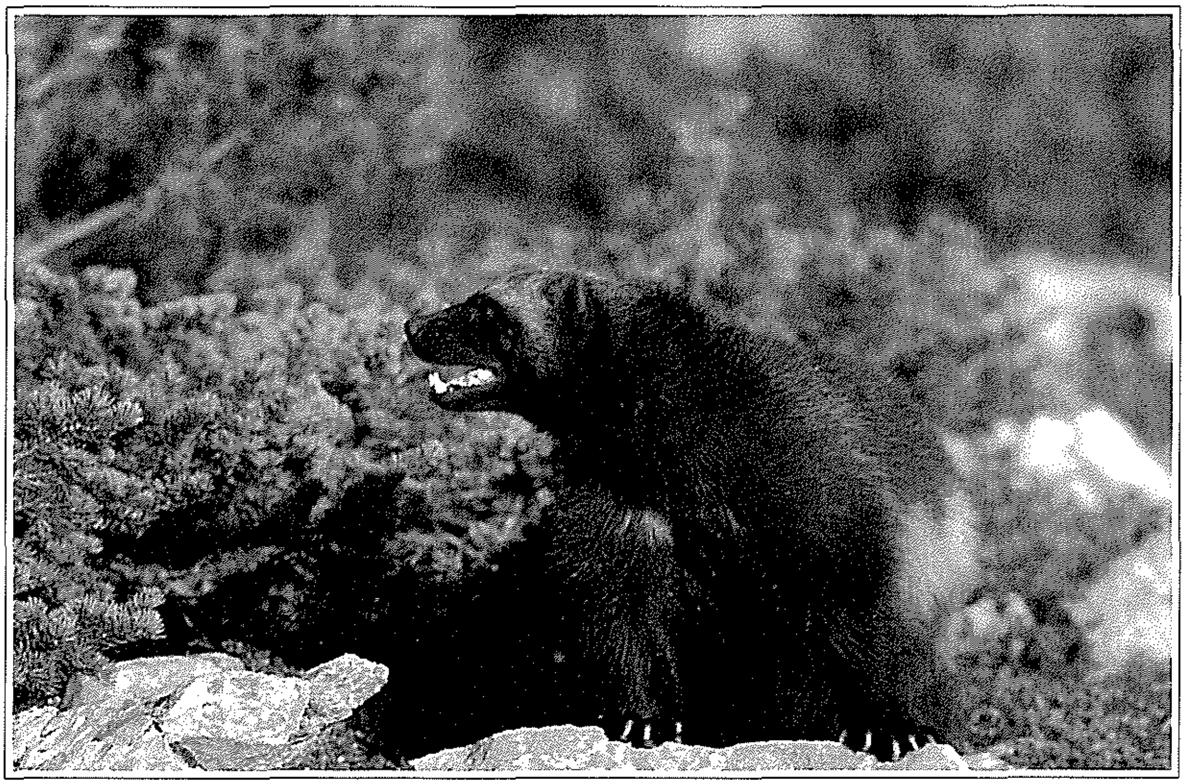
Yellowstone Science

A quarterly publication devoted to the natural and cultural resources



The Spirit of Yellowstone

Fire Effects on Streams

Tracking Wolverines

Volume 6 Number 3

Another Voice for Science and Interpretation

We have often hoped that our magazine would provoke thoughtful commentary or discussion among readers, but seldom have we received such direct indication. However, the last issue prompted the following letter, which we reprint with permission of the author, William Locke of Bozeman, Montana, who has studied deformation in the Yellowstone caldera:

I couldn't let the *Yellowstone Science* (V. 6, No. 2) interview with Dr. Richard Sellars go by without commenting on its irony. Despite his background in geology, no recognition of the heritage of the national parks and its science intruded on the biologically centered discussion. To be blunt: My perspective of modern geoscience in the parks is that it is at the same level as bioscience was 50 years or more ago.

The primary *raison d' être* for most of the western national parks is geological. The isolation imposed upon Canyonlands, Mount Rainier, Yosemite, Yellowstone, etc. by their geology also delayed homesteading, thus preserving wildlife. Because we see geology as a static stage on which ecological dramas are played out, most parks don't even have a resident geoscientist. Thus, geological research needs in the parks are almost entirely driven by the curiosity of outside scientists rather than national needs. Does this matter? It does when a national outcry arises over the potential of geothermal development affecting Yellowstone. The single best tool to address that issue would have been baseline data on temperature, discharge, and chemistry of thermal features—a database which, to my knowledge, neither exists nor is envisioned. Geology may change slowly but it lacks the flexibility of some biological systems, where managers can be successful at both extermination and introduction, depending on the societal context. We ignore it at our peril.

The Park Service can no more allow their priorities regarding geological research in the parks to be established by outside scientists than they can their bioscience priorities. That science may be good science or even wonderful science (as in Margaret Hiza's article preceding the interview!), but it doesn't necessarily serve national needs. But even goal-setting requires knowledge that, with due respect to the Park Service colleagues, is rare. And knowledge doesn't come cheap. If the Park Service is serious about real science of all kinds rather than knee-jerk responses to issues like fire, bison, and groundwater, it is going to have to find some powerful friends of science in high places, and put <u>their</u> money where <u>its</u> interests lie.

The economic theme is emphasized by Ranger Suderman's review of Dr. Sellars' book. In twenty years of exposure to the national parks I have observed interpretive rangers to be grossly underpaid, enthusiastic, and often highly qualified translators of park science to the public. In our society, however, it is often assumed that "you get what you pay for." The enthusiasm which draws teachers to spend their summers informing and educating at less-than-minimum wages (after housing deductions) also costs them credibility in the long run. Very little could be more effective in the cause of science in the national parks than a successful strike by ranger-interpreters!

We invite other readers to share their comments on issues prompted by our features on Yellowstone science and resources.

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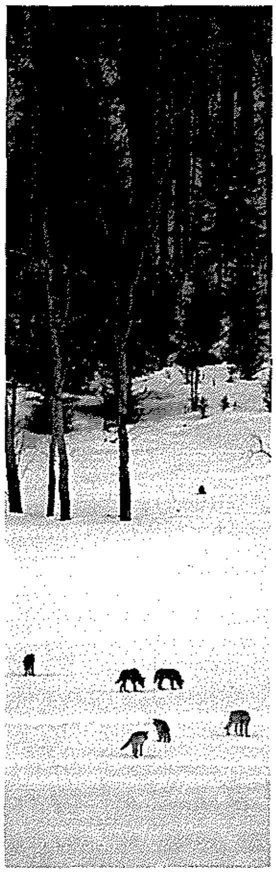
Volume 6 Number 3 Summer 1998



On the cover: Photo of captive wolverine in the Bridger Mountains, by wildlife photographer Michael H. Francis. Photo of wolfpack, above, by Dan Hartman.

Table of Contents

Yellowstone Science is published quarterly, and submissions are welcome from all investigators conducting formal research in the Yellowstone area. Correspondence should be sent to the Editor, *Yellowstone Science*, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190.

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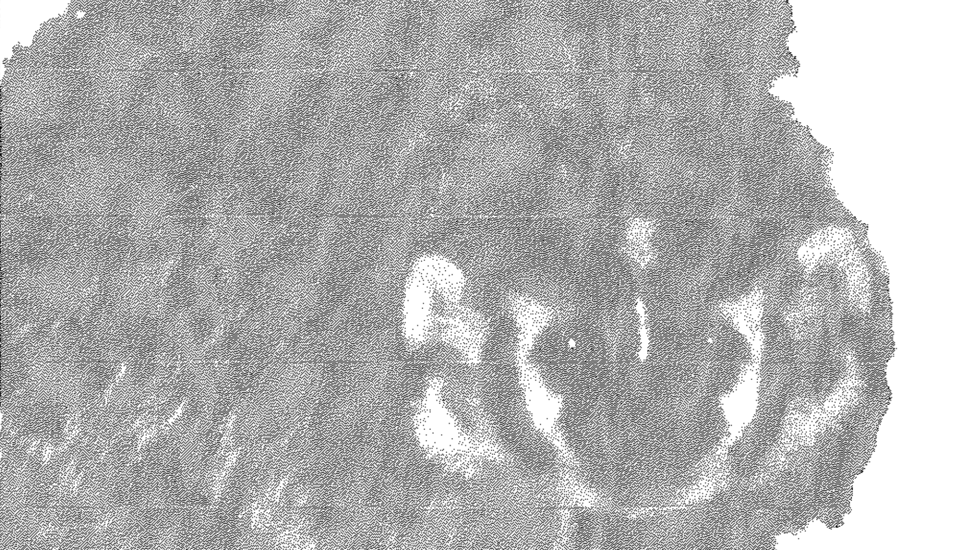
Searching for "Skunk Bears"

The Elusive Wolverine



by Betsy Robinson and Steve Gehman

Wolverines (*Gulo gulo*) are among the least-studied and most poorly understood fur-bearing animals in North America. This largest terrestrial member of the weasel family (Mustelidae) is renowned for its ferocity in story and legend, but indeed only two scientific studies of wolverines have been conducted in the lower 48 states. Hornocker and Hash (1981) conducted a seven-year study of wolverines in northwestern Montana during the 1970s, and Copeland (1996) studied wolverines in central Idaho from the winter of 1992-93 through 1995.

Wolverines may never have been numerous, but their numbers and distribution have been drastically reduced in the lower 48 states since the arrival of European humans. Outside of Alaska, the largest wolverine populations in the United States are thought to be in Montana and Idaho, with sightings also reported in Wyoming, Colorado, California, Oregon, and Washington. Montana and Alaska are the only states that still allow wolverines to be legally trapped. Currently, an average of eight wolverines are trapped in Montana each year.

Information about the historic and present abundance and distribution of wolverines in and around Yellowstone National Park is scant. Schullery and Whittlesey (1992) documented 12 reports of wolverine sightings between 1806 and 1883, and noted three additional statements about wolverine presence. Consolo Murphy and Meagher (in press) searched park records from 1883 through 1995 for evidence from in and around the park and found 104 sightings, 25 track reports, 4 additional records, and 1 museum specimen. However, records were often lacking in the detail necessary to evaluate their reliability and accuracy. They concluded that there was a likelihood that Yellowstone National Park helped support a resident wolverine population and that more information was needed on this rare carnivore's status and distribution.

Natural History of the "Skunk Bear"

Wolverines are known as "skunk bears" because of physical features and behavioral characteristics that remind people of both skunks and bears: light stripes that often extend from the face down the sides of the wolverine; a habit of marking carcasses on which they are feeding with musk or urine; a stocky, low-slung body and broad head; incredible olfactory abilities; and scavenging habits. Wolverines weigh between 30 and 60 pounds, possess long, sharp claws that allow them to dig through deep, frozen snow, and have extremely powerful jaws that can crush frozen bones.

During winter, wolverines are known to visit avalanche chutes where unwary bighorn sheep, mountain goats, elk, or moose may have been caught and buried by a snow slide. In the winter of 1993-1994, Steve discovered just such a scene in upper Cache Creek. A bull elk had been buried in several feet of snow by an avalanche. Two wolverines used their acute sense of smell to locate the carcass, their long claws to excavate the frozen animal, and their powerful jaws to gradually consume it. By the time Steve happened on the scene all that was left was the elk's skull and piles of its hair, along with a series of trails made by the wolverines as they visited the carcass over a period of days or perhaps weeks. Wolverines feed almost exclusively on carcasses during winter, but are omnivorous the rest of the year, consuming berries, insect larvae, bird eggs, and even porcupines.

Wolverines seem to require true wilderness, and in sizeable chunks. Some of the animals in Copeland's study had home ranges of 770 square miles, and wandered up to 125 miles while dispersing. These figures put wolverines in the company of other wide-ranging carnivores such as grizzly bears and wolves. Male wolverines require larger home ranges than females, and often a single male's range overlaps with the ranges of several females.

One adaptation that helps wolverines cover such large ranges in winter is the large size of their paws in relation to their body. All members of the weasel family have five toes, compared to four toes for the canids and felids. In addition, the wolverine has a distinctive chevron-shaped interdigital pad. The wolverine tracks that we have found in the Yellowstone area measured 4 to 4 1/2 inches wide.

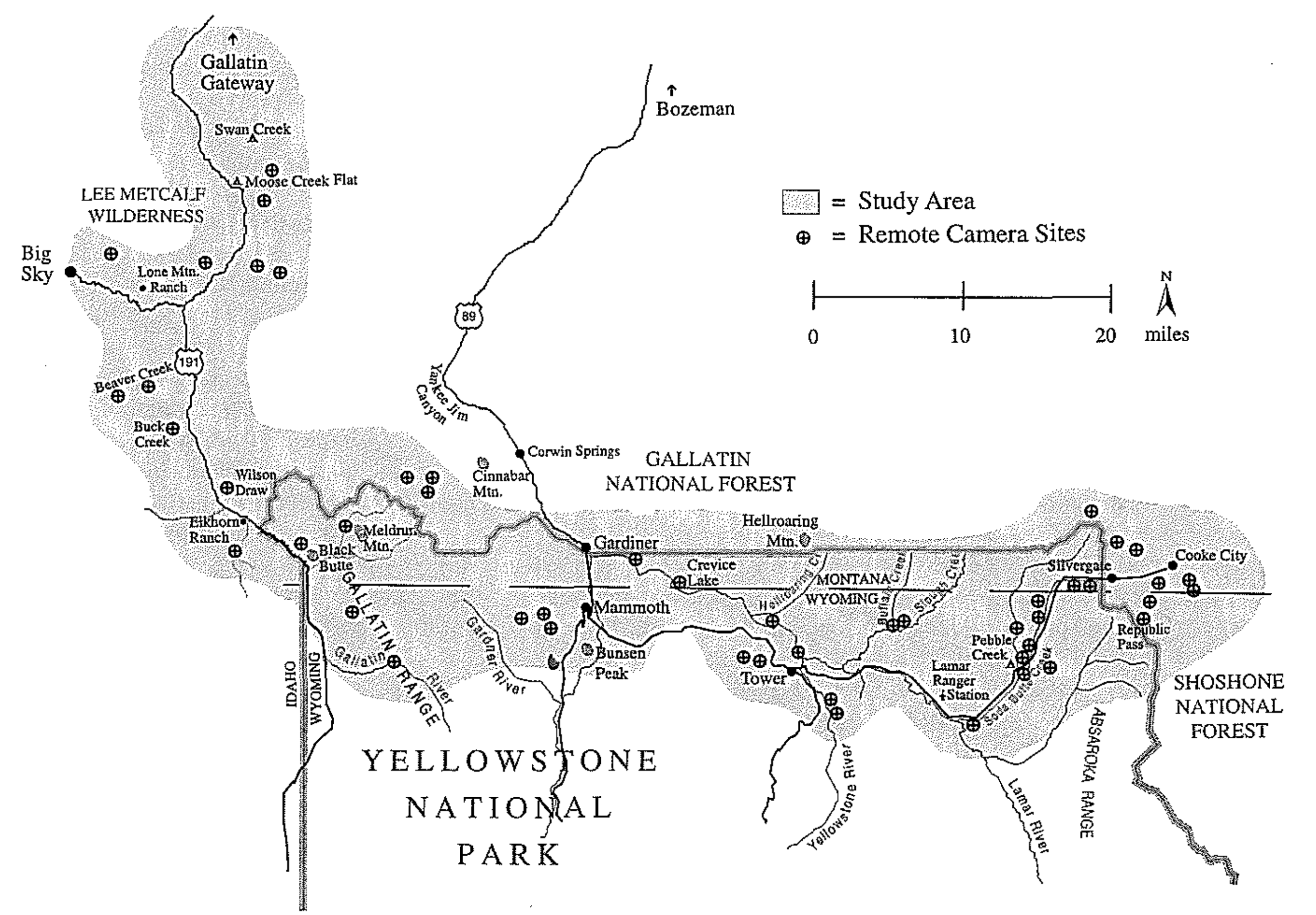
Wolverines have an unusual reproductive strategy that is shared by other mustelids as well as bears. In all cases, the animals mate in spring or early summer, the egg is fertilized and develops for a short time, and then development is suspended for many months. In the case of the wolverine, the period of suspended development may last for almost a year before the fetus implants in the mother's uterus and development continues. Once that happens, gestation lasts approximately a month. Young are born in February or March and stay with their mother through the summer. Evidence from Copeland's study suggests that extended family groups may stay together even longer. He found wolverines visiting den sites of animals believed to be cousins, and fathers seemingly sharing parental duties. Perhaps the most surprising discovery of his study is that wolverines are not loners, as once was assumed.

