YELLOWSTONE CENTER FOR RESOURCES

ANNUAL REPORT 1999

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Yellowstone Sand Verbena
Photo by Jennifer Whipple.

Yellowstone Center for Resources
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Contents

Introduction

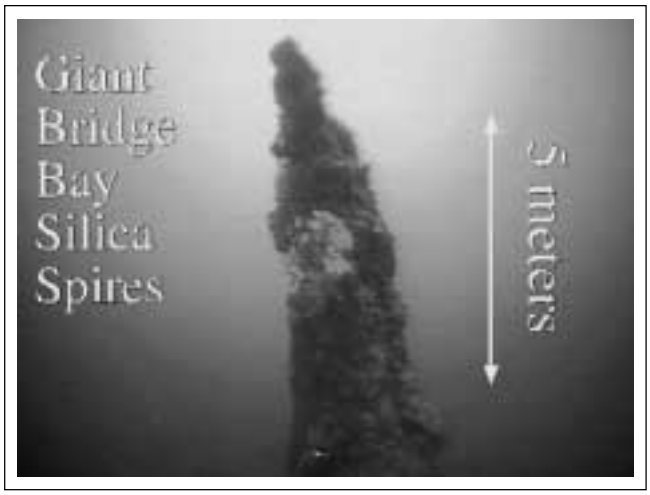
The last year of the twentieth century marked the sixth year for the Yellowstone Center for Resources. It was a good year. After securing an improved budget foundation in 1998, continued progress was made toward the conservation of cultural and natural resources through sound science and management.

Paleontologists and park staff identified Eocene mammal fossils on Mount Hornaday. Toward the end of the year, Yellowstone at last gained a full-time park archeologist to oversee a growing program devoted to these prehistoric and historic sites, and associated researchers discovered an intact buried hearth along the Madison River. Another new staff specialist with a background in architecture and preserving historic structures joined the cultural resources team. Of cross-disciplinary interest was the participation of 100 American Indians in the "Buffalo March" from Rapid City, South Dakota, to Yellowstone to honor and bring attention to the plight of the park's bison herd, which is the subject of a decade-long effort to produce an interagency management plan. And special funds supported the collection and transcription of oral history interviews on ecological process management, an "experimental management" concept adopted by Yellowstone some 30 years previous and still undergoing an extensive evaluation process.

It was another good year for some of the rare or endangered species in the region. Grizzly bear reproduction was fairly high and mortalities were low. Gray wolves continued their recovery throughout the park and beyond. The peregrine falcon was removed from the list of endangered species due to the nationwide success of recovery efforts; a record 14 eyries were found in the park. But all news was not good, as trumpeter swan populations continued to decline across the tri-state region, the Rocky Mountain population of whooping cranes diminished, several species of native fishes were petitioned for listing as "threatened," and several other species of concern do not show any promise of population increases.

While the park endured seismic shakeups without sufficient geologic staff expertise, we were grateful for the continued cooperation of hundreds of researchers from other government agencies, universities, and private institutes. We sponsored our fifth in a series of science conferences about greater Yellowstone, in which experts from many disciplines shared concerns about the pervasive invasion of exotic organisms and how they threaten native biodiversity. We also produced, with the help of many park employees in other divisions, the *State of the Park* report—a detailed summary of the status of park resources, programs, and challenges to tackle in the coming century. There is no shortage of work yet to be done. Yet, as we close the twentieth century—the first full century of park management—we take some pride in our small steps toward an improved baseline of information on cultural and natural resources, as well as in their ongoing protection. For more information about specific topics of interest, readers may contact us or investigate the park's web site at *www.nps.gov/yell*.

John D. Varley
Director, Yellowstone Center for Resources



A seven-meter-tall spire in Bridge Bay. The spire field in Bridge Bay has approximately 12–18 individual spires and was originally discovered in 1997 by scientists at Eastern Oceanics (Dave Lovalvo) and the University of Wisconsin at Milwaukee (Val Klump, principal investigator). Photo courtesy Tony Remsen.

Part I. Resource Highlights

Underwater Spires Discovered in Yellowstone Lake

Geologists in Yellowstone recently discovered an extraordinary new world of hydrothermal features below Yellowstone Lake. Scientists from the U.S. Geological Survey, the University of Wisconsin at Milwaukee, and Eastern Oceanics continued a long-term study of the bottom of Yellowstone Lake with new equipment capable of conducting high-resolution bathymetric, seismic reflection, and magnetic mapping surveys. Although only able to intensively map the northern quarter of Yellowstone Lake, they discovered an array of interesting features, including dozens of circular steep-walled depressions from 5 to 800 meters across, and hundreds of pinnacles and spires.

The spires occur singularly or in clusters and may be up to 35 meters tall and 50 meters in diameter. The few spire samples studied so far had a light-colored, porous interior mantled with a coating of iron oxide. Laboratory analysis indicates that the spires are chemically composed of amorphous silica; images from a scanning electron microscope reveal that samples contain remains from a broad variety of diatoms and botryoidal and filamentous bacteria. The spires also have trace amounts of heavy metals commonly associated with hydrothermal vents.

The formation of both spires and circular depressions is related to deep-seated fluid circulation that occurred over the past 12,000 years and left visible vents on the lake bottom. Other features seen during the survey include recent faults and submerged former shorelines. Though researchers hypothesized that the vent field in Bridge Bay is now inactive, the sheer number of features now known on the Yellowstone Lake bottom suggests very active vent sites, some of which may yet be creating spires and other formations.

Yellowstone Heritage and Research Center Progresses

The planning process continues for the Yellowstone Heritage and Research Center, a museum and archival collection storage facility. In 1999, Yellowstone's request to the National Park Service (NPS) Line Item Construction funding program was accepted, and the park is listed to receive $4.8 million in 2002 for construction. On May 5, 1999, current sites under consideration were examined and scored, and four sites in Mammoth and near Gardiner were rated most highly. These sites will be included in the environmental assessment for the project.

Other planning includes the drafting of a comparability study using program information from recent NPS and outside museum construction projects. The cultural resources branch chief assisted in formulating a proposal for a "Greater Yellowstone Geoecosystem Learning Center" in response to a servicewide call for learning centers as part of the Natural Resource Challenge. She also met with potential funders for the Heritage and Research Center and facilitated logistics for a January curatorial meeting with national curators and consultants. A surplus trailer for temporary archival and museum collection storage was acquired from Zion National Park.

Fifth Biennial Science Conference a Success

Resource information staff provided planning and logistical support for the park's fifth biennial science conference on the Greater Yellowstone Area. Planning actually began in 1998, with the chosen theme of "Exotic Organisms in Greater Yellowstone: Native Biodiversity Under Siege." The "virtual" program committee convened in February 1999 and accepted papers from more than 35 speakers. Highlighted guest speakers were Dr. Daniel Botkin from the University of California at Santa Barbara, who presented the Superintendent's International Luncheon Lecture; Dr. Holmes Rolston from Colorado State University, who presented the Aubrey L. Haines Lecture; and Dr. Barry Noon, also from Colorado State, who presented the A. Starker Leopold Lecture.

About 150 persons attended the conference, which was held at the Mammoth Hotel. Conference registration fees adequately covered the expenses associated with speakers' travel and conference logistics and promotion. An arrangement was made with the editors of the former *Great Basin Naturalist*, now the *Western North American Naturalist* journal, to peer review and publish accepted manuscripts submitted by conference participants in lieu of the less-prestigious conference proceedings. Publication will likely occur in 2001.

Three Museums Declared at Risk

The Secretary of the Interior included three Yellowstone buildings in his *America's Landmarks at Risk* annual report to the U.S. Congress—the Norris, Madison, and Fishing Bridge museums. The report cited physical deterioration stemming from the effects of weather and deferred maintenance, extensive rodent problems, and thermal activity at Norris as reasons for the listing. The report also recommended that the park prepare condition assessment reports on these buildings.

The Norris, Madison, and Fishing Bridge museums were designated National Historic Landmarks in 1987. The designation recognized the museums as the best examples of Rustic style buildings in the National Park System. The buildings were designed by architect Herbert Maier in 1929, and the Laura Spelman Rockefeller Foundation funded their construction through the American Association of Museums. The museums served as models for hundreds of buildings constructed throughout the

nation, especially for projects under the auspices of New Deal programs of the 1930s.

National Historic Landmarks, a step above the National Register of Historic Places listing, have exceptional value in illustrating or interpreting U.S. heritage in history, architecture, technology, and culture. The Old Faithful Inn, the Northeast Entrance Station, and Obsidian Cliff are also National Historic Landmarks.

Park staff are preparing text for an interpretive brochure to explain the museums' history and their influence in the evolution of the National Park Service Rustic style of architecture. Funding sources to rehabilitate the buildings are also being investigated.

Lake Trout Threat Continues

For the past four years, the Aquatic Resources Center has devoted a majority of the summer field season to removing lake trout from Yellowstone Lake. Knowledge gained about the seasonal and vertical distribution of this large predator has been regularly applied to the park's adaptive management approach. Information gained from 1998 tagging studies and hydroacoustic surveys was used to select the most promising gillnetting locations in 1999. As no additional tracking or other lake trout movement surveys were conducted in 1999, the lake trout program was dedicated solely to lake trout removal.

The combination of intensive gillnetting in West Thumb and angler catches throughout the lake suggests that the NPS lake trout removal program is meeting the goal of preserving cutthroat trout in Yellowstone Lake. The following summary observations can be made:

- Gillnetting results since 1995 indicate that mature lake trout reside primarily in West Thumb, which has consistently yielded the highest catches of lake trout.
- All identified spawning areas are in the West Thumb/Breeze Channel area.
- Hydroacoustic assessments also indicated that most of the lake trout reside in West Thumb.

These short-term results suggest that the current capacity of park staff to maintain this level of lake trout control is adequate. These results must be interpreted with caution, however, because almost all the gillnetting effort has occurred in the West Thumb area. Telemetry studies in 1998 confirmed that although large adult lake trout reside mostly in the West Thumb portion of the lake, they do move to many other areas. Late summer distribution gillnetting and angler reports suggest that medium-size lake trout are widespread throughout much of the lake. These factors suggest that in the long-term, new spawning sites will be established and additional subpopulations established. As the abundance of either existing or newly established populations declines, a much higher level of netting effort will be required to sustain high lake trout mortality rates.

To address these long-term needs, the NPS has acquired new funding to obtain a commercial gillnetting boat and additional staff that will be solely dedicated to a greatly expanded netting effort throughout the lake. Design and boat construction phases are underway, and the additional control measures will be fully operational during the 2001 field season. This level of long-term commitment will greatly assist the NPS in meeting its responsibility to preserve the Yellowstone cutthroat trout in its native habitat.

Whirling Disease Studied

After whirling disease was confirmed in rainbow trout in the Madison River near Ennis, Montana, Yellowstone fishery biologists initiated a testing program for park fish populations. Between 1995 and 1998, young rainbow trout, Yellowstone cutthroat trout, brown trout, and mountain whitefish captured during electrofishing surveys of several boundary area streams were examined for the presence of disease-causing spores. No evidence of infection or population declines attributable to the disease was found during these early surveys. In the fall of 1998, however, a small sample of cutthroat trout from Yellowstone Lake indicated the

presence of whirling disease spores in approximately 10–25 percent of the fish. Length-age relationships suggested that the infected cutthroat trout were between two and five years old.

Although the information gained in 1999 has not adequately provided the answers required to make assessments or recommendations related to the Yellowstone Lake cutthroat trout population, preliminary observations can be summarized as follows:

- Many of the adult cutthroat trout throughout the lake have a mild incidence of whirling disease infection. These fish range from four to eight years old, suggesting that the parasite has been in the basin for a number of years.
- If the older infected fish identified in this study were parasitized as fry, it appears that some cutthroat trout in Yellowstone Lake are able to survive infection without any obvious long-term effects.
- The failure to detect the parasite through sentinel cage tests may be indicative of less than optimum environmental conditions (particularly water temperature) for the infectious stage of the whirling disease parasite. Unlike the typical springtime infection observed in streams adjacent to the park, the peak period for infection in Yellowstone Lake may be in the fall, similar to high-elevation lakes in Colorado.

Cutthroat trout fry held in a sentinel cage in a Yellowstone Lake tributary to test for whirling disease. NPS photo.

Continued monitoring of stream temperatures, ongoing examination of incidental catch from gillnetting surveys, and additional sentinel cage exposure studies in the next several years should provide considerable clarification related to these preliminary observations. This will enable park biologists to determine whether cutthroat trout fry in Yellowstone Lake may be less vulnerable to whirling disease because most have already migrated downstream into the lake by the time of peak parasite emergence. Continued examination of distribution with a focus on parasite densities, age classes of fish affected, and protective habitat should assist the NPS in preserving this valuable native fish species.

Peregrine Falcon Delisted

The peregrine falcon was removed from the list of endangered species on August 26, 1999, and is now managed as a species of special concern. Provisions afforded by the Endangered Species Act require that the peregrine be monitored closely for the next five years to ensure its recovery. The park continues to be a stronghold for peregrines in the Northern Rockies. A new eyrie was found in 1999, bringing the total number to 14. In spite of unusually cold and wet weather conditions in the spring and early summer, which typically result in the loss of young, 19 young fledged in the park.

Oral History Projects

Two private groups initiated projects to interview members of American Indian tribes affiliated with Yellowstone in 1999. Ehnamani, a Native American group from Bozeman, Montana, led by Crow/Santee Scott Frazier and Ojibwe John Potter, worked with Crow historian Lawrence Flatlip to gather Crow oral histories about the park and potential ethnographic information. In September, the cultural resources branch chief, cultural resources assistant, and park exhibit specialist represented the park at Ehnamani's "Prayer for Wolves" at the Lower Blacktail cabin.

The Idaho Mythweaver group planned to work with high school students on the Nez Perce, Confederated Salish and Kootenai, Shoshone-Bannock, and Crow reservations on oral interview techniques they can use to interview their elder family members about Yellowstone. This information will be presented to the park for use in interpretive programs and exhibits, and documenting place names and past tribal uses of the park for the cultural resources program and the archives.

Cultural resources assistants continued to work on an oral history project to interview important figures in the park's management of natural resources. The Fee Demonstration program provided funds for the project, which initially targets the history of ungulate management in Yellowstone. Charissa Reid and Sally Plumb interviewed former park employees who worked on the ungulate management program in the park's past. Yellowstone's former chief biologist, Glen Cole, a pioneer of natural regulation in the NPS, attended the park's fifth biennial scientific conference in the autumn of 1999 and was interviewed twice during his visit.

National Historic Landmark Nominations

In the fall of 1999, the National Trust for Historic Preservation contracted with Front Range Research Associates, Inc., of Denver, Colorado, to prepare a National Historic Landmark nomination for Fort Yellowstone and for other U.S. Army-constructed buildings throughout the park. Included are the Bechler and Norris Soldier Stations, the Buffalo Lake snowshoe cabin, and the Roosevelt Arch. The nomination will focus on the army's role in protecting the park, and will be submitted under the National Historic Landmark theme of "Conservation of Natural Resources."

The importance of Fort Yellowstone as a physical representation of the U.S. Army's role in the history of our national parks has long been recognized. The U.S. Army entered Yellowstone in 1886. The 35 army buildings, dating from three main construction periods (1891, 1897, 1908), present an almost complete "picture of an extraordinarily handsome Western Army post at the turn of the century" (Battle and Thompson, Fort Yellowstone Historic Structure Report, 1972).

Front Range Research is also preparing a National Register of Historic Places nomination for the larger Mammoth Hot Springs area. The nomination will include about 200 buildings constructed by the U.S. Army, the National Park Service, and concessioners. The significance of the Mammoth Hot Springs Historic District lies in its association with the development of the NPS administrative and concessioner policies, and in its architecture.

Cultural resources staff continued to work on revising National Register nominations for some of the park's historic roads and, in cooperation with the Division of Resource Management Operations and Visitor Protection, gathered supportive documentation to seek determinations of eligibility for the park's snowshoe cabins.

A Good Year for Bears

In the Yellowstone ecosystem, 1999 was a year of average to above-average abundance of most high-quality bear foods. The winter of 1998–99 was considered to be a mild one on upper and lower northern winter ranges and in the Madison-Firehole valley. Despite the mild weather, the number of winter-killed elk and bison carcasses counted on transect sites was higher than the long-term average.

During early to mid-spring, the most commonly observed grizzly bear feeding activity was scavenging on ungulate carcasses. Grizzly bears also dug up pocket gopher caches in localized areas where they were particularly abundant. Elk calves, an important late spring and early summer food source, were preyed upon extensively by some individual bears. The numbers of spawning cutthroat trout counted in Yellowstone Lake tributaries were similar to the long-term averages on most streams, except for those in the West Thumb area, which were below average.

Throughout the summer, grizzly bears grazed clover and dug up yampa roots in localized areas where these foods were abundant.

Army cutworm moths, an important bear food in late summer and fall, were present and attracted large numbers of bears to high-elevation moth aggregation sites on the eastern side of the ecosystem. The production of whitebark pine cones, as measured at transect sites, was above average in most areas of the ecosystem. The one exception was the Pitchstone Plateau area, where few cones were observed. Excavation of red squirrel middens for whitebark pine seeds was the most frequently observed fall grizzly bear feeding activity. In some areas, biologists also found evidence that grizzly bears had climbed into whitebark pine trees and broken off branches to obtain cones. During October, localized areas where grizzly bears had dug up pocket gopher caches were again evident.

Fifteen females with 26 cubs-of-the-year were observed in the park in 1999. The average litter size was 1.7 cubs per litter, with 5 one-cub, 6 two-cub, and 3 three-cub litters. There were two known grizzly bear mortalities (one natural and one management removal) and one known black bear mortality (vehicle collision).

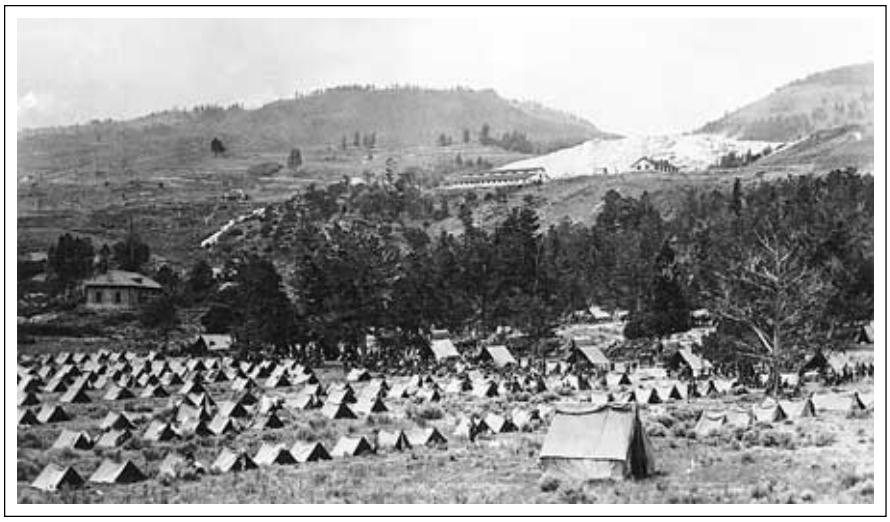
There were 78 reported incidents of bear-human confrontations (incidents of actual or perceived aggression in which no one was hurt). Grizzly bears were involved in 52 of these confrontations and black bears were involved in 19. Seven confrontations were with an unknown species of bear. There were only two injuries to humans inflicted by bears, both by grizzlies.

There were seven reported incidents in which bears damaged property but did not obtain human foods, all involving grizzly bears. This number was a significantly greater number than the 10-year average of 1.2 per year reported from 1989 to 98. There were four incidents in which bears obtained human foods or garbage in the park in 1999. Three incidents involved grizzly bears and one involved a black bear.

In 1999, there were 201 bear-related incidents in which management action was taken. Two grizzly bears were captured in management actions within the park. One was translocated to another area of the park, and one was removed from the population and sent to a zoo. Four grizzlies were translocated into the park. None were known to be involved in further bear-human conflicts for the rest of the year. No black bears were captured or removed, and no nuisance black bears were accepted.

All the capture efforts that were related to bear-caused property damage occurred in the Indian Creek Campground area in July and August. In August, a 180-pound subadult male grizzly that had damaged six tents was captured adjacent to Indian Creek campground. The bear stepped on, tore, and crushed a decoy tent placed near the trap and was caught. DNA extracted from hair collected from the captured bear matched DNA from hair collected from a tent damaged at a nearby backcountry campsite. Dr. Lisette Waits at the University of Idaho calculated that the chance of a DNA match to any other grizzly bear in the park was approximately one in 20,597. The bear was deemed a danger to public safety and not suitable for release back into the wild. Under a special permit from the U.S. Fish and Wildlife Service, the bear was held at the Grizzly Discovery Center in West Yellowstone until park staff could find a suitable zoological institution to house the bear. In September, the young bear was shipped to the Wildlife Way-Station, a private, non-profit sanctuary for injured, neglected, and homeless wild animals in Sylmar, California.

The decoy tent, used in combination with a blueberry-baited trap, to lure the Indian Creek tent-crushing grizzly. NPS photo.



A rare view of a U.S. Army encampment in Lower Mammoth, 1912. Photo postcard purchased at the National Parks Antique Show.

Part II. Cultural Resource Programs

The Branch of Cultural Resources continued to grow through additions in staff and program funding. In June 1999, Rodd Wheaton, the Intermountain Region's Assistant Director for Cultural Resources and Partnerships, and Pat O'Brien, Program Manager for Cultural Resources and National Register Programs, made a visit to the park and reviewed the cultural resources program, physical resources, and long-range plans. In January, as newly rehabilitated office space became available in the historic cavalry barracks which houses the Yellowstone Center for Resources (YCR), four cultural resources branch staff moved their offices from the old Fire Cache building.

Dr. Ann Johnson joined the park staff as a full-time, permanent archeologist toward the end of 1999. Ann was duty stationed at Yellowstone from the Rocky Mountain System Office in 1995, but at long last can devote more of her energy to Yellowstone's program, coordinating archeological research and overseeing ongoing National Register inventory and evaluation of the park's archeological resources. Elaine Hale, who had previously worked for four years as a seasonal employee on the cultural compliance portion of the park's Federal Highways program, was hired as a term cultural resources technician whose duties, in addition to continued road-related work, are to assist other divisions with cultural compliance, work with cultural landscapes, and facilitate paleontological surveys of the park.

Lon Johnson also joined the staff as a term cultural resources technician, functioning as the park's primary coordinator for implementing requirements mandated by Section 106 of the National Historic Preservation Act. Lon oversees the National Register inventory and evaluation of the park's historic buildings and other structures. He is assisting with the review and editing of historic resource studies on *The History of the Concessions of Yellowstone National Park* and *History of the Administration of Yellowstone National Park*, and associated National Register multiple property

nomination forms. Lon also works on the park's cultural landscapes and National Historic Landmarks programs. Lon is licensed to practice architecture in Montana and Oregon, and prior to coming to Yellowstone he was the coordinator for the National Register of Historic Places for the Montana State Historic Preservation Office and the Montana Historical Society.

Kara Mills returned for a second summer as a cultural resources assistant and worked on Federal Highways historical research and compliance and American Indian consultation meetings. She researched American Indian collecting policies and regulations, and provided general assistance on ethnographic issues.

To supplement the funds available from the Yellowstone base budget for cultural resources ($285,000), support for 1999 projects was obtained from the Cultural Resources Preservation Program ($178,200), Backlog Cataloging ($17,600), Museum Collection Preservation and Protection Program ($26,100), Federal Highways program ($177,400), Fee Demonstration program ($69,540), Challenge Cost Share program ($5,400), Cultural Cyclic Maintenance tracked by the Maintenance Division ($84,500), and private funds from the Yellowstone Association ($34,441), for a total budget of $878,181.

Additional Support to Park Management

Branch Chief Laura Joss continued to participate in the park's Government Performance and Results Act process, and was responsible for the development, tracking, and reporting of cultural resources components. Branch staff also provided cultural resources information for the *State of the Park* report and the park's forthcoming *Business Plan*.

The branch chief was selected to be co-chair of the park's Board of Survey, which reviewed more than 50 accident and property loss reports to determine negligence and/or liability. As a team member of the park's Research Permit Review Panel, she reviewed more than 200 new applications or requests to renew studies with potential impacts to cultural resources and to ensure compliance with requirements to catalog and properly store collected specimens. She participated in the Interpretation Division's effort to produce a *Long-Range Interpretive Plan* and attended associated planning workshops. Branch staff also participated in planning efforts for the rehabilitation of the Canyon Visitor Center and the design of a new Old Faithful Visitor Education Center.

Branch staff spent considerable time participating in planning efforts related to prescribed fire management, commercial services, and winter use. Elaine Hale represented the branch on the Mammoth Quality Circle committee, an ad hoc group that identifies and helps carry out projects that address safety issues or improve conditions in the area. The archeologist, museum technician, cultural resources assistant, and branch chief assisted in archeological and archival research and cultural compliance following the December 4 rockslide in the Gardner Canyon. Elaine Hale initiated emergency compliance procedures, documenting the slide and clean-up operations as requested by the Montana State Historic Preservation Officer.

ARCHEOLOGY

It was a good year for finding and investigating new sites reported by both visitors and employees. It was a challenge for the park's cultural resource staff to get out to these locations and complete site documentation. Volunteers continued to contribute to Yellowstone's archeology program in a variety of ways ranging from cataloging information and participating in fieldwork to precise mapping of the Obsidian Cliff quarry boundaries using global positioning systems, a project that will continue for several more years.

Surveying Road Corridors

Before ground-disturbing activities such as road construction can occur, surveys are completed to determine the presence and potential National Register eligibility of archeological resources in the affected areas. The majority of fieldwork conducted in Yellowstone during 1999

by the Office of the Wyoming State Archaeologist (OWSA) was in support of road improvements in the park, funded by the Federal Highway Administration. Under Paul Sanders' direction, OWSA undertook National Register testing at 13 prehistoric sites between Canyon and Lake Junction. A Scottsbluff point (~6800 B.C.) was excavated at site 48YE448. Half the tested sites were considered eligible for the National Register of Historic Places. A small inventory of 30 acres along Otter Creek, a tributary of the Yellowstone River, recorded a historic bear-feeding site.

Another OWSA project was to identify site boundaries and to investigate the potential for buried cultural materials at site 24YE14, west of Gardiner, Montana. Here, the cultural horizons are exposed along an eroding ravine, and most of the site is buried by slope wash. Pelican Lake and McKean projectile points were found, and seven uncalibrated radiocarbon dates ranged from 1700±60 BP to 5200±40 BP. It was determined that the site had intact buried stratified cultural deposits. Archeogeologist John Albanese interpreted the geology and provided clues into the local environment and how it has changed.

The Museum of the Rockies (MOR) crew tested two prehistoric sites and inventoried the highway right-of-way between Madison Junction and West Yellowstone, as well as selected short segments between Tower and Canyon along the Dunraven Pass road. Of note was an intact buried hearth found along the Madison River. This discovery is unusual, as features of any kind have been extremely rare in the interior of the park. This find provides hope that more cultural horizons with integrity can be found in the future. More interesting were localized concentrations of flake debris that apparently represented the first stages of knapping adjacent to a primary obsidian source between Madison Junction and West Yellowstone. It looked as if the flakes had not been disturbed since the flintknapper left.

Paul Sanders and an OWSA crew search for buried materials in the park near Gardiner, Montana. NPS photo.

Research Investigations and New Discoveries

Museum of the Rockies crews also inventoried a backcountry trail that extends from the north end of Yellowstone Lake to the Lamar Valley. Unfortunately, rainy weather made field work difficult and fewer sites were recorded on this project than expected; some areas should be revisited in the future. Selected inventory along the Yellowstone River connected areas inventoried in 1998 and 1997, which almost completed the archeological inventory of the river from Fishing Bridge to Reese Creek, at the park's north boundary.

MOR tested site 24YE7 in the Black Canyon of the Yellowstone for National Register evaluation and research purposes. They identified a well-defined Late Prehistoric component and a diffuse deeper component. The park is planning a district National Register nomination for this area.

The terraces on the north side of the Madison River valley area of the Bannock Trail's entry into Yellowstone National Park (north of West Yellowstone, Montana) were inventoried during four days of MOR field-

work. The Bannock Trail is not visible as a specific set of ruts or trail in this area, and the documented sites appear to represent transitory camps. Archeologists hypothesize that base camps would have been present outside the park in the vicinity of Hegben Lake but are now submerged. Researchers would like to continue inventories along the Bannock Trail route in the future.

On August 30 and 31, and September 1, 1999, eight students, one student leader, and one camp director from the Oregon Museum of Science and Industry (OMSI) participated in the archeological survey of areas along the Gneiss Creek and Campanula Creek drainages as part of the Bannock Trail inventory. Park staff and the MOR crew of three worked with the OMSI students for three days to inventory and record site information. The archeologist gave an initial orientation and provided guidance for the inventory methodology. The students received additional instruction for the remainder of the time from the MOR crew of professional archeologists. All activities took place within the park, with the inventory beginning at the western boundary and proceeding east. Nine new prehistoric archeological sites were documented through this combined effort.

In September, the Wyoming National Register Consulting Committee and Wyoming State Historic Preservation Office staff participated in salvaging four large fire-cracked rock features at site 48YE380 on Yellowstone Lake. John and Evelyn Albanese mapped the site as part of this project. Preliminary analysis suggests that these four features are on the same level as the roasting pit salvaged in 1998 and the fire-cracked rock feature salvaged in 1992. Macrofloral analyses will be obtained for the contents of the features. Radiocarbon dates were obtained for Feature 3 of 1580+/-60 BP and Feature 4 of 1640+/-60 BP. It is interesting that although seeds and lodgepole pine cones were recovered in previous analyses, the 1999 work again failed to recover any bone. This supports an interpretation of plant processing and cooking in these features.

Jim Truesdale, an independent archeologist from Laramie, Wyoming, inventoried the Madison and Canyon campgrounds. Of note, he found a reworked Eden point at Madison. This suggests human occupancy of the park by about 7,000 B.C.

