YELLOWSTONE SCIENCE

volume 17 • number 3 • 2009

Interview with Historian Paul Schullery

Willow–Bird Relationships on the Northern Range

Land Use in Greater Yellowstone

Questioning Greater Yellowstone's Future
Climate, Land Use, and Invasive Species

The 10th Biennial Scientific Conference on the Greater Yellowstone Ecosystem

October 11–13, 2010

Mammoth Hot Springs
Yellowstone National Park

Facing the Future

In November 2009, approximately 90 professionals representing academia; county, state, and federal agencies; and non-governmental organizations convened at Montana State University for a workshop titled "Climate Change, Land Use Change, and Invasive Species as Drivers of Ecological Change in the Greater Yellowstone Area" in order to develop a 20-year science agenda on these topics. These three external ecosystem drivers threaten to dramatically alter Greater Yellowstone's public and private lands. Changes caused by these forces are likely to have cascading effects on virtually all park resources. Understanding how they might influence wildlands and their consequences for ecosystem management are important challenges for scientists and managers. This workshop was held to steer the research community toward the most important scientific needs of Greater Yellowstone land managers and to inform agency research funding by setting science agendas and identifying information gaps. Outcomes of the workshop will be shared in a technical report and in a future issue of *Yellowstone Science*.

Results will also be presented at the 10th Biennial Scientific Conference on the Greater Yellowstone Ecosystem, Questioning Greater Yellowstone's Future: Climate, Land Use, and Invasive Species, which is scheduled for October 11–13, 2010, at Mammoth Hot Springs in Yellowstone National Park. The goal of this conference is to generate discussion on these drivers, offering participants an opportunity to help shape this region's future. Key questions to explore during the conference include:

- How is the Greater Yellowstone climate likely to change in the near future and how do climate projections compare with historical patterns?
- What ecological changes are underway as a result of changing climate and land use, and what will be the consequences for human and natural systems?
- In what ways do increasing demands on public and private lands threaten a sustainable future?
- Which nonnative species pose the greatest threat for the region and what are some of the anticipated environmental, social, economic, and human-health consequences of invasive species?
- What new administrative, technological, and scientific tools and strategies are required to address the challenges of changing climate and land use and the threats from invasive species?

The conference Call for Papers will come out in January 2010. Information on both the workshop, including the post-workshop summary, and the conference can be found at www.greateryellowstonescience.org.

We hope you enjoy the issue.

USDA FOREST SERVICE 2008/TIM CAMPBELL

Sunset over the Greater Yellowstone Ecosystem from Two Top Mountain in the Gallatin National Forest.

Yellowstone Science

a quarterly devoted to natural and cultural resources

volume 17 • number 3 • December 2009

Tami Blackford
Editor

Mary Ann Franke
Associate Editor

Janine Waller
Graphic Designer
Assistant Editor

Emily Yost
Assistant Editor

Artcraft Printers, Inc.
Bozeman, Montana
Printer

Yellowstone Science is published quarterly. Support for *Yellowstone Science* is provided by the Yellowstone Association, a non-profit educational organization dedicated to serving the park and its visitors. For more information about the association, including membership, or to donate to the production of *Yellowstone Science*, visit www.yellowstoneassociation.org or write: Yellowstone Association, P.O. Box 117, Yellowstone National Park, WY 82190. The opinions expressed in *Yellowstone Science* are the authors' and may not reflect either National Park Service policy or the views of the Yellowstone Center for Resources.
Copyright © 2009, the Yellowstone Association for Natural Science, History & Education.
For back issues of *Yellowstone Science*, please see www.nps.gov/yell/planyourvisit/yellsciweb.htm.

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

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

on the cover:
A song sparrow singing.
©Tom Murphy

FEATURES

4 **Sort of a Historian: Paul Schullery Retires**
In this interview, historian Paul Schullery reflects on the values and policies that have shaped Yellowstone throughout his storied career.
Interview by Tom Olliff and Tami Blackford

19 **Willow–Bird Relationships on the Northern Range**
An analysis of the relationships between willow growth and songbird community diversity.
Lisa M. Baril, Andrew J. Hansen, Roy Renkin, and Rick Lawrence

27 **Land Use in Greater Yellowstone**
The ways the land in the Greater Yellowstone area is used, developed, and protected has changed dramatically over the last 30 years. How will those changes affect the ecosystem as we know it?
Andrew J. Hansen

DEPARTMENTS

2 **News & Notes**
YCR Chief Tom Olliff Moves to Inventory and Monitoring Network • Greater Yellowstone Area Grizzly Bears Relisted • 2009 Summer Bison Count • Superintendent's 2008 Natural Resource Vital Signs Report • Yellowstone's First Bioblitz

NEWS & NOTES

NPS

YCR Chief Tom Olliff Moves to Inventory and Monitoring

Tom Olliff, Chief of the Yellowstone Center for Resources since 2006, left his position November 6, 2009, to become the Coordinator of the Greater Yellowstone Inventory and Monitoring Network (working with Yellowstone and Grand Teton national parks and Bighorn Canyon National Recreation Area) in Bozeman, Montana. Olliff will continue to serve as one of the Intermountain Region representatives on the National Park Service Climate Change Steering Committee and will co-chair the Adaptation Workgroup.

Greater Yellowstone Area Grizzly Bears Returned to Threatened Status

Grizzly bears in the lower 48 states were originally listed as threatened under the Endangered Species Act in 1975 due to the curtailment of their range, high mortality, and the genetic isolation of populations from one another.

In 2007, the U.S. Fish and Wildlife Service (USFWS) designated the Greater Yellowstone population of grizzly bears a distinct population segment (DPS), removed them from threatened status, and transferred control of grizzly bears in the DPS outside of Yellowstone and Grand Teton national parks from the federal government to the states of Idaho, Wyoming, and Montana.

On September 21, 2009, grizzly bears in the Greater Yellowstone area were returned to federal protection under the Endangered Species Act by U.S. District Judge Donald Molloy. Molloy said the conservation strategy on which the USFWS based its delisting was "unenforceable and non-binding on state and federal agencies," and did not meet the requirement of the act to ensure rules were in place to protect bears after delisting.

The order concedes that the grizzly bear population size within the recovery zone is not unacceptably small and that grizzly bears are recovered over a significant portion of their range. However, Molloy charged that the service did not adequately consider the impacts of climate change and other factors on whitebark pine nuts, a key grizzly bear food source.

The USFWS has filed a request asking the judge to amend his decision and will join the Department of Justice in considering options for an appeal if the judge's decision is not amended.

2009 Summer Bison Count

Yellowstone's 2009 summer bison population abundance estimate was 3,300 bison, compared to 3,000 bison in summer 2008 and 2,900 adult and yearling bison in late winter 2009. The peak population estimate of 4,900 was recorded in the summer of 2005.

The 2009 estimate is based on a series of aerial surveys conducted in June and July. The population includes 2,800 adult and yearling bison, and 500 calves of the year, and is nearly equally distributed between the central and northern range herds.

The observed rate of population change this past year is within the natural expected range for wild bison. The rate at which wildlife populations increase in abundance is a reflection of the combined effects of reproduction and mortality, and is heavily influenced by the age structure of the population and habitat conditions encountered over time.

Specific management actions under the Interagency Bison Management Plan (IBMP) may be modified based on expected late winter population levels as corroborated by the summer population estimate. The IBMP is designed to conserve a viable, wild bison population while protecting Montana's brucellosis-free status. The five cooperating agencies operating under the IBMP are the National Park Service, the USDA Forest Service and Animal and Plant Health Inspection Service, the Montana Department of Livestock, and the Montana Department of Fish, Wildlife and Parks.

Superintendent's 2008 Natural Resources Vital Signs Report Released

Yellowstone has released its first "Superintendent's Report on Natural Resource Vital Signs." According to the report, the park faces challenges from environmental changes taking place inside and outside park boundaries.

This report reviews research and data on more than two dozen indicators selected to monitor the condition of park natural resources. It indicates that greater effort is needed to revitalize the cutthroat trout and trumpeter swan populations. It also raises concerns about how air pollution from outside the park may be changing native plant habitat inside the park.

The report is part of an ongoing effort to better understand the Greater Yellowstone Ecosystem by gathering, analyzing, and making data widely available for decision-making and research needs. The report is available on the Greater Yellowstone Science Learning Center website at: www.greateryellowstonescience.org.

Yellowstone's First Bioblitz

On August 28 and 29, 2009, approximately 125 volunteer scientists from across the country gathered in the northwestern corner of Yellowstone National Park to conduct the park's first bioblitz. A bioblitz is a 24-hour event that brings together professional and amateur scientists, students, and local natural historians to explore, share findings, and educate the public about biodiversity. It is a way to document species composition and presence in a survey area at a specific point in time.

Participants worked together to observe and identify as many local plant and animal species as possible in the area between Mammoth Hot Springs and Indian Creek. More than 1,100 species were documented during the event and that number continues to grow as taxonomic experts work in labs to identify additional organisms.

The Yellowstone National Park bioblitz was also an opportunity for volunteer scientists to work across disciplines. Nematologists worked closely with botanists, and mycologists offered samples of giant puffball mushrooms to entomologists for dissection in search of burrowing insects.

Participating scientists documented many of the less-studied organisms in Yellowstone. Mike Ivie, associate professor and curator of entomology at Montana State University, noted that "there are 450 species of beetles found around elk and bison carcasses on just the northern range. That is perhaps a third of the beetle species in the park, yet not one of them has had its ecological role studied in the way we have studied bears, wolves, elk, or coyotes.… Mammals comprise less than 1% of the multicellular biodiversity in an ecosystem. What are the other 8,000 species that are expected to occur in Yellowstone National Park, and what are their roles in the system?"

NPS/RODMAN

Park visitors were able to view and explore specimens collected during the bioblitz.

P. OSTOVAR

This tiger beetle was first documented in the park during the bioblitz.

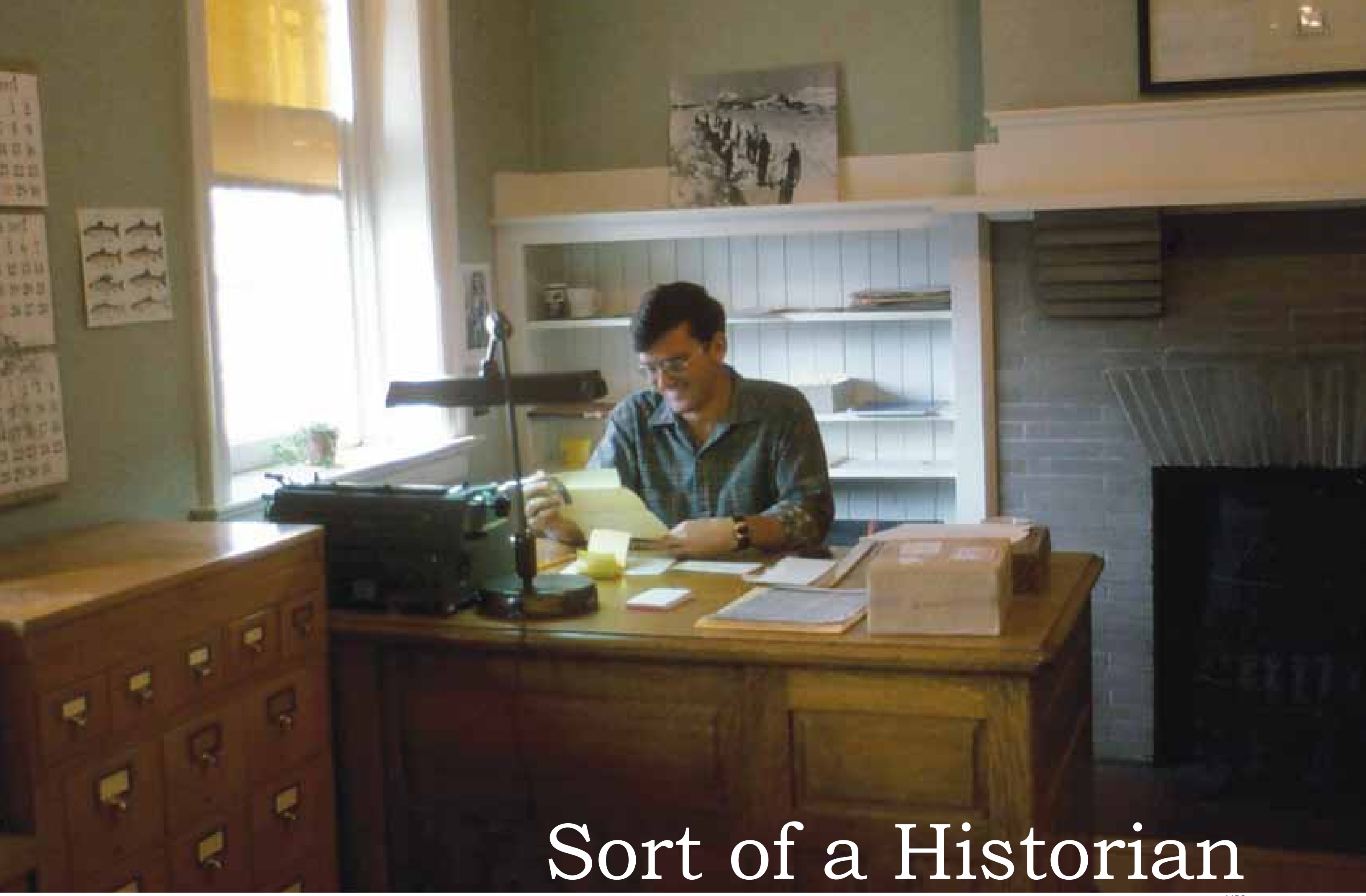
Jessica Rykken of Harvard University's Museum of Comparative Zoology organized teams to collect annelid worms, millipedes, centipedes, isopods, ants, and bees. The specimens were sorted during the bioblitz, packaged, and sent to taxonomic experts across the country. One hundred and twenty-eight fly species were documented for the first time in the park during the bioblitz.

At the conclusion of the survey on August 29, bioblitz participants shared their findings with visitors at the Albright Visitor Center in Mammoth Hot Springs. Visitors of all ages took part in hands-on activities including watching a 3-D bug show, playing a bird-call memory game, viewing live birds of prey, exploring skulls and animal tracks, and viewing specimens under microscopes.

The Yellowstone National Park bioblitz was funded by a generous grant from Canon U.S.A., Inc., to the Yellowstone Park Foundation. Those monies were matched in 2008 by federal funds from the National Park Service's Centennial Challenge for the Greater Yellowstone Science Learning Center. The planning team for this event included staff and volunteers from the Yellowstone Association, the Big Sky Institute at Montana State University, Rocky Mountain College, and Yellowstone National Park.

For more information on the event, including a map of the research area and a list of documented species, visit the bioblitz page on the Greater Yellowstone Science Learning Center website: http://www.greateryellowstonescience.org/getinvolved/outreach/bioblitz/yellowstone.

YS



Sort of a Historian

NPS

Paul Schullery at the desk supposed to have been Hiram Chittenden's in the park historian's office, 1974.

In January 2009, Yellowstone Center for Resources Chief Tom Olliff and Yellowstone Science *editor Tami Blackford sat down with Paul Schullery to interview him following his retirement in December 2008. Paul first worked in Yellowstone National Park as a ranger-naturalist in 1972, and throughout his career held a variety of positions in the park, including historian-archivist, technical writer, senior editor in the Yellowstone Center for Resources, chief of cultural resources, and environmental protection specialist. He holds a B.A. from Wittenberg University and an M.A. from Ohio University in American history, and an honorary doctorate of letters from Montana State University. Paul is the author, co-author, or editor of 40 books about nature, conservation, history, and outdoor sport, including 10 books about Yellowstone. He has authored a series of books about the history, natural history, and cultural complexities of the sport of flyfishing. He is the recipient of numerous awards and honors, including the Wallace Stegner Award, given by the University of Colorado Center of the American West for "a sustained contribution to the cultural identity of the American West." In 2002 he wrote and narrated the ABC/PBS film* Yellowstone: America's Sacred Wilderness, *for which he received Wildscreen International's Panda Award for screenwriting. He was also an advisor for and appears in the recent Ken Burns film* The National Parks: America's Best Idea.

Yellowstone Science (YS): How did you fall into this life?

Paul Schullery (PS): "Fall" is the right word for it. No one could have been more surprised by it than I was. The first time I dropped out of graduate school, in 1970, I had virtually no idea of what to do next, so it was easy to imagine that I might as well just try some things. For all I knew, I'd do that my whole life. When I first came to Yellowstone to work in '72 I figured it would be a fun way to spend a summer and then I'd do something else.

YS: But why Yellowstone in the first place?

PS: I'd been to Yellowstone in '62 as a kid on the stereotypical family vacation. At some point between then and when I finally came to work in Yellowstone, I became aware that the West had a powerful attraction for me, but I didn't know why, or even what part of the West. Then in the summer of '69—hard to believe that was 40 years ago—when I was a college student in Ohio, a pal and I made a big trip around the West in his Mercury station wagon, and we stopped in Yellowstone to see another pal who had a summer job as a gate ranger at the South Entrance. He wasn't much interested in the outdoors, so he worked at the gate all day and seemed to spend the rest of the time in his trailer reading paperback novels.

Well, the reading sounded great to me too, but unlike him I really did enjoy the outdoors, so this looked like a pretty sweet deal. My spectacular blitheness at the time still makes me laugh. I said, "Gee, this is swell, Jim. How'd you get this job?" And he said, "Oh, it was easy. My dad just called Congressman Miller." I realized that my dad also knew Congressman Miller, so that was that as far as I could see. I was so naïve I didn't realize that this wasn't how everybody got a job in Yellowstone. It didn't occur to me that our dads both happened to be prominent Republican citizens of our community and there might be a connection there. I just filed the idea away in my head, and a year or so later I got around to having my dad call Congressman Miller. Sure enough, I got a job in Yellowstone. Ignorance really did amount to bliss.

What makes all this even goofier is that Glacier was my first choice. At the time, when you filled out the paperwork, you were asked to name your first, second, and third choice for where you'd like to work. I'd never been to Glacier, but I'd heard that the crowds were smaller there than in Yellowstone. Maybe I thought it would give me more reading time. I knew essentially nothing about these parks. I had no idea what I was getting into.