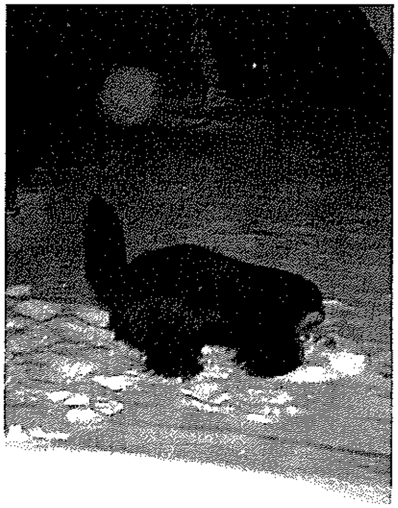
The Yellowstone Study: Slowly Accumulating Evidence

For the past five winters we have searched for wolverines and other carnivores on the northern range of Yellowstone National Park and the adjacent Shoshone and Gallatin national forests. Our work has focused on determining the presence/absence of a number of medium-sized mammalian carnivores: weasels, pine martens, fishers, river otters, wolverines, bobcats, mountain lions, lynx, foxes, coyotes, and wolves in various locations and habitats across the northern range. In particular, we have been interested in determining the extent to which the three rarest of these carnivores (fisher, wolverine, and lynx) are present in the northern portion of the ecosystem.

The northern Yellowstone carnivore study was begun by Sue Consolo Murphy

Map showing locations of remote camera stations and study area used by the authors.





Two photos of what have been identified as wolverines captured with infrared cameras at the remote camera sites. Photos in this article courtesy of the authors.

of Yellowstone National Park's Center for Resources using hair-snagging devices, then expanded by Dr. Robert Crabtree of Yellowstone Ecosystem Studies (YES), under whom we have been conducting the study. We have employed three methods in searching for our target species: hair-snares, remote camera stations, and snow-track transects.

Hair snares consisted of barbed wire spirals surrounded and encased by cylindrical tubes of wire mesh. Snares were placed under fallen trees, root systems, or dense branches to minimize snow accumulation on them, and were baited with small amounts of ungulate flesh, fish, or processed sardines. Commercial trapping lure was applied to vegetation near each site to lure animals.

Each remote camera station consisted of a Trailmaster Infrared Game Monitoring System, a bait package, and an application of trapping lure. The camera was triggered when an animal broke the infrared beam position under the suspended bait. The system was capable of daytime and nighttime photographs, and recorded the date and time of all animal visits.

We used two types of transects to collect carnivore track data. Detection or reconnaissance surveys were conducted primarily to cover as much distance as possible in areas of suspected high-quality habitat. Enumeration surveys were conducted to document all carnivore tracks observed while following predetermined transect routes, so that track densities could be compared among habitat categories and among years.

Results of Our Search Efforts

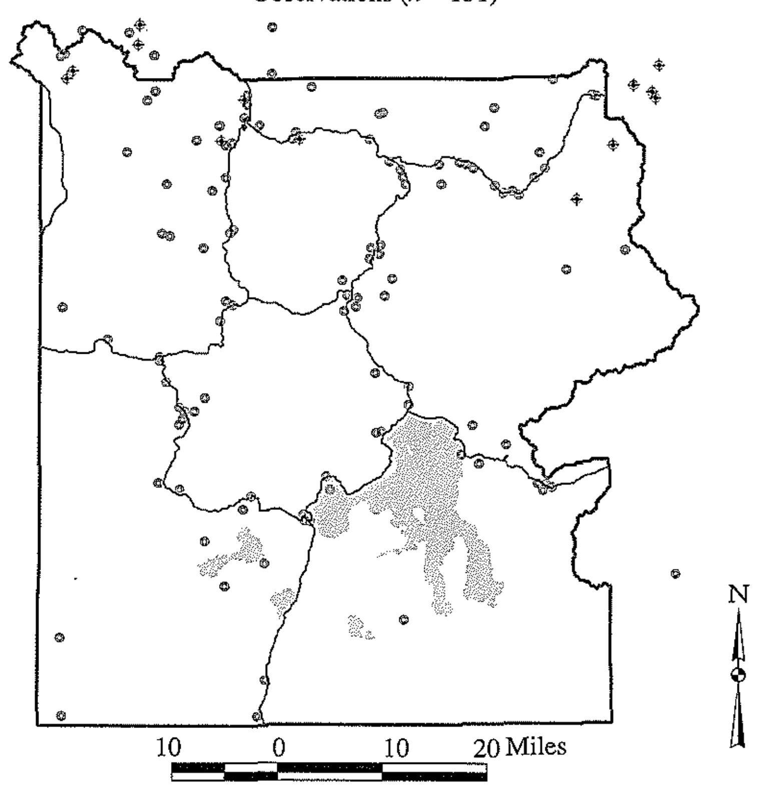
Wolverines or their tracks were detected 19 times during the first five winters of YES survey efforts. No confirmed wolverine hairs were collected during 2,668 nights of hair-snare operation at 42 sites. However, Consolo Murphy did collect a wolverine guard hair from a snare located on the north slope of Mt. Washburn during the winter of 1989-90. Wolverine was one of six carnivore species to visit our 55 camera stations. During 2,600 total nights of camera operation, wolverines made two visits and were photographed eight times. Most of our wolverine data were obtained from track observations. Wolverine tracks were observed five times during 140 snow transects that covered 403 miles (648 km), and an additional 12 times during other aspects of the project.

Our first wolverine photos were obtained during the winter of 1993-94 in Cinnabar Basin, approximately 3 miles (4.5 km) north of the park. We had received several reports of wolverine activity in that area, and decided that it would be a good place to test our skill at using the camera system. After 51 nights of camera operation, a wolverine showed up and took two photographs of itself. This incident taught us a valuable lesson about the level of patience required to obtain data on these wide-ranging animals. In January 1997, we obtained a second set of photographs of a wolverine, taken south of Cooke City approximately 3.7 miles (6 km) from the park boundary. Betsy discovered the tracks while on her way to check a remote camera, and followed them into the camera site. The camera system indicated that the wolverine had investigated the site at 10:30 a.m. the previous day.

In December 1997 we shifted our carnivore survey efforts from Yellowstone's northern range to the northwestern corner of the park and nearby portions of the Gallatin and Madison ranges. Between December 3, 1997 and March 18, 1998, we used 10 camera systems at 20 sites, and conducted 53 track transects covering 155 miles (250 km).

A ski trip along the Specimen Creek drainage in February, 1998 yielded some exciting and mysterious findings. After discovering fresh tracks made by a group of four or five wolves in the lower reaches of the drainage, we skied on and found tracks of a wandering wolverine that intersected the trail three times in a 1.2-mile (2-km) segment. Upon reaching our camera station located approximately 4.3 miles (7 km) up the trail, we immediately noticed something amiss. All that remained of the infrared transmitter unit was its back plate and nylon strap that held it to a tree. The main body of the transmitter had been broken off, though four stout screws had originally attached the back of the unit to the main body. There were no human tracks in the vicinity of the camera site, and all other components of the camera station remained undisturbed. What animal could have done the damage? Perhaps a moose or elk kicked it. But then the transmitter body should have been lying nearby in the snow; we searched the area thoroughly, digging down through the top 16 inches (40 cm) of snow, but found nothing. Perhaps the wolverine whose tracks we saw earlier in the day was the culprit; its tracks came within 0.3 mile (0.5 km) of the camera site on that day; maybe it had visited the site two to three weeks earlier when the damage was done. Unfortunately the camera system was malfunctioning at the time of the incident and no photographs were obtained of the de-

Wolverine Observations
Yellowstone Area
Observations (n = 151)*



+ Data collected during authors' surveys (1992-1998) n = 14

◦ Others (1944-1997) n = 137

* Park records contain some reports without sufficient data to display a map location.

structive animal. We will never know what happened, but we place our bets on the skunk bear.

We documented an additional three wolverine track sets during our efforts this past winter: a second set in the Specimen Creek drainage, and two sets in the Gallatin National Forest within 22 miles (35 km) of the northwest corner of Yellowstone National Park.

Since mid-1995 the park has received 19 reports of 24 wolverine sightings and two additional reports of tracks, bringing the total to 164 observation records—only slightly more than one for each year of the park's history.

The Future of Wolverines in Greater Yellowstone

Wolverines have the potential to be important indicators of ecosystem health and integrity. We know that, like other carnivores, they have been affected by human activities. Their historic numbers and distribution were drastically reduced, probably as a result of some combination of factors such as decimation of prey populations, widespread predator control programs, and habitat alteration and fragmentation. Recently, Copeland documented a wolverine abandoning her den in response to a skier traveling through a mountain bowl where her den was located, indicating the wolverines' vulnerability to human presence.

With increasing pressure being placed upon wildland habitats by recreationists, industry, and land developers, the potential for further impacts to wolverine populations is significant. In August 1994, the U.S. Fish and Wildlife Service was petitioned by several environmental groups to list the wolverine as a threatened or endangered species under the Endangered Species Act. Ironically, the petition was refused in April 1995 on the grounds that not enough information existed regarding their current distribution and population status. In order to use the wolverine as an indicator species, we must first develop a more complete database on its abundance and distribution. Our goal is to assist in the compilation of such a database; we hope to spend the next ten winters helping to survey the wildlands of the Yellowstone ecosystem for wolverines, as well as for fishers and lynx. The more we learn about these rare carnivores, the better we will be able to protect them and their habitat for long-term survival in greater Yellowstone.

Betsy Robinson and Steve Gehman are self-employed wildlife biologists based in Bozeman, Montana. Both authors instruct college-level field ecology courses for the Wildlands Studies program of San Francisco State University, and lead natural history tours in the western United States. Steve has worked on various research projects in greater Yellowstone since 1984, and has been the lead project scientist on the northern Yellowstone carnivore study since 1992. Betsy has been involved in several research projects on mammalian carnivores in greater Yellowstone and Alaska, but describes her passion as birding.

Suggested Reading

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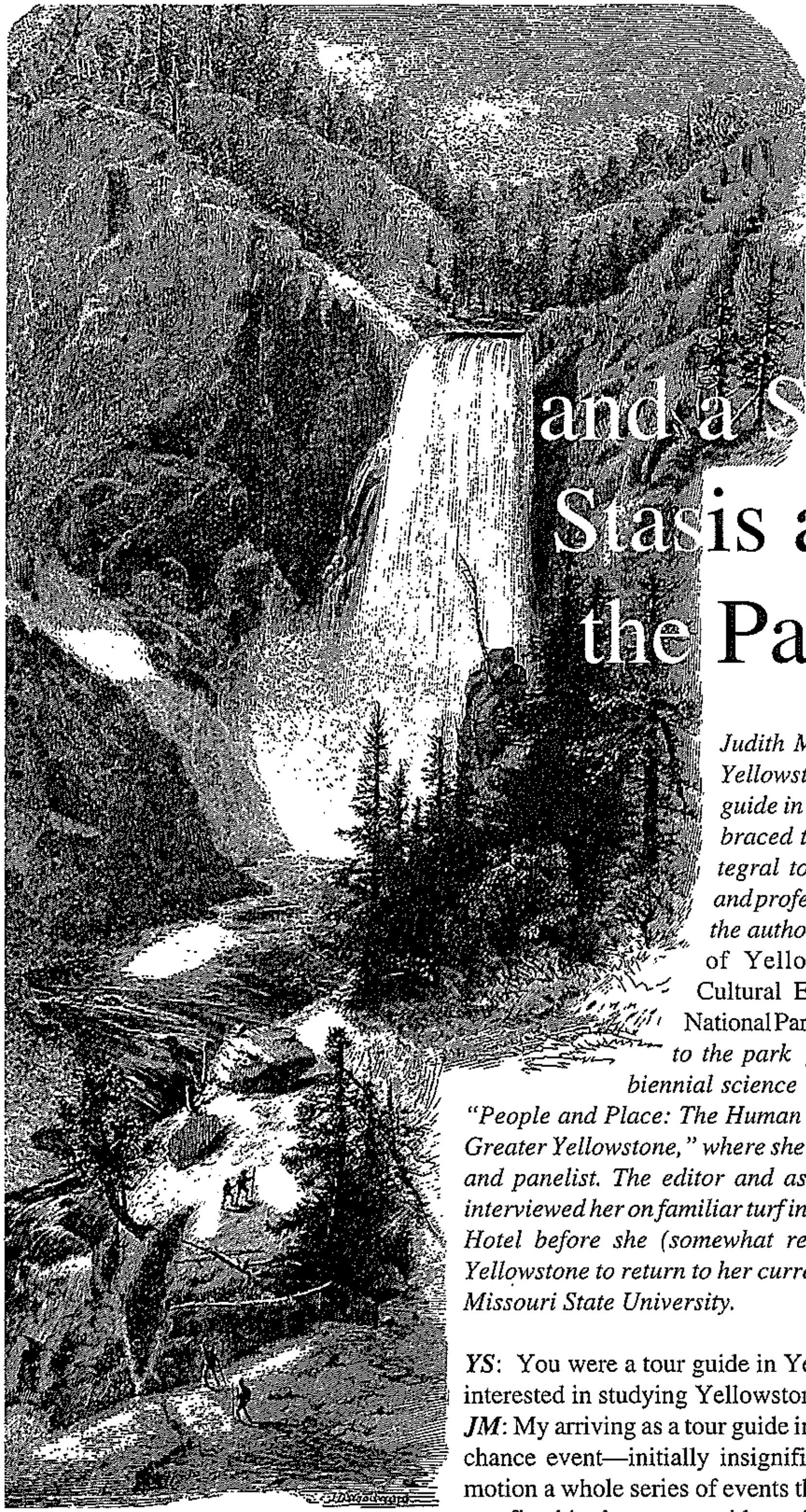
Schullery, P., and L. Whittlesey. 1992. The documentary record of wolves and related species in the Yellowstone National Park area prior to 1882. Pages 1-3 to 1-173 *in* J.D. Varley and W.G. Brewster, eds. Wolves for Yellowstone? A report to the United States Congress, vol. 4, research and analysis. NPS, Yellowstone Natl. Park, Wyo.

