganic forms of nitrogen that are available for plants and are the products of net nitrogen mineralization, which is a good index for the availability of inorganic nitrogen to vegetation.

The soil communities of burned lodgepole pine forests seemed to conserve nitrogen after the fires (Turner et al. 2007b). Although concentrations of nitrate and ammonium in the soil are elevated shortly after fire, the microbial community traps the nitrogen and prevents it from being lost in the system. The soil "consumes" more nitrogen than is produced, creating a nitrogen "sink" (Fig. 2). Most of the nitrogen stocks in these ecosystems are stored in the soil. We found that stocks of nitrogen lost in the fire were actually recovered by about 40–70 years after fire (Smithwick et al. 2009). To determine whether nitrogen might limit vegetation soon after fire, we conducted a nitrogen fertilization experiment three to five years after the Glade Fire that occurred during summer 2000. We found no difference between growth rates or foliar nitrogen concentrations in lodgepole pine seedlings among controls and the low and high fertilizer application. The foliar nitrogen concentration was also quite high for lodgepole pine, indicating the seedlings were doing well (Romme et al. 2009).

We also studied stands 15–17 years after the 1988 fires, and it does not appear that lack of nitrogen has yet limited the growth of the young lodgepole pine (Levitt 2006; Turner et al. 2009). In 14 stands sampled during 2003, the nitrogen concentration in new lodgepole pine foliage was generally above the critical value that indicates nitrogen limitation. This was observed across a wide range of tree densities—although the very high-density stands are beginning to show evidence of nitrogen limitation. Nitrogen limitation may still occur later during succession as primary production continues to increase.

Post-fire coarse wood (fallen trees) is conspicuous and variable in lodgepole pine forests. Coarse wood affects decomposition, soil biota, and ecosystem processes. It is an important long-term source of carbon and nutrients for the ecosystem. As with other ecological responses to fire, the rates of tree-fall and abundance of coarse wood varied a lot across the burned landscape. As of 2002–03, 74% of the fire-killed trees measured in 131 stands had fallen (26% were still standing), but among stands, all trees could be standing or all could have fallen. Trees were more likely to be still standing at high elevations.

Various structural elements (legacy logs, recently fallen contact and elevated logs, pine saplings, open soil) in the post-fire stands influence ecological processes. Because most of the fire is carried through living vegetation, not ground vegetation, post-fire stands still have "legacy logs" or pre-fire coarse wood. Indeed, only about 8% of the downed coarse wood that was present in the forests before the fires was actually consumed by the fires (Tinker and Knight 2000). We found that the legacy logs and newly fallen trees affect decomposition, which was slowest under elevated logs and fastest under legacy logs

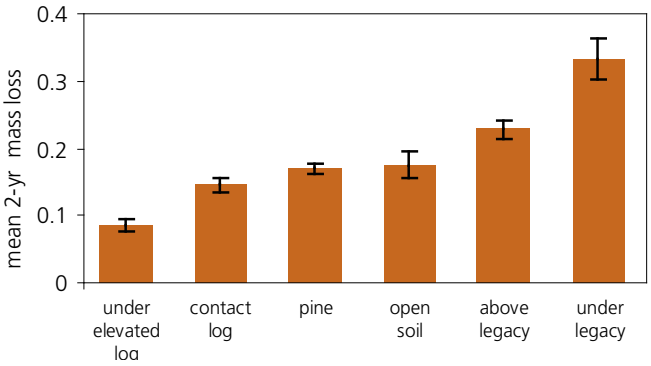


Figure 3. Decomposition was slowest under elevated logs, fastest under legacy logs (after Remsburg and Turner 2006).

NPS/J. SCHMIDT

In some areas, elk consumed burned bark after the 1988 fires.

(Fig. 3; Remsburg and Turner 2006). In addition, nitrification and net nitrogen mineralization rates were lowest under elevated logs and greatest under bare soil (Metzger et al. 2008).

Effects on Wildlife

The direct effects of the 1988 fires on wildlife were relatively small. The substantial 1988–89 winter elk mortality was primarily due to a severe winter with high snow depth and density after several mild winters (Singer et al. 1989). The successional patterns of vegetation will affect many taxa (Taylor 1969, 1980).

Elk used the burned forest in the initial post-fire years when wolves were not yet present. They even consumed burned lodgepole pine bark, which is apparently more palatable than unburned bark, though it is still not a very good source of nutrients (Jakubas et al. 1994). Elk avoided burned forest on the northern range, though food was scarce (Singer and Harter 1996). Elk increased their summer use of the burned forests when wolves were present in 2000–02 (Mao et al. 2005). In recent years, elk have used burned forest even when fallen trees and dense lodgepole pine trees might have been expected to impede their use of these areas. Although abundant coarse wood was hypothesized as a potential mechanism for protecting young seedling aspen from browsing, we found 89% of aspen seedlings were browsed in burned forests on the subalpine plateau (i.e., summer rather than winter elk range). Extremely high log densities may reduce elk use at very fine scales, but these extremely dense log piles are rare (Forester et al. 2007).

Summary

The 1988 Yellowstone fires initiated change in the landscape, but they definitely were not an ecological catastrophe. I am reminded of Jean-Baptiste Alphonse Karr (1849) who said, "The more things change, the more they remain the same." The fires increased landscape heterogeneity, modified patterns of wildlife habitat use, and initiated long-term dynamics of carbon release and sequestration, yet lodgepole pine is still dominant in Yellowstone, native plant and animal communities persist and thrive, and ecosystem processes recovered quickly.

Yellowstone is remarkably resilient to fire, and natural processes were clearly at work in the years following the fires (Turner et al. 2003b; Romme and Turner 2004; Schoennagel et al. 2008). The general insights gained from studies of the 1988 fires underscore the unique and important contributions of large wilderness areas like Yellowstone to science and management. Insights from these spaces may apply in other forests with natural, stand replacing fire regimes.

YS

Acknowledgements

I thank my colleagues, especially Bill Romme, for two decades of fruitful research collaboration and acknowledge the contributions of numerous students and postdoctoral scientists to these long-term studies. The work reported here was funded by multiple sources, including the National Science Foundation, USDA National Research Initiative, Joint Fire Science Program, U.S. Department of Energy, National Geographic Society, and the Conservation and Environment Program of the Andrew W. Mellon Foundation. Field and logistical support from Hank Harlow and the University of Wyoming–National Park Service Research Center and the staff at Yellowstone National Park is also greatly appreciated.

COURTESY OF THE AUTHOR

Monica G. Turner is the Eugene P. Odum Professor of Ecology in the Department of Zoology, University of Wisconsin–Madison. Turner first visited Yellowstone in 1978, when she worked at Old Faithful as a ranger-naturalist through the Student Conservation Association. That formative summer confirmed her decision to become an ecologist. Turner has a long-standing interest in studying natural disturbances and has conducted research in Yellowstone since 1988. Research by Turner, with her collaborators and students, has addressed the effects of fire on vegetation, carbon and nitrogen dynamics; movement patterns and habitat use by elk; interactions between fire and bark beetles; and implications of climate change. She is currently co-editor in chief for the journal *Ecosystems* and serves on the editorial boards of *BioScience*, *Landscape Ecology*, and the *Quarterly Review of Biology*. In 2004, she was elected to the National Academy of Sciences.

References

Despain, D.G. 1990. *Yellowstone vegetation: Consequences of environment and history in a natural setting.* Boulder, CO: Rinehart Publishers.

Forester, J.D., D.P. Anderson, and M.G. Turner. 2007. Do high-density patches of coarse wood and regenerating saplings create browsing refugia for aspen (*Populus tremuloides* Michx.) in Yellowstone National Park (USA)? *Forest Ecology and Management* 253:211–219.

Gerla, P.J., and J.M. Galloway. 1998. Water quality of two streams near Yellowstone Park, Wyoming, following the 1988 Clover-Mist wildfire. *Environmental Geology* 36 (1–2): 127–136.

Gresswall, R.E. 1999. Fire and aquatic ecosystems in forested biomes of North America. *Transactions of the American Fisheries Society* 128(2):193–221.

Jakubas, W.J., R.A. Garrott, P.J. White, and D.R. Mertens. 1994. Fire-induced changes in the nutritional quality of lodgepole pine bark. *Journal of Wildlife Management* 58 (1):35–46.

Kashian, D.M., M.G.Turner, and W.H. Romme. 2005a. Variability in leaf area and stemwood increment along a 300-year lodgepole pine chronosequence. *Ecosystems* 8:48–61.

Kashian, D.M., M.G. Turner, W.H. Romme, and C.G. Lorimer. 2005b. Variability and convergence in stand structural development on a fire-dominated subalpine landscape. *Ecology* 86(3):643–654.

Lathrop, R.G. 1994. Impacts of the 1988 wildfires on the water-quality of Yellowstone and Lewis lakes, Wyoming. *International Journal of Wildland Fire* 4(3):169–175.

Legleiter, C.J., R.L. Lawrence, M.A. Fonstad, W.A. Marcus, and R. Aspinall. 2003. Fluvial response a decade after wildfire in the northern Yellowstone ecosystem: A spatially explicit analysis. *Geomorphology* 54:119–136.

Levitt, E.A. 2006. Sources of variation in soil nitrogen availability among post-fire lodgepole pine stands in Yellowstone National Park. MS thesis, University of Wisconsin–Madison.

Mao, J.S., M.S. Boyce, D.W. Smith, F.J. Singer, D.J. Vales, J.M. Vore, and E.H. Merrill. 2005. Habitat selection by elk before and after wolf reintroduction in Yellowstone National Park. *Journal of Wildlife Management* 69(4): 1691–1707.

Metzger, K.L., E.A.H. Smithwick, D.B. Tinker, W.H. Romme, T.C. Balser, and M.G. Turner. 2008. Influence of coarse wood and pine saplings on nitrogen mineralization and microbial communities in young post-fire Pinus contorta. *Forest Ecology and Management* 256:59–67.

Meyer, G.A., S.G. Wells, R.C. Balling, A.J.T. Jull. 1992. Response of alluvial systems to fire and climate change in Yellowstone National Park. *Nature* 357:147–150.

Millspaugh, S.H., C. Whitlock, and P.J. Bartlein. 2000. Variations in fire frequency and climate over the past 17,000 yr in central Yellowstone National Park. *Geology* 28(3): 211–214.

Minshall, G.W., C.T. Robinson, and D.E. Lawrence. 1997. Postfire response of lotic ecosystems in Yellowstone National Park, USA. *Canadian Journal of Fisheries and Aquatic Sciences* 54(11):2509–2525.

