Yellowstone Science

A quarterly publication devoted to the natural and cultural sciences

20,000 Leagues Under Yellowstone Lake
Predators and Thermophiles
Finding Fishers
Wolf Summer

Volume 3 Number 4

Thanks!

With this issue of *Yellowstone Science*, we complete our third year of publication. There are at least two reasons that's worth mentioning here. The first is that we want to thank all the people who have helped us put this publication together and keep it going. Yellowstone's former superintendent, Bob Barbee, and current superintendent, Mike Finley, have given the project the endorsement it has needed. The Yellowstone Association's annual grants to cover printing and production costs have been indispensable. Many Yellowstone National Park staff members have helped out in ways beyond counting. And of course the many researchers who have generously donated their time to write articles, give interviews, make suggestions, and provide information for news stories have made *Yellowstone Science* a vital and helpfui publication.

We're gratified and sometimes even surprised at the interest this little magazine generates, and how far it reaches in the Greater Yellowstone community and beyond. We hope that doesn't sound self-congratulatory, because it isn't meant to; the real congratulations go to all the people whose participation and enthusiasm have kept the idea of a science-based Yellowstone periodical thriving.

As you may have already noticed, we're now entering a new phase in this publication project. We can't fairly expect the Yellowstone Association to maintain its current funding level indefinitely, and so we're going to ask for your help in keeping the presses running. We might be more hesitant to do this if we hadn't already received literally hundreds of requests from people who are willing to pay to receive *Yellowstone Science*. This level of interest is heartening, not only because it suggests that the magazine is well received, but also because it gives us hope it can become more self-sustaining.

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Yellowstone Science

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Volume 3 Number 4 Fall 1995

Bob Lindstrom

See page 19

On the cover: A gathering of predators; a montage of images prepared to celebrate this year's predator conference, by Renee Evanoff.

Above: Thermophile conference organizer Anna-Louise Reysenbach of Rutgers University collecting "black filaments" at Calcite Springs.

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

Support for *Yellowstone Science* is provided by the Yellowstone Association for Natural Science, History & Education, a non-profit educational organization dedicated to serving the park and its visitors. For more information about the Yellowstone Association, including membership, write to P.O. Box 117, Yellowstone National Park, WY 82190.

Stalking the Elusive Fisher

Finally, the existence of this rare predator is confirmed

YES

by Steve Gehman

It was mid-February 1985. My friend Michael Osgood and I had spent three days skiing from West Yellowstone to Shoshone Lake, and were just settling into our sleeping bags inside the quinzhee that we built for shelter within a mile or so of the Shoshone Geyser Basin. In the early evening darkness we heard a clanging of pots from our snowshelf kitchen outside. We slid out of our bags, down the entrance tunnel, and out into the darkness with flashlights clenched between our teeth, to see a medium size, dark animal bounding away with a two-pound block of cheese from our food bags.

As we shouted and moved toward the animal, it dropped the cheese and disappeared into the nearby forest. We re-

trieved the cheese and the remainder of our food and cooking equipment and returned to the comfort of our snowhouse. Within a few minutes, as we sat discussing our encounter and wondering about what we had just seen (it seemed too large and too dark to be an American marten), the animal came bounding into our quinzhee and perched itself at the base of the sleeping platform. From less than six feet away, illuminated by flashlights, we saw the dark brown fur, long bushy tail, and red eyeshine of a fisher. We sat motionless and stared at this creature, mesmerized by its boldness and beauty. After five or ten seconds, the fisher turned and disappeared into the darkness from whence it came. So began my interest in fishers in the Yellowstone Ecosystem.

During the winter of 1992-93, I had the opportunity to become involved in the Northern Yellowstone Carnivore Study, a cooperative project between Yellowstone National Park and Yellowstone Ecosystem Studies (YES), a nonprofit research organization based in Bozeman, Montana. The effort was initiated by Sue Consolo Murphy of the National Park Service (NPS), Mary Harter (NPS), and Bob Crabtree (YES) in an effort to expand our knowledge of medium-size mammalian carnivores in the northern portion of the Yellowstone Ecosystem. The objectives of the study are to evaluate various inventory and monitoring techniques for carnivores, to determine presence and distributions of carnivores, and to assess habitat relations of the various species. Although we are interested in all carnivores, our primary target species include some of the lesser studied animals such as American marten, fisher, wolverine, lynx, and mountain fox.

Over the past three winters, numerous people have participated in operating remote camera stations, maintaining hair snaring devices, and conducting snow track transects in efforts designed to learn more about these animals. Mary Harter and Sue Consolo Murphy developed and implemented field techniques for the study in the winter of 1992-93, with assistance from YES personnel Rob Ahl, Ammy Gillesberg, and me. During the past two winters, I have served as project leader for YES, and have received help in the field from numerous student volunteers, interns, and YES staff. In particular, interns Rob Ahl and Betsy Robinson deserve special acknowledgment for contributions of time and energy to the project. During each of the three winters of study, we have also received field assistance and support from YES "research volunteers" (approximately 25 individuals) who volunteered a week or more of their time participating in YES's "Searching for Carnivores" research expedition.

One highlight of the study occurred this past winter, when fishers were captured on film at two of our remote camera stations in the Cooke City area. The first fisher photo was taken on the morning of January 9, 1995, in the Republic Creek drainage south of Cooke City. We had been tantalized by the prospect of fisher presence in the area since early in 1993, when a photo from one of our first camera stations showed us the rump and tail of a nearly black mustelid digging in the snow and facing away from the camera. Bob Crabtree and I suspected it to be a fisher, but could only cautiously label it as a "possible" fisher in our project reports and discussions.

During the remainder of that first winter and throughout the second winter of study, we worked hard to confirm what we suspected, but came up only with a few sets of probable fisher tracks (there is potential for overlap in track size between marten and fisher, so confirmation of fisher presence from tracks alone is questionable). Needless to say, we were quite excited to see the unobstructed profile of a fisher on our film from the Republic Creek site. In late February 1995, a second fisher was photographed at a camera station along the northeast boundary of Yellowstone National Park, at Wolverine Pass (approximately 6 miles northwest of the Republic Creek site). This photo was of a lesser quality than the one from Republic Creek, but nevertheless provided a conclusive view of a fisher.

These photos leave no doubts in our minds that fishers occur in the northeastern portion of the Yellowstone Ecosystem. The dark brown color of the animals, the lack of any orange coloration showing along the edges of the neck, chest, or belly (a typical pattern in martens, the most likely alternative animal), the large bushy tail; the relatively blunt, rounded shape and low profile of the ears; and the relatively robust appearance and large size of the body, all support our conclusion that the animals in the photos are fishers and not martens.

To confirm our identifications of these animals as fishers, Betsy Robinson and I made estimates of the body and tail lengths of the animals by careful scrutiny of the photographs and the camera sites. We revisited both camera sites and made numerous measurements of the areas photographed and of vegetation included in the photos. We also took photographs of rulers and an 18 x 18-inch grid placed in the locations of the photographed animals. These photos were then used to compute correction factors that were applied in estimating the actual sizes of the animals from measurements of the animals on the original photos (see Vol. 2, No. 1 of *The Tracker*, a YES publication, for more specific descriptions of size estimation techniques and results). Resultant estimates indicated that the aninals' bodies and tails were within normal ranges for fishers, and were larger than comparable measurements for marten.

After a century of both speculation and doubt about the presence of fisher in the Yellowstone Ecosystem, we are extremely pleased with these confirmations. These recent sightings, probable tracks in classic fisher habitat, historical sightings, and two fisher specimens from unknown locations in the Yellowstone region all point to a probable historic population.

This information raises some fascinating questions. For example, how could a 5- to 10-pound predator go unnoticed for so long? How well distributed are they? Do fisher have a thriving, viable population in Yellowstone or are they isolated and threatened? One thing is for sure. There is no substitute for partnerships: pooling our resources and getting out in the field and looking. What else could be waiting for us to discover? We hope we can expand our efforts to learn more about distributions, abundance, and habitat use of these elusive carnivores.

Steve Gehman is a project leader with Yellowstone Ecosystem Studies. *For more information on YES, see the interview with Bob Crabtree on page 4.*

Information Warriors

Creative approaches to getting science done in Greater Yellowstone

Yellowstone Ecosystem Studies president and founder Bob Crabtree, a few years ago in Logan, Utah, leading a group howl with captive coyote pups. Linda Broome photo.

Dr. Robert Crabtree is perhaps best known among Yellowstone researchers for his recently completed six-year study of coyotes, but his research and education interests have broadened considerably since he launched that important study. In this interview, conducted at his Bozeman, Montana, office in August, he explains not only the origin of the coyote study but also the much more wide-ranging emphasis of his current efforts. Readers may find Bob's ideas and experiences of special interest because of the current political climate, with its aggressive attention to reducing agency budgets and encouraging partnerships of various kinds between resource professionals, institutions, and the public.

Starting With Coyotes

YS: How did you get interested in doing research in Yellowstone?

BC: When I was a kid coming to Yellowstone, or hearing about it, or seeing about it on T.V., I just fell in love with the place. I knew I wanted a Ph.D. in wildlife from the time I was in the 6th grade. In 1974, the summer between my sophomore and junior year in high school, I was a bus boy at the Old Faithful Inn.

YS: It was coyote research that eventually brought you here as a researcher. How did you get involved with coyotes?

BC: I always loved dogs, and I thought that I would love to study coyotes since I first saw them, in 1974. Years later, I did my first study of coyotes on the Hanford Nuclear Reservation [*in southern Washington state*], for my Ph.D.

YS: What made Hanford special? Why study them there instead of somewhere else?

BC: Because that was the first study of a natural, undisturbed, unexploited population of coyotes.

YS: You might elaborate on why that matters.

BC: Almost all coyote populations are exploited, which means that humans are killing them. When a wildlife population is under that kind of pressure, its social and biological character is probably very different than it would be if all mortality was natural. Without knowing how the

population would behave without human exploitation, we can't really understand how our exploitation affects it.

YS: So what did you learn?

BC: A lot. Because it's known that many animals compensate for exploitation by producing more offspring, I just figured that the litter size at birth in this unexploited population would be very low, but litter size at birth was normal. It was the litter *survival* that was extremely low.

There are a lot interesting things that happen when you let a coyote population go without human interference. Their average age is much older, and they become socially stable because humans aren't constantly disrupting their packs by killing so many of them. But I also learned a lot about research and how it works.

YS: For example?

BC: There are those neat things you see by studying something five years in a row. It takes that kind of continuity to begin to learn about complexity. For example, here in Yellowstone, we're in our sixth year of studying the coyotes on the Northern Range, and it takes that long to get even a glimpse of how things work.

YS: Can you be more specific?

BC: In Yellowstone, I caught a pup in a den in June 1990, and we've been able to follow his progress through coyote society ever since. He just picked up Alpha status this year and his pack had its first litter. That was after he twice failed to take over the territory of another Alpha male in the last two years. You don't get to see that stuff unless you follow an animal for a long time.

