Yellowstone Science

A quarterly publication devoted to the natural and cultural resources

Tracking Yellowstone's Red Fox

The Sediment of History:
Coring Crevice Lake

2001 Christmas Bird Count

Volume 10 Number 1

New Year, New Perspectives

The new year brings new perspectives to Yellowstone. On this mid-winter day as snow flurries swirl outside my window, I'm afforded this momentary lull to look forward and back in the same breath — to endings, beginnings, and a continued desire for better understanding. With the arrival of the next superintendent, Suzanne Lewis, and a new administration, another chapter in the Yellowstone story begins. But just as life and death cycle through nature, we also commemorate the passing of scientist Frank Craighead and honor his pioneering work in conservation biology and ecosystem management. At the same time, the year 2002 signals another benchmark as *Yellowstone Science* enters its 10^{th} year of reporting the advances in science and additions to the body of knowledge on natural and cultural resources of the park.

In this issue, Dr. Cathy Whitlock of the University of Oregon discusses her research that interprets Yellowstone's natural history through examining core samples from Crevice Lake. She begins by studying present-day vegetation to figure out how it evolved through the years. In the course of this process, Cathy hopes to discover how long the forests have been the way they are today and how sensitive they were to environmental change in the past, at present, and in the future. Her findings on vegetation and climate change could prove useful in a variety of fields including fire, elk, and bear management.

While some of Yellowstone's charismatic animals have been studied in great detail, relatively little is known about its red fox population. Historical records indicated that Yellowstone's red foxes had undergone several population fluctuations and that they exhibit an unusual variety of coat colors. Also, the restoration of wolves to the park is likely having an impact on fox distribution in and around the park. Curiosity about these issues led Yellowstone's education program coordinator, Bob Fuhrmann, to investigate this elusive species. Fuhrmann's work provides significant new information on this previously under-studied member of the Yellowstone ecosystem. It also establishes an important pre-wolf baseline on habitat use by foxes.

Contributing to the inventory and monitoring function of the park, park ornithologist Terry McEneaney presents the findings of the annual Christmas Bird Count, now in its 29^{th} year.

As the new year unfolds, many challenges remain in understanding and preserving the resources of the park, and the Yellowstone Center for Resources recommits itself to addressing them.

RJA

Yellowstone Science

A quarterly publication devoted to the natural and cultural resources

Volume 10 Number 1 Winter 2002

Table of Contents

Editor
Roger J. Anderson

Assistant Editor and Design
Tami Blackford

Assistant Editors
Kevin Schneider
Alice K. Wondrak

Printing
Artcraft, Inc.
Bozeman, Montana

Cover: Red fox in Lamar Valley. Photo by Alden Whittaker.
Inside Cover: The Craigheads trap a grizzly bear during their Yellowstone field studies, 1961. NPS photo.
Above: Fox tracks on Blacktail Plateau. Photo by Bob Fuhrmann.

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

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,* write to Yellowstone Association, P.O. Box 117, Yellowstone National Park, WY 82190.
Yellowstone Science is printed on recycled paper with a linseed oil-based ink.

Reading Yellowstone's History Through Crevice Lake Sediment Records

An Interview with Dr. Cathy Whitlock

Cathy Whitlock's team coring Crevice Lake. NPS photo.

In February 2001, former Yellowstone Science *editor Sue Consolo Murphy and Kevin Schneider skiied to Crevice Lake to interview Dr. Cathy Whitlock. By studying sediment layers removed from the floor of Crevice Lake and other lakes in the region, Cathy hopes to gain a better understanding of past changes in the climate, vegetation, and role of fire in the Greater Yellowstone Ecosystem. In October 2001, Cathy presented the opening keynote at the Sixth Biennial Scientific Conference on the Greater Yellowstone Ecosystem.*

Yellowstone Science (YS): Would you like to start by telling us a little about yourself? A short biography?

Cathy Whitlock (CW): I'm at the University of Oregon where I'm a professor in geography.

YS: So do you consider yourself a geographer? Paleobotanist?

CW: That's a good question. I describe myself as a paleoecologist, because I start with the present-day vegetation and try to understand how it evolved. How long have the forests been the way they are today? How sensitive are forests to environmental changes in the past, at present, and in the future?

YS: What are your degrees in?

CW: I received my undergraduate degree at Colorado College, and my M.S. and Ph.D. degrees at the University of Washington, all in geology. When you study paleoecology, you can come at it from a geological perspective, where you're looking at earth history, or you can come at it from an ecological perspective, where you start with the present vegetation and go backwards.

Paleoecology research actually fits well into all three disciplines—geology, ecology, and geography—and I've been in all three departments during my career. My first job was at the University of Pittsburgh in geology, but before that I was a postdoctoral fellow in botany at Trinity College in Dublin, Ireland. I love being in a geography department because geographers look at spatial patterns across the landscape and study how these patterns change through time. Paleoecology is intrinsically geographical.

YS: You mentioned that you started your work in the Yellowstone ecosystem, though, in the Tetons in the mid-1980s?

CW: Yes, in graduate school I was interested in how the Tertiary-age forests in the Jackson Hole area changed as the Tetons lifted up. I was working with Dave Love of the U.S. Geological Survey, who was an inspiring and enthusiastic mentor. But I was continually drawn to the more recent past, because I love to hike and be outdoors. For me, it's great fun to look at vegetation and wonder why it has its current composition and pattern. Ultimately for me, this tie to the present has been more exciting than studying plants that went extinct a long time ago.

When I finished graduate school, I

began researching the Quaternary vegetation history of the Yellowstone and Grand Teton area. I focused on trying to understand how the forests developed since the last ice age by studying Holocene pollen records. I was really interested in measuring the sensitivity of past ecosystems to climate and environmental change. We know that the climate is changing at present, and a lot of model projections show that there'll be enormous ecological adjustments in the future with global warming. The only way to understand the sensitivity of ecosystems to future changes is to look in the past and see how they responded to previous extreme conditions, such as periods of glaciation, drought, and extreme warming.

YS: And when we talk glaciation in the Yellowstone ecosystem, we're going back how far?

CW: The last glaciation ended somewhere between 17,000 and about 13,000 years ago. That's when the ice left the Yellowstone Plateau, the Yellowstone Lake area, and glaciers retreated back into the Absarokas. Glaciers around here (at Crevice Lake) extended down to the Chico Hot Springs area [north of Yellowstone National Park], and, as they retreated, lakes were formed in ice-block hollows and scoured basins.

YS: And you think Crevice Lake was left behind by the glaciers?

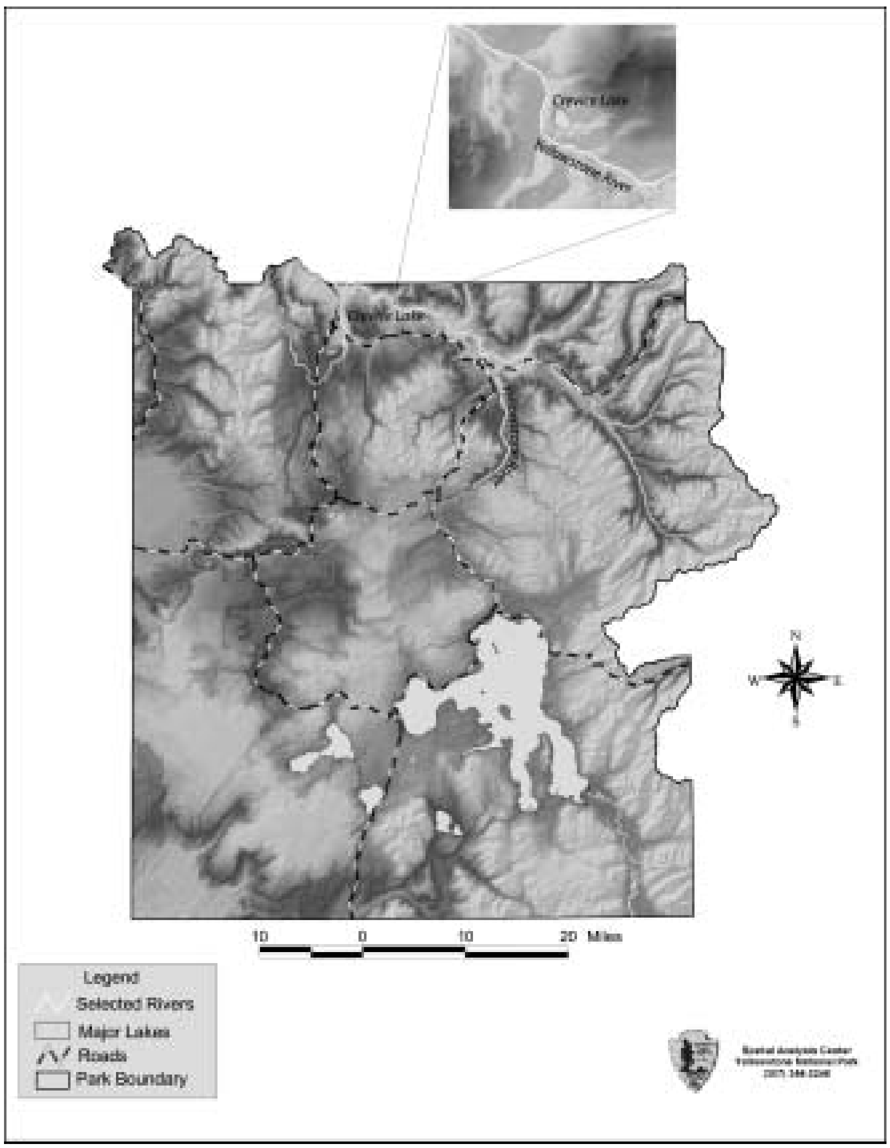
CW: Crevice Lake is a real puzzle, because this area was scoured out by large floods at the end of the glacial period. These floods formed when an ice-dammed lake in the Lamar area was drained and an enormous amount of water roared through the canyon where we are now. This flood left deposits of gravel 100 meters above the level of Crevice Lake.

One theory we have is that the depression that contains Crevice Lake was a scour feature created by that flood, perhaps in a big eddy. But, in truth, we're not sure how and when the depression formed. We know it had something to do with the deglaciation, but it's hard to imagine the sequence of events that led to this isolated little lake.