Anyway, in late May, this would have been '72, I showed up in Mammoth and discovered that I wasn't going to be a gate ranger and spend my summer reading trashy paperbacks. I was going to be something called a ranger-naturalist. I was going to have to stand up in front of people and talk. Imagine my surprise.

YS: What was the young Paul Schullery like?

PS: Clueless, but apparently I was tolerably likeable because everybody I worked with was endlessly patient. I did have sense enough to be intimidated by the job, of course, but Yellowstone was instantly exciting. I immediately wanted more of this. I read everything I could find, and pretty much right away I seemed to realize how important Yellowstone was. I guess I described this in *Mountain Time* [1984]—how quickly I found a sense of cause and personal direction. All the other seasonals I met seemed to have a passion for nature and conservation and they all knew so much about the park. I just stepped right into that excitement.

…Yellowstone was instantly exciting. I immediately wanted more of this. I read everything I could find, and pretty much right away I seemed to realize how important Yellowstone was.… I found a sense of cause and personal direction.


NPS

Historic pageant at Old Faithful anticipating the arrival of President Ford in 1976. *From left:* Don Arceneaux, Paul Schullery, John Whitman, and Susan Sindt.

YS: How did you get involved in Yellowstone history?

PS: I was interested in history when I got here. My undergraduate major was history. I didn't necessarily expect to use that in Yellowstone, but one day that first summer I was looking at some of my paperwork, probably a pay slip, and I noticed that unlike my new friends who were called ranger-naturalists, my official title was ranger-historian. So I went over to the administration building to see Stan Canter, the assistant chief naturalist, one of those patient people who saw me through that first year. I said, "Stan, I see here that I'm called a ranger-historian. Does that mean that I'll get to do research or something?"

And Stan said, "No, Paul, actually, that was the only way we could hire you. See, when the word came down that we had to hire you, you were so completely unqualified for any job here that we had to reactivate this old historian position." I began to understand the importance of Congressman Miller in my life.

It's a funny story now—that I could be so naïve—but I felt terrible about it. I was from the '60s, and I believed in justice. Some of the other seasonals had spent years trying to get any sort of job in the park service. They went to college for years to be qualified for this work, and I just waltzed right to the front of the line because my dad knew Congressman Miller. I wondered if I should quit, but Stan disagreed. He said that usually the "politicals"—that's what we were called—worked out pretty well, and he insisted that I'd already proven myself, so I shouldn't worry about it. Apparently the congressmen who dispensed these patronage jobs checked into us before giving us jobs, which amounted to a kind of quality control, and the system worked pretty well. The most famous political I heard of back then, at least I think he was a political, was Jack Ford, Gerald Ford's son, who was a law enforcement ranger at Tower one summer in the mid-seventies. I heard he was a good ranger.

Joanne Timmins [Chief of Administration in Yellowstone] tells me that some years later the patronage jobs eventually did get phased out. Apparently they even tried political appointments as high up as the superintendency in one park. It didn't go well.

YS: Tell us more about your interest in history.

PS: Well, even though my title was meaningless, they let me be sort of a historian anyway. When I arrived in 1972, we gave an interpretive walk around historic Fort Yellowstone, just a one-hour stroll with a ranger-naturalist. In 1973, someone decided to convert it into a living history program. We got replica uniforms of 1915 noncommissioned cavalry officers, and presented the walk as if it were 1915 and we were showing those early visitors around an active army post. By default, I became our researcher. Someone decided it was okay to give me a key to the archives, and I spent a lot of time looking for useful information for the walk.

NPS

The Yellowstone Archives (pictured here circa 1974) contain National Park Service records (*left*) dating from the creation of the Service in 1916 as well as army records (*right*) from the military administration of Yellowstone 1886–1918.

Looking back, I realize that I couldn't have asked for a more meaningful way to start being a practicing historian. I got to explore and use the Yellowstone Archives. I communicated with the National Archives to acquire copies of other records from the army period. I met other living history specialists. Eventually I built up a file of reference materials we could use to give a little more depth to what was at first a fairly rote presentation. It was fun to be able to rattle off the 1915 price of eggs, or announce various obscure regulations, or quote from the orders of the day. I liked to whip out my copy of the little red book of regulations and read to visitors about not letting their laundry flap in the breeze because it spooked the stagecoach teams.

NPS

Paul reads army regulations to visitors on a living history tour of Fort Yellowstone in 1976.

YS: Where were the archives?

PS: Upstairs in what is now called the Albright Visitor Center. The room on the northwest corner of the second floor was the historian's office. I was told that the grand old desk in that room (*page 4*) had once been used by Hiram Chittenden, and I knew it was the room where Aubrey Haines worked when he was park historian in the 1960s. Stepping into that grand a tradition was daunting, but it was also seriously cool.

Anyway, the archives were in the room next door to the historian's office, along the north side of the building. It was mostly army records and some older NPS records, a real treasure trove. Every box was full of interesting stuff—the whole story of how the park got where it was. I always use the example of the first time I found myself looking at a signed Theodore Roosevelt letter as a way of illustrating how exciting the material was, but really it wasn't about this or that document, it was the richness of the whole documentary record that was so exciting. Every important modern park issue has its biography in the archives.

YS: What else did you do with the archives?

PS: The important thing was continuing Aubrey's work at refining the collection, and trying to call attention to the importance of the material. I suppose my biggest project was overseeing the completion of the microfilming of the army-period records, which had been started in the 1960s. I also indexed some of the earliest army correspondence, from the 1880s and 1890s.

NPS

Formerly occupying just a small in room in the Albright Visitor's Center, the Yellowstone Archives is now a part of the National Archives and is housed within the Yellowstone Heritage and Research Center in Gardiner, Montana.

But the archives also opened up research directions for me personally. In 1974, when I started spending winters working in the archives, it occurred to me that the archives provided a perfect focus for a thesis project. My master's thesis [Ohio University, 1976] and my first articles in history journals grew out of those winters.

YS: So there wasn't much public interest in the archives at the time?

PS: Hardly any. Once in a while someone would show up, but even visits from park staff were pretty rare. Except for Aubrey, who gathered most of the oldest material together in the 1960s, essentially creating the archives, professional historians had hardly made any use of it. Most didn't even know it was there.

And here's something that I think has been especially important about history research in Yellowstone. At least as long as I've been around, scientists have been among the most serious supporters of the need for an energetic history program. [Biologist and later Chief Biologist] Mary Meagher had been park curator in the 1960s, and she understood why the collections were so important. She used the archives for her park wildlife history research, and was a great advocate for their development. And [NPS wildlife ecologist] Doug Houston, [NPS plant ecologist] Don Despain, and [U.S. Fish and Wildlife Service biologist and later Director of the Yellowstone Center for Resources] John Varley all took a personal and professional interest in the collections. I can't say how much it meant to me, as a brand-new historian, to have those people interested in what I might find. This was before very many people in the historical profession saw much use in exploring the scientific issues involved in the history of the park movement in America—before most of us had even heard terms like "environmental history" or "historical ecology." The humanities and sciences didn't overlap much then.

Subversive Years

YS: Speaking of science, in 1968, the National Park Service started implementing what people call natural regulation or ecological management. In 1972, we began to allow fires to burn, which must have been completely counterintuitive in the country at the time.

PS: That's right, and it wasn't just the fires. A lot of the things we interpreters were telling visitors, or asking them to believe, must have seemed counterintuitive, if not downright subversive. As these policies changed, Yellowstone was full of surprises, especially for visitors who'd been coming there for years: "You're letting the forests burn? We gotta throw the fish back? We can't feed the bears? Who *are* you people?" These were big changes all at once, and though most people were willing to listen, some of this was a pretty hard sell even to sympathetic audiences.

It was a great time to be an interpreter, though. We had all these exciting new messages to try to get across, in a world that was just starting to awaken to an environmental consciousness. It was easy to be buoyed up on a sort of Earth-Day hopefulness, to want to go out there and spread the good word. I hope it's still like that for them today. I remember how often we'd stay after our evening programs and talk and talk with people around the fire for a long time. We'd come back from our evening programs so jazzed from all the talking and sharing that it would take hours to unwind.

A lot of the things we interpreters were telling visitors, or asking them to believe, must have seemed counterintuitive, if not downright subversive. As these policies changed, Yellowstone was full of surprises, especially for visitors who'd been coming there for years…


STEVE SCHULLERY

Paul presents a traditional campfire talk at Indian Creek campground in 1973.

YS: You talk about spreading the good word. Today we have so much new science to work from, and there was so much less then. How did you even know what the "good word" was?

PS: Sometimes we didn't. When it came to the new policies, the word was good, and worth spreading, but it was also pretty vague. Each new season in the 1970s we [in the NPS] had another year of the new management program for grizzly bears, fish, bears, fire, or whatever under our belts, and there was a little more information to go on.

YS: How did the public receive all this?

PS: You'd have to ask some of the others who were working with the public then to get a good cross-section, but it was pretty rare that anybody in my campfire audiences spoke out against what I was saying. Partly that was because most of what I was telling them was just generalities, but also I eventually realized that, even though this policy and ecology stuff was at the center of my personal world, most park visitors hadn't heard anything about it. Yellowstone issues were just beginning to rise to national interest. The grizzly bears or the elk might make the nature magazines or the hook and bullet press, but they didn't show up much yet on the nightly news. The folks who came to my campfire programs were enthusiastic about the park, but I discovered that very few of them were even marginally aware of the controversies.

Of course it wasn't like that for the superintendent, or the park biologists. I wasn't in the line of fire and they were, but even in the 1970s it seemed to me that some critic or other, maybe a scientist or conservation group or some other regional interest group, was always unloading on the bosses about what was wrong with park policy.

YS: Nothing new about that.

PS: No, that's old news in Yellowstone, but even in the 1970s I was told that it was intensifying. It was a bad time for any federal agency to make big policy changes and say "Trust us!" The public always has its doubts about the feds, but this was in the last days of a really unpopular war we were losing, to say nothing of Watergate.

And natural regulation, as good an idea as it turned out to be, was such an easy target, being based on unfamiliar theory and even on political expediency. It made a lot of people nervous.

But I'd like to reinforce something you mentioned a minute ago, an amazing change that has occurred in just a few decades, and it has to do with information. We now have so much wonderful research and scholarship that it's almost unimaginable how different it was only 40 years ago. When I started work in 1972 the only book-length history of the park that we sold in the visitor centers was a trimmed-down version of Hiram Chittenden's book, which said essentially nothing about the park's history after 1900. Imagine! In 1974, both Aubrey and Richard Bartlett published their first books of Yellowstone history, but again, neither book carried the story beyond the late 1800s.

It was even worse with wildlife information. In 1973, Mary Meagher's monograph on the bison appeared. That was a real scientific milestone, but otherwise we had very little besides tourist booklets and standard field guides to offer the pubic. For a while we sold a reprint of Murie's 1940 monograph on Yellowstone coyotes, which was great natural history but didn't answer any of the questions we were getting in the 1970s. We didn't even have a book about the famous bears. The overhaul of NPS management policy only got rolling in the late 1960s, and it was in such an early stage that the science was still in the works, and information was pretty sparse.

YS: So how did you handle that?

PS: As near as I could tell, we must have done pretty well. I don't know how it was earlier, but by the 1970s a lot of the seasonal ranger-naturalists had biology or other science backgrounds. They were smart people, and I think they generally intuited their way toward a more complete narrative for their programs. Most of the campfire programs weren't about policy, of course; they were about all the park's famous wonders, and there was lots to say. And at that time, the public was probably getting most of their information about how nature works from *National Geographic* and Disney-type television shows, so they weren't all that demanding an audience.

But what I remember as most important was that the biologists rescued us. They wrote dozens of these handy information papers, one- or two-page mimeographed summaries, on all the important subjects. When it came to really specific questions about park wildlife or about the changing policies, we lived on those things. We had little racks of them behind the visitor center desk at Mammoth; I guess the other visitor centers did too. Though we couldn't have known this at the time, I can see now that several of those little essays were classic statements of policy intent or even ecological theory. I always thought they should have been put together in a book. Maybe they still should.

And every year at seasonal training, the biologists would come and give us updates on the hot wildlife issues.

YS: By "biologists" you mean Mary Meagher, Doug Houston, Glen Cole—

PS: And Don Despain, and the guys in the U.S. Fish and Wildlife Service office. They'd all take a turn and explain their research, especially what might have happened over the previous winter when most of us were far away doing other things.

I suppose the other thing that impresses me most when I think back on that era is that we seasonal interpreters were the ones who were counted on to go out and explain all this startling new policy stuff to the public.

YS: Isn't that what interpreters had always done?

PS: Yes, but historically, the advocacy of cutting-edge policy changes wasn't a big part of the tradition of the ranger-naturalists. In the early days of the National Park Service, the 20s and 30s, ranger-naturalists were most often known for giving successful but superficial canned presentations aimed at the audience's lowest common denominator. They were called "Sunday supplement scientists." Remember that for 50 years we ranger-naturalists were the foremost purveyors of the myth of the Madison campfire of 1870, when the Washburn Party was supposed to have cooked up the idea for the park. And here we were in the 1970s, being called on to help explain change rather than tradition. Sure, we were better educated, and a lot of us were already activated by the environmental movement, but I still cringe when I wonder what I must have said during all those hundreds of hours I talked to people at my campfire programs and nature walks.

Today's interpreters probably have the opposite problem. There's such an overwhelming wealth of exciting science, with data and analytical methods that get more incomprehensibly complex all the time. It must be hard to keep up. But as an old interpreter, I envy them the luxury of that abundance.

YS: But all that great new information has been accompanied by a tremendous increase in public attention to Yellowstone's issues. You mentioned that it was intensifying in the 1970s, and even then it probably seemed like all that interpreters could handle, but it is even more intense today. What accounts for such a dramatic change?

PS: Speaking as a historian, I'd love to be able to ask the five most recent superintendents, if only Jack Anderson and John Townsley were still alive, to reflect on that question. Nobody could track that as well as they could. But I agree with the conventional wisdom that several things all tended to ratchet up Yellowstone's dialogues, or fights, or whatever they should be called. One thing everybody points to is the media's discovery that environmental issues could make headlines. I'm told that post-Watergate journalism changed, too, as more journalists saw stories in terms of their potential for Watergate-style drama, or exposure, or, worst of all, professional glory.

…An amazing change that has occurred in just a few decades…has to do with information. We now have so much wonderful research and scholarship that it's almost unimaginable how different it was only 40 years ago.

YS: Conrad Smith's studies of the media coverage of the fires of '88 would seem to reinforce that.

PS: I think so, and I think that most people agree that the fires of '88 were the biggest change of all. For the first time, the park became nightly news. This gave Yellowstone stories a kind of status, or visibility, that didn't automatically go away just because the fires went out. After 1988, several smart, well-connected journalists with a national reach were making a significant part of their living from Yellowstone issues. Then wolves happened, another wonderful story with a perpetual appeal to journalists and the public. By the time of wolf recovery it may not have been so much that the media watched Yellowstone closely for a new story, as that a new story from Yellowstone was by definition important.


NPS/PEACO

Paul Schullery, Wolf Fund founder Renee Askins, Resource Interpreter Norman Bishop, and Acting Superintendent Rick Smith attend a briefing at the Crystal Creek wolf pen in October 1994.

Natural Regulation Turmoil

YS: You keep returning to your experiences as an interpreter, even when the question is about some big policy issue.

PS: Yes, it surprises me a little too, but I guess that many of my basic notions about how things work or don't work in Yellowstone have grown out of those six summers in the '70s when I was having to learn what the park was about and then go out and explain it to regular people. We took it all so personally. The stakes were so high.

YS: What stakes?

PS: I stumbled into Yellowstone at a unique time of turmoil. As you pointed out, there was this revolution in national park management underway, and a lot of the attention focused on Yellowstone. Some of this came about because of the environmental movement, but there was so much happening at once. There were the ripples from the Leopold and Robbins reports [1963], there was more and more new environmental legislation, and the sciences relating to wildlife and the environment were drivers in the whole conversation over the parks. There was so much new thinking.

There's a statement from this period that I think symbolizes the change. In 1968, when the NPS was looking hard at the problems around the Fishing Bridge development, [Park Biologist] Bill Barmore did a report on the ecological realities of the situation and concluded that if we had it all to do over again, we probably wouldn't have built a development right there at the outlet of Yellowstone Lake, in such an ecologically sensitive area. I think that remark, with its conjectural, open-minded tone, symbolized a new era in NPS thinking, when, at least now and then, it was okay to take a harder look at all the old ideals and dream of new ones. As the NPS started to take science more seriously, it was impossible to avoid taking a harder look at all those things. I see the effects of this change, in spirit at least, in many later issues. Fill in the blanks. If we had it to do all over again, we wouldn't have wiped out the wolves. We wouldn't have introduced commercial feed crops in Lamar Valley. We wouldn't have fought natural fire for a century. We wouldn't have dumped nonnative fish into park waters.

NPS/BILL VOIGT

Nonnative fish like this brook trout, caught in Little Blacktail Creek, were historically stocked in park waters in order to provide sportfishing opportunities.

Underneath pretty much every controversy, no matter how grand or mundane, is the question of how wild Yellowstone should be—how far back are we willing to stand? Can we ever just let nature happen?

YS: But some people would ask, what's the point of saying it if there's nothing we can do about it?

PS: But we can be aware. I think that keeps our collective conscience running. It's still a great exercise to ask those questions. Would it ever possess us today to go to the shore of Yellowstone Lake and build a huge bright yellow hotel with lights blazing like a beached ocean liner?

YS: Back to the stakes you mentioned.