Remsburg, A.J., and M.G. Turner. 2006. Amount, position, and age of coarse wood influence litter decomposition in postfire *Pinus contorta* stands. *Canadian Journal of Forest Research* 36(9):2112–2123.

Romme, W.H. 1982. Fire and landscape diversity in subalpine forests of Yellowstone National Park. *Ecological Monographs* 52(2):199–221.

Romme, W.H., and D.G. Despain. 1989. Historical perspective on the Yellowstone fires of 1988. Special issue, *BioScience* 39(10):695–699.

Romme, W.H., D.B. Tinker, G.H. Stakes, and M.G. Turner. 2009. Does inorganic nitrogen availability limit plant growth 3–5 years after fire in a Wyoming lodgepole pine forest? *Forest Ecology and Management* 257:829–835.

Romme W.H., and M.G. Turner. 2004. Ten years after the 1988 Yellowstone fires: Is restoration needed? In *After the fires: The ecology of change in Yellowstone National Park*, ed. L.L. Wallace, 318–361. New Haven, CT: Yale University Press.

Romme, W.H., M.G. Turner, R.H. Gardner, W.W. Hargrove, G.A. Tuskan, D.G. Despain, and R.A. Renkin. 1997. A rare episode of sexual reproduction in aspen (*Populus tremuloides* Michx.) following the 1988 Yellowstone fires. *Natural Areas Journal* 17(1):17–25.

Romme, W.H., M.G. Turner, G.A. Tuskan, and R.A. Reed. 2005. Establishment, persistence, and growth of aspen (*Populus tremuloides*) seedlings in Yellowstone National Park. *Ecology* 86(2):404–418.

Schoennagel, T., E.A.H. Smithwick, and M.G. Turner. 2008. Landscape heterogeneity following large fires: Insights from Yellowstone National Park, USA. *International Journal of Wildland Fire* 17(6):742–753.

Schoennagel, T., M.G. Turner, and W.H. Romme. 2003. The influence of fire interval and serotiny on postfire lodgepole pine density in Yellowstone National Park. *Ecology* 84(11):2967–2978.

Schoessow, B.R., and D.B. Tinker. Forthcoming. Factors related to Canada thistle (*Cirsium arvense*) persistence and abundance in burned forests in Yellowstone National Park, USA. *Biological Invasions*.

Singer, F.J., and M.K. Harter. 1996. Comparative effects of elk herbivory and 1988 fires on northern Yellowstone National Park grasslands. *Ecological Applications* 6(1):185–199.

Singer, F.J., W. Schreier, J. Oppenheim, and E.O. Garton. 1989. Drought, fires, and large mammals: Evaluating the 1988 severe drought and large-scale fires. Special issue, *BioScience* 39(10):716–722.

Smithwick, E.A.H., M.G. Ryan, D.M. Kashian, W.H. Romme, D.B. Tinker, and M.G. Turner. 2009. Modeling the effects of fire and climate change on carbon and nitrogen storage in lodgepole pine (*Pinus contorta*) stands. *Global Change Biology* 15(3):534–548.

Smithwick, E.A.H., M.G. Turner, M.C. Mack, and F.S. Chapin, III. 2005b. Postfire soil N cycling in northern conifer forests affected by severe, stand-replacing wildfires. *Ecosystems* 8(1):163–181.

Smithwick, E.A.H., M.G. Turner, K.L. Metzger, and T.C. Balser. 2005a. Variation in NH4+ mineralization and microbial communities with stand age in lodgepole pine (*Pinus contorta*) forests, Yellowstone National Park (USA). *Soil Biology and Biogeochemistry* 37:1546–1559.

Taylor, D.L. 1969. Biotic succession of lodgepole pine forests of fire origin in Yellowstone National Park. PhD diss., University of Wyoming, Laramie.

Taylor, D.L. 1980. Biotic succession of lodgepole-pine forests of fire origin in Yellowstone National Park. National Geographic Society Research Reports 12:693–702.

Tinker, D.B., and D.H. Knight. 2000. Coarse woody debris following fire and logging in Wyoming lodgepole pine forests. *Ecosystems* 3(4):472–483.

Tinker, D.B., W.H. Romme, W.W. Hargrove, R.H. Gardner, and M.G. Turner. 1994. Landscape-scale heterogeneity in lodgepole pine serotiny. *Canadian Journal of Forest Research* 24(5):897–903.

Turner, M.G., W.H. Hargrove, R.H. Gardner, and W.H. Romme. 1994. Effects of fire on landscape heterogeneity in Yellowstone National Park, Wyoming. *Journal of Vegetation Science* 5:731–742.

Turner, M.G., and W.H. Romme. 1994. Landscape dynamics in crown fire ecosystems. *Landscape Ecology* 9(1):59–77.

Turner, M.G., W.H. Romme, and R.H. Gardner. 1999. Prefire heterogeneity, fire severity, and early postfire plant reestablishment in subalpine forests of Yellowstone National Park, Wyoming. *International Journal of Wildland Fire* 9(1):21–36.

Turner, M.G., W.H. Romme, R.H. Gardner, and W.W. Hargrove. 1997. Effects of fire size and pattern on early succession in Yellowstone National Park. *Ecological Monographs* 67(4):411–433.

Turner, M.G., W.H. Romme, R.A. Reed, and G.A. Tuskan. 2003a. Post-fire aspen seedling recruitment across the Yellowstone (USA) landscape. *Landscape Ecology* 18:127–140.

Turner, M.G., W.H. Romme, and D.B. Tinker. 2003b. Surprises and lessons from the 1988 Yellowstone fires. *Frontiers in Ecology and the Environment* 1(7):351–358.

Turner, M.G., E.A.H. Smithwick, K.L. Metzger, D.B. Tinker, and W.H. Romme. 2007b. Inorganic nitrogen availability after severe stand-replacing fire in the Greater Yellowstone ecosystem. *Proceedings of the National Academy of Sciences* 104(12):4782–4789.

Turner, M.G., E.A.H. Smithwick, D.B. Tinker, and W.H. Romme. 2009. Variation in foliar nitrogen and aboveground net primary production in young postfire lodgepole pine. *Canadian Journal of Forest Research*.

Turner, M.G., D.B. Tinker, W.H. Romme, D.M. Kashian, and C.M. Litton. 2004. Landscape patterns of sapling density, leaf area, and aboveground net primary production in postfire lodgepole pine forests, Yellowstone National Park (USA). *Ecosystems* 7(7):751–775.

Turner, M.G., D.M. Turner, W.H. Romme, and D.B. Tinker. 2007a. Cone production in young post-fire *Pinus contorta* stands in Greater Yellowstone (USA). *Forest Ecology and Management* 242:119–206.

Zelt, R.B., and E.E. Wohl. 2004. Channel and woody debris characteristics in adjacent burned and unburned watersheds a decade after wildfire, Park County, Wyoming. *Geomorphology* 57:217–233.

Wildland Fire Management Policy

Learning from the past and present and responding to future challenges

Tom Zimmerman

Wildland fire is one of the most important vegetation-shaping factors that land managers deal with. It is our highest risk, most complex, and potentially highest consequence program. Wildland fire management policy is the most important element in defining the direction, scope, and focus of the program. What is policy? If we look it up in Merriam-Webster's dictionary, it is a "high-level overall plan embracing the general goals and acceptable procedures, especially of a governmental body." It is interesting to see that the dictionary defines policy as a province of a government. Fire policy is a course of action to guide present and future decisions and to identify procedures and means to achieve wildland fire management goals and objectives. It is adopted and developed by a group of people, specifies principles for management, and involves commitment to implement it and carry it forward.

The components of policy include those driving factors that give us a need for policy and determine its influences. Policy is also comprised of supportive processes identified through policy elements. The main results and outcomes of these processes are performance, achievements, and lessons learned. Results and outcomes set the program requirements, guide our management procedures, define this broad course of action, and facilitate program implementation. Theoretically, a good, sound policy facilitates both efficiency and accomplishment.

If we look back at historical fire policy, the driving factors are:

The state of our knowledge. In many cases, our early policy was based on an immature knowledge of ecology and the natural role of fire. The state of our knowledge is also comprised of current economics and politics, including awareness of whether we are protecting values, valued resources, or perpetuating resources for the future.

Our capability to respond to implementing the policy. In the early twentieth century we did not have the capability to respond to a lot of fires; our organization shaped our actions. Safety is key to our capability and will continue to be a concern in fire management.

Personal or agency perspectives and experiences. In many cases, these are the dominant driving factors that influence policy. If you do not believe that, take a look at the changes in our country's foreign, domestic, and economic policies that come with each administration.

Early fire policy was shaped around agency perspective and driven by political interest. It called for suppression of all fires and it was one of the most rigid policies in fire management history. From 1968 through 1988 we saw a shift from fire "control" to fire "management." During this transition we went from a single focus with the objective of excluding fire

A Civilian Conservation Corps fire crew lines up for a meal at a fire camp on Mirror Plateau in 1935.

NPS, YELL-3443Z

In 1932, Yellowstone firefighters put out a spot fire. Early policy called for the suppression of all fires.

to multiple objectives that included wildfire suppression, prescribed natural fire, and management-ignited prescribed fire.

Prior to 1988, policy reflected multiple fire types: wildfires included initial-attack fires, controlled fire, containment fire, or confinement fire; prescribed fire included management-ignited prescribed fire and prescribed natural fire. We were also on the verge of reclassifying prescribed natural fire into active or inactive categories. The number of boxes used to classify fire began to build confusion among managers. The 1988 Report on Fire Management Policy affirmed direction for the Department of Agriculture and the Department of the Interior but led into classifying all fires as either wildfires or prescribed fires, which included prescribed natural fires.

As a direct result of the Yellowstone fires and the policy of 1989, fire managers placed a greater emphasis on planning and preparedness, particularly to constrain prescribed natural fire. Prescribed natural fire direction required line officer certification in an attempt to restore the involvement of line officers in decision making and management of the fire. Some impacts of these constraints were positive because they increased our preparedness and improved long-term accountability.

Post-1989 fire policy is comprised of the same components and similar driving factors as historical policies. Our state of knowledge has advanced significantly; many of our milestones of the last 20 years have been in the advancement of scientific knowledge, technology, and improved awareness of fire as a natural process and fire effects. As fire managers looked back on the effects of fires in the late 1980s, they found that fire exclusion did not support resource management objectives and that they were unable to achieve full fire exclusion. We found that there were serious consequences associated with fire suppression and the techniques and tools used to suppress fires. We have also associated economics with the impacts of fire on communities and economic values, and the cost of fire suppression. Safety and political pressures continue to be concerns. The need for greater interpretation of and information sharing is emerging as an important component of the program.