YS: You mentioned that you had a National Science Foundation (NSF) grant, along with some other folks. What, specifically, are the questions you're trying to answer here, by coring Crevice Lake?

CW: My colleagues, Sheri Fritz and Lora Stevens [from the University of Nebraska], and I have a grant from the NSF Earth Systems History Program to look at long-term drought frequency in the northern Rockies. We're interested in the severity and frequency of droughts in the past. In this project, we're looking at long lake sediment records in Yellowstone and near Glacier National Park.

At Crevice Lake, my student Mitch Power is looking at charcoal records to reconstruct the fire history of the watershed, because fire is a good indicator of drought. I am looking at the pollen record to understand past changes in the vegetation. Sheri and Lora and student Jeffrey Stone are looking at the diatom and isotopic records in the sediments to reconstruct changes in the lake level through time. We are also working with Ken Pierce, Joe Rosenbaum, and Walt Dean of the U.S. Geological Survey (USGS), who are examining the cores for changes in sediment composition and geochemistry that might indicate periods of drought. The study of Crevice Lake is a multidisciplinary project, and we're hitting it with all our specialties.



Crevice Lake is located in the north-central portion of Yellowstone National Park, near the Yellowstone River.

Crevice Lake's depth, combined with its relatively small surface area, prevents the lake from turning over, preserving annual accumulations of sediments intact. NPS photo.

YS: How was it you chose to study Crevice Lake?

CW: I knew from work that had been done by the U.S. Fish and Wildlife Service that Crevice was very deep. For its size (6.7 hectares), it's exceptionally deep—about 30 meters. Its great water depth relative to its surface area suggests that the water column does not mix seasonally all the way to the bottom. This means that the bottom waters lack oxygen and do not support a benthic [cold water] fauna. Lakes that are permanently anoxic at the bottom are fairly rare; most lakes are oxygenated during fall and spring turnover of the water column. Because Crevice Lake supports little or no benthic activity in its deepest part, the layers of sediment that are deposited each season are preserved intact and not disturbed by critters living in the mud. Cores from lake sediments that preserve such annual "laminations" look like tree-ring records, in which each year can be seen as a distinct couplet.

YS: What do you mean by "laminations?"

CW: Lamination is just a general term for layering. We say that the sediments are annually laminated when layers are deposited in discrete layers according to the season. For each year, there is a dark winter layer, full of organic matter, and a light summer layer, rich in summer-blooming diatoms or carbonates. Crevice Lake has thousands of these seasonal layers going back to its beginning. These annual couplets are called "varves." So Crevice Lake is technically a varved sediment lake.

YS: How did you determine that Crevice Lake was one of these varved lakes?

CW: I went to the lake in 1990 and collected a core of the upper 20 cm of sediment with a small sampler that one throws over the side of a raft. The sediments that were recovered in that sampler were indeed finely-laminated, and that got me really excited. In 1992 a crew and I came back with rafts and more elaborate equipment, and we retrieved a longer core of about 60 centimeters. We counted the laminations in that core and realized that we had recovered about 300 years of the lake's history. Identifying layers with abundant charcoal particles gave us a glimpse of fire history during the last few centuries. Having affirmed that Crevice Lake was both unique and important, I've been working since then to organize a group of researchers to study the entire post-glacial record and do it properly. It's taken eight years, but here we are.

"The only way to understand the sensitivity of ecosystems to future changes is to look in the past and see how they responded to previous extreme conditions, such as periods of glaciation, drought, and extreme warming."

YS: Is this the only lake in Yellowstone that's known to be laminated?

CW: Yes. I've looked at all the lake surveys from the park, and probably taken more sediment samples from Yellowstone lakes than anyone, and Crevice is the only lake that we've found that's varved. Most of the lakes that are the size of Crevice Lake are about 10–15 meters deep at the most. Because these lakes are relatively shallow, the water column is mixed yearly all the way to the bottom, stirring up the seasonal layers.

YS: What makes varved lakes so significant in terms of research?

CW: The sediments of non-laminated lakes are valuable for understanding what has happened on time scales of decades and centuries, and we've studied a lot of other lakes in the park trying to understand the broad temporal changes in vegetation and climate since the last ice age. But Crevice Lake, with its varved record, offers the opportunity to study annual variations in climate. For example, El Niño events happen on yearly time scales, and it would be nice to know the frequency and impact of El Niño and other short-term climate variations over the last 1,000 years.

YS: How will you recognize that when you see it in the cores?

CW: El Niño years are often associated with lower than normal winter precipitation in Yellowstone. At Crevice Lake, we may find indicators of low precipitation, snowpack, or soil moisture in the sediment record. For example, more charcoal in a particular layer at Crevice Lake would indicate more fires and dry conditions. Particular diatoms may also indicate evaporation rates and lower lake levels associated with drought.

YS: How are the layers likely to look different reflecting drought, or reflecting the 1988 fires?

CW: To study the 1988 fires, we'll start at the top of the core and count down 13 annual laminations. That 13^{th} layer preserves the history of events that occurred in 1988. From my previous work, I expect that that layer will have abundant charcoal fragments, diatoms that indicate warm summer conditions, and an oxygen isotope record that suggests greater evaporation. The geochemistry may also show changes indicating that the lake became slightly more saline as a result of the drought.

YS: So drought is not necessarily indicated by an ash layer, or the presence of fire.

CW: Right. The environment in a dry year is different than in a wet year, and we use all our tools to look for evidence of these differences in the sediments of the lake. These tools then provide various proxy of drought.

YS: Does the fact that you see charcoal layers give you any ideas about the size of the fires that laid down that charcoal?

CW: No. Our goal is to get a network of lakes to figure out fire size. In a particular year, it will become clear that one watershed burned, while another didn't. A network of sites allows us to reconstruct this bigger fire pattern. In the same way, the environmental history of Yellowstone is one piece of a bigger puzzle, that of trying to understand the history of the entire Rocky Mountain region.

YS: Don't you also look at pollen analysis? And are there certain plant species that distribute more pollen, or less, in a drought year?

CW: Yes. Pollen is a great tool for studying vegetation history, but it is less useful for identifying short periods of drought. Because it takes years for the vegetation to change, pollen records are not as sensitive as charcoal records to year-to-year variations in climate. You could say that pollen is a blunter tool for studying past environments. I say this because pollen is airborne and the pollen that lands on the surface of a lake eventually sinks and is incorporated into the sediments. The pollen record is an integration of the pollen rain of the watershed. From pollen data, we can't deduce exactly where the plants were growing within the watershed. We also can't discriminate between an open forest with widely spaced trees and a closed forest with large meadows. What the pollen record does provide is information on past changes in vegetation composition. On a short time scale, these may be changes caused by a forest fire.

For instance, I sometimes find a lot of fireweed pollen in the record after a fire event. More often, however, I find that the pollen record registers little evidence of a fire. Pollen records are best used to detect gradual changes in vegetation that are related to large-scale shifts in climate. For example, if the climate became colder, the pollen of high-elevation trees, including spruce and fir, would become more abundant. If it got warmer, pollen of low-elevation species, such as sagebrush and greasewood, would increase in the record. At Crevice Lake, we might see more limber pine and juniper pollen during periods of prolonged drought.

YS: What will you be able to learn about fire frequency?

CW: Many people said that the fires of 1988 were a 300- or 400- year event. But that idea was based on that the fact that the oldest trees here are about 300-400 years old and probably established after fires. Two points, the 1988 fires and the age of tree establishment, aren't much evidence for cyclicity, and the lake-sediment records allow us to look at fire frequency over much longer periods of time. We've done very detailed fire history studies in the Central Plateau, and what we've found is that there is no fire cycle. Rather, fires are frequent when the climate is warm and dry and less frequent when conditions are cool and wet. Fire frequency has continually varied as a result of the changing climate. I suspect we'll see that same story here at Crevice Lake.

YS: Based on this one lake, how large an area, geographically, can you reconstruct?

CW: The pollen and charcoal record will give us a picture of what is happening within and near the watershed.

YS: But certainly not in the whole ecosystem.

CW: No. That's why you need a network of sites. The size of the lake you look at determines the size of the geographic area that you can assess. A small lake collects pollen from a relatively small area, whereas the sedimentary record from, say, Yellowstone Lake integrates the pollen of an enormous area. One learns about the vegetation history of the Yellowstone Lake area by studying several small lakes in different environmental settings within the watershed.

YS: 2000 was a major fire year in the western United States, but not so much in the Yellowstone ecosystem. Much of

Cathy (on the left) examines a section of core removed from the bottom of Crevice Lake. This piece of core will be carefully packaged in plastic wrap and aluminum foil and then sent on to a laboratory for further analysis. NPS photo.

western Montana and Idaho burned, but we didn't have many fires in the park, so would you expect to see that show up in last year's lamination?

CW: No. We look at biggish microscopic particles (100 microns in diameter), and those particles are not transported very far. Small particles, like soot or ash, can be transported great distances before they are deposited. From studies we did after the 1988 fires in Yellowstone, we determined that the large charcoal particles provide the best record of fires within the watershed and allow us to separate local fires from those that are happening elsewhere in the region.

YS: So you're not interested in stuff that may be coming from Oregon or Washington.

CW: No. I suppose it would nice if one record could provide a picture of environmental changes across the entire West, but the devil is in the details, and one learns more by reconstructing the history of many small watersheds than by looking at a single site. The Crevice Lake watershed burned in 1988, so I'm hoping we'll see charcoal from that event in the sediments, but I don't expect that we'll see much charcoal from more distant fires. We also have a good fire history record from the Slough Creek area, from Cygnet Lake in the Central Plateau, and from the southern part of Yellowstone at Trail Lake.

YS: Have you done any coring in Yellowstone Lake?

CW: We do have cores from Yellowstone Lake, and I have collected cores from small lakes around Yellowstone Lake as well. The vegetation history goes back 14,000 years or more, and begins with a period of tundra, followed by a period of spruce, fir, and whitebark pine forest, and ends with the development of lodgepole pine forest.