Archeologists continue to investigate pre-contact use of obsidian. Prior to 1999 fieldwork on the Madison River and associated highway corridor, researchers hypothesized that if people were coming into the park from southern or central Idaho, that is where evidence of such travel would be present. The evidence would be in artifacts sourced to the many Idaho obsidian sources. This year, the scientists also changed their sampling strategy. Previously, they were trying to get at least one obsidian artifact chemically sourced from every site. There is a problem of a small sample in this approach, and archeologists decided to intensively sample specific sites while not entirely abandoning the goal of sampling as large a group of sites as possible. In the first group of samples, one site had five obsidian sources represented. Obsidian Cliff, Bear Gulch, and Cougar Creek sources dominated, with single specimens from Teton Pass (variety 2) and Lava Creek Tuff (Grassy Lake Reservoir locality). Cougar Creek is an obsidian source in the Madison River valley and does not appear to have a very wide distribution. Other than Bear Gulch, the expected Idaho obsidian sources were not identified. Yellowstone obsidians are rarely identified in central and southern Idaho archeological sites, so there appears to have been little pre-contact movement back and forth between these two areas. The travel appears instead to have been east and northward along the Madison River.

Assistance to Other Divisions and Parks

On September 27, 1999, the archeologist and the branch chief visited Grant-Kohrs Ranch National Historic Site to assist in an archeological survey and associated compliance activities. On November 4, staff from the Interpretation Division and the Branch of Cultural Resources surveyed an area northwest of Soda Butte and

A Native American consultation meeting, May 20, 1999. NPS photo.

documented a possible cache of tipi poles. On November 16, the branch chief and cultural resources technician surveyed the north end of Mt. Everts for reported archeological sites and paleontological resources.

ETHNOGRAPHY

The branch chief researched the anthropological, historical, and regulatory background of repeated requests from Sioux tribes to be considered affiliated with Yellowstone. The result of this research was a report on *Tribal Consultation/Affiliation: Background Research on Sioux Interests in Yellowstone*, which led to the park's adding Lakota/Sioux tribes in Montana, North Dakota, and South Dakota as affiliated with the park. Also, due to new information in the park's draft ethnographic overview and assessment, the Kiowa were added as an affiliated tribe.

At the request of the Shoshone-Bannock tribe, the branch chief traveled to Fort Hall in May to meet with elders and tribal Land Use Office staff. Current park issues and projects of interest were discussed. The branch chief also continued to coordinate fee waivers for all affiliated tribal members entering the park for traditional purposes, and helped plan the second "American Indians and Cultural and Natural Resources Management: The Law and Practice Regarding Federal Lands" course, which she also attended from September 20 to 24 at the Wind River Indian Reservation, Wyoming.

Intergovernmental Consultations

The branch chief facilitated Native American government-to-government consultation meetings at Yellowstone on May 20–21, 1999. Tribes historically affiliated with the park—Blackfeet, Confederated Salish and Kootenai, Crow, Eastern Shoshone, Gros Ventre and Assiniboine, Kiowa, Lakota/Sioux, Nez Perce, Northern Arapaho, Northern Cheyenne, and Shoshone-Bannock—were invited to discuss current issues and projects. These included the winter use plan and environmental impact statement (EIS), the *Long-Range Interpretive Plan*, current archeological and ethnographic projects, and diversity recruitment efforts. Twenty-one representatives from the 11 affiliated tribes attended.

An entire day was devoted to discussions about the *Draft Environmental Impact Statement for the Interagency Bison Management Plan for the State of Montana and Yellowstone National Park*. Seventy-nine tribes from across the country had expressed concern about this issue, and all were invited to send designated representatives to the meeting. Sixteen tribes and Native American organizations sent a total of 29 representatives: Assiniboine-Fort Belknap; Cheyenne River Lakota; Colville; Comanche Tribe; Confederated Salish and Kootenai; InterTribal Bison Cooperative; Little Shell Band of the Chippewa Cree Tribe; Nez Perce; Oglala Sioux; Onondaga Nation; Rosebud Sioux; Santee Sioux; Sisseton-Wahpeton Sioux; Turtle Mountain Chippewa;

Winnebago Tribe of Nebraska; and Yurok-Karuk.

On October 6–7, the branch chief facilitated additional consultations for the bison management plan and for the *Draft Winter Use Plan/EIS for Yellowstone and Grand Teton National Parks and the John D. Rockefeller, Jr., Memorial Parkway*. More than 80 tribes from across the country were invited to send designated representatives to the meeting. Nine tribes and Native American organizations had a total of 11 representatives in attendance: Assiniboine and Sioux (Fort Peck); Cheyenne River Sioux; Confederated Salish and Kootenai; Crow; InterTribal Bison Cooperative; Lac Courte Oreilles; Nez Perce; Rosebud Sioux; and Winnebago Tribe of Nebraska. The InterTribal Bison Cooperative, which represents almost 50 tribes, presented a consolidated tribal position on the bison issue. The park offered to hold a winter use plan/EIS consultation at the park during the winter season, and will continue to hold future bison and winter use consultation meetings twice a year.

After discussing bison and winter use, tribes historically affiliated with the park were invited to discuss other current issues, including planning efforts, cultural resources, and fire management. A special session focused on diversity recruitment efforts. Five representatives attended from the Assiniboine and Sioux (Ft. Peck), Cheyenne River Sioux, and Crow tribes. Meeting minutes were distributed to chairs of all affiliated tribes.

Additional Work on Bison Management Issues

On February 8, YCR Deputy Director Wayne Brewster and the cultural resources branch chief attended a meeting of One People, One Nation, held in Big Sky, Montana, and answered questions about the interagency bison management plan and EIS.

On February 27–28, Yellowstone rangers and cultural resources staff assisted with logistics and processed a public assembly permit for a ceremony celebrating the arrival of approximately 100 American Indian participants in the "Buffalo March," *Tatonka Oyate Mani (They Walk for the Buffalo People*). The marchers left Rapid City, South Dakota, on February 7, 1999, to travel 507 miles by foot, car, and horse to Yellowstone National Park to honor and bring attention to the plight of Yellowstone's bison herd. Led by Sicangu Lakota traditional leader Joseph Chasing Horse, the group carried a buffalo pipe, three sacred staffs adorned with eagle feathers, buffalo hide and leather, and a ceremonial bundle containing other items relating to bison. Participants included Lakota, Nez Perce, Navajo, Apache, Tuscarora, Algonquin, Crow, Assiniboine, Southern Ute, Northern Cheyenne, and Blackfeet tribal members. While in Yellowstone, Joseph Chasing Horse presented a program, arranged by the branch chief, on "Lakota Star Knowledge" to park staff and the public. Chasing Horse was joined by Turhan Clause, a Tuscarora from western New York, and Tyler Medicine Horse, a Crow who resides in Livingston, Montana. Both men discussed the cultural history of native people and bison, and Tyler played flute music for the group. Park photographer Jim Peaco

The Buffalo March reaches Yellowstone, February 28, 1999. NPS photo.

filmed the presentation for the park's archives. Chasing Horse also made a presentation and drummed for the Mammoth School.

In 1998–99, the agencies working on a bison plan had received 16,501 comments, mostly from Native Americans, regarding the cultural resources section of the EIS. Tribes and tribal organizations made 17 resolutions related to bison management in and around the park.

In March, park wildlife biologist John Mack and the cultural resources branch chief presented talks to and answered questions from a group of 25 Lakota, Nakota, Dakota, Ojibwe, and Ponca youths and adults who had traveled to the park to educate the youths about bison. Information was presented about the park's bison management program, the bison management plan/EIS, and the tribal consultation process. In July, park wildlife biologist Wendy Clark and the branch chief made presentations to 15 Dull Knife College students from Lame Deer, Montana, and the Northern Cheyenne reservation. Topics were bison management, cultural resources, and the park's work with American Indian tribes.

On July 28–30, the branch chief participated in a multi-park meeting in Denver with representatives from the NPS Washington Office and other agencies to assist the bison EIS team in formulating responses to public comments on issues regarding Native American interests and involvement with bison management. A community dinner was held that evening to welcome the tribal representatives. Many tribal members took the opportunity to explain the personal connections they have to bison, and the importance of bison to their tribes.

Oral Traditions

Two private groups initiated projects to interview members of American Indian tribes affiliated with Yellowstone in 1999. Ehnamani, a Native American group from Bozeman led by Crow/Santee Scott Frazier and Ojibwe John Potter, worked with Crow historian Lawrence Flatlip to gather potential ethnographic information and Crow oral histories about the park. In September, the cultural resources branch chief, cultural resources assistant, and park exhibit specialist represented the park at Ehnamani's "Prayer for Wolves" at the Lower Blacktail cabin.

The Idaho Mythweaver group planned to work with high school students on the Nez Perce, Confederated Salish and Kootenai, Shoshone-Bannock, and Crow reservations on oral interview techniques they can use to interview their elder family members about Yellowstone. This information will be presented to the park for use in interpretive programs and exhibits, and documentation of place names and past tribal uses of the park for the cultural resources program and the park archives.

Nez Perce National Historic Trail

On July 24, the branch chief, along with representatives from the Nez Perce Tribe and Yellowstone's Division of Resource Management Operations and Visitor Protection, rode a segment of the Nez Perce National Historic Trail (NHT) that runs through Pelican Valley. During the ride, the tribal members told family stories about the 1877 flight of the Nez Perce, and park staff shared information about the trail's location through Yellowstone.

On October 18, Stan Hoggatt, Nez Perce NHT historian and outfitter, presented a seminar at the park on the "Nez Perce Triumph at Clarks Fork Canyon." He has extensively researched the location of the Nez Perce trail on the east side of the park. While in Yellowstone, he presented a great deal of new information.

The branch chief served as a non-voting governmental representative on the Nez Perce NHT Foundation and worked with the Forest Service to revise the NHT auto route map.

Ethnographic Overview and Assessment

Branch staff distributed and gathered additional comments on the final draft of the *Documentary Overview of Native Americans and Yellowstone National Park*. In October, YCR staff met with authors Larry Loendorf and Peter Nabokov to discuss park comments. The authors agreed to produce a revised draft in early 2000.

Holiday Toy and Book Collection for Oglala Indian Children

In June, tornadoes struck the remote village of Oglala on the Pine Ridge Indian Reservation in South Dakota. As winter set in, many Oglala families were still struggling to recover from the loss of homes or property. The Oglala Lakota/ Sioux are one of the American Indian tribes culturally affiliated with many parks in the Intermountain and Midwest regions. To assist the Oglala during this difficult time, the branch chief, working with staff from Agate Fossil Beds National Monument, Badlands National Park, Fort Laramie National Historic Site, Jewel Cave National Monument, Scotts Bluff National Monument, and Wind Cave National Park, initiated a holiday collection of toys and books for the Oglala children. Thanks to generous donations from NPS and concessions staff, five vehicles full of toys and books were taken to Oglala on December 11. Some employees from Yellowstone drove personal vehicles as far as 1,200 miles round trip to make the delivery. Upon their arrival, all were pleased to see about 75 extremely happy children and their families receive these gifts.

Historic Roads and Bridges

The Cultural Landscape of Park Roads

A five-person team of student architects, landscape architects, and historians from the Historic American Buildings Survey/Historic American Engineering Record (HABS/HAER) division of the National Park Service's Washington Office spent 12 weeks documenting historic roads and bridges in the park. The project is an update of a similar project conducted by HAER in 1989. While the previous work focused on the park's primary roads and bridges, this project looked mainly at secondary roads, scenic loop drives, and bridges not previously documented. The team studied the road landscape, its significance in the development of Yellowstone's transportation system, and its influence on the visitor experience. Historic research resulted in the development of a draft addendum to Mary Shivers Culpin's report on *Yellowstone Roads and Bridges* (HAER WY-24).

The addendum provides further historic research into the development of the Grand Loop Road and the creation of NPS road standards. The scenic roads documented are: the Gardiner to Mammoth High Road; Firehole Canyon Drive; Firehole Lake Drive; roads providing access to the Grand Canyon of the Yellowstone; the road to the summit of Mount Washburn; and the Virginia Cascade Drive. The bridges documented are the "Corkscrew" or Loop Bridge, the Canyon Bridge spanning Jay Creek, the Chittenden Memorial Bridge over the Yellowstone River, and an addendum to the Golden Gate viaduct. The appendix also includes documentation of the Clematis Creek culvert.

At the end of the year, NPS staff were reviewing the draft HAER report. Draft drawings were provided to the park for comment at the fieldwork closeout. Final drawings and historic contexts will be produced within two years, and after external review, submitted to the Library of Congress. The project was funded by the Federal Highway Administration and represents a continuing effort to complete documentation of the park roads begun by Mary Culpin.

Road Improvement or Reconstruction Work Currently in Progress

East Entrance Road. Work was accomplished towards the repair of the road washout and thermal vent failures on the Mary Bay portion of the reconstructed segment of the East Entrance Road. Large rip-rap was laid down in a design that would protect the road base from wave action damage. Smaller rip-rap still needs to be placed along the shoulder of the road in the area being repaired. When that is completed, the final asphalt will be placed to the full 30-foot width. The remaining repairs will be completed in the 2000 construction season. The failed plastic thermal vent tubes were replaced with traditional clay pipe, and the stone masonry headwalls were reset in their original locations at the end of the 1998 construction season.

Redesign of the parking area west of Fish-

ing Bridge began in 1999. Repairs to the historic Fishing Bridge were begun under a traffic closure during October. Precautions were taken to protect the exposed bridge deck from weather and damage from snow-removal equipment. All construction obligations should be completed for this portion of the Fishing Bridge segment of the East Entrance Road during 2000.

The major reconstruction and widening of the 7.5-mile segment between the East Entrance and Sylvan Pass is scheduled for construction in 2002. Archeological resources have previously been identified, and unnamed features documentation was submitted in 1994. The road will maintain its current alignment, but increase to a 30-foot width will be achieved by widening into the uphill slope, leaving the retaining walls and guard walls unaltered except for repairs. This undertaking will involve development of a final plan for the contouring of the Sylvan Pass material source. This material source will remain active until the East Entrance and Dunraven Pass roads are reconstructed.

Northeast Entrance Road. In November of 1999, work was completed on the resurfacing and road base repair of the Northeast Entrance Road. The repairs to the sagging masonry wall located at the east end of Lamar Canyon were completed. Construction of the new Warm Creek stock trailhead parking area was completed without impact to archeologic site 24YE16. Improvements to the Northeast Entrance Station area were completed according to plans approved by the Montana State Historic Preservation Office (SHPO).

Arnica Creek-to-Little Thumb Creek/ Bridge Bay-to-Lake access. HK Construction was awarded the contracts for these combined projects, and work began on the reconstruction and widening of the Arnica Creek-to-Little Thumb Creek segment as well as the resurfacing of the previously widened Bridge Bay-to-Lake access segment. Repairs at the Bridge Bay road bridge included the addition of natural stone, providing more of the original character of the historic park roads compared to previously constructed modern road structures.

Although cultural resources were not affected by this landslide on the road between Mammoth Hot Springs and the North Entrance, the slide may bump up the maintenance schedule for this section of road. NPS photo.

Mammoth to the North Entrance. Although scheduled for 2007, the reconstruction of the road between Gardiner and Mammoth may rise toward the top of the park's priority list. On December 6, 1999, a landslide 1 3/4 miles south of Gardiner, Montana, (between Eagle Rock and Chinese Gardens) closed the road for several days. Additional loose material was blasted from the cliff face to facilitate safe clean-up and continued use of the roadway. The old road alignment (the unpaved Gardiner High Road) was put into temporary service to provide emergency and essential access to Mammoth. Emergency consultation was initiated with Montana SHPO. No cultural resources were affected by the landslide, and the clean-up operation revealed minimal damage to the road and utility corridor located under the road. The road was re-opened for public use four days later. Historic research conducted this summer under the HAER documentation project indicated that landslides in this area have consistently reoccurred over the last 100 years. Further investigation showed that the abandoned Gardiner High Road is also constructed on unconsolidated landslide material.

Madison-to-Norris. Section 106 consultation for the phased reconstruction and partial realignment of the Grand Loop Road was com-

pleted for the first phase. The environmental assessment for the entire Madison-to-Norris project was made available for Wyoming SHPO, the Advisory Council, and public review in February 1999. In June, a memorandum of agreement (MOA) mitigating the adverse effect of the relocation of the Tanker Curve portion of the Grand Loop Road was signed by the park, Wyoming SHPO, and the Advisory Council, with the Federal Highway Administration's concurring signature. The MOA provides for the development and placement of wayside interpretive panels depicting historic transportation through Yellowstone National Park within the Madison-to-Norris road segment.

Tower-to-Canyon (Dunraven Pass). Reconstruction and widening of this segment of the Grand Loop Road is scheduled to begin in fall of 2001. Resource inventory and mapping were undertaken in 1999. Due to the delicate geologic resource issues at Overhanging Cliff and other areas along the upper portions of the road, Superintendent Michael Finley decided to limit widening of this segment to 24 feet.

Fishing Bridge-to-Canyon (Hayden Valley). The rehabilitation and resurfacing of this 15-mile segment of road is planned for 2001. Some additional pullouts will be added, but no other work will be done on the parking and picnic areas along this segment of the Grand Loop Road. Resource mapping began with the archaeological inventory and the recording of unnamed features located within the road right-of-way. The Otter Creek road that leads from the existing road alignment to the area formerly used for bear feeding and viewing was inventoried by Paul Sanders. No repairs are currently planned for the Dragon's Mouth/Mud Volcano or Sulphur Caldron parking lots, both of which are being affected by evolving thermal features.

Data Recovery

Following a previously approved plan, data recovery was conducted in a portion of National Register eligible site 48YE867 during the 1998 field season to mitigate the effects of construction activities. The final report, *Archeological Data Recovery at Site 48YE867: Historic and Prehistoric Occupations Below Gibbon Falls, Yellowstone National Park, Wyoming, Project 254E,* by Paul H. Sanders and Dale L. Wedel, was accepted by Wyoming SHPO and the Advisory Council in June 1999. This concluded compliance for the site as required by Section 106 of the National Historic Preservation Act.

Determination of Eligibility Requests

The archeological sites associated with the Federal Highway Administration program for which Yellowstone requested determinations of eligibility for the National Register of Historic Places in 1999 included eight prehistoric sites (two eligible, six ineligible); three historic archeological sites (one eligible, two were not evaluated); and three multi-component sites (one had prehistoric and historic components eligible, one was ineligible, and one was not evaluated).

Monitoring

Cultural resources staff provided ongoing monitoring of road construction activities to ensure that park resources would not suffer adverse impact. Monitoring was provided for prehistoric occupation sites, historic CCC dump sites, National Historic Landmarks, historic bridges, masonry retaining walls, and historic road segments being affected by thermal features and natural landslides.

Historic Buildings and Structures

Museums at Risk

The Secretary of the Interior included three buildings in Yellowstone National Park in his *America's Landmarks at Risk* annual report to the U.S. Congress—the Norris, Madison, and Fishing Bridge museums. The report cited physical deterioration stemming from the effects of weather and deferred maintenance, extensive rodent problems, and thermal activity at Norris as reasons for the listing. The report also recommended that the park prepare condition assessment reports on these buildings.

The Norris, Madison, and Fishing Bridge museums were designated National Historic Landmarks in 1987. The designation recognized the museums as the best examples of Rustic style buildings in the National Park System. The buildings were designed by architect Herbert Maier in 1929, and the Laura Spelman Rockefeller Foundation funded their construction through the American Association of Museums. The museums served as models for hundreds of buildings constructed throughout the nation, especially for projects under the auspices of New Deal programs of the 1930s.

National Historic Landmarks, a step above the National Register of Historic Places listing, have exceptional value in illustrating or interpreting U.S. heritage in history, architecture, technology, and culture. The Old Faithful Inn, the Northeast Entrance Station, and Obsidian Cliff are also National Historic Landmarks.

Park staff are preparing an interpretive brochure to explain the museums' history and their influence in the evolution of the NPS Rustic style of architecture. Funding sources to rehabilitate the buildings are being investigated.

Historic Structures Inventory

The three-year parkwide inventory of more than 900 historic buildings is drawing to a close. In November, the consultant delivered individual inventory forms and photographs that will enable cultural resources staff to quickly retrieve information on the current and recommended National Register status of most buildings. As time permits, consensus determinations of eligibility will be sought from the appropriate State Historic Preservation Officers.

List of Classified Structures

Yellowstone National Park's historic buildings and structures were officially entered onto the List of Classified Structures (LCS). The LCS is the primary nationwide computerized database containing information about National Park Service-owned historic buildings and structures. The LCS shows Yellowstone has 907 buildings and structures listed in the National Register of Historic Places or eligible for listing. The 907 buildings and structures represent almost one-quarter of the NPS Intermountain Region's list.

National Historic Landmark Nominations

Fort Yellowstone. The importance of Fort Yellowstone as a physical representation of the U.S. Army's role in the history of our national parks has long been recognized. The U.S. Army entered Yellowstone in 1886. The 35 army buildings, dating from three main construction periods (1891, 1897, 1908), present an almost complete "picture of an extraordinarily handsome Western Army post at the turn of the century" (Battle and Thompson, Fort Yellowstone Historic Structure Report, 1972). In the

Fort Yellowstone in 1913. "...an extraordinarily handsome Western Army post..."

Fort Yellowstone in 1969. The fort looks similar today, and it hasn't changed much since 1913. NPS photos.

fall of 1999, the National Trust for Historic Preservation contracted with Front Range Research Associates, Inc., of Denver, Colorado, to prepare a National Historic Landmark nomination for the fort and for other U.S. Army-constructed buildings throughout the park. Included are the Bechler and Norris Soldier Stations, the Buffalo Lake snowshoe cabin, and the Roosevelt Arch. The nomination will focus on the army's role in protecting the park, and will be submitted under the National Historic Landmark theme of "Conservation of Natural Resources."

Other National Register nominations. In conjunction with the Fort Yellowstone nomination, Front Range Research, Inc., of Denver is also preparing a National Register of Historic Places nomination for the larger Mammoth Hot Springs area. The nomination will include about 200 buildings constructed by the U.S. Army, the NPS, and concessioners. The significance of the Mammoth Hot Springs Historic District lies in its association with the development of the NPS administrative and concessioner policies, and in its architecture.

Cultural resources staff continue to work on revising National Register nominations for some of the park's historic roads and, in cooperation with the Division of Resource Management Operations and Visitor Protection, gathering supportive documentation to seek determinations of eligibility for the park's snowshoe cabins.

History

The branch chief became the Wyoming State membership representative for the American Association of State and Local History. The final draft of two Historic Resource Studies, *The History of the Development of Concessions* and *The History of Administrative Development* were under review by park staff and were sent to the SHPOs and the Advisory Council for comment. Written by Mary Culpin, these two volumes provide historic contexts for the development of the infrastructure of Yellowstone. *The History of the Development of Concessions* is being prepared for publication.

Christine Whitacre, historian at the Regional Office in Denver, assisted the park as acting historian from July 1 to 30. She completed historical documentation for Federal Highways projects; revised statements of significance for Yellowstone's snowshoe cabins; researched the Baronette Bridge site; initiated a historic survey of pre-1950 authorities regarding wildlife distribution, and provided technical assistance to the gateway community of West Yellowstone. She also continued to coordinate the park's historic structures survey and National Register/National Historic Landmark nomination projects.

Oral History

Charissa Reid and Sally Plumb, cultural resources assistants, continued to work on an oral history project to interview important figures in the park's management of natural resources. The Fee Demonstration program provided funds for the project, which initially targets the history of ungulate management in Yellowstone. Reid and Plumb interviewed former park employees who worked on the ungulate management program in the park's past. Yellowstone's former chief biologist, Glen Cole, a pioneer of natural regulation in the NPS, was able to attend the park's fifth biennial scientific conference in the autumn of 1999 and was interviewed twice during his visit.

Glen Cole, Yellowstone's former chief biologist. Photo courtesy Mr. Cole.

Museum

In 1999, Yellowstone's museum staff consisted of the supervisory museum curator, a museum aide, seasonal or temporary museum technicians, and a summer intern. In the spring,

seasonal technician Kirk Dietz was accepted to an NPS intake trainee program and transferred to the position of curator at the Presidio of San Francisco. All museum technicians were funded almost exclusively using project monies raised from NPS sources and the Yellowstone Association (YA), which also funded the intern. This funding enabled the staff to complete a number of important projects and to make substantial progress on other multi-year projects. During 1999, volunteers contributed a total of 611 hours to the museum program.

Cataloging

In fiscal year 1999, the park's total number of museum items reached 306,439. The collection includes objects and specimens from the disciplines of archeology, ethnology, history, biology, paleontology, and geology, plus field records generated during archeology and natural science projects. Less than half of the collection has been cataloged into the NPS's collections management software, "Re:discovery" (also known as ANCS+). During fiscal year 1999, the park cataloged over 2,500 objects in a project funded by the NPS's Backlog Cataloging Program. This program only funds cataloging of objects received or generated by the park before 1987. The park expects to receive additional funds in 2000 that will likely eliminate most of Yellowstone's backlog of eligible objects. However, most remaining uncataloged objects were received or generated after 1987 and will have to be cataloged using other types of funding. An additional 13,000 objects and specimens were cataloged before the advent of computers; the NPS chief curator's staff is expected to begin scanning parks' older catalog records next year.

Funding from YA enabled the curator to hire a contractor to re-catalog many of the park's works of art that were originally poorly or inadequately cataloged. The improved data will assist in the completion of the above-mentioned scanning project and will help the museum staff meet the growing number of research requests relating to fine arts in the museum collection.

Researchers have already begun to benefit from another YA-funded project that included a systematic survey of a set of 30 oversized photo albums that once served as the primary finding aid for the park's photo archive. The albums contain black and white prints that correspond, for the most part, to the cellulose nitrate and glass-plate negatives cataloged in the park's museum collection. However, use of the albums by researchers often posed difficulties for park staff because the images were never cross-referenced to the original, cataloged negatives. During this project, prints in the albums were compared to images cataloged into the park's museum database and annotated with their correct catalog numbers. Prints discovered to have no surviving corresponding negative were marked for reproduction.

Outreach

More than 700 research and reference requests—15 percent from park staff and 85 percent from outside researchers—were met during the year. This reflects a continuation of the trend over the last six years of greater use of the collection by outside researchers, as in-park use remains relatively constant or increases at a more gradual pace. Various museum staff members now spend in excess of 30 hours per week assisting researchers. During 1999, research and reference requests, as well as requests for VIP tours or access to the collection for special projects, came from scholars working on books, journal articles, dissertations, and theses about Yellowstone; filmmakers, videographers, and producers of CD-ROMs; park interpreters and resource managers; visiting scientists; environmental organizations; members of the media; members of American Indian tribes in the park for consultation meetings; elder hostel groups; Yellowstone Association Institute classes; neighboring museums; and the general public. The greatest demand was for historic images (including photographs, postcards, and stereographs); artwork; ephemera (such as historic brochures); and access to the vehicle collection. Use of the herbarium also continued to be heavy, particularly during summer months.

Products generated by many of these researchers, including books, articles, documentaries, and web pages, ultimately serve to educate millions of people about Yellowstone.

Twenty outgoing loans were approved during the year, involving a total of 96,552 objects and specimens.

Curator Susan Kraft served as guest editor of an issue of the NPS journal *CRM* (Cultural Resource Management), working on donated time. The issue (Volume 22, No. 10) focused on historic railroads and featured a number of articles concerning railroads in the greater Yellowstone region. Kraft prepared a foreword for the issue for NPS Associate Director Kate Stevenson, co-wrote the introduction ("Historic Railroads in the National Park System and Beyond") with NPS Historian Gordon Chappell, and wrote an article about the five railroads that historically served the Yellowstone area: "Through 'the Greatest Gateway to the Greatest Park'–Dudes on the Rails to Yellowstone." The latter summarized for the first time in one article the history of passenger rail service to Yellowstone. For an earlier issue of *CRM*, Kraft wrote "Conservation of a Yellowstone Studebaker Wagon," an article describing the conservation of the buggy now on exhibit in the Old Faithful Inn lobby.

C.J. "Buffalo" Jones beating a bear that is hanging upside down from a trap in which it caught its leg. Jones served as game warden in Yellowstone from 1902 to 1905. Although not of the best quality, this image is so far the only photographic evidence the park has of the methods Jones used to deal with habituated bears. It was purchased by the park along with other materials relating to Jones and an essay by Jones detailing his experiences in Yellowstone.

The curator delivered several talks on behalf of the park during the year, including presentations on integrated pest management for museums at the annual "Partnership Opportunities for Federally-Associated Collections" meeting held in San Diego, and the annual meeting of the Museums Association of Montana held in Sidney. The curator also participated in a scoping meeting on exhibits for the proposed new Old Faithful Visitor Education Center.

To improve service to the many researchers who seek access to Yellowstone's museum collections, the staff embarked on a two-year project, made possible by the Recreation Fee Demonstration program, to place images of the most in-demand historic photographs as well as selected artifacts and works of art on Yellowstone's web site. This effort will serve researchers who cannot visit the park personally, should help reduce the staff time needed to serve these researchers, and will also help preserve the collections by reducing the need to handle original materials. During 1999, staff compiled a list of the most requested historic photos as well as signature Yellowstone artifacts and works of art—including tools used in early park surveys, army artifacts, and paintings by Thomas Moran and other noted artists. Several museum staff members were trained to use scanners and began scanning photographs and images of key artifacts that had been photographed. Many of the items were recataloged in order to provide more detailed caption information.

The Yellowstone Park Foundation agreed to raise funds to have Thomas Moran's diary and selected other rare documents in the park's collection photographed, scanned, and tran-

scribed. The project will begin as soon as a donor is found.

Preservation

Museum staff completed the last year of a three-year project, funded by the servicewide Museum Collections Preservation and Protection Program, to preserve portions of the historic photograph and objects collections that were in jeopardy due to substandard storage conditions. Yellowstone's photograph archive contains approximately 90,000 images—almost one-third of the museum collection—and is by far the most in-demand part of the collection. Some of the park's most important historic artifacts and natural science specimens were re-housed to prevent damage during earth tremors and routine handling. The project also improved access to thousands of photographic images by removing them from overcrowded and hazardous conditions and placing them in archival sleeves that enable them to be safely viewed and handled.

Another Recreation Fee Demonstration project enabled the park to address long-standing safety issues in the museum collection, and to continue the much-needed work of preserving the park's world-class collection of historic vehicles. Numerous Office of Safety and Health Administration (OSHA) violations in both of the park's museum storage areas—the historic vehicle collection storage room in Gardiner and the collections room in the basement of the Albright Visitor Center—were corrected. The vehicle room was cleaned and organized to allow safe passage between and viewing of items. Vehicles harboring rodents were cleaned and covered with dust covers to prevent the spread of hantavirus. Lead tests revealed that the greatest lead hazard in the room is posed by the some of the vehicles that were evidently painted with lead paint. This discovery allowed staff to take appropriate precautions, such as donning personal protective equipment when cleaning the vehicles. A preventive maintenance plan was written for the vehicles and will be implemented as funding becomes available.