Our capability to respond to and manage fires is an increasingly critical factor, which is influenced by interagency cooperation, a driving factor in policy after 1989. Interagency perspective shifted to protecting valuable resources, managing fire for resource benefits, and acceptance and use of fire on the landscape. The seriousness of potential consequences, such as community protection and personal loss, became a driving factor and had an increasingly important role in shaping policy. Before 1989, the fire community perceived the public's role in wildland fire as personal risk and responsibility, but that has shifted toward public participation in decision making and development of management direction.

Our current fire policy is the most flexible policy we have ever had. It combines multiple objectives and specifically incorporates science. It allows fire managers to do what we should, rather than what we could, which we have historically done whether it was needed or not. The present policy advocates more wildland fire use and more application of fire to accomplish resource benefits. It advocates appropriate management response, which was the cornerstone of the 1995 Federal Wildland Fire Management Policy.

Since 1989, we have learned that fire has a critical natural role and that we need to manage it where possible. We have learned that one size does not fit all situations. Appropriate management response is relevant and timely, and it is something that we should make greater use of since it is included in our policy. An example of management changes is in 1988, we spent over a million dollars to keep the Huck and Mink fires in the Teton Wilderness separate and save an area of timber blow-down. In 2000, we spent about $150,000 to manage fire though that same blow-down area in the Enos Fire, and we

NPS/JIM PEACO

Firefighters spraying water over the business district in Cooke City, Montana, in 1988. The seriousness of potential consequences, such as community protection and personal loss, became a driving factor in shaping fire policy after 1988.

are pretty happy with results. The thought process of how we use and manage fire changed over a 12-year period; we learned there are different ways to manage individual fires.

We have learned that our roles and responsibilities in protecting the wildland-urban interface need clarification. This role as a responsible organization has become confused over time. Our fire management activities are increasingly focused on the wildland-urban interface; almost every large smoke column is visible from somewhere and people watch it. Historically, we worked in remotely-based situations in wilderness or inaccessible areas where most people could not see the smoke columns and did not know what was happening. The social acceptance of the long-term impacts of smoke, air quality, and visibility is becoming so important that it may be a constraining factor in the future.

Our current fire policy is the most flexible policy we have ever had.... It allows fire managers to do what we should, rather than what we could....

We have learned that not all fires should be or can be suppressed, although we continue to struggle with that lesson. In Stephen Pyne's 2004 book, *Tending Fire*, he reflects on some of the lessons learned in the last century. He states that the options are to do nothing with fire management and let nature take its course, try to exclude all fires and deal with the effects of that, conduct the burning ourselves through the application of wildland fire use or prescribed fire and minimize wildfire acres, or go out and change the combustibility of the landscape. But the reality, he says, is that we are not capable of fully accomplishing any of those alternatives and even if we could, none of them would work completely.

I think the real lesson that we have learned is about what we can do in suppression. Based on social, economic, and ecologic needs and our own capabilities, we have learned that we must have a policy that allows for and fosters a balanced fire management program. We must be able to suppress unwanted fires when we need to, apply fire through management and prescribed fires when we need to and can, manage fires from ignitions that we can use for resource benefits where feasible, and apply non-fire treatments to reduce hazardous fuels around high-value areas.

Our fire environment is changing and this will have remarkable impacts on fire management and our program complexity. Our fire regimes, the types of fires we experience, fuel situations and fire behavior, and the timing, extent, and area of the fires are all changing. We are on a rapidly increasing trend of fire complexity that shows no sign of decreasing. This complexity is a composite of acres burned, numbers of fires, fire season length, explosion of the wildland-urban interface, fuel types and changes in fuel types, and altered fire regimes.

The complexity of fires that we are dealing with is increasing and our capability to respond is decreasing. Early fire management between the 1940s and 1960s started out with an almost non-existent organizational capability, which we quickly addressed. We created agencies, organizations, and training. We developed a sophisticated firefighting operation and, after a point, our organizational capability surpassed the complexity of the fires. We became pretty good at what we were doing, though this was during some of the coolest and wettest climate periods of the twentieth century. Once we peaked though, a slow erosion of our capabilities started and continued until the 2001 national fire plan infusion of monies and additional staffing. Following that our operational capability has continued to slowly erode since 2001.

Though our capability to respond to fires is decreasing, we are rapidly improving decision-making support with wildland fire science and technology information. The fire community has always pursued development of improving information assessment, analysis, and application. Now this support is in forms that help us deal with specific pieces of information that we are lacking to make better decisions. Use of prescribed fire as a tool has been steadily increasing and shows strong potential for continued improvement. Managing wildland fires for resource benefits, which is only a small part of the program, has only been in place for 30 of 40 years, but is rapidly increasing.

It is going to take the sum of organizational capability, science and technology, decision support, managing fires for resource benefits, and prescribed fire application to match the increasing fire complexity. Our capability to manage fires for resource benefits may be limited in the future. Future policy

JENNIFER J. WHIPPLE

Firefighters line up for a meal at the Old Faithful fire camp in 1988. Firefighting resources now need to be more mobile.

will have to promote increased efficiency. It is going to have to guide us through the smart and safe use of limited fire management resources. We can no longer just throw resources and money at fires or try to exclude all fires. Fire suppression costs are increasing and future policy will need to help guide effective cost management and cost responses.

Our resources will have to be mobile; we will not be able to commit firefighting resources for long durations on all fires. Specific management policies have been adopted since 1989 that focus on more fire-specific needs and include appropriate management response, implementing a full range of tactical responses, and applying an individual set of tactics. Will we continue to see declines in our workforce; will we be augmented by another organization's workforce? We do not know what will happen. We have to manage future fire seasons within constraints and our policy in the future is going to have to reflect and facilitate this.

When we manage fires we are also dealing with economic, social, and political problems. This is no longer a simple fire-vegetation dynamic. The future policy has to allow for strategic creativity in light of diminished capability. Our capability can increase in certain ways but it will not be the same way of the past: overwhelming mass of resources, and relentless shovels to the dirt. Societal demands and needs will continue to affect fire policy. Some estimates show that while economic growth is slowing, 5 to 6 million new homes will be built in the next 10 years in some western and Sunbelt states, particularly in southern California, Arizona, and the coastal Southeast. All of those homes will be built in the wildland-urban interface or expand the interface. Under this scenario, nearly all fires in these areas will be wildland-urban interface fires within 10 or 15 years. How are we going to respond to that? What responses are acceptable? These issues need to be addressed in our policy.

More importantly, future policy must clarify terminology. We struggle with terminology that is confusing to the public and even our own fire community. Appropriate management response is a seemingly understandable term but has not been fully implemented because it is the most misunderstood and misused policy term we have right now. You might think, while looking back at previous policies and terms we have produced, that policy makers sit around the room spinning a random buzzword generator. We have had good terms in the past. Prescribed natural fire was a pretty good term; people understood that, so we changed it! I expect to open up the dictionary and find definitions for some of our terms that say, "For bureaucracies, look for antonyms; for all other organizations look for synonyms." We need a policy that clarifies and simplifies terminology and presents a common message. We have had policy at times that is confusing, and because it is hard to understand, it does not get down to the field or to the public (or if it does, the public does not understand it). If our own practitioners do not understand it, we will not be able to succeed.

Future policy needs to clarify the importance of different ignition sources and how we can respond. This policy must be flexible and responsive to change—change will not disappear. This policy will need to allow us to plan and implement the full range of management responses drawn from the full tactical response spectrum. It is going to have to simplify wildland fire management and its understanding for all audiences. It will need to foster a balanced program. This program will be a mix of protection activities, maintenance activities, restoration, and fire application. It will have to be based equally on ecological, social, economic, and political considerations.

Our fire management program is going to continue to grow and change in both temporal and spatial extent; it is going to continue to become increasingly more complex. The ecological significance of how we are managing fire is going to continue to change. To continue program improvement, we must have a continually responsive policy. The simple fact of this is there is no going back. We are not going back to any previous policies; that is not acceptable. Our program is highly visible to the public, media, and politicians. Fire management is no longer ignored and we want to make it something that is adored, but it is hard to get there without a good policy.

Again drawing from Webster's dictionary definition of policy, fire policy must provide "prudence and wisdom" in the management of wildland fire. I think that is something we should all keep in mind. If we have a policy that allows us to do that, it will be successful.

YS

COURTESY OF THE AUTHOR

Tom Zimmerman is the program manager of Wildland Fire Management Research, Development, and Application at the USDA Forest Service's Rocky Mountain Research Station in Boise, Idaho. His focus is primarily on providing wildland fire science, decision support tools, and science integration to the national interagency wildland fire community. Zimmerman is involved in national training cadres in advanced incident management, area command, and advanced fire use applications. He has served on Type 2 and Type 1 incident management teams, interagency fire use management teams, and is currently an area commander on a national interagency area command team. His experience also includes field, state, regional, and national office assignments with the Bureau of Land Management, National Park Service, and Forest Service.

Moving From Fire Management to Learning to Live with Fire

George Weldon

JENNIFER J. WHIPPLE

In 1988, I had 16 years of experience and training. I thought fire managers were in charge, but the fire season that year clearly showed me that we were not. At the time I was working on the Beartooth Ranger District of the Custer National Forest. I remember briefing the forest supervisor and the district ranger about why we needed to manage the Storm Creek Fire, which started in mid-June in the Absaroka-Beartooth Wilderness, for resource benefits. I made some fire behavior projections and told the managers that under the worst conditions the fire would be 3,000 acres in size. At the end of the 1988 fire season, the Storm Creek Fire covered 104,000 acres—I was a little off in my calculations.

The 1988 fire season was an extraordinary event. It was, at least in my mind, truly unexpected fire behavior. I had never seen nor heard people talk about what we were seeing that particular year. I was especially proud of the National Park Service in terms of how bold they were to stay on the mission of fire management that they believed in. All of the fire leaders at the time did an incredible job of keeping the public and firefighters safe under conditions that we were not trained for or had experienced before. I still am in awe of that. I hope that as fire leaders, we can do as good a job in the future as those folks did in the fire season of 1988.

To know where you are going, every once in a while you have to look back at where you have been, and for me that means looking at the history of fire in our ecosystems, fire management, and the environment. There was a lot of fire in the Flathead National Forest and Glacier National Park ecosystem prior to 1930. There are several reasons for that: it was a fairly dry period, but also the agencies did not have much firefighting capability to speak of. Between 1930 and 1980, we became pretty successful in excluding fire from this area and built up a significant capability in firefighting. For example, the first smokejumpers, Rufus Robinson and Earl Couley, jumped out of an airplane in 1940 to put out a fire in the Selway-Bitterroot Wilderness in the Marten Creek Drainage.