Yellowstone Science Interview:
Judith Meyer



Yellowstone and a Sense of Place: Stasis and Change in the Park Experience

Judith Meyer came to Yellowstone as a tour guide in 1980, and embraced the park as integral to her personal and professional life. As the author of The Spirit of Yellowstone: The Cultural Evolution of a National Park, *she returned to the park for the fourth biennial science conference on "People and Place: The Human Experience in Greater Yellowstone," where she was a speaker and panelist. The editor and associate editor interviewed her on familiar turf in the Mammoth Hotel before she (somewhat reluctantly) left Yellowstone to return to her current position as a geography professor at Southwest Missouri State University.*

YS: You were a tour guide in Yellowstone, and because of that, you became more interested in studying Yellowstone academically.

JM: My arriving as a tour guide in Yellowstone is a classic example of how one little chance event—initially insignificant or unrelated to what happens later—sets in motion a whole series of events that later result in something completely different. I was first hired as a tour guide not because of any particular interest in Yellowstone or national parks or nature interpretation, but because in the early 1980s, the dollar was weak relative to the French franc and the German mark, and a lot of Europeans were taking vacations to the United States. Hence, global economics created a market for foreign-language-speaking tour guides in American national parks, and I could speak German, so I got a job in Yellowstone. However, once here, it was the strangest thing. Although I'd traveled quite a bit, I had never really felt at home anywhere. But I got off the bus here at Mammoth, and for the first time in my life, I felt I didn't want to leave. I felt I belonged here.

After three summers in the park, I enrolled in a master's program in environmental communication at the University of Wisconsin-Madison and took my first geography course as an elective. The course was "Space and Place" with Yi-Fu Tuan. Tuan introduced me to geography as an academic discipline and to the idea that one could study not just the impact people have on the landscape, but the impact the land has on people. Tuan suggested that literature, music, and paintings—media often considered too subjective to provide any real or quantifiable information about the world—can and should be studied by geographers because of what these things reveal about the relationship between people and places. So, I quickly finished an M.S. in environmental education and moved across campus to do a Ph.D. in geography, all the while following for fun the writings of Stephen J. Gould and his punctuated equilibrium model of biological evolution. All of a sudden, things started to come together.

YS: Was it your dissertation that culminated in the book, *The Spirit of Yellowstone*?

JM: Yes, the book is my dissertation, thinly disguised.

YS: Did you base your conclusions on interviews with people, on the historic record, or on other kinds of documentation?

JM: On the historical record. I think the difference between history and geography is that with history you're looking at a sequence over time, and geographers look at events in a place, but still over time–how did the passage of time affect this place.

YS: I was sparked by the comparison you made between Stephen J. Gould's punctuated equilibrium theory of natural evolution and human cultural evolution. Can you explain that a bit more?

JM: I began every chapter of my dissertation with a quote from Gould explaining one more piece of the punctuated equilibrium model—at least the pieces that related to what I perceived as Yellowstone's evolution as a place (as opposed to the space around it). Punctuated equilibrium (I think the groupies now call it "punk eke"!) suggests that the evolution of different species on the planet can be explained, at a very broad scale, by long periods of stasis (equilibria) and brief episodes of change (the punctuations). Most speciation occurs during and following the punctuations, the times of environmental change, whereas most of geologic time has been spent in stability. Until the idea of punctuated equilibrium appeared, most biologists explained evolution in terms of the changes, the divisions, the points at which species appear or disappear. Gould and his partner, Niles Eldridge, were the first to suggest that the long periods during which nothing happens should be considered important, too.

At the same time, geographers were grappling with how to study the relationship between people and places. We know that every place is unique, but should we just describe individual places—this place here, that place there—or should we attempt to categorize them somehow? Can we generalize about the types of houses built by people living in the tropics, or the types of agriculture developed by people living on grasslands? What set the evolution of these individual places or cultures or landscapes in motion? Do all industrializing nations go through a period of exploiting nature and then later begin protecting it? I started thinking about how Gould might explain how Yellowstone evolved from *terra incognita* to what it is today: an internationally recognized place. If the world is just a collection of discrete places that have no unity, then what does that say about the national parks? Should each park be managed autonomously, or should they all be managed out of Washington, D.C.?

YS: Was that the fundamental question you asked in your dissertation?

JM: Well, not the fundamental question; there were several questions, but that's an important one. First of all, I have to put in a disclaimer regarding punctuated equilibrium as an explanation for cultural evolution. Biological evolution is driven by natural selection; cultural evolution is driven by human forces: greed, politics (which may be the same thing), religion, love, compassion, and so on. But punctuated equilibrium emphasizes stasis. Gould made people pay attention to the long periods of time during which species do not change, do not split off and evolve into other species. I looked at the academic literature on the national parks, at Aubrey Haines' history of Yellowstone and all the Yellowstone histories, and found that the authors always focused on change: "This was a transitional time; this was when the car was introduced; this was when the first hotel was built." Very little attention was paid to the long periods of time during which *nothing changed.*

For example, for many people, Yellowstone is (or was) the place where one feeds bears along the road. Much has been written when and why feeding the bears started and ended, and whether it was good or bad, but few have tried to explain how integral this beggar bear image was to experiencing "the Yellowstone" and not "the Yosemite" or "the Grand Canyon." Why here? Why not there? Why is this image of Yellowstone so powerful and why has it been so powerful for so long? Gould suggested biologists should begin thinking about how long a species has existed, how well-adapted or fortuitous it must be to have been around for so long. Why did feeding bears in Yellowstone last such a long time and make such a lasting impression on the American public?

Another point Gould makes with punctuated equilibrium is the lack of determinism or progress in biological evolution. The ancestors of an amoeba in a primordial sea were not somehow predestined to ooze out of the ocean and evolve into dinosaurs or human beings. Evolution is based on chance events. It was the culmination of a series of historically contingent but nonetheless chance events that formed the ozone layer and

"Maybe we should stop condemning history and accept it for what it was (and is). In Yellowstone's origins lay the potential of everything the park is and will become: beggar bears, horse-drawn carriages, automobiles, the "Let it Burn" policy, the wildfires of '88. We are stuck with this particular landscape, this geography, and this human history...there is much that the park has come to mean, and park managers need to be sensitive to this history and these meanings when enacting new policies."

allowed life to crawl out of the ocean. It is not progress or predetermination that causes meteors to strike Earth. There is nothing inherently "good" or "better" about one particular organism that allows it to survive changing environmental conditions such as nuclear radiation, forest fires, or floods. Species are limited by their genetic heritage in terms of whether they have what it takes to survive disturbances.

Another part of this same idea is that ancestral species are entities in their own right. For as long as they exist, species are not "in a state of becoming," they simply *are*. Evolution is a branching process, not a ladder where one thing is necessarily replaced by something else.

Gould warns that we should move away from thinking about "higher" or "more complex" or "better" when we talk about the environment. These are human constructs, not natural divisions.

In thinking about the history of the national parks and the idea of an "ideal" national park, I think in the back of our minds it's comforting to think that progress is inevitable, that we're going to reach some more perfect state of national park-ness. However, it may be that we should consider thinking about the parks as end products or entities in their own right. Rather than saying that Yellowstone was incomplete or inadequate, or that we had the wrong idea of what Yellowstone should be when we fed the bears, why not admit that we have changed our minds about what Yellowstone should be? Now we have a *better*...no, now we have a *different* conception about what national parks represent. Maybe it has been the ideal Yellowstone National Park—not the ideal national park—all along. Maybe we should stop condemning history and accept it for what it was (and is). In Yellowstone's origins lay the potential of everything the park is and will become: beggar bears, horse-drawn carriages, automobiles, the "Let it Burn" policy, the wildfires of '88. We are stuck with this particular landscape, this geography, and this human history. We can't rewrite the past, and managers can't expect the public to forget the past so quickly. There is much about Yellowstone that people have always loved, there is much that the park has come to mean, and managers need to be sensitive to this history and these meanings when enacting new policies.

YS: Is it fair to describe the historian's job not so much to judge what was done in a previous time, but to set it in the context of that time? In 1872 we didn't have a complete idea of what Yellowstone National Park was or should be, and we've added to that idea over the years.

JM: I think you're exactly right. Our perception of Yellowstone, what it is, what it does to us, has branched over time, grown richer. We haven't forgotten the old experiences, but have added new ones as well. That's what makes management so difficult. Now there are parts of this gloriously bushy Yellowstone experience that conflict with one another. The national park idea, in terms of management policies, I think, has evolved as a linear replacement. In Yellowstone's earliest decades, there really weren't many rules. You could do just about anything you wanted: fish, hunt, build hotels, swim in the hot springs. Now you can swim/soak in the hot springs. OK, you can't really swim in the hot springs, either (not legally), but you can soak in a hot tub, or in the rivers warmed by the hot springs. You can't hunt. And at first you could feed the bears, but now you can't. Now you can hear wolves howl again. I think that the people who were in the park in 1872 felt that Yellowstone was *something*, something *real*. It was not in the state of becoming something else.

YS: That's *within* the park. Certainly it could be argued that within the National Park System there has been branching; we have different parks with different policies.

JM: I think there has been branching, incredible branching, in terms of the Service's attempt to protect nature—look at the national seashores, historic sites, and recreation areas. As the nation's perception broadened as to what sort of nature should be protected, so did the geographic extent and variety of NPS jurisdiction. We now have the NPS protecting and interpreting the Statue of Liberty as well as Sandy Hook. The NPS has been very responsive to the needs of America. But we know that national seashores are different from national recreation areas, which are different from Yellowstone and Glacier. Management of different types of units (such as national recreation areas versus parks) typically is the exchanging of one strategy for another, although I recognize that management strategies are not usually contradictory. Rarely does the Park Service make a 180° change on management policies the way it did in Yellowstone with bears, wolves, or swimming in hot springs.

My point is that even within one park, one place over time, our affection for this place has been an accumulation rather than replacement of meanings. A portion of the public—I'm related to some of them!—still thinks that it's not Yellowstone if you can't feed the bears. That particular part of the Yellowstone experience or expectation is fading, times are changing, but some of us see the little salt shaker bears and other beggar-bear-days memorabilia, and we shudder (or laugh). We know that the Yellowstone that produced those cute bears isn't a "pristine ecosystem" or the "wilderness" we want to think Yellowstone is today. But it was, and still is, an important part of what Yellowstone *means*. We all need to remember that, whether we are park managers, outdoor enthusiasts, environmentalists, whatever! I worry that in our rush to "do the right thing" in terms of ecosystem management and nature preservation we may lose part of the Yellowstone experience that hasn't changed until now, the stasis.

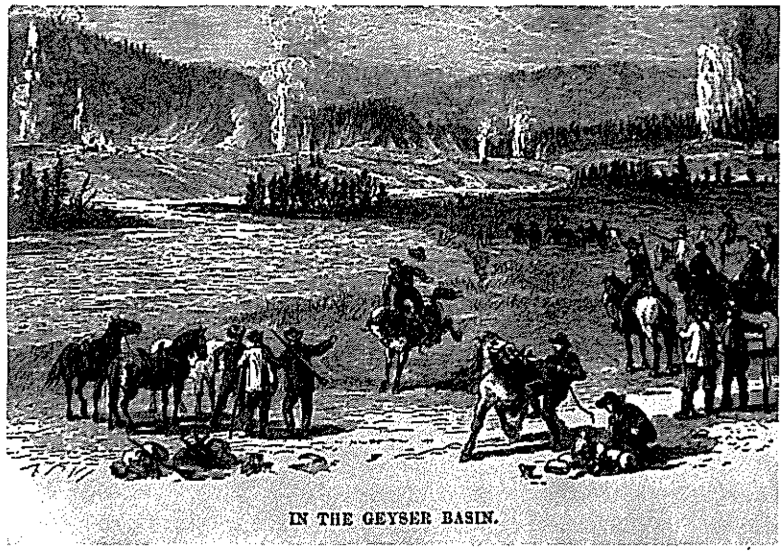
For my dissertation, I looked at everything I could find describing individual tourists' experiences in the park. Initially, I was looking for signs of change. I hoped to track the course of change, the impetus for change, the moments of change. I looked at the earliest accounts first, the "discovery accounts," and tried to make my way chronologically through the literature and noticed that much of the material in the earliest accounts was simply copied into later accounts. Even Ferdinand Hayden, one of Yellowstone's "official discoverers," copied from other explorers' accounts of thermal features in Iceland and New Zealand as well as from descriptions from the Washburn-Langford-Doane and Folsom-Cook-Peterson expeditions to Yellowstone. Nathaniel Langford, too, pretty much knew what he was going to see here and what he was going to say. Once the discovery accounts were published, however, everyone started copying the Yellowstone experience and it was codified very early. For example, it was standard practice to write that when you pull up to Old Faithful, it will give you a greeting salute. I honestly can't believe that for every person who wrote that when he or she pulled up to Old Faithful, the geyser erupted, it really happened! Or, hundreds of people wrote letters home or wrote in their diaries that "as we said good-bye to Old Faithful and Geyser Hill, Giant, Beehive, Giantess, Grand, Old Faithful, and Castle erupted as if in a parting salute."

YS: Based on the geysers' eruption patterns today, I've always found that very suspect!

JM: But that's not the point. This was a creation myth. We need to be careful not to discount that now, because not everybody got here, and these accounts made other people feel good about Yellowstone, which may be one reason why it's still here.

YS: So do you describe the Yellowstone experience as many different things?

JM: What I tried to say in *Spirit of Yellowstone* is that these historical accounts are not just interesting as Langford's account or Washburn's account. If you look at the accounts collectively, as a body of literature or evidence, there are the origins and subsequent evolution of the elements of the Yellowstone experience that we recognize today. The themes, even the words, I found woven throughout the earliest accounts are still evident today in descriptions of Yellowstone. In my dissertation, I tried to quantify the information in the accounts, I suppose because academics need statistics to verify the existence of anything. I then tried to graph the persistence of certain themes. It turns out that almost all of the earliest accounts remark on the beauty of the park or make some mention of the park as *wild*. That's what was/is important here. Or nationalism or patriotism or respect for the democratic government of this country: that we would establish a *people's* park. Whether it really was a people's park or not, whether minorities came or not, wasn't as important as the *idea* that Yellowstone wasn't going to turn anyone away, that Yellowstone belonged to them, too.



Drawing depicting simultaneous eruptions of many geysers on Geyser Hill in Edwin Stanley's 1880 Rambles in Wonderland.