Unstable shelving units in both storage areas were reorganized, stabilized, and bolted to walls as needed to prevent tipping and injury, per OSHA requirements. All flammable supplies were identified and placed in a flammables storage cabinet. Deteriorating photo chemicals were documented and disposed of in cooperation with Montana State University. Museum cabinets containing hazardous materials (such as specimens treated with arsenic) were identified and labeled with appropriate warning signs. Ammunition containing black powder was assessed in consultation with several ordnance and firearms curators at military and NPS museums, and found to be safe for long-term storage. These actions improved safety in museum storage areas and will allow for increased access by the public.

Research has shown that Yellowstone has one of the largest collections of historic vehicles in the NPS, and the largest collection of Yellowstone vehicles anywhere, including the largest collections of Abbot-Downing stagecoaches and White Motor Company Yellowstone buses. The Abbot-Downing Company, based in Concord, New Hampshire, made the "Cadillac" of stagecoaches, used throughout the world for overland travel, mail, touring, and other purposes. Yellowstone, the last national park to embrace the automobile, was Abbot-Downing's last major customer. The White Motor Company of Cleveland, Ohio, made the first buses for a number of national parks, including Yellowstone.

Nitrate negatives. Toward the end of the year, a grant proposal submitted by the curator became the top-scoring project in the NPS to receive funding under a special initiative by the Washington Office to reformat cellulose nitrate negatives onto safety film. Cellulose nitrate negatives (common into the 1940s) become volatile over time, and can spontaneously combust when subjected to the heat of a normal photo enlarger or unfavorable storage conditions. To be used, they must first be copied at specialized labs onto safety film, from which prints can then be made. Yellowstone has one of the largest collections of nitrate negatives in the NPS, consisting largely of images taken by park staff

from the 1920s to the 1940s that are in enormous demand for research and education. This funding will enable Yellowstone to have all of its negatives that remain in nitrate form only—approximately 12,000 images in all—copied onto safety film beginning next year. Prior to this project, the curator had been contracting for reformatting using a variety of funding sources as they became available, and estimated that it would take at least 10 years to complete reformatting of all the park's nitrate film. The Washington Office initiative will enable reformatting to be completed over the next 2–3 years, and will save the park more than $100,000 in lab fees.

Notable acquisitions. A number of important items were added to the museum collection during the year. An 1887 oil painting of the Lower Falls entitled *Great Falls and Canon of the Yellowstone*, by noted American artist James Everett Stuart, was donated after being on loan to the park for several months. The painting became the second work by Stuart to be added to the park's museum collection in as many years.

As in 1998, YA funding enabled the curator to purchase a number of critically important items for the museum, including the Buffalo Jones collection of rare documents and photographs owned by Yellowstone's historic gamekeeper, and a never-before-seen essay and photograph documenting Jones's practice of trapping and beating problem bears. Also acquired were two important 1890 amateur paintings, one of the Mammoth terraces, and one featuring Larry's Lunch Station at Mary Mountain. Prior to this find, a single photograph was the only known image of this lunch station, a significant concessions operation in early park history. At the National Parks Antique Show, held for the first time in Billings, the curator purchased a set of real photo postcards (privately taken photographs printed as postcards) of the U.S. Army in Yellowstone in 1912. The postcards feature extremely rare views of soldiers marching, camping, and posing by thermal features throughout Yellowstone, and offer details never before seen of the army in the park.

Following a brief presentation by curator Susan Kraft, the Yellowstone Park Foundation agreed at its fall board meeting to pursue funding to purchase the Susan and Jack Davis Collection for Yellowstone National Park. The Davis Collection is the finest private collection of Yellowstone-related postcards, ephemera, photographs and other materials in the world, and would increase the research and educational value of the park's museum collection substantially. A Yellowstone Park Foundation board member agreed to fund appraisal of the collection, and the museum staff began searching for qualified appraisers.

A rare view of soldiers marching in Yellowstone, 1912, probably taken by a member of the 18th Infantry. The caption reads "Firehole Gibbon River Road." Photo postcard purchased in a set at the National Parks Antique Show.

Herbarium. The park herbarium, part of the museum collection, continued to be used extensively, especially during the summer months, by both park personnel and outside researchers. The collection includes approximately 7,600 specimens of vascular and nonvascular plants that are identified and mounted, with 6,121 specimens of vascular plants that are also catalogued into ANCS+. During 1999, 240 additional specimens were collected for the

Yellowstone herbarium, primarily plants not well represented in the collection, new park records, and exotic plants gathered to document their arrival and spread. A backlog of approximately 2,500 specimens remains to be identified, labeled, mounted, and cataloged. Attempts to secure backlog catalog funding to complete this work have so far been unsuccessful, as the criteria by which project proposals are judged currently favor cultural collections.

New field collections. Collections of natural science specimens and cultural artifacts made under approved collecting permits were, as usual, a significant source of new museum items. Natural science collections (including biological, paleontological, and geological specimens), either physically in the park or reported to the park by outside collectors, now include 45,837 specimens, twice the number reported in 1998. The archeology collection now has 107,065 items, or more than one-third of the total museum collection, a figure which includes some of the 77,427 artifacts housed at the NPS's Midwest Archeological Center (MWAC) in Lincoln, Nebraska. (Yellowstone collections at MWAC are not fully accounted for, and thus are not all included in Yellowstone's total.) The number of items at MWAC is expected to remain static, as the park is now the designated repository for all archeological materials collected within Yellowstone.

Most natural science collections made in Yellowstone are, under the terms of their permits, removed from the park for research and storage. In 1999, the park issued 255 permits authorizing the collection of specimens. Federal regulations governing collecting permits stipulate that materials collected under research permits and retained in any repository remain the property of the United States. Such materials are managed as part of the park's museum collection. Although collectors are requested to contact the curator's office for an accession number (establishing federal ownership) before they leave the park, only 10 collectors (approximately 4 percent of the total) had contacted the curator's office at all by the end of the year.

National Historic Preservation Act

Section 106 Compliance

In Yellowstone, each division is responsible, under the guidance of and assistance from cultural resources staff, for initiating and completing Section 106 review, as required under the National Historic Preservation Act (NHPA), for projects that could potentially affect National Register-eligible or listed historic properties. In 1999, a full-time cultural resources technician was responsible for coordinating this compliance and for other regulatory and NPS cultural resources requirements, and also provided technical assistance to help properly manage and care for the park's historic properties.

A National Environmental Policy Act/ NHPA training was held in September, with 40 participants from Yellowstone and other regional parks. Cultural resources technician Lon Johnson handled logistics. Also, several buildings are proposed for construction in Yellowstone (a new visitor center in the Old Faithful historic district and a rehabilitation of the Canyon Village visitor center; a new collections storage facility near the North Entrance or in the Mammoth Hot Springs Historic District; and a new public restroom building, also in the Mammoth District). Cultural resources staff represented historic preservation concerns to the sponsoring divisions.

Section 106 Project Summary

Under Section 106, Yellowstone National Park submitted 18 projects to the Wyoming State Historic Preservation Officer for formal review and comment. The park found that no historic properties were affected for two undertakings, the new sewage plant at Old Faithful and a prescribed fire at Grant. Findings of no adverse effect were reached for the remaining 16 undertakings: re-roofing the Mammoth Clinic; painting the Lake and Mammoth hotels; restoring the Lake Hotel columns; installing lighting and landscaping in the Lamar Buffalo Ranch Historic District; installing experimental lighting in the

Old Faithful Historic District; relocating a building from the Old Faithful Historic District to the Tower Historic District; rehabilitating the Madison Campground amphitheater; tree planting, erosion control, and phone line trenching in the Madison Campground; installing an elevator in the Fort Yellowstone cavalry barracks (now the Yellowstone Center for Resources building); installing steps at the Fort Yellowstone guard house, a sidewalk on the Fort Yellowstone parade ground, and handrails at the Albright Visitor Center; and placing roadside boulders at Obsidian Cliff.

The park also began consultation with the Wyoming SHPO, seeking comments on the proposals to rehabilitate the Canyon Visitor Center and a new Old Faithful Visitor Education Center. Both the Wyoming and Montana SHPOs were updated periodically as planning proceeded on the proposed Heritage and Research building.

PALEONTOLOGY

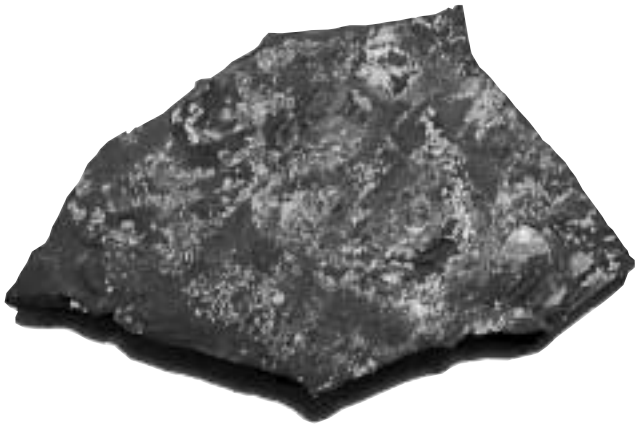
The park's paleontological program duties are shared between the YCR's branches of cultural and natural resources. In 1999 the Branch of Cultural Resources provided assistance in the inventory and documentation of paleontological resources in the park. More than 20 fossiliferous stratigraphic units have been documented, containing fossil plants, invertebrates, vertebrates, and trace fossils. Yellowstone preserves an extensive geologic record ranging from the Precambrian through the Holocene. Except for the Silurian, rocks of nearly every geologic time period are exposed within the boundaries of the park.

With the assistance of cultural resources technician Elaine Hale, paleontologist Bill Wall from the Department of Biology, Georgia College, led a team of students to continue their paleontological survey of Yellowstone from July 4 through 11. The group completed additional inventory and collected fossil leaves from the Cretaceous formations located in the Mt. Everts region. The college will provide information on these collections to the park. This group attempted to locate additional vertebrate fossils in the Eocene rocks at the Mt. Hornaday site, where a mammal jaw fragment was found in 1998, but were unable to re-locate the site. The group also visited fossil locality sites emerging from Paleozoic rocks in the Mt. Holmes area.

On August 5, 1999, mountain lion researcher Craig Whitman led the branch chief and several other branch staff, the GIS specialist, and the Tower district ranger on a grueling hike to survey a portion of the upper reaches of Mt. Hornaday. Matt Smith, director of the Natural History Exhibit Hall in Livingston, joined the group to provide paleontological expertise. They hoped to find additional remains of the tentatively identified *Titanothere* jawbone fragments that Craig had found in 1998. This rhinoceros-like dinosaur lived in the area during the late Eocene period 37–50 million years ago. The participants conducted intense inventory and photo-documentation to locate any associated mammal fossils, and used GPS equipment to record the site's precise location. They found abundant fossilized wood, but only a few small fragments of fossil bone of tentative identification. It appears that the fossil remains of the Eocene mammal were re-deposited at this secondary location as a result of a volcanic mudflow.

Cultural resources staff and volunteers conducted a pedestrian inventory of areas within the Mount Everts region, resulting in the recovery of marine fossils (small shells) in what appears to be a dolomite matrix. The fossil locations (recently discovered and previously identified) were recorded using GPS equipment and digital photographs.

On another trip, civil engineer Nancy Ward led staff and volunteers to a previously undocumented and hard-to-access site in the Tower fossil resource region. The staff documented a large area containing a wide variety of fossil plants, recorded GPS locations, took digital photographs, and collected samples. Park staff are attempting to classify the various fossil leaves collected from this site so they may be accessioned into the park's museum collections.



A mollusk fossil recovered from the landslide debris on the North Entrance Road in December 1999. NPS photo.

This location is identified as part of the Sepulcher Formation of the Cenozoic fossiliferous unit. Large quantities of fossils remain *in situ* within the various depositional layers exposed at this location. Abundant fossils are also scattered along the ground.

A fragment of sedimentary rock containing a mollusk fossil was recovered from the landslide debris that covered the North Entrance Road in December 1999. Mesozoic and Cenozoic fossiliferous units have been identified in the Mt. Everts fossil region with both marine and non-marine rock well exposed. Staff hoped to examine the landslide debris for additional fossils as weather permitted.

The branch chief prepared and presented a paleontological survey funding request to the Yellowstone Park Foundation board and provided the foundation director with a proposed itinerary for a potential paleontology supporter. Together with staff from the Division of Resource Management Operations and Visitor Protection, the branch chief completed the Yellowstone paleontology portion of the NPS geological resources survey.

Partnerships

The branch chief facilitated meetings for the Yellowstone Museum Partnership—18 museums, historical societies, preservation agencies, and national parks representing greater Yellowstone. At the October 22 meeting in Yellowstone, the group agreed on an informal organizational structure and vision statement. Ongoing partnering projects include linked web sites, joint museum displays, shared conservation services, disaster response plans, brochures, and traveling exhibits and educational programs to help national and international visitors learn about the greater Yellowstone area. Planning also continues for new collection storage facilities for many of the partners. The group spent time at each meeting discussing facility plans to ensure that efforts among our members are not duplicated.

The branch chief participated in planning for the 2000 Montana Historical Society Montana History conference, which will be held in West Yellowstone.

Research Library and Archives

In 1999, staff made considerable progress in both the park library and archives in backlog cataloging, computerization, and acquisitions. After joining our existing part-time library staff of Alissa Cherry and Barbara Zafft, full-time term library technician Kathryn Lancaster added immeasurably to the amount of work that was accomplished. Dr. Patricia Owens worked as a contract employee, and Frankie Collins worked as a VIP for the entire summer. Ann Haag from Eastern Washington University served as an academic intern in the park's photo archives for part of the summer.

Harold Housley was hired as a temporary archives technician to assist researchers using the archives, work on computer cataloging of the archival holdings, process acquisitions, organize and upgrade storage of the collections, and increase access via the Internet. Due to the 1998 water leak in the archives, Harold's first assignment was to draft a disaster plan for the research library and archives. Once that was completed, he began work on encapsulating the library's large map collection. He spent several weeks inventorying and cataloging the National Ar-

chives documents collected by historian Mary Culpin for her project on the history of park concessions. He also began the large project of transferring the 1,500-page master archival inventory to the park's new "Re:discovery" computer program that will allow "Boolean" searching. Harold and Frankie completed the acquisition, computer inventory, and arrangement in the archives of a large series of records from the park's protection division.

Library staff updated the cataloging system to a networked version of the "Micro-Cat" system, and the library gained several new "Fire King" archival file cabinets. Two large computer scanning projects added hundreds of historic photographs from the park archives to a computer database. The large film library belonging to the Interpretation Division was turned over to the park library, and staff hope to eventually obtain funding to have this collection accessioned and cataloged. Dr. John Landrigan, a park VIP for many years, attended the official opening of Yellowstone's new Old Faithful Snow Lodge in May and videotaped the event. This completed his project to record the history of its construction, and he presented the park library with a copy of the compact disc containing all historic information.

Librarian Kathryn Lancaster traveled to Dillon, Montana, to obtain the complete records of the Greater Yellowstone Coordinating Committee, in order to add that important record series to the park archives. She later attended the national NPS library steering committee meeting in Seattle.

The archivist attended the annual National Park Paper Show in Billings, bearing the library's duplicate items. He was successful in trading many of these items for rare items that the library did not have. Throughout the summer, he also worked with Ron Lerner, a rare book collector from Texas, in arranging a trade of two of the library's duplicate books for a number of rare books that the park did not own.

The new Old Faithful Snow Lodge. NPS photo.

Soda Butte Creek, impaired by historic mining-related activity upstream and outside the park. NPS photo.

Part III. Natural Resource Programs

Air, Land, and Water

Air Quality

Park staff continued to participate in the Greater Yellowstone Area Clean Air Partnership. The primary focus of this group was to prepare an assessment identifying Greater Yellowstone Area (GYA) air quality issues and conditions, air pollution sources, and monitoring efforts. The assessment also summarized known information and identified monitoring needs with recommendations for future management actions.

Snowmobile emissions and air quality concerns continued to stay in the news as the park's controversial winter use planning and compliance process continued. Park staff assisted the NPS Air Resources Division with the compilation of a servicewide report on air quality concerns related to snowmobile usage. Park staff gave a presentation on snowmobile emission issues at the National Park Service Air Quality Summit in Estes Park, Colorado.

Mining Impacts

New World Mine. Staff time devoted to tracking and responding to the New World Mining District Response and Restoration Project increased as the U.S. Forest Service began the initial stages of planning for restoration. Yellowstone staff reviewed and commented on several technical documents and work plans. Park staff, along with staff from the NPS Water and Geologic Resources divisions, also participated in several technical and public planning meetings.

Mineral Hill Gold Mine. YCR staff continued to monitor this project and attend community task force meetings. TVX Gold, Inc., suspended operations in September 1996 and announced in December 1998 that the mine would close. Closure and reclamation is expected to begin in 2000.

McLaren mine tailings. Park staff continued to work with NPS Water Resources staff to explore options for treatment and removal of the McLaren mine tailings located upstream from and just outside of the park's northeast boundary.

Disturbed Lands Reclamation

Reclamation of the Turbid Lake Road continued in 1999. This road was part of the East Entrance Road from 1903 until a major reconstruction of the East Entrance Road between 1928 and 1936 realigned a portion of the road to follow along the Yellowstone Lake shore. The original segment, now referred to as the Turbid Lake Road, was abandoned.

Park and Montana conservation corps staff decompacted another one-half mile of the roadbed to encourage revegetation. They excavated stream crossings and reshaped road cuts to restore the original drainage, and mulched, transplanted, and seeded the area with native plant species. Additional funds are being sought to complete the project in 2000.

The park received $15,000 from the NPS Geologic Resources Division to have one-foot contour topographic surveys done of five abandoned gravel pits that the park wants to reclaim as material becomes available. The pits (Mesa #2, Mesa #3, Natural Bridge, Swan Lake, and Swan Lake East) are visual scars with large unvegetated areas. Reclamation will entail filling the pits back to approximate original contour, followed by revegetation with native plant species. The primary sources of clean fill are "digouts" of substandard road base that accumulate during the course of the park's multi-year road reconstruction program. With a coordinated plan, the park can accomplish reclamation of the sites using park staff and equipment, and through Federal Lands Highway Program (FLHP) funding associated with the removal of the substandard roadbase. The topographic surveys were needed to develop a final grading plan for staged reclamation.

Earth Sciences

Dr. Paul Doss and Dr. Nancy Hinman were selected to fill a GS-12 geomorphologist position and a GS-11 geothermal geologist position, respectively. They report to work in June 2000.

Park staff hosted a mini-conference in September to discuss earth science research being conducted throughout the park. U.S. Geological Survey (USGS) and university scientists as well as park staff gave presentations on geological, geochemical, geophysical, geothermal, hydrological, and microbial topics.

Water Resources

Mary Hektner continued to work with NPS Water Resources Division staff in the implementation of the Montana/NPS Reserved Water Rights Compact. Stream flow, pH, and conductivity were monitored at the gauging station on Soda Butte Creek near the park's northeast boundary. Due to the lack of hydrologic expertise within the park, a U.S. Forest Service hydrologic technician conducted the work under an interagency agreement with the Gallatin National Forest. The NPS Water Resources Division continued to provide technical oversight.

A term of the Water Rights Compact requires that the Montana Department of Natural Resources and Conservation notify the NPS of all well permit applications within the Yellowstone Controlled Groundwater area. The state of Montana received 15 applications in 1999. The NPS did not object to any of the applications. None would result in a calculable reduction in the surface water flow of a Category 3 or 4 stream or its tributary (*i.e.,* Crevice, Dry Canyon, Slough, Tepee, and Soda Butte creeks), and the water did not meet the criterion to be classified hydrothermal, for which restrictions apply.

In December 1998, the NPS objected to an application for 20 gallons per minute from a spring in the Soda Butte Creek drainage. In January 2000, the Montana Department of Natural Resources and Conservation terminated the application because it was "determined that surface water (including springs) is not available for appropriation except for the month of June in any year."

Chloride flux monitoring. Park staff and

contract workers continued to collect water samples on the four major rivers to monitor levels of chloride flux, an indicator of changes in geothermal output. Dr. Irving Friedman, retired from the USGS, continues to provide oversight of the water sample analysis by the USGS Water Resources Division (Denver) as well as data analysis and interpretation.

Park staff continued to work with hydrologists from the USGS Water Resources Division (Cheyenne) as the USGS completed the first of a three-year, in-depth National Water Quality Assessment of the Yellowstone River basin. The assessment will evaluate various measures of water quality, including measurements or samples of bed sediment, fish tissue, surface-water samples, and aquatic ecology. Sampling within the park included Soda Butte Creek, a tributary to the Yellowstone River, in recognition of its impaired water quality caused by historic mining-related activity upstream and outside of the park.

Wetlands

Wetlands were mapped and described along the Grand Loop Road between Canyon and Fishing Bridge, and Tower to Canyon as part of the parkwide road reconstruction program. Preparation of a publication about the park's wetlands, co-authored with the U.S. Fish and Wildlife Service, continued and will be completed in 2000. More than 10 project clearances were reviewed to ensure that impacts to wetland resources would be avoided or minimized.

AQUATIC RESOURCES

Cutthroat Trout Monitoring

Since the 1994 discovery of lake trout *(Salvelinus namaycush)* in Yellowstone Lake, park fisheries biologists have expanded their studies related to the population structure of Yellowstone cutthroat trout *(Onchorhynchus clarki bouvieri)* in order to assess the current and future potential impacts from the introduced lake

An introduced lake trout (above) with a Yellowstone cutthroat trout (below) that was removed from its stomach. NPS photo.

trout. Surveys of Yellowstone Lake tributaries including Clear, Arnica, and Bridge creeks are used to gather information on abundance, size, and age of adfluvial cutthroat trout entering these streams to spawn.

Clear Creek fish trap. Located on Yellowstone Lake's east shore, this trap has been in operation since the early 1950s to provide annual information about total numbers and sizes of spawning trout. Aquatic Resources Center staff operated the fish trap and weir in 1999, obtaining daily fish counts and collecting data on length, age, and maturity of cutthroat trout entering Clear Creek to spawn. From May through July, a total of 14,270 trout were counted passing upstream through the trap, and 14,047 fish passed through the downstream trap on their return to the lake. A comparison of long-term trends indicates that the highest upstream counts occurred following the implementation of fishing regulations, in the 1960s and 1970s, designed to limit cutthroat trout harvest (Figure 1). The latest upstream count is comparable to the 1995 total, which indicates a reduced number of spawning trout entering Clear Creek.

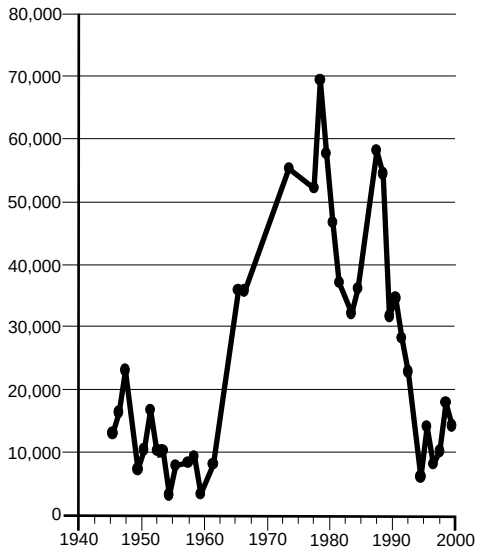


Figure 1. Upstream spawner counts of cutthroat trout entering Clear Creek, 1945–99.

Arnica Creek fish trap. In 1997, a similar type of fish trap and weir was installed in Arnica Creek, a small stream that enters the West Thumb Basin of Yellowstone Lake. This stream was selected for spawner monitoring because it historically contained one of the largest spawning migrations of cutthroat trout in an area of the lake where large, predatory lake trout are now abundant. During 1999, 278 cutthroat trout were counted passing upstream through the fish trap and electronic fish counters. The 295 fish counted traveling downstream to return to the lake indicates that an unknown percentage of upstream migrating trout passed undetected through openings in the weir created during high water. The 1999 upstream count was much larger than the previous year, when only 81 trout were counted. In 1999, ongoing changes were made to the trap design to reduce the error in upstream counts that likely occurred in 1997 and 1998. Therefore, total counts in 1999 are more accurate than the previous two years' data.

Bridge Creek fish trap. Bridge Creek was selected as a monitoring stream in an effort to develop a trap design that requires minimal maintenance for small backcountry streams. In addition to its close proximity to the field office, this stream also contains a large spawning run of Yellowstone cutthroat trout, and it is similar in size to streams that will be monitored in the future. Upstream and downstream migrating trout were counted as they passed through an electronic fish counter, but no trap facility was used. Upstream counts totaled 2,363 fish, and 1,463 trout were counted returning to the lake. The trap structure consisted of an electrical conduit that rarely clogged from drifting debris and experienced only minor problems from high water during spring snow melt. Due to its relatively low maintenance and ease in installation, this trap design will be used for monitoring isolated streams in the future.

LeHardy Rapids dip-netting. Since 1974, dip-netting at LeHardy Rapids has been used to sample the spawning population of Yellowstone cutthroat trout in the Yellowstone River to obtain information on spawner size, age, sex ratios, and growth rates. The Wyoming Game and Fish Department also captured fish at LeHardy for gamete collection to supplement a brood stock they have been developing for the past six years.

1999 sampling results.—Crews sampled spawning cutthroat trout each Monday from June 7 until July 19. Dip-netting was limited to pools along the edges of the rapids, where fish tend to congregate during the spawning run. Fish were placed in large tubs, anesthetized, measured to total length (mm) and weight (g), and visually identified to sex and stage of maturity. Scales were taken weekly from the first 20 mature fish captured to obtain length-specific stratified age and growth rates (10 fish samples of each sex in each 10-mm size class). Fish were marked with a caudal punch, revived, taken upstream of the rapids, and released.

A total of 289 mature cutthroat trout were netted at LeHardy Rapids. The largest sample (99 fish) was captured on June 21. Mature cutthroat averaged 396 mm in total length, slightly larger than the 25-year average of 392 mm. Males were larger than females.

Brood stock.—Brood fish were captured by dipnet each week from June 14 to July 8. Fish sex and stage of maturity were visually identified. Individuals likely to spawn within one week were transported to live cages and separated by sex. Fish not likely to spawn within a week were released. At the end of each sampling week, fish were paired, and one ounce of eggs was collected from each female and fertilized with a small amount of milt from the paired male. Non-lethal ovarian fluid samples were taken from each spawned female to test for Infectious Hematopoetic Necrosis Virus (IHNV). Once spawned, fish were measured (total length, mm), weighed (g), given an upper caudal fin clip, and released. In 1999, 108 pairs of fish spawned. All females tested negative for IHNV. Continued spawner monitoring and gamete collection is planned for the 2000 field season.

Lake Trout in Yellowstone Lake

For the past four years, the Aquatic Resources Center has devoted a majority of the summer field season to removing lake trout from Yellowstone Lake. Knowledge gained about the seasonal and vertical distribution of this large predator has been regularly applied to the park's adaptive management approach. Information gained from 1998 tagging studies and hydroacoustic surveys was used to select the most promising gillnetting locations in 1999. As no additional tracking or movement surveys were conducted in 1999, the lake trout program was dedicated solely to lake trout removal.

Gillnetting. By 1998, park fishery staff had refined gillnetting strategies to maximize the catch of two of the three life history phases of lake trout while minimizing the incidental catch of cutthroat trout. Current netting efforts are focused on non-predatory juvenile lake trout found at depths exceeding 50 m (150 ft), and on predatory lake trout >600 mm in total length (TL) that reside at intermediate depths (10–30 m) for much of the year but move into shallow water areas to spawn in the fall.

Gillnetting since 1995 has indicated that medium-size (400–600 mm TL) lake trout reside in shallow water where the cutthroat trout prey base is most abundant. Because the potential for incidental cutthroat trout catch is high in these areas, the park purposefully avoids setting gillnets to target this lake trout life history phase.

The use of more efficient netting techniques and longer gillnets resulted in an expanded netting effort in 1999. More than 1,600 units of netting effort captured 5,700 lake trout. As in 1998, most were juvenile fish caught in deep water in the West Thumb area, but nearly 1,000 spawning lake trout were captured in 1999. The low cutthroat-to-lake trout catch ratios observed in previous years continued (Table 1).

Table 1. Gillnetting effort (number of 100-m net-nights), number of lake trout caught, and cutthroat trout-to-lake trout catch ratio.

LAKE TROUT GILLNETTING PROGRAM

Year	Effort	Lake Trout Caught	Cutthroat: Lake Trout
1994	39	2	252:1
1995	250	153	6.6:1
1996	401	580	1.7:1
1997	538	863	2.5:1
1998	1,415	7,792	0.13:1
1999	1,626	5,748	0.08:1

Lake trout distribution and catch rate locations appear to have stabilized over the past four years. Between 1995 and 1998, the lake trout catch rate was strongly correlated with netting effort. However, the highest level of netting thus far yielded a reduced catch of lake trout when compared to the previous year, suggesting that the current netting effort has significantly slowed the rate of lake trout population expansion. Additional negative impacts to this population are suggested by data collected at Carrington Island, where the average length (and potential reproductive capacity) of spawning lake trout has decreased by about 100 mm between 1996 and 1999 (Figure 2).

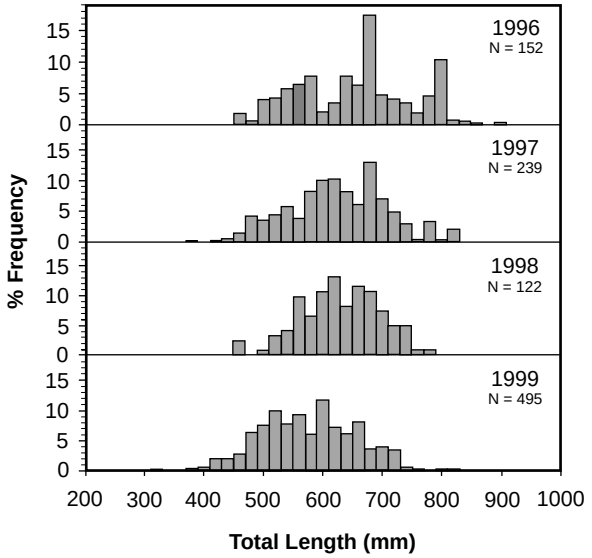


Figure 2. Length frequency of mature lake trout netted at Carrington Island, 1996–99.

Since 1995, more than 15,000 lake trout have been captured in Yellowstone Lake. Most have been captured in West Thumb and Breeze Channel, where most of the gillnetting has occurred. Current population-level impacts may be greatest on the larger size classes. In 1996, the estimated natural mortality rate of adult lake trout (>600 mm TL) was about 9 percent. The greatly expanded netting effort of the past several years has been accompanied by a nearly four-fold increase in the annual mortality rate of these larger fish. Bioenergetics modeling (estimates of how many cutthroat trout the lake trout could potentially eat) suggests that the lake trout removal program has saved about 750,000 cutthroat trout from predation by lake trout.