In addition to this long-term history, we also have studied environmental changes since the park was established in 1872. At Crevice Lake, we'll be able to identify the sediment layer that was deposited in 1872 and compare the history prior to that date with what has happened in the 20th century. For example, it should be possible to look at the impacts of changing elk numbers through time. Some people have claimed that rates of erosion may have increased when elk populations were high. If so, we should see evidence of it in the magnetic and geochemical properties of the sediment. Even small changes in the level of dust or surface run-off in the lake can be measured in the sedimentary record. Sheri Fritz, along with folks from the University of Minnesota and I, did a study on the northern range in the 1980s, looking for post-park/pre-park changes and evidence of erosion in the Lamar area. It turned out that the biggest signal we got was the increased dust during periods of road construction. If elk had an erosion impact in that area, it was less than the impact of road building.

Winter is the ideal time of year to conduct this coring operation because the lake's frozen surface allows researchers to core into the deepest parts of the lake without using a boat. NPS photo.

YS: And you're doing similar coring operations in other lakes in Montana?

CW: We are. I have a pretty good understanding of the environmental history of the Yellowstone ecosystem, and the goal now is to put Yellowstone's history into the bigger picture that includes other areas in northwestern North America. We're coring lakes in western Montana and Idaho to fill in some of the gaps.

YS: How long will the process take that will allow you to analyze these cores that we saw you pull out this week? Several years? Lots of microscopic analysis?

CW: Lots of hours at the microscope. First, the cores are going to the University of Nebraska, where they will be split open and photographed, and a chronology will be established by counting the layers and getting some radiocarbon dates. Then sediment samples will be sent to different laboratories. The University of Oregon will get samples for pollen and charcoal analysis. The University of Nebraska will look at the diatoms and stable isotopes. The USGS will be examining the geochemistry and sediment magnetism. It's going to be a couple of years before we have some results and can put together the history.

YS: And about how long are those cores?

CW: The total depth of sediment recovered from Crevice Lake is about 6 meters.

YS: Representing…

CW: Probably somewhere between 12,000 and 14,000 years. But don't hold me to that until we get some radiocarbon dates and have a chance to count the annual laminations!

YS: Like with tree rings.

CW: Yeah.

YS: Why can you only go back 14,000 years? Is that as far down as the corer goes?

CW: I'm guessing that's when the glaciers left here and the lake was formed. 14,000 years ago is about the time of the floods that moved through the Yellowstone Canyon. The lake was probably formed by that event. At least it is hard to imagine a lake here before that time.

YS: So literally, today, we finally discovered the origin of the term, "hitting rock bottom." Because you pull that core out and it shows approximately when the lake's origins were.

CW: Right! We literally hit the rocks that underlie the lake sediments, and that's as far as we can core with our equipment.

YS: Can you describe how you're taking these cores out of the lake?

CW: We're using a piston corer, which is a meter-long stainless steel tube with a piston in it. We lower it by rods down to the depth at which we want to take a sediment core. We secure the piston at the bottom of the tube so it can't move and we basically push the tube past the piston and collect a meter of sediment. Then we pull it out and extrude it on the ice surface, wrap it up in plastic wrap and foil, put more rods on, and go back down into the same hole. Deeper and deeper until we hit the bottom. And it's not hard to know when we reach the bottom. You just…stop (laughter).

YS: So, what's the real application for your research? Is it to judge climate trends or climate changes and their ability to affect ecosystems? How might this be used?

CW: There are many ways to answer that. But for one, when you're managing an area, you want to know whether the current vegetation is typical or completely anomalous. Were the fires of 1988 unprecedented, or do fires of that size occur frequently? It is necessary to identify the range of variability for an ecosystem, so that land managers know when current conditions exceed the range of variability of conditions in the past. Paleo-data are one of the few ways to establish that long-term range of variability. How dry has it been in Yellowstone in the past, and how often have large fires occurred? Most management schemes recognize that we cannot make the national parks look like they did in 1850. It wouldn't be possible and it wouldn't make any sense. 1850 was just one period and may not have been typical of anything. Knowing the range of historical variability, on the other hand, allows us to evaluate whether or not the current ecosystem is pretty much behaving the way it has for the past 2,000 or 3,000 years.

YS: And that certainly would pertain to elk management and fire management.

CW: Absolutely. And the other consideration for managers is climate change. How much drought can these systems take? How much fire can they take? Are we seeing the effects of global warming now with the death of whitebark pine or not? So our NSF project is an effort to tackle some of these climate questions—using the past to establish the historic range of variability.

YS: Have you seen evidence of death of whitebark pine already in some of your work?

CW: Not here. I'm doing some work in the Bitterroots where you can see the whitebark pine decline in the pollen record in the last few decades.

YS: We've certainly heard a lot about it up in the Glacier National Park area.

CW: Yes, it's a big concern.

YS: In doing this research in Yellowstone, can you think of one outstanding episode of adventure, or excitement, or discovery that you might share?

CW: Well, I just get excited working with the lake sediments. That sounds dumb, but every lake tells a different story, and you never know quite what you're going to find until you collect some cores. The cores contain the history of the watershed, and each history is a little different. Coring remote lakes in Yellowstone has offered its share of field adventures. We've had our gear brought in by helicopters and we've had it hauled on horses and on our backs. The misadventures, lousy weather, and improvised technology of past expeditions provide for hours of conversation and humor on the next field trips.

NPS photo.

Cathy Whitlock has been a Professor in Geography at the University of Oregon since 1990, where she currently serves as Head of the Geography Department and as President of the American Quaternary Association. She received a Ph.D. in Geological Sciences from the University of Washington in 1983, and has held research and teaching positions at Trinity College Dublin, Carnegie Institute, and the University of Pittsburgh. Dr. Whitlock's research focuses on the sensitivity of forests to past environmental changes as well as the potential response of vegetation and fire regimes to future climate change. She has conducted research in Europe, China, and the Pacific islands, but her primary interests have been in the western U.S. Her research has been published in over 70 scientific papers and books, and she is co-editor of a volume on the Quaternary environments of the former Soviet Union.

Tracking Down Yellowstone's Red Fox: *Skis, Satellites, and Historical Sightings*

by Bob Fuhrmann

Photo by Michael Francis.

Relatively little is known about the red fox population of Yellowstone National Park and its surrounding areas, yet a variety of historical and anecdotal records indicate that Yellowstone's red foxes (*Vulpes vulpes*) have undergone several population fluctuations and exhibit an unusual variety of coat colors. Further, the restoration of wolves to Yellowstone is likely having an effect on fox distribution in and around the park, and fox sightings have increased in recent years. Curiosity about these things, coupled with the general lack of knowledge regarding Yellowstone's red fox population, led me to investigate red foxes in Yellowstone.

Prior to this study, the only formal research project that examined the red fox in Yellowstone was a medium-sized carnivore study (Gehman, Crabtree, & Consolo Murphy 1997). Results obtained from baited camera stations and track surveys indicated that red foxes were present throughout Yellowstone's northern range. My research aimed to investigate the potential variety of red fox subspecies living in this region and describe the kinds of habitat they use. The result was a multi-faceted project focusing on field methodologies and including archival research and oral history.

Biogeographic Background of the Red Fox

During their expedition up the Missouri River in 1804–1806, Lewis and Clark catalogued many species of plants and animals. In the upper Missouri drainage, they reportedly identified a "great-tailed fox" which they presumed to be the Rocky Mountain red fox (*V. v. macroura*) (Cutright 1969). This sighting probably came from near the Missouri in north central Montana. In addition, Audubon notes that a fox similar to what Lewis and Clark described was collected from a trapper before 1850 on the upper Missouri River. This fox was mostly gray and had a rather large tail, and was presumably collected in central or eastern Montana.

In 1969, however, Hoffman et al., who examined sighting and trapping records in Montana, indicated that prior to 1950, the only population of red fox (*V. v. macroura*) inhabiting Montana was in the higher elevation forests (*e.g.*, Yellowstone National Park), indicating that they were absent from low elevation valleys (Hoffman, Wright, and Newby 1969). These foxes were restricted to mountainous areas of extreme western and southwestern parts of the state. The discrepancies between Lewis and Clark and Audubon compared with Hoffman make it appear that red foxes were present in this region during the early 1800s but might have disappeared between that period and the 1950s, raising the question: where did they go? One possibility is that foxes on the plains of eastern Montana were extirpated through predator eradication programs in the early decades of the 20th century.

After 1950, red foxes were commonly seen in lowland and agricultural areas, especially throughout eastern and central Montana, but the origin of the animal's habitation of these areas is unclear. If these foxes are the Rocky Mountain red fox (*V. v. macroura),* they could have descended from the montane habitats back to the plains following the conclusion of the large scale predator eradication programs alluded to earlier. Conversely, the European red fox (*V. v. fulva*) could have migrated from the surrounding region to fill the niche of the Rocky Mountain fox.

European red foxes were brought to the eastern U.S. in the 18th century for fox hunts, but many escaped the jaws of the hounds or fur farms and successfully adapted to new environments. Prior to the 1800s, red fox distribution west of the Mississippi River was limited to the mountainous regions of the western United States, possibly including central and eastern Montana. Presently, it is believed that the European red fox inhabits agricultural and other human-disturbed habitats at lower elevations (the extent of the European red fox's expansion has been attributed, in part, to the widespread habitat changes brought on by agricultural development), while the mountain fox still resides in the high-elevation montane/alpine zones of the Rocky, Sierra, and Cascade mountain ranges and the boreal forests of Canada, Alaska, and the northern Great Lakes states (Sheldon 1992). However, it is unknown whether there is a dividing line between these two subspecies or if there is an integrade zone where they co-exist.

Potentially, the endemic red foxes inhabiting isolated mountain ranges of the lower 48 states are relics from the Wisconsin glaciation (Aubry 1983). If this hypothesis is true, the mountain foxes would not be well adapted to low elevation grasslands under the current climatic conditions and mix of competing predators (Merriam 1900). We know that the high elevation red fox has survived in the higher elevations of the Greater Yellowstone Ecosystem since the Wisconsin glaciation, but more information is needed to validate the historic distribution of red fox within the Greater Yellowstone Ecosystem.