But to get back to your question of how I got here, that Hanford study brought me to Yellowstone, which also has an unexploited coyote population I could study. Besides wanting to study another coyote population, I also hoped that I could really sink my teeth into something long-term and bigger scale. Studying an entire community ecosystem, rather than just one species, really has always been on my mind.

YS: A lot of people are probably curious how a scientist comes into an entirely new area and launches a study. With your Yellowstone coyote study you could read what had been written by earlier researchers, especially Adolph Murie's 1940 monograph *Ecology of the Coyote in Yellowstone*, but where do you start out in the field? What do you do first?

BC: Some of it is actually very simple. For example, I went out to various places on the Northern Range and listened to the vocalizations of the packs, and from that I could get a general idea of how the packs were spread around, and what their territories were.

Renee Evanoff

A contented coyote photographed in Yellowstone's Lamar Valley the winter following the fires of 1988.

On the other hand, when I was doing something that informal, I limited my mind to those things that you can capture in a sort of snapshot first impression. Beyond that? I felt I really had to have no preconceptions of what was going on.

YS: So what kind of things can you capture in a snapshot?

BC: Basically just a spatial layout of things.

YS: How does that work? How did you determine what the spatial layout of the packs was?

BC: If you're experienced with coyotes, you can pretty much figure out that two different vocalizations you're listening to—that is, the vocalizations of two different groups of coyotes—are probably happening on opposite sides of the boundary that separates the territories of those two packs.

YS: How can you be sure you're hearing a pack and not just some random coyotes out there wandering around?

BC: If they do what is called a group yip-howl, they're a pack, period. And once you know where the packs are, you can work out their territorial boundaries. Boundaries between packs frequently follow some physical feature that is obvious on the landscape, like a stream or a cliff, and so by looking around it's possible to begin to get an idea of where the pack territories are.

That's really important information for my study, too. Ninety percent of all captures of coyotes occur outside of their territorial boundaries, so just by listening to the packs, I had a pretty good idea of where to set my traps.

YS: You say that most coyotes are most often captured outside their own territory? How can that be?

BC: They are a lot harder to trap when they're at home. They seem to be extremely averse to anything abnormal in their territory. If they come across anything unusual, like a scent, or a hole, or anything else associated with a trap, they completely avoid it.

On the other hand, when they leave their own territory, they're very exploratory. They're curious about what's going on outside their territory, so they spend a lot of time reading signals and signs and marks from other coyotes. The same thing happens in other coyote studies; we know that if we want to catch a coyote, we better move a couple of miles away.

YS: How did you get from studying one species to studying the whole system?

BC: There was a point during my study when I asked myself, should I be going other places in my career, or really try to jump into a long-term ecological study of the coyote here? The timing seemed good because John Varley [*then-Yellowstone chief of research*] was encouraging so much ecosystem-type work here, and the interest and amenities provided by Yellowstone were so strong. It was tough to decide but I decided to stick with the coyotes and do what was really needed, a long-term study. It takes a lot of time to really capture the dynamics of a population, with a bunch of packs. Coyotes live 10 or 15 years, and a lot of those packs are stable, with the same Alpha pair for six years on the average. My goal is to look at all the elements of that, so that I can develop a complete picture of what makes it tick. But the coyote is a great way to look at the bigger picture. The coyote, in Yellowstone as well as across North

America, has its hands in many places. Just studying the coyote in the Yellowstone Ecosystem brings you to so many other related ecosystem components and places that it can't help being interesting and fruitful.

Launching a Bigger Project

YS: When you decided to go for the bigger study, rather than just putting in three or four years and leaving, how did you go about developing the necessary administrative machinery to carry it off. To put in place a long and complex study, you have to become a bureaucrat, don't you?

BC: True, and that process was the birth of Yellowstone Ecosystem Studies (YES). I had taught at an elderhostel when I first got here and I was really impressed with the quality of students in that group. I've spent a lot of time with kids—high school, special Olympics, boy scouts, and so on—and I thought "My God, these are the best students I've ever seen, and they want to do this so much they're paying for it." From there, I got involved in Earthwatch as a way to augment funding and go on some Earthwatch expeditions and learn how it was done. That was really good experience. I saw all these people doing good work, and I just thought "Wow, this is a really great way to educate people and get some good research done!"

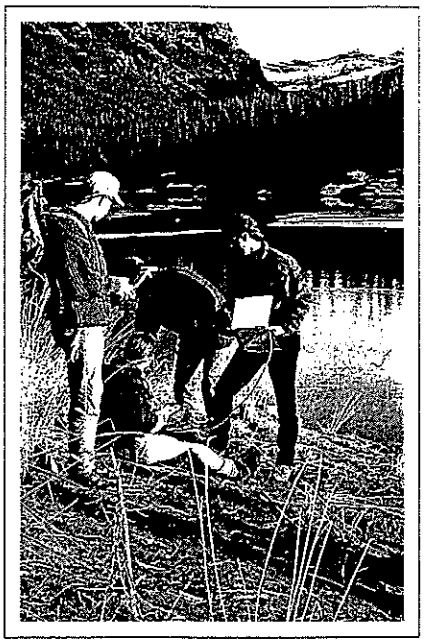
YS: This question applies both to your coyote study and to your work with YES. How do you find such good participants? You attracted some very fine graduate students to your coyote study, and it's going to produce a great number of graduate papers and publications. How do scientists go about finding such people?

BC: There's a little bit of recruitment on my part, but Yellowstone does a lot of the work itself. For example, in 1990 I put one letter in the Animal Behavior Society newsletter, saying that I was seeking interns, and I still get letters inquiring about that. I think I got more than 350 responses, and more than 300 of those were from people with college degrees, seeking field experience. Yellowstone's a great place for that experience.

YS: There's a fair amount of skepticism in some scientific circles about using volunteers—that is, people without all the formal training you have yourself—to gather data. There's an opinion out there that the results aren't as scientifically rigorous or trustworthy. How has that worked for you?

BC: I don't think there's anything magical about unleashed graduate students out there collecting field data on their own. There's nothing that automatically makes them better at doing science than anyone else. In my experience with both graduate students and many YES volunteers, the road to quality information is a matter of being excited about it. That means that the people are nurtured to do good work, they get supervision 100 percent of the time, and they are given attainable goals. You don't ask someone without training in wildlife biology to do something that is beyond them. If you keep your expectations sensible, you get great results. We've done blind tests of the data gathering, and the quality of the data from the volunteers is as high or higher as it is from people with degrees in the field being studied.

Patrick Cone



Paul Richer

Crabtree and YES interns recording data on coyote observations, and the YES team during alpine lake survey.

Integrating Ecosystem Research

YS: Give us an example of what you would have folks like that do. Say somebody came in and they happened to have a bachelor's in geography or something at least remotely connected to your work. What kind of information would you be training them and turning them loose to get?

BC: Pebble counts along streams, collecting scats on trails, operating a global positioning system, clipping vegetation, observing wildlife and recording what they're doing, and a lot of other things. The point of this is that the kind of research that's coming on the horizon is baseline inventory monitoring, the sort of work that will tell us how these wild ecosystems are holding up under our use, and it doesn't take a rocket scientist to do it. If the supervision is good, and the group works together well, then these folks can make a big difference.

Let me put this another way. When it came to the broad-based research I wanted to achieve, academia wasn't enough. The traditional, university-based research approaches weren't handling that kind of thing. This ecosystem-scale community-level research I had in mind needed a broader approach. YES and programs like it are a whole new format.

YS: It's also pretty adventurous for all the people associated with the traditional research bodies, like the agencies and the universities.

BC: There has been a lot of talk of partnerships, but it's programs like YES that are really pioneering some of them. Believe me, it's difficult. I'm not saying

YES

YES researcher Patricia Zuwerink with YES volunteers and staff establishing GPS location of woody debris on Soda Butte Creek in northeastern Yellowstone National Park.

this just happens. Politically it's very challenging and scientifically it's very challenging.

You have these four basic groups of people: the management and regulatory agencies, the academic community, the corporate world, and the lay public. All four groups are going to be involved in the future of the resources in this ecosystem, and all will have some say in how the resources get used.

YS: They're not known for getting along well.

BC: Right, but what is starting to make it work now is the common denominator among them: they all need information. They all may want it in order prove different things, but at least they all agree they need it. That universal need is what led to the establishment of YES, in 1993.

YS: How do you decide what you are going to focus on? It seems like almost every resource out there is in contention between at least two groups. Where do you start?

BC: We start with initial surveys, formal and informal, of the research management agencies of the Yellowstone Ecosystem. We took what they told us, synthesized it, and looked at the common needs of the agencies and the academic community.

We also focused on the studies that were underway, ones that had made a good start but were running out of funding. These were especially important to us, because, as I said earlier, we want long-term information, and these studies might give us an opportunity to build on something that already existed. You might say we took an inventory of how big or broad the study was and how long it had been going, and then decided if it could be kept going with our kind of minimum funding. We would look at a study and ask ourselves a lot of questions about it: Can we get the necessary permits and permissions to continue it? Can we scrounge some radio equipment from an agency, maybe find some temporary quarters for staff from some other agency, maybe get some academic or corporate funding? Is there high-tech assistance available in global positioning systems? Then we laid it all out on the table so we could see the gaps, and tried to fill them. Of course if you're running a number of studies at once, you find that sometimes they fill each other's gaps.

So we would work with all these available resources, trying to fill in the holes from various places, and providing a sizeable labor force.

Who Does the Work?

YS: When it comes to the labor force—your volunteers, or participants, or whatever you might call them—have you found that they prefer only the glamorous work? Aren't some of your studies a little abstruse for them?

BC: That hasn't been a problem. We attract an amazingly diverse group of people, and some prefer the more famous kinds of studies, but we do dilute the glamour with the serious dose of hard work they all do. Just being in Yellowstone is enough for them, really; it re-

YES staff biologist Steve Gehman (center, with intern and volunteer looking on) examines a whitebark pine tree for possible blister rust.

YES

YES researcher Patricia Zuwerink and her team of volunteers conducting stream transect studies.

wards them.

YS: What else attracts them?

BC: I think it's this feeling that they want to do something different with their vacation time. They make a tax-deductible donation to YES, and then they work on a project. They can see results. They often say something like, "You know, I've been getting tired of just getting my glossy magazines [*from conservation organizations*] in the mail, and I'm not sure where my contribution to Organization X went last year. This was a chance for me to not only have a great experience in a world-class ecosystem, but to know where my money is going."

YS: How long do they typically work?

BC: Anywhere from 8 to 13 days. Some stay for several projects, say for over a month, and the return rate is quite high.

YS: How many were involved in YES projects last year?

BC: About 100.

YS: How many different projects were they working on?