Historians and other academics like to point out that Yellowstone was popular because is was "commodified." The railroads, especially, but also politicians and others wanting to be rich and/or famous, turned Yellowstone into a commodity—made it available, accessible, and desirable. Yellowstone was marketed to the public, and the public "bought" it, so this school of thought goes. But my point is that whether Yellowstone was created by the words and images of the discoverers or by its marketers (or both), the Yellowstone idea *did* sell, and we *did* save this place. And some of the reasons for saving this place can be traced over time. In the literature, and in people's hearts, there is something about this place that hasn't changed.

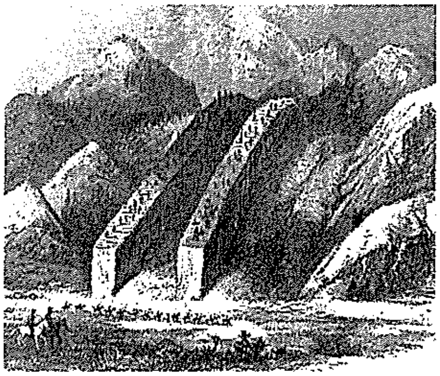
YS: Do you recommend preserving some of those core experiences which have been there all along?

JM: Yes. Some of them can't be saved; they're gone, and for most of them that's a good thing.

YS: For example, offering the opportunity to feed the bears?

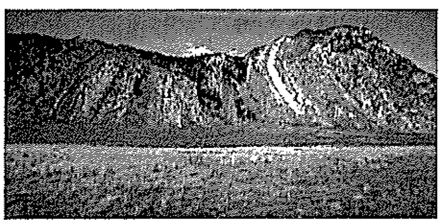
JM: To feed the bears, or swim in a hot spring. I'm worried now that we're moving really fast and some things are being inalterably replaced. The corkscrew bridge on the old East Entrance road is gone because now we have cars and a road that comes up over Sylvan Pass. The swimming pool at Old Faithful is gone. We have discounted history, and the stasis part of the evolution of Yellowstone as place, as being something inferior or incomplete or on its way to becoming what the park is. In terms of where we look to determine management strategies, history is often discounted in favor of science or politics or economics.

When Malcolm Forbes put his ranch just north of Yellowstone up for sale, the government was not especially aggressive in its attempts to acquire the land, despite the fact that the Forbes ranch included a unique landform called the Devil's Slide. Instead, the Church Universal and Triumphant bought the land and it's now known as the Royal Teton Ranch. Someone should have looked at Yellowstone's historical record and noticed that almost every person entering the park from the north, upon coming around the bend in the Yellowstone River and seeing Devil's Slide, said something along the lines of, "What a strange geologic feature! Now I know I'm entering Wonderland." This isn't just an isolated anecdote; this is evidence that Devil's Slide is a part of the Yellowstone experience and should be a part of the park. It is a shame that it's not. If one looks at the historical record, Grasshopper Glacier and the whole Cody Road belongs to Yellowstone. I know it's unfeasible to add these places to the park now (you can't get things through Congress like you could in 1872), but if someone had



> **"I think making the roads wider and faster isn't necessarily a good thing. Maybe waiting in line, bumper-to-bumper, is part of the Yellowstone experience, and we don't need to drive 45 miles an hour...people *sacrificed* to come to this place...If they were going to climb mountains, they had to do it on foot...They were going to get dirty. I don't think we need to try so hard to make Yellowstone 'easy' today."**

Above: Devil's Slide drawn by Thomas Moran for Nathaniel Langford's first article on Yellowstone in Scribner's *in 1871. (This was drawn sight unseen, since Moran didn't make it to Yellowstone until the following year when he came with Hayden.)*
Below: The real Devil's Slide. All photos in this article courtesy the author.



thought to consider the historical or perceptual importance of Devil's Slide when deciding whether to buy the Forbes ranch, this vital piece of Yellowstone might physically be a part of the park today.

YS: Could we preserve those experiences without legislatively changing the boundaries of the park?

JM: Those are just examples. I don't think anything will ever happen to increase the size of the park now, but I think it's important that we understand that history matters and history can be a tool of managers and planners and environmentalists. When we make policy, we need to remember there are cultural experiences in this place, not just ecosystems. Maybe considering history will build a stronger case against adding new recreational activities that don't hurt the environment but just don't belong here.

I think making the roads wider and faster isn't necessarily a good thing. Maybe waiting in line, bumper-to-bumper, is part of the Yellowstone experience, and we don't need to drive 45 miles an hour through the park. It is obvious from descriptions of the park experience that people sacrificed to come to this place. They knew it was going to be hard; it was not necessarily going to be expensive, but there was some hard work involved. If they were going to climb mountains, they had to do it on foot. If they were going to cross streams, they had to ford them. They were going to get dirty. I don't think we need to try so hard to make Yellowstone "easy" today. I really did worry a bit when the hot tubs went in behind the Mammoth Hotel (although I've since soaked in one with about ten other "savages"!) To me, that experience (except for the friends) could have been "anywhere U.S.A." You can do that in a Ramada Inn. That's not part of the Yellowstone experience historically.

YS: There are many people who would vote for you to be a future superintendent. But let's go back to something more basic. I think of geographers as making maps, using maps. Are maps and images still important in helping define this place?

JM: I didn't focus on maps in my dissertation, but I did look at how maps were used in guidebooks. It is interesting that before 1915, when automobiles were first allowed in the park, most Yellowstone guidebooks had a one-page map of the whole park showing the Grand Loop road. Or, there was a big fold-out map tucked inside a pocket glued to the back. In any case, there was a map of the whole park. After 1915, one starts to see guidebooks with maps of different segments of the park: a map of the northeast quadrant, a map of the northwest quadrant. The message sent by the format of the guidebook had changed from "come see the whole park; get a sense of this place" to "come see Mammoth Hot Springs; come see Old Faithful." It is as if the park experience could be broken down into discrete bits or pieces.

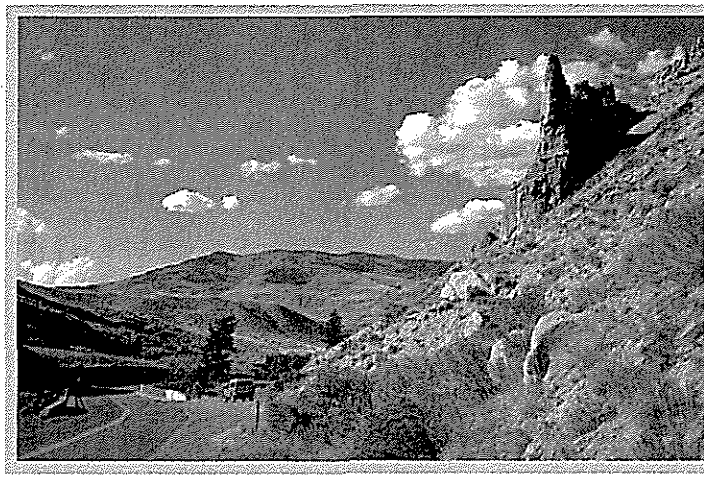
YS: We still present the park boundary that exists today, not some of those historically and geographically important features that you mention. The Devil's Slide, the Cody Road, Grasshopper Glacier aren't on any of the maps. Other specialists such as hydrologists and biologists are annoyed by that very arbitrary boundary. Perhaps for an equally important but different reason the historians and geographers are annoyed by it because it ignores the wholeness of place. Maybe we should try and change what we interpret and promote. The maps could be expanded to include these things as important to the history and the experience.

JM: Someone read at the conference from John Stoddard's 1898 observation of Eagle's Nest Rock, that little piece of sedimentary rock with the osprey nest on top (which was only intermittently occupied) along the Gardiner Road.

YS: And incidentally, has been recently reoccupied.

JM: I thought I saw a nest up there again! Eagle's Nest Rock was such an important stop on a tour of Yellowstone, especially in the 1870s and 1880s, when the United States had just lived through a civil war, and again during and after World War I. The eagle's (or osprey's) presence represented a sort of religious and political sanctioning of the park and of the national park idea. Now, no one stops there; there isn't even a little sign. Maybe that's good, because if osprey are nesting there, we don't want to disturb them. But to those who understand the significance of Eagle's Nest Rock, that place has meaning. Every time I drive by there, I look up and I feel good. I feel good about Yellowstone and the nation.

YS: As we rebuild the park's roads, we talk about whether or not to interpret this piece of natural history or cultural his-



"On three sides this is guarded by lofty, well-nigh inaccessible mountains, as though the Infinite Himself would not allow mankind to rashly enter its sublime enclosure. In this respect our Government has wisely imitated the Creator. It has proclaimed to all the world the sanctity of this peculiar area. It has received it as a gift from God and, as His trustee, holds it for the welfare of humanity. We, then, as citizens of the United States, are its possessors and guardians. It is our National Park. Yet, although easy of access, most of us let the years go by without exploring it! How little we realize what a treasure we possess is proven by the fact that, until recently, the majority of tourists were foreigners!"

John L. Stoddard's Lectures. 1898. Vol. 10., p.208

tory. As we plan to reconstruct the road in the Gardner Canyon we have an opportunity to consider safety of parking and disturbance of little ospreys. Part of what helps us make that decision is having someone point out to us the value of a place, because that may have gotten somewhat lost.

As a researcher, how else would you like to contribute to the body of knowledge about Yellowstone and therefore to its continued management and conservation?

JM: First, I think we need to look at each park individually. Yellowstone's particular model of preservation and use isn't going to work for Indiana Dunes or Sandy Hook or the Everglades or the parks of Kenya or Iceland. The Yellowstone model works for Yellowstone.

Second, I think we need to pay more attention to the people in each park who tell us what is historically appropriate for that particular place. Does that mean we now have to go back and read every single thing ever written about Yosemite and Glacier to understand the sense of place in those parks, or to figure out what is historically appropriate? No, not necessarily. If nothing else, my examination of Yellowstone's evolution as a "place" reveals that the early years are really the most important in terms of setting the stage for the park's development. Everyone copied the discovery accounts. The conditions following Yellowstone's "discovery"—Langford publicizing the park (and himself), Hayden telling tourists where to stop and how to feel—set the stage for subsequent evolution. We don't need to do years of research to get a sense of each park. We should concentrate on the early years.

Gould calls this the importance of initial conditions. He suggests that in biological evolution, the "disturbance" (for Yellowstone, the designation of the national park) and conditions following the disturbance set the parameters for what happens next, who gets a foothold on the available resources or niches. I think the initial conditions that spurred the creation of a park, the effectiveness of the early movers and shakers, and the public's initial response to that park are very important in determining what that park will come to mean as well as be.

YS: You mentioned the automobile as an event that really changed the way we view the park. What were some of other events throughout history that were major changes?

JM: Mission 66 (and the horror of Canyon Village!) This all goes back to my fear of uniformity and the idea that one way of doing things works for everybody. "Hey! Let's build the same buildings in all the parks"—even though that is not in keeping with this place. [*Ed. note: Mission 66 was a major effort begun in the 1950s to modernize roads and facilities in many national parks for visitors and employees; the goal was to complete construction by the National Park Service's fiftieth anniversary in 1966.*]

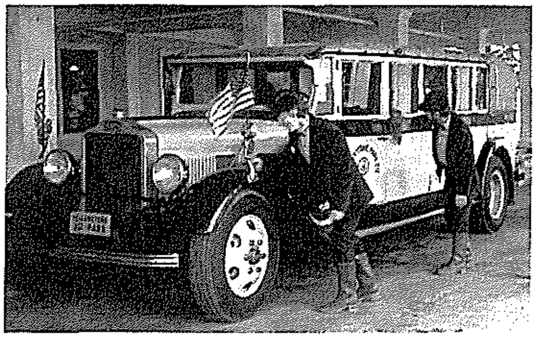
YS: Many park employees have commented "I've worked in this visitor center before, three parks ago! I've lived in this house in another park; it's the same floor plan."

JM: And now that's part of Yellowstone; we have the imprint of Mission 66 and the standardization. This was the nation's real attempt to bring the parks up to snuff, and the only way to do that cost-effectively was to build the same thing in all the parks. But that's presumptuous, that nature is just a stage and we could plop down our artifacts and that they wouldn't disturb the experience or have an impact; they did.

YS: We have this debate as some of the Mission 66 structures approach 50 years old—the point at which we must evaluate them for their potential historic value—and some of us say, "Please, let's have an earthquake before we have to save some of them!" Yet other people comment, only somewhat tongue-in-cheek, that they are also representative of a national trend in the tourism industry, toward making all the hotels into motels that looked familiar and comfortable, so you knew when you set out across the country what to expect. That uniformity in entrance stations and motels and restaurant facilities in parks was an accurate reflection of what society seemed to want at that time.

JM: And Yellowstone accommodated that. But we never tore down the Old Faithful Inn, and we still spend the night there. The uniqueness of place and respecting the influence of the past in making it unique, I think, is evidenced in Yellowstone in such a beautiful way. I worry because the fires of '88 could have taken out the Old Faithful Inn, could have taken out our archives. And the caldera's going to explode, so our time is limited. We don't need to speed up that natural deterioration or change by embracing modernity with open arms at the expense of our past. We need to be careful.

YS: Since you were in the park as a tour guide throughout the early 1980s, what kinds of changes have you observed in



Tom Woods and Lee Whittlesey—in an example of traditions kept alive in the park—polishing one of the old touring cars in anticipation of William Penn Mott's visit for the dedication of the restored ranger station at Lake.

how Yellowstone treats its culture or its sense of history? We think we've come a long way, at least in establishing more positions in cultural resource management and science, but it helps us to have the opinions of other folks on whether we've actually made progress.

JM: The Yellowstone attitude is commendable. I think the Park Service, surrounding communities, and individuals are all paying more and more attention to history. People who care about the park's past are here, working to preserve it. Lee Whittlesey was my teacher in 1980, and now he is the park archivist. Leslie Quinn and Paul Shea were in those first batches of tour guides and tour-bus drivers to be trained in the late '70s and early '80s by Lee; Paul now runs a bookstore in West Yellowstone and Les trains tour guides/ drivers, drives a tour bus, and writes the commentary handbook. There are a lot of people around who are working actively to keep the spirit of the stagecoach drivers alive.

YS: Some of the folks you mentioned, like yourself, point out that the role of the concessioner in portraying Yellowstone, in saving and interpreting its history, is still underrepresented and undervalued.

JM: I definitely had a sense of "Oh, you're just a tour guide; you're not a ranger" when I worked in the park. This came both from the public and from some of the rangers. But I *loved* being a tour guide and preferred the work, I suppose, to that of some of the rangers' jobs. I would much rather travel for three days with a group around the park than give five tours of Old Faithful over the course of the day. But in the eyes of the public and academics, the Park Service is good and concessioners are bad. All concessioners do is speed up and contribute to the "commodification" of the park: "Buy your piece of the park at my souvenir shop and then get out so you can make room for the next person in line." That attitude is absolutely contrary to my experience as a concessioner employee in the park.

YS: Wasn't the concessioners' role—the Haynes' photo shops and the postcards and stereo cards—in documenting and interpreting the park history very important? We've neglected for a long time the important role that the concessioners have had not only in selling the Yellowstone experience but in preserving it.