The Influence of Wolves and Coyotes on Red Fox

Another area which requires more study is the question of how the restoration of wolves to Yellowstone is affecting the area's foxes. For most of the 20th century, Yellowstone had only two canid predators, foxes and coyotes (*Canis latrans*). In 1995, wolves (*C. lupus*) were reintroduced. This reintroduction will likely have major impacts on the other canids in the ecosystem. A review of 16 separate studies of sympatric coyote and red fox populations indicates that coyotes have a tremendous negative impact on fox populations (Crabtree and Sheldon, in press). In Yellowstone, track surveys and remote cameras demonstrated that 90 percent of known fox locations occurred on the periphery of or in between coyote territories in the northern range (Gehman, Crabtree, and Consolo Murphy 1997).

Wolves are known to kill coyotes and may exclude them from core areas of pack ranges. Since 1995, many coyotes have been killed or displaced by the wolves. Due to decreased competition for space and food, foxes seemed to fill in behind the missing coyotes. In one area of the Lamar Valley where there were four contiguous coyote territories containing 25–30 coyotes prior to wolf reintroduction, there are now no coyote packs. In this same location, a high concentration of fox sightings have been reported

Adam Kaufman, one of Bob's field assistants, collects data with a GPS receiver on the Beartooth Plateau. Photo by Bob Fuhrmann.

__Figure 1.__ Historic fox sightings in Yellowstone National Park, 1892-1985.

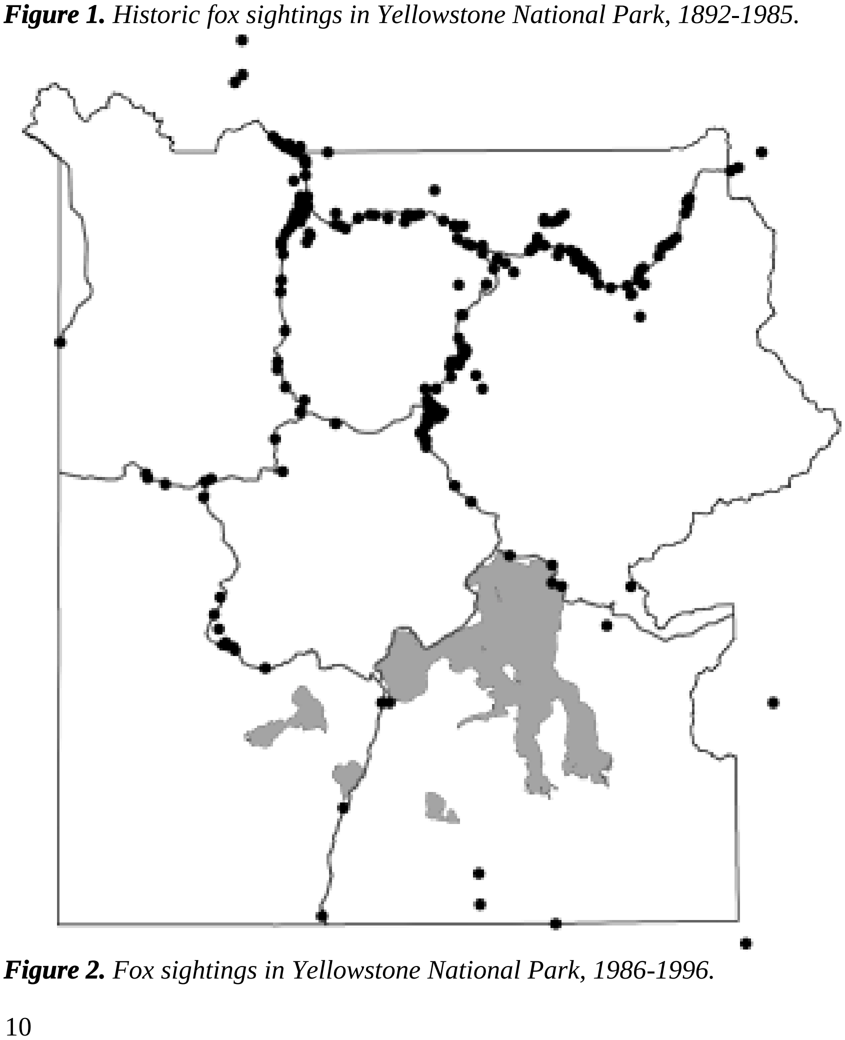


__Figure 2.__ Fox sightings in Yellowstone National Park, 1986-1996.

compared to what was documented in the few years prior to 1995. This indicates that wolves can have an indirect effect on the occurrence and distribution of red fox. Future studies will be able to compare habitat use patterns with what I observed in this study to determine if red foxes' habitat use also shifts.

Yellowstone Sightings, Distribution, and a Fox of a Different Color

I began my historical research on Yellowstone's red foxes by examining the park's sighting records. Sighting records collected over long periods of time will often provide an indication of the presence or absence of a species, and possibly indicate major trends. The records from 1880 to 1900 indicated that foxes were frequently observed in the early decades of the park's history (Varley and Brewster 1992). According to Yellowstone's second superintendent, P.W. Norris, some park officials were very adept at distinguishing species and even color morphs of the red fox. Norris stated that foxes were "numerous and of various colors, the red, grey, black, and the cross varieties (most valuable of all) predominating in the order named" (Norris 1881).

Shortly after the turn of the last century, however, reports of red foxes within Yellowstone National Park were sporadic, and sightings uncommon. It appeared that the once frequently sighted red fox was on the decline. Those sightings that were reported occurred in diverse areas of the park (see Figure 1). These foxes were consistently light- and gray-colored, especially at higher elevations. Following and possibly as a result of the extirpation of wolves in the 1920s, there was a marked increase in coyote observations and a decrease in red fox sightings.

The frequency of red fox sightings did start to increase in the late 1980s, but this was likely the result of increased interest and reportage rather than an actual increase in red fox numbers. Two events, an official rare mammal sighting program instituted in 1986 and a coyote study initiated in 1989, marked the beginning of a period in which the number of red fox sightings steadily grew. Since then, red foxes have been reported throughout the Greater Yellowstone Ecosystem in all months of the year in areas ranging from riparian communities at low elevations (1,500 meters) to alpine tundra at elevations exceeding 3,000 m (see Figure 2). Because of the nocturnal behavior, habitat use, and relatively low densities of red foxes in Yellowstone, many employees and visitors have never seen one in the park. Many long-time area residents say they have never seen a fox in their travels in and around Yellowstone, and an examination of recent sighting records of red fox in Yellowstone (Figure 2) confirms that most sightings occur along the road corridor, where Yellowstone's visitors spend most of their time. In fact, most of the fox sightings that I personally collected in Yellowstone were in the headlights of my car.

In addition to examining the park's red fox sighting records, I also talked with long-time residents in Yellowstone and the surrounding communities to learn about their recollections of foxes in this region. Trapper Martin Kolence, born in 1911 and raised around Livingston, Montana, does not remember any foxes in the "low country" prior to World War II (pers. comm. 1995). In all of his hiking, camping, fishing, and hunting in the Greater Yellowstone Ecosystem, he can remember seeing only one fox prior to the 1950s, and never saw a fox track. He did recall his father shooting a fox by their house on Trail Creek Road around 1920. He believes that foxes from the lower Yellowstone River Valley colonized the Livingston and Paradise Valley areas beginning in the 1950s. He does remember hearing of foxes inhabiting the higher elevations around Yellowstone National Park, and once saw a very light-colored one that was captured in Tom Miner Basin. Kolence and other trappers called these high-elevation foxes "frosty butts" because of their light color. This pattern of red foxes' being present in higher-elevation forests, yet absent from lowlands, is supported by Hoffman (Hoffman, Wright, and Newby 1969).

Adding to the intrigue of elevational distribution of fox in the northern Yellowstone region is the variation in their coat colors, such as was described by Kolence. Analysis of park records suggests that foxes at lower elevations usually have red fur. In contrast, a large percentage of reports from higher elevations throughout the region, including the Beartooth Plateau, note a gray or cream ("frosty butt") color phase (see Figure 3). This coat color has not been described previously in the wild. Also, a red fox hit by a vehicle between Mammoth Hot Springs and Tower Junction in 1998 was about 60 percent black, with intermixed red fur patches. When asked about this dark color, many current wildlife biologists in the park had never seen or heard of anything like it (though Superintendent Norris had mentioned this dark appearance in the 1880s). Other color anomalies exist, including red foxes without the diagnostic white tail tip, and a handful of a nearly white or "ghost" color phase.

These findings led me to a variety of unanswered questions. What could account for the unexpected patterns in foxes at different elevations? What might account for the unique coloration of foxes in the northern Yellowstone region? And where were foxes, and why? These questions beckoned personal investigation into the current status of Yellowstone's mysterious red fox.