Angler removals. In 1999, the early lake trout angling season was again in effect, but anglers were not required to report their VAR postal survey catch cards to estimate the effectiveness of the extended season. Unlike the previous year, weather conditions were highly favorable for angling success, yet in 1999 the angler catch of lake trout was similar to that observed in 1998. Fewer than 100 lake trout were reported caught during the first two weeks of the season. Interviewed anglers indicated that they caught about 30 cutthroat trout for every lake trout captured. The annual total is estimated to be approximately 1,500 lake trout removed by anglers. Although small compared to the numbers captured by gillnetting, this represents the annual conservation of about 75,000 cutthroat trout. Equally important, most of the lake trout captured by anglers are the medium-size, shallow water residents that are not targeted by the gillnetting program.

Long-term prospects. The combination of intensive gillnetting in West Thumb and angler catches throughout the lake suggests that the NPS lake trout removal program is meeting the goal of preserving cutthroat trout in Yellowstone Lake. The following summary observations can be made:

- Gillnetting results since 1995 indicate that mature lake trout reside primarily in West Thumb, which has consistently yielded the highest catches of lake trout.
- All identified spawning areas are in the West Thumb/Breeze Channel area.
- Hydroacoustic assessments also indicated that most of the lake trout reside in West Thumb.

These short-term results suggest that the current capacity of Aquatic Resources Center staff to maintain this level of lake trout control is adequate. The above results must be interpreted with caution, however, because almost all the gillnetting effort has occurred in the West Thumb area. Telemetry studies in 1998 confirmed that although large adult lake trout reside mostly in

the West Thumb portion of Yellowstone Lake, they do move to many other areas of the lake. Late summer distribution gillnetting and angler reports suggest that medium size lake trout are widespread throughout much of the lake. These factors suggest that in the long-term, new spawning sites will be chosen and additional subpopulations established. As the abundance of either existing or newly established populations declines, a much higher level of netting effort will be required to sustain high lake trout mortality rates.

To address these long-term needs, the NPS has acquired new funding to obtain a commercial gillnetting boat and additional staff that will be solely dedicated to a greatly expanded netting effort throughout the lake. Design and boat construction phases are underway, and the additional control measures will be fully operational during the 2001 field season. This level of long-term commitment will greatly assist the NPS in meeting its responsibility to preserve the Yellowstone cutthroat trout in its native habitat.

Whirling Disease

After whirling disease *(Myxobolus cerebralis)* was confirmed in rainbow trout (*Oncorhynchus mykiss*) in the Madison River near Ennis, Montana, Yellowstone fishery biologists initiated a testing program for fish populations in the park. Between 1995 and 1998, young rainbow trout, Yellowstone cutthroat trout, brown trout *(Salmo trutta)*, and mountain whitefish *(Prosopium williamsoni)* captured during electrofishing surveys of several boundary area streams were examined for the presence of disease-causing spores. No evidence of infection or population declines attributable to the disease was found during these early surveys. In the fall of 1998, however, a small sample of cutthroat trout from Yellowstone Lake indicated the presence of whirling disease spores in approximately 10–25 percent of the fish. Length-age relationships suggested that the infected cutthroat trout were between two and five years old.

Since Yellowstone cutthroat trout and rainbow trout appear to have similar susceptibility to whirling disease, concern about the potential for whirling disease to significantly reduce the abundance of the Yellowstone Lake cutthroat trout increased considerably. Because this was the first verified occurrence of whirling disease in Yellowstone National Park (YNP), park managers had to develop new databases and management strategies. In addition to uncertainties about how, where, and when *M. cerebralis* was introduced into Yellowstone Lake, there is no information about the lakewide distribution of the parasite and its effects on individual cutthroat trout. To address this information gap, NPS aquatic resources personnel and the USFWS Bozeman Fish Health Lab initiated a preliminary whirling disease distribution study in 1999.

Because the initial verification of the parasite came from older cutthroat trout, two sources of larger cutthroat trout were used for the distribution study: various size and age classes captured during the fall cutthroat trout gillnet survey, and large cutthroat trout incidentally killed during the lake trout removal effort.

Whirling disease primarily affects the cartilage of young trout whose skeletal systems are not fully developed. The standard method for detecting the presence and severity of the parasite involves the use of "sentinel cages," in which young trout are placed in a stream cage and exposed for 10 days to two weeks under environmental conditions favorable to infection by the parasite. The exposed fish are then

Cutthroat trout fry are placed into a sentinel cage in a Yellowstone Lake tributary to test for whirling disease. NPS photo.

transferred to an isolation facility, where they are kept until they are six months of age, then sacrificed and examined for cranial parasite spores. In 1999, young-of-the-year cutthroat trout were placed in sentinel cages in 12 known cutthroat trout spawning tributaries of Yellowstone Lake (Figure 3). Additional sentinel testing occurred near Fishing Bridge (the primary spawning area immediately downstream of the lake outlet) and at Buffalo Ford.

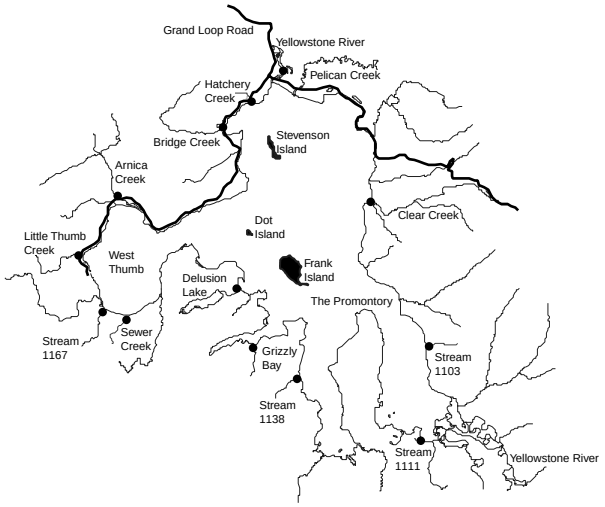


Figure 3. Whirling disease sentinel cage sites on tributaries of Yellowstone Lake, 1999.

The fall gillnetting survey revealed that 9 of 25 cutthroat trout from the Pelican Creek site were infected with *M. cerebralis.* The total length of positive fish ranged from 375 to 475 mm. In contrast, a sample of 25 similarly-sized cutthroat trout captured near Arnica Creek yielded no confirmed parasite infection. Some level of infection was confirmed at most of the 11 sample sites.

Incidental catch of cutthroat trout during the lake trout removal program is restricted to larger individuals. Because NPS fishery personnel intentionally minimize this incidental catch, most of the sample sizes are quite small and consist of larger cutthroat trout from a few restricted areas of the lake. Most of the cutthroat tested for the whirling disease parasite came from the West Thumb area of Yellowstone Lake, where the majority of the lake trout netting occurs. Since sample sizes were small, data for the entire summer were pooled. Fourteen of 75 cutthroat trout collected during 22 separate gillnet sets were confirmed positive, which represents an infection rate of slightly less than 20 percent. Most of the infected fish were older adults, a result similar to that of the fall cutthroat trout survey. No external signs of disease were apparent in any of the sampled cutthroat trout from either of the two netting surveys.

Sentinel cage exposure failed to detect the presence of whirling disease spores at any test site except the Fishing Bridge area. At that site, spores were found in only 7 of 50 young cutthroat. Disease severity was rated mild in all but one fish. Overall population disease severity was 0.2 percent on the MacConnell-Baldwin severity index scale (range of possible values 0–4.0). All of the exposed fry appeared normal prior to testing and after parasite exposure.

Although the information gained in 1999 has not adequately provided the answers required to make assessments or recommendations related to the Yellowstone Lake cutthroat trout population, preliminary observations can be summarized as follows:

- Many of the adult cutthroat trout throughout the lake have a mild incidence of whirling disease infection. These fish range from four to eight years old, suggesting that the parasite has been in the basin for a number of years.
- If the older infected fish identified in this study were parasitized as fry, it appears that some cutthroat trout in Yellowstone Lake are able to survive *M. cerebralis* infection without any obvious long-term effects.
- The failure to detect the parasite through sentinel cage tests may be indicative of less than optimum environmental conditions (particularly water temperature) for the infectious stage of the whirling disease parasite. Unlike the typical springtime infection observed in streams adjacent to the park, the peak period for infection in Yellowstone Lake may be in

the fall, similar to high elevation lakes in Colorado.

Continued monitoring of stream temperatures, ongoing examination of incidental catch from gillnetting surveys, and additional sentinel cage exposure studies in the next several years should provide considerable clarification related to these preliminary observations. This will enable park biologists to determine whether cutthroat trout fry in Yellowstone Lake may be less vulnerable to whirling disease because most have already migrated downstream into the lake by the time of peak parasite emergence. Continued examination of the distribution of *M. cerebralis* with a focus on parasite densities, age classes of fish affected, and protective habitat should assist the NPS in preserving this valuable native fish species.

Native Species Restoration

Beginning in 1997, the Aquatic Resources Center (ARC) renewed a program that focused on restoring westslope cutthroat trout *(Onchorhynchus clarki lewisi)*, a sub-species of cutthroat trout that historically occurred in upper Missouri River tributaries in the northwest region of Yellowstone National Park. That study has focused on the collection of non-lethal genetic samples (fin clips) from westslope cutthroat trout in streams of the Madison and Gallatin river drainages. This information would enable park biologists to more accurately describe the distribution of hybrid versus pure populations. Independent testing of samples from 1997 indicated that only one site, the North Fork of Fan Creek, contained a genetically pure westslope cutthroat trout population (Table 2). Four fish sampled in Fan Creek near the confluence of the Gallatin River were also found to be pure, although the small sample size prevented extrapolation of those results to fish throughout the entire stream.

In 1998, ARC expanded databases related to distribution and abundance of genetically pure westslope cutthroat trout in the park by performing a more extensive genetic survey of Fan Creek and its tributaries, and collecting information on abundance and life history strategies of westslope cutthroat trout in those streams. Genetic results from this recent survey also

Table 2. Genetic sample site, sample size, and percent hybridization of westslope cutthroat trout samples from Yellowstone National Park, 1997–98: N = number of samples analyzed from each site, WS=westslope cutthroat trout, YS=Yellowstone cutthroat trout, RB=rainbow trout.

Sample Year And Site	N	% WS	% WS x YS	% WS x RB	%WS x YS x RB	% RB
1997						
North Fork Specimen Creek	6	-	17	17	66	-
East Fork Specimen Creek	16	25	75	-	-	-
Grayling Creek	30	50	10	33	7	-
Fan Creek	4	100	-	-	-	-
North Fork Fan Creek	1	100	-	-	-	-
East Fork Fan Creek	33	76	15	6	3	-
1998						
East Fork Specimen Creek	23	39	61	-	-	-
North Fork Fan Creek	35	100	-	-	-	-
East Fork Fan Creek	31	81	16	3	-	-
Fan Creek Tributary	10	50	30	10	-	10
Fan Creek (WC3)	31	77	3	13	6	-
Grayling Creek	31	56	19	11	15	-
Cougar Creek	34	50	50	-	-	-
Cougar Creek	17	59	41	-	-	-
Stellaria Creek	16	88	6	6	-	-
Gneiss Creek	10	-	-	50	30	20

suggest that the North Fork of Fan Creek is the only stream in YNP that contains genetically pure westslope cutthroat trout. Cutthroat trout in Stellaria Creek and the East Fork of Fan Creek contained evidence of low-level hybridization with both Yellowstone cutthroat trout and rainbow trout. All other populations analyzed that year were hybridized substantially with both species.

Cutthroat trout were most numerous in the North Fork of Fan Creek, which had an estimated trout density of 380 fish per kilometer of stream, and trout abundance increased farther up into the headwater reaches. The East Fork of Fan Creek contained 200 trout per kilometer of stream, while Stellaria Creek yielded very few fish per 100 meters of stream sampled.

By examining the length and age structure of fish samples in individual streams, it can be inferred whether a population is resident in a particular stream. Cutthroat trout in the North Fork of Fan Creek averaged 3.9 inches (98 mm) in total length, and younger fish were more abundant there than in other Fan Creek tributaries. The examination of scales confirmed that trout collected from the North Fork of Fan Creek ranged from young-of-the-year to age three. Larger fish were found in other portions of the Fan Creek drainage, with individuals averaging 7.5 inches (191 mm) in the East Fork of Fan Creek and 7.0 inches (179 mm) in the Fan Creek mainstem.

Anecdotal information indicates that the age groups sampled in the North Fork of Fan Creek are perennial residents of that stream. Trout that were marked in 1998 were recaptured at or near their original marking locations in 1999. However, visual examination of these fish revealed no adults (pre- or post-spawners) in any sample. In contrast, post-spawning fish were clearly evident during surveys in Stellaria Creek the following week. Additional spawning surveys in the mainstem of Fan Creek in late June were inconclusive, although the presence of large fish compared to other sites indicated that these fish were probably mature.

Based on this limited life-history data, it appears that the only verified pure population of westslope cutthroat trout in the park may be fluvial fish that use other streams in the drainage for different periods of their life stage. Maturing fish may be dispersing downstream at some time during the year, then returning to their natal stream in spring to spawn. Current study needs that could be addressed with a combination of radio telemetry, tagging, and visual surveys include information on when these fish mature, and the specific location of spawning areas and juvenile and adult wintering habitats. This critical information will be needed to ensure that these pure cutthroat populations can be protected from non-native species threats (*e.g.*, hybridization) which would prevent park managers from using these verified pure populations as source fish for future restoration projects.

Canyon Creek. Beginning in 1997, ARC staff initiated a pilot study to restore westslope cutthroat trout to Canyon Creek by removing non-native trout with electrofishing gear and testing the effectiveness of an artificial barrier in preventing these trout from returning to the stream. Specific objectives were to capture as many fish as possible, but concentrate on mature age groups and limit new recruitment of young fish. The study also examined the overall efficiency of electrofishing as a tool to remove non-native trout that threaten future re-introduction efforts of westslope cutthroat trout in other park streams.

From July through September 1999, ARC staff removed 1,616 trout from Canyon Creek using electrofishing gear. Comparable efforts in 1998 yielded nearly 6,500 non-native trout. Multiple-pass depletion techniques indicated that an average of 94 percent of the estimated 1,156 trout in standardized stream sections were removed by electrofishing in 1999. From 1997 through 1999, our combined efforts have resulted in the removal of 13,109 brown trout, rainbow trout, and brook trout (*Salvelinus fontinalis)*.

In each year of this study, larger mature fish were more easily captured than juvenile fish. While many of the fish captured in 1997 and

1998 were young-of-the-year brown trout or rainbow trout, a proportionally smaller percentage of young fish were captured in 1999. In addition, although mature trout greater than 10 inches (254 mm) were captured in previous years, none were found in 1999. The predominant age group in the 1999 catch was one-year-old fish, those yearlings that were typically more difficult to capture the previous year. An estimated 98 percent of mature adults remaining in the stream at the end of 1998 were removed by electrofishing in 1999. The absence of numerous young-of-the-year trout further indicates our success in removing mature pre-spawning trout in previous years.

By releasing marked trout below the barrier and examining fish captured above, we were able to examine if the barrier was successful in preventing non-native trout from re-entering the study reach. Following improvements to the barrier in June 1998, no marked fish were located upstream during our removal efforts. In 1999 results were similar, in that none of the nearly 600 trout fin-clipped and released below the barrier in previous years were found upstream in the study reach. We now have two years of data indicating that the barrier is functioning properly, and that upstream immigration into the study reach from downstream sources is no longer likely.

Based on findings during 1999, electrofishing methods are removing more trout from Canyon Creek than previously suspected. The annual decrease in the total number of fish captured, particularly mature adults, combined with a reduced number of young-of-the-year trout indicates that we are decreasing the abundance of non-native fish populations while eliminating a significant proportion of future age groups. Continued electrofishing removal efforts in 2000 will likely provide additional information about the success of the study, allowing us to assess other removal methods, if needed, to complete project goals.

Reese Creek. Reese Creek is the northernmost tributary to the Yellowstone River within Yellowstone National Park, and the only stream

Reese Creek fish trap. NPS photo.

within the park in which water withdrawal by private landowners occurs. In 1932, the northern boundary of Yellowstone National Park was expanded to include the entire Reese Creek drainage. The purchase of the land, however, did not include water rights. Three diversions and a road culvert are located in the lower 2.0 km of the stream. Since 1984, park fisheries personnel have periodically monitored fish movement in Reese Creek from the upper diversion downstream to the mouth at the Yellowstone River. It was suspected that juvenile trout move into the diversion ditches and become isolated from the stream's main stem when water-taking reaches a peak during irrigation season.

In 1991, a minimum flow agreement was reached to help prevent complete dewatering of the stream, and self-cleaning fish screens were installed at the head of each diversion. That year, two Parshall flumes were installed to monitor streamflow volumes. The screens, however, did not function properly, and became clogged with debris. Objectives for 1999 were to: 1) install and monitor retrofitted solar powered self-cleaning fish screens, 2) monitor spawning activity and fry emergence, and 3) monitor effectiveness of fish passageways.

Reese Creek was electrofished on 11 occasions in 1999. The study area was divided into six different reaches extending upstream from the mouth to the third diversion. The diversion

ditches were surveyed, but fish captured in diversion ditches were not counted in the section in which the diversion occurred. Captured fish were measured to total length (mm), weighed (g), and visually identified to species, sex, and stage of maturity. Fish from each section were given a different fin clip in order to monitor movement throughout the stream and released.

Five species of fish and cutthroat/rainbow trout hybrids were collected during electrofishing surveys. Cutthroat/rainbow trout hybrids were the most abundant fish captured (42%), followed by mottled sculpin (*Cottus bairdi)* (28%), brown trout (13%), rainbow trout (12%), Yellowstone cutthroat trout (3%), and brook trout (2%). Marked trout were collected both upstream and downstream from the section in which they were initially captured. Sculpin, however, were absent above a small cascade at the end of section 1, suggesting that they were unable to ascend the cascade. Unidentified trout fry were collected throughout the sampling season. Peak fry capture occurred on August 20, and correlated with peak creek temperature.

Fish passageways worked effectively and allowed fish to move both upstream and downstream. The self-cleaning fish screens appeared to function as intended, as only one fry was captured in a diversion and no interruption in flow to the irrigation ditches was detected.

Firehole River. In 1999, Wyoming Game and Fish Department personnel continued to work with the Aquatic Resources Center to collect rainbow trout from the Firehole River. The ongoing project objective has been to obtain adult and subadult rainbow trout over a five-year period to establish a brood stock. Individuals produced by this brood stock will be used to stock waters not managed for endemic species within the state of Wyoming.

The three collection sections were located between Midway Geyser Basin and Firehole Cascades. Sampling from a 12-foot raft fitted with electrofishing gear occurred on May 20 and October 12 and 13. A second raft was used to transport selected fish to a tank truck. Rainbow trout were measured to total length (mm), weighed (g), and transferred to the tank truck, released, or sacrificed for disease testing. A large range of size classes were kept to ensure multiple year classes would be included in the brood stock. All other species captured were measured, weighed, and released or used for disease testing.

A non-native invasive species, the New Zealand mudsnail (*Potamopyrgus antipodarum*) has been found in several areas in the Firehole River. In order to help prevent the spread of this species, all equipment was sprayed with a bleach solution and allowed to dry overnight before being moved to another section of river. In addition, because these snails can pass through the digestive system of fish alive, all fish taken for brood stock were isolated in holding tanks until such a time as biologists were certain that all snails were passed through the fish digestive systems.

Rainbow trout and brown trout were the only species collected in the sample sections. In three days of sampling, 524 rainbow trout were captured, ranging from 76 to 382 mm in total length and were most abundant downstream from the Lower Geyser Basin. Of these fish, 300 (ranging from 178 to 382 mm in total length) were kept for brood stock, 51 were sacrificed for disease testing, and the remaining fish were released. Since 1997, a total of 766 rainbow trout have been taken from the Firehole River for brood stock development.

An additional 420 brown trout were captured, of which 63 were used for disease testing. Total length of brown trout ranged from 105 to 419 mm. They were most abundant upstream from the Lower Geyser Basin. Disease testing showed fish to be pathogen-free at a 95 percent confidence level.

BEARS

Yellowstone National Park protects and maintains populations of grizzly bears (*Ursus arctos*) and black bears (*Ursus americanus*) as part of the park's native fauna. The Interpretation, Maintenance, Resource Management

Operations and Visitor Protection, and Yellowstone Center for Resources divisions each have staff who contribute to management efforts designed to reduce or prevent the chances of bear-inflicted human injuries, bear-caused property damages, and human-caused bear mortalities. To be successful, bear management must be a parkwide, multi-divisional effort.

The Bear Management Office (BMO) coordinates the implementation of the park's Bear Management Plan and records data related to bear management activities in the park. Yellowstone is a member of the Interagency Grizzly Bear Study Team (IGBST), and staff assist with research on bear food habits, habitat use, behavior, and population dynamics. BMO personnel also assist with ecosystem-wide grizzly bear policy recommendations designed to ensure scientifically-based resource decisions. In addition, the BMO is responsible for the oversight of nuisance wildlife management and for wildlife disease, wildlife DNA, and rare mammal monitoring. In 1999, the BMO consisted of one permanent biologist, one term technician, one seasonal technician, and two summer seasonal volunteers. BMO staff produce a detailed report on grizzly bear monitoring and management, copies of which may be obtained by contacting the YCR or visiting the park's web site at *www.nps.gov/yell/nature/bears*.

Population Monitoring

Bear sightings. There were 1,537 bear sighting reports recorded in YNP in 1999, including 787 observations of grizzly bears, 352 of black bears, and 49 of unidentified bear species. In addition, there were 227 reported observations of grizzly bear sign, 68 of black bear sign, and 54 of sign from unidentified bear species. The first recorded grizzly bear activity of the year was on March 4, when two different sets of tracks were observed, one near Turbid Lake and the other west of Cottonwood Creek along the Yellowstone River. The first recorded black bear activity was on March 22, when a cross-country skier observed tracks in front of the Bechler Ranger Station. The last recorded black bear activity was a track observation on November 21 in the Hoodoos south of Mammoth Hot Springs. The last recorded grizzly bear activity was a track observation along the road at the west end of Lamar Valley on November 20, 1999.

Grizzly bear scat containing whitebark pine. NPS photo.

Grizzly females with cubs. As part of grizzly bear population monitoring in the ecosystem, the IGBST counts the number of adult female grizzly bears with cubs-of-the-year (COY) each year because adult female grizzly bears with COY are the most reliable segment of the population to count. The smaller average home range sizes of females with cubs, as well as the number of cubs per litter and pelage-color combinations of different family groups, aid in identifying individual adult females. Adult female grizzly bears in the Yellowstone ecosystem generally have a three-year breeding interval. Thus, the number of different females with COY counted over a three-year period gives an estimate of the number of adult females in the population.

In the GYA, 33 females with 63 COY were counted in 1999. Of those, 15 females with 26 COY were observed in the park. The average litter size in the park was 1.7 cubs per litter, with 5 one-cub litters, 6 two-cub litters, and 3 three-cub litters.

Observation flights. As part of the IGBST grizzly bear population monitoring program, BMO staff conducted two series of observation flights in the Lamar, Pelican/Clear Creek, Two Ocean Plateau, Washburn, and Firehole/Hayden bear management units. During the first series

of flights (16.1 observation hours), 17 grizzly bears were observed in 10 groups. The mean group size was 1.7 bears/group. None of the observed grizzly bears were radio-marked. No black bears were observed during the first round of observation flights. The signals of five radio-collared bears were determined to be in the survey units, however none of these bears were observed. During the second series of observation flights (14.2 observation hours), 12 grizzly bears were observed in eight groups. Mean group size was 1.5 bears/group. One of these grizzly bears was a radio-marked sow with a single, unmarked COY. The signals of six additional radio-collared grizzly bears were determined to be in the survey units, but they were not observed. There were two black bears observed during the second series of flights. The low number of marked groups of bears (5.6%) observed during the flights suggests that either collared bears avoid detection from overhead flights or that only a small proportion of the bears in the park are radio-marked. The IGBST plans to use this data along with observation flight data collected from outside of the park to calculate a capture-mark-recapture population estimate for grizzly bears in the Yellowstone ecosystem.

Bear mortalities. There were two known grizzly bear mortalities and one known black bear mortality within YNP in 1999. One of the grizzly bear mortalities was due to natural factors (interspecific predation by a larger grizzly bear) and one was a management removal (sent to a zoo). The black bear mortality was caused by a bear-vehicle collision. The one human-caused grizzly bear mortality in 1999 was approximately equal to the 10-year average of 0.7 (± 1.1 SD) human-caused grizzly bear mortalities per year from 1989–98. The one human-caused black bear mortality level was also approximately equal to the 10-year average of 1.1 (± 1.0 SD) human-caused black bear mortalities per year from 1989–98.

On June 11, Grant area personnel responded to a reported bear-jam just south of the fire exhibit in the Lewis River Canyon. Upon their arrival, the rangers saw no bear, but 150 yards off the road they found the carcass of a female grizzly bear cub-of-the-year on which another bear had been scavenging. The carcass was collected and sent to the Montana Department of Fish, Wildlife and Parks' (MDFWP) laboratory in Bozeman, Montana, for necropsy. Most of the cub's carcass had been consumed, but the necropsy indicated that the trauma to the cub had occurred prior to death. The skull was crushed and contained several large puncture wounds. The injuries were consistent with predation by a larger bear.

On August 22, a 180-pound subadult male grizzly that had damaged six tents was captured adjacent to Indian Creek campground. The bear stepped on, tore, and crushed a decoy tent placed near the trap and was caught. DNA extracted from hair collected from the captured bear matched DNA from hair collected from a tent damaged at a nearby backcountry campsite. Dr. Lisette Waits at the University of Idaho calculated that the chance of a DNA match to any other grizzly bear in the park was approximately one in 20,597. The bear was deemed a danger to public safety and not suitable for release back into the wild. Under a special permit from the U.S. Fish and Wildlife Service, the bear was held at the Grizzly Discovery Center in West Yellowstone until park staff could find a suitable zoological institution to house the bear. On September 27, the young bear was shipped to the Wildlife Way-Station, a private, non-profit sanctuary for injured, neglected, and homeless wild animals in Sylmar, California.

On July 11, Old Faithful rangers responded to a report of a dead black bear along the road near the Firehole picnic area. The carcass of an approximately 250-pound, adult male black bear was transferred to the MDFWP lab for necropsy. An unknown vehicle had struck the bear, which was estimated to be 15+ years old. The bear had a broken right femur, evidence of blunt trauma, internal bleeding and bruising, and shredded claws indicative of a bear gripping the pavement upon impact with a vehicle.

Availability of Bear Foods

In the Yellowstone ecosystem, 1999 was a year of average to above-average abundance of most high-quality bear foods. Whitebark pine cone production, as measured at transect sites, was significantly above average. The winter of 1998–99 was considered to be a fairly normal, mild one in the Madison-Firehole valley and on upper and lower northern winter ranges. Despite the mild weather, the number of winter-killed elk (*Cervus elaphus*) and bison (*Bison bison*) carcasses counted on transect sites was higher than the long-term average recorded from 1992–98.

During early to mid-spring, scavenging on ungulate carcasses was the most commonly observed grizzly bear feeding activity. Grizzly bears also dug up pocket gopher (*Thomomys talpoides*) caches in localized areas where they were particularly abundant. Elk calves, an important late spring and early summer food source, were preyed upon extensively by some individual bears. The numbers of spawning cutthroat trout counted in Yellowstone Lake tributaries were similar to the long-term averages (1989–98) on most streams, except for those in the West Thumb area, which were below average. Spawning cutthroat trout, available to bears with home ranges adjacent to Yellowstone Lake during the late spring and early summer, rank as one of the highest sources of net digestible energy available to bears in the Yellowstone ecosystem. Throughout the summer, grizzly bears grazed clover (*Trifolium* spp.) and dug up yampa roots (*Perideridia gairdneri*) in localized areas where these foods were abundant.

Army cutworm moths, an important bear food in late summer and fall, were present and attracted large numbers of bears to high-elevation moth aggregation sites on the eastern side of the ecosystem. The production of whitebark pine (*Pinus albicaulis*) cones, as measured at transect sites, was above average in most areas of the ecosystem. The one exception was the Pitchstone Plateau area, where few cones were observed. Excavation of red squirrel (*Tamiasciurus hudsonicus*) middens for whitebark pine seeds was the most frequently observed fall grizzly bear feeding activity. In some areas, biologists also found evidence that grizzly bears had climbed up into whitebark pine trees and broken off branches to obtain cones. Whitebark pine seeds are an important fall food because of their high fat content and their potential abundance as a pre-hibernation food source. During October, localized areas where grizzly bears had dug up pocket gopher caches were again evident.

Army cutworm moth survey, September 1999. NPS photo.

Grizzly Bear Food Sources

Ungulates (mostly elk and bison), cutthroat trout, and whitebark pine nuts are three of the highest sources of net digestible energy available to grizzly bears in Yellowstone. Due to the importance of these foods to bears, YNP staff monitor the annual availability of these resources within the park.

Winter-killed ungulate carcasses. Greater Yellowstone is unique among North America's areas of occupied bear habitat because of the substantial use grizzly bears make of ungulates during the spring. On average, approximately 79 percent of the energy obtained by adult male grizzlies and 45 percent of the energy obtained by adult female grizzlies in the Yellowstone ecosystem are estimated to come from meat. In contrast, more than 95 percent of the energy obtained by both adult male and female grizzly bears in Glacier National Park comes from vegetation. Ungulates rank as the second highest

source of net digestible energy available to grizzly bears in the GYA. Ungulates are also important because they provide a high-quality food source during early spring, before most vegetal foods become available to bears.

Grizzly bears feed on ungulates primarily as carrion from March through May. Between early April and mid-May each year, park staff survey 28 routes covering 82.5 km of winter range in the Firehole River drainage, 17 km in the Norris Geyser Basin, 32 km in the Heart Lake area, and 233.5 km on the northern winter range for winter-killed ungulate carcasses. Teams of at least two people snowshoe, ski, or hike survey routes and record the location, species, sex, and age class of ungulate carcasses found; bears and bear sign (tracks, scat, feeding sign) observed from the survey routes; and evidence of scavenging or predation by grizzly bears, black bears, and other carnivores. In 1999, 13 bison carcasses and 41 elk carcasses were documented along the 365.0 km of survey routes completed. The overall rate of one ungulate carcass observed per 2.5 km of survey route in thermally influenced ungulate winter ranges (Firehole thermal area, Norris Geyser Basin, and Heart Lake area) was greater than the long-term average of one large mammal carcass observed per 6.4 km of survey route recorded from 1992–98. The northern winter range carcass surveys have been conducted under the current format for only three years; therefore, a long-term average has not yet been established.