JM: It was very important. Certainly, concession employees today reach more people than NPS staff. When we talk about Haynes' contribution, academics especially (one of our roles is to critique) say, "Oh, he only promoted the park to make money; he was a business man." No, he did it because he *loved* this place. He did it because he wanted to share the park with the public.

And we all know that if we kick everyone out of here and don't "sell" the park, it will cease to exist. Yellowstone cannot exist solely as an ecosystem for scientists to visit once a year to take measurements. This place lives in people's hearts and minds as the birthplace of the national park idea (although it wasn't really the birthplace; the national park idea was a long time coming before Yellowstone National Park was established). We are all a bundle of purposes. We all love nature. And we all love to buy things. By the same token, many concessioners wanted people to know, understand, appreciate, and appropriate money for Yellowstone. I don't think we should cast all concessioners in a bad light, as greedy capitalists. Most of them were (and are) in love with this place.

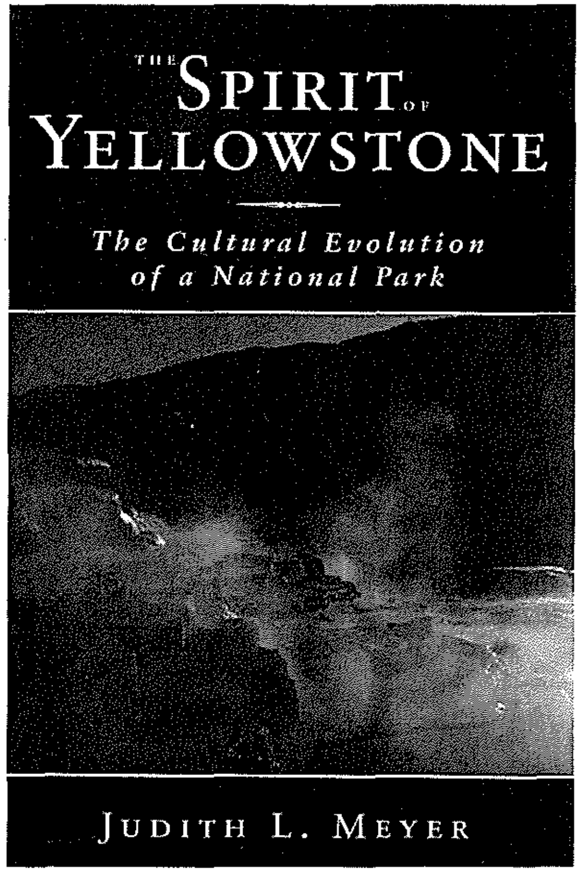
YS: What has stayed the same since 1872 in the sense of place? What are the similar ideas and visitor experiences?

"...we all know that if we kick everyone out of here and don't 'sell' the park, it will cease to exist. Yellowstone cannot exist solely as an ecosystem for scientists to visit once a year to take measurements...[M]any concessioners wanted people to know, understand, appreciate, and appropriate money for Yellowstone. I don't think we should cast all concessioners in a bad light, as greedy capitalists. Most of them were (and are) in love with this place."

JM: I think the general public still sees the park as magnificently beautiful and wild. Unfortunately, what we too often remember is all the little comments we hear along the lines of, "It looked better on the postcard," or "I was here 50 years ago when Old Faithful Geyser was higher, and the mudpots were more colorful." We hear those sorts of things, but we don't hear the people who just stand at Artist Point and look at the falls. People are still moved by the beauty and power of this place. Even though we know that the bison are being shot, that elk populations were managed, trees were cut, and crops were planted, most visitors still respond to the wildness of it all. We respond to the patriotism. We come to be educated and take part in ranger programs, pick up brochures and read about how much travertine is laid down over the course of a year. We come to recreate. We still think hiking in Yellowstone is in some way healthier than walking through downtown Chicago. If we polled visitors at the gates today and asked, "Give me 12 words that describe the purpose of this park or what you got out of your trip," I think the same themes that were in the earliest accounts of a Yellowstone experience would still be there today.

Book Review

The Spirit of Yellowstone: The Cultural Evolution of a National Park *by Judith L. Meyer, Rowman & Littlefield Publishers, Inc., Lanham, Maryland, 1996, 115 pages, $26.95 (hardcover).*



Like many longtime employees of Yellowstone, Judith Meyer came to work for the park concessioner for one summer and found herself returning year after year. "I had no idea how deeply Yellowstone's spirit would touch my soul," she writes. In her own words, "Yellowstone houses a spirit of place: an infectious, irresistible force that stirs something within so many of us." This book, a variation on her doctoral thesis, appears to be her quest to define that spirit of place. As a professor of geography, she applies the rigorous scholarly tools of her trade to this end. Though lyrically written, the general public may find the analysis a bit academic. But the many of us who have also heard the siren's call will appreciate this intriguing and probing attempt to quantify the ideal that we too hold dear. Whether this lofty goal is achievable or not, the book immediately earns an important place in the literature of Yellowstone merely for naming this ethereal concept, "a spirit of place," and inclining us to look at the park in this way.

From its introduction, we come to understand that this book has two primary objectives. First, "it is an examination of Yellowstone's profoundly evocative, affective, and attractive spirit; the park's ability to move us intellectually, physically, and emotionally." It is an investigation of those "taken possession of by it"—the generation of park visitors who, in describing and communicating their experiences to others, created the park as a recognized "place." This book is, at its core, a literature review. In seeking out the evasive spirit of Yellowstone, Meyer delves into the minds of the explorers, park promoters, and early visitors through their writings.

The second objective is even less measurable. In asserting that Yellowstone is not just a national park, it is "place," she calls us to look beyond the park as just an ecological entity. The author suggests that Yellowstone is a human artifact and that it is we who assign meanings to its landscape. In the course of the book, she encourages park managers to take this notion of "spirit of place" into account when making management decisions.

Meyer takes a refreshingly different view of park history. Despite the title of her first chapter, "Revolutionary Ideas and Evolutionary Processes," instead of framing the park's history in terms of society's changing attitudes toward nature, she focuses on what has remained the same. Hers is a history of visitor perceptions. She reviews the literature from 1870 to 1991 and finds six themes that recur across the decades: the park's beauty, its uniqueness, its tourism and recreation capabilities, its wildness, its democratic ownership, and its scientific and educational values. She notes how, in recent times, Yellowstone has been criticized for the changeable nature of its management policies. She quotes former Superintendent Bob Barbee saying that park management "is an uneasy truce between what science tells us is possible and what our value system says is appropriate." She suggests that adopting a new perspective, one "that releases park managers from society's changing attitude toward nature and acknowledges the importance of people's affection for parks as places" may resolve some of the criticism aimed at the NPS and bring about a new appreciation of the national parks.

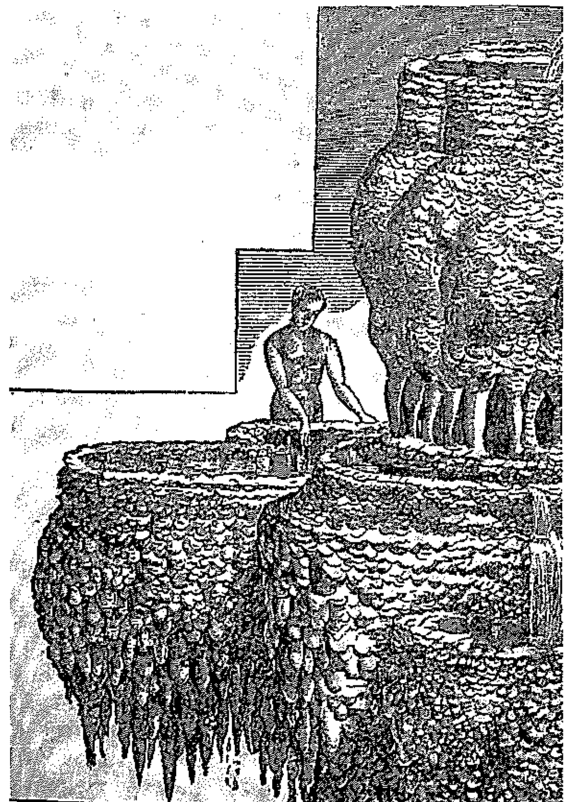
Meyer acknowledges that the leaders of the three famous expeditions to the Yellowstone were not its true "discoverers." Still, she notes, it was their prolific writings that captured the imagination of the nation. Her analysis of these writings shows that each of the expedition leaders relied heavily on the descriptions of Yellowstone written by those who preceded them. After the park was established, the first guidebooks and the journals of early visitors continued to recite the wonders of Yellowstone in language uncannily similar to the discovery accounts. It was these original works, she proves, which seared an image of Yellowstone into the collective mind of the American people and began to define Yellowstone's spirit of place. Another chapter takes this line of thought deeper by comparing the early accounts of the area's major features: Mammoth Hot Springs, Tower Fall, Old Faithful, the Grand Canyon of the Yellowstone, Upper and Lower Falls, and Yellowstone Lake.

She also notes how the early art of Yellowstone—the sketches, photographs, and chromolithographs that accompanied the discovery accounts —was as integral as the writings in creating the public's image of Yellowstone as "place." As an aside, the book includes interesting comparisons between the artwork Thomas Moran did before he'd been to the park and that which he created after he'd seen the area for himself. As a result of the early descriptions and artistic renderings, Meyer suggests that, from the outset, people have always come to Yellowstone somewha t "preprogrammed" to encounter and interpret the park in certain ways—and yet such expectations do not "preclude fascination and surprise" in each visitor's experience of the place.

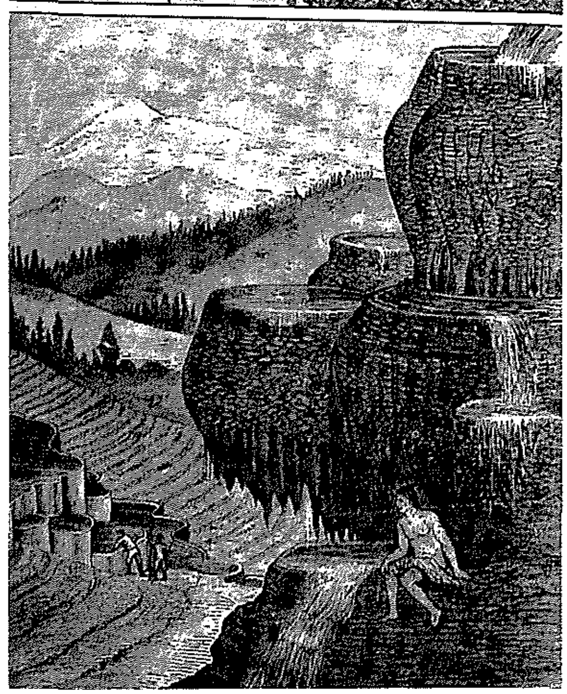
Meyer continues by investigating the changing visitor experience in Yellowstone. She observes that, historically and recently, attempts to provide recreational activities have been blamed for the degradation of park resources. She points out that, from the moment of its inception, Yellowstone was to be a place for the people—a refrain ever familiar to those aware of the dual mandate of the NPS mission. She chronicles this history through the park's infrastructure, from the building of roads, bridges, and hotels to transportation; from stagecoaches to touring cars to individual cars. She notes that the tradition of group travel predates the ranger campfire program, and for that matter, even the NPS itself. Through the diaries of early visitors she documents the companionship of the stagecoaches, the legendary tall tales of the drivers, the camaraderie of the campfires at the tent camps, and the singing of the "savages" that, in her mind, made these early days the glory days of Yellowstone. Meyer laments the loss of this tradition.

I think she is trying to say that, in pondering what recreational uses are appropriate, tradition and a spirit of place should be taken into account. She diverges from scholarly objectivity to occasionally state some strong opinions on various visitor uses such as snowmobiling. While I was not entirely sure where chapter five was taking me, it was an enlightening and delightful journey down Yellowstone's memory lane.

If Meyer's intent was to examine Yellowstone's spirit and those "taken possession by it," then she was successful, unearthing through meticulous research compelling and little-known quotes from the massive body of literature written about the park. Her other objective was to encourage people to think about Yellowstone as more than a national park and to urge managers to incorporate this concept into management decisions. Whether this goal is attained will be up to each reader. However, if an unwritten intent of this book was to get people pondering what the spirit of Yellowstone is to them, then this book succeeds mightily.



A sketch entitled "Ornamental Basin at Mammoth Hot Springs of Gardiner's River" from F.V. Hayden's Twelfth Annual Report. *The sketch is a highly abstracted hot spring and a mythical figure.*



This second sketch from H. Butterworth's Zigzag Journeys *(circa 1892) of similar hot spring formations, clearly indicating the tendancy of the times to mystify the Yellowstone "experience," but with the addition of a more realistic view of the terraces in the background. (The exact same sketch is found in F.K. Warren's* California Illustrated.)

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Stream Ecosystem Responses to the 1988 Wildfires

by G. Wayne Minshall, Christopher T. Robinson, and Todd V. Royer

The 1988 wildfires in the Greater Yellowstone Area (GYA) provided an important opportunity to assess the effects of large scale disturbance on stream ecosystems over time. Research conducted by the Stream Ecology Center of Idaho State University has documented these changes and their effects on stream biota during the last nine years. We examined environmental and biological responses of 20 streams in Yellowstone National Park (Fig. 1) each year for the first five years following the extensive wildfires in 1988 and we studied a subset of these streams in 1994, 1995, and 1997. Our findings demonstrate an integral relationship over time between a stream and its catchment (drainage basin) following large-scale disturbances such as wildfire. However, individual streams varied considerably in their responses, depending on such things as size and local variations in precipitation, geology, and topography, with major ecological changes occurring each year following the fires. We were especially amazed by the major physical changes in streams that occurred even between 1995 and 1997. Indeed, some streams in fire- "ravaged" watersheds such as parts of Cache Creek changed more in the last three years than in the first six post-fire years.

The changes with time and among streams were readily apparent in photographs taken from the same location and position each visit—a form of documentation called re-photography. The conditions were then documented by measurements of channel morphology, substratum particle-size distribution, and accumulations of woody debris. We expect that these changes in habitat conditions will be reflected in differences in the abundances and kinds of organisms found in the streams. Documenting these changes is important, as aquatic insects are the "groceries" that the park's trout consume for sustenance and growth.

Our Working Hypotheses

Current theoretical constructs (ideas) for flowing water (lotic) ecosystems provide a rich framework from which to postulate ecosystem response to large scale disturbances such as forest fire. Paramount to such knowledge is recognition of (a) the integral association between stream ecosystem responses and terrestrial conditions of the surrounding watershed; (b) the crucial linkage between aquatic and terrestrial food bases and the trophic composition of the fauna in streams, and; (c) the importance of stream size as a modifier of land-water interactions.