Tracking the Elusive Mountain Fox

To investigate red foxes in Yellowstone, my colleagues and I employed both old and new field techniques. Snow tracking, one of the oldest forms of learning about mammals during winter, is a "tried and true" field technique of

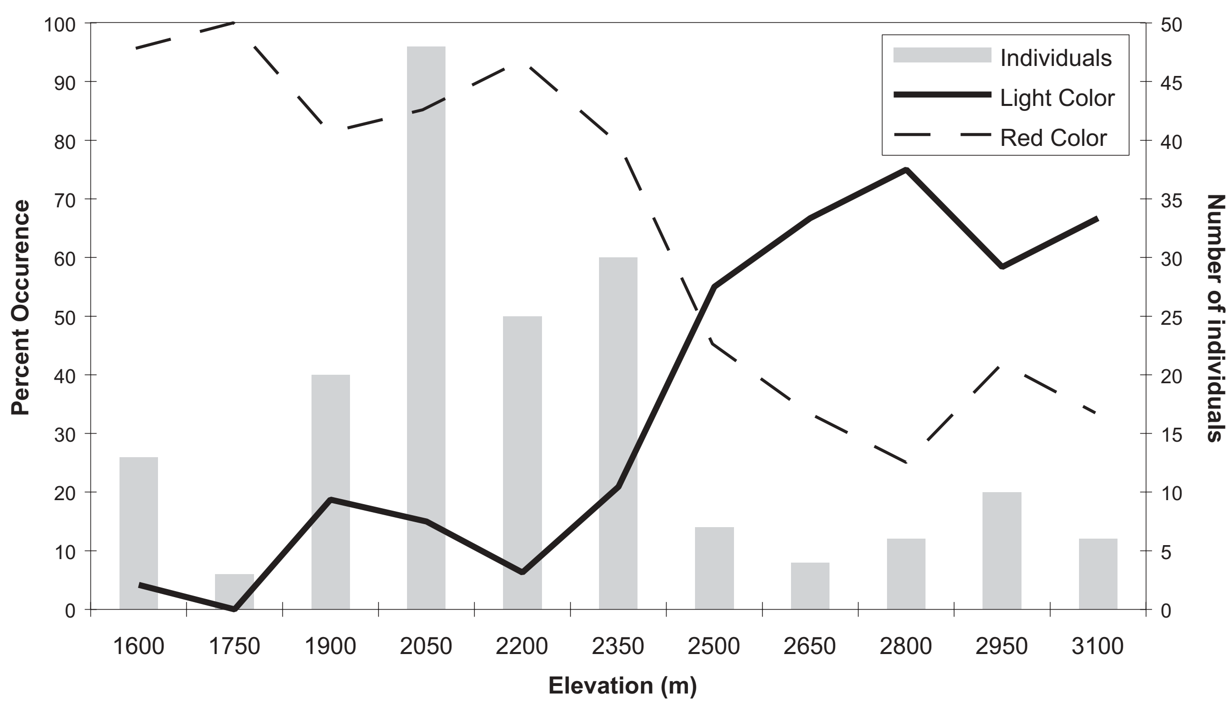


Figure 3. *Red fox color frequency by elevation.*

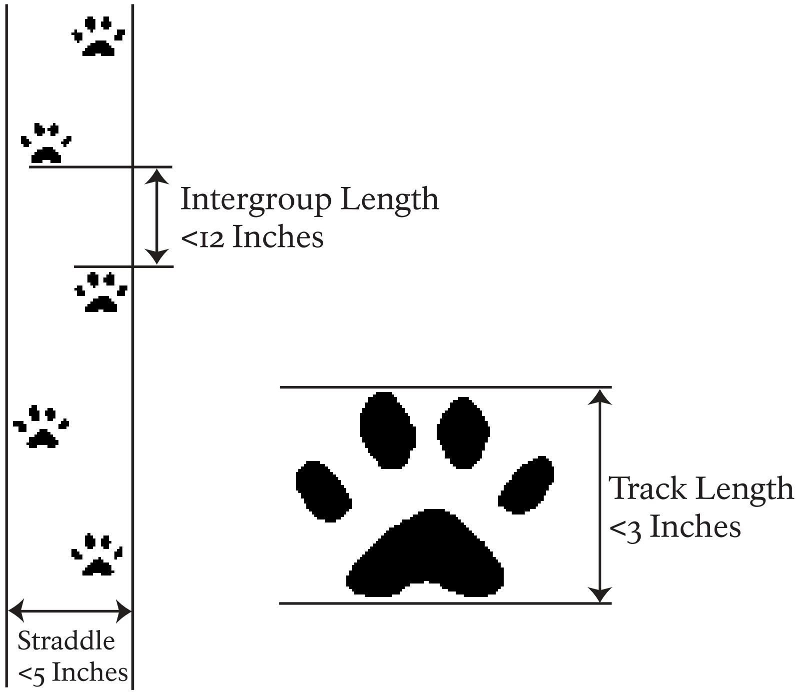


Figure 4. *The "12-5-3 Rule:" Measurements used to identify fox tracks (not to scale).*

bounty hunters, sportsmen, and biologists. When hunting was a way of life, the difference between reading tracks well and not understanding them could mean the difference between life or death. This study, along with others, shows that tracking can be a very useful tool to biologists (Johansen 1989).

Snow tracking has both advantages and disadvantages. It can provide very accurate, detailed information on movement and behavior patterns with minimal researcher impact, the main advantage being that the research animal is usually not disturbed. Tracking can be very cost-effective, requiring only a map, clipboard, and data sheets. However, additional expenses can be incurred with the use of Global Positioning System (GPS) units and handheld computers to gain more accurate data. Snow tracking provides information during winter only but can provide insights into year-round habitat utilization. Nearly all red foxes in a given population belong to a breeding group (pair or trio), and maintain territories year round. Therefore, we might be able to predict a fox's summer range by identifying its winter range, keeping in mind that foxes tend to cover more ground in the winter in search of food.

On the other hand, tracking can be difficult because of unpredictable snow conditions, resulting in variability in the quality of data collected. Frequent snow, wind, and melting makes snow tracking difficult and often fruitless. The nocturnal behavior of red foxes in Yellowstone also makes direct observation techniques difficult. During this study, I observed very few foxes while tracking and traveling to transect sites. Despite the disadvantages, my colleagues and I decided that the most plausible and least invasive way to study the distribution and habitat use of Yellowstone's foxes was to track them through the snow. To accomplish this, 25 ski transects were established between Mammoth Hot Springs, Wyo., and Island Lake on the Beartooth Plateau. Each ski transect was traversed at least twice during each field season from December through March in the winters of 1994–1995 and 1995–1996. In addition, we monitored the road corridor from Mammoth, Wyo., to Cooke City, Mont., for fox activity during both seasons. Most of the transects followed established ski or snowmobile trails, allowing us to cover more than 186 kilometers.

The Fox Track

Our next challenge was to distinguish coyote and fox tracks from one another. Using data previously collected by James Halfpenny of Gardiner, Montana, Gehman et al. (in the medium-sized carnivore study mentioned earlier), and by me, we developed a formula: red fox tracks were defined as any set of tracks with an intergroup distance of less than 12 inches, a straddle of fewer than five inches, and a track length of less than three inches (Figure 4). This was dubbed the "12-5-3 Rule." To maximize accuracy, these measurements were taken in at least three locations along a track set, because using only one of these measurements would not verify that a fox made the tracks. All three of the measurement criteria had to be met in order for a fox track to be distinguished from a coyote track. The most reliable and discriminating criterion was clearly straddle. These measurements excluded small coyotes and, potentially, a few large foxes.

The behavior of an animal could also be ascertained by looking carefully at clues left in the snow. For example, coyotes and foxes travel differently. If tracks went under something, we measured the height of the object above the snow. If the object was one foot off the ground and no belly rubs were found on the snow, this suggested a fox track. Also, different odors occur from scent marks produced by foxes and coyotes and we were able to distinguish them. Examining several aspects of the track set allowed us to differentiate fox and coyote tracks and collect behavioral data.

GPS Tracking

Global Positioning System (GPS) units were used to collect locations and elevations of fox tracks observed along the track transects. While skiing the transects, fox tracks were systematically searched for on both sides of the trail, and when a set was located, the GPS unit was activated and UTM coordinates were logged. The tracks were first backtracked, so as not to disturb the fox and bias its behavior. If time permitted, the tracks were also forward-tracked.

Track sets were followed for distances

ranging from 150 to 1500 meters. Different limiting factors determined how long we followed a track set. Some track sets were lost because of our inability to determine where the fox was traveling relative to the plentiful tracks of other animals. Other limiting factors were malfunction or battery failure of the GPS unit or handheld computer. At times, tracking was discontinued because the fox traveled into areas unsafe for researchers, for instance, areas with high avalanche danger (*i.e.,* steep slopes), ice that was not stable enough to support a human, or areas occupied by a bison herd. Each GPS had pre-programmed function keys to collect data such as snow type, scent marks, forage sites, and bed sites. Approximately every 150 m, we established a habitat collection point and entered it on the GPS. At these points, we collected habitat characteristic data such as cover type, distance to ecotone (edge), slope, aspect, and snow depth, and entered it on handheld computers. GPS base station files were used to differentially post-correct GPS field files. Once corrected, these data were estimated to have an accuracy of two meters or less.

We determined habitat availability from the GIS, defined as a 500–meter buffer on either side of a tracking transect. This distance was chosen because it included more than 95 percent of the track sets followed. Other habitat variables such as elevation, slope, and aspect were extracted from the GIS layers relative to those parameters.

Findings

Habitat Use

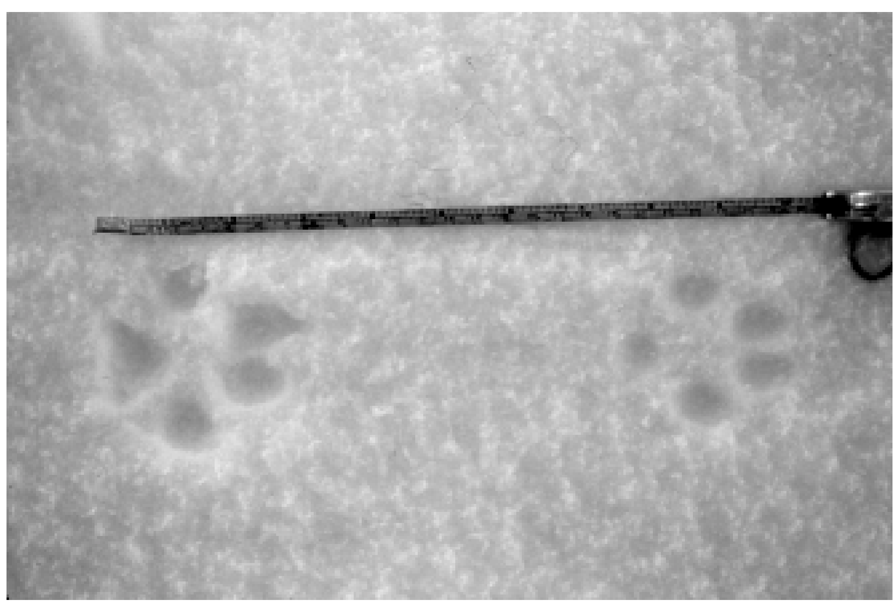
A total of 77 kilometers of fox tracks were followed during two winter field seasons. These tracks were found on all of the trails skied throughout the northern Yellowstone region. Despite a wide range of elevations and habitats, red foxes were found to be contiguous in distribution across this area. Fox tracks were located at all elevations from 1,350 to 3,000 m. Frequent sightings in areas that were not formally examined for fox tracks, such as Paradise Valley between Livingston, Mont. (1,350 m) and Gardiner, Mont. (1,585 m), further demonstrates the contiguous distribution of fox throughout the northern Yellowstone ecosystem. Although red foxes were found to inhabit almost every habitat type in the study area, their use patterns (preference and avoidance) of specific habitat components differed by elevation and season.