PS: At its most heartfelt level, the controversy over natural regulation exemplifies warring human value systems—the highest stakes going in our society. The extreme positions are the easiest to identify. There's the intensely agricultural versus the purely wilderness, or, put in another way, the zoo versus the wildland. From the beginning, even when natural regulation wasn't such a loaded term, a lot of people took the concept very personally. The very idea of natural regulation confronted us with hard questions. Was the park going to farm its elk, grizzly bears, and other charismatic features? If so, to what degree? Or was the park going to foster some larger and very hard-to-define resource called "wildness," and leave the details, like the size of each wildlife population, up to the wild community to sort out? How you answered that question depended a lot on how you perceived humanity's place on the planet. Underneath pretty much every controversy, no matter how grand or mundane, is the question of how wild Yellowstone should be—how far back are we willing to stand? Can we ever just let nature happen?

It's ironic, really. I mean, here we are, probably the most nature-dominating culture in human history and yet we've created this institution that requires us to let nature make its own decisions.

Park Service Culture and Counterculture

YS: Let's shift gears and talk about something you've alluded to a few times, this whole idea of agency culture. Today there's a lot of park staff in what might be called the loyal opposition—the ranger who has the bumper sticker that says "Wolves: government sponsored terrorists," or the interpreter who works for


NPS

Yellowstone NPS historians: Lee Whittlesey, Aubrey Haines, Paul Schullery, and Tom Tankersley on Dot Island in 1993.

the Buffalo Field Campaign on her days off. Was that prevalent back in '72? Was it different when you had a lot of people who had been here for a long time? Was the culture more unified back then?

PS: That's another question I wish we could ask former superintendents. Things like that don't necessarily show up in the official administrative record, so you can't just go to the archives and track it over the decades. In its earliest decades, the agency apparently had much more of a military mood, and a higher premium was put on abject loyalty. But even then if you read the right memos you can see that some issues involved some pretty heated internal disagreements. I suspect that until the social movements of the '60s, when the nation began to get a little more tolerant of dissent generally, there weren't nearly as many opportunities for the sort of loyal opposition you're talking about. Back then, much of the opposition that we regard as normal today probably wouldn't have been regarded as loyal in the first place.

But I don't think that's what you're talking about.

YS: No, this is about something much more visible, like staff overtly working in opposition to some official position.

PS: The episode of dissent that must come to mind first happened in the 1960s, when Aubrey Haines' attempted to rewrite NPS history by demonstrating the mythic nature of the Madison Campfire story. Lee Whittlesey and I devoted much of a book to this whole sad affair. It cost Aubrey personally and professionally for taking on the agency's most cherished fairy tale. But I guess that Aubrey's case isn't the kind of thing you're talking about either, because he didn't go public. He wrote his memos, did his homework, and stuck with the chain of command. He was totally loyal, even though the hard-liners in Washington stopped just short of physical violence to try to shut him up.

In 1988 [then Chief of Public Affairs] Joan Anzelmo told me that there were park staff who were simultaneously working as stringers [reporters] for the wire services. Some people, including I think Joan, saw this as disgracefully disloyal, like spying, but I'm sure the people doing it believed they were serving the highest cause. Of course, it's easy for me to sympathize with them; I never had to clean up the messes that resulted in these situations.

I do wonder how the broader agency culture judges dissenting behavior even today. I can remember not that long ago one older park service lifer commenting on some loyal opposition by saying, "It must be a bitch to take that paycheck."

On the one hand there's validity to a comment one of Yellowstone's rangers once made, "I don't see no anchor tied to *your* ass." Which was to say, if you don't like it here, you can leave. But on the other hand, a lot of us would feel like quitters if we didn't stick with the work and try to fix whatever problem we perceive, rather than bailing out at the first sign of trouble.

Somewhere I still have the mimeographed handout given to me my first year as a ranger-naturalist that had a diagram showing precisely how long my sideburns could be. It seems trivial now, but those old standards were a holdover from the agency's early military leanings. It felt like a big deal at the time, and some of it really did matter. This was the same time when female ranger-naturalists were required to wear those demeaning stewardess outfits rather than a real ranger uniform. The whole tradition was long overdue for a cleanup. Keith Hoofnagle, the great ranger-illustrator in the 1970s, was always doing cartoons in NPS publications that took on whatever tradition seemed to have lost its validity. My favorite was one about a supervisory ranger with a big pot belly who disapproved of young rangers with beards. I bet it was taped to the wall in offices all over the National Park Service. That's effective dissent.

YS: But it's still not the kind of conflict we see today.


NPS/R.ROBINSON

Three female rangers at the ribbon cutting ceremony for John D. Rockefeller, Jr. Memorial Parkway, September 1972.

PS: Well, how about [Resource Management Coordinator] Jim Sweeney's Yellowstone employee organization, about 20 years ago? It was called something like the Yellowstone Park Preservation Council. I don't know what brought it on, but to my knowledge that was the first time that park staff formally organized in opposition to management or policy.

YS: That's more like the examples I mentioned.

PS: When you've had a chance to watch the adversarial thing, the we-versus-they relationship that seems to persist any time you have people in charge of other people, you can't help feeling it shouldn't have to be so destructive. Sometimes the differences really are irreconcilable, but I think most employees tend to underrate the accessibility of their bosses, and don't give themselves enough credit for being able to communicate some important idea or even to have an effect on the thinking of the superintendent.

Here's a different angle on it. If there's a hostile administration in Washington, superintendents have to walk the same tightrope as the rest of us when *they* become the loyal opposition. The difference is that if it's you or me, the advocacy groups don't write editorials insisting we lay down in front of the bulldozers. Someone is always volunteering some superintendent somewhere for professional suicide on behalf of the good cause of the day. But except for that, maybe the realities of the situation aren't all that different no matter where you are in the chain of command. [Former Yellowstone superintendent] Bob Barbee once told me that if you find yourself in one of those situations where you're the loyal opposition and you decide to fall on your sword over some issue, make it count, because the next day the agency will still be doing business as usual and someone else will have your job and will probably just do what you refused to do.

More Luck and Peculiar Career History

YS: You mentioned coming back to Yellowstone in 1988. What brought you back as a full-time employee?

PS: In the summer of 1988 I was in Pennsylvania working as a magazine editor. I was watching the fire story on the nightly news, wondering what was really going on when, thank heavens, John Varley called and asked me if I'd like to come out and help them explain the fires to the world. That sounded just perfect to me.

By the way, this was another one of those unorthodox appointments, like being a political seasonal. The National Park Service was taking a lot of flak for its fire policies, the fires were being mishandled wholesale by the media, and the director [William Penn Mott, NPS Director in 1988] instructed Bob Barbee to hire someone to help tell the story as it looked from inside. Bob told the director that he knew just the guy, and John called me. I've been grateful for that opportunity on a daily basis ever since. And my dad didn't even have to call Congressman Miller.


NPS/JEFF HENRY

Bob Barbee, then superintendent of the park, speaks at a press briefing during the fires of 1988. Barbee chose Schullery to help communicate the science of the fires to the media.

YS: What did you do?

PS: In a way it was like 1972 all over again. My learning curve was vertical. Mostly I did what we called "translation," putting the science and history of fire into regular English for a broader audience. I wrote and co-wrote a lot of things. Then once the first flurry of politics and post-fire reviews and advocate position-staking was passed, we just moved on to other things. If we thought something needed doing and no other office in the park was doing it, we'd give it a try. By the early '90s we were the Yellowstone Center for Resources "Publications and Events" office and were doing a lot of things, like the reports to Congress on wolves and different topical annual reports. I was also doing the occasional history research project, like on wolves, but a lot of our energy went into *Yellowstone Science* and the conferences. I don't mind telling you that even in the research office, some of my colleagues were very uncomfortable about having someone like me around. And even if what I was doing was important, why was I doing it in a science office?

YS: It just wasn't being done then.

PS: There was even a little grumbling that the research office was no place for a "propagandist." I'm still surprised that I was able to laugh off such a mean-spirited insult, but I guess there just wasn't time to worry much about it. We knew what we had to do, and it mattered. Nobody anywhere in the chain of command ever told me to lie or twist any story. That wasn't what this was about. I'd spent the previous 15 years watching Yellowstone's policy get misrepresented in the press, and seeing important science get ignored just because nobody felt the obligation or had the time to explain it. In a way, for all the other mistakes that park managers might have made along the way, failing to foster public understanding was the most harmful. We wanted to find ways to make the policies and the science more accessible. And we were sure there had to be ways to get scientists to explain their science to a popular audience.

YS: That's tough for scientists. They're not trained to do that.

PS: Apparently some of them are trained that they *shouldn't* do that, like it's beneath the dignity and purity of their calling. But that wasn't what we heard from most of them. What has always impressed me about the researchers I've worked with here is that they're really good at explaining their work. They can sit down with you and in a brief conversation tell you what they're doing and what it means. They are an amazingly articulate crowd. It's only when they're assigned to write it down in those same informal terms that they tend to freeze up. That's one reason that when we started *Yellowstone Science* we ran interviews in every issue. It was just another way of getting at all those great scientific stories. Without fail, the researchers we interviewed were really good at explaining their work, and all those interviews brought a nice relaxed, conversational element to *Yellowstone Science*. I always thought we should do a book of those interviews.

YS: Where did *Yellowstone Science* come from?

PS: Just the other day, John and I were trying to remember whose idea it was to start our own magazine. The best we could do was agree we both thought of it. Research in the park was booming, and had increased several-fold since the '70s. By 1990, we found ourselves with something like 300 active research projects. We couldn't imagine why we shouldn't make a publication that featured and celebrated all that great science.

YS: You say that as if others *could* imagine why not.

PS: Oh, sure. The NPS had a policy prohibiting individual parks from having their own publications. I assume that the higher-ups in Washington didn't trust field units to do a good job with such an enterprise. If we hadn't been Yellowstone National Park, with a sympathetic superintendent and Yellowstone's long tradition of going our own way, I doubt we ever would have gotten *Yellowstone Science* off the ground.

YS: It's still true.

PS: There was even a daft NPS policy against spending money on Apple computer equipment. Anyone with the sense God gave a goose knew that Apples were by far the best machines for doing desktop graphics work. Luckily, we were able to go to our friends down the hall in the [U.S. Fish and Wildlife Service] fisheries assistance office. They were allowed to spend money on Apples, so we channeled some money, probably Yellowstone Association funds, to them so they could buy our first Mac.

That experience, just the process of getting past the bureaucracy so we could get on with the actual work, established in my mind a mood I've never lost about *Yellowstone Science*. As much good as it has done for 17 or 18 years now, I still receive every new issue with a fresh burst of gratitude and a sigh of relief that once again Yellowstone has gotten away with doing the right thing.

YS: What were the right things? What did you want to accomplish with *Yellowstone Science*?

NPS/J. WALLER

The number of research projects in Yellowstone increased dramatically from the 1970s to 1990, when there were approximately 300 projects. Much of the research in Yellowstone today focuses on hydrothermal features and thermal biology.

PS: We had all these lofty ambitions. We wanted to celebrate science and increase respect for a scientific attitude among everyone who cared about the park. We identified the researchers as the core audience because we wanted this publication to help make Yellowstone's scattered researchers into a self-aware community. I think it was when the first issue came out that I sent a copy to the editor of *BioScience* to thank them for being such a good model of what we were trying to do.

We also wanted to reduce the amount of what was known as "barstool biology." Bob Barbee used to say that a man can live down the road from a nuclear power plant his whole life and never assume he knows the first thing about nuclear physics, but put that same man on the edge of an elk winter range and in two years he's an ecologist. Yellowstone has always had more than its share of instant experts. Getting the scientific story out there had to help. I guess it sounds pretentious now, but we really believed we could elevate the public conversation about Yellowstone. Even if only a few of the interested people read *Yellowstone Science*, maybe it would serve notice to the others that they couldn't get away with quite so many half-baked opinions. I'm sure that's why we put all the regional congressional offices on the mailing list, too. We wanted to make it really hard for anyone to still believe they were immune to information. I realize that there's no measuring just how well we succeeded, but I think we made a difference.

YS: What you're saying makes it sound like *Yellowstone Science's* editorial line was partly the product of the controversies of the '70s.

PS: Well, it sure was for me. There was this long tradition, all over the West, really, of knee-jerk fed-bashing. I think John and Bob were able to stay philosophical about it, probably because they were on the front lines and were so used to being exposed to that sort of behavior. But I still took it personally and ran into it all the time. Like in 1986, when I was living in Livingston [Montana] and writing full time, I revised my book on the bears of Yellowstone [first published in 1980] for a second edition. When the publisher took the book to the buyer at the gift shop at one of the region's museums, the fellow's first question was "This isn't some more of that park service crap, is it?" You'd like to hope that respectable institutions would be a little more grown up—like maybe noticing that the park service has never really had the corner on crap—but it seemed almost fashionable to say those things about the park.

Anyway, I'm sure it was because of watching and experiencing all that, I bent over backward to try to ensure that *Yellowstone Science* gave no rational person reason to worry whether or not this was a trustworthy publication. I didn't even ask our own staff to write for it for a while, even though they were often the best qualified people, because I didn't want *Yellowstone Science* to be perceived as just a house organ. After a while, once we started hearing that it was pretty well received, I eased up and we started publishing our own people. Now, nobody gives that sort of thing a thought. *Yellowstone Science* is just this swell publication about Yellowstone science.

YS: So who thought of the biennial scientific conference series?

PS: That was Bob Barbee. It was a great idea just for the sake of the park and for the sake of science. Those first conferences were so exciting, such a big adventure. Everybody—scientific critics, scientific supporters, and mostly people who were doing important science with no axes to grind—showed up. The hallway conversations were great.

YS: Did you encounter the same kind of skepticism there?

PS: I don't think so. We worked really hard at establishing co-sponsorship with the relevant scientific societies for each conference. Credibility just followed that, as well as having world-recognized keynoters established a fine tone for the whole thing. Yellowstone, just the chance to visit the place, is a great positive incentive when you extend an invitation to some notable person to come and talk.

YS: Was it easy to get co-sponsors?

PS: It was, but we went out of our way to keep a low NPS profile on the program committees, just to make sure all these people from the societies were comfortable about this whole thing. The program committees did all the critical scientific work, reviewing the abstracts, arranging the agenda, that sort of thing.

I think our biggest failure with the conferences hasn't been the involvement the scientific community; they've been enormously supportive. It's been our poor record at engaging the other federal and state agencies, especially the U.S. Forest Service. They showed up sometimes, and I think that sometimes they even trusted us, but they just didn't have anything like our professional stake in having conferences like this. I got the impression that the forest service research and resource-management culture rewards keeping your head down, which is pretty hard to do at any conference in Yellowstone.

NPS/PEACO

Superintendent Suzanne Lewis speaks at the 8th Biennial Scientific Conference on the Greater Yellowstone Ecosystem. The 10th Conference in this series will be held in October 2010.

But other than that the conference series has been wonderfully productive. We aimed each conference at as interdisciplinary a crowd as we could, and that paid off. If you've got those eight proceedings volumes sitting on your shelf, you're in a position to get a handle on almost any of Yellowstone's research fields. That's my kind of propaganda.

Policy and Perplexity

YS: Let's talk some more about the history of natural regulation. It's an idea, or a theory. It didn't start out as a policy.

PS: No, it didn't. It was just a scientific term to describe certain elements of how an ecological system functioned, particularly how a species' population was regulated in response to its environment. As I understand this, the topic as a research field seemed to gain scientific currency in the 1940s and 1950s, when the first book on natural regulation was published. It was first discussed in Yellowstone in the late 1960s and early 1970s in relation to the northern Yellowstone elk herd. James Pritchard reviews the history of the term in Yellowstone in his book *Preserving Yellowstone's Natural Conditions* [1999]. Anyone wanting to even pretend they're qualified to discuss Yellowstone's wildlife-management policy story has to read that book.

YS: But "natural regulation" in Yellowstone eventually meant something else.

PS: I guess it's come to mean whatever anybody wants it to. It's been tossed around so loosely that I don't suppose people even give its scientific meaning much thought. It started out as a term applied only to studies of the northern Yellowstone elk, but eventually, and apparently for most people nowadays, the term has come to mean everything about how Yellowstone is managed, including fisheries regulations, fire, wolf recovery, and all the rest. In a way, it's just an expansion of the recommendations that George Wright made in the 1930s, that the park's ecological processes should be allowed to act more freely than they were.

YS: Glen Cole was the champion of the idea, the guy that rolled this rock off the cliff—and yet during the controversies of the '70s and '80s, when his name was getting dragged through the mud, there was never a peep from Glen, who was still working for the park service [Cole transferred to Voyagers National Park in 1976].

PS: As I recall it, the part that seemed to get the most national attention in the 1970s involved the grizzly bears rather than the elk. Supporters of the Craigheads were relentless in their attacks on the park, especially on Jack Anderson and Glen Cole, and much of it was mean besides being misinformed. You're right—Glen was demonized. It must have been awful for him, but somehow he set it aside. He just said that science would sort it out. He would publish his interpretations, others would publish theirs, and we'd find out who was right.

YS: That didn't satisfy many people.

PS: No, it didn't. It was frustrating all around. Again, the stakes seemed so high. By '74, when the Craigheads published their first computer model, they predicted the fairly quick extinction of the grizzly bear population. Even for people who were willing to give the park service the benefit of the doubt and allow that Glen's population estimates, which were far higher than the Craigheads', might be right, it seemed reckless to take the chance that he was.

In fact, in a way, that fundamental disagreement is what the debate over natural regulation often has come down to. What is the highest purpose of Yellowstone, and is that purpose enhanced or diminished by taking risks? On the one hand, you could argue that Yellowstone National Park is too valuable to take the chances that have been taken—like closing the dumps in the hope that the grizzly bears would resume their wild food habits, or letting the elk population increase in the hope that their numbers would reach some sort of equilibrium. For some people, especially those of a more husbandry-oriented temperament, natural regulation was too risky, too much of a crapshoot.

On the other hand you could argue with just as much rhetorical force that Yellowstone National Park is too valuable to waste by not taking precisely such chances—that Yellowstone's greatest value to the planet is that it is one of the few places left where we can still let nature make so many decisions, and that even the risk that we may do some harm to the park's natural communities is worth it for what we will learn in the trying.

YS: Is it possible now, almost 40 years later, to declare a winner in those debates?

PS: I suppose. Sort of. Bear biologists today seem to agree that Glen overestimated the size of the grizzly bear population in the 1970s, and that the first Craighead computer model probably did the opposite. So you can track some of the arguments like that and do some scorekeeping.