We have come a long way since then to significantly increase our capability. We were very successful between 1930 and 1980 at excluding fire from these and other fire-dependent ecosystems across the western U.S. This period is the major reference we have used to develop our current models of incident management teams and fire management strategies. Now we must stop and examine these models and incident management teams to see if they are still effective under changed conditions. Our fire history clearly indicates that fire will eventually occur no matter the number of fires we extinguish. An example of this is the Gash Creek Fire in the Bitterroot National Forest in 2006. Between 1931 and 2006, we suppressed about 72 fires in that area. The 73rd fire was the Gash Creek Fire, which covered 8,000 acres. We spent $8 million on suppression. We must recognize that although we have the capability to delay fires under certain conditions, they will eventually occur in these ecosystems, and putting fires out in these ecosystems is not a sustainable operation. The fire community must get better at making recommendations for critical decisions in applying and delaying fire in fire-dependent ecosystems and landscapes.

As climate changes and fires easily exceed our operational capability to suppress and control, the lesson that we are not in charge and cannot know the future in a rapidly changing fire environment continues to be reiterated. This was demonstrated by the fires of 2000, 2003, 2006, and 2007. We need to begin seeing fire as a process like earthquakes, tornadoes, and floods, which are events we cannot control or manage. Under the right conditions, fuels, weather, and topography

Changes in Large Fire Management Since the 1988 Yellowstone Fires

An Incident Commander's Perspective

Steve Frye

Steve Frye *began his career in resource management as a seasonal firefighter in Elk River, Idaho. He also worked in Glacier, Big Bend, North Cascades, and Yellowstone national parks, where he was directly involved in the operational response to the fires of 1988. He has served in numerous Type 1 wildland fire overhead positions, including operations section chief and incident commander on Northern Rockies National Incident Management Teams and as an area commander for National Area Command Teams. Frye retired from the National Park Service as the superintendent of Katmai National Park and Preserve in 2006 and is currently an area operations manager for the Montana Department of Natural Resources and Conservation.*

COURTESY OF THE AUTHOR

We learned very quickly and dramatically from the Yellowstone fires of 1988. The fires were a preview of the fire management challenges and opportunities of the next 20 years. At the time many of us heard statements like "we'll never see this kind of fire behavior again in our lives." But we heard them repeated in 2000 on the Bitterroot National Forest when we heard folks say, "This is an anomaly—we will never see this again." Yet during the 2002 Biscuit Fire in the Siskiyou National Forest people said, "This is very unusual. It is highly unlikely that we will see this again in our lifetime." In spite of these recurring statements, we continue to exceed our fire behavior standards in terms of anomaly and believability.

When I look at the fires of the last 20 years, I am reminded that "the more things change, the more they remain the same." A chronology of the '88 fires appears in the *Greater Yellowstone Fires of 1988 Phase II Report*, transmitted on October 12. It notes that at a meeting in West Yellowstone on August 26, line officers, area commanders, incident commanders, and representatives from the Boise Interagency Fire Center decided that the Greater Yellowstone Area (GYA) would be divided into zones for strategy purposes—something we do today. Area command would release crews, helicopters, one infrared aircraft, and other resources to priority fires outside the GYA. This was because declining fire suppression resources coupled with a continuation of severe fire behavior made it difficult to maintain perimeter control strategies on the GYA fire complex. Area command placed a great emphasis on the suppression of new fires and assigned a zone coordinator to deal with fire suppression issues on all GYA fires outside the park. The report goes on to say that high intensity fires, characterized by routine torching, crowning, and spotting, easily crossed hand and dozer lines, major highways, the Madison River, and Yellowstone Canyon. That was a significant statement about the difficulty that managers were having in containing fires across the GYA.

Reports for the 2007 fires in the northern U.S. Rockies make similar statements about difficulty in containment. In an August 1, 2007, letter by the Northern Rockies Geographic Coordinating Group, agency administrators noted that:

> *Fuel conditions in the northern Rockies are reaching all-time records and fire behavior has proven to be unforgiving. The fire environment has exceeded our operational capability in many fuel types. Fire managers must realize that recent and upcoming fire seasons are not business as usual and take into account that the fires' high resistance to control will force us to use tactics that focus entirely on keeping the public out of the way of large fire growth and ensuring fire personnel are not put at risk. More helicopters, more crews, and more engines may have very little influence until weather and fuel conditions moderate.*

Our experiences in 1988 were truly a preview of the next 20 years.

We have resolved many of the difficulties that caused us great problems in 1988. Large-fire managers take advantage of the strategies and lessons learned from that fire season, such as improved and increased coordination and communication. In 1988, we had difficulties in moving resources from one area to another and the only means of communication between fire managers was the telephone. There were not opportunities to talk about the situation with an adjacent fire manager

if you were not sitting by the phone or meeting face-to-face. Today, large-fire managers face different challenges such as development in the interface, declining resource availability, climate change, and expanding expectations for Incident Management Teams.

Development in the wildland-urban interface presents the largest and most complex issues and changes for wildland fire managers since the '88 fires. Development causes managers to reposition our limited resources from areas that need protection. It also dramatically increases the number of agencies and entities that managers engage with. We engaged with local communities to a limited degree and did not engage to any effective degree with the local volunteer fire departments during the '88 fires, though this got better as the fire season went on. We did, however, enjoy a substantial amount of engagement with those pretenders to various political thrones who chose to use Yellowstone as a stump for their political aspirations.

The wildland-urban interface is not an uncommon situation for wildland firefighters anymore. As firefighting resources are increasingly limited, area commanders, incident commanders, and agency administrators are required to think outside of the box for strategies and ask the difficult question, "When is enough enough?" We have declining resource availability; we have fewer crews, engines, air tankers, and helicopters. In 1988, we had as many as 9,500 firefighters in the GYA at any given time. Over the course of that fire season, more than 25,000 firefighters were part of the fire management response. We had about 1,000 crews in 1988—today we have half as many. Heavy equipment was used in 1988 and it is often touted as a force multiplier. Over the last few years we have increased our use of this equipment, though it has long-term consequences for the landscape.

Firefighters are at the frontline of climate change as extremely aggressive fire behavior occurs in different fuel types and conditions. They may not think of it in those terms, but the firefighting line is one place where we are dealing with the consequences of climate change on the ground. We are experiencing extremely aggressive fire behavior in fuel types and at elevations that we have not experienced before and considered perimeter control areas.

As a result of successful large fire management since the '88 fires, managers are also called on to engage with an increasing array of organizations and issues and a diversity of expectations beyond wildfire management challenges. For today's incident commanders, large fire management is all about relationships—personal and biophysical. That is a challenge we have been able to effectively meet because of the diversity that incident management teams bring to fire problems. Incident managers have been called to provide leadership in a wider variety of incidents and responsibilities, such as floods, hurricanes, and other disasters because of their ability to bring order out of chaos and recognize the importance of human relationships, protecting people and property. This responsibility beyond wildfire challenges is in the context of fewer resources and incident management organizations.

The issues associated with wildland-urban interface pressure incident management teams to deal with problems that exceed any organization's capability. Because of increasingly limited resources and increasing demand, managers are frequently forced to make difficult decisions about how and where to allocate available resources. However, under the circumstances of incidents like the Cedar Fire of 2003 in California, we would not be able to control the fires even with all of the world's firefighting resources. Managers will need twice the resources to continue to meet current expectations and maintain necessary response capabilities assuming the number of fires stays at or below the current level.

To succeed, the fire community needs to be smarter about what we do with what we have and recognize that there are an increasing number of circumstances where our capability and capacity are exceeded by the natural and developed environment. In summary, I would like to mention two adages that were relevant in 1988 and are still today: (1) Mother Nature always bats last and (2) things are more like they are today than they have ever been before.

NPS/JIM PEACO

Military fire crews walk to buses at the Northeast Entrance in 1988. That year there were as many as 9,500 firefighters in the GYA at any given time. As fire-fighting resources are increasingly limited, managers must think outside of the box.

NPS

In 1988, fires approached gateway communities like West Yellowstone. Today's fire management challenges are about the decisions we make about applying and withholding fire in fire-dependent ecosystems and the effects of fire on people.

determine what a fire is going to do—not the number of firefighters, smokejumpers, or air tankers. The fall fires of 2007 in California stopped when the Santa Ana winds quit blowing, no matter how many resources we had. Managing fires is not about more money or more resources, it is about the decisions that we make about applying and delaying fire in these ecosystems. We need to focus on how we can mitigate these events in terms of the risks to people and values we need to protect.

The challenge is that fires are not the problem; it is the effect of these fires on people. In the 1960s and 1970s, federal land management agencies moved from fire suppression to fire management. I think the challenge for fire managers now is to move from fire management to learning how to live with fire. People do not like to be hot, they do not like to be cold, they do not like to breathe smoke, and they do not like their houses to burn down. It is important that we manage the public's expectations. Federal land management agencies do not have the capability to solve the wildland-urban interface problem. I think it is very important that we say that. It is a hard thing to say because we work for the American people and because our {Forest Service's] motto is "caring for the land and serving people." I question whether I am serving the people when I am unable to protect someone's home, but that is a fact. We need to tell people that first: we cannot protect your home.

Private landowners need to think about survivable space rather than defensible space. Local, state, and federal assets may not be available to protect a person's home when a fire visits. We have to think about survivable types of communities and structures so when a wildfire comes through, the structure will be standing afterward even though it had no defense assets to protect it. We have to start thinking that way immediately and manage the expectations of the public and agencies accordingly. We cannot promise something that we cannot provide.

From my perspective, the Wildland Fire Use Program, established in the Selway-Bitterroot Wilderness in 1972, is the most successful portion of the Forest Service's fire management program. After 36 years of managing fires for resource benefits, this area has smaller, less intense fires even during extreme fire weather. From 1996 to 2005, the patch size of these fires was significantly smaller than that of fires outside the wilderness. This is not because we used more smokejumpers and air tankers, it is because fires are bumping into areas that burned there from 1972 to 1996. This is successful from a resource perspective, but it also protects communities in the Bitterroot Valley. Because of this fire use program, we have not only allowed natural processes to function in wilderness but we have protected the valley by reducing the risk of large catastrophic fires. Having fires present across the landscape in a manner where fire size and intensity is self limiting is a desired condition we must all strive for in the fire-dependent ecosystems we live and work in.

We will have a similar model of the program in the Bob Marshall Complex, which was started about 10 years after the Selway program. I would forecast that 10 years from now we will be able to show a map of the Bob Marshall Wilderness Complex and see the same type of result as in the Selway-Bitterroot.