Prior to this study, little was known about fox habitat use in this area. My research suggests that foxes generally prefer habitats that are close to the edge of a major structural change in vegetation, or "ecotone." Sagebrush and older growth forests are important as escape cover for foxes because they provide a high degree of visual security. Over 87 percent of our distance-to-habitat edge measurements were <125 m from an ecotone, and 50 percent of the track sets were <25 m from an ecotone.

I observed distinct differences in habitat preference between foxes tracked at low and high elevations, however. Below 2,100 m (approximately 6,930 feet), they showed less selection for old growth forest, even though red foxes frequenting open habitats below 2,100 feet are often chased and occasionally killed by coyotes (Gese, Stotts, and Grothe 1996). These foxes frequently used open and sagebrush areas, and avoided coyotes temporally (through nocturnal behavior) and spatially (by using areas outside coyote core areas). The main habitats used by foxes at this elevation were mesic meadows, and sagebrush (52%). The sagebrush offered cover that effectively hid foxes from coyotes. Foxes also used older growth Douglas-fir, spruce-fir, and lodgepole pine stands that provided protective cover. Foxes remained closer to escape cover when using open cover types at low elevations than when they traveled in sagebrush and forested areas. Sagebrush may provide the most protective cover for foxes.

Above 2,100 m, where coyotes were rare, I assumed that foxes would be more likely to venture farther into and spend more time in open areas to catch small mammals. Instead, they utilized heavier forest cover and had lower mean distances to edge than those below 2,100 m. At these higher elevations, however, foxes utilized the edge of open mesic habitats 27 percent and spruce-fir forests 30 percent of the time.

These habitat differences could be the result of variations in preference between two subspecies, as mountain foxes (*e.g., V. v. macroura*) are reported to prefer subalpine forests and European red foxes (*V. v. fulva*) to prefer more open cover types (Aubry 1983). Or, other factors may account for the difference between these two elevational zones. They may have been related to sub-specific preferences or variations in prey availability at different elevations. Although it might be conjectured that one such factor could be the lack of coyotes above 2,100 m in the winter, a recent coyote study in Yellowstone and my personal observa-



Measuring red fox tracks. Photo by Bob Fuhrmann.

tions suggest that coyotes do not have defended territories above 2,100 m, and are absent from high elevations during winter, making them a non-factor in accounting for differences in fox habitat use above and below 2,100 m (Crabtree and Sheldon, in press). The dissimilar habitat use of low and high elevation foxes, however, could be associated with the differences in genotypes and phenotypes I observed.

Morphology

Some evidence suggests that there are genetic, phenotypic, and potentially morphometric differences between red foxes above and below 2,100 m in the Yellowstone region. Foxes at higher elevations may have adapted to colder climatic conditions, and generally have "frosty butts."

Based on an examination of 21 tissue samples collected from trapped and road-killed red foxes, there appear to be two genetically distinct populations of red foxes inhabiting the northern Yellowstone ecosystem, separated by elevation. Interestingly, although there is no distinct geographic barrier separating them, very limited gene flow occurs between these elevational zones. The fox subpopulations show a degree of division comparable to that found between island and mainland red fox populations in Australia, which shows that they have been isolated for many years (Lade et al. 1996). More questions may be answered about the genetic separation of these subpopulations through further analysis of tissue samples.

With no geographic barrier separating low and high elevation foxes, it might be assumed that the high elevation foxes might disperse to lower elevations and establish home ranges in the more hospitable lower environments, or that low elevation foxes might move to higher elevations to avoid coyotes. However, the limited gene flow indicates low dispersal in either direction. In general, canids are thought to interbreed extensively (Sheldon 1992). There are wolf-dog hybrids, coyote-dog hybrids, and the red wolf is thought to be a combination of gray wolf and coyote (Sheldon 1992). Sympatric coyotes and wolves in Ontario appear to have been morphologically converging in body weight and length over the last 40 years (Schmitz and Lavigne 1987). It is unusual, then, that there is such limited gene flow between subpopulations above and below 2,100 meters.

Foxes in the Yellowstone area have adapted to survive in harsh winter conditions at high elevations. They exploit higher elevations more regularly than coyotes, which may be a spatial competition avoidance mechanism on the part of foxes (Gehman, Crabtree, and Consolo Murphy 1997; Crabtree and Sheldon, in press). In addition, foxes seem to be better adapted to hunting in deep snow than coyotes. Foxes have large feet in proportion to body size when compared to coyotes. An adult coyote weighs about 13.5 kg (30 lbs.) in Yellowstone, which is three times as large as an adult fox (4.6 kg or 10.1 lbs.), but its track size is not three times as large. Foxes' sizable feet and long track length act like snowshoes, allowing them to stay on top of the snow instead of sinking.

A lighter colored fox live trapped at Island Lake, Beartooth Plateau. Photo by Bob Fuhrmann.

Morphologic divergence is another possible test of population isolation, depending on the amount of time the populations have been segregated and the extent to which phenotype characteristics are plastic. Although the morphometric data do not indicate that there is a statistically significant difference in fox size along the elevational gradient found within the study area, high elevation foxes living in harsher environments did tend to have larger bodies and smaller ears than low elevation foxes.

Another interesting variable was hindfoot length. The trend indicated that foxes at higher elevations may have larger hind feet than those at lower elevations. Foxes at higher elevations have to withstand significantly deeper, less dense snow, and longer periods of it. Therefore, the hind feet should be longer and larger to act like a snowshoe and reduce foot loading (lower kg/cm^2). With the small sample size, this appears to be the case. Most of the foxes I observed at high elevations had very small toe pads (~3 mm wide x ~10 mm long) and an abundance of fur covering all of the pads in their entirety, including the heel pad. This could potentially keep the foxes' paws from forming ice crystals while traveling in deep, less dense snow. In addition, abundant fur on the feet (as in lynx) decreases foot loading and increases the snowshoe effect. Such small pad size and large amounts of fur were never observed at low elevations.

Summary

Due to the small sample size and lack of genetic information from other fox populations, I was unable to determine the exact taxonomic origin of the foxes at higher elevations in Yellowstone National

Park and the Beartooth Plateau. Since this is the only study of the Rocky Mountain subspecies *(V. v. macroura*), further research is needed to compare the two fox subpopulations studied to those of other regions such as the grasslands of eastern Montana or central Wyoming and other parts of the Rocky Mountains. In addition, the high elevation foxes should also be compared with the red foxes inhabiting northern Canada and Alaska (*V. v. abietorum*). This would assist in identifying the origin of these high elevation foxes. Depending on its origin, an isolated fox subspecies may have existed and could still remain today in the alpine regions of the Greater Yellowstone Ecosystem.

From the differences in coat color, habitat use, and morphology, it appears that foxes at higher elevations (>2,100 m) are unique. This study was unable to determine the exact cause of this uniqueness, but did show that two subspecies of fox may occupy the northern Yellowstone ecosystem. This study also provided a pre-wolf baseline on habitat use patterns for low and high elevation foxes, but more research is needed. I hope that someone takes advantage of the opportunity to reexamine red fox distribution and habitat use after wolves have fully established themselves in northern Yellowstone.

This study was completed as a collaborative effort with Bob Crabtree, Yellowstone Ecological Research Center; Lynn Irby, Montana State University; Yellowstone National Park; Gallatin National Forest; Shoshone National Forest; Montana Fish, Wildlife and Parks; and Wyoming Game and Fish.

Literature Cited

Aubry, K. B. 1983. The Cascade red fox: Distribution, morphology, zoogeography, and ecology. Ph.D. diss., University of Washington.

Crabtree, R. L. 1993. Gray ghost of the Beartooth: On the taxonomic trail of the mountain fox. *Yellowstone Science* 1(3).

Cutright, P. M. 1969. *Lewis and Clark: Pioneering naturalists*. University of Nebraska Press, Lincoln.

Gehman, S., R. L. Crabtree, and S. Consolo Murphy. 1997. Northern Yellowstone carnivore study. *Annual Report Series*, U.S. National Park Service and cooperators.

Gese, E. M., T. E. Stotts, and S. Grothe. 1996. Interactions between coyotes and red foxes in Yellowstone National Park, Wyoming. *Journal of Mammalogy*, 77(2):377–382.

Hoffman, R. S., P. L. Wright, and F. E. Newby. 1969. Distribution of small mammals in Montana. Mammals other than bats. *Journal of Mammalogy* 50(3):579–604.

Johansen, O. J. 1989. Lynx winter habitat selection in central Troms County, Northern Norway. Master's Thesis, Idaho State University.

Lade, J. A., N. E. Murray, C. A. Marks, and N. A. Robinson. 1996. Microsatellite differentiation between Philip Island and mainland Australia populations of the red fox (*Vulpes vulpes*). *Molecular Ecology*, 5(1):81-87.

Merriam, C. H. 1900. Preliminary revision of the North American red foxes. Proc. Wash. Acad. Sci., 2:661–676.

Norris, P. W. 1881. *Annual report of the superintendent of the Yellowstone National Park to the secretary of the interior for the year 1880*. Washington, D.C.: GPO.

Sargeant, A. B. and S. H. Allen. 1989. Observed interactions between coyotes and red foxes. *Journal of Mammalogy*, 70(3):631–633.

Schmitz, O. J. and D. M. Lavigne. 1987. Factors affecting body size in sympatric *Ontaris Canis*. *Journal of Mammalogy*, 68(1):92–99.

Sheldon, J. W. 1992. *Wild dogs: The natural history of the nondomestic canidae*. San Diego: Academic Press, Inc.

Varley, J. D., and W. G. Brewster, eds. 1992. *Wolves for Yellowstone? A Report to the United States Congress, Volume IV Research and Analysis.* Yellowstone National Park, Wyo.: National Park Service.