But the great thing about Yellowstone is how it keeps revising the questions we have to ask. When you try to do a straight "grading" of earlier science based on today's science, you find that too many of the ground rules have changed in the meantime. We've learned so much since then. And we've introduced huge new variables, like wolves and fire. It's true that the elk didn't destroy the northern range as some people predicted, and the grizzly bear population is at least twice as large as it was in 1974, which might seem to argue for Glen's viewpoints. But since his time so many other things have changed that scorekeeping may not be that convincing or even helpful. And things are still changing so fast. I know there are some pretty confident opinions about park ecosystem processes now, but if the historical record is any indication of how this works, all the juries are still out.


NPS/PEACO

Now grizzly bears dig for moths and grubs, not garbage.

YS: Even if scorekeeping isn't that useful, there must be some lessons we can learn from the first 40 years of the debates over natural regulation.

PS: You mean, like big-picture things, rather than specific stuff about elk and bears and badgers?

YS: The big-picture things.

PS: There are many, and I guess everybody has their own list, but for me two things always come to mind right off.

I don't mean to suggest that if we'd rejected the idea of trying natural regulation it would have been the end of the world.… Yellowstone would still be here.… But Yellowstone would be a less exciting and inspiring place and the experience would be a smaller and dumber one. We would have settled for a lesser Yellowstone, and we would have deserved it.

For me, the first is that somehow Glen Cole, whether he was right or not on any specific scientific point or interpretation, had a remarkable sense of direction for a higher use of Yellowstone. I think he ranks up there with Charles Adams and George Wright as a visionary thinker for national parks. And he was backed by a small group of equally visionary colleagues testing that vision. Not just his fellow biologists, and not just the superintendent. There were some determined bureaucrats in Washington, DC, like [Assistant Secretary of the Interior] Nathaniel Reed, who really backed up Yellowstone through this very difficult period. I can't guess at the odds against such a gathering of personalities in science and management happening right then.

The second thing is the inescapable realization that whatever we may think of the natural regulation era so far—and there are apparently still plenty of people who still think the whole thing has been a lousy idea—we have learned infinitely more about Yellowstone's wild character by letting it loose than we would have if we'd stuck with trying to control it. I think it's impossible to overstate the magnitude of what Yellowstone has taught us since the 1960s, and almost all of that new knowledge was only possible because we kept our bloody hands off the place.

I don't mean to suggest that if we'd rejected the idea of trying natural regulation it would have been the end of the world. If 40 years ago we'd decided to keep slaughtering thousands of elk to satisfy commercial agriculture's ideas of what the park's vegetation should look like—or if we'd introduced public hunting to accomplish the same thing, which was pretty close to happening in the late '60s—or if we'd kept feeding the bears, or continued all the other old-fashioned nature-husbandry that was so entrenched here—Yellowstone would still be here. Millions of people would still come from all over the world, and they'd enjoy something special called Yellowstone National Park. But Yellowstone would be a less exciting and inspiring place and the experience would be a smaller and dumber one. We would have settled for a lesser Yellowstone, and we would have deserved it.

CRAIGHEAD COLLECTION

Bear biologists John and Frank Craighead, circa 1966.

The Wisdom of Wildness

YS: Yellowstone's controversies are famous for never ending, but they do evolve. There have been big changes since Glen Cole and the Craigheads were at odds. The grizzly bear population is officially recovered [see page 2]. Wolves are back. So are mountain lions. Fires are allowed to burn. The 2002 National Research Council report put the overgrazing question to rest. It seems like the philosophical questions about how to manage Yellowstone have entered a new stage. Now we have issues of global change that threaten to recalibrate the entire ecological community of Greater Yellowstone. Does our history with different management approaches have anything to teach us about what to do when Yellowstone has changed that much? Is there a point to natural regulation when humans have altered the place so severely? Is natural regulation viable?

PS: These are important questions, but anyone who's studied the history of the national parks sees warning lights flashing when they hear them. They echo the rhetoric of scenarios that have come up again and again, and not just in Yellowstone. The scenario is that something changes, someone announces that the change requires urgent action, and the opportunists rush in. In World War I, lumber companies tried to justify logging Olympic National Park's old-growth forests to help with the war emergency. That was an especially cheap shot, of course, but it typifies how we think.

YS: How does that apply here?

PS: It has always applied here. We're only human. We usually look for justifications for our preconceptions, our preferred interests, or just our convenience. Here's an example of how we can get this wrong, even for the most admirable of reasons. In the 1960s, the Craigheads, who were without question great heroes of grizzly bear science, genuinely believed that we had to keep feeding the bears because the natural setting had been

Horseback in the Gallatin Range, circa 1976.

NPS

NPS/BLACKFORD

With the Chief of the Yellowstone Center for Resources, Tom Olliff (*left*) on the day of this interview in January 2009.

DALE GREENLEY

Flyfishing on the Madison River, October 2004.

NPS

At Slough Creek cabin, 1991.

so altered historically that the bears could not survive without our "help." The Craigheads didn't specify or quantify what the natural setting had lost that was so important to the bears, and they didn't have to. Most people at the time probably would have agreed that Yellowstone must somehow be diminished from earlier times; that was our preconception at the time. All these people meant well, but they sold nature short. The bears have now proved it. They're doing just fine. All we had to do was give them room. I suspect that the American national parks are full of opportunities to stop selling nature short.

YS: But isn't it different if the setting actually is changed?

PS: I'm coming to that. First we have to make sure we understand our motivations. Historically the belief that nature can no longer do some job was usually just a self-serving excuse to get in there and do something intrusive that we always wanted to do anyway. Here's another example. For generations in the United States, we sportsmen have justified hunting, in part, as necessary to control wildlife herds that had lost their predators. That justification was always a little disingenuous, but it's just another reason why Yellowstone makes so many people nervous. Yellowstone proves that if we really want to and are willing to make some adjustments in our thinking and our priorities, maybe we can let nature sort out those wildlife herds. Maybe we can even reintroduce the predators.

Yellowstone has always exported its lessons. Look how widely we exported the principles behind catch-and-release fishing. People, whether managers or scientists or the public, come here, they learn, and they take lots of ideas home where they have an effect on how things are done. And Yellowstone is now exporting the idea that maybe nature doesn't need us quite as much as we thought. That worries a lot of people with more traditional views on nature, and you can bet that at the first hint of new changes in Yellowstone's ecological community, like from global climate change, there will be a rush to step in and get Yellowstone "under control." And what they will want to control first is Yellowstone's subversive effect on public perspectives on nature.

YS: Okay. But what if the system really is permanently or irretrievably altered? Don't we have to ask ourselves if we should do something?

PS: Asking is always good. But now that we have four decades of experience with natural regulation, and now that we see the great benefits of natural regulation, in terms of what we learn and in terms of what we get to experience in the park, how will we decide which parts of that gift to compromise?

YS: Wait a minute. What do you mean by "what we get to experience"?

PS: Ever since it was established, Yellowstone was about authenticity. The first generation of wildland conservationists, like George Bird Grinnell, saw Yellowstone as a rare opportunity to preserve a relic of an earlier North America, where people could get a glimpse of an earlier land. It wasn't a perfect glimpse; even Grinnell knew that. It still isn't, and I don't suppose it ever will be. Authenticity isn't like pregnancy. It's a relative quality. The Mirror Plateau is more authentic as a wildland than the Old Faithful parking lot. So, over the generations since Grinnell, other people have come along, like George Wright, or Starker Leopold, or Glen Cole. Each of them had enough new knowledge or insight to identify ways to heighten the authenticity. Wolf recovery symbolizes that continued heightening of authenticity, getting us a little closer to the wildness we now seem to value most highly here.

YS: That sounds good, but what if the original authenticity isn't even possible anymore?

PS: It isn't anyway, is it? That was the trouble with the idea that we could freeze-frame Yellowstone's setting to portray the park the day it was created. It never was possible, but we tried hard. Horace Albright [Yellowstone superintendent in the 1920s] favored a superficial authenticity in which large wild animals were kind of parked at various locations so visitors

…even if global change reaches the point where there are fundamental or alarming shifts in how things work in this wildland, we still better be prepared to ask ourselves a lot of questions before we start mucking around with things.… Whatever authenticity the parks still hold onto today is the only reason they're such important barometers of planetary health. Let's be careful about tossing that away.

could get a feeling for how a wild setting *looked*; he wasn't interested in free-running ecological systems. We long ago outgrew the Albright view. Now authenticity has more to do with witnessing a wild system at work. The best we can ever hope for is the authenticity of the moment, the authenticity that arises from ecological processes cranking along with as little meddling from us as possible. We always had to meddle, and we always will. But surely by now we've noticed that we always meddled more than we really had to.

Well, even if global change reaches the point where there are fundamental or alarming shifts in how things work in this wildland, we still better be prepared to ask ourselves a lot of questions before we start mucking around with things. Even with global change, the continuum of authenticity is still there, and maybe we'll slide around a little on it. And maybe some legislation will kick in, say if global change threatens a species we're obligated by law to protect. But that doesn't mean we have to throw out the ideal, or blow off the ideal of authenticity as a guide.

On my cynical days, I suspect that what's more likely to happen is that some species will already be on the ropes, and global change will be a contributing excuse for either abandoning the species altogether or using its protection as an excuse to get in and mess with wildness and compromise authenticity elsewhere in the park. I don't think that the NPS managers in place will necessarily make these bad decisions; I think they will be set up to make them by the tone of the times. We're getting more and more fatalistic about the future of wild nature just at the time that Yellowstone is telling us more clearly than ever before that wild nature is what the parks need most


NPS/PEACO

Paul celebrated his retirement with colleagues in January 2009.

to serve us. This isn't just about some photogenic wild animals. Whatever authenticity the parks still hold onto today is the only reason they're such important barometers of planetary health. Let's be careful about tossing that away.

So I guess I see our appropriate reaction to global change in Yellowstone the way I see our appropriate reaction to all those other things that if we had them to do over again we wouldn't do them. The national parks do this all the time. They interpret Andersonville [Civil War prison camp] and other dark moments in our history. Mistakes are important history. We can admit that we wish these things hadn't happened, but with that given, we can also re-imagine them as object lessons, things we should be compelled to think about, and to interpret for the public. With that approach, the effects of global change on the Yellowstone landscape just becomes one more thing Yellowstone can teach us about.

YS: That sounds like a nice ideal, but on the ground managers will still have some very difficult decisions to make, if it looks like some species is about to wink out because we're just standing there watching.

PS: Yes, and I agree that will raise important questions about the whole ideal of parks. Is it more important to prop up a single species, even at the expense of the rest of the natural system? Is it more important to keep the species, even if it means slipping back to Horace Albright's more theatrical idea of authenticity? Or will wildness itself win out as the true measure of the authenticity of the place? I don't have answers to those questions, but I can almost guarantee you that when the time comes to ask them, the social and political pressures will be to sell nature short and step in before we really should.

Gratitude

YS: You've been part-time with the park service for the last 10 or 12 years so that you could also pursue your own writing projects. Is it safe to assume you'll keep writing now?

PS: That's the idea. My list of books I want to write keeps getting longer rather than shorter. But I hope to keep working with you guys, too. Lee [Whittlesey] and I always seem to have some historical project going, and Lee and Sarah Bone (NPS GIS specialist) and I hope to finish up the wildlife history project we've been working on intermittently for many years now.

YS: Any other thoughts to add?

PS: Well, I didn't get to list all the people I'm grateful to have worked with and learned from. I'm so grateful I got to live in such a magical place and be involved all these years in a cause that matters so much to the world. I had no idea that could happen, and it has been an amazing ride. For me it all comes down to gratitude.

YS

Willow–Bird Relationships on Yellowstone's Northern Range

Lisa M. Baril, Andrew J. Hansen, Roy Renkin, and Rick Lawrence

COURTESY OF LISA BARIL

SOME WILLOWS (*Salix* spp.) are severely height suppressed, unable to grow taller than a few feet, while others have recently increased in height. Four years ago we asked how the observed increase might affect songbird diversity in the region. Our objective for this article is to share some results of our study of birds and willows in Yellowstone's northern range, but first we offer a brief history of willow growth there.

Background

Willows are wetland plants requiring plenty of water for growth and survival. They can be found along riparian regions throughout Yellowstone, but can grow near springs, seeps, and in any area where water is plentiful. Riparian areas represent transitional zones from rivers, lakes, and streams to adjacent uplands. Because of this intermingling of contrasting environments, riparian zones tend to be some of the most highly productive and ecologically rich environments in the northern Rocky Mountains. An estimated 80% of bird diversity in the northern Rocky Mountains can be found in riparian zones, and several species are found exclusively in these regions (Berger et al. 2001). Moose (*Alces alces*) and beavers (*Castor canadensis*) are dependent on riparian vegetation for forage (Stevens 1970; Wolf et al. 2007). The industrious beaver uses it for dam and lodge building materials as well. In addition to providing important habitat for numerous species, woody riparian vegetation, including willow, alder (*Alnus* spp.), cottonwood (*Populus* spp.), and aspen (*Populus tremuloides*) help stabilize stream banks, maintain nutrient cycles, and regulate water temperatures (Naiman and Décamps 1997).

The majority of willow communities in Yellowstone are found in the Yellowstone River delta, Bechler Meadows, and in areas north of the Madison River. Smaller areas of willow are found in the northern range, a low elevation region in the northern section of the park where the largest Yellowstone elk herd resides during winter. Elk preferentially forage on mature, degenerating grasses and forbs during winter, but also use woody browse including willow, alder, cottonwood, and aspen (Christianson and Creel 2007). Because willow is generally rare in the northern range, even low levels of browsing can have enormous effects on willow growth patterns, which in turn can affect bird diversity. We chose to study willow–bird relationships in the northern range because of the region's unique history of willow growth and recent history of increased willow growth following decades of height suppression.

Photographic comparisons of willow stands in the late 19th and early 20th centuries with current photos of the same area reveal considerable declines in willows (Chadde and Kay 1991). Studies of pollen grains in the northern range lake sediments reveal a decline in willow since 1920 (Barnosky et al. 1988; Engstrom et al. 1991). The loss and low stature of willows has been attributed to factors including extensive elk herbivory, fire history, a warmer and drier climate, and a lower population of beavers, whose activities stimulate willow growth (Yellowstone National Park 1997).

However, biologists have observed that although establishment of new willow plants has been limited, some willow stands in the northern range have increased in height and areal extent since 1997 and 1998. Comparing aerial photos from 1992 to 2006, we found an overall net gain in the areal extent of willow, alder, cottonwood, and aspen across riparian areas throughout the northern range (Baril 2009). Ripple and Beschta (2003) found increased height in several willow stands between 1977 and 2002, and high spatial resolution imagery indicated that willow, alder, and cottonwood increased in areal extent in the Lamar River-Soda Butte Creek confluence between 1995 and 1999 (Groshong 2004). Biologists regard the recent increases in height growth as an "ecological release" in which some northern range willows, previously unable to reach the height of tall willow stands in other regions of Yellowstone, are now experiencing more favorable conditions that have allowed for the observed increase in growth.

This release of woody vegetation coincides with the reintroduction of wolves (*Canis lupus*) in 1995 and 1996, stimulating the hypothesis that it may be the result of a trophic cascade involving wolves, elk, and willows (Ripple and Beschta 2004; Smith 2005). Elk constitute the majority of wolf diets in the northern range, resulting in a reduction of elk available to browse woody vegetation (Smith 2005). Reduced elk densities could lead to eventual increases in willow growth. Alternatively, elk may behave differently in the presence of wolves by evaluating foraging areas in terms of predation risk. Photo comparisons have revealed that low-risk willow stands in the northern range (i.e., those in uplands with a large viewshed in which to detect predators) remained height suppressed while the majority of willows in high-risk areas (i.e., those in valley bottoms where predators are more difficult to detect) exhibited significant height increases (Ripple and Beschta 2006).

KATY DUFFY

A distinctively plumaged yellow warbler.

COURTESY OF LISA BARIL

Released willow along upper Slough Creek.

It is also hypothesized that the recent increase in willow is the result of longer growing season temperatures, as willow growth is limited by the number of days during the growing season where temperatures rise above freezing (Despain, pers. comm.). Creel and Christianson (2009) suggest an interaction between biotic (reduced elk densities) and abiotic (decreased snow accumulation) influences on patterns of willow height release in the northern range. Interestingly, increases in willow height growth have not occurred uniformly, indicating that whether recent increases are the ultimate result of climatic factors and/or a trophic cascade, stand-level biophysical characteristics such as nutrient availability, slope, aspect, and other drivers are important proximate factors in determining which stands of willows are significantly increasing in height growth. For example, Tercek et al. (in press) identify a pre-existing suite of abiotic factors contributing to variable willow height release while sampling in two of the three releasing willow sites reported here.

The Effect of Willow Growth on Bird Diversity

Regardless of the causes of willow height increases, the recent expansion of willow may lead to changes in patterns of bird diversity and could have important consequences for bird species in the region associated with willow and other woody riparian vegetation. Since willow-riparian communities are rare in Yellowstone, especially in the northern range, an increase in this habitat type would be beneficial to the guild of species nesting and foraging in willows. A guild refers to a group of species that exploits resources in a similar way (Root 1967). We identified seven species occurring in the region associated with this guild: yellow warbler (*Dendroica petechia*), common yellowthroat (*Geothlypis trichas*), Wilson's warbler (*Wilsonia pusilla*), willow flycatcher (*Empidonax traillii*), warbling vireo (*Vireo gilvus*), song sparrow (*Melospiza melodia*), and Lincoln's sparrow (*Melospiza lincolnii*) (Berger et al. 2001; Jackson 1992). Several of these species also breed in aspen and cottonwood;

however, they are commonly found in willow communities.

To evaluate the potential consequences of increased willow growth on bird diversity, we compared willow structure and bird community composition across three willow growth conditions: short, suppressed; intermediate, released; and previously tall (i.e., tall prior to 1998 when the height release of willow was first observed). Ideally, we would have data on bird assemblages before released willows began to increase in growth; however, as we do not, surveying birds in suppressed willows will shed light on the species most likely inhabiting released sites prior to increased growth. Surveying previously tall willows will provide a frame of reference for the typical bird community associated with a well-established willow stand as well as enable us to make predictions about which species may begin to colonize released sites.