Counting whitebark pine cones on a transect survey, September 1999. NPS photo.

Cutthroat trout spawning. Grizzly bears are known to prey on cutthroat trout in at least 36 different streams tributary to Yellowstone Lake. In 1987, Reinhart and Mattson (1990) estimated that approximately 44 different autonomous bears were making use of spawning streams around Yellowstone Lake. Beginning May 1 each year, eight streams in or near the Lake developed area and four streams in the Grant Village area are checked daily to detect the presence of adult cutthroat trout. At the onset of spawning until most adult fish return to the lake, teams of two persons do weekly visual counts of adult trout to estimate peak periods and relative magnitude of spawning runs. While making fish counts, observers record bear sign (bear sightings, fish parts, hair, scats, and tracks). Tracks and track measurements are used to determine the number, species, and association of family groups of bears. In 1999, a total of 806 spawning cutthroat trout was counted during the peak week in the 12 monitored frontcountry tributaries to Yellowstone Lake. Grizzly bear activity was observed on nine of these streams and black bear activity on three. The numbers of spawners counted during the peak week were similar to the long-term averages (1989–98), except for streams in the West Thumb area, which were below average.

Whitebark pine seeds. During years with low availability of natural bear foods, especially

in the fall, bears often seek alternate foods in association with human activities; both the number of bear-human conflicts and human-caused bear mortalities increase during the fall season. As part of an ecosystem-wide whitebark pine survey, cone counts are conducted at 19 transects located within the ecosystem. Park staff conduct cone counts on the 10 transects located within Yellowstone. Cone counts at these 10 transects averaged 43 (± 60 SD) cones per tree in 1999. This was greater than the long-term (1987–98) average of 12 (± 29 SD) cones per tree per year for all transects located within the park.

Confrontations and Conflicts with Humans

Confrontations. In 1999, there were 78 reported incidents of bear-human confrontations (incidents of actual or perceived aggression in which no one was hurt) in the park. Grizzly bears were involved in 52 of these confrontations and black bears were involved in 19. The species of bear could not be determined in seven confrontations.

Bear-inflicted human injuries. There were two grizzly bear-inflicted human injuries in YNP in 1999, and no injuries inflicted by black bears or unidentified bears. The number of grizzly bear-caused human injuries was greater than the 10-year average of 0.8 (± 1.2 SD) human injuries recorded per year from 1989–98. The number of human injuries inflicted by black bears or unidentified species of bears was approximately equal to the 10-year averages (0.1± 0.3 SD and 0 per year, respectively) recorded from 1989–98.

On August 27, a woman from New York and a man from Switzerland were day-hiking on the Black Butte trail towards Bighorn Peak. Approximately 3.5 miles from the trailhead they had a surprise encounter with an adult female grizzly and two yearlings. The hikers had been chatting but not making, as they described, "enough noise." They suddenly heard what they described as a drawn-out moan. Unsure what it was, they took another step or two and then saw a bear less than 10 yards away. The woman did not initially see the cubs; instantly, while saying "It's a bear," she stepped off the trail and dropped into a ball. The bear charged to her. The woman could feel the bear's breath on her ear and back when the bear huffed a couple of times, but the bear did not touch her. The man stepped off the trail as the sow ran past at the woman. He was then approached by two yearling cubs that did not touch him. The man deployed pepper spray at the yearling cubs but was unsure if he actually hit them. The female bear turned away from the woman and charged toward him. He continued to spray and fell onto his back; the bear did not make contact. The hiker, thinking the bear was going to attack him, put one leg up. The adult bear swatted his leg, inflicting two gashes and two shallower scratches. The adult bear sniffed at the cloud of pepper spray, ran off, then returned again. Both hikers remained very still on the ground. All three bears left the area, and the hikers returned to the trailhead, where a passerby gave them hydrogen peroxide to wash their wounds. The hikers then drove themselves to Bozeman and received medical attention. The wounds, although not serious, were monitored for infection. The incident was reported to park staff a couple of days later, and bear warnings were posted on the trail.

On September 22, a male backpacker hiking alone encountered an adult female grizzly bear and two yearlings on the Black Butte trail, approximately 4.1 miles from the trailhead. The hiker heard a branch snap, looked up, and observed a bear running through the trees in his direction; the two other bears were nearby. The man dropped to the ground in an effort to protect himself against injury. The sow ran straight to his head and bit him at least twice before moving down his unprotected lower right side where she bit him again, causing a deep laceration. At first the man attempted to "play dead," but stated that after the bear had his head in her mouth he changed strategies and fought back. He tried to deploy his pepper spray but was unable to get the safety off. As the attack continued, the man's bear spray was knocked from his grasp, and his

backpack was torn from him. Twice the bear left, but when the man stood up the bear returned and attacked again. After the attack ended and the bear finally left, the man hiked to the trailhead and flagged down a passing motorist. Park rangers responded, treated the man's injuries, and had him flown by helicopter to Eastern Idaho Regional Medical Center, where he was treated. BMO and ranger personnel checked all trails in the area by helicopter and evacuated all other hikers, posted closure signs on all nearby trails, and retrieved the man's backpack and personal belongings. Whitebark pine middens as well as bear scats containing whitebark pine seeds were found at the incident site. The Black Butte trail and adjacent trails were closed for several weeks following the incident. These trails were not reopened until late in the fall.

Bear-caused property damages. There were seven reported incidents in which bears damaged property but did not obtain human foods in YNP in 1999. All incidents involved grizzly bears. The number of incidents of grizzly bear-caused property damage was significantly greater than the 10-year average of 1.2 (± 1.2 SD) per year reported from 1989–98. The number of incidents caused by black bears or bears of unidentified species was lower than the average (1.7± 0.9 SD and 1.7± 1.8 SD) reported from 1989–98. Incidents in 1999 included a bear that bit the bumper of a truck, breaking a tooth; several instances in which a bear damaged campers' tents in Indian Creek Campground or nearby backcountry campsites (*see "Bear mortalities," above)*; and an animal that bit and tore the vinyl spare tire cover off of a GMC Jimmy 4x4 parked in the driveway of a park residence near Stephens Creek.

Obtaining human foods. There were four incidents in which bears obtained human foods or garbage in the park in 1999. Three incidents involved grizzly bears and one involved a black bear. The number of incidents of grizzly bears obtaining human foods was greater than the 10-year average of 1.8 (± 1.5 SD) per year from 1989–98. The one incident of black bears obtaining human foods was lower than the 10-year average of 2.5 (± 2.4 SD) from 1989–98; the 10-year average of unidentified species of bear is 0.6 (± 0.8 SD) incidents. Specific incidents included cases in which park visitors illegally threw food to bears, and several in which people left food or garbage unsecured or unattended. In one case, a contractor working on the reconstruction of the East Entrance Road was given a warning concerning improper garbage storage. The contractor had attended a "Living and Working in Bear Country" orientation session prior to beginning work in the park.

Bear Management Actions

In 1999, there were 201 bear-related incidents in Yellowstone in which management action was taken, including:

- 154 incidents in which park rangers responded to roadside bear-jams to ensure the safety of park visitors and bears;
- 20 postings of bear warnings at campsites, trails, or other areas;
- 12 temporary closures at campsites, trails, or other areas;
- 2 incidents in which bears were trapped in management actions in developed areas; and
- 13 incidents in which bears were hazed by methods such as clapping, yelling, or firing 12-gauge "cracker" rounds.

Most bear management actions occurred in the Tower (36%), Mammoth (22%), Lake (11%), and Grant (10%) subdistricts.

Grizzly bear management captures/removals. Two grizzly bears were captured in management actions within YNP, compared to the 10-year average of 1.3 (± 1.5 SD) nuisance grizzly bears captured from 1989–98. One was translocated to another area of the park, and one was removed from the population and sent to a zoo (*see "Bear mortalities," above*). A third capture involved a non-target bear that was released on site. All the capture efforts that were related to bear-caused property damage occurred in the Indian Creek Campground area in July and August. The one nuisance grizzly bear removed

from the ecosystem compares to a 10-year average of 0.2 (± 0.4 SD) grizzly bears captured and removed each year from 1989–98.

Grizzly bears trapped outside of and relocated into YNP. To reduce bear-human conflicts and promote grizzly bear conservation in the ecosystem, the park sometimes accepts bears involved in conflicts in the states of Wyoming, Montana, and Idaho for translocation into the park. Four grizzly bears were translocated into the park in 1999. In May, a sub-adult female who killed sheep along the South Fork of the Shoshone River was released in the Dunraven Pass area, but left the park during summer and denned on the Shoshone National Forest. A sub-adult male who killed two calves along the South Fork of the Shoshone River in June was released in north-central Yellowstone; he was located in the Hayden Valley area in the autumn, kept moving south, and probably denned on the Bridger-Teton National Forest. In August, a young adult male was captured during a research study in an area experiencing cattle depredations near Union Pass, Wyoming. The bear was released in the Blacktail Plateau area and denned north of the park. A 500-pound adult male caught preying upon sheep in the Targhee National Forest in September was released on the Mirror Plateau and, in early November, was still within the park. None of the bears translocated into the park was known to be involved in further bear-human conflicts for the remainder of the year.

Black bear management captures/removals. There were no black bears captured or removed in management actions within YNP in 1999, compared to a 10-year average of 0.8 (± 1.3 SD) nuisance black bears captured and 0.2 (± 0.4 SD) removed each year from 1989–98. The park did not accept any nuisance black bears from state agencies for relocation into the park in 1999.

Improving food storage. Each summer, visitors spend more than 650,000 use nights camping in developed areas within YNP, and many park campgrounds are located within or adjacent to high-quality bear habitat. This has led to bear-human conflicts in the past. To reduce the chance of bear-human conflicts within campgrounds, park staff have installed bear-proof food-storage boxes in the hiker/biker loops of park campgrounds, because these visitors generally are not traveling with a vehicle in which to store their food. However, the number of bear-proof food storage boxes is not sufficient to accommodate large tour groups. In recent years, two different grizzly bears have obtained human foods from bike tour groups in park campgrounds. Bears that obtain human foods from campgrounds are especially dangerous because they often become aggressive and may damage property, injure people, and eventually have to be removed from the population.

The BMO obtained funding for the purchase of 39 bear-proof storage boxes through an NRPP grant in 1997. The Anaconda Job Corps constructed food storage boxes in 1998. Thirty-

The Indian Creek tent-crushing grizzly bear. NPS photo.

one food storage boxes were installed in 1999: 12 at Norris Campground, 6 at Slough Creek Campground, 5 at Tower Falls Campground, 4 at the Madison government housing area for use by residents to store personal grills, 2 at Pebble Creek Campground, and 1 each at Mammoth and Indian Creek campgrounds. The remaining food storage boxes will be installed in the spring of 2000.

Technical Assistance and Outreach

The bear biologist and his technicians provided data, advice, management recommendations, and technical support to 50 state and federal agencies, universities, media representatives, and private groups in 1999 on topics such as bear-human conflict management, safety in bear country, and bear ecology. Requests varied from news organizations, such as NBC News and *Outside* and *Backpacker* magazines, to other national parks, forests, and neighboring state wildlife managers.

Park managers recognize that visitor education is a key component in implementing the park's bear management program. The long-term survival of bears in the Yellowstone ecosystem depends on park visitors and surrounding communities understanding bears and bear management practices. To meet this goal, BMO staff presented 39 bear-related educational talks and slide shows to various groups in 1999. Other YCR and interpretive staff gave additional programs.

BIRDS

Threatened and Endangered Species

Bald eagle. In 1995, the U.S. Fish and Wildlife Service downlisted the bald eagle from endangered to threatened due to the significant population gains made over the last three decades. Certain specific populations, however, are not completely recovered due to heavy metal contamination problems in the Great Lakes region, and habitat encroachment and development problems associated with riparian zones in the desert southwest.

Within the park, a total of 14 eaglets fledged from 26 active nests during 1999. Nest substrate instability, a result of the 1988 wildfires, caused minimal problems for nesting pairs; however, in following decades we expect large numbers of trees to topple to the ground. This will undoubtedly result in nest failure, loss of nest sites, and sudden changes in the locations of nesting territories. It has occasionally been documented that bald eagles will take over previously occupied osprey nests, and the incidence of takeover appears to be increasing due to the competition for nest sites. In 1999 alone, two previously known osprey nest sites were occupied by bald eagles.

The mid-winter bald eagle survey was conducted for the thirteenth consecutive year in the park and on portions of the northern range outside of the park. A total of 25 eagles were counted on January 8, 1999. Of the total, 22 were identified as bald eagles and 3 as golden eagles. The northern range outside of Yellowstone continues to be a hot spot for wintering eagles, possibly in relation to carrion availability from the regular- and late-season elk reduction hunts. Weather continues to play a major role in eagle distribution, as does prey and carrion availability.

Peregrine falcon. On August 26, 1999, the peregrine falcon was "delisted," or removed, from the list of threatened and endangered species. However, provisions afforded by the Endangered Species Act require that it be monitored closely for the next five years to ensure its recovery. (See *"Other Species of Special Interest,"* below.)

Whooping crane. The whooping crane is currently classified as an endangered species. This endemic North American species continues to be the rarest and most endangered crane in the world. Population figures as of December 1999 placed the wild population at 252, and the captive population at 132, for a total world population of 384 cranes.

A cross-fostering experiment to create a new migratory flock of whooping cranes began in the Rocky Mountains in 1975. Under the

direction of the U.S. Fish and Wildlife Service, researcher Rod Drewien transported whooping crane eggs from Wood Buffalo National Park in Alberta, Canada, and placed them under incubating sandhill cranes on Gray's Lake National Wildlife Refuge in Idaho. The main focus of the cross-fostering experiment was to have sandhill crane adults hatch and raise whooping crane young. The hope was that the sandhill cranes would lead immature whooping cranes on migration to a sandhill crane winter safehaven at Bosque del Apache National Wildlife Refuge in New Mexico.

Initially, the cross-fostering experiment showed promising signs, but eventually problems developed. Of particular concern were high crane mortality and whooping crane mating behavioral problems associated with the experiment. However, a significant amount of valuable information was gained as a result of this study. In summary, 289 eggs were removed from the wild for this experiment, which resulted in the Rocky Mountain whooping crane population reaching a peak of 35 subadults and adults in 1985.

Whooping crane. Photo by Terry McEneaney.

As of 1999, only two adults had survived from the original Gray's Lake experiment, and they resided within the GYA. These birds were not paired. One bird has resided in a remote area of YNP for years, and the other frequents the Centennial Valley of Montana. In addition, the YNP bird biologist has been monitoring a sandhill-whooper hybrid since its discovery in 1992. The bird was frequently seen with a sandhill crane and carefully monitored. This bird has significant scientific value, since it could allow us an opportunity to see whether it can reproduce successfully in the wild. This important piece of information could assist whooping crane recovery efforts in the future. Unfortunately, this hybrid crane could not be located during the 1999 field season and is presumed dead.

Another whooping crane experiment occurred in the Rocky Mountains in 1997–98. Four young whooping cranes raised in captivity at Patuxent Wildlife Research Center in Maryland were transported to a ranch in eastern Idaho as part of an experiment to learn how to establish a new migratory flock of whooping cranes in North America. The birds were trained to follow an ultralight aircraft.

In the autumn of 1997, these cranes traveled from eastern Idaho to the Bosque del Apache National Wildlife Refuge in New Mexico following the aircraft. Two of the cranes were killed by predators on the wintering grounds. The two remaining "ultralight" cranes began their spring travels north on March 5, 1998, staging for a month in the San Luis Valley of Colorado. Once moving again, the birds had problems with fences and powerlines. (Collisions with wires continue to be the greatest cause of mortality for immature whooping cranes.) These cranes were quickly recaptured and released into a presumably safer environment in Yellowstone.

In May 1998, these two ultralight whooping cranes were released in the Slough Creek area of the park. This area proved to be troublesome.

Visitors came in close contact with the birds, creating imprinting problems. Later that summer, an effort was made to recapture the cranes, but only one was caught. This bird was transported to a remote area of the park. The other crane remained in the vicinity of Slough Creek until it migrated out of the area that fall. Both birds returned to the wintering grounds. In the spring of 1999, one of these birds died in northern Utah of causes yet to be determined, leaving a lone survivor residing in eastern Idaho for the summer.

The prognosis for whooping cranes in the GYA is not promising, and they may disappear from the area in the near future. The Whooping Crane Recovery Team met in Wisconsin on September 22, 1999. The ornithologist presented an update on the status of whooping cranes in YNP and the GYA. The recovery team has de-emphasized efforts to establish this species in the GYA in the immediate future, citing mortality, disease, habitat, pair-bonding, imprinting, and state support issues, to name a few. The team recommended the Wisconsin-Florida corridor as the best experimental site for establishing a migratory flock of whooping cranes.

Other Species of Special Interest

Peregrine falcon. The peregrine falcon has been removed from the list of endangered species and is now managed as a species of special concern. The park continues to be a stronghold for peregrines in the Northern Rockies. A new eyrie was found in 1999, bringing the total number of eyries to 14. In spite of unusually cold and wet weather conditions in the spring and early summer, which typically result in the loss of young, 19 young fledged (Figure 4).

Monitoring peregrine eyries is a time-consuming task, involving a minimum of three visits to each eyrie per year. Beginning in 2000, a minimum of one-third of all known eyries in the park are expected to be checked each year, thus completing a full parkwide production survey every three years. This will allow the park ornithologist time to check additional cliff faces for new eyries as well.

The park works closely with two peregrine falcon working groups (Montana and Wyoming), with which it has been an active participant since peregrines were found in the GYA. Yellowstone also works closely with the Peregrine Fund, which hosted a victory celebration in Boise, Idaho, on August 26, 1999, when the peregrine was officially delisted.

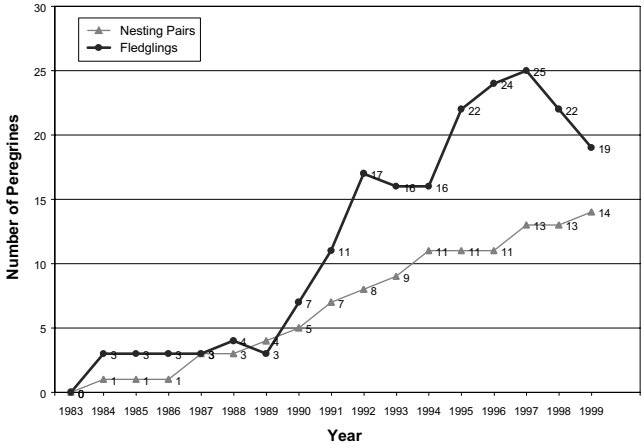


Figure 4. Peregrine falcon productivity.

Trumpeter swan. The YNP resident trumpeter swan population continues to show signs of a population at risk. Traditionally, the Centennial Valley of Montana has been a hot spot for cygnet production in the GYA. However, events over the last several years have led to a reduction in breeding swans and fledged cygnets. The number of adult swans in YNP has declined over the years and currently stands at 20 individuals. In recent years, trumpeter swan nest attempts have ranged from four to 10 per year. There were only six nest attempts in 1999, compared with nine in 1998.

A Greater Yellowstone Trumpeter Swan Working Group was organized in 1997, and YNP's staff ornithologist chairs the group. Annual population and production data for GYA trumpeter swans are collected, and management activities are communicated between agencies at these meetings. A meeting took place in YNP in the fall of 1999, with more than 30 members in attendance.

Paradise Valley trumpeter swan flock.— Yellowstone began to participate in trumpeter

swan conservation issues in Paradise Valley (north of the park) due to the potential threat posed by exotic mute swans. In the 1960s, a private landowner purchased a pair of mute swans for aesthetic purposes. By the late 1970s, the mute swan population had grown to a high of 120 individuals. Fearing potential competition with native trumpeter swans in YNP, the NPS became involved in a program to reverse this threat. In 1987, YNP staff presented a slide program to Paradise Valley landowners who showed an interest in helping resident trumpeter swans. An informal agreement was reached indicating the importance of eliminating mute swans immediately and replacing them with captive-raised trumpeter swans. The biggest obstacle was finding private funding to pay for the program, particularly since the purchase of captive trumpeter swans can be very expensive. Generous support from the Cinnabar Foundation and the Chevron Corporation, in addition to contributions from private citizens, allowed this program to proceed on schedule.

One of only 20 resident adult trumpeter swans found in the park in 1999. Photo by Terry McEneaney.

The staff ornithologist, with the help of landowners and park rangers, began to eliminate the first mute swans in the fall of 1987. By 1989, the mute swan population was reduced to 13 individuals, and trumpeter swans were introduced into Paradise Valley. In 1991, trumpeter swans outnumbered mute swans nine to two in Paradise Valley. By the mid-1990s, mute swans were eliminated from Paradise Valley altogether.

Throughout the years, the Paradise Valley trumpeter swan program has experienced two major setbacks: 1) two captive swans and one wild swan were illegally shot or poached on the DePuy Ranch on December 2, 1995, and 2) severe floods on the Yellowstone River during the spring and summer of 1997 and 1998 flushed many swans downriver, leading to a major decline in the flock. In 1999, one captive swan pair managed to fledge five cygnets on one ranch and a wild swan pair fledged a single cygnet. However, in 1999, the flock in Paradise Valley totaled 21 swans, compared to 20 found in the park.

Molly Islands colonial nesting birds. The Molly Islands colonial nesting bird census was conducted in mid-May, early June, early August, and mid-September 1999. The Molly Islands consist of two small islands on Yellowstone Lake appropriately named Rocky and Sandy islands, due to the nature of their nesting substrate. The census techniques applied this year were consistent with those conducted over the last several years. However, due to logistical difficulties on Yellowstone Lake, only aerial surveys were employed.

Yellowstone Lake remained in a deep freeze much later than normal in 1999; therefore, pelicans were late in arriving at the islands. On Rocky Island, a total of 58 pelican nests were initiated on the highest part of the island. Pelican nesting was restricted to one aggregation. Double-crested cormorants constructed 50 nests within this pelican aggregation. High water levels, as a result of snow runoff, threatened the colonial nesting birds again this year. Once the flooding receded, only 10 American white pelican nests and 35 double-crested cormorant

nests remained, all of which were successful. Of the 90 pairs of California gulls that attempted to nest, 51 nesting pairs were successful in raising young. The four Caspian tern nests were reduced to two due to flooding. The following young fledged from Rocky Island: 12 American white pelicans, 98 double-crested cormorants, 90 California gulls, and 2 Caspian terns.

On Sandy Island, a total of 70 American white pelican nests were initiated in one large aggregation, but only 52 nests were successful in rearing 90 young. Double-crested cormorants did better than expected, with 25 successful nests out of the 40 initiated, resulting in 50 fledged young. As usual, no Caspian terns nested on Sandy Island.

In summary, 1999 was a year of low colonial nesting bird production due to the late nesting season, cold temperatures, and flooding. Total production on the Molly Islands resulted in fledging 102 American white pelicans, 148 double-crested cormorants, 90 California gulls, and 2 Caspian terns. As the exotic lake trout management program continues in Yellowstone Lake, so too, the status of the Molly Islands birds will play a more critical role in assessing the impacts of this exotic organism on endemic piscivorous bird species. At this time, however, lake trout do not appear to have adversely affected colonial nesting bird production. Climatic conditions continue to appear to play the most important role in influencing bird production on these islands.

Osprey. The YNP osprey population fared better than expected in 1999. Egg laying was later than normal due to the late spring weather, resulting in 62 nesting pairs fledging 88 young. Tree nest-site instability and weather continued to play a role in influencing osprey productivity in the park. The incidence of bald eagles taking over osprey nest sites was noticeable this year and was documented at two sites. Monitoring the population dynamics of ospreys and other piscivorous bird species is especially important as biologists chart lake trout numbers over time.

Harlequin duck. The harlequin duck population in YNP continues to maintain itself and is only mildly variable from year to year, with generally 16–20 pairs residing in the park. Monitoring adults is the most effective method of keeping track of population vigor and trends. Monitoring annual productivity is not cost effective, as data collection is extremely time-consuming and difficult due to the remoteness of many of the areas in which harlequins are found. Productivity is extremely variable from year to year and is highly influenced by weather, such as flooding.

Harlequin duck male and female in the park. Photo by Terry McEneaney.

Common loon. The common loon population in YNP continues to fluctuate from year to year. There were 14 nest attempts in 1999, yet only two young managed to reach fledgling age. A total of 42 adults were found in the park in 1999 (numbers have ranged between 34 and 51 individuals). Yearly fluctuations in adult numbers and in the production of young are the result of variable weather conditions. Flooding during the month of June was primarily responsible for the poor loonlet production.

Other Research and Monitoring

North American Bird Migration Count. Yellowstone participated in the North American Bird Migration Count for the seventh consecutive year in 1999. This count is designed to collect quantitative and qualitative spring bird migration information on a continental scale. The survey is traditionally scheduled each year on the second Saturday in May. On May 8, three

observers recorded a total of 2,963 individual birds. A total of 85 bird species were recorded during the count, including 70 species within YNP.

Breeding bird surveys. Three breeding bird surveys were conducted in 1999. This songbird data was sent to the continental clearinghouse located at the Patuxent Wildlife Research Center in Laurel, Maryland, and is included in the information available online at *www.mp2-pwrc.usgs.gov/bbs*. Data from these surveys are used to develop population trends for North American songbirds. Yellowstone's breeding bird surveys date back as far as 1982.

Glacier Boulder route survey. The Glacier Boulder route survey documents birdlife found exclusively in lodgepole pine. The transect begins at the Glacier Boulder trailhead near Inspiration Point. The point count census consists of 30 stations and is conducted entirely on foot. Census protocol for this survey is similar to that of a breeding bird survey. This was the fourth year in a row that this survey was conducted, establishing additional baseline data for neotropical migrant landbird monitoring.

Christmas Bird Count. The 1999 Christmas Bird Count (CBC) marked the twenty-seventh year that the survey has been conducted in the Yellowstone area. During count day, December 19, a total of 34 species comprising 1,986 individuals were recorded. Five additional species were recorded during count week. Highlights of the CBC included one Harris' sparrow and two Virginia rails during count day, and one northern saw-whet owl and two marsh wrens during count week. The northern saw-whet owl, found on December 20 in Gardiner, Montana, constituted a new species for count week. As of 1999, a grand total of 95 species have been recorded on CBC day, and 97 species during CBC week. This Christmas Bird Count had the highest public participation ever—22 people. Temperatures ranged from -12 to 30°F. Conditions were mild, and rivers that would usually have been frozen were not. A slightly above average number of species were observed. Record numbers of Canada geese (275) and green-winged teal (27) were also documented.

New bird records. Two new species of birds were added to the bird checklist in 1999. On August 27, 1999, a wandering tattler was found in Porcelain Basin (Norris Geyser Basin) by park visitor Larry Schmahl. Mr. Schmahl provided excellent details of his observation of this unique shorebird, and the information has been submitted to the park bird records. On October 30, 1999, Anita Varley found a small owl that had been killed by black-billed magpies in front of the administration building. The owl was identified as a flammulated owl and has been preserved for placement into the park's scientific bird collection.

As of 1999, 311 species of birds have been documented in the park since it was established in 1872. The Yellowstone National Park bird checklist was last revised in June 1996. It is available on the park website at *www.nps.gov/yell*.

Website revision. The park website coordinator and the staff ornithologist worked incrementally to change and refine the bird information on Yellowstone's website. Plans call for a more detailed section on birds, which will include information on threatened and endangered birds, species of special concern, and neotropical migrant landbirds; instructions on how to add bird observations to park bird records, and on how to contribute to the Yellowstone Park Foundation's Yellowstone Bird Fund and their current projects; a revised bird checklist; access to bird population trend data; and annual reports.

Computerized database. Over the last two years, an effort has been made to computerize the bird database, and progress is slowly being made.

Environmental assessments and status reviews. The most important park assessments in 1999 that utilized bird data were highway construction, winter use, and bison management. The U.S. Fish and Wildlife Service contacted the staff ornithologist regarding status reviews for the black tern and sage grouse.

Injured and road-killed birds. A protocol

for handling injured and road-killed birds was introduced in 1996 to standardize procedures and prevent turning over birds to unqualified rehabilitators, which heightens the possibility of losing valuable bird information. Procedures were again followed very well in 1999. The only professional bird rehabilitator the park uses is Big Sky Wild Care of Bozeman, Montana. Salvageable road-killed birds are added to the Albright Visitor Center museum collection each year.

Swallow, woodpecker, and raven management. Swallows, northern flickers, and ravens continue to pose obstacles for the people responsible for the care and management of park buildings. In addition, there are some health risks associated with some of these species. These birds are protected by law under the Migratory Bird Treaty Act, so mitigation options are limited. With proper installation, plastic netting can be used to discourage nesting in selected areas of high public use.

Other Partnerships

Trumpeter swan video. The staff ornithologist spent a large percentage of his time in 1999 working on the production of a trumpeter swan conservation video entitled "Save the Yellowstone Trumpeter Swan." Private funding for this project was provided by the Bernice Barbour Foundation through the assistance of the Yellowstone Park Foundation. Work involved video planning; development of a film schedule and video script; film layout; and video production. The video is designed to be broken down into two parts: a 10-minute version for general visitor center audiences, and a 29-minute version for other audiences.

Bird impression. In the fall of 1998, a cast or impression was discovered in a geothermal sinter deposit by graduate student Alan Channing from the University of Wales. The staff ornithologist was called in to assist Mr. Channing in determining if the impression was that of a bird. It was determined that the cast was indeed that of a bird, and it was remarkably well preserved, with details such as feather tracts, legs, neck, head, and bill evident. The specimen was collected and later identified as an American coot (*Fulica americana*). The bird cast was transferred to the Museum of the Rockies, where it is being temporarily stored pending further analysis. Museum of the Rockies paleontologist Jack Horner is working with his associates and Mr. Channing on a scientific publication scheduled for the fall of 2000.

National Geographic field guide. The ornithologist assisted the National Geographic Society in revising the second edition of the "Field Guide to the Birds of North America." This is one of the most popular bird field guides in North America. The ornithologist provided GYA species distribution data. In the past, range and distribution maps for this geographic area have sometimes been inaccurate due to the lack of knowledge of species in this area.

