YELLOWSTONE RESOURCES & ISSUES

2002

Division of Interpretation

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Yellowstone National Park

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PREFACE

In this book, you will find information about the park's history, natural resources, cultural resources, issues, and major areas. This material was provided and reviewed by park researchers, resource specialists, and planning staff.

The book is organized to present key facts at the beginning of each chapter, then an overview of the subject, and finally resources you can consult for more details. Some material is repeated in different sections of the book to accommodate people who will not be reading the entire book.

Information about Yellowstone constantly changes; the information provided here is current as of March 2002. You can find updates and more information on the park website (www.nps.gov), in park publications and exhibits, or by asking the park's interpretive rangers who staff the visitor centers.

We welcome your feedback and comments.

INTRODUCTION

The Beginning of an Idea

One of the most enduring legends of Yellowstone National Park involves its beginning. In 1870, explorers gathered around a campfire at the junction of two pristine rivers, overshadowed by the towering cliffs of the Madison Plateau. They discussed what they had seen during their exploration, and realized that this land of fire and ice and wild animals needed to be preserved. Thus, the legend goes, the idea of Yellowstone National Park was born.

It is a wonderful story—and a myth. But those men were real, and so was this land they explored. Thanks to their reports and the work of explorers and artists to follow, the United States Congress established Yellowstone National Park in 1872. The Yellowstone National Park Act says, in part, that "the headwaters of the Yellowstone River . . . is hereby reserved and withdrawn from settlement, occupancy, or sale . . . and dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people." In an era of expansion throughout the young nation, the federal government had the foresight to set aside land deemed too valuable to develop.

For the following 18 years, Yellowstone was "the national park." Then in 1890 Congress established three more national parks: Sequoia, General Grant (now part of Kings Canyon), and Yosemite. Mount Rainier followed in 1899. In 1906, Congress passed the Antiquities Act, which gave the president authority to establish national monuments. By 1914, the United States had 30 national parks and monuments, each managed separately and administered by three different federal departments—Interior, Agriculture, and War. No unified policy or plan provided for the protection, administration, and development of these parks and monuments.

The management of Yellowstone from 1872 through the early 1900s, which is described in Chapter 1, helped set the stage for the creation of an agency whose sole purpose was to manage the national parks. Promoters of this idea gathered support from influential journalists, railroads likely to profit from increased park tourism, and members of Congress. The National Park Service Act was authorized by Congress and approved by President Woodrow Wilson on August 25, 1916:

> There is created in the Department of the Interior a service to be called the National Park Service, [which] . . . shall promote and regulate the use of the Federal areas known as national parks, monuments, and reservations . . . by such means and measures as conform to the fundamental purpose to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

TWO "ORGANIC ACTS"

The laws creating Yellowstone National Park and the National Park Service are both called "The Organic Act" because each was significant enabling legislation. However, the name most often refers to the law that created the National Park Service. To avoid confusion, in this book we will refer to the laws by their official names: The Yellowstone National Park Act of 1872 and The National Park Service Act of 1916.

Units in the National Park System

Total, as of March 2002: 385

- 1 *International historic site*
- 3 *Natl. battlefield parks*
- 1 *Natl. battlefield site*
- 11 *Natl. battlefields*
- 40 *Natl. historical parks*
- 77 *Natl. historic sites*
- 4 *Natl. lakeshores*
- 28 *Natl. memorials*
- 9 *Natl. military parks*
- 74 *Natl. monuments*
- 57 *Natl. parks*
- 4 *Natl. parkways*
- 17 *Natl. preserves*
- 18 *Natl. recreation areas*
- 2 *Natl. reserves*
- 6 *Natl. rivers*
- 3 *Natl. scenic trails*
- 10 *Natl. seashores*
- 9 *Natl. wild & scenic rivers and riverways*
- 11 *Sites without designation*

The National Park System

Today, the National Park Service (NPS) manages approximately 83 million acres in 49 states, the Virgin Islands, Puerto Rico, Guam, and American Samoa. Delaware is the only state without an NPS unit.

National parks are the oldest, most well known part of the system and are usually areas of spectacular natural scenery relatively untouched by human development. National parks are established by acts of Congress. National monuments are areas of historic or scientific interest established by presidential proclamation. National historical parks and national historic sites are both set aside to commemorate some facet of the history of the people of those areas. Many national memorials fit this description, but some of these are also set aside because of important historical issues not specifically linked to the site of the memorial, such as Mt. Rushmore and Vietnam Veterans. Most other types of National Park System units are well defined by their titles.