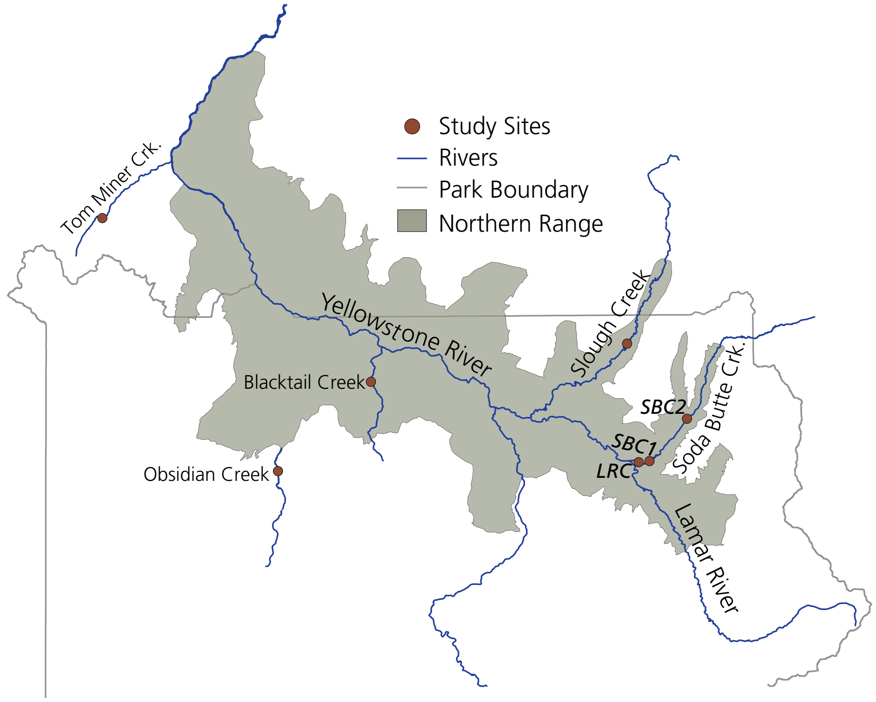


Figure 1. Map of study area and survey locations. Previously tall = Tom Miner Creek and Obsidian Creek; released = Blacktail Deer Creek, Lamar River confluence (LRC), and Slough Creek; suppressed = Soda Butte Creek 1 (SBC1) and Soda Butte Creek 2 (SBC2).

This study was conducted in and around Yellowstone's northern range, defined as the 153,000 hectare area in the Lamar and Yellowstone river watersheds occupied by Yellowstone's northern wintering elk herd (Fig. 1). The majority of the northern range lies within Yellowstone National Park while the remainder lies within the Gallatin National Forest and various private lands north of the park. Vegetation in the region is principally non-forested grasslands and sagebrush steppe in the lower elevations, while conifer forests predominate at higher elevations (Houston 1982). Willows occur along riparian areas and in springs and seeps along valley bottoms.

COURTESY OF LISA BARIL

Beaver construction along Tom Miner Creek.

Methods

We surveyed two or three sites in each of three willow growth conditions: suppressed, released, and previously tall. Suppressed sites were those with willows that were generally less than 80 centimeters tall and exhibited intense browsing; released sites were formerly height suppressed in part by browsing, but exhibited substantial height gain (>12 inches) and reduced browsing since 1998; previously tall sites were generally 150–200 centimeters tall prior to 1998 and have historically showed little evidence of browsing (Singer et al. 2004 funding report).

Willow sites meeting these criteria were considered for sampling if they were 1) supported by groundwater recharged by a stream; 2) contained enough willow plants for adequate sampling; and 3) were within 15 kilometers of a road for relative ease of access.

Previously tall sites were located along Obsidian Creek in Yellowstone just south of the northern range and along Tom Miner Creek in Tom Miner Basin west of the northern range because willow sites meeting the previously tall growth condition criteria were absent on the northern range. The slightly higher elevation at these sites, resulting in deeper snows, limits winter use and hence browsing by elk. Additionally, these sites, located outside of Yellowstone, were subject to hunting, potentially changing patterns of elk use there. Released sites were located along upper Slough Creek, Blacktail Deer Creek, and along the Lamar River-Soda Butte Creek confluence. Suppressed sites were situated in two locations along Soda Butte Creek.

At each site, between four and sixteen 40-meter radius circular sample plots were placed at least 100 meters apart. In total, we sampled 67 willow plots stratified across the three willow growth conditions: 23 plots in released sites, 21 plots in suppressed sites, and 23 plots in previously tall sites. In each of these sample plots we surveyed willow structure, species composition, and the bird community. We then averaged values to obtain an overall measure for each of the three growth conditions.

Characterizing Willows

We described the three willow growth conditions in terms of vertical and horizontal vegetation structure. To assess vertical cover or density we used a 5.5 meter Robel pole with 0.5-meter alternating black and white stripes. Measurements were collected at 16 samples point per plot. At each sample point an observer would walk one meter in a random direction from the Robel pole and record the vegetation type (other or willow) and the percentage of the Robel pole obscured by that vegetation in each height class up to the maximum height of the vegetation type present. This technique also allowed us to calculate foliage height diversity, a measure of overall vertical structural complexity. Higher values indicate more complex vegetation while lower values indicate simple vegetation structure.

To assess horizontal vegetation cover, height, and frequency of willow occurrence, we used the line-intercept method, recording the percent willow cover, number intervals containing willow (frequency), and willow height for every 1-meter interval along a 40-meter measuring tape in each sample plot.

COURTESY OF LISA BARIL

Field technician Mark Paulson taking vegetation measurements.

Lower canopy cover values indicate greater willow patchiness and open spaces between willows, whereas high canopy cover values indicate fewer open spaces and higher canopy closure. All willows encountered were identified to species.

Characterizing Bird Communities

Birds were sampled in the three willow growth conditions using standard point count techniques (Hutto et al. 1986). Three 10-minute rounds of point counts were conducted for each sample plot from June through mid-July of 2005 through 2007. We used four indices for examining differences in birds between growth conditions: richness, abundance, the Shannon-Weiner diversity index, and the Renkonen index of community similarity. Richness is the average number of species observed while abundance is the average number of individuals observed. The Shannon-Weiner diversity index takes into account both richness and evenness in abundance, providing an overall value of bird diversity. The Renkonen index computes the degree of overlap in bird communities between willow growth conditions and is expressed as percent similarity.

We then compared the abundance of each of the seven species identified earlier as belonging to the willow-riparian guild. While other species such as the fox sparrow (*Passerella iliaca*) also belong to this guild, they occur more rarely and are therefore difficult to quantify, so we only included species commonly found in this habitat type that differ in their response to variation in willow structure.

Results

Willows

We found a total of 14 willow species across all three growth conditions (Fig. 2). Eleven species occurred in released sites, ten in previously tall sites, and nine species in suppressed sites. The released and previously tall sites generally contained similar proportions of several species having similar water and soil nutrient requirements (USDA Natural Resources Conservation Service 2007). Suppressed sites, however were dominated by a single species, *S. exigua* (65%), which was rare (<2%) in released and previously tall sites.

S. exigua is an extensively clonal species that reproduces asexually when the flood regime does not create favorable conditions (bare, moist soils) for seed germination (Douhovnikoff et al. 2005). Its presence may indicate that suppressed sites are of marginal quality for sexual reproduction. In contrast, the flood disturbance regime in released and previously tall sites may be such that reproduction through seed germination is more common, leading to the greater willow species diversity observed there. However, this is purely speculation, as the ratio of plant establishment by seed versus clones among growth conditions is unknown. Although *S. exigua* and other willow species found in suppressed sites are able to attain heights comparable to those found in previously tall and released sites, they

	Suppressed (n = 23) x ± SE	Released (n = 21) x ± SE	Previously tall (n = 23) x ± SE	F	P	Differences
Height (cm)	61.55 ± 19.03	143.08 ± 18.34	179.17 ± 19.91	15.08	<0.0001	P,R S
Horizontal cover (%)	9.61 ± 3.15	21.42 ± 3.29	60.39 ± 3.15	76.75	<0.0001	P R S
Frequency (%)	26.53 ± 3.95	30.48 ± 4.13	73.48 ± 3.95	31.34	<0.0001	P R,S
Foliage Height Diversity	0.45 ± 0.12	1.39 ± 0.12	1.69 ± 0.13	29.37	<0.0001	P,R S

Table 1. Willow structural characteristics between suppressed (S), released (R) and previously tall (P) willow sites. Under "Differences," spaces between letters indicate significant differences.

have not done so in suppressed sites sampled in the northern range. Differences in height between growth conditions has been largely attributed to ungulate herbivory, but site specific variation in biophysical characteristics such as soil quality, nutrient availability (Tercek et al. in press), and hydrology (Bilyeu et al. 2008) can have significant impacts on willow growth.

Willow frequency was high in previously tall sites. Willows averaged 180 centimeters in height, with high foliage height diversity revealing structurally complex willows (Table 1). Not only were these willows tall, dense, and structurally complex, but they also showed high horizontal cover, representing 60% of the total cover in previously tall sites. In contrast, suppressed sites contained fewer willows and much shorter willows that were structurally simple in nature. Willows in these sites averaged only 62 centimeters in height, a third of previously tall willow height, and represented only 10% of the horizontal cover. Previously tall and suppressed sites represent the two extremes of willow growth in the region and differed significantly from one another in all variables measured.

Released willows were intermediate between suppressed and previously tall sites sharing structural attributes representative of each. Released willows were nearly as tall as previously tall willows (143 centimeters vs. 180 centimeters) with similar vertical structural complexity. Willow frequency, however, was similar between released and suppressed sites. Horizontal cover in released sites was twice that found in suppressed sites and a third of that found in previously tall sites. These findings reveal that while willows in released sites have attained a similar height and vertical structural complexity as in previously tall willows, they have increased only slightly in horizontal cover and have not successfully recruited new willow plants. In other words, existing plants are getting larger, but the population of willows in a given location is not increasing, a finding supported by other studies (Wolf et al. 2007).

Lack of willow recruitment may be partially attributed to prolonged absence of beavers in the northern range since the early to mid 1900s (Jonas 1955). Beaver and willow are mutualists in the region. Willows provide beavers with forage, dam, and lodge building materials, while beaver activity promotes the growth and establishment of willow by raising local water tables and creating favorable conditions for growth and germination (Wolf et al. 2007; Bilyeu et al. 2008).

Following abandonment of riparian areas by beavers, streams banks began to erode and channels became narrower and more incised, causing the groundwater that is important to the establishment and growth of willows to decrease (Wolf et al. 2007). While decreased browsing by elk may be allowing for increased growth of existing willow plants, recruitment of new willow plants may require recolonization of released sites by beavers (Wolf et al. 2007). In recent years, surveys of beavers along northern range streams have shown that they are increasing, which could eventually lead to an increase in the population of willows (Smith and Tyers 2008).

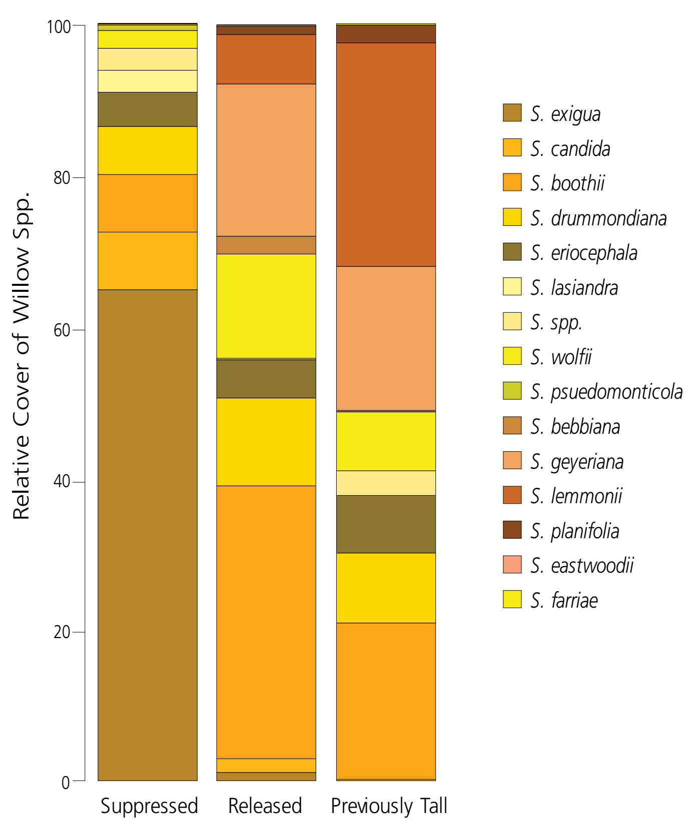


Figure 2. Relative cover of willow species in suppressed, released, and previously tall sites.

COURTESY OF LISA BARIL

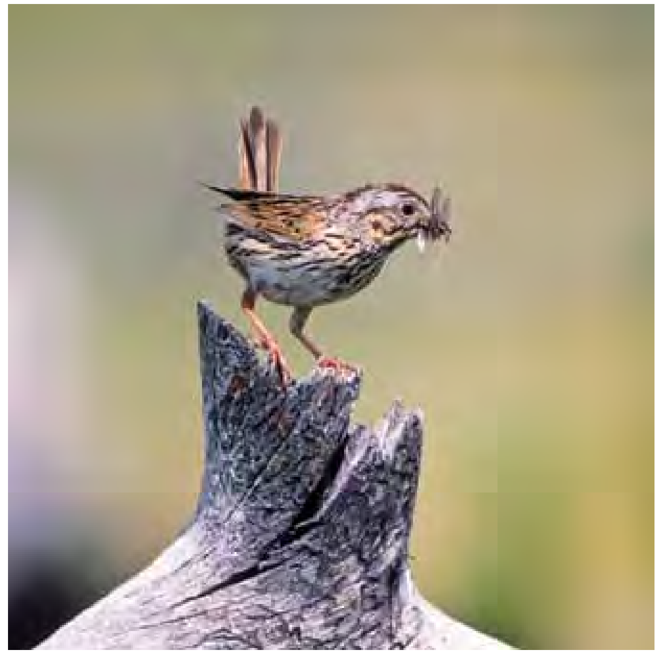
Yellow warbler nest in a released willow stand.

However, the extent to which beaver activity has historically modified northern range stream flow and sedimentation is spatially limited and highly variable over time. (Persico and Meyer 2009). Fluctuating climate and the high velocity of many northern range streams can prevent the construction of dams and subsequent modification of stream flows.

Birds

We recorded 2,724 individuals belonging to 33 species across all three growth conditions over the three years of surveys. Previously tall willows were significantly greater in species richness, abundance, and diversity than suppressed willows (Table 2). Birds reduce competition by foraging and nesting at different vegetation heights. Some species prefer to nest and forage on or near the ground, others the middle vegetation layer, while others prefer the canopy. Even within the same vegetation layer, two or more species can occur simultaneously through differences in foraging and nesting behavior. The relatively complex willow structure found in previously tall sites allows for resources such as food and nesting substrates to be more finely partitioned among a greater number of species than is allowed in the shorter and structurally simple suppressed sites.

The relatively low Shannon-Weiner diversity index indicates that suppressed sites were dominated by a few highly abundant species, primarily savannah sparrows (*Passerculus sandwichensis*) and other species typically associated with wet meadows. This was not the case in previously tall willows. The higher Shannon-Weiner index revealed a more even distribution across several species. Given that suppressed and previously tall sites differed greatly in willow structure, it is not surprising that there was only 34% overlap in species between these two bird communities.



©TOM MURPHY

A Lincoln's sparrow captures a mayfly.

In contrast, released sites were similar (66%) to previously tall sites, but also shared 59% of the species found in suppressed sites. The intermediate structure of released willows provided habitat suitable for species occurring in both growth conditions. Released condition willows were intermediate in richness between the previously tall and suppressed condition, but were similar to the previously tall condition in abundance and diversity. Despite the apparent lack of establishment of new willow plants and significantly lower horizontal cover in the released condition than in the previously tall condition, bird abundance and diversity were similar between the two, suggesting that measures of vertical structural complexity are more important than horizontal structure in influencing bird community variables in our study.

Only two bird species in the willow-riparian guild were found in all three willow growth conditions: the common yellowthroat and Lincoln's sparrow (Fig. 3). This suggests that they are somewhat general in their habitat associations, although both occurred more frequently in released and previously tall

	Suppressed *(n = 23)* x ± SE	**Released** *(n = 21)* x ± SE	**Previously tall** *(n = 23)* x ± SE	**F**	**P**	**Differences**
Richness	2.93 ± 0.34	5.72 ± 0.33	7.52 ± 0.34	48.04	<0.0001	P R S
Relative Abundance	3.85 ± 0.39	5.98 ± 0.37	6.46 ± 0.41	14.64	<0.0001	P,R S
Shannon-Weiner Diversity	0.76 ± 0.06	1.51 ± 0.06	1.78 ± 0.07	62.46	<0.0001	P,R S

Table 2. Bird species richness, abundance, and diversity between suppressed (S), released (R) and previously tall (P) willow sites. Under "Differences," spaces between letters indicate significant differences.

sites than in suppressed sites. Both species are ground nesters. Lincoln's sparrows frequently forage on the ground while common yellowthroats forage near the ground, gleaning insects from leaves. As they do not require tall willows for nesting or foraging, they were able to occupy all three growth conditions. The greater horizontal cover in released and previously tall sites afforded more foraging and nesting opportunities than were available in suppressed sites and likely accounts for the higher abundance observed there.

Suppressed willows were unable to support song sparrows, warbling vireos, yellow warblers, willow flycatchers, and Wilson's warblers (Fig. 4). This indicates that each of these species requires willows of at least a certain height and greater horizontal cover than were available in suppressed sites. Song sparrows, warbling vireos, yellow warblers, and willow flycatchers occurred in both released and previously tall willows, however, their abundance was greater in previously tall sites, probably because of the greater horizontal cover there.