One of the values of wilderness is the ability to experiment. This program has been a grand experiment and we need to replicate and implement this model beyond wilderness and even in the wildland-urban interface. We have to explore, expand, and extrapolate this model. Why can't we have every acre of national forest system lands under a fire use program? We are a land and resource management agency. Why can't our agency administrators consider resource objectives on every acre when

JENNIFER J. WHIPPLE

Employees at the supply unit at the Old Faithful fire camp in 1988. As fire seasons grow longer, our resources will need to be increasingly mobile to manage other fires in the area.

The challenge is that fires are not the problem; it is the effect of these fires on people.

they develop their fire management strategies and tactics? Why can't we have a fire use program in the wildland-urban interface where we can bring fires closer to the communities to reduce that threat in the future? Multiple large fires will occur in the northern Rockies and significantly affect people and communities without the expansion of the Wildland Fire Use Program to other areas. We need to act now.

As we experience changes in our fire environment and the way we do things, we will have to manage fires differently. Typically we manage fires by building up resources, and when the fire starts slowing down and is considered more under control, we demobilize those resources. That is the way we were trained and it worked very effectively in the 1970s and 1980s when it rained and the fire environment was a lot different. It does not work in the current fire environment where fires may be 90 or 120 days in duration. We have to manage these long-duration events by moving resources in and out and having the right resources in the right place at the right time. We need to figure out from an interagency perspective how we can do a better job of managing these long-duration events. We need to work with our communities so that they understand our objectives and rationale. We are not going to be able to camp thousands of firefighters next to communities all summer to keep fires from coming into the communities. This is not effective, it is too costly, and exposes our folks too much. How we manage one fire significantly affects our capability to manage other fires in the area. If we continue to manage the way we did in the 1970s and 1980s, we will end up spending a lot of money, expose our people unnecessarily, and reduce our capability to manage other events that may be higher priority than the fire we are currently managing.

There is some good news: from 2000 to 2007, at least 10% of the forest burned in half of the national forest units in the northern Rockies. That provides us with immense opportunities to adjust our fire management plans to take advantage of changed landscapes. It is a great opportunity to be prepared and reduce the effects of future multi-million acre events. We have numerous studies that show the high percentages of our efforts and expenses that go to protecting communities.

But there are other investments we need to make. Thirty-three percent of water used in the West comes off national forests. We cannot forget about water; it is increasingly important to protect Western watersheds as the climate changes. Try going without water for a day and then go without your home for a day and then figure out which is the priority. Our strategies and tactics need to consider managing fire for resource benefits; this is a major tool for protecting and enhancing watersheds. Managers will need to look for solutions to this issue and recognize that mechanical treatments will have limited effects. We do not have the capability to treat forests at a scale where it would be effective, and it would not be desirable due to other impacts on resources. The Forest Service will not log our way out of the wildland-urban interface issue. We need to use mechanical treatments in the right areas, but our primary tool is going to be fire.

The Forest Service can make these changes by changing fire management plans at the field level, from the bottom up. This is a key element of how to manage fires in the future. To do this, we will need to have conversations with our partners and the public about what our vision is for the future, how we are going to get there, and develop implementation strategies. We need to start having conversations to create a common vision for how people are going to protect their homes. We need to work with local planners to manage the interface because development plans are being created without knowledge of fire. We need to expand the fire use program into the wildland-urban interface, manage fires differently, and use fuel and mechanical treatments in critical areas that will help us to allow fires to burn when it makes sense.

The Forest Service cannot solve this issue independently. We need to operate in an interagency manner and need public support to manage public lands. It is critical that land and resource management plans and people recognize the importance of our fire-dependent ecosystems. The time to act is now. If we do not act on this, who will? If we do not act boldly now, then the result will be significant effects of wildfire on people. People must be willing to experience short-term effects to reduce the risk of more significant effects later on.

YS

COURTESY OF THE AUTHOR

George Weldon is deputy director of Fire, Aviation and Air for the Northern Region of the USDA Forest Service. Weldon began his career in 1972 on the Shasta Trinity National Forest engine crew. In 1975 he was a Missoula Smokejumper. He has worked on six forests in Region One in positions including district ranger and deputy forest supervisor. Prior to his current position, Weldon was the forest supervisor of Ashley National Forest in Vernal, Utah.

COURTESY OF THE AUTHOR

Future Forests, Future Fires

Norm Christensen *is a professor of ecology and the founding dean of the Nicholas School division of environmental sciences and policy at Duke University. He has served on numerous advisory panels on the ecology and management implications of natural disturbance, especially fire, and the dynamics of forests across the U.S. He contributed to the National Park Service's evaluation of fire management programs following the 1988 fires in the Greater Yellowstone Area and a panel on the ecological consequences of the fires. He is currently conducting research on disturbance and the restoration of southeastern forest ecosystems.*

One century ago, America was having its first public debate on fire management, although the term "fire management" did not actually appear in the discourse. This debate was about "light burning," that is, whether fires should be intentionally set and allowed to burn in the understories of forests. To be sure, this was not an argument about restoring fire to its natural role in the ecosystem. While some people might have agreed that fires occurred naturally, few would have argued that fire had a natural role. No, this argument was about whether to diminish the risk of catastrophic wildfires by using fire to alter forests as American Indians had done. The experience of John Wesley Powell as director of the U.S. Geological Survey, especially with the Paiute on Arizona's Kaibab Plateau, convinced him that periodic burning was the best way to avoid large wildfires in western forests. However, Gifford Pinchot, who became the first chief of the USDA Forest Service in 1905, had mixed feelings about this so-called "Paiute forestry."

Notwithstanding his beautiful prose about fire burning through the giant sequoia forest understory and his concerns about the destructive nature of crown-killing wildfire, John Muir was vehemently opposed to light burning. He called fire "the master scourge and controller of the distribution of trees," and claimed that "notwithstanding the immense quantities of timber cut every year for foreign and home markets and mines, from five to ten times as much is destroyed as is used, chiefly by running forest fires that only the federal government can stop" (Muir 1901). To him, light burning was just an excuse for more human land exploitation.

The debate about light burning ceased abruptly and entirely when the Great Fires of 1910 burned three million acres in Idaho and Montana and took the lives of more than 80 people, most of them firefighters. Federal policy following that event forbade intentional burning in any public forest or shrubland and wildfires ignited by any source were to be suppressed, and that's where it stood for the next quarter century. Indeed, after 1917, states that allowed prescribed burning on public or private land risked the loss of federal funds for land management.

However, for some foresters, the idea that fire might be managed rather than suppressed would not die. By the mid-1930s, Herman Chapman's careful documentation of the importance of fire for southeastern longleaf pine forests and his advocacy for the use of prescribed fire in its management was winning converts like Herbert Stoddard in the South and Harold Weaver in the West. Chapman put the topic of prescribed fire on the agenda of the 1935 annual meeting of the Society of American Foresters, of which he was then president. By all accounts, it was one of the most tumultuous discussions at such a meeting before or since.

That was indeed a busy year for fire and fire policy. In April 1935, the Forest Service formally promulgated what had been implicit policy for nearly two decades: that the aim for any wildland fire was to obtain control over it by 10 AM on the day after it was first reported. Nonetheless, nearly 2 million acres of forest burned in the western U.S. that year. In a paper entitled, "Experimental Ecology in the Public Service" (1935), the iconic ecologist Frederic E. Clements opined, "Under primitive conditions, the great climax forests of the globe must have remained essentially intact, since fires from natural causes must have been both relatively infrequent and localized." Despite accumulating evidence and voices to the contrary, by 1935 there was a consensus among most forest scientists and managers that (1) fire in forests and shrublands is mostly a human-

caused problem, (2) we can successfully keep fire out of forest and shrubland ecosystems (an idea reinforced by the advent of smoke chasing and jumping), and (3) suppressing fire would have no adverse consequences.

Over the next quarter century, evidence from people like Harold Biswell, Ed Komarek, and Bud Heinselman challenged each of those assertions. By the 1960s, there was widespread agreement among most ecologists and some managers on four points that were completely contrary to the previous conventional wisdom.

- Fires are not random or chance occurrences; they ignite and burn in particular ways as a consequence of the confluence of climate, weather, ignition sources, and the growth of fuels.
- Fire regimes—the typical frequency and behavior of fire—and ecosystems have co-evolved. The flora and fauna of many shrub and forest ecosystems are not simply resilient to fire, they depend on it. Fires come and go, at least in part, in response to the growth patterns of the fuels they burn.
- Exclusion of fire from these co-evolved ecosystems has significant consequences, often affecting the establishment and growth of shade and fire intolerant species, and closure of the forest understory.
- Fire exclusion—as opposed to fire suppression—is mostly an illusion. The absence of fire can actually increase the amount and flammability of fuels, increasing both the risk and severity of future fires.

What's more, the continued occurrence of severe fire seasons and the exponential growth in the costs of fire suppression were raising doubts among many managers about the viability of "absolute" fire suppression as a national policy. These concerns were heightened by passage of the Wilderness Act of 1964, which limited human intervention on tens of millions of remote forest acres.

In 1967, the Forest Service relaxed its 10 AM policy for early- and late-season fires. A year later the National Park Service dropped its fire exclusion policy altogether and began to implement the first of several programs aimed at restoring fire to its "natural role" in ecosystems. The Park Service began implementing prescribed fire programs in the late 1960s, using artificially ignited fires in the Everglades and giant sequoia groves, and allowing lightning fires to burn within preset guidelines in the high-elevation forests of the Sierra Nevada and, beginning in 1972, Yellowstone National Park. In 1977, the Forest Service further modified its policy to allow local fire managers to consider alternatives to full suppression, including the use of prescribed fire.

NPS, YELL-34463-4, I. DANECK

A firefighter creates a trench above Rustic Falls in Yellowstone, 1936. Following the Great Fires of 1910, federal policy forbade intentional burning in any public forest or shrubland.

NPS

A news team from Salt Lake City covered the 1988 fires in Yellowstone. The fires of 1988 were the first of many events that kept fire in the limelight of public attention and fully politicized its management.

Over the next decade, fire management and science steadily progressed. We gained a greater understanding of how and why fires ignite, and the factors that influence their spread from one tree or shrub to the next and across complex landscapes and terrain. The concept of fire cycles gained wider currency as ecologists, ever prone to jargon, began to talk in terms of patch mosaics, metastability, and change thresholds. Aside from some unhappiness about fire's aesthetic impacts in places such as the giant sequoia forests, fire management programs were growing in number and size, and going well.

Nevertheless, it would have to be said that most of this change was invisible to the average person on the street. To my parents, for example, the phrase "beneficial fire" was an oxymoron and Smokey Bear remained the most prominent icon for public land management.