BC: We have 22 projects, so its an average of about four or five volunteers in a group.

YS: How are these projects set up? How do you supervise them?

BC: We have a volunteer to staff ratio of 3:1. We never violate that. We never have more than 8 volunteers in a group. Here's the makeup of a typical team. We have a leader who is an academic or a person with a masters- or Ph.D.-level education. Often there will also be a logistics person, sort of field manager, who is well-versed in backcountry skills or natural history, and often is also an emergency medical technician (EMT). There may be an intern, too, someone who has a degree but is sort of a learning apprentice in the program; a fraction of the volunteer contribution also goes to sustaining the intern's room and board. The internship program is another exciting aspect of YES. The interns are cream of the crop kids that really need field experience in order to further their education or seek employment. They work for two to six months, depending upon the needs of their program and the project they take on; each of them spends their whole internship focused on one project.

YS: The interns are from universities? You find them through your academic contacts?

BC: We get two or three resumes a week. They just roll in, we interview the top ones, and we get wonderful people. The result is that in the projects that also have interns, the ratio of volunteers to staff is really 2:1. We'll have the leader, the logistics person, the intern, and then six volunteers.

What is Being Studied?

YS: Describe some projects.

BC: We're in the third summer of an alpine lake survey, working in cooperation with the U.S. Forest Service. We've taken on the Absaroka-Beartooth Wilderness Area, and we monitor air quality, acid precipitation, and so on. And we're using that opportunity to expand the breadth of the work, so we're surveying insects and small mammals and songbirds while we're up there. I figure if you're in there, you have a duty to try to help, so we're part of the National Fish and Wildlife Foundation's Partners in Flight program. That means we're out there trying to monitor species lists and neotropical migratory songbirds. That's all part of what you do if you're on the alpine lake survey. It's pretty inclusive.

Another one is trying to evaluate high-resolution technology as an aid to developing a long-term monitoring strategy for grizzly bears and other large mammals. Here we have one-meter resolution satellite imagery, and we're trying to be able to see if this technology can help us develop landscape profiles, in order to better predict where bears and other large mammals might go by matching up what is on the ground in terms of habitat requirements with high-resolution spectral signatures from satellites. It may be a much more efficient way of telling us what's available at any given time for these animals. And while we're there, we're running transects to look at whitebark pine surveys, which is helping the forest service and the park service out with their surveys of that sensitive species, which is a very important food source for grizzly bears.

I might add that a big goal of this work is to make it as nonintrusive as we can. We're really trying to help develop techniques that facilitate passive research of these secretive carnivores. We don't want to interfere with them while we're studying them. So we're looking at where they've been, recording what they've dug up and eaten, collecting scats, and all those things that will help us learn how they live.

Another project is one started by Wayne Minshall of Idaho State University. He and his colleagues started a research project just before the 1988 fires, to study how the burns would affect a variety of stream ecosystem processes. Again, YES

is focused on trying to make the most of some of these pre-existing ecological experiments, and Wayne's is perfect for us. Wayne started with funding from Yellowstone National Park, and actually he had been working that area before the fires, so there was a fabulous opportunity to study the same ecosystems before and after the fires. We're very excited about that; how many times in a continent's lifetime do you get a chance to study a wonderful fire like that? YES has now extended Wayne's work an additional three years.

That study has helped Wayne, and Wayne has gotten involved with Andrew Marcus [*Montana State University*], who is working on the geological processes that affect those same streams. So here you have a guy who studies the non-living parts of streams working with the guys studying the living parts of streams, and they worked together to find additional funding. We gave seed money to Andrew to get him going on Soda Butte Creek, which is a perfect paired watershed with Cache Creek; that means that now a burned and an unburned watershed, right next to each other, are being studied and compared. What started out as a fairly specific study has blossomed into something much broader, with the participation of all four groups I mentioned earlier.

YS: I'm sure you wouldn't mind elaborating on how your earlier coyote study fits into all this.

BC: Actually, to understand the coyote study you have to talk about wolf recovery. I give the park service a lot of credit for recognizing that we were going to need to know a lot more about a lot of species if we were going to get wolves, just as they recognized that one way or another, wolves were on their way. It's well known that wolves have a major impact on coyotes, and so it seemed important to understand the coyote before the wolves arrived. That foresight is still paying off, by the way; we now know, for example, that since the wolves of Yellowstone were killed off early in the century, the coyote has been the number one ungulate predator here. And so the coyote study was funded for six years by the park service, and YES has adopted the coyote study and has developed a monitoring program for measuring the four or five key parameters in the coyote population. Again, there's no overstating the value of continuing a long-term project. Just being out there to continue watching packs and individuals we've gotten to know for five or six years is worth it. We can passively do some really intensive research without having to trap the coyotes.

YS: What *are* those key parameters of the coyote population?

BC: One is litter size. Because of the radiotelemetry we did, we know that every pack has five or ten den sites, so we can visit those den sites and find the pups every year. Two others are pack size, in early winter and late winter. A lot of dispersal goes on between early winter and late winter. Others are things like recognition of individual pack members, by pelage characteristics or individual markings, and the behavior of the packs at carcasses.

Another project we're especially excited about is the medium-sized carnivore study. The forest service has a mandate to choose some indicator species, to help them monitor the health of the ecosystem, and they've chosen the medium-sized predators. It was Sue Consolo Murphy of the park service in Yellowstone who really got it started. A few years ago she experimented with putting out hair-snagging devices to try to identify which animals were out there, and I though this was a great project for YES. We got involved, and a bunch of folks in the park were receptive, so right now we have three cooperative partnerships on paper, challenge cost-share agreements, involving Yellowstone National Park, Gallatin National Forest, the Targhee National Forest, Idaho Fish and Game, and YES.

By the way, these studies have caused some fascinating stuff to happen. I recently got a call from some folks in Cody that know a taxidermist who has a pelt from a fisher caught in the upper Clark's Fork area in 1888. People from the National Cancer Institute working with Montana State University are trying to extract DNA from it, so that if we ever do get a modern specimen we can see if it's a match to the earlier animal.

YS: Besides the wonderful time a lot of people have, and the important scientific interchange you just described, what comes of all this YES activity? For example, scientists measure productivity in terms of publications; how are you doing there?

BC: Since the coyote study began, but mostly since YES was established, our work has resulted in a long list of publications: 6 M.S. theses, 6 scientific publications, 11 scientific reports to various management agencies, 1 popular book, more than 60 spoken presentations, 15 professional paper presentations, 1 nationally televised film, 3 YES newsletters, and 13 popular articles in magazines.

YS: One of the oldest debates in the scientific community is over what role scientists should take in the political dialogues. Some people see it as a matter of conscience to advocate certain political actions, and others see it just as much a matter of conscience to stay aloof of that process. YES works with people from so many institutions and agencies that it must be very complicated for you sometimes. How do you respond when someone asks you why you don't become political advocates on behalf of some good cause?

BC: I give them two reasons. First, I think everyone has a role to play, but that it's very difficult to play more than one role well. We stick to our one role, which is the gathering of information, and by doing so we do not blur our purpose.

Second, I think all those roles are important, but that at the foundation of all the elements of the dialogues is information. Information from the ecosystem is what needs to be listened to most. I guess that if we had a motto it would be something like, "The earth is speaking, and we're trying to listen to it."

So we're warriors for nothing beyond information and having that information collected objectively so that all four of the groups I mentioned—the agencies, the universities, the corporations, and the general public—know the same things and make decisions based on the same information.

For more information about Yellowstone Ecosystem Studies, write to P.O. Box 6640, Bozeman, MT 59771.

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P.O. Box 117 - *Yellowstone Science*
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Yellowstone Science

A quarterly publication devoted to the natural and cultural sciences

Attention Friends of *Yellowstone Science*:

Here in Yellowstone, we're past the stage of trying to put a good face on the latest rounds of federal belt-tightening, both real and threatened; this is a time of crisis for the national parks, and a great many important and carefully managed programs are at risk. Unlike law enforcement, emergency medical response, sewage lift pumps, or some other parts of the park's operation, a communication program like *Yellowstone Science* can be perceived as somehow "optional" these days. On a much happier note, we gather from your response to this publication over the past three years that it fills a real need, so we are determined to keep it going.

Since it first appeared, *Yellowstone Science's* printing costs have been covered by a generous annual grant from the Yellowstone Association. All other costs, especially staff time, are covered by the National Park Service. Authors of articles are not paid; their abundant hard work has all been voluntary, and often quite time-consuming. The Yellowstone Association, as a matter of tradition and policy, does not tend to fund long-term, open-ended projects, and though they've been very supportive, we should not expect them to provide support forever.

With all that in mind, we are going to try an experiment. Once a year, starting with this letter, we will invite all recipients of *Yellowstone Science* to donate $10 (or more) to the annual production of the magazine. Anyone who requests information on how to receive *Yellowstone Science* will get a similar letter. We hope the response will be good enough to keep us chugging along; maybe there's even a chance we could actually upgrade the publication with some full color. If the response is inadequate, we will investigate setting up the irksome (for you and us) and time-consuming (mostly for us) procedures required for a subscription system.

This donation is tax deductible as provided for by law. Make your check payable to the Yellowstone Association, and note that it is for *Yellowstone Science*. Send it to the Yellowstone Association, P.O. Box 117, Department YS, Yellowstone National Park, WY 82190. If you like *Yellowstone Science* a lot, please consider a larger donation. Remember: your donation does not fund salaries. The donations all go into production costs.

Thanks for your past enthusiasm and many kind words about this little publishing enterprise.

Paul Schullery

Paul Schullery
Editor

20,000 Leagues Under Yellowstone Lake

Strangeness and beauty in the hidden deeps

by Val Klump, Tony Remsen, Dave Lovalvo, Pat Anderson, Russell Cuhel, Matt Kaplinski, Jerry Kaster, Jim Maki, and Robert Paddock

The three million annual visitors to Yellowstone National Park become well acquainted with the world famous geysers, mud pots, hot springs, and "rotten egg" smells that have become landmark sights and aromas of this, the oldest national park. What they are unaware of, however, are some equally fascinating and unusual sights (and probably even smells) beneath the waters of Yellowstone Lake. For in addition to its famous population of cutthroat trout, some of the deepest regions of Yellowstone Lake are the sites of sheer cliffs, gas fumaroles, hot springs, and unique populations of freshwater sponges.

The Center for Great Lakes Studies' interest in Yellowstone Lake actually began in 1983 when a small grant from the National Park Service brought two of us (Val Klump & Jerry Kaster) to Yellowstone for the first time to study the nutrient history of the lake over the last 100-150 years. Scattered and somewhat anecdotal evidence had suggested that the lake was undergoing a gradual nutrient depletion during the last century. This was in contrast to the typical recent history of many lakes, which are experiencing nutrient enrichment as a consequence of changing land usage, agricultural practices, and natural aging processes. It was apparent from the very beginning, however, that Yellowstone Lake was different.