Wilson's warblers were found exclusively in previously tall sites. They frequently forage at willow heights of 60 centimeters to 120 centimeters (Hutto 1981). While willows grew this tall in released sites, Wilson's warblers were absent from these areas. This indicates that Wilson's warblers not only require willows of intermediate height, but also a dense horizontal distribution of willow. Because they have specific structural requirements, are restricted to montane willow communities, and are declining across the region (Ruth and Stanley 2002), relatively high elevation willow stands, such as those found in Yellowstone, are important for the persistence of Wilson's warblers in the region. If released sites increase in horizontal cover, this species may begin to colonize these areas.

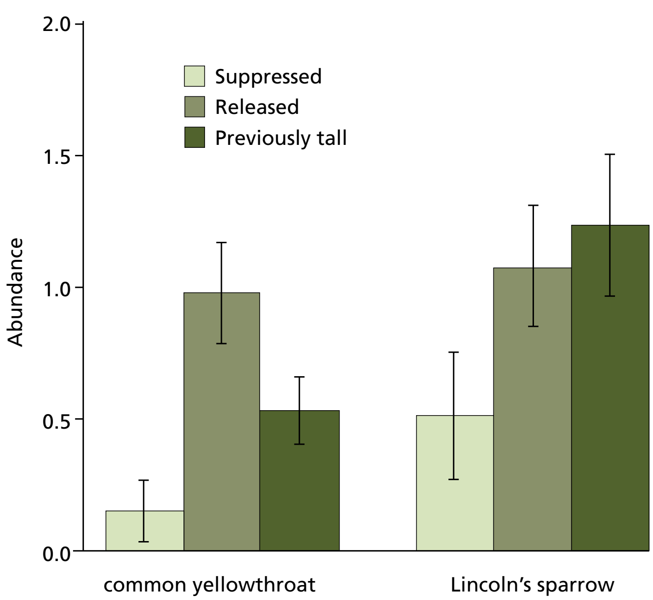


Figure 3. Common yellowthroat and Lincoln's sparrow abundance across the three growth conditions.

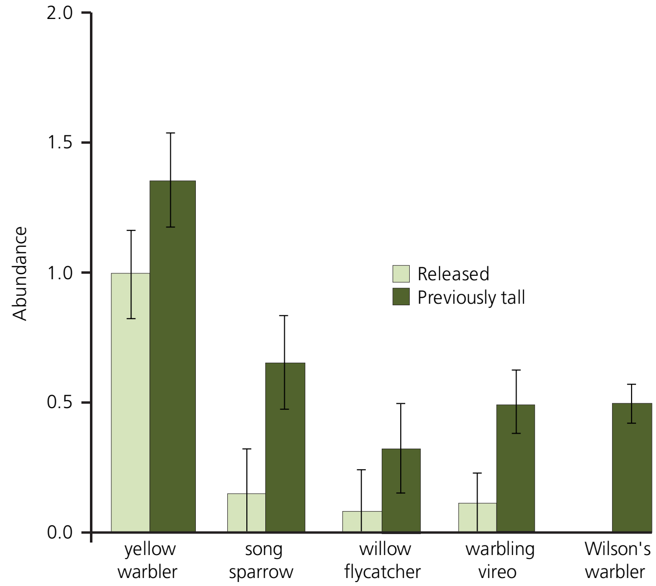


Figure 4. Abundance of bird species in released willows and previously tall willows.

Conclusions

Overall, we found that willow structure generally increased in complexity from structurally simple height suppressed willows to structurally complex previously tall willows and that this variation in complexity influenced bird community variables and the abundance of riparian and willow dependent bird species. These results provide the first examination of the significance of an increase in a rare, but important habitat type for birds in the region.

The shorter, sparsely distributed suppressed willows prevented the establishment of several species belonging to the willow-riparian guild, except for common yellowthroats and Lincoln's sparrows, which were found to be habitat generalists within the range of willows that we sampled. If suppressed sites attain heights similar to those of released sites, common yellowthroat and Lincoln's sparrow will likely increase in abundance there. An increase in willow frequency and horizontal cover in released sites will likely attract Wilson's warblers to these areas and increase the abundance of willow- and riparian-associated species already occupying these sites.

The majority of focal species in our study appear to have been absent or present in low densities in the northern range during Jackson's (1992) study. Prior to willow height release, song sparrows and yellow warblers both occurred in low densities, while Wilson's warblers, willow flycatchers, and warbling vireos were absent in the sites sampled in the northern range (Jackson 1992). However, it appears that the recent increase in willow growth is not yet sufficient to allow for colonization by Wilson's warblers.

A future goal may be to compare nesting success across sites to determine if those species occurring in all growth conditions, especially released and previously tall, differ in reproductive success. It may be that released sites, relatively low in willow frequency and cover, have more edge habitat. A greater amount of edge habitat might allow predators to locate nests more easily and decrease reproductive success in these areas. Monitoring nest success would add another dimension to our understanding of willow–bird habitat relationships.

This study represents a snapshot in time of the bird community across a range of willow growth conditions in the region. Yellowstone's bird program is continuing to monitor willow sites surveyed in this study and is now in the fifth year of data collection—the beginning of a long-term dataset on willow–bird relationships in Yellowstone's northern range.

YS

Acknowledgements

Funding was provided by the NPS Yellowstone Center for Resources. We would like to thank Terry McEneaney and Yellowstone staff for assistance with this research, particularly Doug Smith, Heidi Anderson, Christie Hendrix, and Christine Smith. We also thank field assistants Karl Fairchild, Julie York, and Mark Paulson.

COURTESY OF LISA BARIL

Lisa Baril received her Master's Degree from the Department of Ecology at Montana State University in Bozeman. This study represents a portion of her Master's research, which was completed in the fall of 2009. She also works as a seasonal biologist with the Yellowstone bird program.

Dr. Andrew Hansen is a professor and director of the Landscape Biodiversity Lab at Montana State University in Bozeman. He has a PhD in ecology from the University of Tennessee. His research focuses on interactions among biodiversity, ecosystem processes, and land use, with an emphasis on landscape management.

Roy Renkin is a Vegetation Management Specialist in the Yellowstone Center for Resources at Yellowstone National Park. Willow height release ranks second only to the fires of '88 as an "ecological marvel" during his 30-year Yellowstone career.

Dr. Rick Lawrence is a professor of remote sensing in the Land Resources and Environmental Sciences Department at Montana State University. He is also the director of the Spatial Sciences Center there. His work focuses on the use and application of remote sensing technologies in managed and natural ecosystems. His doctorate in remote sensing is from Oregon State University.

Literature Cited

Barnosky, C.W., H.E. Wright, Jr., D.R. Engstrom, and S.C. Fritz. 1988. The relationship of climate to sedimentation rates in lakes and ponds. *In* First annual meeting of research and monitoring on Yellowstone's northern range, F. Singer, comp., p. 4. Yellowstone National Park, WY: National Park Service, Yellowstone National Park.

Berger, J., P.B. Stacey, L. Bellis, and M.P. Johnson. 2001. A mammalian predator–prey imbalance: Grizzly bear and wolf extinction affect avian neotropical migrants. *Ecological Applications* 11(4):947–960.

Bilyeu, D. 2006. Effects of elk browsing and water table on willow growth and physiology: Implications for willow restorations in Yellowstone National Park. PhD diss., Colorado State University.

Christianson, D. and S. Creel. 2009. Wolf presence and increased willow consumption by Yellowstone elk: Implications for trophic cascades. *Ecology* 90:2454–2466.

Christianson, D. and S. Creel. 2007. A review of environmental factors affecting elk winter diets. *Journal of Wildlife Management* 71(1):164–176.

Chadde, S.W., and C.E. Kay. 1991. Tall-willow communities on Yellowstone's northern range: A test of the "natural-regulation" paradigm. *In* The Greater Yellowstone Ecosystem: Redefining America's wilderness heritage, eds. R.B. Keiter and M.S. Boyce, 231–262. New Haven, CT: Yale University Press.

Douhovnikoff, V., J.R. McBride, and R.S. Dodd. 2005. *Salix exigua* clonal growth and population dynamics in relation to disturbance regime variation. *Ecology* 86:446–452

Engstrom, D.R., C. Whitlock, S.C. Fritz, and H.E. Wright, Jr. 1991. Recent environmental changes inferred from the sediments of small lakes in Yellowstone's northern range. *Journal of Paleolimnology* 5(2):139–174.

Groshong, L.C. 2004. Mapping riparian vegetation change in Yellowstone's northern range using high spatial resolution imagery. PhD diss., University of Oregon.

Hutto, R.L. 1981. Seasonal variation in the foraging behavior of some migratory western wood warblers. *The Auk* 98:765–777.

Jackson, S.G. 1992. Relationships among birds, willows, and native ungulates in and around northern Yellowstone National Park. MS thesis, Utah State University.

Jonas, R.J. 1955. A population and ecological study of the beaver (*Castor canadensis*) of Yellowstone National Park. Thesis, University of Idaho, Moscow.

Naiman, J.R., and H. Décamps. 1997. The ecology of interfaces: Riparian zones. *Annual Review of Ecology and Systematics* 28:621–658.

Olechnowski, B.F., and D.M. Debinski. 2008. Response of songbirds to riparian willow habitat structure in the Greater Yellowstone Ecosystem. *The Wilson Journal of Ornithology* 120:830–839.

Persico, L., and G. Meyer. 2009. Holocene beaver damming, fluvial geomorphology, and climate in Yellowstone National Park, Wyoming. *Quaternary Research* 71(3):340

Ripple, W.J., and R.L. Beschta. 2004. Wolves and the ecology of fear: Can predation risk structure ecosystems? *BioScience* 54: 755–766.

Ripple, W.J., and R.L. Beschta. 2003. Wolf reintroduction, predation risk, and cottonwood recovery in Yellowstone National Park. *Forest Ecology and Management* 184:299–313.

Root, R.B. 1967. The niche exploitation pattern of the blue-gray gnatcatcher. *Ecological Monographs* 37(4):317–350.

Ruth, J.M., and T.R. Stanley. 2002. Breeding habitat use by sympatric and allopatric populations of Wilson's warblers and yellow warblers. *Journal of Field Ornithology* 73:412–419

Singer, F.J., L.C. Zeigenfuss, R.G. Cates, and D.T. Barnett. 1998. Elk, multiple factors, and persistence of willows in national parks. *Wildlife Society Bulletin* 26(3):419–428.

Smith, D.W. 2005. Ten years of Yellowstone wolves, 1995–2005. *Yellowstone Science* 13(1): 7–33.

Smith, D. W., and D. B. Tyers. 2008. The beavers of Yellowstone. *Yellowstone Science* 16(3):4–15.

Stevens, D.R. 1970. Winter ecology of moose in the Gallatin Mountains, Montana. *Journal of Wildlife Management* 34(1):37–46.

Tercek, M.T., R. Stottlemyer, and R. Renkin. In press. *Northwestern American Naturalist.*

USDA Natural Resources Conservation Service. PLANTS Database. http://plants.usda.gov (accessed 15 March 2007).

Wolf, E.C., D.J. Cooper, and N.T. Hobbs. 2007. Hydrologic regime and herbivory stabilize an alternative state in Yellowstone National Park. *Ecological Applications* 17(6):1572–1587.

Yellowstone National Park. 1997. Yellowstone's northern range: Complexity and change in a wildland ecosystem. Yellowstone National Park, WY: National Park Service, Yellowstone National Park.

Species and Habitats Most at Risk in Greater Yellowstone

Andrew J. Hansen

THE BROAD-SCALE ECOLOGICAL and human patterns of the Greater Yellowstone Ecosystem (GYE) (Fig. 1) are relatively well understood. Keiter and Boyce (1991) placed ecological processes and organisms in Yellowstone National Park in the context of the broader GYE. Glick et al. (1991) focused on the interplay between natural resources and local economics. Clark and Minta (1994) explored how government and social institutions influence management of the GYE. Hansen et al. (2002) quantified change in land cover and use in the GYE during 1975–1995 and examined the consequences for biodiversity and socioeconomics of local communities. Noss et al. (2002) rated the ecological importance of 43 "megasites" outside of protected areas based on ecological and land use factors. Gude et al. (2007) evaluated the consequences of past, present, and possible future land use on several indices of biodiversity.

These assessments and other studies have identified several successes and challenges in maintaining viable species, communities, and ecosystems across the GYE. Management of elk populations, recovery of the threatened grizzly bear, and reintroduction of wolves have involved both large, complex landscapes and extensive collaboration in research and management among federal and state agencies, private land owners, and nongovernmental organizations. The remaining challenges stem largely from the fact that GYE is a highly connected ecosystem undergoing rapid human growth and land use intensification yet composed of multiple private and public ownership types and management jurisdictions that sometimes do not correspond well to ecological boundaries. Some of the current challenges involve management of fire, the spread of weeds and disease among natural and human components of the system, and the loss of key low-elevation habitats due to rural and urban development on private lands. These changes have been vexing to managers because of the large spatial scale over which they occur and the need for coordinated management among many stakeholders. Potential emerging management issues include threats to wildlife (such as elevated grizzly bear mortality) from expanding backcountry recreation and climate-induced changes in habitat and water.

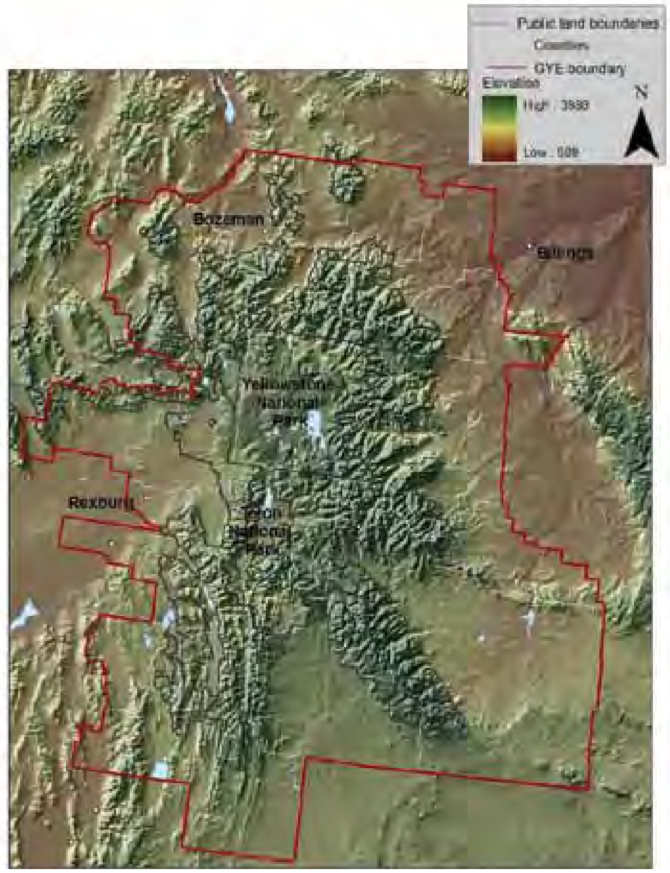


Figure 1. Map of the Greater Yellowstone Ecosystem as defined by Hansen et al. (2002).

This article is drawn largely from a report that was prepared for the U.S. Forest Service (USFS) (Hansen 2006) to assess the major factors that influence species and ecosystem viability across the GYE as a context for the analysis and management of biodiversity.

Changing Land Use in the GYE

Although 64% of the GYE is publicly owned (Hansen et al. 2002), critical resources and habitats are under-represented within the protected lands. This is because the public lands in the GYE are relatively high in elevation, harsh in climate, and low in primary productivity, whereas the private lands are primarily in valley bottoms and floodplains with longer growing seasons and higher plant productivity (Hansen et al. 2000). Consequently, hot spots for biodiversity and many ungulate winter ranges are largely on private lands (Hansen et al. 2002). The 20 counties of the GYE had 426,167 residents in 2007 (Woods and Poole Economics 2008), most living in small cities. Suburbs, agricultural lands, and rural residential homes radiate out from the cities toward the public lands. The national forests provide for multiple use of natural resources, including recreation, forest products, forage, and minerals. The national parks serve both as nature reserves and as sites for public recreation.

The GYE is undergoing a transition in demography and land use. The dominant change in land use has been from ranching and farming to urban and exurban development (defined as 1 home per 0.4 to 16.2 hectares). Developed land has increased faster than the rate of population growth. While the GYE experienced a 58% increase in population from 1970 to 1999, fueled partially by wealthy in-migrants attracted by the natural amenities, the area of rural lands supporting exurban development increased 350% (Gude et al. 2006) (Fig. 2).

Some 11% of the total land area of the GYE and 43% of the private lands are subject to crop agriculture, exurban, suburban, and urban use (Hansen unpublished data). Of the many miles of river flowing through private lands in the area, 89% of the streamsides are within 1.6 kilometers (1 mile) of homes, farms, or cities. Among aspen and willow habitats, critical for wildlife, only 51% of those on private lands in the Greater Yellowstone area are more than 1.6 km from these more intense human land uses.

KARL BIRKELAND/USDA FOREST SERVICE

A backcountry skier investigates snowpack along Lionhead Ridge in the Gallatin National Forest.

Major uses of the national forests include livestock grazing, logging, mining, and motorized and nonmotorized recreation. A comprehensive assessment of rates and locations of logging has not been done across the GYE. It appears that rates of logging vary among national forests and time periods. In general, large-scale commercial logging was more widespread in the 1970s and 1980s, when staggered-setting clearcutting occurred over large portions of the Targhee National Forest and in portions of the Gallatin National Forest. Less extensive timber harvesting was done on the Shoshone, Custer, and Bridger-Teton national forests. More recently, timbering operations have focused on smaller sales of house logs, fuel reduction projects, and salvage logging of burned areas. Many of the extensive road systems that were created in association with logging have been closed by the USFS during the past decade. Livestock grazing is extensive on the national forests of the GYE. However, historical and current levels of livestock use and its effects on the ecosystem are not well known.