Based on these fundamental principles of stream ecology, we developed three primary hypotheses:

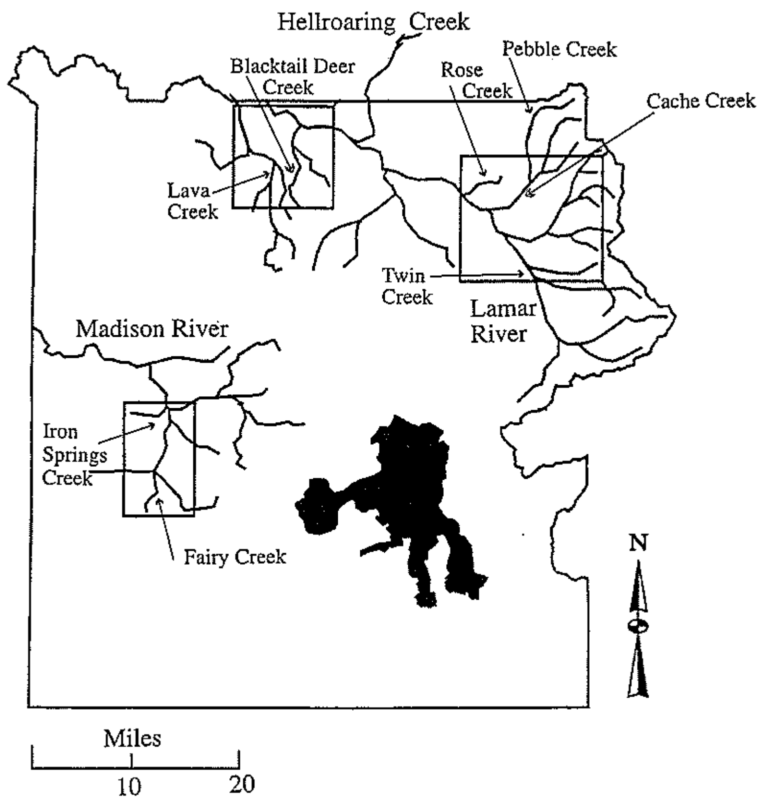


Figure 1. Location of the streams and major water bodies in the study. Rose, Pebble, and Amphitheater (to the right of Pebble) creeks are unburned (in ≤ 5% of catchment) reference streams; the remainder were burned (in ≥ 50% of the catchment) by wildfires in 1988.

1. Stream response will reflect changes in the structure and composition of adjacent terrestrial vegetation following wildfire. Since forest regeneration following wildfire is a long-term process, extending up to 300 years in the GYA, stream ecosystems were expected to respond similarly and to change progressively with temporal changes in plant community structure within a catchment.

2. Changes in environmental conditions will be reflected in the relative differences in amounts of food resources produced within (authochthonous) and outside (allochthonous) a stream and, in turn, the trophic composition of macroinvertebrate assemblages will reflect temporal changes in the food base among streams.

3. Major differences among streams, in terms of intensity of the effects of fire and recovery rates, will occur because of differences in stream size, watershed slope, and aspect. Watershed slope and aspect significantly influence the timing and rate of runoff and the type and amount of riparian and upland vegetation.

More-specific hypotheses addressed major ecosystem components that were associated with the general points above. In addition, we predicted long-term alterations associated with the recovery of riparian and terrestrial vegetation, and consequent shifts of instream food resources and retention characteristics.

Chronology of Changes in Stream Conditions Following Wildfire

It was insightful to separate the temporal responses of streams to wildfire into four periods: (1) immediate changes (the time of active burning to a few days after); (2) short-term changes (from a few days to the end of the first year); (3) mid-term changes (the second year to sometime beyond the tenth year); and (4) long-term changes (from tens to hundreds of years). The precise length of each period depends on the degree of disturbance by fire and the environmental conditions of burned catchments such as weather and climate, topography, geology, soil conditions, and forest type. The immediate and short-term effects were expected to be the most dramatic and to alter stream conditions profoundly, relative to those before the fires. The mid- and long-term changes in stream ecosystems were hypothesized to parallel the successional replacement of the terrestrial vegetation.

Immediate Effects

Beginning in late September of 1988, we examined the fire effects in 18 burned and 4 reference streams (one of each was eventually eliminated from consideration). Losses in upland and riparian vegetation and the almost instantaneous conversion of terrestrial vegetation to charcoal and ash resulted in immediate changes in the amount of light and quality of organic matter, i.e., food resources entering the streams. The most striking immediate changes within stream channels were the incineration and scorching of emergent mosses and heat fracturing (splaying) of rocks in and adjacent to smaller streams. Although most burned trees remained standing, many downed trees and large limbs were observed within and/or bridging streams. We also counted up to 10 dead cutthroat trout in our 250-m long study sections in mid-sized (3rd order) Cache Creek and the West Fork of Blacktail Deer Creek. These are believed to have died as a direct result of the fire (see below). However, we also know of another instance on a tributary to the Little Firehole River where an errant drop of fire-retardant was responsible for a number of fish deaths.

Most dissolved chemical measures increased in streams of burned catchments the first year following the fires. Based on studies by other researchers in 1988 on the effects of wildfire on Glacier National Park streams (Spencer and Hauer 1991), we believe dramatic and rapid increases in stream phosphorus and nitrogen levels occurred during the Yellowstone fires due to inputs from ash and smoke gases, respectively. We speculate that high ammonia levels that entered the water from the smoke were responsible for the observed fish mortalities. Few or no immediate deleterious effects of fire were evident in algae growing on rocks (periphyton) or macroinvertebrate assemblages, even in the smallest streams observed. These impacts are more difficult to discern due to the small size and rapid decay rates of the organisms involved, although lotic macroinvertebrates are adversely affected by exposure to ammonia.

Our investigation revealed distinct differences in the effects of wildfire on streams of different size. Following fire, small headwater tributary streams (1st and 2nd order—e.g., Fairy Creek and the upper parts of Blacktail Deer Creek) were more physically and chemically variable than intermediate-size streams (3rd and 4th order —e.g., Cache and Hellroaring creeks) or reference streams. In general, smaller streams had a greater proportion of their catchments burned than larger streams. For our study streams, the mean catchment burned was 75 percent for 1st- and 2nd-order streams and 50 percent for 3rd- and 4th- order streams (Fig. 2). However, we observed during aerial and ground reconnaissance that the catchments of many fire-affected 3rd- and 4th-order streams throughout Yellowstone Park and along its northern boundary were less than 50 percent burned, and those of larger streams were even less burned. (No streams larger than 6th order are found in the park.) Consequently, the impact on biological properties also appeared more pronounced in smaller streams, although intermediate-size burned streams located in steep terrain with confined flood plains (e.g., 3rd-order Cache and Hellroaring creeks) experienced greater overland flow and associated effects on the biota than did other large study streams.

The most consistent outliers from the general patterns found in this study Fairy and Iron Springs creeks, were attributable to one or more relatively unique features. These two streams were located along the west side of Yellowstone in an interior-type climate, characterized by a

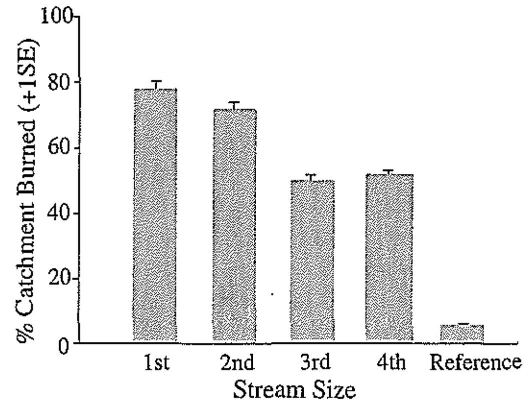
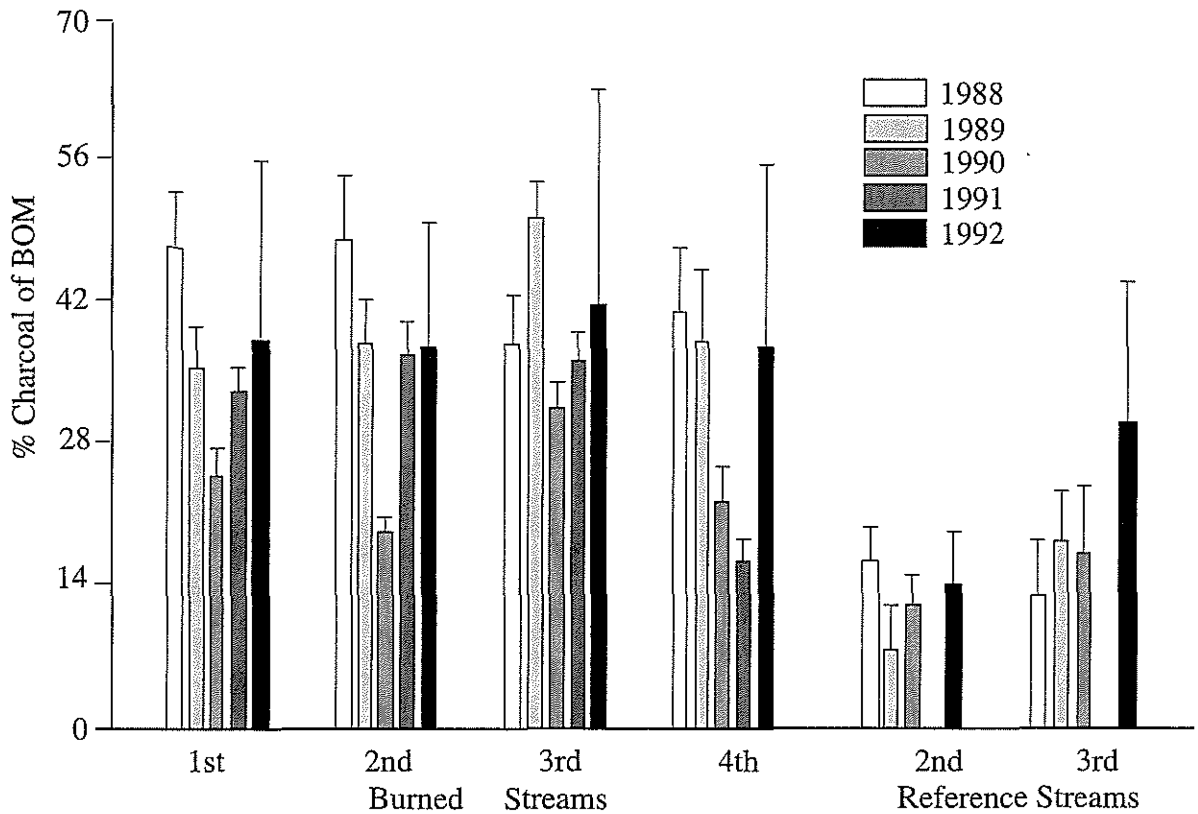


Figure 2. The percent catchment area burned by wildfires in 1998 for each of the four most abundant stream sizes and the reference sites used in this study.

Figure 3. The percent of benthic organic matter estimated as charcoal in streams of burned catchments and nearby reference streams following the 1988 fires.



spring peak in precipitation and Douglas-fir cover, and underlain by different base rock (rhyolite) than the other streams we examined, which are located in the northeastern corner of the park on andesite rock in a montane-type climate characterized by Engelmann spruce cover. In addition, the 2nd- order site at Fairy Creek had the lowest gradient of any study stream and was unforested and strongly influenced by geothermal springs. A large proportion of flow in Iron Springs Creek is groundwater; thus this 3rd-order site displayed little variation in flow and usually did not freeze over in winter.

Short-term Changes

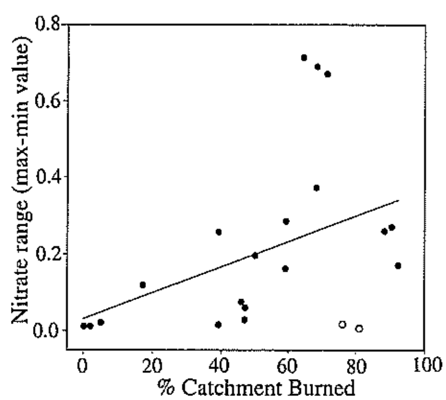
From October 1988 to March 1989, macroinvertebrate abundance and richness decreased in 6 of 8 sampled burned sites, whereas these values increased or remained constant in reference streams. Because rainfall was minor and then the ground became frozen and snow-covered and the streams ice-covered for most of the time, no physical disturbances from runoff occurred during this period. Therefore, we attribute these changes to high amounts of charcoal (>40 percent) in stream benthos as a result of the fires (Fig. 3) and the absence of unburned organic matter and algae. We had expected that burned materials would be the principal source of allochthonous organic matter at this time; however, we had not anticipated that ice and snow cover would reduce the amount of light reaching the streambed and severely limit the growth of attached algae.

We believe that the input of charcoal decreased the palatability and quality (e.g., increased carbon:nitrogen values) of organic matter resources as food. For example, in a food utilization study of some selected stream invertebrates, only 1 taxon of 11 examined could exploit burned organic matter as a food source (Mihuc and Minshall 1995). Periphyton biomass also decreased in burned streams (except Iron Springs Creek) during this period, although comparable changes were observed in reference streams. Data since 1989 indicate charcoal is still being added to burned streams, but in reduced amounts. After 1990, most fire-related effects appear to be caused by physical disturbance of the streambed associated with higher peaks in runoff rather than by changes in food resources.

Spring melting of the 1989 snow pack was much slower than anticipated (P. Farnes, Snowcap Hydrology, Bozeman, Montana, pers. commun.). Consequently, although several periods of "blackwater" associated with overland flow from heavy rains occurred between spring runoff and our August 1989 sampling, streambed erosion and channel alterations generally were much less than expected or than occurred in later years. However, several 1st- through 3rd-order streams, particularly Cache Creek and Hellroaring Creek catchments, did show substantial channel alteration and rearrangement of woody debris. In addition, reductions in flow and substrate heterogeneity were observed in burned streams, as indicated by changes in annual coefficients of variation for these measures between 1988 and 1990. No comparable changes in either velocity or substratum occurred in the reference streams. A number of studies in other areas of the West have documented similar changes in burned streams resulting from increased sediment loads and peaks in runoff.

Most dissolved constituents, especially nitrates, were higher in August 1989 than in October 1988, apparently in response to rainstorms during or immediately prior to the summer 1989 sample collections. In contrast to other ions (e.g., phosphate) that displayed only immediate changes in concentrations, temporal changes in instream nitrate levels typically reflected regrowth and reinvasion by adjacent terrestrial vegetation. Similarly, we found a direct correlation between nitrate loss and percent catchment burned in the Yellowstone study streams (Fig. 4). These findings are consistent with the well-known fact that vigorously growing plants actively sequester nutrients and delay or prevent their runoff into streams. Other changes in environmental conditions seen in the first year were the downstream movement of charcoal and fine sediment and increases in the temperature of burned headwater streams.

Figure 4. Nitrate levels in stream water versus the percent of the respective catchment burned.