NPS photo.

Bob Fuhrmann has worked in Yellowstone National Park for almost 10 years. Since 1998, he has served as the Education Program Coordinator for the NPS, coordinating most of the student groups that visit the park. This includes a residential program for fourth through sixth graders, a summer educational program for local students, and the Junior Ranger program.

From 1994 to 1998, Bob researched red foxes in the northern Yellowstone area in order to earn his master's degree in fish and wildlife management from Montana State University in Bozeman. While completing his degree, Bob also worked full time as a lead interpretive park ranger at the Albright Visitor Center in Mammoth Hot Springs.

Before coming to Yellowstone, Bob worked at various jobs across the western United States. These included researching stream and aquatic ecology on the North Slope of Alaska; studying blackbirds in central Washington; and operating a ski lift near Seattle. Bob received a Bachelor of Arts degree in biology and a secondary education teaching certificate from Lawrence University in Appleton, Wisconsin. He grew up in a northern suburb of Chicago.

Outside of work, Bob enjoys spending time with his family, including his two-year-old son. The great outdoors has always been fascinating to Bob. He loves to kayak on the Yellowstone River (outside of the park, of course), backcountry/telemark ski, and hike the many trails in and around Yellowstone.

2001 Yellowstone Christmas Bird Count

by Terry McEneaney

On December 16, 2001, the Yellowstone Christmas Bird Count (YCBC) was conducted in the Gardiner, Montana, and Mammoth, Wyoming, areas. This YCBC marks the 29th year for this traditional bird survey. The established center point for this bird count is the North Entrance of Yellowstone National Park and extends 7.5 miles from this point in any direction, with boundary limits basically east to Blacktail Ponds, north to the mining town of Jardine, Montana, and northwest to Corwin Springs, Montana. The YCBC is divided into teams of observers to maximize landscape coverage. All bird species and total individual birds detected during the count day are included in the final results. Additional birds incidentally observed three days before and three days after official count day are included in another category called the count week totals.

Since the YCBC is totally voluntary, the number of observers showing up in any given year is never known until count day. However, each year at least a half-dozen skilled observers repeatedly return to participate. Weather conditions highly influence overall participant turnout as do personal holiday plans. The number of people participating in the YCBC has little bearing on the number of bird species or individuals detected during count day. In fact, weather plays a greater role in finding birds than does the number of participants. Because of access limitations in the winter, experience has shown birds can be best counted in specific habitats. The more inclement the winter weather (*e.g.,* cold temperatures and deep snows) the better the birding, since birds are concentrated primarily near bird-feeding stations, riparian areas, and geothermal or open water areas. Birds are also less concentrated during mild weather conditions, since natural foods are more available. Ironically, the largest number of participants show up during years of mild weather conditions when birding is just average or below average (Figure 1). Hence, mild weather years for the YCBC result in few bird rarities being detected.

The 2001 Yellowstone Christmas Bird Count tallied a total of 34 bird species and 1,675 individual birds (Figure 2). The mild weather conditions resulted in an average number of species and a slightly above average number of individual birds observed. As expected due to the mild weather, a record of 22 observers showed up for the 2001 YCBC, tying the previous record set in 1999, another mild year. Temperatures during the 2001 YCBC ranged from 12 to 27 degrees F., with 3–12 inches of snow, depending on the elevation, and the edge of the rivers were not even frozen.

Three bird records were broken during the 2001 YCBC. A total of 389 common redpoll were detected in the count area this year, compared to the previous record of 148 set in 1989. The irruption of common redpolls was the result of a rare superabundance of food, namely Douglas-fir seed cones, alder catkins, and exposed grass seed heads, coupled with an early winter storm forcing redpolls into the area in November. Two yellow-rumped warblers were also detected, whereas only one was seen in 1983, 1987, and 1990. Additionally, seven song sparrows were found this year compared to the previous record of six observed in 1988. Two marsh wrens were also found during the 2001 YCBC; this ties the record set in 2000. Four northern flickers were found in 2001, tying the previous record set in 1987. Species that are regularly detected such as the common goldeneye, hairy woodpecker, downy woodpecker, dark-eyed junco, and American tree sparrow could not be located due to the mild winter weather conditions.

In conclusion, a grand total of 95 species have been recorded on the YCBC (97 species with the YCBC and count week combined) during the 29 years the count has taken place. This year, mild weather conditions resulted in an average number of bird species detected, and a slightly above average number of individuals observed. However, experience has shown that colder temperatures and above average snow depths are the optimum conditions for finding the greatest bird richness and abundance during the YCBC. Participants are reminded of these factors when deciding on attending future YCBC's. Regardless, the Yellowstone Christmas Bird Count tradition continues and a fun time was had by all.

Editor's Note: A more detailed summary of past Yellowstone Christmas Bird Count results and methods can be found in the Winter 2001 issue of Yellowstone Science.

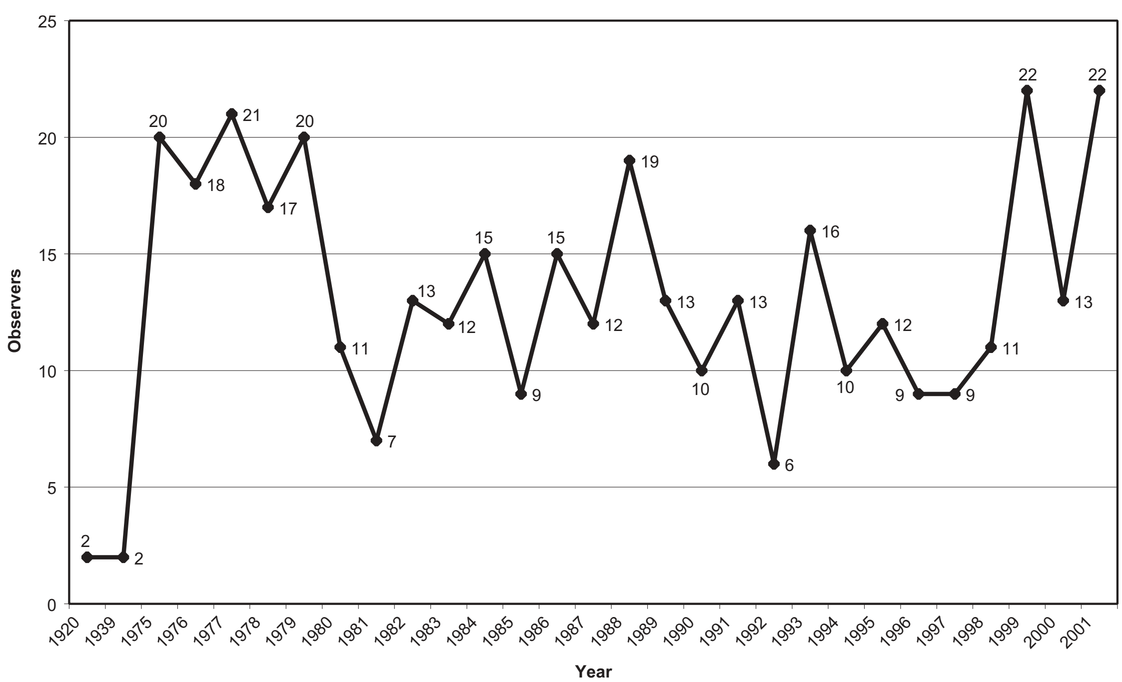


Figure 1. *Total participants in Yellowstone Christmas Bird Counts. Photo above: common redpoll. NPS photo.*

Species	**Yellowstone NP** (in Wyoming)	**Yellowstone NP** (in Montana)	**Outside Yellowstone NP** (in Montana)	**Totals**
Green-winged Teal	25	11		36
Mallard	51	66		117
Barrow’s Goldeneye		12		12
Common Merganser			5	5
Bald Eagle	6	5	6	17
Rough-legged Hawk		1		1
Golden Eagle		2	2	4
Common Snipe	2			2
Rock Dove	26		22	48
Belted Kingfisher	1	1		2
Northern Flicker	1		3	4
Horned Lark	1			1
Gray Jay	4			4
Steller’s Jay	1		4	5
Pinyon Jay			35	35
Clark’s Nutcracker	39		22	61
Black-billed Magpie	63	8	46	117
Common Raven	49	13	58	120
Black-capped Chickadee	3		8	11
Mountain Chickadee	50		21	71
Red-breasted Nuthatch	9		10	19
Marsh Wren	2			2
American Dipper	10	28	4	42
Townsend’s Solitaire	22	5	20	47
Bohemian Waxwing	19		50	69
Yellow-rumped Warbler	2			2
Song Sparrow	4		3	7
Gray-crowned Rosy Finch			120	120
Black Rosy Finch			2	2
House Finch			36	36
Common Redpoll	75		314	389
Red Crossbill	17			17
Pine Siskin	55		60	115
House Sparrow	15		120	135
Totals	**552**	**152**	**971**	**1675**

Total Species: 34 **Additional Species Count Week : 2**

Figure 2. *Yellowstone Christmas Bird Count results from December 16, 2001.*

New Superintendents for Yellowstone and Grand Teton National Parks

On December 14, 2001, new superintendents were named to Yellowstone and Grand Teton National Parks. Suzanne Lewis, a 22-year veteran of the NPS, will manage Yellowstone National Park, and Steve Martin, a 26-year NPS veteran, will manage Grand Teton National Park and John D. Rockefeller, Jr., Memorial Parkway. Lewis and Martin will assume their new responsibilities in early February 2002.

"The selections of these individuals were approved by Interior Secretary Gale Norton because of their successful records working in collaboration with others to accomplish community conservation objectives," said Regional Director Karen Wade.

Suzanne Lewis is currently the superintendent at Glacier National Park, where she manages over 1,013,000 acres, a staff of approximately 525 during the height of the summer season, and an annual operating budget of over $11 million. She began her NPS career as a seasonal park ranger in 1978 at Gulf Islands National Seashore.

Suzanne Lewis, Yellowstone's new superintendent. Photo courtesy Glacier National Park.

Steve Martin, Grand Teton National Park's new superintendent. Photo by Steve Harrel.