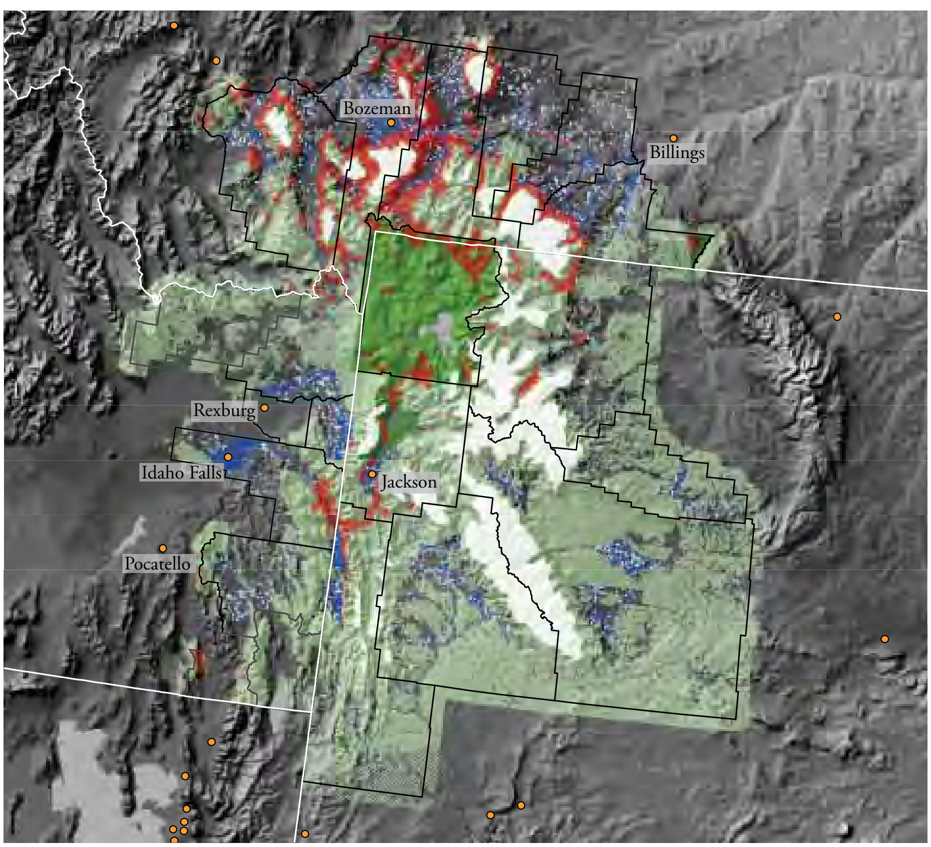


Figure 2. Distribution of rural homes across the 20 counties of the GYE in 1999. Home data were derived from county tax assessor records and validated with aerial photographs (see Gude et al. 2006). Biodiversity hotspots were assessed by bird species presence and diversity.

Some forms of public recreation have likely increased dramatically on the national forests in recent decades. Use in winter by snowmobiles and in summer by ATVs and motorcycles is extensive and increasing. Similarly, use of backcountry areas by hikers, skiers, fisherman, and campers appears to be rapidly increasing. Comprehensive data on these motorized and nonmotorized uses have not been compiled across the public lands of the GYE. However, travel management is currently receiving much attention across the region.

JEF WITCOSKY/USDA FOREST SERVICE

Natural regeneration of *Pinus ponderosa,* ten years after a clearcut harvest in the Shoshone National Forest.

Effects on Wildlife

Land use intensification exerts influences on wildlife both in and near logging, agriculture, and human settlements as well as in the remaining natural parts of an ecosystem. Perhaps the most obvious repercussions are loss, fragmentation, and degradation of habitat. Conversion of natural habitats to agriculture or other intensive human land uses causes these areas to become inhospitable for many native species. Community diversity declines as habitat area is reduced. Smaller habitats can support fewer individuals within a population, hence rates of extinction increase with habitat loss. The spatial pattern of habitat also influences biodiversity potential. Habitats with small patch sizes, increased edge to area ratios, and increased distance among patches fail to support habitat interior specialists and species with poor dispersal abilities. Within forest stands, logging and other vegetation modifications may simplify the number of canopy layers and other elements of forest structure, reducing the microhabitats available to organisms and limiting biodiversity (Hunter 1999). Habitat destruction in the GYE has occurred primarily in valley bottoms with more fertile soils as a consequence of agricultural and urban development (Gude 2006). Logging has fragmented forested habitats in parts of the GYE (Powell and Hansen 2007); however, recovery is now underway as logging rates have dropped. While exurban development has been increasing, the area of native habitats converted to lawns, homes, and driveways is generally small relative to the remaining habitat.

NPS/PEACO

Livestock grazing is extensive on the national forests of the GYE.

Human land use can also have repercussions on ecological processes. For example, agriculture and urbanization in western Colorado have altered climate and nutrient deposition in the Colorado Rockies, with negative consequences for biodiversity in Rocky Mountain National Park. Natural processes likely altered by humans in the GYE include water quantity and quality in some rivers and streams and reduced natural disturbances such as wildfires. Irrigation leads to unnaturally low summer stream flows in some dry years with likely consequences for aquatic and riparian species. Also, water pollution levels are likely increasing in some rivers due to effluent from rural homes. Many of the rivers of the region are dammed or channelized, resulting in loss of or reduced flooding, riparian succession, and riparian habitat diversity (Merigliano 1998; Hansen et al. 2003). Fire suppression by humans in lower elevation forests has likely led to reduced initiation of succession, loss of early seral habitats, and reductions in wildlife species dependent upon early seral habitats (Litell 2002). In the longer term, human fire exclusion will likely lead to unnatural fuel accumulation, and large and severe fires that may be outside the range to which native species are adapted.

Some consequences of land use change are much less visible because they involve not habitats but the organisms within habitats. Human activities often result in changed numbers and distributions of native species, as well as the introduction of alien species and pathogens. As a result, biotic interactions among species are changed, and ecosystem traits are altered. Exurban and agricultural development in the Rockies has been shown to lead to increases in mesopredators such as coyotes, skunks, and corivids, and decreases in reproductive success of prey species such as neotropical migrant birds (Odell and Knight 2001). Rural development and agriculture in and near floodplains in the GYE has resulted in increased predators and brood parasites on native birds and reduced reproduction by

NPS

Invasive dalmation toadflax (*Linaria dalmatica*).

some neotropical migrant birds which may be putting regional populations at risk (Hansen and Rotella 2002). Invasive plants are able to spread from rural homes and agricultural fields into adjacent natural habitats. The number of documented exotic plants in Yellowstone National Park has increased from 85 in 1986 to more than 200 in 2009 (GYSLC 2009), possibly due in part to development on surrounding private lands. Also, exchange of disease among wildlife, domestic livestock, and pets is a growing concern in the GYE. For example, several native wildlife species contracted brucellosis, likely from domestic livestock, and are now managed to minimize risk of transmission back to livestock (Yellowstone National Park 1997). Similarly, whirling disease has been introduced to local rivers and streams, causing substantial reductions of rainbow trout populations.

Humans also interact directly with native species through exploitation and inadvertent disturbance. Domestic pets may range considerable distances from rural homes and displace and kill wildlife. Bird feeders and other food sources may attract wildlife to rural homes, leading to the need to control or destroy unwanted or dangerous wildlife. Increases in roads and vehicle usage escalate the potential for roadkill. Finally, backcountry recreation such as hiking and off-road vehicle use is increasingly popular in and around natural habitats and can displace wildlife, influencing reproduction, survival, and population dynamics. Such human activities in the GYE have led to increasing levels of grizzly bear mortality (Schwartz et al. 2007), raising concern about the viability of the population under continued human expansion and land use intensification.

Although most of these human activities are centered on private lands, Hansen and DeFries (2007) outlined four general mechanisms through which land use change on private lands may impact biodiversity on public lands (Table 1). Land use may (1) destroy natural habitats and reduce the effective size of the larger ecosystem which can: simplify the trophic structure as species with large home ranges are extirpated; cause the area of the ecosystem to fall below that needed to maintain natural disturbance regimes; and reduce species richness due to loss of habitat area; (2) alter characteristics of the air, water, and natural disturbances moving through public lands; (3) eliminate or isolate seasonal habitats, migration habitats, or habitats that support source populations; and (4) increase human activity along public land boundaries, resulting in the introduction of invasive species, increased hunting and poaching, and higher incidence of wildlife disturbance.

Table 1. General mechanisms by which land use in surrounding areas may alter ecological processes and biodiversity within reserves. From Hansen and DeFries, 2007.

Mechanism	Type	Description
Change in effective size of ecosystem	Minimum dynamic area	Temporal stability of seral stages is a function of the area of the park relative to the size of natural disturbance.
	Species area effect	As natural habitats in surrounding lands are destroyed, the functional size of the park is decreased and the risk of extinction in the park is increased.
	Trophic structure	Characteristic spatial scales of organisms differ with trophic level such that organisms in higher levels are lost as ecosystems shrink.
Changes in ecological flows	Initiation and runout zones	Key ecological processes move across landscapes. "Initiation" and "run-out" zones for disturbance may lie outside the park.
	Location in airshed or watershed	Land use in upper watersheds or airsheds may alter flows into reserves lower in the watershed or airshed.
Loss of crucial habitat	Ephemeral habitats	Lands outside of parks may contain unique habitats that are required by organisms within the park.
	Dispersal/migration habitats	Organisms require corridors to disperse among parks or to migrate from parks to ephemeral habitats.
	Population source-sink habitats	Unique habitats outside of parks are population "source" areas required to maintain "sink" populations in parks.
Increased exposure to human impacts	Edge effects	Negative human influences from the park periphery extend some distance into the park.

Identifying Management Priorities

Limited resources dictate that land managers focus on legal requirements, elements most important to biodiversity and ecosystem function, those most at risk due to human activities, and those at which management has the best chance of success.

Species

Terrestrial mammal and bird species that have been identified as at risk by the USFS in the national forests of the GYE are listed in Table 2. Management to maintain the habitats and ecological processes needed by these species should help to retain many of them. Large tracts of late seral coniferous forests are required by Canada lynx, fisher, wolverine, American marten, northern goshawk, boreal owl, and three-toed woodpecker. The black-backed woodpecker is dependent upon such forests that are recently burned. Ponderosa pine forests with large trees and open canopies that result from frequent fire are key habitats for Lewis's woodpecker and flammulated owl. Species dependent upon riparian habitats include bald eagle, yellow-billed cuckoo, and river otter. Vigorous sagebrush habitats are required by pygmy rabbit, brewer's sparrow, burrowing owl, Columbian sharp-tailed grouse, and sage grouse. Grasslands, often in large tracts and maintained in adequate condition by fire or grazing support black-footed ferret, black-tailed prairie dog, Baird's sparrow, grasshopper sparrow, and Sprague's pipit. In contrast to these species, which are mostly dependent upon habitats and processes, both the grizzly bear and wolf are currently most limited by interactions with people and livestock. Management of animal–human conflicts may be required to maintain these species.

NPS/HARLAN KREDIT

A male three-toed woodpecker.

Habitats

Terrestrial habitats identified as most at risk in the GYE are listed in Table 3. These include habitats that are high in community diversity and energy production, and support species that specialize on these habitats, are relatively low in aerial cover in the GYE, and/or are threatened by human activities such as fire exclusion. The importance of these habitats and their vulnerabilities varies across the national forests of the GYE.

Table 2. Terrestrial mammal and bird species identified as at risk under the Endangered Species Act by the USFS in the national forests of the GYE (USDA 2004). Omitted are aquatic species and species not amenable to USFS management strategies. Threats and management strategies were derived from NatureServe (www.natureserve.org/explore/servlet/NatureServe).

Threatened, Endangered, or Candidate Species	Primary Habitat	Key Threats	Key Management Strategies
Gray wolf ***Canis lupus***	General	Human-induced mortality	Manage human–wolf conflicts
Grizzly bear ***Ursus arctos***	General	Large home range; loss of low-elevation habitats; loss of whitebark pine; human-induced mortality	Reduce human-induced mortalities; provide low-elevation habitats; restore whitebark pine
Canada lynx ***Lynx canadensis***	Coniferous forest	Harvest; large home range; fragmentation of coniferous forest habitats; loss of diverse age structure of habitat; loss of prey; unnaturally low fire frequency	Management of roads and human access; fire management to restore habitats; minimize human harvest
Bald eagle ***Haliaeetus leucocephalus***	Riparian, costal	Recovered following pesticide effects and habitat loss	Maintain riparian and lacustrine habitats
Yellow-billed cuckoo ***Coccyzus americanus***	Riparian	Edge of range; loss of cottonwood and willow habitats	Maintain and restore riparian habitats
Black-footed ferret ***Mustella nigripes***	Prairie	Loss of prairie; loss of prey; disease	Protect current populations; captive breeding and release

Exurban development as seen from Peets Hill in Bozeman, Montana.

Table 2 continued.

USFS Sensitive Species	Primary Habitat	Key Threats	Key Management Strategies
Fisher ***Martes pennanti***	Coniferous forest	Harvest; fragmentation of old-growth coniferous forest	Maintain large tracts of old-growth forest, including low-mid elevations
North American wolverine ***Gulo gulo***	Coniferous forest	Large home range; human encroachment; harvest	Maintain habitat for prey populations, including at low-mid elevations; minimize human harvest
American marten ***Martes Americana origins***	Coniferous forest	Harvest; fragmentation of old-growth coniferous forest	Maintain large tracts of old-growth forest, including low-mid elevations
Northern goshawk ***Accipiter gentiles***	Coniferous forest	Harvest; fragmentation of old-growth coniferous forest	Maintain large tracts of old-growth forest
Boreal owl ***Aegolius funereus***	Coniferous forests	Loss of prey due to timber harvest; large home range	Maintain large tracts of suitable habitat, large snags, aspen stands
Three-toed woodpecker ***Picoides tridaclylus***	Coniferous forests	Loss of older forest	Maintain older seral stages and structural complexity
Black-backed woodpecker ***Picoides arcticus***	Recently burned areas, old-growth coniferous forest	Fire exclusion; timber harvest	Maintain crown fire regimes; maintain structural complexity in timber and salvage units
River otter ***Lutra canadensis***	Riparian, lacustrine, coastal shores	Local trapping; loss of riparian habitat	Maintain riparian habitats
Flammulated owl ***Otus flammulatus***	Ponderosa pine	Loss of large snags and forest structural complexity	Maintain large trees and structural complexity
Lewis's woodpecker ***Malanerpes lewis***	Ponderosa pine, cottonwood	Loss of large snags; densification of open stands	Maintain large snags and open canopy with fire and silviculture
Black-tailed prairie dog ***Cynomys ludovicianus***	Grasslands	Loss of prairie; disease	Maintain habitats
Baird's sparrow ***Annodramus bairdii***	Grasslands	Loss and alteration of habitat due to agriculture and grazing	Maintain medium-height grasslands in large tracts
Grasshopper sparrow ***Ammodramus savannarum***	Grasslands	Loss of grassland habitats; alteration of natural fire	Maintain large tracts of grasslands; manage fire to produce relatively sparse cover
Sprague's pipit ***Anthus spragueii***	Grasslands	Loss of grassland and wetland habitats	Maintain grassland and wetland habitats
Pygmy rabbit ***Brachylagus idahoensis***	Shrubsteppe	Loss of shrub-steppe habitats	Protect shrubsteppe habitat, especially on floodplains
Brewer's sparrow ***Spizella breweri***	Sagesteppe	Loss of sagebrush	Maintain vigorous sagebrush communities
Burrowing owl ***Athene cunicularia***	Sagesteppe	Loss of sagebrush	Maintain sagebrush communities
Columbian sharp-tailed grouse ***Tymphanuchus phasianellus columbianus***	Sagesteppe	Loss of sagebrush	Maintain sagebrush communities; manage grazing
Sage grouse ***Centrocercus urophasianus***	Sagesteppe	Loss of sagebrush	Maintain sagebrush communities

Table 3. Habitats identified as at risk in the GYE. Aerial extent estimates from Parmenter et al. (2003) and Powell and Hansen (2007).

Habitats at Risk	Ecological Importance	Aerial Extent	Key Threats
Braided large river floodplains	High in species richness and net primary productivity (NPP); seral stages support specialists species	~1% of GYE	Inhibition of natural dynamics through dams, bank stabilization, irrigation; exurban development
Other willow, cottonwood, and riparian forests	High in species richness and NPP	~1% of GYE	Flood control; dewatering through irrigation; livestock grazing; exurban development
Grasslands	Specialist species	35% of GYE (w/sagesteppe)	Ex- and urban development; agriculture; livestock grazing; alteration of fire regime; conifer encroachment
Sagesteppe	Specialist species	35% of GYE (w/grassland)	Ex- and urban development; agriculture; livestock grazing; alteration of fire regime; exotic species; conifer encroachment
Aspen	High in species richness and NPP; several specialists species	~1% of GYE	Lack of disturbance to reduce conifer competition and stimulate aspen regeneration; excessive herbivory
Ponderosa pine	Specialists species	<1% of GYE	Alteration of fire regime; encroachment by other conifers; logging
Productive low elevation Douglas-fir forest	Moderately high in species richness and NPP	~5% of GYE	Fire exclusion leading to densification, fuel build-up, and a more severe fire regime; logging; exurban development
Early post-fire structurally complex coniferous forest	Specialist species	Highly variable*	Fire exclusion in low to mid elevations
Mature and old growth coniferous forest	Specialist species	5% of GYE	Fragmentation by logging and roads
Whitebark pine	Food source for grizzly bear	5% of GYE	Climate change; disease

*unpredictable crown fire causes high variability in aerial extent

Indices of Biodiversity

Various methods are available to develop biodiversity indices that integrate across species, habitats, and other aspects of biodiversity. Two comprehensive efforts of this nature have been completed for the GYE. Noss et al. (2002) performed a quantitative assessment aimed at prioritizing lands outside protected areas for conservation value. The analysis considered measures of biodiversity including imperiled species, bird species, aquatic species, and rare plant communities; vegetative, abiotic, and aquatic habitat types; and high quality habitat for five focal mammal species (wolverine, lynx, grizzly bear, gray wolf, and elk). Units of land across the GYE were rated on these measures. The SITES selection algorithm was used to assemble and compare alternative portfolios of sites. (SITES attempts to minimize portfolio "cost" in land area while maximizing attainment of conservation goals in a compact set of sites.) The sites were evaluated for irreplaceability (a quantitative measure of the relative contribution different areas make to reaching conservation goals) and vulnerability (based on expert opinion with data on human population growth and land use). Of the 43 sites that best fulfilled the conservation objectives; 15 were identified as of greatest importance because they rated high in both irreplaceability and vulnerability. The Teton River Area near Jackson, Wyoming, and Henry's Fork near Island Park, Idaho, had the highest scores. The resulting maps of the sites (Figure E10 in Noss et al. 2002) and tables of scores for irreplaceability and vulnerability offer guidance to land managers on locations of high conservation value.