The 1988 fires in Yellowstone brought fire management out of the wings and into the glaring lights of center stage. It was bad enough that nearly half the park's forest cover burned, visitors were sometimes denied entrance, and nearby communities were threatened. But that some fires were allowed to burn under what was considered "some damn fool let it burn" policy was "insanity." As Steve Pyne is fond of saying, the Yellowstone fires had all the makings of a celebrity scandal.

JENNIFER J. WHIPPLE

Snow on September 10, 1988, near Old Faithful. Snow succeeded in dousing the Yellowstone fires, after aggressive firefighting could not.

The 1988 fires were a watershed event for fire management. We may debate the challenges of a prescribed natural fire program on this landscape, but those fires were most emphatically *not* an ecological disaster. They have taught us much about the role of disturbance on large landscapes and about the remarkable resiliency of ecosystems in general. They have also taught us a great deal about public understanding or misunderstanding of the natural world and, even more, about the challenges of managing that world.

The 1988 fires were the first of many events that would keep fire in the limelight of public attention and fully politicize its management. Subsequent major fires in Yosemite, the devastating 1991 fires in and around Oakland, and the 1994 fire season with 34 fatalities were all cause for scrutiny of the concept of fire management. Even so, review after review reaffirmed the idea that fire was a critical and inevitable natural process that, according to the Review and Update of the 1995 Federal Wildland Fire Management Policy (2001), must be "integrated into land and resource management plans and activities on a landscape scale."

Since 2000, a steady stream of megafires—including Los Alamos, Rodeo-Chedeski, Hayman, and Biscuit—have repeatedly confirmed the fallacy of the assertion that fire can be excluded from ecosystems without consequence. Indeed, ask the average person on the street why the West is burning up, and he or she can likely provide at least a simplistic explanation of the evils of past fire policy. This awareness provided much of the impetus for passage of the Healthy Forests Restoration Act of 2003, a widespread but underfunded attempt to remedy fuel conditions.

But, as many of the papers from this meeting suggest, healthy forest initiatives are a simplistic response to a complicated dilemma with many underlying causes. Fire suppression has been effective in some places and not others. Even where it has been effective, its effects on fire regimes vary considerably. The flammability of some places is a consequence of land management actions such as logging or grazing that were taken many decades before the 10 AM policy was implemented or light burning was advocated. Increasing human access to and numbers of people living in fire-prone ecosystems has not only increased ignitions and provided additional fuel, it has greatly increased liability and altered public reactions to fire. Weather conditions have been favorable for ignition and fire spread across much of the West over the past eight years, and this is very likely due to long-term trends associated with global warming. In 2007, fire research, management, and, primarily, suppression consumed nearly 60% of the entire budget of the Forest Service. If current trends prevail, the proportion of natural resource management dollars spent on fire will continue to increase.

Like the 1988 fires, each of the more recent massive fires has also begged a variety of questions about appropriate post-fire responses. Just how effective are Burned Area Emergency Response tactics? Is it appropriate to salvage valuable timber in public forests where wildlife and water are the primary management priorities? What are the ecological costs of doing so?

The 1988 fires were a watershed event for fire management…. They have taught us much about the role of disturbance on large landscapes and about the remarkable resiliency of ecosystems in general.

So, here we are a century after the first fire management debates, 70 years after the promulgation of one of the first formal fire policies, and 20 years after the first fire celebrity scandal. And here I am, well into a paper entitled "Future Forests, Future Fire" and not having said a single word about the future.

When meeting organizers pressed me for a title, that one seemed pretty good! How could I *not* come up with something to say around such a nifty alliteration? But, aside from stating the obvious, that the future of our forests and the future of fire are hopelessly intertwined, I now admit that the future is at best hazy. There are, however, some things that we can say with certainty. Our forests will continue to change—in many places this means that they will become increasingly flammable. The world around our forests will continue to change in ways that affect the likelihood, size, and severity of future fires and, just as importantly, the patterns of forest recovery that proceed from those fires. The human population will continue to increase, further altering fire regimes, increasing the costs of fire events in human life and property, and constraining fire management options. Even so, forests will become ever dearer

as our need for their ecosystem services, wildlife, recreation, and inspiration increases with our ever growing numbers. In short, fire management will at once become more compelling and more daunting.

My title for this paper is incomplete. I should have said "Future Forests, Future Fires, Future Fire Management." Guy Pence of Boise National Forest has suggested that the 10th Standard Firefighting Order should be changed from "Fight fire aggressively, having provided for safety first" to "Manage fire aggressively, having provided for safety first." For those who may not know, the 10 Standard Firefighting Orders were signed by Forest Service Chief Richard McArdle in 1957. They were an outgrowth of a review of fire fighting protocols that was commissioned on the heels of a tragic 1956 fire that claimed lives of 11 firefighters in California's Cleveland National Forest. That review considered lessons learned from 16 fires from 1935 and 1956 in which firefighters died. Here they are:

10 Standard Firefighting Orders

1. Keep informed on fire weather conditions and forecasts.
2. Know what your fire is doing at all times.
3. Base all actions on current and expected behavior of the fire.
4. Identify escape routes and safety zones, and make them known.
5. Post lookouts when there is possible danger.
6. Be alert. Keep calm. Think clearly. Act decisively.
7. Maintain prompt communications with your forces, your boss and adjoining forces.
8. Give clear instructions and be sure they are understood.
9. Maintain control of your forces at all times.
10. Fight fire aggressively, having provided for safety first.

I have no doubt that each of these 10 orders speaks to specific individual and personal tragedies over those previous 20 years. I take Guy Pence's proposed amendment to the 10th order as a plea for better integration of fire management and firefighting. I could not agree more. But I wondered if, analogous to McArdle's review, we were to examine the lessons of the past 20 years, we might be able to articulate 10 Standard Fire *Management* Orders. Well, I'm not sure if these are exactly the right ones, but here are my 10:

1. *Know what it is you are trying to accomplish and why*. It is not sufficient to say that we are restoring fire itself. While fire is essential in many ecosystems, it is not the endpoint of management. Rather we manage fire—we suppress it, restore it, and prescribe it—in order to conserve key things such as fuel conditions, natural and historic objects, wildlife, and key processes such as energy flows and element cycles. Our goals must be formulated in terms of these measures of forest sustainability.
2. *Set realistic goals*. We set fires, extinguish fires, and in various ways manage fuels across a range of fire regimes. The fact that certain things are easy to do at one end of that range too often leads to hubris regarding what can be accomplished elsewhere. Prescribed fire is virtually an oxymoron in many fuels, and forest restoration treatments of the kind that diminish wildfire risk in semiarid ponderosa pine stands are neither feasible nor effective in many other forest types.
3. *Manage the cycle—the entire process of change—not just the fire*. Fire is just one moment, albeit a transformational moment, in a process of change. The nature of a fire, any fire, is determined only in part by conditions—weather, fuel moisture, etc.—unique to that moment. Much fire behavior is a consequence of a century or more of ecosystem change preceding it. Furthermore, its behavior will influence the patterns of change that proceed from it over the decades and centuries that follow.
4. *Manage less for desired future conditions and more for desired future change*. This order follows from the previous one. Change is constant, and, as we have learned in several recent foreign conflicts, efforts to restore a particular condition with no thought about the change that will follow are likely to produce unhappy consequences. Across many parts of the West, we have embarked on a process of forest restoration to produce fire resistant structures. But, without a plan and the resources to manage the change that will inevitably follow this restoration, we will very soon return to high fire risk conditions.
5. *Variation and complexity matter—conserve them!* Perhaps the greatest ecological lesson of the 1988 fires was their variability and the equally remarkable diversity of recovery patterns and biological communities they produced.

JENNIFER J. WHIPPLE

The safety of firefighters like these is of paramount concern when managing fires. This crew from Alabama watches Echinus Geyser erupt in the Norris Geyser Basin, 1988.


NPS, YEL-34525

History should inform, but not dictate, future fire management approaches.

We now know for certain that the diversity of so many special places is a consequence not just of disturbance, but of variations in disturbance and the processes of change they produce. For this reason, managers should avoid homogeneity in their practices.

6. *Eschew arbitrary boundaries, which means almost all boundaries.* This is, of course, a basic tenet of ecosystem management. The 1988 Yellowstone fires and other subsequent fire events have brought home the fact that the spatial extent of fire, and of the many processes that are affected by fire, have little relationship to jurisdiction or ownership boundaries or the boundaries we use to define social and cultural categories such as urban and wildland. This is particularly important where the scale of fire or any other process approaches or exceeds the scale of ownerships and jurisdictions.
7. *The world is changing—expect surprise and manage to accommodate it.* In its 2007 reports, the Nobel Laureate Intergovernmental Panel on Climate Change pleaded with world governments to take steps to mitigate greenhouse gas emissions and thereby slow global warming. The panel also warned that some warming and associated climate change is inevitable and that environmental managers should take steps to adapt to it. Forests and related ecosystems must be a priority for such adaptation. Diversity and complexity provide a critical buffer for change. The loss of complexity and resilience in many of our forests is a matter of great concern, not just with respect to fire, but with regard to a great many natural and human-caused disturbances.
8. *Pay attention to history, but not too much attention.* Although the concept of historical range of variation has been a powerful addition to our understanding of fire in forests, the fire cycle is a very simplistic model of real-world change. Henry Chandler Cowles's wonderful depiction of succession as "a variable approaching a variable rather than a constant" (1901) is much closer to the truth. The fires in Yellowstone and elsewhere have taught us that each disturbance cycle is different. This is an especially important lesson in our rapidly changing world. Changing climate may well redefine both the nature of future fires and the nature of the ecosystems they produce. Diminished air and water quality and the redistribution of species across Earth's surface are producing ecosystem change that has no historical precedent. I will repeat something I said in 1991 at the first Greater Yellowstone Ecosystem Biennial Scientific Conference: naturalness—defined as that which was before people mucked things up—is to ecosystem management as the frictionless plane or an ideal gas is to physics.
9. *Remember, you are mostly managing people*. Fire management is not an academic matter; it has great consequences for human life and property. If nothing else has been learned on this matter in the past 20 years, it is that attempts to manage fire and fuels at landscape scales and across jurisdictional boundaries must have the engagement of all communities and stakeholders. The history of past forest use and perceptions about forest managers' intentions—lock it up or log it—will be an inevitable subtext for community-based management.
10. *You only think you know what you're doing—be humble, manage adaptively.* This 10th order is an especially apt capstone to a week in which we have rehearsed in detail the wealth of new data and understanding that have come from experience and research in Yellowstone and elsewhere. We have no choice but to learn on the job—adaptive management is critical. We must ensure that our monitoring is directly relevant to goals and objectives (1st order) and that research is addressing our most pressing uncertainties. The world is changing, but uncertainty is an unacceptable excuse for inaction. Indeed, in a world of change, there is no such thing as inaction.