During her 11-year tenure there, she served in a variety of positions including park technician, park historian, supervisory park ranger, and management assistant to the superintendent. Chosen in 1988 for an international assignment to the Republic of Haiti, she assisted the United Nations' efforts to preserve, protect, and educate Haitians in the preservation of cultural resources. In 1989, Lewis was appointed acting superintendent for Christiansted National Historic Site and Buck Island Reef National Monument in the U.S. Virgin Islands. She was selected in 1990 as the first superintendent for the newly-created Timucuan Ecological and Historic Preserve—a 46,000-acre national park in Jacksonville, Florida. Lewis served as the superintendent for the Chattahoochee River National Recreation Area in Atlanta, Georgia, from 1997 to April 2000, where she managed one of the busiest national recreation areas in the United States, with more than 3.5 million visitors annually. Lewis graduated in 1978 from the University of West Florida, earning a B.A. (Magna Cum Laude) in American History.

Steve Martin is currently superintendent of Denali National Park and Preserve where he is responsible for all aspects of the management of the 6.2 million-acre park. The park has 100 permanent and 200 seasonal employees and an average annual budget of about $15 million.

Prior to assuming the superintendency at Denali, Martin was superintendent of Gates of the Arctic National Park and Preserve, an 8.2 million-acre park encompassing part of the Brooks Range of northern Alaska. He moved to Alaska from Yellowstone National Park, where he was chief of concessions. Prior to that assignment, Martin was chief of resource management and visitor protection at Voyageurs National Park in northern Minnesota. Before Voyageurs, he was the north district ranger and Old Faithful district ranger at Yellowstone. Martin began his career in 1975 as park ranger at Grand Canyon National Park, where he supervised the Colorado River field operation. He earned a B.S. in Natural Resource Management from the University of Arizona in 1975.

Frank Craighead, 1916–2001

Frank Craighead recently passed away in Moose, Wyoming, his longtime home. He was 85. Best known for their groundbreaking studies of grizzly bears in Yellowstone from 1959 to 1970, brothers Frank and John Craighead were pioneers in the field of conservation biology as well as in the development and use of radio telemetry and other methods of marking and tracking animals for purposes of scientific research. The Craigheads' activism and the degree to which they refused to limit their findings to scientific outlets had sometimes proved vexing to the NPS, since their work, as well as their disagreements with the park service, were chronicled by the national networks and press in addition to magazines and nature television like National Geographic.

But it was their high public profile, in fact, that allowed the Craigheads to give the world something even more valuable than tracking technology: popular awareness of the concept that wildlife preservation and management required an ecosystem approach. Through their research and its publicity, the Craigheads showed us that even Yellowstone National Park, with its 2,221,773 acres, wasn't big or complete enough as an ecological unit to fully provide for the grizzly and other species that utilized the land within its boundaries. They didn't invent the idea, but they put the term "Greater Yellowstone Ecosystem" onto the lips of managers and laypeople alike.

Frank Craighead's legacy also includes a substantial body of scientific papers and popular books published with his brother John, such as the classic *Field Guide to Rocky Mountain Wildflowers.* He also authored *Track of the Grizzly* and *For Everything There is a Season: The Sequence of Natural Events in the Grand Teton/Yellowstone Area***.**

Frank Craighead, Grand Teton National Park. Photo courtesy Jackson Hole News.

Winter Season Includes Operational Changes

On December 17, Acting Superintendent Frank Walker announced that a one-year operational program to help address winter issues in Yellowstone will be in effect this winter season. The changes include putting additional park personnel and volunteers on the snow roads, improving grooming and visitor education, and attempting to reduce employees' exposure to unhealthy and unsafe conditions. The operational changes do not limit the number of snowmobiles allowed in the park this winter season.

Walker noted that ongoing winter use planning in Yellowstone National Park has identified some serious issues related to employee health and safety, human/animal conflicts, air quality, noise, and deteriorating visitor experiences, and that winter planning and preparation of a Supplemental Environmental Impact Statement are underway and will address these concerns in the long term. The issues that have been identified, however, require interim, short-term actions this winter. The changes will be implemented on the road segment between the West Entrance and the Old Faithful area, a 30-mile segment of road (out of the 180 miles that are open for snowmobile use).

The first is designed to help reduce exposure of employees and visitors to high levels of air pollution and noise at Yellowstone's West Entrance Station: all West Entrance permits will be pre-sold at several locations in the community of West Yellowstone, including the Chamber of Commerce and various snowmobile rental outlets and hotels/motels. Visitors should plan to purchase their entrance passes at those community locations, rather than at the entrance gate. Also, additional express lanes will be open for employees to check gate passes. This will reduce idle time at the gate and, hence, the accompanying tremendous build-up of exhaust fumes which has adversely affected the health of gate employees in years past. Pre-selling passes will also give park staff an opportunity to provide information to visitors in a more relaxed atmosphere.

In an effort to reduce disturbance of wildlife by wintertime motorized users, volunteers and park staff will present educational programs on low impact snowmobiling at the Chamber of Commerce, various hotels, and other facilities in the community of West Yellowstone. The park will also explore the use of volunteers to serve as "hosts" within the park to help visitors better understand and use low impact snowmobiling techniques.

Park staff will be monitoring bison movements on the road between West Yellowstone and Old Faithful, and the speed limit between the West Entrance and Old Faithful will be lowered from 45 mph to 35 mph to attempt to reduce conflicts.

Because late night snowmobile use creates safety issues, potential wildlife/human conflicts, and decreases the effectiveness of grooming, Yellowstone will continue to recommend that all visitors not travel the roads during hours of darkness (specifically between 9 p.m. and 8 a.m.).

Rough snow roads reduce the quality of visitors' experience and create safety and health concerns for both visitors and employees. To help address this, Yellowstone will be double-grooming the West to Old Faithful roads on many nights. The park will work with the town of West Yellowstone on an experimental program using a town groomer in the park during mid-day.

Historic Yellow Buses Return to Yellowstone

This past fall, Yellowstone National Park acquired eight antique yellow buses that were once used to transport visitors through the park. Originally purchased by the Yellowstone Park Company between 1936 and 1939, the vintage White Motor Company Model 706, 14-passenger motor coaches were part of a fleet that ultimately numbered 98 buses. The same motor coaches were used by several other national parks, including the red "Jammers" still in use at Glacier and blue buses once used in Rocky Mountain National Park. Zion, Bryce Canyon, and Mt. Rainier also purchased the same type of motor coaches. The buses recently purchased by Yellowstone came from the Skagway (Alaska) Streetcar Company and were in a nearly unaltered condition, with the original Yellowstone National Park license plates remaining on the vehicles. Despite the fact that the buses were in great shape and appeared to have many more years of service in them, the owners of the Skagway Streetcar Company decided to sell them to purchase older buses. Although still undecided as to where the buses will be used, they are assigned for visitor transportation to the park concessioner, Amfac, and are intended to provide park visitors with a quality historic experience.

Yellowstone National Park Interpretive Publications Receive National Award

On November 27, Acting Superintendent Frank Walker proudly announced that a series of eight self-guiding trail booklets produced by the National Park Service was recently awarded the grand prize at the National Association of Interpretation's annual Media Competition.

The award was announced on November 14 in Des Moines, Iowa, during the annual meeting of the National Association of Interpretation, a professional organization encompassing federal, state, local, and private institutions in which interpretation and education are primary missions.

Production of the self-guiding trail booklets was funded by a generous anonymous donation to the Yellowstone Association. The booklets are used by millions of visitors each year to explore the Upper Geyser Basin (including Old Faithful Geyser), Grand Canyon of the Yellowstone, Mammoth Hot Springs, Fort Yellowstone, Norris Geyser Basin, Fountain Paint Pots, Mud Volcano, and West Thumb Geyser Basin. The publications were cited for their excellence in design and appeal to a wide range of users.

Yellowstone Proposes to Build Heritage Center

Yellowstone's museum, archives, and library collectively protect more than 5 million items—treasures such as the first paintings and drawings ever made of what is now the park, including works by artist Thomas Moran; more than 90,000 photographs illustrating park history and resources from the days of trappers and the earliest explorers of the region; American Indian artifacts; natural science collections documenting the park's wildlife, plants, and geology; historic vehicles, including stagecoaches and the first bus in Yellowstone's fleet; an archive documenting park management from its inception through U. S. Army administration to the present; and a library containing most of the rarest publications on Yellowstone.

For decades, this growing collection has been primarily housed in the basement of the Albright Visitor Center, a building not originally designed for any of its current uses. In 1989, the park was cited by the Office of the Inspector General for the poor preservation conditions of its museum collection and archives, which are actually scattered among five facilities, all of which are cramped and lack environmental controls and adequate fire protection. The limited space also severely restricts use by the general public and more than 1,000 researchers who seek direct access to the collections each year. These researchers produce books, articles, films, videos, web sites, and other media that educate millions of people about Yellowstone.

To correct these deficiencies, the park proposes to build a new 32,000-square-foot Yellowstone Heritage and Research Center to preserve current collections, allow for an estimated 25-year growth in important new collections, provide adequate public access, and include a modest space for changing exhibits. The NPS line-item construction budget for 2002 includes $6.1 million dollars for the first phase, which includes storage for all but oversized objects (such as historic vehicles and large furniture), a new library, some work space for visiting researchers, and staff offices. Future (presently unfunded) phases will provide for preservation and display of the historic vehicle collection and for added research and lab facilities for the numerous scientists who conduct studies in Yellowstone each year. An estimated $6–8 million will be needed for future phases, for which the park hopes to secure private donations and grants.

An environmental assessment to examine the alternatives and impacts related to this facility was released in January 2002. The preferred alternative is to locate the Heritage Center on already disturbed park land, a former gravel pit, adjacent to the town of Gardiner, Montana, about five miles north of park headquarters. Construction is likely to commence in late 2002 or early 2003, and completion of the first phase is anticipated in 2004–05.

Public comments related to the proposal may be sent through February 25, 2002 to Heritage Center, P.O. Box 168, Yellowstone National Park, Wyoming, 82190.

One of Yellowstone's yellow buses, in Skagway, Alaska. Photo by Paul Schullery.