Mid-term Changes in Post-fire Stream Systems

The mid-term responses (1990 to present) of Yellowstone stream ecosystems to wildfire were driven primarily by impacts from high runoff from snowmelt and localized rainstorms and by regrowth of terrestrial vegetation. Although some major effects of fire were evident in the first three post-fire years, the biota in the burned streams appeared to be on a "fast recovery track" (*sensu* Minshall and Brock 1991), aided by relatively little change in channel morphology and progressive regrowth of the riparian vegetation. However, 1991 was marked by at least two large runoff events that caused major physical changes in all burned streams having moderate to steep gradients. Ewing (1997) also noted that suspended sediment loads in the Lamar River were elevated in 1991 in response to higher than average precipitation. All stream sizes examined (1st through 4th order) were affected but changes were most dramatic in 3rd-order streams (e.g., Cache Creek, Fig. 5). In Cache, disturbance of the channel expanded beyond the recent channel bounds (unvegetated by shrubs) to encompass the entire width of the historically active channel. The existing pre-fire channel was obliterated and the historic channel was leveled from bank to bank by a combination of scour and fill events.

Additional channel modifications were observed in 1992, especially in the Cache Creek headwater (1st and 2nd order) tributaries. In Cache Creek, headwater stream channel morphology changed only moderately during the rest of the period (1993-

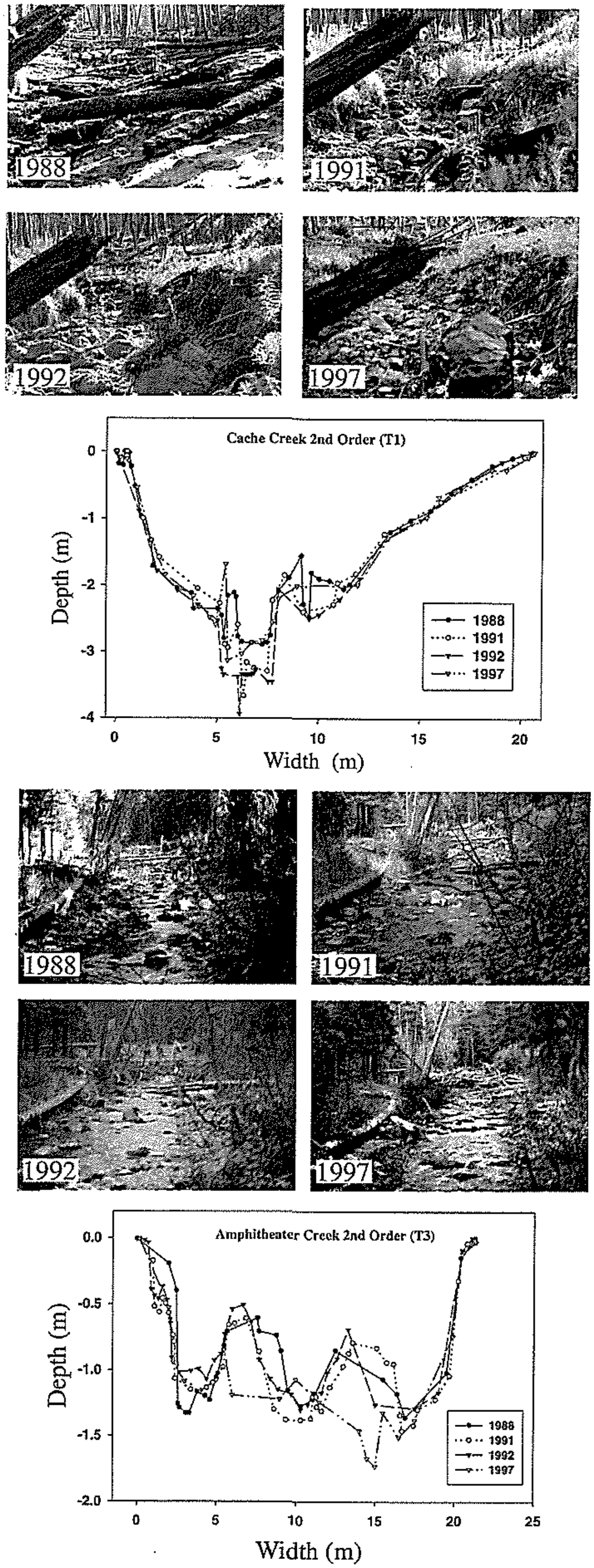


Figure 5. Comparison of photography and channel cross-section profiles of a stream in a burned catchment (upper: Cache Creek, a 2nd-order site) relative to one in an unburned catchment (lower: Amphitheater Creek) during the nine years of study.

1997). However, in many places along these streams, the flow tended to move back and forth across the valley floor in a temporally braided fashion, as deposition and erosion created new flow paths. In 3rd-order Cache, in all years during this period except 1994, dramatic changes in channel conditions were seen at most or all transects. In 4th-order Cache, year-to-year changes in channel form and substratum conditions were relatively minor until 1997, when a wave of cobblestones entered the section and the thalweg (an imaginary line that runs the length of the stream and stays in the deepest part of the channel) shifted from the left side of the bankful channel to the right side. In general, each of these major disturbances was reflected in declines in biotic properties and served as important "resets" or delays in lotic ecosystem recovery. Thus, in overview, major alterations in the stream channels and (by inference) the biotic community appeared to move progressively downstream over time, from the headwater tributaries in 1989, 1991, and 1992; to Cache 3° between 1991 and 1997; and, finally, to Cache 4° in 1997.

Our results thus far show the importance of stream discharge and gradient in mediating physical disturbances associated with adverse intermediate effects (e.g., channel scouring and sediment loading) resulting from wildfire. High-gradient streams responded sooner (i.e., at lower flows) than did low-gradient streams. At comparable discharges, high-gradient streams underwent greater physical disturbance than did similar-sized low-gradient streams. For instance, high-gradient burned streams displayed major changes (cutting or filling) in channel cross-section morphology in 1991 and 1992, whereas channel morphology of low-gradient burned streams and reference streams remained relatively constant (Fig. 6).

Data on substrata embeddedness suggest that a pulse of fine sediments moved from burned watersheds into headwater streams and then gradually into larger burn streams during the first five years. Median substrate size also decreased in 1st- through 3rd-order burn streams following 1988 and remained low through 1992. An unexpected finding from our study was the maintenance of large

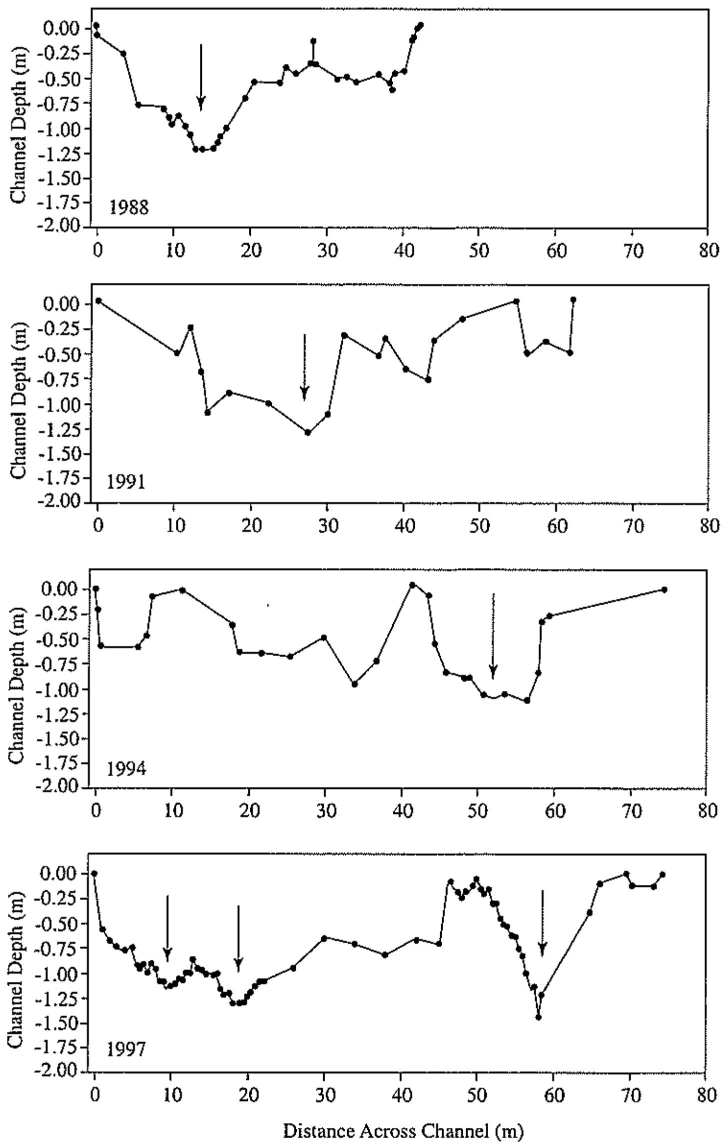


Figure 6. Cross-sectional profiles of the Cache Creek 3rd-order site for four selected years of substantial change at one (t-4) of five permanent transects established in 1988. Arrows denote locations of flowing water within the channel under baseflow conditions. Note the shifting and widening of the main channel after 1988.

amounts of fine inorganic sediments in headwater burn streams during the first five years. We expected these materials to be rapidly removed and then increase again after 5 to 10 years. Because Yellowstone streams have lost a considerable amount of retentive capacity due to steepening of the hydraulic gradient, straightening of the channel, and loss of large woody debris as a result of increases in peak discharge following the fire, we believe the "maintenance" of silt and sand resulted from continued input from the surrounding catchments. This continued input also is suggested by an increase in percent charcoal of the organic matter deposited on the bottoms of streams in 1992. Although the remaining embeddedness data have yet to be analyzed, our qualitative impression is that most of the fine materials had been flushed from the system by year 5, after which their influence was overshadowed by bedload movement of pebbles, cobbles, and boulders from 1993 to 1997.

Woody debris in streams retains organic matter and sediment and provides valuable habitat for fish and macroinvertebrates. Within the burned catchments, woody debris came and went in all of the streams throughout the mid-term time interval. Initially, the 1st through 3rd-order burn streams contained more large wood pieces than did 4th-order burn streams. This can be attributed to the lower competency of high flows to move larger pieces of wood and to the closer proximity of trees to the main channel in smaller streams. The higher volume of the snow-melt flows in larger streams moved even the largest pieces of wood (including whole trees), leaving few pieces to stabilize the low-flow channel for longer than a year. However, later in the period (1995 to 1997), discharges were sufficiently high in the 3rd-order streams to cause them to converge with the 4th-order sites in terms of low abundance of large woody debris.

But the high flows in the years 1995 to 1997 undercut banks and felled many snags into the 3rd- and 4th-order stream channels. These collected on point bars, at the heads of islands, and in the shallows of braided sections, where the longevity of the large woody debris may extend beyond a year. Small streams had lower debris volumes because a large portion of fallen trees remained outside the channel margin. Other researchers have found an inverse relationship between stored organic matter and stream size, where 1st-order streams contained 75 percent and 3rd-order streams held only 20 percent of the organic matter in the stream channel. Although we did not find this response to hold initially, this did eventually occur in our study streams, due to much higher export of wood from the 3rd- and 4th-order streams. We not only found an increase in woody debris loading in all stream sizes immediately following catchment fire, but we expect that many of the standing fire-killed snags will fall and enter the channels over the next 10 years. Significant rearrangement of pre-fire, fire-felled, and newly-contributed woody debris in channels is still taking place.

As noted earlier, stream ecosystems are profoundly influenced by the condition of their watershed. We were struck by the fact that, many of the conifer seedlings that germinated in the year following the fires were 6 feet or more in height by 1997 (Fig. 7). We also observed that many of the charred tree trunks of whole forests killed by the fire were still standing (Fig. 8). In another 10 years, it is expected that these "seedlings" will be 18 to 20 feet tall and that almost all of the dead snags will be down. These changes, occurring over a relatively short time, will dramatically alter the kinds and amounts of food resources in streams and change the availability of large woody debris. The changes that have taken place over the past nine years and are likely to occur over the next decade are expected to be the most dramatic to occur over the postulated 100- to 300-year recovery sequence.

Figure 7. Photograph showing the height of seedlings in 1995, indicating the extent of recovery of the trees that will replace the snags when they fall.

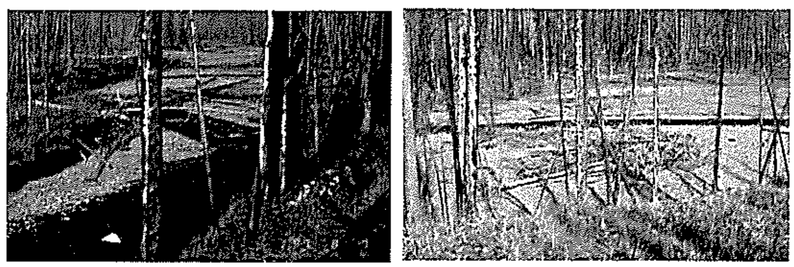


Figure 8. Two photos showing that many of the dead snags are still standing. All photos this article courtesy the authors.

Predicted Long-term Changes

Based on our short- and mid-term results, long-term predictions for stream habitat development can be made for streams in burned catchments. Nearly all headwater streams are accruing pieces of wood. These are important in the formation of pool habitat in steep-gradient streams. As wood stabilizes, longer-lasting pools are expected to form which should increase habitat for fish. However, because less wood was found in the larger (3rd- and 4th-order) burned sites toward the end of the first 10 years, we anticipate fewer pools will form in fire-affected larger streams than in corresponding reference streams. In turn, a decrease in adult fish density should accompany habitat development. Large trees should again enter stream channels, forming deep pools and maximizing fish habitat, about 150 years following the fires. However, habitat diversity also should decrease in the streams as the forests in their catchments reach full development (climax).

Macroinvertebrate communities in burned sites displayed major changes in response to the observed changes in instream habitats. For example, burned sites exhibited differences in trophic group composition from that found in reference streams, suggesting alterations in food resources and a shift to more trophic generalists. However, macroinvertebrate response appeared to be more individualistic rather than associated with community properties such as species richness and diversity. These properties showed substantial recovery within the first year following the wildfires, whereas assemblage composition displayed significant changes that were apparent even in post-fire year 9.

The changes wrought by fire can affect macroinvertebrates in ways other than through alterations in food resources, such as via higher water temperatures. Individual life histories and life styles respond in different ways and in different degrees to these various changes. Opportunistic species, particularly those well-suited for dispersal through drift and with relatively short generation times (such as chironomids and *Baetis*), seem to be especially adapted to conditions following fire, regardless of their trophic niche. In contrast, other species decreased in abundance soon after the fire and showed little or no recovery during the study. This was particularly noticeable among the Ephemeroptera, especially the dorso-ventrally compressed taxa (e.g., *Cinygmula*, *Epeorus*, and *Rhithrogena*).

Our results emphasize the importance of studying stream ecosystems for many years following large-scale disturbance. Conclusions based on only one or a few years of data can be misleading in terms of overall trends, as evidenced by the apparent "devastation" of stream ecosystems immediately after the 1988 fires, their rapid progress toward "recovery" in post-fire years 1 and 2, their equally abrupt downturn in post-fire years 3 and 4, and their massive reorganization in years 7 to 9 (Fig. 5). Far too little data exist on conditions for extended periods after fire to know for certain whether our predictions for Yellowstone will prove correct. In fact, the initial recovery trajectory seen for Yellowstone streams is much different—faster initially, with longer time delays before major storm impacts were seen—than expected, based on research we have done in central Idaho. The absence of comparable data on long-term effects, high year-to-year variability in post-fire disturbance impacts among streams of different size, and differences in recovery trajectories from those found in other Rocky Mountain streams provide strong arguments for obtaining an extended temporal perspective for Yellowstone lotic ecosystems in the aftermath of the 1988 fires.