We have learned much, nevertheless, we should not kid ourselves into thinking that someone a decade or two from now won't look back, smile, and wonder, "What the hell were they thinking?" We have learned much; we have much to learn.

YS

References

Clements, F.E. 1935. Experimental ecology in the public service. *Ecology* 16:342–363.

Cowles, H.C. 1901. The physiographic ecology of Chicago and vicinity. *Botanical Gazette* 31: 73–108.

Muir, J. 1901. *Our National Parks*. Boston and New York: Houghton, Mifflin and Company.

Nature Notes

Fire, Smoke, and Grizzly Bears

A Yellowstone Fire Lookout Reminisces About the Fires of 1988

COURTESY OF THE AUTHOR

Kerry A. Gunther

I stood watching the helicopter getting smaller and smaller as it disappeared into the distance and the roar of its engine faded away. The helicopter was headed back to the Fishing Bridge helispot after dropping me off at the top of Pelican Cone in Yellowstone National Park. It would return with an 800-lb. sling load of food and supplies that would support me for the next four months. I originally took the job in 1984 expecting to stay for just one summer, but the spring of 1988 would be my fifth as the Pelican Cone Fire Lookout.

The Pelican Cone Fire Lookout is not the traditional tower type structure. Since the lookout cabin is situated above treeline on the top of the highest mountain in the area, a tower is not necessary to see over the trees. The cabin is very small, just 14½ by 14½ feet. The walls are aligned precisely north to south and east to west, an advantage for calculating the azimuth of forest fires. The cabin has windows all the way around, five per wall, so that you can easily spot fires in any direction. Most of the other fire lookouts in the park have at least one more window on each wall, making them spacious in comparison. Much of the cabin's limited space was taken up by the wood stove, firewood box, propane cook stove, table, food cabinets, counter tops, fruit cellar trap-door, and bed. With those necessities lining the four walls and the Osborne Fire Finder in the middle of the floor, you could not walk more than two-and-a-half steps in any direction without turning.

There was also a metal chair and a small wooden stool with old glass power-line insulators on each leg. You were supposed to stand on the stool when the fire lookout was engulfed in a lightning storm. Back in 1984, the idea of standing on that small stool seemed ridiculous, so I had thrown it outside. During the first real lightning storm I experienced in the lookout, the copper cables running down the four corners of the cabin from the lightning rod on the center of the roof were glowing and humming from the electricity in the air, bolts of lightning were shooting horizontally across the windows, and the crack of the thunder was so loud that it rattled my teeth. During the storm I quickly retrieved and stood on that ridiculous stool. By the end of that first summer I was pretty adept at standing on the stool and reading a book while lightning bolts rained down around the little cabin.

At an elevation of just 9,643 feet, Pelican Cone was the lowest of the park's four active fire lookouts in 1988. The other three, Mount Washburn, Mount Sheridan, and Mount Holmes, were all well over 10,000 feet. What it lacked in height, however, it more than made up for in location. Pelican Cone is situated northeast of Yellowstone Lake where the prevailing southwesterly winds sweep across the large high-elevation lake, move up Pelican Valley, then over the Mirror Plateau. As the frequent afternoon thunderstorms rise over the plateau, they shower the area with lightning. Even given these conditions, the area seems to get far more than its share of lightning-ignited fire starts compared to other areas of the park. Some believe that the underlying magma being closer to the surface in this area dries soils, vegetation, and fuels, making conditions more conducive to fire ignition. Regardless of the causes, during my first four years as the Pelican Cone Fire Lookout, I spotted and called in more fire starts than any of the other lookouts.

In addition to its strategic location for spotting fires, Pelican Cone also has what I believe is the best panoramic view in Yellowstone Park. To the south is Pelican Valley, a large non-forested valley bottom with one of the highest densities of grizzly bears in the park. South of the valley are Turbid Lake and Indian Pond, two small crater lakes formed by hydrothermal explosions. Slightly further south is Yellowstone Lake. Formed by a volcanic caldera, it is the largest lake above 7,000 feet in North America. Still further to the south you can see the magnificent Teton Mountains, 70 miles away, jutting straight up into the sky. To the east of Pelican Cone is the Absaroka Mountain Range, where dozens of grizzly bears gather each summer to lick up thousands upon thousands of army cutworm moths from high elevation talus slopes at the bases of the headwalls of glacial cirques. To the north you can see Specimen Ridge and the Mirror Plateau. In February of 1894, the notorious poacher Edgar Howell skied over the Mirror Plateau en route to Pelican Valley while pulling a toboggan loaded with supplies all the way from Cooke City to poach some of the last surviving bison in the park. To the west of Pelican Cone is Upper Pelican Valley, which contains the Mud Kettles, Mush Pots, and other unique thermal features. Looking further west you can see White Lake, where an unfortunate Swiss woman

JEFF HENRY

The fire lookout has a panoramic view of Pelican Valley.

COURTESY OF THE AUTHOR

The Mist Fire was spotted on July 9, 1988.

was pulled from her tent and eaten by a grizzly bear in 1984. Up in the Pelican Cone fire lookout, looking through my 2,000-mm telescope from five miles away, I was the last person to see her alive, a lone backpacker heading up Astringent Creek in the early evening.

In 1988 it was obvious from my first day on Pelican Cone that things were different from my previous four years there. Most years when I arrived on Pelican Cone in the spring, there were still large snow drifts on the northeast sides of all the hills down in Pelican Valley. These drifts were not present in the spring of 1988, and most of the snow had melted on top of Pelican Cone. The large snowdrift on the northeast face of the mountain that I depended on for drinking water was significantly smaller than in previous years. That snowdrift usually lasted until late July and the four 33-gallon plastic garbage cans of melted snow that I had stored would last me at least another two weeks. After my stored water was exhausted, the park's helicopter would bring a cargo net of five-gallon cube-tainers of water. If the helicopter was fighting forest fires outside the park, the Lake Rangers would ride up on horseback with a string of mules loaded with water. Some years both the helicopter and the rangers were assigned to fires outside the park and I had to hike down over 1½ miles from the summit to the nearest spring, and carry my water back up to the top on a pack-board, five gallons at a time. In the winter of 1987–1988 snowpack in the park was only 31% of the long-term average; it seemed obvious that I would run out of water early. I did not know it then, but my stay on Pelican Cone would be cut short that summer; drinking water would not really be an issue.

On July 9 I spotted a lightning-strike fire in the Mist Creek drainage. I called in the fire's coordinates, including azimuth, UTMs, and vertical angle, to fire dispatch 700 Fox. Unlike the fires I had spotted the previous four years, which had torched a tree or two and then quickly gone out, the Mist Fire continued to burn and grow, moving in a northeasterly direction away from Pelican Cone. Just two days later I spotted two more lightning-strike fires, one in the Raven Creek drainage and one in the Clover Creek drainage. The Raven fire threw up a lot of smoke but remained a surface fire and just crept along. But the Clover Fire blew up, became a crown fire and quickly grew, heading first north, then east. On July 20, I spotted yet another lightning-strike fire near Lovely Pass, northeast of Pelican Cone. Despite the dark sooty smoke column billowing up from the fire that choked the air, blackened the sky, and obscured my scenic view, I named it the Lovely Fire.

Within a short time the flanks and flaming fronts of all these fires had burned into each other and were re-named the Clover-Mist Fire Complex. It became the largest fire complex in the park during July and August. From Pelican Cone I could see its towering convection column rising high into the air, a spinning vortex of ascending hot air and gases that carried smoke, ash, and burning embers over great distances. On August 20, a day often referred to as Black Saturday, the Clover-Mist Fire was pushed by extremely strong winds that reached over 60 mph, creating a fire storm that burned over 55,000 acres in one day. By October 10 it had burned an estimated 319,575 acres inside and outside of the park and was the second largest fire complex in the Greater Yellowstone Ecosystem that fire season.

The Pelican Lookout job was unique in that in addition to spotting and calling in forest fires, I observed grizzly bears from the lookout and collected data on their habitat use, predation on elk calves, and interactions with backcountry hikers, horseback riders, and fishermen. On the evening of July 21, I was watching an adult grizzly bear foraging in the northeast end of Pelican Valley in the Raven Creek Drainage. There was a light haze of smoke in the valley coming from the large North Fork fire to the west and the Snake Fire Complex to the southwest. At the time, smoke from the Clover-Mist Complex was blowing to the northeast, away from my location. As I watched the bear eating the stalks of elk thistle, the wind shifted and a thicker, heavier smoke began blowing into the valley from the northeast. The prevailing southwest wind had changed to a northeast wind, rare in Pelican Valley. I noticed that unlike in

the Disney movies the bear did not panic and run. It simply continued moving from elk thistle to elk thistle, bending over each stalk with a paw, shredding the stalk and eating out the insides. The bear appeared completely uninterested and unconcerned about the approaching fire. As the smoke thickened, it became more difficult for me to see the bear through my spotting scope. At times the smoke was so thick that I could not see the bear at all. The bear still did not panic, but continued foraging, occasionally lifting its head and calmly sniffing from side to side.

Distracted by the bear, my mind failed to register the ramifications of the change in wind direction. I should have realized that the light haze of smoke from fires far to the west and southwest of my location had changed to thick dark smoke from the much closer fire now coming at me from the northeast. Suddenly my two-way radio crackled to life. "120-Gunther this is 700 Fox." The fire dispatch office had called to tell me that the Clover-Mist Fire had changed direction and was now headed my way. It was just before dark, not enough light left to send a helicopter to get me. They told me that the fire should lie down in the cool evening air and that they would have a helicopter dispatched to evacuate me at first light in the morning.

I turned from watching the bear to the south and peered over to the northeast side of Pelican Cone. I could see a wall of flames headed toward me but still several miles away. The strong northeasterly winds had kicked up what was once the slow, back-burning trailing edge of the fire and made it the flaming front of a crown fire heading in my direction. There was really nothing I could do but wait and watch. I made a bowl of popcorn, pulled up my lawn chair, and watched the fire until late in the evening. After it got completely dark, I could no longer see landmarks from which to gauge the fire's distance from me or rate of movement toward me. The torching trees below me began to seem awfully close. My first thought was to hike the 12 miles south away from the fire and to the road. I could follow Pelican Creek and jump in if the flames got too near me. Instead, I chose to wait for the helicopter coming in the morning. At about 1 AM, exhausted from the adrenaline rush of the oncoming fire, I went back into the lookout and crawled into my cot.