Montana Bird Records Committee. The Montana Bird Records Committee meets once or twice a year, depending on the volume of information, to review new bird records. The staff ornithologist is chairman of this committee. This high profile committee keeps the park up-to-date on the latest advances in ornithology.

Wyoming Bird Records Committee. Similar to the Montana program, the Wyoming Bird Records Committee meets once a year in the spring to review bird records. The staff ornithologist was elected to the Wyoming Bird Records Committee in 1998. YNP participated

Alan Channing of the University of Wales (center) and his assistants upon discovery of the bird impression in the park. Photo by Terry McEneaney.

for the first time in the May 1999 meeting in Lander, Wyoming, where the ornithologist was selected as committee chair for the next three years.

Neotropical migrant groups. Yellowstone National Park typically participates in three neotropical migrant working groups, the Montana and Wyoming Partners in Flight, and the international Western Working Group Partners in Flight. Ornithologists from all over the West, including Canada and Mexico, participate in this group. They are currently focused on prioritizing species and developing conservation plans. Meetings occur twice a year in different areas of the West. The staff ornithologist was unable to attend any of the 1999 neotropical migrant working group meetings due to budget shortages.

Adopt a biosphere reserve and recycled uniform program. Yellowstone continues to assist the two adopted biosphere reserves in Mexico (Mariposa Monarca and Manantlan). We continue to offer logistical support, as well as to provide them with recycled NPS uniform components. In 1999, a large shipment of uniform components was sent to the Mariposa Monarca Biosphere Reserve.

Public Contacts and Outreach

Each year the park ornithologist gives bird lectures to the concessioners' guides and other public and private organizations, and responds to hundreds of letters of inquiry about bird information. Topics addressed during speaking engagements in 1999 included: "How to Conduct a Bird Walk;" "Center Stage-Back Stage: Two Different Views of Yellowstone Birds;" "Identifying and Aging Bald and Golden Eagles;" "Trumpeter Swan Management—Past, Present, and Future;" "Status of the Whooping Crane in YNP and the Greater Yellowstone;" "Non-Indigenous Birds of Greater Yellowstone—Their History, Status, and Management" for Yellowstone's Science Symposium focussing on exotic species; an Avian Adventures panel and a bird identification workshop for the Greater Yellowstone Coalition; and a presentation on feathers for Exploring Yellowstone.

BISON

Wild, free-ranging bison continued to thrive in the Yellowstone area, summering throughout the park and in some adjacent, high-elevation ranges, and migrating to winter range in geothermal areas and lower elevation grasslands both in and outside the park. Controversy has grown for the last three decades over the management of bison leaving the park in winter.

Long-Range Planning

Bison moving from the park onto Montana public or private land have been shipped to slaughter or shot because some of them carry brucellosis. An interagency effort resulted in the release for public comment on a plan and environmental impact statement for long-term bison management in June 1998. The stated purpose of the plan is to maintain a wild, free-ranging population of bison and address the risk of brucellosis transmission to cattle in Montana, while permitting the bison herd within the park to fluctuate in response to natural ecological processes. Alternatives for management ranged from testing all bison in Yellowstone and sending to slaughter those that test positive for exposure to brucellosis, to establishing tolerance zones for bison that wander outside park boundaries onto public lands in winter. Approximately 67,500 public comments were received, the content of which was still being analyzed at the end of the year as the participating agencies struggled to achieve a consensus on a final preferred alternative, to be released in 2000. Public interest in bison management was high (*see "Cultural Resource Programs," page 11*).

In February 1999, about 50 American Indians from different tribes left Rapid City, South Dakota, en route to Yellowstone by foot, car, and horseback to honor and bring attention to the plight of bison. Participants paralleled a traditional migratory route used by both bison and earlier generations of Lakota. When the group entered the park's North Entrance on February 27, it numbered 100 marchers and horses. The group carried buffalo hide, leather,

and a pipe; three sacred staffs adorned with eagle feathers; and a bundle of items related to bison. In a public ceremony, the marchers played music and sang, and several performed flesh offerings in honor of the bison.

While the involved federal agencies—the National Park Service, the USDA Forest Service (USFS), and the USDA Animal and Plant Health Inspection Service (APHIS)—agreed on the basic elements of a sound, workable plan, the state of Montana still reserved full endorsement of the plan. The NPS agreed that when a safe, effective vaccine against brucellosis in bison was developed, they would vaccinate bison within Yellowstone National Park boundaries. The USFS agreed to adjust the management of livestock grazing allotments to maintain critical separation between bison and cattle. And APHIS clearly stated that the proposed federal plan would not jeopardize Montana's brucellosis class-free status, a designation that is crucial to the transport of livestock across state lines for commerce.

However, discussions with the state reached an impasse in late 1999 and, as a result, the federal agencies announced that they would move forward with a final proposal that would manage bison with minimal lethal control while protecting cattle. The federal plan would allow very limited numbers of bison in three well-defined zones north and west of Yellowstone National Park (Reese Creek, Eagle Creek/Bear Creek, and Horse Butte) that would be buffered with areas in which no bison would be permitted. Added actions to separate bison and cattle were proposed. Research studies of potential brucellosis vaccines and effective delivery mechanisms continued.

Interim Management

Concerns raised by the high bison mortality during the winter of 1996–97 prompted modifications to the previously approved *Interim Bison Management Plan.* The modifications were designed to reduce the number of bison that would have to be killed if they moved beyond the park boundary. In early 1999, the Montana Department of Livestock killed 90 adult bison by shipping them to slaughter (four additional bison were killed as part of the capture operations).

Bison Research

Studies continued on bison ecology and the ecology of the *Brucella* organism in the wild. As mentioned previously, researchers continued testing vaccines for their safety in bison and in non-target wildlife species including coyotes, pronghorn, mule deer, moose, bighorn sheep, birds, and rodents. Results from the non-target vaccine studies show that the vaccine does not cause mortality or morbidity and is safe in non-target species. Work is continuing on vaccine testing in bison, but results in 1999 show that RB51 is safe in calf and yearling bison. A study is also underway in cooperation with the Fish and Wildlife program at Montana State University to develop methods for conducting aerial surveys that will provide scientifically defensible bison population estimates, including correction factors that will account for the proportion of animals not observed during the surveys. Additionally, continuing funding by the U.S. Geological Survey Biological Resources Division is supporting several multi-year bison research projects including: bison ecology in Hayden Valley, winter use by bison of groomed park roads, statistical analyses of 30 years' bison data collected by former USGS biologist Dr. Mary Meagher, reproduction and demography of brucellosis infected bison, epidemiology and pathogenesis of brucellosis in bison, genetic analyses of *Brucella* and development of a PCR-based diagnostic system, continuation of risk assessment for transmission of brucellosis from bison to elk, and continuation of *Brucella* vaccine safety trials.

As a result of a settlement agreement related to managing winter visitor use in Yellowstone and Grand Teton national parks and the John D. Rockefeller, Jr., Memorial Parkway, the NPS began monitoring bison movements and road use in Hayden Valley and between Mammoth Hot Springs and Gibbon Falls. Ground crews of two persons each conducted visual

Bison are thriving in the park. NPS photo.

surveys at randomly determined dates and times to record bison numbers, locations, behavior, movements, and use of road segments and adjacent corridors. Observations were augmented with monthly aerial surveys and photographs taken by automated cameras at eight defined points. Crews completed 64 ground surveys in each area between December 13, 1998, and March 27, 1999. They recorded 2,458 observations of bison groups; group size ranged from 1 to 135 in Hayden Valley and from 1 to 62 in the Mammoth-to-Gibbon area. A small percent of the observations (5.8% in the Mammoth-to-Gibbon area and 9.4% in Hayden Valley) were of bison on groomed winter roadways. Of 2,299 photographs taken by the remote cameras, only 184 were of bison, 8 percent of which were on the oversnow vehicle roads. Aerial surveys indicated that the number of bison in both study areas remained fairly stable from early to mid-winter. But in March, numbers of bison decreased by nearly 25 percent in Hayden Valley and more than doubled in the Mammoth-to-Gibbon area. The monitoring of bison movements and road use continued for another winter (1999–2000) beginning in December 1999. Results from this latest year's effort will be summarized in mid-2000.

In a related study conducted from November to May of 1997–98 and 1998–99, Montana State University graduate student Daniel Bjornlie found that while bison did travel on the park's groomed winter roads, they used natural travel corridors and their own established trails, such as the Mary Mountain trail across the Central Plateau, much more often. Bjornlie found that bison in the Mary Mountain-Firehole herd spent 69 percent of their time foraging for food, and only 7 to 8 percent travelling. His observations indicated that 63 to 88 percent of all bison travel took place off of park roads and trails, and an average of 17 percent was on the roads groomed for oversnow vehicles. Bison were very inactive at night, regardless of the level of snowmobile activity. However, Bjornlie did observe a negative correlation between bison use and road traffic; when travelling on roads, bison had a negative reaction to snowmobile or snowcoach traffic 75 percent of the time.

Wildlife Surveys and Sampling

Northern range ungulates. Yellowstone National Park staff again shared costs and time with the Northern Yellowstone Cooperative Wildlife Working Group (comprised of the National Park Service; the Montana Department of Fish, Wildlife and Parks; the USDA Forest Service; and the USGS Biological Resources Division) to complete counts of ungulate herds on the northern range.

Elk. Poor flying conditions prevented completion of the 1998–99 winter elk count until January 30, 1999, inside the park and February 11, 1999, outside the park. Potential difficulties in estimating the total number of wintering elk occurred because some animals may have migrated out of the park between the flights, and because the flights occurred during a legal late-season hunt that takes place north of the park boundary each year in January and mid-February. A count of 7,122 in the park and 4,620 out of the park were combined for a total of 11,742. In March 1999, a classification survey found 34 calves per 100 cows in the northern herd.

During optimal counting and flying conditions, the 1999–2000 northern range elk count was completed on December 27, 1999, and observers counted 14,538 elk.

Mule deer. Dr. Tom Lemke of the Montana Department of Fish, Wildlife and Parks con-

ducted a helicopter survey of mule deer on the northern range in and outside the park on April 27, 1999, and counted 1,677 animals. Mule deer recruitment was estimated to be 46 fawns per 100 adults.

Pronghorn. A late-winter count of pronghorn was conducted on March 25, 1999. A park biologist observed 204 animals, 12 percent fewer than the 1998 spring count of 231. Two park volunteers, Dr. Jim and Mrs. Edna Caslick, conducted road surveys for the fifth consecutive year to assess pronghorn distribution and evaluate possible effects of bison management activities on pronghorn.

On February 10 and 11, 1999, biologists from Yellowstone and the University of Idaho captured and radio-collared 30 adult female pronghorn between Mammoth and Gardiner for two new research projects. The captured animals were sampled for genetics, diseases, and nutritional state. The University of Idaho study will attempt to determine how many fawns are born and survive each year, assess the causes and timing of fawn mortality, and assess doe nutritional condition and stress. Ten fawns (five male and five female) were captured in 1999, and by July 5, six fawns had died. Another study, in cooperation with Montana State University, will assess habitat use patterns of radio-collared pronghorn.

On August 6, 1999, the late summer pronghorn composition count was conducted. A total of 109 pronghorn (43% of the population) was counted—73 does, 16 bucks, and 20 fawns. The fawn to doe ratio was 27:100, and the buck to doe ratio was 22:100.

Bighorn sheep. The Montana Department of Fish, Wildlife and Parks conducted the annual aerial helicopter survey on April 27 and 30, 1999, and located 181 bighorn sheep (91 ewes, 29 lambs, and 61 rams) in and outside of Yellowstone National Park. The count was up 47 (35%) from the 1998 survey, but was not substantially different than the five-year average of 191 bighorns counted during the spring survey. Lamb recruitment for the entire survey area increased from 11 lambs/100 ewes in 1998 to 32 lambs/100 ewes in 1999. The annual 1999 ground count, usually conducted in December, was not completed until January 13, 2000, when only 57 bighorn (24 rams, 22 ewes, 6 lambs, and 5 unclassified) were seen with ratios of 23 lambs and 109 rams per 100 ewes. Although the Northern Yellowstone Cooperative Wildlife Working Group concluded that ground counts are less reliable than aerial counts for monitoring the total sheep population, they have continued to conduct ground counts as a supplement; the ground surveys allow closer observations of bighorns' physical condition and age.

During 1999, fragmentary remains of six to 10 bighorn sheep were found in close proximity on Mount Everts in northern Yellowstone. Identified evidence included horn sheaths from four or five ewes and one ram, as well as two radio collars from a recent graduate research project. Biologists inspecting the scene concluded that the group of sheep had likely been killed by a lightning strike.

Bison. Approximately once a month, NPS staff conducted aerial surveys of the entire bison population. On December 4, 1999, a total of 2,470 bison were counted. As of December 31, 1999, no bison had been killed or removed as part of management actions under the *Interim Bison Management Plan* for the 1999–2000 winter.

Geology and Geothermal Resources

The park was still without a geologist during 1999. As a result, seasonal technician Tim Thompson compiled and analyzed data pertaining to seismic and geothermal activity, provided geothermal assessments, and continued long-term data collection pertaining to geysers and hot springs. Several volunteers assisted the technician by continuing to compile data on changes in geyser activity for the historical record. Geothermal assessments for the Canyon-to-Fishing Bridge road overlay and proposed construction of a new Old Faithful Visitor Center delayed the intended five-year summary report

of major changes in geothermal activity. With the help of U.S. Geological Survey scientists, YCR staff analyzed and addressed several infrastructure problems associated with geothermal activity. In March of 1999, the technician presented an abstract and talk on the statistical problems associated with modeling changes in Old Faithful Geyser's behavior.

Earthquakes and Seismicity

The University of Utah's seismic stations documented more than 1,200 earthquakes in the Yellowstone region during 1999. On the Richter scale, the earthquakes ranged from less than 1.0 to 5+ magnitude. As is generally the case, the majority of the earthquakes within the park and caldera boundary occurred in swarms. In recent years, concentrated swarms of seismic events were observed at a location northeast of West Yellowstone and west of Norris. These seismic events continued to be observed during 1999.

An earthquake of magnitude 5.3 occurred on August 20. The approximate epicenter was in the Red Rocks Wildlife Refuge area west of the park. The earthquake was felt in the Norris campground and in Gardiner, Montana. It has yet to be determined if the seismic waves penetrating the caldera influenced geothermal activity.

Old Faithful Geyser

Old Faithful Geyser continued to show signs of longer intervals between eruptions (IBE). While this does not suggest that the geyser is showing signs of dormancy, the state of the geyser system has significantly changed. Since the Biscuit Basin earthquake of 1998, "short mode" eruption-recovery times have almost disappeared. As has been documented many times in the past, Old Faithful Geyser has two distinct operational modes: short duration eruptions lead to short recovery times, and long duration eruptions lead to long recovery times. During 1999, the mean and median IBE were 84.8 and 87 minutes, respectively, based on 2,116 eruptions (Figure 5). This represents an increase in mean IBE of approximately 4 minutes during 1999, and an increase of approximately 21 minutes since 1945. With the vast majority of visitors wanting to view an eruption of Old Faithful Geyser, the increased recovery time forces visitors to wait longer and remain in the Upper Geyser Basin for extended amounts of time, placing greater demands on other resources and infrastructure.

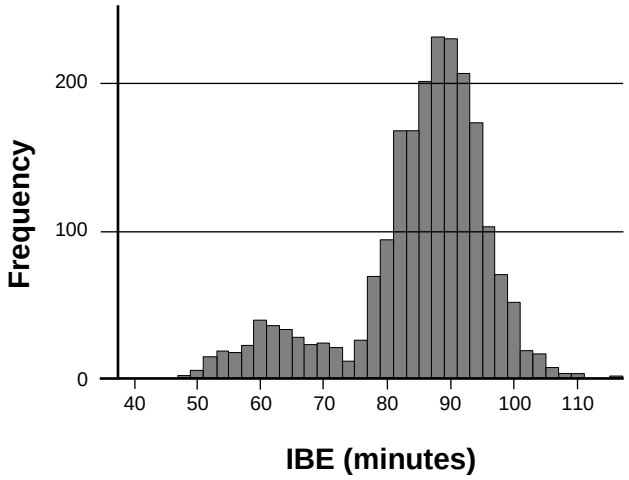


Figure 5. Old Faithful Geyser's 1999 interval of time between eruptions, based on 2,116 observations.

To better understand the shift in the operating system of Old Faithful Geyser during the last decade, histograms of IBE for the years 1999 and 1989 were constructed from the electronic dataframe. Twenty percent of these eruptions were the result of Old Faithful operating in a shorter recovery time mode of less than 80 minutes. The median indicates that 50 percent of the time a visitor must wait longer than 87 minutes to view two eruptions, yet 80 percent of the time a visitor must wait 80 minutes or longer. In comparison, the mean IBE during 1989, based on 5,603 eruptions, was approximately 78.5 minutes, with a median of 82 minutes (Figure 6). During 1989, the percentage of IBE less than 80 minutes was 41 percent. Hence, much of the reason for the increased mean IBE observed during the past two years can be explained by the geyser system operating far less often in a shorter eruption-recovery mode.

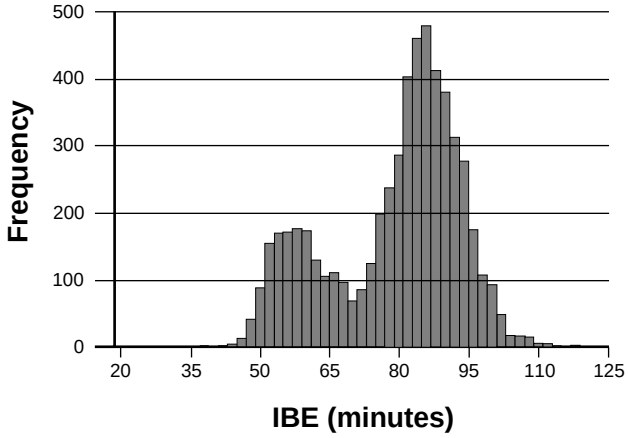


Figure 6. Old Faithful Geyser's 1989 interval of time between eruptions, based on 5,603 observations.

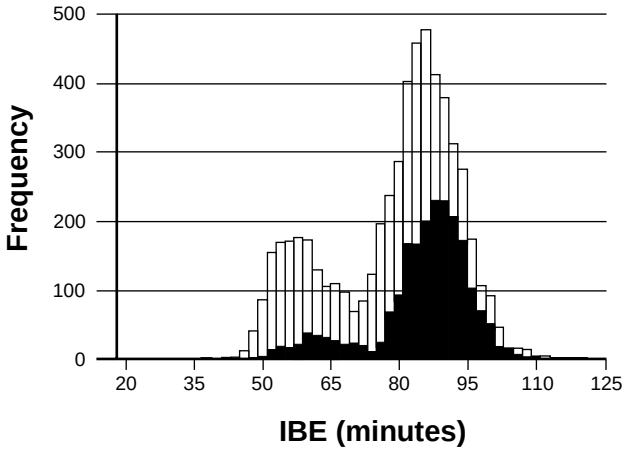


Figure 7. Old Faithful Geyser's 1989 (open bars) and 1999 (solid bars) interval of time between eruptions.

Observations made during 1999 also suggest that the Old Faithful Geyser IBE is undergoing an overall increase (Figure 7). There is striking evidence in favor of an overall increase in IBE; not only has the proportion of short-mode eruptions decreased, the entire distribution appears to have shifted toward increased recovery time between eruptions. It is unlikely that the apparent change in distribution is an anomaly of a larger sample size being compared to a smaller sample size. In order to account for the difference in number of observations, the seasonal technician (a mathematician and statistician with the Oregon Institute of Technology) conducted a statistical simulation procedure known as a *bootstrap* that involved taking 1,000 random samples, each including 100 IBEs, from both 1989 and 1999. The procedure produced 1,000 sample means for each year (Figure 8). *Normal theory* under large sample sizes provides normal distributions of sample means. The results of the analysis brought forth striking evidence in favor of a large shift in distribution toward increasing sample mean IBE.

It is hoped that YCR analyses based on long-term monitoring projects can provide managers with scientific evidence upon which decisions can be based. If Old Faithful Geyser continues toward longer recovery times, one can expect visitors to linger in the basin longer, significantly changing impacts on visitor services.

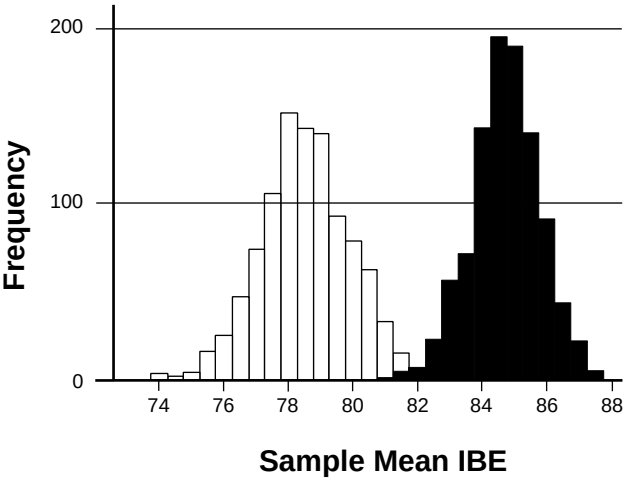


Figure 8. Distribution of mean IBE for Old Faithful Geyser, 1989 (open bars) and 1999 (solid bars). Data represent mean IBE for sample populations of 100 measurements (n = 100).

Other Long-Term Monitoring

Long-term monitoring of other selected geysers as indicators of geothermal activity continued in 1999. In the eight years of long-term monitoring of these geysers, natural fluctuations in activity have been documented.

Upper Geyser Basin. For Castle Geyser, 140 IBE were recorded, of which 122 followed major eruptions and 18 followed minor eruptions. The mean and median recovery times of major IBE were 707.9 and 704 minutes, respectively. These values represent a significant increase in mean recovery times between eruptions of Castle Geyser compared with the 1998 mean of 695.1 minutes.

For Daisy Geyser, 1,187 IBE were recorded, with a mean and median of 107.9 and 108 minutes, respectively.

For Plume Geyser, 3,107 IBE were recorded, resulting in a mean and median of 38.7 and 37 minutes, respectively. There were six reported eruptions of Giantess Geyser during 1999. Plume's IBE was significantly influenced during at least two of the Giantess eruptions. Giantess' short-term influence on Plume's IBE has been well documented in the past.

Grand Geyser continued to have long recovery times between eruptions; 239 IBE were recorded, with a mean and median of 721.8 and 728 minutes, respectively. During 1998 and 1999, Grand's IBE showed significant decreases during the autumn. In previous years, Grand often had increased IBE during the fall months. There is a strong possibility that when Giant Geyser is active, there is a drain of energy away from the Grand Geyser complex.

Giant Geyser had seven known eruptions during 1999, a significant reduction from the 49 recorded eruptions during 1997 and the approximate 21 eruptions during 1998.

The Fan and Mortar geyser complex was quiet, with no recorded activity since May 1998.

Other geyser monitoring. Flood Geyser in the Midway Geyser Basin produced very unstable eruption patterns, resulting in the longest recovery times observed in recent years. Five hundred IBE were recorded, with a mean and median of 168.5 and 135 minutes, respectively. The longest interval recorded was 1,834 minutes, representing a recovery time of one day, six hours, and 34 minutes.

The monitoring of Great Fountain Geyser, located on the Firehole Lake Drive, resulted in 125 IBE, with a mean and median of 643.9 and 630 minutes, respectively.

For the past four years, there has been no widespread annual disturbance in the Norris Geyser Basin. It has yet to be determined if the lack of an annual disturbance is related to the large number of earthquake swarms that continue in the Mt. Holmes area. For Echinus Geyser, 221 IBE were recorded, with a mean and median of 168.5 and 135 minutes, respectively. These values do not reflect the true nature of Echinus during 1999, as IBE ranged from approximately 40 minutes to as long as 374 minutes. Echinus was highly unpredictable and appears to be in a phase of reduced energy level.

Both Rustic and Glade geysers were active in the Heart Lake Geyser Basin.

Geothermal Activity and Highways

The technician consulted with a Federal Highways' technician and other scientists with respect to road failure due to geothermal activity. Road failure due to geothermal heat and fluid transfer were documented in several areas of the park—Mud Volcano, Rabbit Creek, the Norris-to-Mammoth road, and Mary Bay. Road failure and potential road failure at Rabbit Creek and Mary Bay appear to be the result of a geo-board or moisture barrier that was placed in the roadbed near areas of potential geothermal activity. The evidence suggests that these barriers have a tendency to trap heat and condensation, moving this energy laterally under the asphalt roadbed. There is extreme heat buildup in the fill material—93^{o}C at Mary Bay and 85^{o}C at Rabbit Creek. As fluids and heat build, the fill may liquify, allowing a loss of fill material and a softening of asphalt layers.

At the Flood Geyser pullout on the Grand Loop Road, heavy soil erosion continued to create problems in the area of Flood Geyser and Circle Pool. Originally, the pullout was part of the roadbed. The new road was moved approximately 20 meters away from the embankment to escape the heat buildup that created problems for winter snowmobiling. A barrier between the fill and asphalt was used to protect the road and the pullout from heat. As with the Rabbit Creek and Mary Bay areas, heat was transferred laterally toward the embankment. Approximately 10 meters downslope of the parking area, soil temperature was as high as 67°C at a depth of 10 cm. The intense focused heat broke down the rock and fill material in such a manner that heavy rains washed the fine particles downslope and into Circle Pool.

Geothermal Assessment and Inventory

The technician compiled and completed assessments for two proposed construction plans, the Canyon-to-Fishing Bridge road overlay and a new Old Faithful Visitor Center. In compiling the resources assessment for the road project, a history of known problems at Sulfur Caldron was documented. Detailed contour (5-foot contour intervals) maps of the Mud Volcano thermal area were discovered. As a result, the assessment proved a valuable tool in motivating research and compiling past information in a concise form.

The proposed Old Faithful Visitor Center caused some concern due to the proposed size and depth of the building. Given the proximity to Old Faithful Geyser, it was determined that a deep basement could possibly intersect thermally-influenced groundwater. Since there is no evidence that the current buildings in the vicinity have affected the geyser, geologists suggested that foundation and basement work be kept at a depth comparable to existing buildings. Given the problems created by thermal and moisture barriers, use of such materials should take into consideration methods to transport heat and condensation buildup in underlying soils and rocks.

VEGETATION

Park personnel and outside researchers continued to use the herbarium, which is part of the museum collection, especially during the summer months. The collection includes approximately 7,600 specimens of vascular and non-vascular plants that are identified and mounted, with 6,121 specimens of vascular plants that are also catalogued into the NPS' Automated National Catalog System (ANCS+). During the 1999 field season, 240 specimens were collected for the herbarium. These specimens were needed to strengthen the collection, especially to document the native flora in undercollected parts of Yellowstone's remote backcountry and the arrival and spread of exotic species.

Plant Inventories

Seven species of vascular plants previously not reported as occurring within the park were discovered. *Cymopterus nivalis* Wats. [snowline cymopterus], *Thlaspi montanum* L. [wild candytuft], *Mirabilis linearis* (Pursh) Heimerl [narrowleaved four-o'clock], *Orobanche corymbosa* [flat-topped broomrape], and *Carex nigricans* Retz. [black alpine sedge] were all located. These native species are presumed to be a long-term component of Yellowstone's flora that has been previously overlooked. Additionally, two new exotic species were discovered and subsequently eradicated. *Daucus carota* L. [Queen Anne's lace] was located by West District resource management personnel, and *Arctium minus* (Hill) Bernh. [burdock] was discovered in the lawn of a residence in lower Mammoth. In addition, *Listera convallarioides* (Sw.) Nutt. [broad-lipped twayblade], originally collected in 1885 but subsequently not relocated, was confirmed to occur within the park.

Chara zeylandica, a circumtropical stonewort (a type of algae) was originally collected by Ross Skinner in 1944 from a thermal spring near Three Rivers Junction. The presence of this species in Wyoming at a relatively high elevation is surprising, as it is far beyond its natural distributional range. In 1984, Dr. Vernon Proctor verified the presence of this taxa in the thermal feature. During the summer of 1999, Dr. Proctor requested that an examination of the thermal feature and collection of *Chara* be made to verify that this unusual population is still surviving in the warm water of this pool. Material sent to Dr. Proctor confirmed the continued survival of this tropical plant in one thermal feature in the backcountry of Yellowstone.

Summer fieldwork focused on rare plant surveys associated with various construction projects in the park. The primary focus was on the road from Canyon Junction to Fishing Bridge Junction for the parkwide road reconstruction program. In addition, possible trail reroutes were surveyed to prevent inadvertent impacts on species of special concern. Trail sections examined included Fan Creek, Cold Creek Junction,

Ferris Fork near Three Rivers Junction, and the lower portion of Pelican Valley. Various other possible construction sites were also investigated. Twenty different "species of special concern" or rare plants were located during the summer field season, including multiple populations of several of the species.

Vegetation Management and Research

Hazard tree removal. The management biologist assisted resource management and concessions staff in removing hazard trees in the Canyon Campground and Lake developed areas.

Fire management. The management biologist served as contracting officer and liaison with Dr. Ron Wakimoto and graduate student Kris Sanders of the University of Montana, the Boise Interagency Fire Center, and Yellowstone's fire management program on a $22,000 grant to assess the utility of FARSITE fire behavior models in comparing model outputs with the known behavior of fires in Yellowstone.

Pest management. Annual pesticide use proposals and pesticide use logs were compiled as part of the parkwide integrated pest management (IPM) operation. Ninety-two pounds of active ingredient were applied as herbicides in conjunction with the park's integrated weed management program during 1999. The IPM coordinator received and responded to 31 pest complaints related to mice, packrats, and other small mammals (12); bats and bat mites (6); swallows and swallow mites (2); and ants, spiders, and other miscellaneous insects (10).

USDA resource survey. The management biologist served as the incident commander in support of the Interior West Resource Inventory, Monitoring, and Evaluation Program as implemented by the USDA Forest Service Rocky Mountain Research Station in the park. He was responsible for coordination, planning, logistics, and implementation of the survey effort over an 11-week period involving 30 field personnel and an operating budget not-to-exceed $100,000. The survey was completed for 280 forested plots and included 50 hours of helicopter access, one week of boat access, and more than 200 person-days of non-designated backcountry camping without incident to persons, property, or wildlife.

Grizzly bear cumulative effects modeling. Data analysis was completed for the revision of the habitat coefficients used in the computerized grizzly bear cumulative effects model, and a report to be published as a USFS general technical report was compiled. Following the coefficient update, a complete habitat modeling exercise was undertaken for the eight-million-acre area identified as the core area for grizzly bear recovery. The results of the modeling exercise are to be incorporated as baseline data in the Grizzly Bear Conservation Strategy.