In addition to the potential influences of climate, fire, food web fluctuations, human development, and so on, Yellowstone Lake added another obvious forcing function to the list: geothermal and hydrothermal activity. Even a cursory glance around the shores of the lake from Steamboat Point to Mary Bay to the West Thumb reveals the lake's unique tectonic setting. Much of today's Yellowstone Lake is situated in a vast volcanic caldera formed some 600,000 years ago in a monumental explosion that sent the equivalent of a 60-km diameter chunk of rock into the atmosphere in one of the earth's largest known volcanic eruptions. Today, most of the park's geothermal features are clustered around the rim of this caldera.

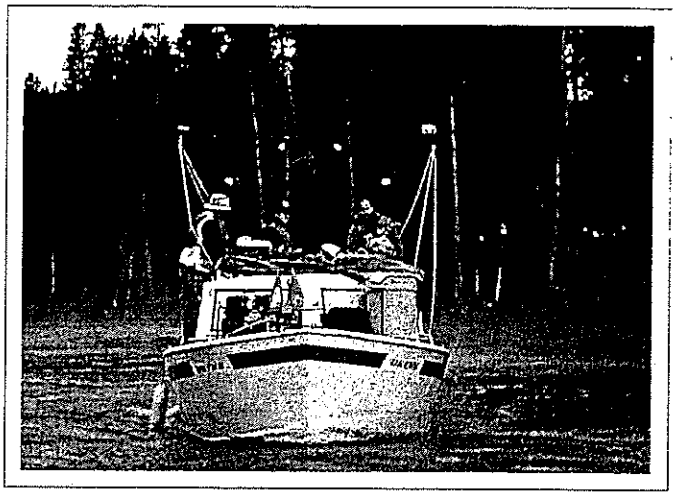
Both groundwater and geothermal fluids have unique chemistries that can substantially influence local biogeochemical conditions. The best examples of this are the spectacular hydrothermal vent systems found on mid-ocean ridge spreading centers and geothermally active seamounts. Seawater reacting with molten rock (largely basalts) at high pressure produces submarine fountains of nutrient-and mineral-rich hot water, which supports the incredible hydrothermal vent communities that amaze the scientist and layman alike. The question was, does Yellowstone Lake experience an analogous, albeit far smaller, phenomenon, and has the subterranean plumbing of the lake had an impact on its chemistry and biology?

Our initial exploration of Yellowstone's unseen underwater world began in 1984 and 1985 with simple scuba reconnaissance of some of the near shore shallow water hot spots—particularly in Sedge and Mary bays. In 1986, a grant from the National Geographic Society provided the opportunity for our first extended look and some detailed sampling of the vents and geothermal features found in the vicinity of the Sedge Rock between the mouth of Sedge Creek and Steamboat Point. Bubbles breaking at the lake surface mark some of the small but numerous hydrothermal vents and submerged fumaroles.

These vent fluids contain hydrogen sulfide, the agent responsible for the "rotten egg" aroma of many fumaroles in the park. White granules of elemental sulfur, that coat rocks and plants found in the fluid plume, are the diver's surest underwater marker of geothermal activity. This white precipitate is formed by the oxidation of sulfide by sulfur bacteria that derive energy for growth from the process and are examples of chemosynthetic organisms, i.e., those that use chemical energy for biosynthesis. Temperatures of these fluids are high (higher than 80°C, or 176°F) but are so quickly cooled by the vast amount of diluting lake water that thermal plumes are barely detectable even a few inches away. Like their deep-sea counterparts, the hydrothermal springs in Sedge Bay are enriched in silica, up to 20 times the levels found in the open lake. Silica is an essential nutrient for the major group of photosynthetic phytoplankton in the lake—the diatoms—microscopic plants that construct a shell (called a frustule) out of silica to literally form a "glass house." In fact, the sediments of the lake consist largely of diatom frustules. Like tiny ghosts that fall to the bottom and become buried, these little silica fossils bequeath us a picture of the history of the lake by preserving a record of the past plant life and plant abundance.

One of the most interesting thermal features seen to date, and only in Sedge Bay, is a "fault-like" swath of colorful bacterial mats, roughly a meter in width and trending perpendicular to shore in depths of 5 to 10 m (16 to 33 feet). The mats appear to consist of both chemosyn-

thetic and photosynthetic microorganisms and vary from white to orange to green to purple. Sediments beneath the mats are warm and chemical gradients sharp. In association with some of these mats are very high densities of nematodes (round worms) and small oligochaetes (aquatic earthworms). Three different species of these worms (of the family tubificidae), common in lakes but unusual in such dense congregations, have been identified. Feeding on a bacterial diet, these 2-3 cm (0.7-1.9 inches)-long worms live upside down in a narrow niche with their tails in cold lake water and their heads in otherwise barren sands that quickly reach over 50-80° C (122-176° F)— temperatures too hot for worm life.

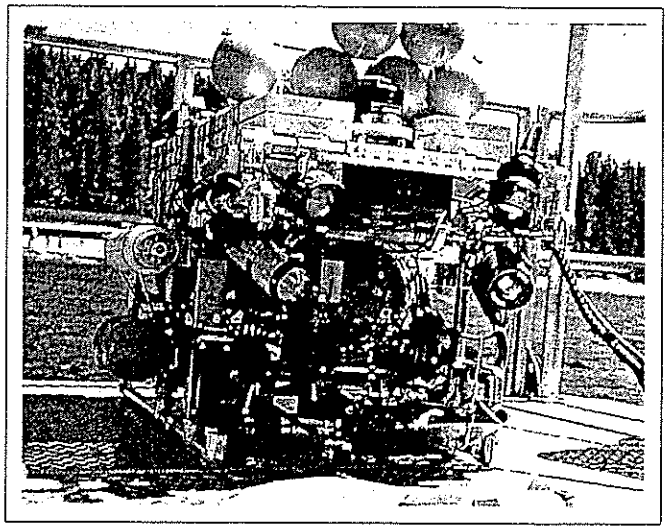


U.S. Fish and Wildlife Service vessel the R/V Cutthroat, the "floating headquarters" of the research team for several years. All photos in this article are courtesy of Val Klump.

This "worm sauna" may represent a lifestyle unique to Yellowstone Lake fauna. Occasionally, free-swimming large solitary leeches or a relatively uncommon species of oligochaete from the genus Lumbriculus have been observed, presumably attracted by the bacterial smorgasbord and the life it supports.

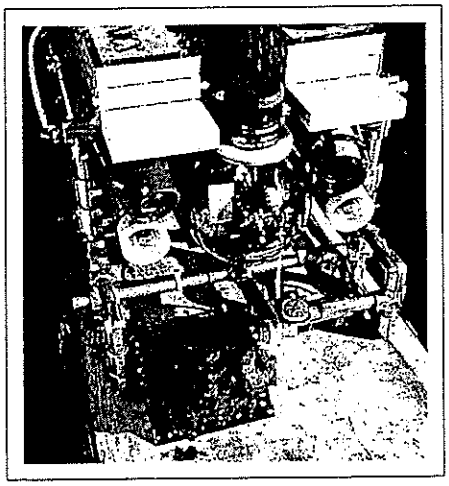
The hottest spot in Yellowstone Lake is Mary Bay. Geophysicists Paul Morgan (Northern Arizona University) and David Blackwell (Southern Methodist University) have measured thermal gradients in the lake bottom that reach 100° C (212°F) within a meter of the sediment-water interface, and the resulting flux of heat is a thousand times higher than the average for the Rockies. Scuba diving in the shallow nearshore areas of the bay reveals a scene from an AlkaSeltzer commercial. Curtains of gas bubbles escape vigorously from a warm sandy bottom pock-marked by miniature cones and depressions. The rapid ebullition of gas entrains sediments and water, pushing up saucer-sized conical domes of sand that evolve into shallow hollows with only pea-sized pebbles and stones too heavy to be winnowed away by these bubble fountains. The gas is high in carbon dioxide and radon, and a plume of radon-enriched water can be followed out into the lake for nearly 1.2 m (2 km).

Scuba diving, however, has limitations. Divers are restricted to shallow water and short bottom times in order to avoid decompression and the potential problems it entails, especially when working at high altitudes. Depths below 60-70 feet are generally "out of range" and hence most of the lake is hidden to direct observation. In 1987, with support from the National Undersea Research Program, we brought new technology to bear on exploring the secrets of Yellowstone Lake in the form of a small submersible robot, or ROV (for Remotely Operated Vehicle). Over the last 8 years we have used Yellowstone Lake as a proving ground for ROV-based exploration and research, while attempting to better understand the role of hydrothermal processes in the limnology of the lake. Our partner in this effort has been Eastern Oceanics, a small, high-technology enterprise operated by a member of our group, Dave Lovalvo. Initially, the ROV system consisted simply of an underwater color video system packaged in a suitcase-sized unit driven by a set of horizontal and vertical thrusters. This drive system allows the operator at the surface to "fly" the vehicle through the water. To this we gradually added a variety of prospecting and sampling tools: temperature probes, 35 mm still camera and strobe, a retractable basket and scoop, a pumping system for recovering water samples, and a computer-operated sipper system that collects water while measuring its temperature and stores samples into an array of syringes for later analysis.



The ROV fully loaded and ready to dive. The round objects on top are fishing net floats that were added for additional floatation, to offset the weight of the sampling gear.

With the ROV as our hands and eyes, the unknown world of Yellowstone Lake was now open to exploration and observation for the first time. Armed with Morgan and Blackwell's map of thermal gradients in the lake and a chart of precision bathymetry generated by group member Matt Kaplinski, we undertook our first look at the deeper parts of the lake. In his survey, Matt had noticed a steep, narrow, and deep topographic feature off Stevenson Island that lay on a line with anomalously high thermal gradients on the bottom. Repeated sweeps with the recording fathometer aboard the R/V



The sampling basket on the front of the ROV is full of "concretional material" collected during a dive in Mary Bay. One of the advantages of this small robotic system was the ease with which the researchers could switch from one sampling tool, such as the sampling basket, to another, such as the water sample sipper.

The crew nicknamed these underwater canyon walls "The Walls of Jericho." Located off Stevenson Island in the deepest known spot in the lake, these outcrops extended for as much as 30 feet above or below the ROV. Unusual for a lake bottom, and suggested tectonic movement. This was also the site of the mysterious "disappearing canyon."

Cutthroat revealed an area of the bottom that dropped precipitously from 270 feet to more than 330 and back up in a mere few boat lengths. With the aid of MiniRanger positioning (a system that relies on shore-based transmitters to triangulate a position within a couple of meters), we returned to this site and sent the ROV down for its first look. What we saw remains perhaps the most spectacular and certainly most surprising of the features we have seen to date.