On July 22, I woke up at about 5:00 AM. It was still dark but I could see the fire down below creeping up toward me. 700 Fox had been right; the fire had slowed considerably during the night. Occasionally a tree would torch, like the strike of a giant match in the darkness. I had been told that the helicopter had other critical missions that morning as well, so I could not bring all my belongings. I packed a small day pack with clothing, and a box that contained the data from the 105 grizzly bear observations I had made that summer, giving me a total of 961 bear observations for my five summers on Pelican Cone. After eating a breakfast of wheat and honey pancakes smothered in syrup, I boarded up the windows and locked the door of the lookout. When the helicopter arrived, we covered the entire lookout in fire shelter cloth, a thick but flexible aluminum foil-like material. All the firewood that I had cut and stacked against the cabin we threw down over the side of the mountain. I was sad at the loss of the firewood, as I had planned a ski trip into the cabin for that winter. We cut down the few small trees and removed anything else that could carry a flame from anywhere near the cabin. Then we boarded the helicopter. As we flew away I looked over my shoulder at the small cabin. Covered in silver fire-shelter cloth it looked like a lunar spaceship landing pod. I wondered if I would return to find nothing but a pile of ashes where the cabin once stood or if the aluminum foil covering would be enough to save the little cabin (it was).

I spent the rest of the summer fighting fire. The day after my evacuation from Pelican Cone I was assigned to a little fire truck, Engine 52, a 1963 jeep with a fairly small capacity of 220 gallons of water, to protect Grant Village from the Shoshone Fire which threatened the facility's buildings. In the days before the fire arrived, we thinned the surrounding forest and removed ladder and ground fuels. Just before the fire arrived we sprayed Silvex foam over all the buildings in Grant Village. As the fire raced toward the development we called in slurry bombers to drop flame retardant around the perimeter to knock down the approaching fire. Any spot fires started by fire brands carried by the updraft of the convection column and dropped within our perimeter were doused with bucket drops of water from helicopters of all sizes. These efforts, in combination with the wall of water we sprayed up with the fire trucks to stop the flaming front, enabled us to save all of Grant Village except for the L-loop of the campground which, due to a weak spot in our defenses, burned.

After the fire threat to Grant Village had passed, I was assigned to work as a National Park Service liaison with the military firefighters in Hayden Valley who were fighting the North Fork Fire. More than 4,000 Army, Navy, Air Force, and Marines had been sent to Yellowstone to reinforce the more than 3,500 firefighters already assigned to the park. We hiked in to Hayden Valley, a high density grizzly bear area, and set up

JENNIFER J. WHIPPLE

Smoke from the North Fork Fire rises above Swan Lake Flats.

camp in a large meadow. At about 5 AM the next morning, well before first light, I was suddenly awakened from a deep sleep by the shouts and grunts of the soldiers. Startled, I quickly sat up in my sleeping bag thinking that a grizzly must be raiding camp. To my surprise the sergeant major had the troops lined up doing calisthenics in the cold mountain air, the soldiers shouting out cadence 1-2-3-4…. I didn't have to worry, no grizzly bear would come anywhere near this camp, so I pulled my sleeping bag up over my head and tried to get back to sleep. Despite the military's best efforts to suppress the fire, the North Fork Fire grew to over 500,000 acres and became the Greater Yellowstone Area's largest fire of the season.

My final fire-related assignment was to survey the park for large mammals that had been killed by the fires. Shortly after the fires subsided, we searched areas where wide fast-moving fire fronts swept across the landscape. We conducted both helicopter and hiking transects. We found a mosaic of burned and unburned forest. While some areas had burned completely and most trees were obviously dead, other areas had a mix of green live trees and black dead trees. On the ground transects we could see that the forest floor was also a mosaic burn. Some areas were covered in fine white ash that blew into our nostrils with every step we took. The white ash was an indication of complete combustion of surface fuels and prolonged deep heating of the soil. It was unlikely that seeds, roots, or microorganisms could have survived the intensity of fire in these areas; vegetation would probably come back very slowly. Where the forest floor was only superficially burned, seeds and roots would have a much higher rate of survival and those areas would re-vegetate quickly.

We found a total of 261 large mammals that had died in the fires, including 246 elk, 9 bison, 4 mule deer, and 2 moose. The smaller groups of elk generally contained a few mature bulls and several cows, calves, and yearling bulls, typical of rutting groups. The largest group, 146 elk clustered into a small low-lying area, appeared to be several harem groups that had bunched together in a last ditch effort to avoid the smoke and fire. We looked at the sooty tracheas of a sub-sample of the dead elk. It appeared that nearly all of the elk died of smoke inhalation before they were burned by the flames. Some of the elk had no external burns at all.

We did not find any dead grizzly bears, black bears, mountain lions, or coyotes within the burned areas. But almost every time we got into a cluster of dead elk, we ran into live grizzly bears or black bears, and lots of them. The bears were scavenging the carcasses of the fire-killed elk. Sometimes when we got to a carcass, bears would explode in every direction. Shouts of "Bear headed your way!" rang out from the next person down the transect line, or our radios blared *"Bear running south down the transect line!"* to warn us. There was never a dull moment, bears springing up in all directions. We ran into single adult bears, sows with cubs, and subadults. Sometimes, waist deep in a jackstraw of burned, dead, fallen trees, we could hear the bears barking warnings to their cubs even before we could see them.

When we surprised a bear or bears we tried to group with our co-workers. Sometimes, hearing the warning shouts of someone further up the line but unable to see the bear or the direction it was running, we resorted to climbing trees, hoping not to get run over by the fleeing bear. At 700 Fox, the dispatcher told us how much fun it was to listen to the carcass crew's radio transmissions. By late September and early October fire radio traffic even of fast-moving fire fronts was mundane, but we were entertaining. They told us that at one point our transmissions sounded especially frantic. They were ready to crank up the rotors on a helicopter and pluck us from the trees with a long line. But then they heard someone say that it was all clear, the bears had scattered into the cover of the burnt forest, and the helicopter rescue mission was canceled.

Finally the snows came and did what thousands of firefighters; four branches of the military; hundreds of fire trucks and helicopters; tons of water; fire retardant and Silvex foam; and millions of dollars could not do. The fall snows had smothered and put out the unprecedented fires of 1988. I did not know it then, but my last year as the Pelican Cone Fire Lookout was over. I would take a better paying, more career oriented job in Yellowstone the following year. I will always have fond memories of my fire lookout experience: the beautiful sunrises and breath-taking sunsets, the star-filled evening skies with an infinite number of twinkling lights overhead, the powerful and awe-inspiring grizzly bears, and the spectacular fires of 1988. I had learned to treasure both solitude and people, and I gained an appreciation of water, something you can only learn from having a very limited supply that you must obtain by melting snow or by having to carry your water for 1½ miles with a 1,000-foot elevation gain from an ice cold spring located far down the mountain. Living in a fire lookout also gives you plenty of time to think things through; you have the rare opportunity to become at peace with yourself and the world. I think it would be good for everyone to spend at least one summer living in a fire lookout.

YS

JEFF HENRY

Kerry Gunther is now the lead of the Bear Management Office in Yellowstone National Park and still looks exactly like he does in this picture from 1986.

From the Archives

NPS, YELL-34447-1

When the Civilian Conservation Corps (CCC) was established in 1933, the greatest perceived threat to the parks was forest fires. During the first year of CCC operation, enrollees began constructing firebreaks, removing deadwood, conducting other fire prevention activities, and erecting telephone lines in parks. These measures were credited for "reducing forest fire losses" by a total of 1,600 acres in the first nine months of 1933. Yellowstone gave fire suppression training to all CCC enrollees, but designated small groups of up to 15 men as the primary fire-fighting teams. These small groups were sent first; if they failed to suppress the fire, other enrollees were called.

Paige, John C. 1985. The Civilian Conservation Corps and the National Park Service, 1933–1942: An Administrative History. Department of the Interior. http://www.nps.gov/history/history/online_books/ccc/ccc4.htm

In this issue

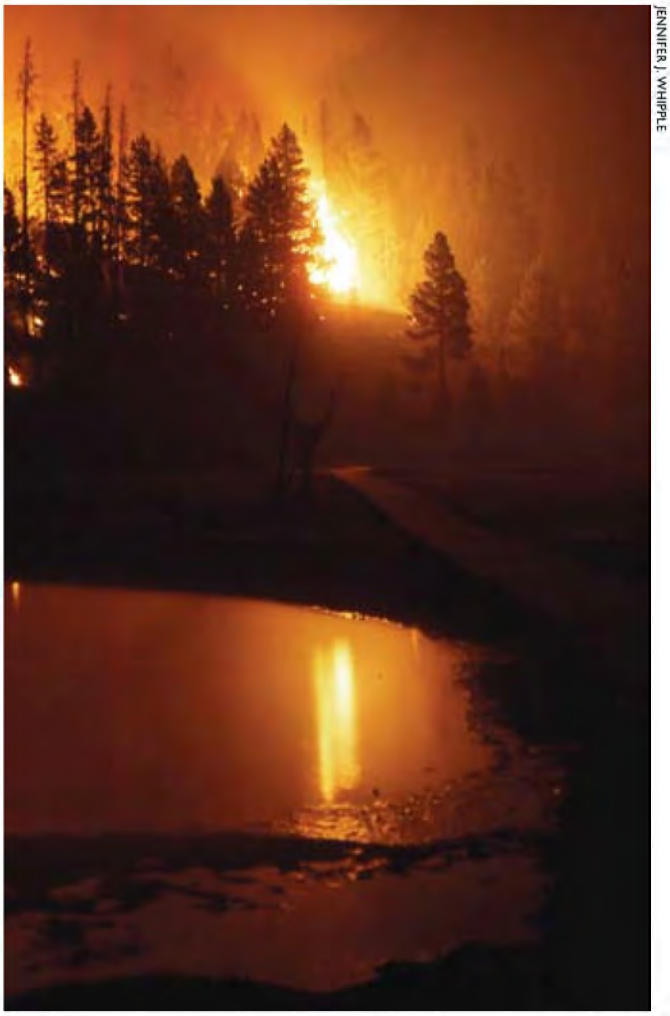
YS

Support
Yellowstone Science

Our readers' generosity helps to defray printing costs.

Please use the enclosed card to make your tax-deductible donation. Make checks payable to the Yellowstone Association, and indicate that your donation is for *Yellowstone Science.*

Thank You!



JENNIFER J. WHIPPLE

Fire blazes above the boardwalk in the Upper Geyser Basin.

YELLOWSTONE SCIENCE
Yellowstone Center for Resources
PO Box 168
Yellowstone National Park, WY 82190

CHANGE SERVICE REQUESTED

PRSRT STD AUTO
U.S. POSTAGE PAID
National Park Service
Dept. of the Interior
Permit No. G-83