Exotic species. Inventory and control information was compiled on exotic plant species for a presentation at the fifth biennial science conference and submitted for publication to *Western North American Naturalist*.

The management biologist supervised two seasonal employees in the establishment and sampling of field exclosures as part of an overall site reclamation effort in the "triangle" area of the park adjacent to Gardiner, Montana. A factorial ANOVA experimental design using fencing, watering, mulching, and herbicide application was employed to assess non-native plant control and concurrent attempts to germinate and establish native plant species. Data analysis was completed and compiled in a first-year progress report.

Aspen. The management biologist cooperated with Oregon State University researcher Dr. William Ripple to establish aspen monitoring transects inside and outside established wolf territories to quantify baseline vegetation conditions. These transects will be sampled over time to document vegetation changes, if any, that may be a result of reduced browsing pressure by elk in response to the presence of wolves.

Wildlife Management and Monitoring

Rare Animal Records

The most notable rare mammal observations reported in the park in 1999 were of moun-

Table 3. Most notable[a] rare animal sightings reported in Yellowstone National Park, 1999[b].

	Type of Report				
Species	Carcass or Captured Animal	Physical Evidence[c]	Observation by Experienced Observer	Observation by Inexperienced Observer	Total
Amphibian[d]	0	0	2	0	2
Badger	0	0	6	0	6
Beaver	1	0	14	2	17
Bighorn Sheep	1	0	20	0	21
Bobcat	0	1	4	3	8
Fisher	0	1	0	0	1
Lynx	0	0	1	0	1
Mountain Goat	0	0	5	4	9
Mountain Lion	7	0	6	21	34
Muskrat	0	0	1	0	1
Pine Marten	0	0	1	0	1
Raccoon	1	0	0	0	1
Red Fox	2	0	9	5	16
Reptile[e]	1	0	5	1	7
River Otter	0	0	6	1	7
Weasel[f]	0	0	7	2	9
Whitetail Deer	0	0	9	1	10
Wolverine	0	0	0	6	6

[a] Common species in unusual locations are not included in this table.
[b] Includes sighting and sign reports from calendar year 1999 turned in to the Bear Management Office as of January 31, 2000.
[c] Physical evidence includes photo, plaster cast of track, track, scat, hair, or DNA sample.
[d] Amphibian observations include 2 blotched tiger salamanders.
[e] Reptile observations include 3 rubber boa, 1 wandering garter snake, 1 bull snake, 1 eastern yellow belly racer, and 1 prairie rattlesnake.
[f] Weasel observations include 5 shorttail weasels, 2 longtail weasels, and 2 unidentifiable weasels.

tain goats, wolverines, raccoons, lynx, and fisher (Table 3). All of these species are rarely observed in the park. The fisher report was a track observation by a researcher who has seen wild fishers and fisher sign in northern Montana.

Road-Killed Wildlife

A total of 87 large mammals were hit and killed by vehicles on YNP roads in 1999 (Table 4). Elk (43%) and mule deer (26%) were the species most often killed in collisions with vehicles. Other species of large mammals hit and killed by vehicles included 7 bison (8%), 16 coyotes (18%), and 4 moose (5%).

The average road-kill rate of all park roads combined in 1999 was 0.3 road-kills per mile of road (Table 5). The rate of road-kills on U.S. Highway #191 was approximately 1.5 road-kills per mile of road, the highest road-kill rate of any park road. U.S. Highway #191 comprises approximately 7 percent of the paved roads in YNP but accounted for 34 percent of the road-killed large mammals documented in the park; it is the only road segment in the park with a 55-mph speed limit (all other roads are posted at 45-mph or lower). Vehicle speeds are known to be a factor contributing to the frequency of road-killed wildlife. Other roads with road-kill rates substantially higher than the park-wide average include the West Entrance Road (0.7 road-kills/mi.), the Norris-to-Canyon road (0.5 road-kills/mi.) and the Canyon-to-Fishing Bridge road (0.5 road-kills/mi.).

The 87 road-kills recorded in 1999 was the second lowest number since year-round record keeping began in 1989, and was significantly lower than the long-term average of 111 (± 20 SD) road-kills per year recorded from 1989 to 1998 (Table 6). The highest number of road-kills previously recorded in the park was 148 in 1994. No road segments had a higher than average number of road-kills in 1999.

Wildlife Disease Monitoring

In 1992, park staff, in cooperation with the Wyoming State Veterinary Laboratory, began a

Table 4. Number of large mammals (30 lbs. or larger) killed by vehicles on different sections of road within Yellowstone National Park, 1999.

	Road Code[a]																
Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**Total**
Antelope	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beaver	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bighorn Sheep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bison	0	0	0	0	0	1	4	0	0	0	0	1	0	1	0	0	7
Black Bear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bobcat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coyote	0	1	6	1	0	0	0	0	0	0	0	0	8	0	0	0	16
Elk	1	2	2	1	0	4	1	0	2	2	2	4	15	0	1	0	37
Grizzly Bear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lynx	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moose	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	4
Mountain Goat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mountain Lion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mule Deer	0	0	3	0	0	1	2	2	0	6	0	5	4	0	0	0	23
Raccoon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Whitetail Deer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wolf	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wolverine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**1**	**3**	**11**	**2**	**0**	**6**	**8**	**2**	**2**	**8**	**2**	**10**	**30**	**1**	**1**	**0**	**87**

[a]Road Codes:
1 Gardiner to Mammoth
2 Mammoth to Tower
3 Tower to Northeast Entrance
4 Mammoth to Norris
5 Tower to Canyon
6 Norris to Canyon
7 Canyon to Fishing Bridge
8 Fishing Bridge to East Entrance
9 Fishing Bridge to West Thumb Junction
10 West Thumb to South Entrance
11 Norris to Madison
12 Madison to West Entrance
13 U.S. Highway #191
14 Madison to Old Faithful
15 Old Faithful to West Thumb Junction
16 Bechler Roads

Table 5. Vehicle kill-rate of large mammals (30 lbs. or larger) on different sections of road within Yellowstone National Park, 1999.

Road Section	Road Code	Miles of Road	Percent of Park Road Total	Number of Road-Kills	Percent of Park Total Road-Kills	Kill Rate (Animals/Mile)
Gardiner - Mammoth	1	5	2%	1	1	0.2
Mammoth - Tower	2	18	7%	3	3	0.2
Tower - NE Entrance	3	29	11%	11	13	0.4
Mammoth - Norris	4	21	8%	2	2	0.1
Tower - Canyon	5	19	7%	0	0	0.0
Norris - Canyon	6	12	4%	6	7	0.5
Canyon - Fishing Bridge	7	16	6%	8	9	0.5
Fishing Bridge - East Entrance	8	27	10%	2	2	0.1
Fishing Bridge - West Thumb	9	21	8%	2	2	0.1
West Thumb - South Entrance	10	22	8%	8	9	0.4
Norris - Madison	11	14	5%	2	2	0.1
Madison - West Entrance	12	14	5%	10	11	0.7
U.S. Highway #191	13	20	7%	30	34	1.5
Madison - Old Faithful	14	16	6%	1	1	0.1
Old Faithful - West Thumb	15	17	6%	1	1	0.1
Bechler Road	16	1	<1%	0	0	0.0
Total		**272**	**101%[a]**	**87**	**97[a]**	**$\bar{x}$ = 0.3**

[a] Does not equal 100% due to rounding error.

Table 6. Large mammals[a] killed by vehicles in Yellowstone National Park, 1989–99.

Species	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Antelope	1	4	6	2	1	2	1	2	2	1	0
Beaver	1	1	1	3	1	0	2	2	0	2	0
Bighorn Sheep	0	0	0	0	1	0	3	1	0	0	0
Bison	7	5	12	7	11	11	11	16	15	13	7
Black Bear	0	1	0	2	0	1	1	0	0	3	0
Bobcat	0	0	0	0	1	0	0	1	0	0	0
Coyote	1	9	3	5	10	19	9	10	5	7	16
Elk	50	35	54	34	37	49	52	64	24	32	37
Grizzly Bear	0	1	0	0	0	0	0	1	0	0	0
Lynx	0	0	0	0	0	0	0	0	0	0	0
Moose	11	10	5	11	9	12	10	8	6	3	4
Mtn. Goat	0	0	0	0	0	0	0	0	0	0	0
Mtn. Lion	0	0	0	0	0	0	0	0	0	0	0
Mule Deer	26	35	40	44	37	51	28	25	25	24	23
Raccoon	0	0	0	0	0	1	0	0	1	2	0
Whitetail Deer	0	1	0	2	2	2	2	0	0	0	0
Wolf	0	0	0	0	0	0	1	2	2	1	0
Wolverine	0	0	0	0	0	0	0	0	0	0	0
Total	**97**	**102**	**121**	**110**	**110**	**148**	**120**	**132**	**80**	**88**	**87**

[a] Species in which adults can reach a weight of 30 pounds or more.

wildlife disease sampling program. The primary objectives of the program are to:

- establish baseline disease data for wildlife species;
- establish disease monitoring protocols for wildlife species that can be used throughout the NPS System;
- survey and monitor wildlife for diseases and environmental toxins; and
- establish a wildlife serum and tissue bank for future analysis.

A Washington Office initiative funded the purchase of sample collection and storage supplies, basic training for park staff in wildlife necropsy techniques, and diagnostic services to be provided by the Wyoming State Veterinary Laboratory. Personnel costs remain unfunded, and carcasses are sampled on a time available basis only.

In 1999, carcasses of one grizzly bear cub-of-the-year, one black bear, two antelope, two bighorn sheep, and two mountain lions were collected. Necropsies were performed on the animals. The grizzly cub appeared to have died from intraspecific aggression by a larger grizzly bear. The adult male black bear died from wounds inflicted by a bear-vehicle collision. The mountain lions appeared to have died from intraspecific aggression from other male mountain lions. One antelope died due to predation by coyotes, and the other antelope appeared to have died by drowning. Both bighorn sheep (one ram and one female lamb) appeared to have died due to complications from pneumonia and malnutrition. In the case of the ram, complications related to old age also were a factor in the death.

After eight years (1992–99) of the program, 192 animals representing 35 different species have been sampled (Table 7). To date, significant findings of the program include:

1) **Rabies.** Tests conducted on 10 little brown bats, seven coyotes, one grizzly bear, two red fox, one silver haired bat, and one mouse were all negative.
2) **Canine parvovirus.** Evidence of canine parvovirus-induced mortality was found in coyotes on the northern range.

Table 7. YNP wildlife health samples, 1992–99.

Species	Number of Samples Collected
Antelope	5
Badger	2
Beaver	1
Bighorn Sheep	7
Bison	1
Black Bear	6
Bobcat	1
Bull Snake	1
Canada Goose	1
Coyote	47[a]
Deer Mouse	4
Elk	22
Great Blue Heron	1
Great Gray Owl	1
Grizzly Bear	4
Little Brown Bat	19
Long-tailed Weasel	4
Moose	5
Mountain Lion	3
Mule Deer	9
Osprey	1
Pine Marten	13
Raccoon	1
Red Fox	4
Red Squirrel	4
Ruffed Grouse	2
Short-tailed Weasel	2
Silver Haired Bat	1
Skunk	2
Snowshoe Hare	5
Uinta Ground Squirrel	4
Vole	1
White Pelican	1
White-tailed Jackrabbit	2
Yellowbelly Marmot	5
Total	**192**

[a] Includes 12 live coyotes sampled for external parasites. Wildlife DNA Tissue Banking Program.

3) **Canine distemper.** Canine distemper-induced mortality was found in a pine marten collected in the Old Faithful area.
4) **Vitamin deficiency.** A little brown bat collected at Grant Village had abnormally soft bones, possibly caused by a phosphorous or vitamin D deficiency.
5) **Louse infestation.** A juvenile white pelican collected from Yellowstone Lake may have died due to a heavy louse (*Piagetiella peralis*) infestation of the pouch.

6) **Intraspecific aggression.** Evidence of intraspecific and interspecific aggression in bears resulted in the deaths of a subadult female grizzly bear, a male COY grizzly bear, and an adult male black bear. Evidence of intraspecific aggression in mountain lions resulted in the deaths of a two-year-old male and a three-year-old male.
7) **Pasteurella and lungworm infestation.** A bighorn ram collected between Mammoth and Gardiner may have died due to lungworm parasites and *Pasteurella hemolytica* leading to pneumonia.
8) **Renal medullary amyloidosis.** A bighorn ewe collected between Mammoth and Gardiner died of trauma due to being hit by a vehicle. The ewe also had kidney lesions indicative of end- stage renal disease caused by amyloidosis.
9) **Pneumonia and malnutrition.** One bighorn sheep ram collected in the Lamar Valley and one bighorn sheep female lamb collected between Mammoth and Gardiner died from complications due to pneumonia and malnutrition. Old age was also a factor in the death of the bighorn sheep ram.

Wildlife DNA Tissue Banking. In 1999, DNA tissue and hair samples were collected from 11 antelope, two bighorn sheep, one black bear, one coyote, three moose, and two mountain lions. In addition, 15 DNA samples were collected from live mountain lions involved in a research project. After nine years of the program (1991–99), samples have been collected from 277 animals representing 11 species (Table 8).

Table 8. YNP wildlife DNA samples, 1991–99.

Species	Number of Samples Collected 1991–99	Number of Samples Still Needed
Antelope	23	27
Bighorn Sheep	8[a]	42
Bison	60	0
Black Bear	6	44
Coyote	22	28
Elk	50	0
Grizzly Bear	2[b]	48
Moose	30	20
Mountain Goat	0	50
Mountain Lion	21[c]	29
Mule Deer	54	0
Whitetail Deer	1	49
Total	**277**	**337**

[a] One sample collected outside YNP from herd that resides inside YNP for part of the year.
[b] These DNA samples are separate from the grizzly bear hair samples collected from hair snares on cutthroat trout spawning streams.
[c] Includes 17 live samples and samples from 4 dead mountain lions.

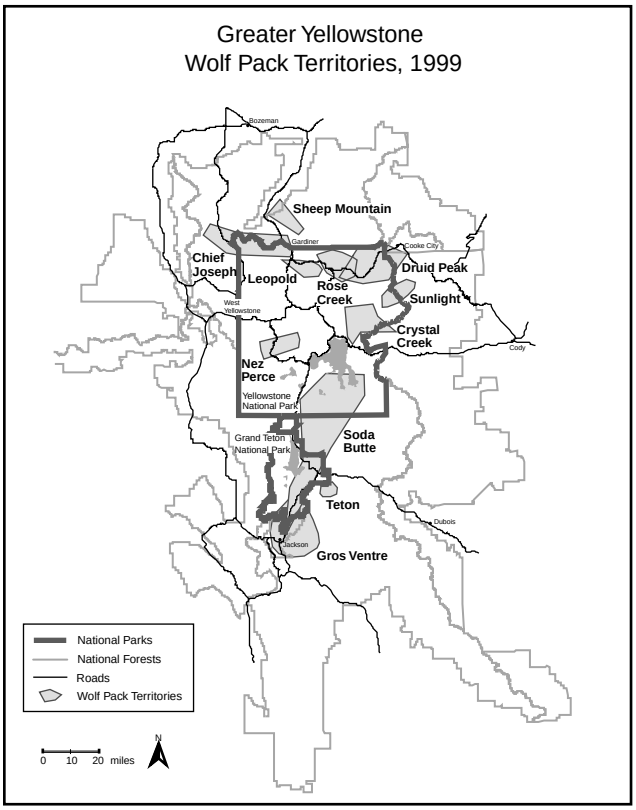
Wolves

Population Status

After a period of rapid increase during the first three years after reintroduction, the growth in the GYA wolf population slowed in 1999. At year's end, the population numbered approximately 118 individuals, 101 of which belonged to 11 packs. Three packs resided entirely outside YNP: two in Wyoming (Gros Ventre and Teton packs) and one in Montana (Sheep Mountain pack). There were no new packs that could be counted toward wolf population recovery in 1999. To meet the requirements for delisting the wolf as an endangered species, 10 breeding pairs with at least two pups-of-the-year that survive until December 31 are needed in each of the three recovery areas for three consecutive years. While eight of the GYA packs had breeding pairs that would count toward recovery, only six of these packs had two pups that survived to the end of the year. Of the five packs that did not count toward delisting, one pack did not breed, the alpha male in two packs died before year's end, and two packs had only one pup surviving as of December 31.

From 1995 through early 1999, Yellowstone National Park staff were responsible for wolf monitoring throughout the GYA. Beginning in February 1999, the U.S. Fish and Wildlife Service stationed two people in Lander, Wyoming, to assist with wolf monitoring and management, especially for wolves residing primarily to the south and east of the park.

Reproduction. At least 64 pups were born



in the GYA in 1999: 12 litters produced by 10 of the established packs, and one litter of three pups born to a wolf pair that is not considered part of an established pack. The only other established pack (Soda Butte) has not produced a litter since 1997. However, the Rose Creek pack had three breeding females, making 1999 the third consecutive year in which more than one Rose Creek female bred. The litters ranged in size from 1 to 7 pups and averaged 5.3 pups.

Only 38 (59%) pups were known to be alive at the end of 1999. This was the lowest annual rate of pup survival that has been recorded in the reintroduced GYA wolf population. (The survival rate ranged from 73% to 81% from 1996 through 1998.) At the end of 1999, 32 percent of the GYA wolf population was pups, compared to an average of 38 percent for the period 1995 through 1999.

Five of the females that bred in 1998 used the same den sites that they did in 1999. Three packs denned for the first time in 1999. Remote telemetry was again used to monitor two den sites on Yellowstone's northern range. Wolf pups in YNP were born between April 2 and April 27; their average birth date was April 13.

Mortalities. In addition to pups that died during spring and summer, 14 wolves are known to have died in the GYA in 1999: six (43%) adults, two (14%) yearlings, and six (43%) pups (born spring 1998). Ten of the losses were human caused: eight were due to control actions for livestock depredation; one was the result of a collision with a vehicle; and one was euthanized due to a capture-related injury. One wolf probably died of disease, two were killed by other wolves, and the cause of one death remains unknown. Ten of the deaths occurred outside the park. Since 1995, most wolf mortalities have been caused by humans in management actions, illegal killings, or vehicle collisions.

Population Movements

Wolf ranges in the GYA expanded very little in 1999, and the territories of the established packs remained essentially the same. The Chief Joseph II pack became autonomous from the Chief Joseph I pack and was renamed the Sheep Mountain pack. The Chief Joseph I pack was renamed the Chief Joseph pack. They ranged north of the park in the Gallatin National Forest. One new pack formed north of the park, but the alpha female died of unknown causes in late 1999. A disperser from the Rose Creek pack, she was the only collared individual in the group. The fate of her uncollared mate and their pups is unknown.

Several wolves dispersed from established packs late in 1999, but it is unknown whether any of these individuals will form new packs. Areas of new wolf activity included the Tower Junction and Sepulcher Mountain areas in northern YNP, the Absaroka-Beartooth Wilderness east of YNP, and the Gallatin National Forest northwest of YNP. Wolf pack territory sizes ranged from 88 km^2 (Sunlight Basin pack) to 2,419 km^2 (Soda Butte pack). Average territory size was 891 km^2.

Leopold pack. Similar to previous years, this pack primarily used the Blacktail Deer Plateau and Swan Lake Flats area in northern YNP. They reproduced for the fourth consecu-

tive year, and used the same den site for the third year in a row. Only one pup from the 1999 cohort survived, leaving a total of 11 wolves in the pack at year's end.

Chief Joseph pack. Considered separate from the Chief Joseph II (renamed Sheep Mountain) pack in 1999, the Chief Joseph pack ranged the northwest portion of the park, as it had from 1996 to 1998. They reproduced a third consecutive year and had six pups. Two pups were killed during a livestock control action that was prompted by their depredation on six sheep in Tom Miner Basin north of the park. This pack totaled eight wolves at the end of 1999.

Rose Creek pack. Another pack with a stable territory, the Rose Creek pack occupied the lower Hellroaring and Slough creek watersheds in the central portion of YNP's northern range. Together with the Crystal and Soda Butte packs, the Rose Creek pack is among the oldest in the GYA. As of early 1999, each of these packs still had their original alpha female from the 1995 reintroduction. Number 9, however, who has made the greatest genetic contribution to the GYA wolf population, was forced out of the pack in late 1999. Her daughter (uncollared #18) has assumed the alpha female role. Field observations indicated that #18 was dominant to #9 before #9 dispersed. Number 9 now resides east of the park in the Absaroka-Beartooth Wilderness and is loosely affiliated with three other wolves. Three Rose Creek females (#9, #18, and #78) produced litters in separate dens during 1999. Number 78 produced five pups, three of which were known to have survived to the end of the year. However, #78's group never rejoined the Rose Creek pack after denning. Most non-alpha wolves in this pack focused their activity around #18's den and her seven pups. Number 9 produced six pups at a new location and raised them with little support from the core pack members. All Rose Creek wolves, except #78's group, used their traditional Buffalo Plateau rendezvous site. Only six total pups from #18 and #9 survived to year's end. At 16 individuals, this is still the largest GYA pack.

Druid Peak pack. The last of the "big three" (Leopold, Rose, and Druid—called the big three because they are so visible and so much is known about them), the Druid Peak pack lived in Lamar Valley. From 1996 through the end of 1999, approximately 50,000 visitors had seen this pack, arguably making them the most viewed wolf pack in the world. They had one litter of six pups, but only two survived. Number 42 (#40's subordinate sister) also denned, but it is unknown if she whelped or experienced a pseudopregnancy. Shortly after #42 localized near a den hole, #40 attacked #42, which could have affected any pups she might have been tending. After #42 abandoned her den hole, an examination of the area never produced any evidence that she had pups. Afterwards, #42 rejoined the main pack. The Druid Peak pack comprised eight wolves at the end of 1999.

Crystal Creek pack. Carving out a year-round existence in Pelican Valley, the Crystal Creek pack has learned to kill bison. The Pelican Valley area, which supports many elk during the snow-free portion of the year, supports very few during the winter. However, several hundred bison live in Pelican Valley, no matter how severe the winter. When bison weaken during late March due to protracted winter conditions, the Crystal wolves increase their frequency of bison kills. In 1999, wolf project field workers observed two bison being killed by the Crystal Creek wolves—both in March. Ten and 14 wolves were involved with the kills, suggesting that it may take more wolves to bring down a bison than it does an elk. Only one pup was observed in the Crystal Creek pack, which had a total of 13 wolves at the end of 1999.

Soda Butte pack. Ranging over the largest area of any pack in the GYA, the Soda Butte pack's territory ran from Jackson Hole to Hayden Valley in YNP. They did not reproduce for the second consecutive year. Alpha female #14 was still without a mate in late 1999, even though she traveled briefly with male #104. About the time #14 was observed with #104, four other pack members (#44, #123, #124, and #126) dispersed. Both #123 and #124 perished, #123 in a fight with the Crystal wolves and #124

due to unknown causes. Number 44 and #126 eventually reunited with #14 to form a pack of three at the end of the year.

Nez Perce pack. Ten wolves were brought from northwest Montana in late 1996 and released in YNP in early 1997. However, eight of the wolves were subsequently removed due to conflicts with livestock. The other two wolves, #70 and #72, survived and are still members of this pack, which resides in the Madison-Firehole area of the park. This pack has also killed bison, and it is the only pack in the GYA that is comprised entirely of gray-colored wolves. In 1999, this pack chose a new den site and produced a litter of five pups, all of which apparently survived through the end of the year, bringing the total pack size to 13 wolves.

Wolf Management Activities

Radio-collaring. This was the second year that a systematic radio-collaring effort took place in YNP. The primary purpose of collaring is to permit monitoring of wolf population dynamics, which is needed to document population recovery for the purpose of delisting the wolf as an endangered species. Twenty-four wolves from seven packs were darted from a helicopter in January and February. The age composition of these wolves was 13 pups (54%), 7 subadults (29%), and 4 adults (17%). Ten males and 14 females were captured. As a result of this effort, 23 wolves from seven packs received radio-collars; the total number of collared wolves at the end of 1999 was 47.

Two Druid Peak wolves were tranquilized and fit with radio collars while biologists collected scientific data. Photo by William Campbell.

One wolf was hit in the leg by a dart, which produced a compound fracture. The two veterinarians who examined the animal both gave it a minimal chance of survival in the wild after treatment. This has been the only wolf that has had to be euthanized in 183 captures.

Wolf condition again appeared exceptionally good. The range of weights for all age and sex classes was 90–130 pounds. Adult females averaged 108 pounds. No adult males were captured. Male and female pups averaged 107 and 96 pounds, respectively.

Denning area closures. To prevent human disturbance of young pups, visitor entry was closed to areas surrounding the dens of the Rose Creek and Druid Peak packs from May 3 to June 30 and from April 16 to July 30, respectively. Closed areas were about four square miles and were centered around the dens. A no-stopping zone was also instituted along the road to Cooke City near the den of the Druid Peak pack to discourage visitors from parking their vehicles outside established turnouts and to keep them from stopping near wolves that were trying to cross the road near the den. Hiking trails in the vicinity of the Rose Creek and Druid closures remained open to visitors. The Daly Creek drainage southeast of the Daly Creek trail was closed to protect Chief Joseph pups from about April 15 to June 15. The trail and the area northwest of the trail remained open to hiking. Newborns at the den sites for the Leopold, Crystal Creek, and Nez Perce packs were protected from disturbance incidental to closures for the Blacktail (March 10 to June 30), Pelican Valley (April 1 to July 3), and Firehole (March 10 to about May 26) bear management areas.

Pen removal. The wolf acclimation pens were removed from the Trail Creek and Fishing Bridge sites during late August 1999. Responsibility for the Trail Creek pen was transferred from the NPS to the U.S. Fish and Wildlife Service. The panels used to construct the pen were transported to the Flying-D Ranch near Bozeman, Montana, to support research on captive wolves with a history of depredation.

Predation on domestic animals. Wolves killed 4 cattle, 13 sheep, 1 foal, and 6 dogs in the GYA during 1999. Although this is more than the total of 15 domestic animals killed by wolves in 1998, it is far fewer than the 72 losses that occurred in 1997. Eight wolves in the Chief Joseph and Sheep Mountain packs were killed during control actions in response to livestock losses; none of them were translocated.

Research Projects

Wolf-prey relationships. Wolf-prey relationships were documented by observing wolf predation directly and by recording characteristics of wolf prey at kill sites. Wolf packs were monitored during two winter-study sessions, when wolves were intensively radio-tracked each day for 30 consecutive days during March and November–December. The Leopold, Rose Creek, and Druid Peak packs were monitored by two-person teams from the ground and from aircraft; the Chief Joseph, Crystal Creek, Soda Butte, and Nez Perce packs were monitored from aircraft only. Behavioral interactions between wolves and prey, predation rates, the total time wolves fed on their kills, the percentage of consumption of kills by wolves and scavengers, condition of wolf prey, and characteristics of kill sites were recorded and entered into a database. The abundance and sex-age composition of elk within wolf pack territories were also estimated.

Project staff detected 110 definite and 206 probable kills made by wolves in 1999, including 276 elk (87%), 14 bison (4%), 7 moose (2%), 2 mule deer (<1%), 3 coyotes (1%), 1 short-eared owl (<1%), 1 wolf (<1%), and 12 unknown prey (4%). The composition of elk kills was 44% calves (0–12 months), 21% cows, 22% bulls, 4% adults of unknown sex, and 9% elk of unknown age and sex. Bison kills included nine calves, two cows, and three adults of unknown sex. Moose kills included two calves, two cows, and three adults of unknown sex. Most bison and moose were killed during late winter. Packs that resided on the northern range averaged one ungulate kill every one to three days during March and one kill every two to three days during November–December.

Wolf genetics studies. Familial relationships among Yellowstone wolves were estimated using microsatellite analysis of DNA that was collected from live-captured or dead wolves, 1995 to 1999. Ninety free-ranging wolves born in nine different packs were genotyped at 23 loci. A wolf pedigree was constructed. Preliminary results suggested that immediately after reintroduction, Yellowstone wolves were more polygynous than in areas characterized by wolves in long-standing populations. This work is a collaborative effort with Eric Mathur and Dorris Hafenbradl at the Diversa Corporation, Janet Zeigle and Larry Joe at the Celera Agen Corporation, Dr. Karl Broman at Johns Hopkins University, Dr. Michael McClelland at the Sidney Kimmel Cancer Center, and John Varley and Sarah (Broadbent) Stevenson in the YCR.

Collaborative research. The wolf project provides financial and in-kind support for collaborative research by graduate students and other research scientists affiliated with other institutions, primarily universities. In 1999, wolf project personnel assisted in supervising five graduate students whose topics included: leadership—ecological implications of social behavior in gray wolves; hunting success of gray wolves and pursuit deterrence signals of elk in Yellowstone; spatial and temporal variability of Yellowstone's northern range elk herd in wolf pack territories; common ravens following gray wolves as a foraging strategy in Yellowstone; and denning behavior of wolves on Yellowstone's northern range. Other collaborative research included: wolf-cougar interactions (Hornocker Wildlife Institute); wolf-coyote interactions (Yellowstone Ecosystem Studies); wolf-elk relationships in the Firehole watershed, and wolf stress hormones (Montana State University); wolf-scavenger relationships (California State University, Berkeley); wolf-carnivore-human interactions (Hornocker Wildlife Institute; Interagency Grizzly Bear Study Team; USFS, Gallatin NF, Gardiner District; and Montana Dept. of Fish, Wildlife and Parks).

Thermal area inventory including GPS point locations. NPS photo.

Part IV. Yellowstone Center for Resources and Parkwide Support

This section describes the work accomplished or coordinated by the YCR staff who provide services for other YCR branches and other park divisions:

- The Spatial Analysis Center, responsible for the park's geographic information system, global positioning systems, and other resource databases;
- Resource Information, which produces publications and provides special programs on natural and cultural resource topics;
- Research Support, which oversees the permitting process for visiting and park researchers; and
- Funding and Personnel Support for the YCR Division.