Instead of 330 feet, the ROV continued to descend into a narrow canyon, reaching nearly 400 feet before being squeezed to a halt 100 feet below the flat lake bottom. The sides of this canyon were reminiscent of the Grand Canyon of Yellowstone on a smaller scale. Exposed outcrops of well lithified sediment strata rose above us as a nearly vertical wall, stepped like some ancient fortress. Why was this here? What forces caused it? How old is it? We are not sure.

In 1992 only weeks after a major earthquake rocked the inhabitants of the Lake area, we returned to this spot now guided by the newer satellite-based global position system (GPS) we had used for the last 3 years. Search as we might, no canyon appeared on our fathometer. It was almost as if the chasm had sealed shut and disappeared from view like Ali Baba's cave. Is it possible, that triggered by the lubrication of an earthquake's tremors, the walls of this canyon collapsed inward filling the deep with tons of mud?

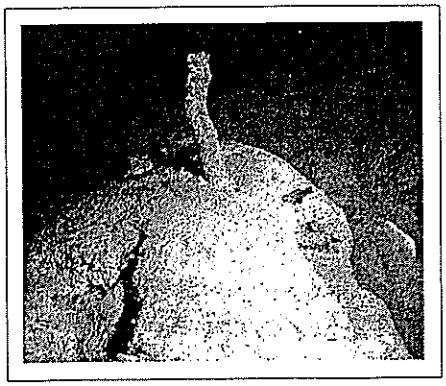
It was in this spot that we observed the hottest hydrothermal springs. In one nearly 400-foot dive in 1990, we recorded temperature spikes up to nearly 120° C, almost 40° C hotter than anything previously seen in shallow water. In response to these soundings, the charted depth of the lake was lowered from less than 300 feet to 380 feet. Has the lake surprised us once more? Have we only missed the needle in the haystack, or has it closed the chasm until some earth-rending event speaks "open sesame?" We hope to take another look.

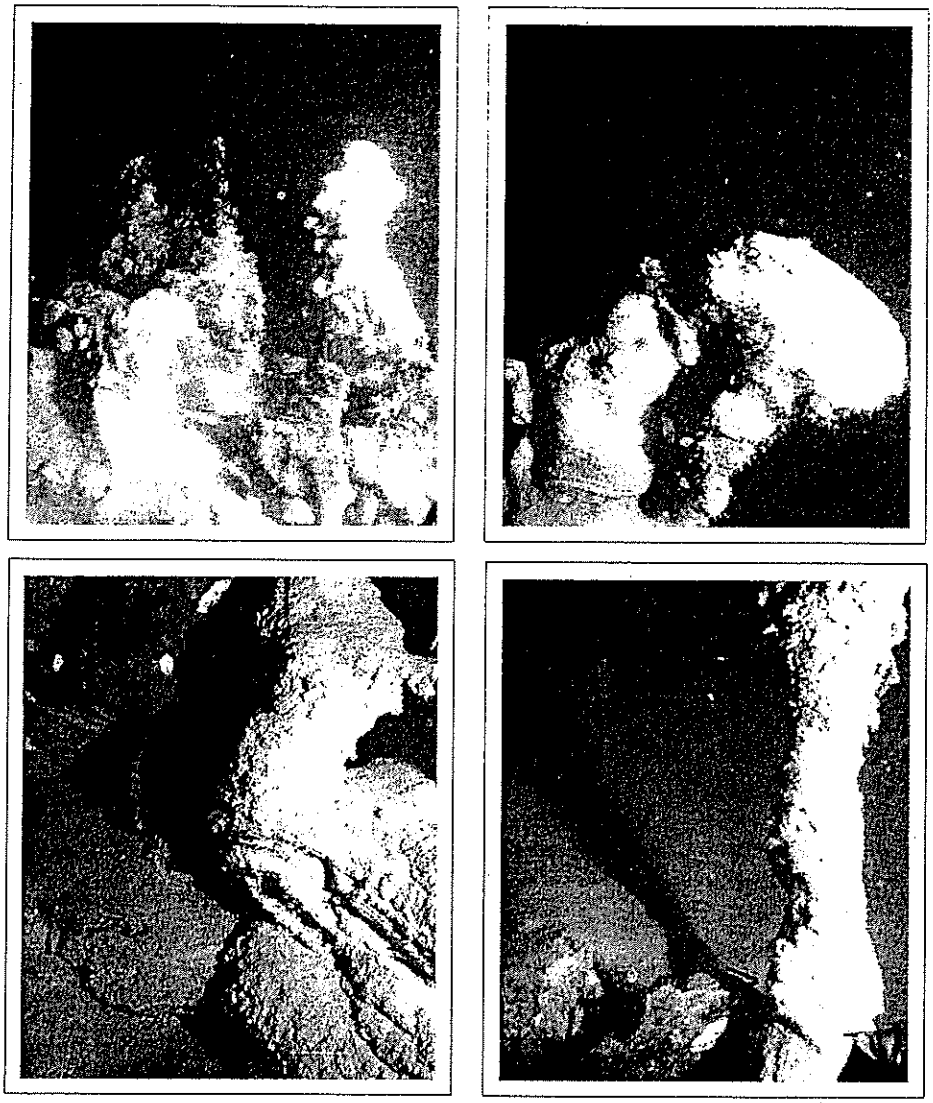
Elsewhere in the lake, mysterious holes and deeps are also seen on the depth chart recorder. Mary Bay is the site of several such "bottomless pits," thought to be old geothermal explosion craters. Dropping from a top plateau at about 60 feet, the deepest of these pits explored to date bottoms out at 150 to 180 feet. Unlike the cold hypolimnetic waters in other parts of the lake (i.e., those waters below the seasonally heated surface layer of the lake that remains cold year-round), the bottom water here is unusually warm, up to 12° C instead of the usual 4° C water of maximum density. The source of this excess temperature is unknown. Heat derived from geothermal sources below and solar inputs from above are both possible factors, if thermal stratification is weakened by bottom-up heating, allowing the downward mixing of warm surface waters. Here, hydrothermal springs are small and dispersed yet, we believe, numerous. The chemistry of these fluids is distinct from lake water, with elevated concentrations of nearly every constituent.

But perhaps the most interesting feature is the one called the "Pipe Garden." Here we have observed foot-long tubes of hardened mud and complex concretions, like tree roots stood on end, protruding out of the bottom silt like sections of discarded plumbing. Upon retrieval, these tubes have proven to be hollow pipes filled with soft mud. Analysis indicates that these pipes are more than 95 percent silica. In other words, they are made of glass.

We hypothesize that these pipes are relict conduits of ancient hydrothermal

At a depth of about 150 feet in Mary Bay, a "fossilized" vent tube from a formerely active thermal flow may indicate that the area was once the site of far more active hot springs than now.





In some areas of Mary Bay, the vent deposits resemble the roots of old tree stumps. Bottom waters here are much warmer in the summer than elsewhere in the lake. Note that in the two bottom pictures freshwater sponges (see arrows) have colonized the deposits.

vents that formed as hot silica-rich fluids cooled and mineralized within the sediments. We believe that these tubes formed below the sediment surface. The constraint provided by sediment cover would serve to channel the flow for periods of time sufficient to precipitate a tube wall, and the sides of the tubes, when examined closely, reveal a vertically laminated stratigraphy like that seen in accreting sediment deposits today. Years later (how long, we don't know) when the flows had stopped, the surrounding sediments slowly eroded away, exposing the subterranean plumbing of the now-defunct vent.

The abundance of this relict piping attests to a much more active past than what we have observed here to date. That is not to say that the situation is quiet or ordinary. Strange holes, like miniature gopher burrows, occasionally mark the sediment surface. Close examination shows no activity, yet unless some advective process keeps the burrow clear the inevitable deposition of silt and sediment would soon fill them in. A clue occurs when one of these holes is seen to burp: a few bubbles pop out and rise to the surface. Occasionally a halo of white precipitate surrounds the opening, an indication of possible sulfide oxidation. Gases collected with a funnel mounted on the ROV reek of hydrogen sulfide. In these warmed waters far below the penetration of sunlight, an unusual assemblage of organisms has been found. Sponges, seen as yet nowhere else in our explorations, cover the pipes and hard outcrops in silver-dollar sized patches. Zooplankton swarms, in densities rivaling backcountry mosquitoes, skitter across our video screen. Something fuels this food chain, and bacterial chemosynthesis supported by sulfidic seeps may be the source.

For an active present, no more active site has been found than the "trout jacuzzi" of West Thumb. On calm days from the lakeshore near the West Thumb Geyser basin, National Park Service naturalist John Dahlheim noted a vigorous disturbance of the water surface that came and went about every half hour, lasting a few minutes. Guided by John's bearings, we dropped our ROV into an underwater grotto that led to a narrowing cavern some 20 feet below the surface. As we reconnoitered our surroundings, a small trickle of bubbles exploded suddenly into a huge eruption of gas, obscuring our camera's vision and entraining enough water to roil the surface of the lake around our 27-foot boat. Through the eyes of the ROV, we watched in amazement as a large cutthroat trout rapidly swam in and out of the bubble field of this underwater geyser, apparently feeding on food stirred up by the turbulent water. Within a few minutes the eruption died down. We observed this cycle several times, and at regular intervals of about 25 minutes the "trout jacuzzi" served up a hot lunch to this trout.

How extensive is this geothermal activity? We have found evidence in nearly all parts of the lake, and indications in some locations that it may have been more active in the past than it is today. Its impact on the biogeochemistry of the lake is still an open question, yet our most recent expedition produced some of the most intriguing data collected to date. In the deep, cold, and lightless hypolimnetic waters of the lake, chemosynthetic bacteria appear to be flourishing. In fact, when integrated over the whole of the lake's depths, chemosynthesis may provide as much "primary production" as the photosynthetic organisms inhabiting the warm sunlit surface layer above. If this phenomenon is a permanent feature of the lake, it will be strong evidence that Yel-

Because of the turbulence, it was difficult to photograph the large cutthroat trout we named "Hot Lunch Charlie" as it foraged for food among the material stirred up by the underwater geyser. In the photo on the right, a linear microbial mat, about 1 m in width, stretches off into the distance as it follows a "fault line" in Sedge Bay. Warmth and chemicals apparently seep upward through the fault, fostering a unique microbial community.

On the bottom near Stevenson Island, the authors found the hottest hydrothermal springs they have measured so far, with temperatures above boiling. The white material may be sulfur, produced by oxidation of hydrogen sulfide coming from the vents.

lowstone is fueled by an "alternative" energy source in addition to sunlight, a geothermal hot plate set to simmer far below the lake's bottom.

The depths of Yellowstone Lake are not characterized by the quiet pastoral existence of profundal life seen in most lakes. The bottom of Yellowstone Lake is a uniquely active environment where the forces of nature create unusual scenes, unusual habitats, and unusual life styles. Slight but sudden shifts in the sublacustrine plumbing could change its impact and it is clear that in many small local areas conditions are created that are unique in limnology and dominated by geothermal and hydrothermal forces. So like the park in general, the lake too contains features both fascinating and unexpected.