Dr. G. Wayne Minshall is professor of ecology in the Department of Biological Sciences at Idaho State University in Pocatello. He has studied the effects of wildfire on streams for nearly 20 years and initiated research on Yellowstone National Park streams while the fires were still raging. Dr. Christopher Robinson is currently a research scientist in the Swiss Federal Institute for Environmental Science and Technology in Duebendorf. He received his doctorate from Idaho State University in 1992 and remained there as a postdoctoral research associate into 1995. During that period he collaborated closely with Dr. Minshall on their Yellowstone fire study and had major responsibility for the completion of the first five years of the project. Todd Royer is a Ph.D. candidate at Idaho State University, where he received his master's degree in 1995. He has been involved with the project since 1992.

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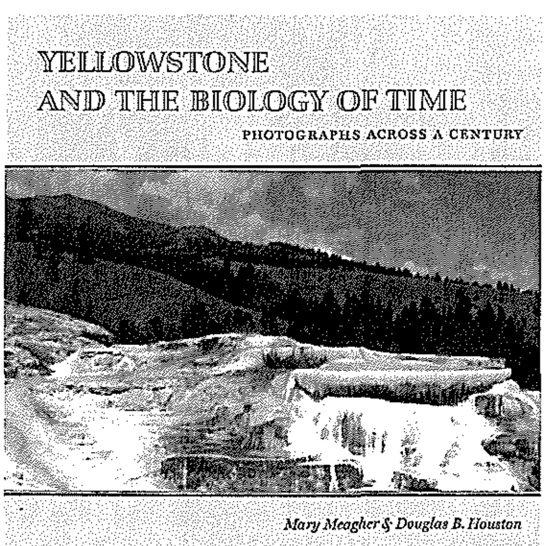
New Publications Available about Yellowstone Resources

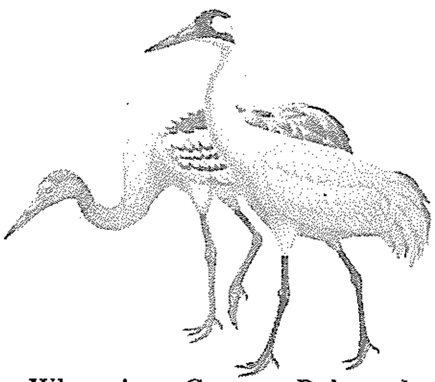
Several new publications are available about Yellowstone resources. A long-awaited book, *Yellowstone and the Biology of Time: Photographs Across A Century,* authored by two former Yellowstone National Park researchers, Mary Meagher and Douglas B. Houston, was published this spring. The book is a compilation of comparative photographs taken in the park; many of the original views date to the 1870s and 1880s, while the most recent retakes come from the years since record fires swept the park in 1988. Meagher and the research that culminated in the book were featured in an interview in *Yellowstone Science* 5(2). To paraphrase from another feature in this issue, the photographs offer a fascinating record of both stasis and change in the Yellowstone landscape. The book is published by the University of Oklahoma Press, and should be available at regional bookstores.



Two reports produced in part by park staff are also available, while supplies last. *Systemwide Archeological Inventory Program: Rocky Mountain Cluster Plan* (YCR-CR-98-1), by J.A. Truesdale with contributions by A. Anderson and A. Johnson, is a compilation of archeological resources throughout 15 parks in the Rocky Mountain Region, including Yellowstone and Grand Teton national parks and the John D. Rockefeller Memorial Parkway. The report discusses the environment and chronology for each of five geographic and cultural areas within this region, and summarizes significant archeological findings in each park, as well as the state of the park's database and additional research and management needs.

A second report, *The Yellowstone Paleontological Survey* (YCR-NR-98-1), by Vince Santucci, documents the state of knowledge about the park's fossil resources. More than 20 fossiliferous stratigraphic units have been identified. Major fossil resources include the Eocene petrified forest deposits in northern Yellowstone. Nearly 150 species of fossil plants from the park have been described, including ferns, walnuts, oaks, sycamores, chestnuts, maples, and sequoias. Fossil invertebrates are abundant in Paleozoic rocks. The most significant vertebrate collection is the Holocene subfossil material of 36 mammalian species collected from Lamar Cave; other known vertebrates include a Cretaceous plesiosaur, a dinosaur eggshell fragment, and several fossil fish from Paleozoic and Mesozoic sediments.

Requests for copies of these reports should be addressed via email to T_Blackford@nps.gov or made by calling (307) 344-2203.



Whooping Cranes Released in Yellowstone

Two whooping cranes, led to New Mexico last fall by an ultralight aircraft, were released May 1, 1998, into northern Yellowstone in an area also used by nesting sandhill cranes. Four whooping cranes were led last autumn from southeast Idaho to the Bosque del Apache National Wildlife Refuge in New Mexico by researcher Kent Clegg, but the other two cranes trained to follow Clegg's ultralight were lost to predators at the refuge.

The two birds began their spring migration from New Mexico on March 5, following the lead of sandhill cranes that winter at Bosque del Apache. The birds traveled to the San Luis Valley in southern Colorado, where more than 20,000 sandhill cranes gather for about a month to gain energy reserves for the rest of their trip north. After leaving the valley on April 11, one bird moved to an area near Craig, Colorado, and the other was located near Baggs, Wyoming. Neither was in good crane habitat and both faced threats from nearby powerlines and fences, according to Tom Stehn, National Whooping Crane Recovery Coordinator. One of the birds was located under a large transmission line and crossed it daily to feed. Collisions with powerlines are the highest cause of mortality for fledged whooping cranes.

Clegg captured the two birds on April 25 and moved them to a pen on his ranch near Grace, Idaho, where the birds had been raised and trained to follow the ultralight. The U.S. Fish and Wildlife Service consulted with several Rocky Mountain states and other federal agencies before Yellowstone agreed to provide a more suitable summer home for the birds.

The ultralight crane migration experiment is part of a broader research effort to learn how to establish a new migratory flock of whooping cranes in North America. The only remaining migratory flock consists of approximately 181 birds that migrate between Northwest Territories of Canada and Aransas National Wildlife Refuge in Texas. The whooping crane population, which is listed as endangered, reached a low of only 15 birds in 1941, but has shown a steady increase since then. There is some evidence that whooping cranes nested in Yellowstone, but information is sketchy. Prior to the release of the two "ultralight" cranes, only one or two whoopers summered in the park each year for the past decade.

Yellowstone to Collaborate With INEEL on Science Projects

The Department of Energy's Idaho National Engineering and Environmental Laboratory (INEEL) will be teaming up with Yellowstone National Park to tackle environmental and energy issues under a five-year interagency agreement. The agreement was signed on May 14, 1998, by the National Park Service (NPS) and DOE's Idaho Operations Office during the "Greening of Yellowstone" conference at the recent 125th anniversary symposium held at Montana State University in Bozeman.

The agreement is intended to allow both agencies to make more efficient use of federal resources in resolving common problems in science, environmental research and restoration, energy management, seismic monitoring, education, and information management. It lays out a process by which the NPS and INEEL will identify specific projects to jointly pursue.

For example, the agencies could jointly develop a portable biogeochemistry laboratory that would allow field studies of the park's world-famous geothermal features. INEEL could apply its expertise in analyzing earthquake data, potential hazards, and ground motion studies; in developing seismic design criteria for buildings in the seismically-active park; and in collaborative research with the U.S. Geological Survey and other researchers doing seismic studies. INEEL's considerable computer resources might be used to supplement the park's hardware and software used in modeling, simulations, and decision-support tools.

INEEL has done extensive work on developing alternative energy sources and technologies to reduce energy consumption and impacts from operations. Ongoing work includes providing assistance to incorporate these technologies at Disney World, and to develop natural gas passenger buses (now used at INEEL) and high-efficiency motors for pumps and electric vehicles. These technologies have natural application to Yellowstone, as the park wrestles with how to reduce operating costs and visitor impacts to park resources. Other possible collaborations involve managing cultural resources, such as historic artifacts or sites sacred to Native Americans—topics in which both INEEL and park staff have considerable experience and interest.

Fifth Geophysical Meeting to be Held in Yellowstone

Papers are invited on new and emerging projects in the fields of geophysics, geology, geochemistry, biochemistry, geology, biology, hydrology, limnology, mapping, remote sensing, and GIS applications for a meeting to be held September 15 and 16, 1998, in Mammoth Hot Springs at Yellowstone National Park. The meeting is open to persons conducting or interested in scientific studies on such topics in the park, and is cosponsored by the U.S. Geological Survey and Yellowstone. A small registration fee is required; for more information about presentations and registration, contact organizer Daniel Norton of the U.S.G.S. at MS 973, P.O. Box 25046, Federal Center, Denver, CO 80225, (303)-674-5150, or Mary Hektner, Yellowstone Center for Resources, P.O. Box 168, Yellowstone National Park, WY 82190, (307)344-2151 or email mary_hektner@nps.gov.

Fishing and Fisheries Management to be Discussed at Conference

The International Fly Fishing Center in Livingston, Montana will be the site of an educational conference on "Fish, Fishing, and Fisheries Management in Yellowstone National Park," to be held October 8 and 9, 1998. All interested persons are invited.

Sessions will cover the history and current management of Yellowstone park fisheries, economics and fishery management, how fishing regulations are established, current and future threats to the fisheries, and how to balance recreational angling and native species restoration.

The conference is sponsored by the Federation of Fly Fishers, the Montana Chapter of the American Fisheries Society, the Greater Yellowstone Coalition, the Yellowstone Park Foundation, and the National Parks and Conservation Association. Registration is $30 per person; for more information call (406) 585-7592 or (406) 222-9369.

Denning Season Nearly Over for Wolves

As of June 1998, about 80 wolves inhabit the Yellowstone ecosystem, not including pups of the year observed by field crews. An intensive period of denning studies is nearly completed. From April through June, two-person crews monitor wolf behavior and litter sizes for the Druid, Rose Creek, Leopold, and Chief Joseph packs. Typically, crews monitor radio-collared wolves' locations and observe wolves for one 48-hour period and two 12-hour periods each week. The crews attempt to minimize their visibility to both the public and the wolves. Wolf observers report that at least nine females have produced pups this spring, and 35 pups have been observed. As many as 40 to 50 pups may have been born. However, due to some expected pup mortalities in their first months, these animals are not yet included in the population estimate.

The December 1997, court ruling that wolf restoration in Yellowstone and central Idaho violated the Endangered Species Act was appealed in February by the U.S. Department of Justice. No date has been set yet for the Tenth Circuit Court to hear the appeal. The ruling has not altered monitoring, research, or management operations by wolf project staff.

The Rose Creek Pack is the largest pack in the ecosystem, which numbers 14 adults or yearlings that reside in the Lamar Valley. As in 1997, multiple litters were born to the pack this spring; 10 pups have been observed with two adult females. A disperser from this pack is now the alpha male of the Druid Peak pack. Another young male disperser has apparently paired with a female formerly of the Druid Peak pack, and they are being referred to as the Sunlight pair.

The Leopold Pack named after the late biologist Aldo Leopold, who first proposed wolf restoration to the park, was the first naturally forming pack in the ecosystem in six decades. The founders were a female originally penned and released at Rose Creek and a young male originally released from the Crystal Creek pen. The pair produced a litter of three pups in 1996, five pups in 1997, and at least four pups this year. The pack makes their home in the Blacktail Plateau area of northern Yellowstone.

The Crystal Creek Pack once dominated territory in the Lamar Valley. Since being displaced by other wolves that killed their original alpha male, they have centered their activity in Pelican Valley, just north of Yellowstone Lake. Five pups were born into the pack in 1997. The alpha female denned this year in Pelican Valley, and one pup has been observed.

The Soda Butte Pack started out with five pack members released in 1995. In 1996, the pack was moved south of Yellowstone Lake, where they continue to make their home. The original alpha male of the park died of natural causes near Heart Lake in March 1997, and the pack has yet to have a new alpha male; thus, no denning activity occurred this year.

The Druid Peak Pack which now numbers three adults and five yearlings, was released from the Rose Creek pen after acclimation in 1996. Since 1997, they have excited park visitors by their frequent presence within the range of spotting scopes. They are tending at least two pups at their den.

The Chief Joseph Pack has split into two groups. The alpha male found the company of two female dispersers from the Rose Creek pack in 1997. Each produced five pups, but one of the mothers was killed in a freak accident in July 1997; she was apparently running at high speed when she impaled herself on a sharp stick. Since then, the alpha male has occupied the northwest corner of Yellowstone with another female, four surviving yearlings, and at least seven pups born this spring. Another wolf from this pack has been seen this spring with six new pups, the father of whom is unknown. A female yearling who wandered widely from the pack's territory last winter was found dead in late June of as yet undetermined causes in the Antelope Creek area of northern Yellowstone.

The Lone Star Pack was short-lived and originally consisted of two wolves temporarily held in the Blacktail Pen in 1996. Shortly after their release near Lone Star geyser, the female, who was pregnant, apparently fell into a thermal pool and died from the burns she received. Her mate traveled widely until he found the company of a female who dispersed from the Nez Perce Pack. The subsequently named *Thorofare Pack* produced five pups in 1997 in southeastern Yellowstone.

In February 1998, the alpha male was killed by the adjacent Soda Butte pack. At about the same time, the alpha female was also killed, but the cause of her death is uncertain. The mortality signal from her collar originated from under an avalanche; biologists could not ascertain this winter whether she died from the avalanche or whether she, too, was killed by the Soda Butte wolves. The five orphaned yearlings have since remained primarily in the southeastern portion of Yellowstone and national forest land to the east.

The Nez Perce Pack currently consists of five young adults, brought as pups from northwest Montana in 1996, and one yearling born into the original Nez Perce pack. The group's former alpha female was removed from the population in the fall of 1997 for killing livestock west of the park. Four remaining wolves were held this winter in the Nez Perce pen, where a pair of the penned wolves produced four pups; all were released into the park on June 22, 1998. A young wolf who escaped the acclimation pen and is the father of the yearling in the pen, paired with a lone female in the Firehole Valley, where they too are tending a den with an unknown number of pups.

The Washakie Pack roams southeast of Yellowstone Park. Four pups were born to the naturally forming family group in 1997, but the alpha male was removed from the population in October 1997 after he killed cattle in the Dunoir Valley. The pack stayed in the area throughout the winter of 1997-98, lacking a breeding male. In May 1998, several of the wolves again preyed upon livestock, and two, including the alpha female, were killed. The hope is that the remaining yearlings will find better habitat away from ranch land.

Errata

In the previous issue of *Yellowstone Science* 6 (2), an error was made in the article on **The Geologic History of the Absaroka Volcanic Province.** Figure 6. (see sketch) should have indicated ash-*fall* coming from the plume of the eruptive column instead of ash-*flow*. The editors regret the error.