The second assessment (Gude et al. 2007) focused on the geographic overlap of biodiversity value and land use intensity in the past, present, and possible future. Historical land use maps were overlain on 11 biodiversity response variables: the current ranges of four species of concern (grizzly bear, elk, pronghorn antelope, and moose); the distribution of four land cover types (Douglas-fir, grassland, aspen, and riparian); and the occurrence of three biodiversity indices (bird hotspots, mammal migration corridors, and irreplaceable areas, from Noss et al. 2002). They found that exurban densities of rural homes occurred at higher proportions within most of these

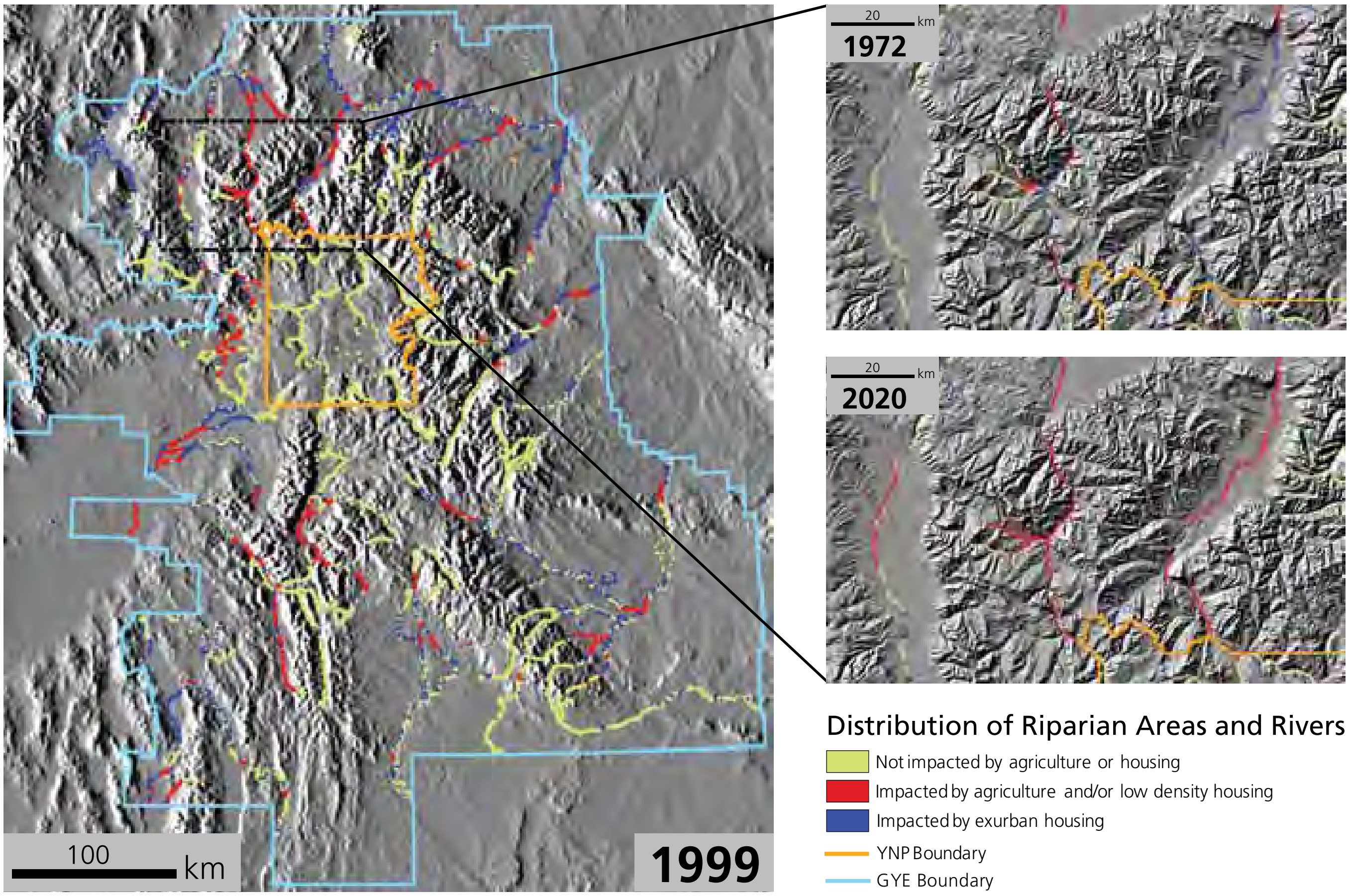


Figure 3. The distribution of riparian areas and rivers across the GYE and the extent of overlap with agricultural and exurban land uses (within 1.6 kilometers) in 1999, for 1972, and projected for 2020 assuming that growth rates from the 1990s continue into the future.

habitats than would be expected at random, indicating that these habitats are at high risk to the negative impacts of development. Additionally, they integrated maps from 1980 and discovered that the percent area of occupied habitat that is impacted by homes has at least doubled for most variables over the past 20 years.

Based on these historical and current analyses of land use, Gude et al. (2007) projected rural home growth 20 years into the future and quantified potential impacts on biodiversity. They simulated five plausible scenarios of rural residential development for the year 2020. These scenarios ranged from low growth, to status quo (current rates of growth continue), to booming growth, and included two scenarios depicting development under growth management. These five maps depicting potential land use scenarios were each overlaid with each of the 11 ecological response maps used for historical analyses. Numbers of rural homes increased from 28% in the low growth scenario to 234% in the boom scenario. Four of the responses (bird hotspots; riparian habitat, Fig. 3; potential corridors; and irreplaceable areas) were forecasted to experience degradation in at least 20% of their area under the status quo and 30–40% under the boom scenario (Table 4). These elements of biodiversity should be considered especially at risk across the GYE. Early warning of the vulnerability of these four habitats to land use change may help managers develop strategies for mitigating future effects.

Climate Change

Climate change presents an especially difficult challenge to land managers. Because the effects of human-induced climate change occur over longer periods of time than those of land use change, management to adapt to climate change is often considered a lower priority. However, natural variability combined with climate change can bring extreme weather that leads to ecological outcomes requiring management action. The extreme fires in the West under the drought conditions of the last five years are an example. Climate change interacts with land use change in ways that challenge management. For example, fragmentation due to land use reduces the connectivity of habitats that is essential to species shifting range under changing climate. Finally, there is considerable uncertainty in our ability to predict the form and outcome of human-induced climate change, which reduces public support to manage for its consequences.

Table 4. The percent of area impacted by exurban development for each of 11 biodiversity response variables. The impacts of exurban development were assumed to extend into one neighboring section (1.61km). Table adapted from Gude et al. (2007).

			Growth Scenario			Growth Management Type	
Response	1980	1999	Status Quo 2020*	Low 2020	Boom 2020	Moderate 2020	Aggressive 2020
Pronghorn Range	2.00%	3.35%	5.83%	5.05%	7.58%	6.06%	4.73%
Moose Range	2.73%	5.49%	7.96%	6.83%	11.11%	7.24%	6.26%
Grasslands	2.99%	5.57%	8.36%	7.02%	11.97%	8.01%	6.87%
Grizzly Bear Range	3.13%	5.98%	8.52%	7.68%	10.70%	7.74%	6.88%
Douglas-fir	2.91%	6.01%	8.85%	7.07%	13.31%	7.82%	7.09%
Elk Winter Range	2.36%	6.26%	9.98%	8.61%	13.47%	9.00%	7.23%
Aspen	5.55%	13.92%	19.53%	15.58%	28.39%	18.74%	17.60%
Bird Hotspots	8.42%	16.91%	23.20%	19.23%	34.36%	21.04%	20.23%
Riparian Habitat	10.22%	17.30%	23.64%	19.43%	31.27%	22.45%	18.77%
Potential Corridors	8.89%	18.79%	24.43%	20.83%	35.38%	22.96%	21.80%
Irreplaceable Areas[1]	11.41%	23.15%	29.61%	25.69%	40.08%	30.88%	26.92%
Integrated Index[2]	11.80%	23.24%	29.93%	25.84%	40.66%	29.28%	26.43%

* Responses are ranked by the proportion impacted in the Status Quo 2020 scenario
[1] Multicriteria assessment based on habitat and population data for GYE species (Noss et al., 2002)
[2] Top 25% of lands important to the four responses most impacted by development under the Status Quo 2020 scenario, including bird hotspots, riparian habitat, potential corridors, and irreplaceable areas.

As climate change becomes more fully manifest, active management will be increasingly needed to maintain ecological function and native species (Hansen et al. 2001). For plant communities that are unlikely to reach suitable environments elsewhere (e.g., subalpine and alpine communities), it may be appropriate to minimize change by manipulating vegetation structure, composition, and/or disturbance regimes to favor the current community. For communities that may be able to reach newly suitable habitats, a reasonable strategy may be to manage some of the current habitat as a reservoir until the community is reestablished in the new locations. Other portions of the current habitat may be managed to encourage change to the species and communities more appropriate for the new environment. Attempting to maintain connectivity among natural habitats is also important for allowing natural dispersal of organisms.

Guidelines for Managing for Biodiversity

This review indicates that the GYE is a complex ecosystem that includes many ecological processes and organisms operating over very large spatial scales and that is undergoing rapid change in climate and land use. Consequently, ecological management presents numerous challenges. Fortunately, the ecosystem has been less altered by human activities than have most areas of the United States and the opportunity remains to sustain ecological processes and native organisms under future global change. The following guidelines are aimed at aiding the management of biodiversity across the GYE.

Biodiversity goals on public lands will best be advanced through land management agencies participating in management at multiple spatial scales, i.e., within federal jurisdictions (e.g., a national forest), among public land jurisdictions of the GYE, and across the public and private lands of the GYE. At the regional scale, public officials can help private land managers

USDA FOREST SERVICE/SCOTT CLEMONS

Island Lake in Wyoming's Wind River mountains on the Bridger-Teton National Forest.

understand ecological connections, prioritize important places, and implement criteria for maintaining biodiversity across the GYE in the face of land use intensification. These efforts should be guided through a scientific assessment of the lands across the GYE that are most important for the maintenance of native biodiversity on public lands.

Human induced climate change will increasingly influence public lands and require management attention. In the coming decade, land managers should conduct their activities in the context of a changing climate, recognizing that current and future forest dynamics will likely differ from the past. In the longer term, ecological engineering may be required to maintain ecological values in the face of substantial climate change.

Careful management of disturbances such as fire, flooding, and timber harvest is needed to maintain the full suite of seral stages and structural complexities across the GYE. In the face of climate and land use change, managers should apply disturbance so as to achieve the dynamic steady state mosaic across the landscape that is required to maintain native organisms. This effort would be advanced through compilation of the wildlife species associated with each seral stage and structural configuration across the habitat types of the GYE and the landscape configuration of seral stages that best promotes maintenance of native species. Also, restoration of habitats now at risk due to lack of disturbance should be a high priority.

More scientific approaches are needed for effective management of recreation on national forests. Data systems are needed to monitor recreation type and intensity in a spatially explicit manner. Research is needed on the effects of various types and intensities of recreation on biodiversity.

Changes in trophic structure can cascade through ecosystems resulting in loss of some native species and alteration of ecosystem function. Land managers can help maintain balanced wildlife communities by maintaining habitat for top carnivores, managing campgrounds and feed lots to reduce food provisioning to mesocarnivores, and controlling noxious weeds.

YS

COURTESY OF THE AUTHOR

Dr. Andrew Hansen is a professor and director of the Landscape Biodiversity Lab at Montana State University in Bozeman. He has a PhD in ecology from University of Tennessee. His research focuses on interactions among biodiversity, ecosystem processes, and land use, with an emphasis on landscape management.

Literature Cited

Clark T.W, and S.C. Minta. 1994. Greater Yellowstone's future: Prospects for ecosystem science, management, and policy. Island Press, Washington DC.

Glick, D., M. Carr, and B. Harting. 1991. An environmental profile of the Greater Yellowstone Ecosystem. Bozeman, Montana, Greater Yellowstone Coalition.

[GYSLC] Greater Yellowstone Science Learning Center. 2009. Resource Brief: Invasive Plants, 3/19/2009. Accessed at http://www.greateryellowstonescience.org/files/pdf/Weeds_Brief_YELL.pdf.

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

Gude, P.H., A.J. Hansen, D.A. Jones. 2007. Biodiversity consequences of alternative future land use scenarios in Greater Yellowstone. *Ecological Applications* 17(4): 1004–1018.

Hansen, A.J., J.J. Rotella, M.L. Kraska, and D. Brown. 2000. Spatial patterns of primary productivity in the Greater Yellowstone Ecosystem. *Landscape Ecology* 15:505–522.

Hansen, A.J., and R.P. Neilson, V. Dale, C. Flather, L. Iverson, D. J. Currie, S. Shafer, R. Cook, and P. Bartlein. 2001. Global change in forests: Interactions among biodiversity, climate, and land use. *BioScience* 51(9):765–779.

Hansen, A.J., R. Rasker, B. Maxwell, J.J. Rotella, A. Wright, U. Langner, W. Cohen, R. Lawrence, and J. Johnson. 2002. Ecology and socioeconomics in the New West: A case study from Greater Yellowstone. *BioScience* 52(2)151–168.

Hansen, A.J., and J.J. Rotella. 2002. Biophysical factors, land use, and species viability in and around nature reserves. *Conservation Biology* 16(4):1–12.

Hansen, A.J., J. Rotella, D.A. Jones, and L.P. Klaas. 2003. Riparian habitat dynamics and birds along the upper Yellowstone River. Technical Report #1, Landscape Biodiversity Lab, Montana State University, Bozeman, MT.

Hansen, A.J. 2006. Yellowstone bioregional assessment: Understanding the ecology and land use of Greater Yellowstone. Technical Report #2, Landscape Biodiversity Lab, Montana State University, Bozeman, MT.

Hansen, A.J., and R. DeFries. 2007. Ecological mechanisms linking protected areas to surrounding lands. *Ecological Applications* 17(4):974–988.

Hunter, M.L., Jr. 1999. Maintaining biodiversity in forest ecosystems. Cambridge University Press, Cambridge, UK.

Keiter, R.B., and M.S. Boyce. 1991. The Greater Yellowstone Ecosystem: Redefining America's wilderness heritage. Yale University Press. New Haven.

Littell, J.S. 2002. Determnants of fire regime variability in lower elevation forests of the northern Greater Yellowstone Ecosystem. Thesis. Montana State University, Bozeman, MT.

Merigliano, M.F. 1998. Cottonwood and willow demography on a young island, Salmon River, Idaho. Wetlands 18(4):571–576.

Noss R.F., C. Carrol, K. Vance-Borland, and G. Wuerthner. 2002. A multicriteria assessment of the irreplaceability and vulnerability of sites in the Greater Yellowstone Ecosystem. *Conservation Biology* 16(4):895–908.

Odell, E.A., and R.L. Knight. 2001. Songbird and medium-sized mammal communities associated with exurban development in Pitkin County, Colorado. *Conservation Biology* 15:1143–1150.

Parmenter, A.P., A. Hansen, R. Kennedy, W. Cohen, U. Langner, R. Lawrence, B. Maxwell, A. Gallant, R. Aspinall. 2003. Land use and land cover change in the Greater Yellowstone Ecosystem: 1975–95. *Ecological Applications* 13(3):687–703.

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

Schwartz, C.C., M.A Haroldson, and K. West. 2007. Yellowstone grizzly bear investigations: Annual report of the Interagency Grizzly Bear Study Team. U.S. Geological Survey, Bozeman, MT, USA.

USDA 2004. Grizzly bear conservation for the Greater Yellowstone Area national forests. Draft Environmental Impact Statement. Gallatin National Forest, Bozeman, MT.

Woods and Poole Economics. 2008. 2008 Desktop Data Files. Washington, D.C.

Yellowstone National Park. 1997. Yellowstone's northern range: Complexity and change in a wildland ecosystem. National Park Service, Mammoth Hot Springs, WY.

From the Archives

NPS

Ranger-illustrator Keith Hoofnagle drew a series of cartoons that appeared in *In Touch,* a National Park Service professional publication for interpreters, lampooning various aspects of NPS policy and culture. This cartoon appeared in the September 1975 issue.

YELLOWSTONE ASSOCIATION

The printing of *Yellowstone Science* is made possible through a generous annual grant from the nonprofit Yellowstone Association, which supports education and research in the park. Learn more about science in Yellowstone through courses offered by the Yellowstone Association Institute and books available by visiting www.YellowstoneAssociation.org.

The production of *Yellowstone Science* is made possible, in part, by a generous grant to the Yellowstone Park Foundation from Canon U.S.A., Inc., through *Eyes on Yellowstone* is made possible by Canon. This program represents the largest corporate donation for wildlife conservation in the park.

Canon

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

CHANGE SERVICE REQUESTED

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

Support

Yellowstone Science

Our readers' generosity helps to defray printing costs.

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

Thank You!

QUESTIONING GREATER YELLOWSTONE'S FUTURE

Climate, Land Use, and Invasive Species

The 10th Biennial Scientific Conference on the Greater Yellowstone Ecosystem

October 11–13, 2010

Mammoth Hot Springs
Yellowstone National Park

**Interested in receiving an email notice when the latest issue of *Yellowstone Science* becomes available on-line?
Email us at: *Yell_Science@nps.gov***