Val Klump, Tony Remsen, Pat Anderson, Russell Cuhel, Jerry Kaster, and Robert Paddock are with the Center for Great Lakes Studies, University of Wisconsin-Milwaukee. Dave Lovalvo is with Eastern Oceanics Inc., West Redding, Connecticut. Matt Kaplinski is with Northern Arizona University. Jim Maki is with Marquette University.

Authors' note: We would like to thank the U.S. Fish and Wildlife Service group with special mention to Ron Jones, Bob Gresswell, Dan Carty, Dan Mahoney, Glenn Boltz, and Lynn Kaeding without whom this work would not have been possible. Thanks to the ROV Cutthroat for service as our "mother ship" and floating electronic nerve center. Thanks also to the National Park Service Research Division and the Bridge Bay and Lake Ranger Station personnel for their support and interest. Valuable assistance in the field has been given by Bob Gresswell, Don Szmania, Jim Waples, George Kipphut, Tim Stauder, Fred Binkowski, Rebecca Lovalvo, Mike Sierszen, John Krezoski, Joel Kostka, Lorie Buchholz, Brian Eadie and Margaret Lansing. Support for this work has been provided by the NOAA National Undersea Research Program, the Graduate School of the University of Wisconsin-Milwaukee, the UWM Center for Great Lakes Studies, National Geographic Society, U.S. Fish and Wildlife Service, and the National Park Service.

Book Review

Strange Genius: The Life of Ferdinand Vandeveer Hayden. By Mike Foster Roberts Rinehart Publishers, Boulder, Colorado, 1994; 443 pages; $29.95 (cloth).

It is easy for those of us who live and work here in the Yellowstone region to acquire a rather myopic view of historical matters, and to regard those whose efforts helped mold some facet of the park's rich history as if their existence began when they arrived in the area. Ask most old hands of the region about F. V. Hayden and you will likely learn that he was the leader of the 1871 Hayden Survey to Yellowstone, and has some of the credit for the passage of the Organic Act that created the park. Ask for a rundown of the man before or after 1871, and you will usually be greeted with many blank stares. Few of us realize that in the fields of (19th century) geology, geography, ethnology, and entomology, Hayden was a major player. It may also be argued that he was the man most responsible for the creation of the U. S. Geological Survey, and should have been its first director.

Strange Genius tells the story of one of the greatest American scientists and naturalists of the last century. It is more than a work of extraordinary scholarship; it is also an extremely well written, enjoyable story and narrative of the life of a great man and his times. The reader is provided here with a window onto the stage of 19th-century science. The view through the window is all one might expect: exciting discoveries tempered by counterproductive jealousies and shameful slanders among most of the players involved (Hayden included). And here we find one of the book's great strengths: while obviously a great fan of his subject, the author came to know him well enough to dislike him in some ways as well. "Hayden is," he tells us, "an apt reminder that ability does not always come wrapped in an attractive package."

The early portions of the work set the stage for the formation of this complex person. In the first chapters we see portrayed the struggles of a youth growing up in 19th-century America with an eager, rich intellect, ambition, and poverty. The results of a nearly nonexistent family and an enthusiasm for any scholarly pursuit created a young man who had trouble focussing his personal and professional desires to cohesive ends, with resultant successes and failures that shaped the scientist who would be Hayden. The author sums these years up beautifully: "Too restless to savor his moments, too ambitious to know what he really wanted, Hayden drove on like a powerful freight train racing into the night without a headlight."

As the story unfolds, we are permitted to watch the development of a great but private man, a man known to anyone of science in his day, and to most of the rest of the literate world as well. His theories of the geology of the American West have not stood well the test of time, but were nonetheless the spark that became the flame of geological study of this area from that time forward. Hayden was admired by many for his work and hated by others for popularizing science with the masses. The author often reveals a Haydenesque ability to explain many of his subjects' theories in layman's terms, and this enhances the readability of the narrative.

And what of Yellowstone? The 1871 Survey is the subject of two (of the 25) chapters of *Strange Genius*. For those who hope to learn more about the details of the Hayden Survey's days in Yellowstone, the book may be disappointing. It does not cover the time spent here in a "day by day" diary form. This is understandable in the context of the entire biography. By devoting two chapters to the survey's visit to the park area, the author acknowledges the importance of this event to both the park and Hayden.

But this was one important event in a life replete with many. As the head of the U. S. Geological & Geographical Survey of the Territories, the largest of the four rival surveys operating in the West at that time, Hayden did more to popularize the western United States than any of his contemporaries. As a result, he was arguably most responsible for showing Congress the need for a permanent agency to continue this work, which became the USGS. He also did more to popularize science as an endeavor than any other American of the 19th century. In an attempt to help the American farmer, he was instrumental in creating the Entomological Commission as an adjunct to his survey. The Commission went through a couple of transformations to become the Biological Survey and, ultimately, the U.S. Fish & Wildlife Service. Among these many accomplishments, the discovery work in the future Yellowstone National Park stands strong, but by no means alone.

A delightful aside in this work is the philosophical position of its author as concerns the art of biography. Dr. Foster disagrees on occasion with historians before him, and, while open about such matters, is fairly respectful to those with whom he disagrees. He is a bit more candidly critical toward biographers who he feels have blatantly ignored facts in order to further their own viewpoints. At the same time, he makes no effort to hide the fact that the Hayden we will meet and come to understand is the Hayden the *biographer* lays before us, whether meaning to or not. "Is it honest," he offers, "to ask readers to make up their own minds when you have selected all the contexts for them?"

Perhaps not, but one cannot come away from *Strange Genius* without the feeling that we are seeing the most of Hayden that anyone has ever shown the world (Hayden included!). The man had his share of virtues and vices, and they are all here. But more, the work provides the reader with an understanding of the times of Ferdinand Hayden, and this is at least as valuable as the understanding provided of the man himself. Consider it a must read, and find it an enjoyable one as well.

Leslie Quinn is Information Specialist and Trainer for T.W. Services in Yellowstone National Park, and a productive researcher of the park's history.

Wolves Have an Eventful Summer

As we reported in our summer issue, Yellowstone's new wolves have begun the process of establishing home ranges, and are having no trouble making a living in and near the park. The Crystal Creek group continued to be sighted regularly in the Lamar Valley area well into the summer, then spent half of July and all of August and September moving between the Lamar Valley and Pelican Valley, with stops at many locations along the way. The six members of this group spent much of their first few months scattered in smaller groups and singles, but began spending most of their time together in August.

The Soda Butte group has used the drainages along the north boundary of the park, being located at various times in the Hellroaring, Buffalo, Slough, and Pebble Creek drainages in the park and in the Absaraka-Beartooth Wilderness Area to the north. As reported in our previous issue, on June 16 a single pup was observed with a member of this group, and it is now established that there is only that one pup, rather than a larger litter. This group has followed roughly the same pattern of behavior as the Crystal Creek pack, traveling apart most of the time until August, when they began to spend most of their time in one group.

Biologists consider it remarkable that two of the three groups successfully mated in captivity; as David Mech noted in our previous issue, it seemed extremely unlikely that mating would occur under the stress of capture and extended confinement. Successful mating in captivity is seen as a very good sign that these wolves have the resilience for a successful recovery program.

The Rose Creek female, wolf 9F, who was recaptured with her eight pups near Red Lodge, Montana after her mate, wolf 10M, was shot and killed, has been in the Rose Creek pen since May 18. Her life has not been without excitement, however. Some time during the last weekend in July, a violent windstorm knocked two large trees down across the fence. The damage was discovered by wolf biologist Doug Smith on Monday morning, July 31, during his routine visit to bring food to the animals. At that time, he discovered that only 9F was in the pen; all eight puppies had left through openings in the fence caused by the falling trees.

Wolf project biologists Doug Smith and Mike Phillips (obscured by lid) lift the lid of one of the wooden shelters in the Rose Creek pen, so that the president and his daughter (center, in front of tree) can see the puppies. On the right, the White House photographer, a Secret Service agent, Mrs. Clinton, and Rebecca Kolsky (a friend of Chelsea) look on.

NPS photos

President Clinton (left), Chelsea Clinton, and Wolf Project Leader Mike Phillips remove meat from plastic bags prior to spreading it around the Rose Creek wolf pen.

Left to right: Wolf project biologists Doug Smith and Mike Phillips, Rebecca Kolsky, Chelsea Clinton, and President Clinton take a peek at wolf pups.

There followed what Wolf Project Leader Mike Phillips described as a "puppy rodeo," as biologists attempted to round up and capture the eight puppies, which then weighed 25 to 30 pounds. Within a few days, five of the eight pups were returned to the pen, the damage was repaired, and it became apparent that the other three pups would probably not leave the area as long as their family was there and food was still provided to them. A greater concern than the puppies leaving the area was their vulnerability to predators, though they were observed at least once standing up to adult coyotes.

On October 9, wolf project biologists and park staff entered the pen to process the pups for release, and discovered that there were now six pups in the pen; apparently one of the three still free had managed to climb the fence to join the family. These six (weighing roughly 50 pounds each) were given shots for parvo virus, rabies, tuberculosis, and distemper, and were fitted with radio collars. Then, on October 11, the gate of the pen was opened and one of the panels of the pen was removed, so that the wolves would have two easy ways to exit the pen. An interesting development this day was that a young male wolf, 8M from the Crystal Creek group, was observed near the pen, interacting with the two free pups.

By October 13, the entire group—mother, pups, and young male—were two miles east of the pen, and by October 15 they had all moved back to the Rose Creek drainage and were near the pen. Biologists consider the arrival and apparent welcome received by 8M as a good sign that 9F will not only have help with the pups this winter, but also will have a mate. As Mike Phillips said of 9F's relationship with 8M, "If she didn't want him around, he would have been gone by now."

The other Rose Creek female, the daughter of 9F, has continued to travel alone in northern Yellowstone, often in the Hellroaring Creek area but as far west

as Swan Lake, and is apparently having no trouble fending for herself. On September 18, biologists documented her first elk kill (which she later defended from four coyotes), though obviously she had been finding food up until that date, and may have made other unobserved kills. She has visited the area of the Rose Creek pen since the mother and pups were returned there, but there is no way of predicting if she might rejoin her mother, or if she will eventually join up with any of the young males from the other groups.

The late spring and early summer months were very good for wolf watchers in the Lamar Valley. NPS ranger-interpreter Rick McIntyre, who spent that time in Lamar, reported about 4,000 visitors watched one or more of the wolves. Rick, who had more than 100 wolf sightings himself, said that the mood of the visitors was overwhelmingly positive. "I haven't received any negative comments from anyone viewing the wolves in the Lamar this season; just the opposite, people were emotional, they were crying, some hugged me and other family members. I guess I felt like the press secretary for the Beatles must have felt."