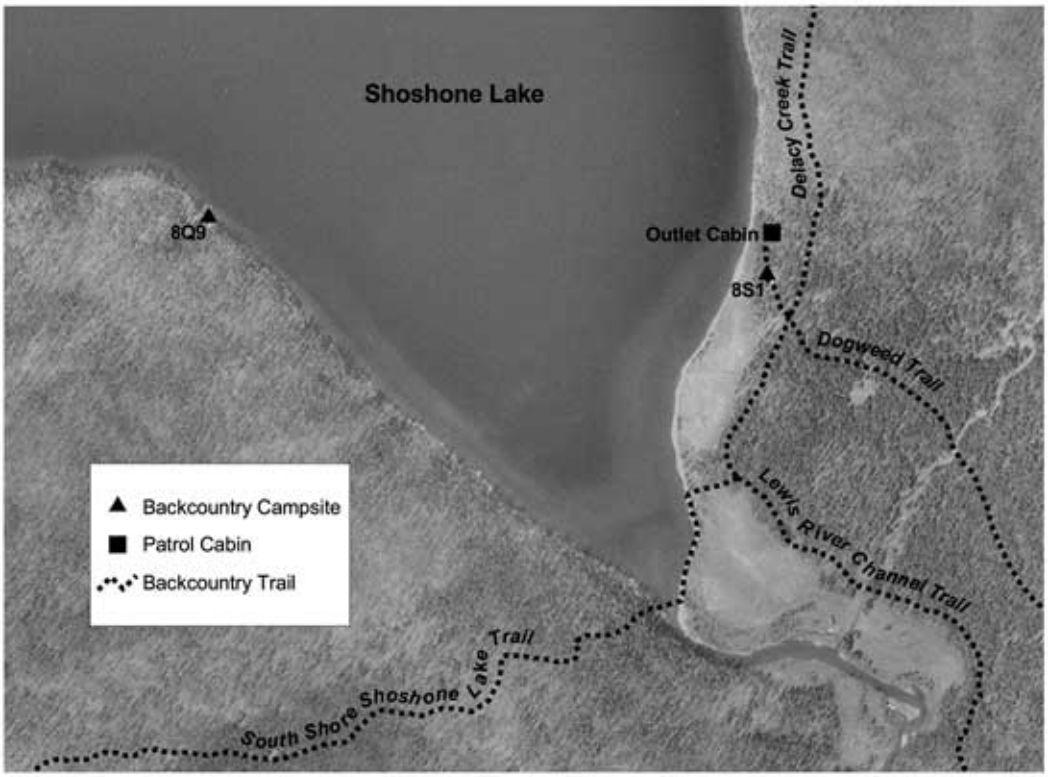
Spatial Analysis Center

The Spatial Analysis Center (SAC) is the home of the park's geographic information system (GIS), global positioning systems (GPS), image analysis, soil information support, and a park resource database system. Its main business is the acquisition, analysis, organization, presentation, and storage of information, especially that concerning the park's cultural and natural resources. SAC's goals are to maintain an up-to-date GIS lab, provide GPS equipment and expertise, increase the GIS and GPS skill level of park staff, acquire new data and make it useful, provide information and technical support to park staff, and make information available to outside agencies and the public.

SAC supports a wide variety of projects, including viewshed modeling for cellular telephone tower installation, whooping crane historic distribution maps, resource maps for proposed construction sites, prescribed burn site maps, database construction for GYA weed locations, maps of different alternatives for the bison EIS, and detailed geyser basin maps for visitor centers. The

following are some of the other projects that SAC staff supported or initiated during 1999:

- Over the last three years, SAC staff have been working with the Maintenance and Resource Management Operations and Visitor Protection divisions to create accurate spatial layers for all the back-country trails, campsites, trail bridges, and cabins in the park. The database has been built by walking every trail and visiting every campsite with a GPS unit. Almost all of the field data collection was completed in 1999. In 2000, these data layers will be error-checked and available from the GIS lab.
- A river and stream hydrology layer was completed, which includes all the "blue lines" (indicating water sources) found on the USGS 1:24,000 quadrangle maps. In addition to feature names, the SONYEW numbers used by the Aquatic Resources Center were added, allowing information about fish populations, water quality, and macro-invertebrates to be joined to the stream segments.
- A spatial inventory of thermal areas, including point locations collected with GPS units and converted into GIS layers, was continued. Data such as temperature, pH, and conductivity were also collected and attached to each point location, along with a digital photograph of the feature. In 1999, 1,200 features in the Upper and Lower geyser basins, Gibbon Geyser Basin, Smoke Jumper Hot Springs, and Shoshone Geyser Basin were added to the 1,100 features surveyed in 1998.
- Spatial databases were created for eight research exclosures (two near Gardiner, one in Mammoth, two on Blacktail Deer Plateau, one near Trumpeter Lake, and two in Lamar Valley) built in the late 1950s and early 1960s. The information includes the actual fence lines, plus the locations of transects, witness posts, photo points, and quadrant points.
- Eighty-three borrow pits have been documented in a spatial database. At-



A map created by the Spatial Analysis Center, with accurate spatial layers for backcountry trails, campsites, and cabins.

tributes such as pit name, deposit type, total area, disturbed area, former use, existing use, and comments about visibility are included along with the pit location.

- SAC staff worked to share cross-boundary data of mutual interest with a variety of different agencies, including Gallatin County, Montana; United States Forest Service (Gallatin, Targhee, Bridger-Teton, and Shoshone national forests); Montana Fish, Wildlife and Parks; Montana State University; University of Wyoming; and many others.
- An accurate GIS layer of all park buildings is nearly complete. The database has links to building databases maintained by the Maintenance and Concessions divisions, the cultural resources branch, and the park's concessioner, AmFac Parks and Resorts.
- Using very accurate GPS units, SAC staff updated the GIS layer of the park's road system. All secondary and service roads are now included along with the main road system. The data includes attributes such as name, road type, speed limit, and road condition.
- SAC staff continued to support projects associated with the Federal Highways program. This involved continuing to update databases for rare plants, archeology sites, and wetlands. In addition, SAC staff provided GPS support for mapping rare plant locations, delineating wetlands, and documenting archeological sites and historic structures.

New Hardware and Software

SAC continued to run its GIS software on Windows NT. In 1999, a powerful server and five new computers were added to the GIS lab, bringing the total number of computers with GIS capability to 14. A scanner, two digital cameras, and another CD writer were also added to the lab. Two image processing software packages, ERDAS Imagine and Environmental Systems ENVI, were purchased to classify remotely sensed images. This is a very cost-effective method of data collection for updating existing layers and detecting changes over time. Five new GPS units were added—a Trimble GeoExplorer II, a Rockwell PLGR, and three Trimble ProX units. Software and dataloggers were upgraded on the six older units, bringing the total number of GPS units available for staff use to 11.

Resource Database Development

SAC staff continued work on a database designed to make relevant resource and infrastructure information more accessible to people involved with project planning, compliance, and implementation. It involved the development of detailed GIS layers tied to a database of information about each developed area and road corridor. The information will include data about historic structures and other important cultural resource information, surficial and bedrock geology, soils, wetlands, important natural resources (*e.g.*, threatened and endangered species, species of special concern, important or delicate habitats), existing infrastructure (roads, trails, and buildings), and other subjects of interest. A simple interface will be developed in 2000, allowing the user to query the database and create maps, charts, and reports. It will also be possible to attach photographs, drawings, and other scanned documents that help clarify a resource situation. This database will be accessible over the park's Intranet.

Outreach

SAC staff continued to make GIS technology directly available to park employees by providing equipment, data, and training. The GIS Lab is available to all employees, and spatial data is accessible over the park network. SAC staff also continued to support GIS software on computers outside of the lab and provide data on CDs to those who were not networked. In November 1999, SAC staff taught a three-day, beginning ArcView class to 15 Yellowstone employees. SAC staff also provided GPS training that included collecting field data with GPS units,

differentially correcting the GPS data, and converting this corrected data into usable GIS layers.

Resource Information

Publications

Several staff changes occurred in the resource information group in 1999; technical writer-editor Sarah (Broadbent) Stevenson moved on in June after more than a decade with the park, and visual information specialist Renée Evanoff reduced her workload to intermittent to accommodate another business opportunity. This made for a noticeable lull in the publication production schedule, marked by the omission of one volume of the typically quarterly *Yellowstone Science,* and fewer than usual issues of *The Buffalo Chip* for the year. The continued outstanding contributions of returning volunteers, writer Mary Ann Franke, retired wildlife biologist Dr. Jim Caslick, and capable assistant Edna Caslick, prevented the flow of resource publications from grinding to a halt.

In its seventh year, *Yellowstone Science* featured articles on the previously missing pages of the Folsom-Cook-Peterson expedition diary, the history of snowmobile use in the park, Yellowstone's amphibians, coyote ecology, whooping cranes, and the use of ground-penetrating radar around Mammoth Hot Springs. One issue featured the complete printed versions of speeches made to the National Academy of Sciences committee reviewing ungulate management in the park. Donations continued to help support the annual printing costs of *Yellowstone Science,* the rest of which were paid through a generous grant from the Yellowstone Association.

The most noted contribution was completed production of the 1999 *State of the Park* report, a 300-page summary of park programs and resources in all disciplines. Done at the request of the park superintendent, the report was begun in 1997 in what was initially envisioned as part of the park's 125th anniversary celebration. Instead, it became Part I of the park's *Business Plan,* and the precursor to a briefer, corporate annual report-type document outlining the standards the park wishes to maintain and the resources needed to provide such service.

Other publications produced in 1999 included the *Yellowstone Center for Resources Annual Report, 1998;* the *1998 Yellowstone Wolf Project Annual Report,* and reports on *Pronghorn Distribution in Winter, 1998–1999,* and the *1998 Beaver Survey.* YCR writers authored features for the quarterly park newspapers handed out to all visitors entering Yellowstone's gates, and contributed to several projects undertaken by the Interpretation Division, such as the development of new wayside exhibits on the northern range and thermal features in the Old Faithful area. Resource information staff assisted the planning office with the layout and printing of *Winter Visitor Use Management: A Multi-Agency Assessment* and *Effects of Winter Recreation on Wildlife of the Greater Yellowstone Area: A Literature Review and Assessment*. Resource information staff again provided assistance to the landscape architecture branch for Yellowstone's *Design Standards*, and helped various staff produce slides and graphics to illustrate their oral and written presentations.

Fifth Biennial Science Conference

Resource information staff provided planning and logistical support for the park's fifth biennial science conference on the Greater Yellowstone Area. Planning actually began in 1998, with the chosen theme of "Exotic Organisms in Greater Yellowstone: Native Biodiversity Under Siege." The "virtual" program committee convened in February 1999 and accepted papers from more than 35 speakers. The visual information specialist designed special artwork to promote the conference through registration materials in print and on the park's website. Publications staff also prepared

and distributed a program of abstracts and agendas highlighting the featured guest speakers: Dr. Daniel Botkin from University of California at Santa Barbara, who presented the Superintendent's International Luncheon Lecture; Dr. Holmes Rolston from Colorado State University, who presented the Aubrey L. Haines Lecture; and Dr. Barry Noon, also from Colorado State, who presented the A. Starker Leopold Lecture.

About 150 persons attended the conference, which was held at the Mammoth Hotel. Conference registration fees adequately covered the expenses associated with speakers' travel and conference logistics and promotion. An arrangement was made with the editors of the former *Great Basin Naturalist*, now the *Western North American Naturalist* journal, to peer review and publish accepted manuscripts submitted by conference participants in lieu of the less-prestigious conference proceedings. Publication will likely occur in 2001.

Dr. Daniel Botkin of the University of California at Santa Barbara presented the 1999 Superintendent's International Luncheon Lecture, "The Naturalness of Biological Invasions." Photo by Paul Schullery.

Presentations, Field Trips, and General Information

Resource Management Specialist (writer-editor) Sue Consolo Murphy responded to some 100 written requests, phone calls, and e-mail inquiries about varied topics, especially ecosystem management, biodiversity, human-wildlife interactions, wildland fire, threatened or endangered species, elk and northern range management, bison management, geology and geothermal activity, and finding employment in Yellowstone or other national parks. She presented 24 illustrated programs as an invited speaker to schools or other organizations in the ecosystem and to groups visiting the park, and arranged for other YCR staff to give talks on topics including those mentioned above as well as aquatic resources management, bioprospecting, bison management, elk and the northern range, and park geology. YCR staff gave a total of at least 139 programs in 1999, and could not accommodate all requests for educational services.

Resource seminars presented by visiting scientists and managers covered "Yellowstone roads—a cultural landscape"; impacts of human activity on bighorn sheep; the response of willows to ungulate browsing on the northern range; the brown bears of Katmai, Lakota star knowledge, and the value of hyperspectral imagery. Resource information staff also taught or assisted with *Yellowstone Institute* courses on wolves, grizzly bears, birds, plants, and small mammals. They gave dozens of interviews and hosted national and international visitors, providing special tours in the field for many of these guests. Resource information staff provided updates for the park's annual interpretive training, the annual resource management workshop, and both NPS and concession employee orientation sessions. Additional information and publi-

cations were added to the park's website, with a considerable backlog of additions still needed there.

Contributions to Other Projects

The resource management specialist continued to participate on an interagency team preparing a Conservation Strategy for long-term management of grizzly bears in greater Yellowstone, and with the interpretation and education subcommittee addressing public release plans for the strategy. Writer-editor Sarah (Broadbent) Stevenson continued to facilitate analysis and interpretation of data on wolf genetics and paternity. She arranged logistics for and participated in a workshop held at the Lamar Buffalo Ranch in the spring, attended by park wolf biologists and technicians from the Diversa Corporation and ZooGen laboratories.

Research Support

Yellowstone has been a magnet for scientific research on everything from archeology to zoology since 1871, when geologist Ferdinand Hayden organized one of the first expeditions into the region. In 1898, the first formal research permit was issued to William Setchell for the study of Yellowstone's microorganisms. Since then, the park has continued to be an important resource to the scientific community, and discoveries made in the park have made significant contributions to scientific knowledge.

Yellowstone's mission to preserve its resources "unimpaired for future generations" makes research support possible. This mission has resulted in a nearly intact ecosystem, complete with tourist amenities. Yellowstone's preserved environment offers an unparalleled place for scientific study. Equally important to Yellowstone researchers is the National Park Service's commitment to make scientific study a priority in determining appropriate activities within the park.

Scientists who study life in extreme environments travel the globe to find the most inhospitable habitats. They go to Antarctica, mid-ocean ridges, super salty tidal flats, the Dead Sea, the Atacama desert where rain never falls... and Yellowstone National Park! Yellowstone's preserved thermal habitats are home to a wide array of unknown microorganisms. Even though microbiologists have barely begun to even identify the microorganisms present in the park,

A dead tree root wad found on Mt. Washburn by researcher Dr. Lisa J. Graumlich of the Mountain Research Center at Montana State University. Pieces of this and similar trees contributed to the first tree ring chronology in the park to go back over 1,500 years. Photo courtesy Dr. Graumlich.

One of many formations in Monument Basin that appears similar to the spires recently discovered on the bottom of Yellowstone Lake. Some of the hundreds of newly discovered pinnacles and spires in the lake are over 60 feet tall. Photo courtesy researcher Dr. Lisa Morgan of the U.S. Geological Survey.

their work has already had a significant impact on science and society.

For example, Yellowstone research microbiologists have contributed to:

- insights into the evolution of life on Earth;
- planning for the search for life on other planets;
- redefining the relationships among living things (plants, animals, bacteria) based upon their genetic similarities and differences;
- discovering how the global ecosystem cycles elements through microbial action; and
- one of the most widely used techniques for DNA fingerprinting.

Yellowstone microbiologists are asking and attempting to solve questions such as:

- Can bioremediation techniques be developed to clean up a variety of toxic wastes?
- Is it practical to use a newly invented method (rather than the current method using toxic chemicals) to remove aircraft paint?
- How can the study of thermophiles teach us about repairing DNA or withstanding toxic doses of radiation?
- How will we recognize fossils from other planets that are evidence that life existed on those planets?
- Can a method be invented to more accurately diagnose brucellosis in bison?

In 1999, 256 research projects were approved; 71 were new, and 185 were continued from previous years. An additional 20 investigators were assisted as they explored the possibility of performing research in Yellowstone, but they never submitted formal applications. About 30 percent of all hypothesis-driven research in Yellowstone attempts to answer questions related to the park's extraordinary animals, such as birds, bugs, and buffalo. Nearly 20 percent of hypothesis-driven research relates to microorganisms, and another 20 percent is dedicated to geology. Studies of the park's aquatic systems and plant populations each account for another 10 percent of research projects. The remaining projects include such important endeavors as archeological surveys, air quality studies, fire conditions monitoring, and paleontology. In addition, 10 percent of all research permits are not driven by the search to prove or disprove a hypothesis. These permits support the education of future scientists by allowing students and their teachers to conduct simple scientific studies in the park.

The responsibility for ensuring that all research activities in Yellowstone are in keeping with the park mission is vested in a Research Review Committee composed of representatives from the Yellowstone Center for Resources, the Office of Planning and Compliance, and the Resource Management Operations and Visitor Protection, Maintenance, and Interpretation divisions. As part of the NPS system of research monitoring and reporting, each year researchers who have been granted permits are required to submit a summary of their work that is published in the park's *Investigators' Annual Report*. The 1997–98 *Investigators' Annual Reports* are available on Yellowstone's web site at *www.nps.gov/yell*.

Funding and Personnel

Base Operating Budget

A base operating budget of $2,531,900 for the YCR was approved by Superintendent Finley in February 1999. This represented an increase of $286,300 over FY98 funding levels. The increase was used to cover salary and benefits increases and to re-establish professional resource management positions in the fields of biology and geology.

Additional Funding

Recreation Fee Demonstration funds. On June 26, 1999, YCR Director John Varley and Budget Analyst Melissa McAdam attended a senior staff meeting called by Superintendent Mike Finley and Assistant Superintendent Marv

Table 1. Projects funded in 1999.

PROJECT TITLE	APPROVED FY99 $	PROJECT LEAD
Develop GIS Databases Yellowstone's Developed Areas Historic Structures (year 1 of possible 3)	$84,000	Ann Rodman
Study Northern Yellowstone Pronghorn Ecology Phase I: Pronghorn Fecundity Study	$90,000	Wendy Clark
Heritage & Resource Center Site Analysis and Preliminary Design (FY98 authorized $30,460 + FY99 authorized $19,540 = $50,000 total for project)	$19,540	Laura Joss & John Sacklin
Make Photo Archives & Museum Collection Accessible via Internet/WWW	$25,000	Susan Kraft
Install Electronic Fish Counters on Remote Spawning Streams	$25,000	Dan Mahony
Grizzly Bear DNA Analysis	$10,000	Kerry Gunther
Rehab Museum Areas for Visitor Access, Safety, Resource Protection	$15,000	Susan Kraft
Conduct Oral History Interviews on Bison/Other Ungulate Management History	$10,000	Lee Whittlesey
Install Aspen Research Plots	$10,000	Roy Renkin
Inventory Geothermal Features	$10,000	Ann Rodman

Jensen to re-authorize funds for FY98 Recreation Fee Demonstration projects and to distribute approximately $2.1 million for FY99 project starts. Because the Fee Demonstration program emphasizes infrastructure improvements, one million dollars of the total available was set aside for the Maintenance Division, and the remaining funds were distributed among all other projects. The YCR submitted 19 new cultural, natural, and GIS projects, of which 10 were at least partially funded, for a total of $298,540. In addition, approved project proposals submitted by the Maintenance Division and the planning office contained allowances for archeological compliance and bison winter studies.

Funding for the projects in Table 1 was approved for FY99 only; requests for funds to continue these projects beyond FY99 will be evaluated in the future. In some cases, the superintendent was only able to provide "seed" money to start the planning process or to explore the feasibility of projects.

Fishing fee program. The YCR received authorization to use $285,000 from fishing permit fee revenue to partially cover the estimated $400,000 total cost of the aquatic resources program in FY99.

Federal Lands Highway Program. Federal Highways funded $396,500 for natural resource inventories, archeological surveys, and resource compliance along the road corridors in the park scheduled for major repair or reconstruction in the near future.

Special Emphasis Program Allocation System. The Branch of Natural Resources did not receive any funding for proposals submitted for consideration under this funding source in FY99.

The Branch of Cultural Resources successfully competed for a total of $221,900 in Cultural Resource Preservation Program and related funding. These funds were used for archive and library preservation projects, updating accession records, historic photo collection storage, National Register evaluations and nominations of archeological sites, and cataloging part of the backlog of museum collection items.

Other Park Service and federal funds. The YCR administered funds and provided support for a number of other federally-sponsored projects in FY99, most significantly the bison management plan and court-ordered environmental impact statement ($74,600), the National Spatial Data Infrastructure information center ($25,000), and USGS grizzly bear studies

and bison-related research ($76,500),

A Challenge Cost Share grant of $4,000 was awarded to park archivist Lee Whittlesey for improvements to the Yellowstone Research Library database, allowing better public access to the collection. Another $1,400 was allocated to produce research copies of fragile historic photographs. Both projects were co-sponsored by the Yellowstone Association.

Private funds. A total of $56,700 was donated to the park by private organizations or individuals for support of wolf recovery program operations, whirling disease surveys, and bear management operations.

Personnel

There were 151 personnel actions processed in FY99. Of special note were the following:

- Glenn Plumb, formerly of Badlands National Park, entered on duty early in FY99 as the Supervisory Wildlife Biologist for the park.
- Regional Archeologist Ann Johnson transferred to the Yellowstone payroll half-time beginning in FY99 and became a full-time Yellowstone employee effective FY2000 (October 1999).
- Recruiting efforts for a supervisory fisheries biologist, a supervisory geologist, and a geothermal geologist were ongoing at the close of FY99 after being delayed by a hiring freeze imposed late in FY98.

Contracting

Twenty-seven contracting actions were processed in FY99, totaling obligations of $742,600 in contracts or task agreements. These mainly involved five projects: the Yellowstone Thermophiles Conservation Project, the Montana Water Compact, archeological surveys and evaluations, bison/brucellosis research, a pronghorn antelope study, and support of the Greater Yellowstone Data Clearinghouse project at Montana State University.

Procurement Actions

There were 853 procurement actions processed in FY99, totaling approximately $631,200.

Clerical Support

There were 851 pieces of correspondence and 276 travel authorizations processed in FY99.

Ann Johnson, Yellowstone's full-time archeologist. NPS photo.

Table 2. Yellowstone Center for Resources distribution of FY99 funds.

Program	Park Base	CRPP	NRPP	Fish Fee	FLHP	Fee Demo	Other NPS	Other Federal	Private	Total	% of Total
Center Support/Science	691,100	-	-	-	-	-	16,000	-	-	707,100	17.5%
Natural Resources	1,274,400	-	-	285,000	177,100	135,000	44,900	53,700	56,700	2,026,800	50.1%
Cultural Resources	285,000	221,900	-	-	177,400	69,540	5,400	-	-	759,240	18.8%
Resource Technology	165,000	-	-	-	42,000	94,000	2,000	25,000	-	328,000	8.1%
Bison Management EIS	116,400	-	-	-	-	-	84,588	26,500	-	227,488	5.6%
Total	**2,531,900**	**221,900**	**-**	**285,000**	**396,500**	**298,540**	**152,888**	**105,200**	**56,700**	**4,048,628**	**100.0%**

Table 3. Funding History of the Yellowstone Center for Resources.
(Records prior to 1993 reflect funding only for the former Research Division.)

	National Park Service Funds											
FY	ONPS	Fees	PFRP	NRPP	CRPP	WRD	FLHP	Fee Demo	Other	USFWS	Oher Federal	Private	Total
83	165,500	-	-	-	-	-	-	-	-	104,000	-	-	269,500
84	501,300	-	-	-	-	161,400	-	-	-	104,000	-	-	766,700
85	588,400	-	-	-	-	133,000	-	-	-	104,000	-	3,512	828,912
86	607,400	-	-	150,000	-	112,000	-	-	-	136,550	-	9,310	1,015,260
87	719,300	-	-	200,000	-	108,000	-	-	-	115,000	-	6,758	1,149,058
88	767,000	170,000	-	250,000	-	172,000	-	-	-	104,000	5,400	2,824	1,471,224
89	793,400	406,000	1,863,000	56,000	-	108,000	-	-	-	133,000	4,000	3,017	3,366,417
90	847,400	-	755,000	56,000	-	75,000	-	-	-	111,650	12,000	2,157	1,859,207
91	916,300	-	785,200	56,000	-	-	-	-	-	148,123	15,000	55,101	1,975,724
92	1,025,660	-	685,000	25,000	-	-	-	-	-	182,050	10,000	10,100	1,937,810
93	1,004,600	-	785,000	16,000	-	-	-	-	-	188,000	-	20,000	2,013,600
94	1,250,000	65,000	-	260,000	33,200	156,000	43,300	-	164,600	55,000	24,600	10,000	2,061,700
95	1,500,000	65,000	-	420,000	45,000	6,800	303,600	-	53,000	20,000	-	5,300	2,418,700
96	1,544,100	274,500	-	404,000	201,100	119,800	626,700	-	38,000	-	64,958	31,504	3,304,662
97	1,674,100	213,400	-	204,000	228,400	-	433,700	340,600	42,700	-	398,300	48,000	3,583,200
98	2,245,600	284,800	-	130,500	242,100	24,000	330,800	31,000	-	-	65,300	37,700	3,391,800
99	2,531,900	285,000	-	-	221,900	-	396,500	298,540	152,888	-	105,200	56,700	4,048,628

APPENDIX I. PERSONNEL ROSTER FOR FISCAL YEAR 1999

		FTE	Borrowed FTE
Headquarters/Professional Support			
Tami Blackford	Secretary/Editorial Assistant	0.69	
Wayne Brewster	Deputy Director	1.00	
Sarah (Broadbent) Stevenson	Technical Writer-Editor	0.79	
Ann Deutch	Administrative Assistant	0.83	
Renée Evanoff	Visual Information Specialist	0.42	
Mary Ann Franke	Resource Naturalist	0.17	
Sara Housley	Clerk Typist	0.37	
Melissa McAdam	Budget Analyst	1.00	
Sue Consolo Murphy	Resource Management Specialist	1.00	
Joy Perius	Administrative Assistant	1.00	
Paul Schullery	Resource Naturalist	0.40	
Stacy Stermitz	Secretary	0.88	
John Varley	Director	1.00	
Advanced Resources Technology/Spatial Analysis Center			
Michael Heiner	Computer Operator	0.09	
Nils Johnson	Computer Operator	0.21	
Viktoria Magnis	Computer Operator	0.82	
Jason Mann	Computer Operator	0.25	
Kirk Meyer	Computer Operator	0.23	
Ann Rodman	Soils Scientist	1.00	
Shannon Savage	Computer Operator	1.00	
Aaron Smith	Computer Operator	0.22	
Rachel Webb	Computer Operator	0.25	
Natural Resources			
Rebecca Anthony	Biological Science Technician	0.45	
Timberley Belish	Biological Science Technician	0.07	
Mark Biel	Biological Science Technician	1.00	
Jennifer Carter	Biological Science Technician	0.86	
Wendy Clark	Wildlife Biologist	1.00	
Stu Coleman	Chief, Branch of Natural Resources	0.26	
Shanna Driscoll	Biological Science Technician	0.09	
Brian Ertel	Biological Science Technician	1.00	
Trisha Giambra	Biological Science Technician	0.44	
Jerry Gitter	Survey Technician	0.06	
Rachael Gray	Biological Science Aide	0.23	
Deb Guernsey	Program Assistant	1.00	
Kerry Gunther	Wildlife Biologist	1.00	
Mary Hektner	Resource Management Specialist	1.00	
Christie Hendrix	Biological Science Technician	0.44	
Bryan Irvin	Biological Science Technician	0.15	
Sharit Koser	Biological Science Technician		0.07
Gregg Kurz	Biological Science Technician	1.00	
Meredee Lloyd	Biological Science Technician	0.46	
Jeff Lutch	Biological Science Technician	1.00	
John Mack	Wildlife Biologist	1.00	
Dan Mahony	Fishery Biologist	1.00	
Misayo Matsuda	Biological Science Technician		0.02

		FTE	Borrowed FTE
Kerrie McCartney	Secretary	0.22	
Terry McEneaney	Wildlife Biologist	1.00	
Richard McIntyre	Biological Science Technician	0.38	
Kerry Murphy	Wildlife Biologist	1.00	
Katherine Nittinger	Biological Science Technician	0.19	
Dan Nolfi	Biological Science Technician	0.30	
Glenn Plumb	Supervisory Wildlife Biologist	0.93	
Roy Renkin	Vegetation Mgmt. Specialist	1.00	
Freya Ross	Secretary	0.12	
Jim Ruzycki	Fishery Biologist	1.00	
Thomas Seals	Biological Science Technician	0.39	
Dan Seifert	Biological Science Technician	0.30	
Hope Sieck	Biological Science Technician	0.16	
Jim Sinclair	Biological Science Technician	0.02	
Doug Smith	Wildlife Biologist	1.00	
Tim Thompson	Physical Science Technician	0.29	
Debra Tirmenstein	Biological Science Technician	0.06	
Jennifer Whipple	Botanist	0.80	
Heather Zachary	Clerk	0.67	
Cultural Resources			
Sean Cahill	Museum Technician	0.22	
Vanessa Christopher	Museum Technician	0.95	
Jon Dahlheim	Management Assistant	1.00	
Kirk Dietz	Museum Technician	0.64	
Leigh Anne Dunworth	Cultural Resources Technician	0.21	
Elaine Hale	Cultural Resources Technician	0.91	
Harold Housley	Archives Specialist	0.77	
Ann Johnson	Archeologist	0.50	
Lon Johnson	Cultural Resources Technician	0.17	
Laura Joss	Chief, Branch of Cultural Resources	0.98	
Susan Kraft	Supervisory Museum Curator	0.99	
Kathryn Lancaster	Library Technician	1.00	
Catherine Lentz	Cultural Res. Program Manager	0.51	
Kerrie McCartney	Secretary	0.10	
Kara Mills	Cultural Resources Assistant	0.39	
Sally Plumb	Cultural Resources Assistant	0.31	
Beth Raz	Museum Aide	0.34	
Charissa Reid	Cultural Resources Assistant	0.16	
Freya Ross	Secretary	0.12	
Lee Whittlesey	Archivist	1.00	
Heather Zachary	Clerk	0.06	
IGBST & BRD			
Maureen Hartmann	Biological Science Technician	0.36	
Jason Hicks	Biological Science Technician	0.34	
Tris Hoffman	Biological Science Technician	0.17	
Craig Jamison	Biological Science Technician	0.38	
Mark Lamoreux	Biological Science Technician	0.17	
TOTAL FTE		**49.71**	**0.09**

APPENDIX II. PUBLICATIONS, REPORTS, AND PAPERS

The following publications and reports published in 1999 were authored or co-authored by Yellowstone Center for Resources staff.

Professional Publications

Bangs, E.E., S.H. Fritts, J.A. Fontaine, D.W. Smith, K.M. Murphy, C.M. Mack, and C.C. Niemeyer. 1999. Status of gray wolf restoration in Montana, Idaho, and Wyoming. Wildl. Soc. Bull. 26(4):786–798.

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