Additional excitement surrounded the wolves on Friday, August 25, when they received a visit from the First Family, who took a break from their vacation in Jackson Hole, Wyoming, to visit Yellowstone. The Lamar Valley was the third stop on the Clinton's park tour, after the Grand Canyon and Old Faithful. Accompanied by Mike Phillips, Doug Smith, Superintendent Mike Finley, and Yellowstone Center for Resources Director John Varley, the presidential party hiked up to the Rose Creek pen, donned rubber gloves, and entered the pen to assist in the feeding (a large contingent of media watched from a distance). Afterwards, the president (wearing an "Operation Wolfstock 95" cap) met with regional representatives of conservation groups in the barn at the Lamar Ranger Station. The president spoke with the group on many subjects, including the need to protect the park from a mine being planned near Cooke City, Montana (the presidential party's four helicopters had flown over the mine site prior to landing at Lamar).

Amid a fairly heated political debate over the future of the wolf program, park staff are preparing for the possible arrival of the second group of wolves this coming winter, though as of early October, Montana Senator Conrad Burns had made good on his promise to ensure that no funding would be provided for this work. Other funding avenues are being investigated. One of the three acclimation pens used last winter, the one at Soda Butte, has been taken down, and two new ones have been constructed, one on the Blacktail Plateau and one on Nez Perce Creek.

Predators Draw a Big Crowd

The third biennial scientific conference on the Greater Yellowstone Ecosystem was held at the Mammoth Hot Springs Hotel from Sunday, September 24, through Wednesday, September 27. Entitled "Greater Yellowstone Predators: Ecology and Conservation in a Changing Landscape," the conference was attended by more than 200 researchers, managers, and the public.

Monday morning, Superintendent Mike Finley welcomed the conferees, and in his opening remarks highlighted the need for all researchers and managers to take an active role in educating the public on how nature really works. His examples included the roles of fire and predators in natural ecosystems. Dan Janzen illustrated his keynote talk on the role of predation in ecosystems with three stories spanning Asia, Australia, Serengeti, and the New World. Nine speakers then addressed multiple species interactions, from lake trout and cutthroat trout, to red foxes and coyotes, to complex communities of carrion beetles.

At the Superintendent's International Luncheon, keynote speaker Stephen Herrero, author of the well-known book *Bear Attacks*, spoke on the topic of "Wild Love"—the dedication and commitment to the wild that he sees as a common characteristic in wilderness and wildlife researchers throughout the world. Following lunch, four speakers addressed behavior of predators, from mountain lion killing methods to helping behaviors of coyotes to reintroduced wolves. Then a session of natural history addressed a variety of species: ravens, tiger salamanders, mosquitoes, and midsized carnivores (lynx, wolverines, fishers, and martens). Scientists discussed techniques of inventorying and monitoring carnivores, and detecting rare or difficult-to-observe midsized carnivores.

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The Superintendent's International Luncheon keynote was delivered by Steve Herrero, University of Calgary ecology professor and a leading figure in carnivore conservation.

At a special wolf update session on Monday evening, Yellowstone wolf project leader Mike Phillips presented an overview of the current status of wolf recovery in Yellowstone, and then introduced cinematographer Bob Landis, who showed his footage of Yellowstone's newly arrived wolves interacting with coyotes, grizzly bears, elk, and bison.

Tuesday morning's keynoter, Dr. Steve French, shared recent applications of molecular DNA techniques to predator ecology, systematics, and conservation, especially that of bears. Then the topic turned to conservation biology and management, nine speakers discussing management of grizzly bears, gray wolves, and midsized predators. Three speakers addressed social science: pelican control in early NPS policy, the economic value of Yellowstone trout, and changing public attitudes toward wolves. Two speakers treated physiological ecology: energetics in marten, and nutritional ecology of bears. Population dynamics and ecology were discussed by two speakers: two on bald eagles, and one on the influence of ungulate carrion on coyote behavior and demographics.

NPS photos

Clockwise from top left: Mike Phillips' well-attended wolf update session on Monday evening gave conference participants an opportunity for a more informal interchange of information on the Yellowstone wolf recovery project. Montana Department of Fish, Wildlife and Parks provided a very popular exhibit of forest carnivores, which was a special added attraction during the poster session.
L. David Mech's Leopold Lecture focused on wolves of North America by highlighting Mech's own experiences with several wolf populations.
The poster session and social hour on Tuesday evening drew a large crowd.

Mark Boyce served as conference summarizer, and the first two very busy days of the conference were concluded with the poster session, the evening banquet, and the presentation of the A. Starker Leopold Lecture. Posters, which were up for most of the conference, were presented on 11 topics, ranging from aquatic insect predators to a test of the attractiveness to bears of the alternative fuel rape ethyl ester. The A. Starker Leopold Lecture, "The Value of Long-Term Carnivore Studies in National Parks," was presented by wolf biologist L. David Mech.

The proceedings of the conference will be published; watch future issues of *Yellowstone Science* for details.

Wednesday, September 27, a special symposium, "Carnivores in Ecosystems," was cohosted by the Northern Rockies Conservation Cooperative and the NPS. This symposium featured a series of invited speakers exploring carnivore topics at greater length (only authors speaking are listed below, though many had coauthors). Steve Minta introduced the symposium with a discussion of Yellowstone as a model system for understanding carnivores, and asking, "Is there a theory of carnivore ecology?" Moderator John Varley introduced the morning session on Greater Yellowstone Carnivores. Paul Schullery traced the history of carnivores in the Yellowstone region, Frank Singer quantified the carnivore prey base, Dick Knight said the bear population is showing signs of saturation in Yellowstone National Park and that we need to learn how better to manage people in the Yellowstone area. Ian Ross and Kerry Murphy spoke on their respective cougar studies, and Ed Bangs listed the big issues in wolf restoration as their feared impacts on livestock, big game hunting, and public land-use practices. Bob Crabtree listed studies of sympatry between coyotes and wolves, and between coyotes and red fox, showing temporal avoidance in the latter two. Steve Buskirk revealed how meso-predators (small mammals of a few pounds or less) are important esthetically and spiritually, affect prey populations, scavenge, disperse seeds, and structure populations of nonprey species, including each other.

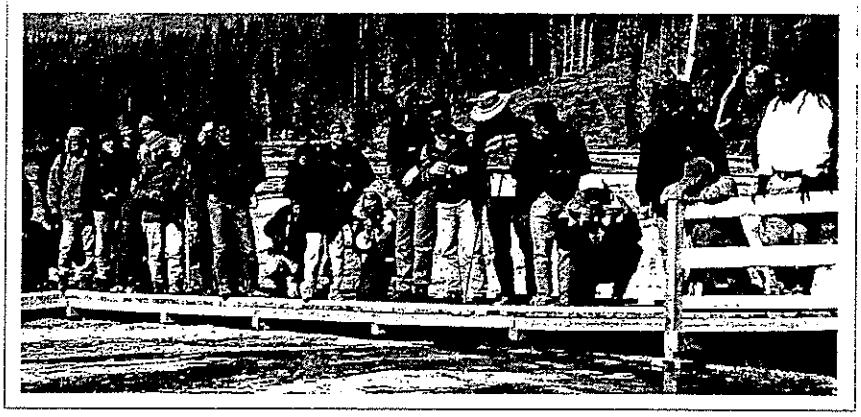
The afternoon session, entitled "The utility of experimental research for ecological theory, conservation, and management," focused on theoretical issues. Fred Allendorf explored genetic considerations—interbreeding, crossbreeding, and inbreeding—as they affect restoration and management of predators. Mark Boyce assessed models for conservation and management. Steve Minta spoke on refocusing experimental questions and scales, and offered recommendations for research and management. Steve Minta and Michael Soule assessed carnivore recovery and conservation in North America, and the session was summarized by Tim Clark, with final remarks by John Varley. It is the intention of the symposium organizers to publish these papers in book form, so watch *Yellowstone Science* for news of that, too.

The fourth conference in this series will be held in 1997. In recognition of the 125th anniversary of the creation of Yellowstone National Park, which will be celebrated that year, the fourth conference will focus on people and their role in Greater Yellowstone. Announcements will be forthcoming in a year or so.

Thermophile Conference Focuses on Science and Policy

Dr. David Gelfand of Roche Molecular Systems, coinventor of polymerase chain reaction (PCR), at Mushroom Pool, origin site of Thermus aquaticus.

Lori Compas photos



Microbiology conference participants field trip to Black Sand Basin.

Pioneering Yellowstone Microbiologist Thomas Brock leading a field trip.

In the foremost gathering of expertise in the history of Yellowstone microbiology research, 110 scientists and other authorities from around the world gathered at Old Faithful September 17-20 to address a variety of issues relating to the park's extraordinary thermophilic microorganism communities. The conference was organized by Yellowstone Center for Resources Management Assistant Bob Lindstrom and Anna-Louise Reysenbach of Indiana University, with funding from the National Science Foundation, the Department of Energy, NASA, and 17 biotechnology companies. Conference organizers aimed to increase communication and establish contacts among the academic, biotechnology, and management professionals involved in studying the park's microbial resources.

Dr. Thomas Brock, whose original discovery of *Thermus Aquaticus* (*Taq*) in a Yellowstone hot spring, led eventually to a revolution in DNA science, with significant impacts in many disciplines, presented the keynote address, setting the stage for a four-day dialogue on the great social and scientific values of the park's thermophilic resources. These resources have been in the news frequently for the past couple of years. A debate has developed in both public and scientific forums over the best way to manage and use these remarkable and long-ignored resources. While some point to the immense social value resulting from the extraction and development of these resources, others have questioned the appropriateness of what "mining" rare park resources for commercial gain. A central issue has often been just what the park (and thus the public who pay the park's bills) should gain from such development.

A full day of presentations and roundtable discussions were devoted to the management of such publicly owned resources, with active audience participation. The use of the resources was considered in terms of intellectual property rights, patenting organisms and genes, trade secret rights, and material transfer agreements. Voluntary contributions, royalty agreements, and a variety of other user-fee arrangements were considered in discussions of ways to reimburse the public for this use.

Just as interesting were presentations on the natural history of Yellowstone's thermophiles, and on the all-important issue of preserving biodiversity. Thomas Lovejoy, science advisor to the Secretary of the Interior, described Yellowstone's thermophiles as "environmental extremists" because they live on the very edges of life's tolerance for extreme environments. He emphasized the utilitarian aspects of preserving biodiversity, pointing out that in today's age of biotechnology, the commercial applications of these unusual life forms is one of the surest proofs that they should be protected.

The philosophical and ethical complications of this argument—that in order to save something we believe should be saved we must first justify saving it on commercial grounds—have long been debated among environmentalists; the entire national park movement is seen by some historians as an exercise in persuading people either that a proposed park has no other possible commercial value or that it will make a lot of money. But Eric Mathur, director of Recombinant BioCatalysis Inc., one of the biotechnology companies represented at the conference, said, "If industry does not support preservation of biodiversity, it probably won't happen." Microbiology research in Yellowstone will probably be one of the vehicles by which future managers and constituents explore the uneasy combination of commerce and esthetics that have always driven the evolution of park management philosophy.

Meanwhile, an estimated 99 percent of Yellowstone's thermophiles remain undescribed by science, and 40 microbiology research projects are currently underway here. Judging from the interest and concern expressed at this conference, this long-unrecognized resource has already generated a sizeable constituency, one that has a significant stake in ensuring that the park's geothermal resources, the diverse habitats for these organisms, are well protected.

The proceedings of the conference will be published by the American Society of Microbiology. Watch for news of this in future issues of *Yellowstone Science.*

Canon USA/National Park Foundation Grant Assists in Search for Rare Park Plants

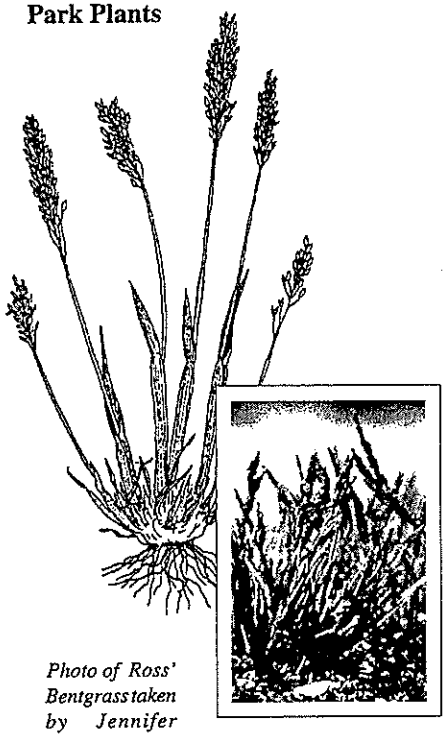


Photo of Ross' Bentgrass taken by Jennifer Whipple, illustration by Jane Dorn.

Among Yellowstone's 1,050 or so known species of plants are two endemics, Ross' bentgrass (*Agrostis rossiae*) and Yellowstone sand verbena (*Abronia ammophila*), both of which are listed as Category 2 under the Endangered Species Act. This listing means that the species may be threatened or endangered, but data is insufficient to establish their vulnerability. As part of its "Clean Earth Campaign," Canon USA recently donated funds to the National Park Foundation, in support of the foundation's "Expedition Into the Parks" program; Yellowstone has received $4,300 to be applied toward additional survey work on these two species.

Some of this survey work has been conducted in the thermal areas where Ross' bentgrass makes its specialized home, while the rest has been devoted to seeking additional populations of sand verbena, which is currently known only from a two-mile stretch of beach along Yellowstone Lake. We hope to run a feature article on these rare species, and the findings of these studies, in a future issue of *Yellowstone Science*.

1995 Grizzly Bear Mortalities High

As of October 5, a total of 16 grizzly bears had been removed from the Greater Yellowstone Ecosystem, the highest known total in more than 10 years. These included seven management control actions (five of these were sent to zoos, in Quebec, New York, and Seattle) and two illegal kills, as well as three bears killed by hunters in self defense. Of these 16, 9 were males, 6 were females, and 1, identified only by a paw, was of unknown sex. Four died in Yellowstone National Park, 6 in Gallatin National Forest, 3 in Shoshone National Forest, 1 in Bridger-Teton National Forest, and 2 on private land in Montana.

The most unusual kills were three male grizzly bears killed after coming into contact with a downed power line in Hayden Valley. On August 21, visitors on horseback discovered the bears, and on August 22, rangers and Montana Power personnel investigated the site. They found a 200 to 250-pound subadult male, a 260-pound adult male, and a 350-pound adult male. The evidence suggested that the bears had encountered the power line over a period of about 10 days, from August 10 to 20. A tree had fallen on the power line, stretching it until it was about a foot and a half from the ground. The line did not break, and so there was no disruption in power to alert Montana Power personnel of a problem.

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Greater Yellowstone grizzly bear mortality was unusually high in 1995.

Missing Wyoming Biologists' Plane Discovered

In late September, two elk hunters in the Teton Wilderness discovered the wreckage of a Western Air Research plane containing the remains of Wyoming Game and Fish Biologists Kirk Inberg and Kevin Roy and their pilot, Ray Austin. The plane disappeared while on a research flight on October 16, 1991, resulting in the largest search in the history of Wyoming.

Inberg and Roy were involved in grizzly bear research during the flight; they were looking for a wounded bear and tracking other bears. As a routine safety precaution, they carried an active radio collar, which could be used to locate them in case of trouble. It appears that the collar was destroyed in the fire of the crash; most of the plane was apparently melted or otherwise consumed in the fire.

According to a report published in the *Jackson Hole News* on September 27, 1995, the wreckage was found "in dense timber on the southeast edge of the 10,870-foot-high Soda Mountain. The site is approximately 11 miles due north of Togwotee Pass and about the same distance by trail from the Turpin Meadows trailhead."

Brucellosis Study Begins

Greater Yellowstone's long controversy over brucellosis has entered a new phase, as a year-long pilot research project has begun to help managers better understand the nature of the disease in Yellowstone bison. The project is a cooperative effort of five federal and four state agencies, including three U.S. Department of Agriculture agencies (Animal Plant and Health Inspection Service, Agriculture Research Service, and Forest Service) two Department of the Interior Agencies (National Biological Service and National Park Service), two Montana state agencies (Fish, Wildlife and Parks, and Livestock) and two Idaho state agencies (Fish and Game, and Agriculture).

The focus of the project is the launching of a long-term evaluation of brucellosis in free-ranging bison in Yellowstone National Park. Ten pregnant cows are to be immobilized so that a

variety of tissue and blood samples can be taken and the animals can be radiocollared. Periodic sampling will determine when and how bison cows or their calves become infected with brucellosis.

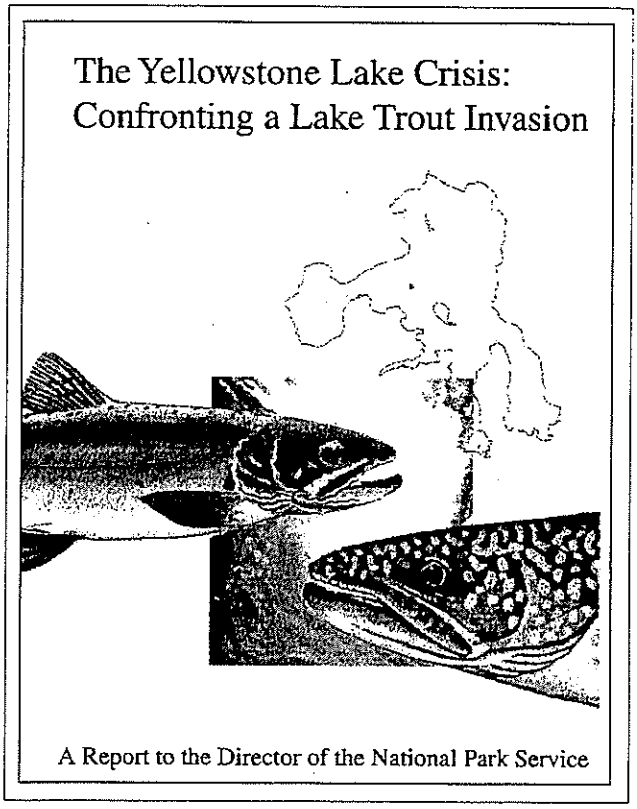
The principal investigator for the project is Dr. Thomas Roffe of the National Biological Service. It is hoped that the study will clarify still-unknown or controversial aspects of brucellosis ecology in Yellowstone, and allow the respective agencies and interests that have so often been at odds about the disease and its management to develop a mutually satisfactory management approach.

Yellowstone Lake Report Available

In early October, the Yellowstone Center for Resources published "The Yellowstone Lake Crisis: Confronting a Lake Trout Invasion," a 35-page report on the recent discovery of a population of non-native lake trout in Yellowstone Lake. This report to the director of the National Park Service is the result of a partnership between many individuals, groups, and agencies that have worked together since the summer of 1994 to address a situation that former Yellowstone Superintendent Robert Barbee described as "an appalling act of environmental vandalism."

In releasing the report, Superintendent Finley emphasized the public's key role in its production. "We're especially grateful to the Montana Trout Foundation and to the many individuals who donated to the Yellowstone Fishery Fund for making this quality information possible," Finley said. At the same time, he pointed out that the struggle to save the cutthroat trout will occur at an especially difficult time: "It's just bad timing that we're going to have to fight this lake trout invasion when government is shrinking. In the long run, saving the cutthroat is good ecology and good economics, but it's going to be expensive."

The report begins with an executive summary, which sets an ominous tone by declaring that "the predicted decline of Yellowstone cutthroat trout will destroy the world-famous fisheries in the lake and its tributaries, including the storied fishery in the Yellowstone River between the lake and the Upper Falls." The executive summary is followed by a detailed report on the discovery of and subsequent study of the lake trout invasion, written by U.S. Fish and Wildlife Service staff. That is followed by an overview of the ecological consequences of a collapsed cutthroat trout population, which notes that at least 42 species of mammals and birds depend to some extent upon the cutthroat trout for food in the Yellowstone Lake Ecosystem. The next paper provides some quantification of the economic values of the Yellowstone Lake fishery, concluding that "the cumulative 30-year value of the cutthroat trout sport fishery assuming the introduction of lake trout had not occurred is estimated at more than a billion dollars." The economic analysis is followed by the report of last February's lake trout workshop held in Gardiner, Montana, during which a group of nationally known lake trout and cutthroat trout authorities gathered to consider the situation. This report concludes that the lake trout are there to stay, but that a determined effort can control the size of the population. Finally, the report provides a draft action plan for the next two years, to set the stage for managers in their development of controls on the lake trout.



In summary, the report elaborates on but does not significantly alter earlier indications that Yellowstone Lake faces a very serious, perhaps disastrous, future unless aggressive action is taken. If there is important new information, it is a growing certainty that such action is technically possible, and is assured of making a big difference in the fate of the native fishes of Yellowstone. That action centers on selective gillnetting of lake trout to hold their numbers down. In 1995, U.S. Fish and Wildlife Service personnel began experimental gillnetting, to identify techniques that will allow them to kill lake trout without also incidentally killing an unacceptably high number of cutthroat trout.

Copies of the report can be obtained by writing to the Superintendent, Yellowstone National Park, P.O. Box 168, Yellowstone National Park, WY 82190. Contributions to the Yellowstone Fishery Fund may be made to the Yellowstone Association, P.O. Box 117, Yellowstone National Park, WY 82190