The National Park Service Mission

The National Park Service has the dual responsibility of preserving parks in their natural state (or, at historical areas, to preserve a scene as nearly as it appeared on a certain date), and, at the same time, making these areas accessible for public use and enjoyment. These two fundamental goals are often incompatible and difficult choices must be made; two basic policies provide some direction:

- Natural resources (plants, animals, water, air, soils, topographic features, paleontologic resources, and esthetic values such as scenic vistas, natural quiet, and clear night skies) are managed to maintain, rehabilitate, and perpetuate their inherent integrity. Native species that have been exterminated should be reintroduced and exotic species eliminated, if possible. Livestock grazing, hunting, and resource extraction are prohibited in National Park System areas, although a few exceptions occur.
- Cultural resources (prehistoric and historic structures and resources, landscapes, archeologic resources, ethnographic resources, and museum collections) are preserved.

To implement these policies, each park unit prepares a General Management Plan/Master Plan that outlines management zones. In Yellowstone:

- Natural zones (most of Yellowstone National Park) protect natural resources and values. All components and processes of park ecosystems, including the natural abundance, diversity, and ecological integrity of the plants and animals, should be maintained. Change is recognized as an integral part of functioning natural systems, and interference is allowed only under special circumstances such as emergencies when human life and property are at stake.
- Cultural or historic zones, such as Fort Yellowstone, preserve cultural resources. Where compatible with cultural resource objectives, the policies for natural zones will be followed. Any action that will adversely affect cultural resources will be undertaken only if there is no reasonable alternative, and all reasonable measures to limit adverse effects will be taken, including recovery of data and salvage of materials.
- Development zones, such as around Old Faithful Geyser, allow for visitor use. Roads, walks, buildings, and other visitor and management facilities may occupy much of the zone and the natural aspect of the land may be altered. However, if a park manager determines that a resource is or would become impaired by public use or development, the manager may limit public use or close a specific area.

As the first national park, Yellowstone continues to be a leader in developing and implementing policies in the National Park Service.

FLORA

8 species of conifers

Approximately 80% of forest is comprised of lodgepole pine

More than 1,700 species of native vascular plants

More than 190 species of exotic (non-native) plants

186 species of lichens

ROADS AND TRAILS

5 park entrances

466 miles of roads (310 paved/primary miles)

950 miles of backcountry trails

97 trailheads

287 backcountry campsites

FACILITIES

9 visitor centers, museums, and contact stations

9 hotels/lodges (2,238 hotel rooms/cabins)

7 NPS-operated campgrounds (454 sites)

5 concession-operated campgrounds (1,747 sites)

2,000+ buildings (NPS and concessions)

49 picnic areas

1 marina

13 self-guiding trails

EMPLOYEES

Approximately 800 people work for the National Park Service at peak summer levels; about 300 year-round

Approximately 3,500 people work for concessioners at peak summer levels

CULTURAL RESOURCES

Approximately 1,100 documented archeological sites

More than 24 affiliated Native American tribes

6 National Historic Landmarks (Obsidian Cliff and 5 buildings)

4 National Register Historic Districts

More than 200,000 cultural objects and natural science specimens

Thousands of books (many rare), manuscripts, and periodicals

90,000 historic photographs

WILDLIFE

7 species of native ungulates

2 species of bears

Approximately 50 species of other mammals

315 recorded species of birds (148 nesting species)

18 species of fish (6 non-native)

6 species of reptiles

4 species of amphibians

3 threatened species: bald eagle, grizzly bear, lynx

2 endangered species: whooping crane, gray wolf (designated an experimental and non-essential population in YNP)

GEOLOGY

An active volcano

Approximately 2,000 earthquakes annually

More than 10,000 hydrothermal features

More than 300 geysers

One of the world's largest calderas, measuring 45 x 30 miles

Approximately 290 waterfalls, 15 ft. or higher, flowing year-round

Tallest waterfall in the front country: Lower Falls of the Yellowstone River at 308 ft.

YELLOWSTONE LAKE

136 square miles of surface area

110 miles of shoreline

20 miles north to south

14 miles east to west

Average depth: 140 feet

Maximum depth: About 400 feet

VISITATION

2001: 2,258,256 entries to the park

Record year: 1992—3,144,405 entries

Winter visitors: more than 140,000

Park Facts

World's first national park

A designated World Heritage Site and Biosphere Reserve

3,472 square miles or 8,987 square km

2,221,766 acres or 899,139 hectares

63 air miles north to south (102 km)

54 air miles east to west (87 km)

96% in Wyoming, 3% in Montana, 1% in Idaho

Highest Point: 11,358 ft. (Eagle Peak)

Lowest Point: 5,282 ft. (Reese Creek)

Larger than the states of Rhode Island & Delaware combined

Approximately 5% of park is covered by water; 15% is grassland; and 80% is forested

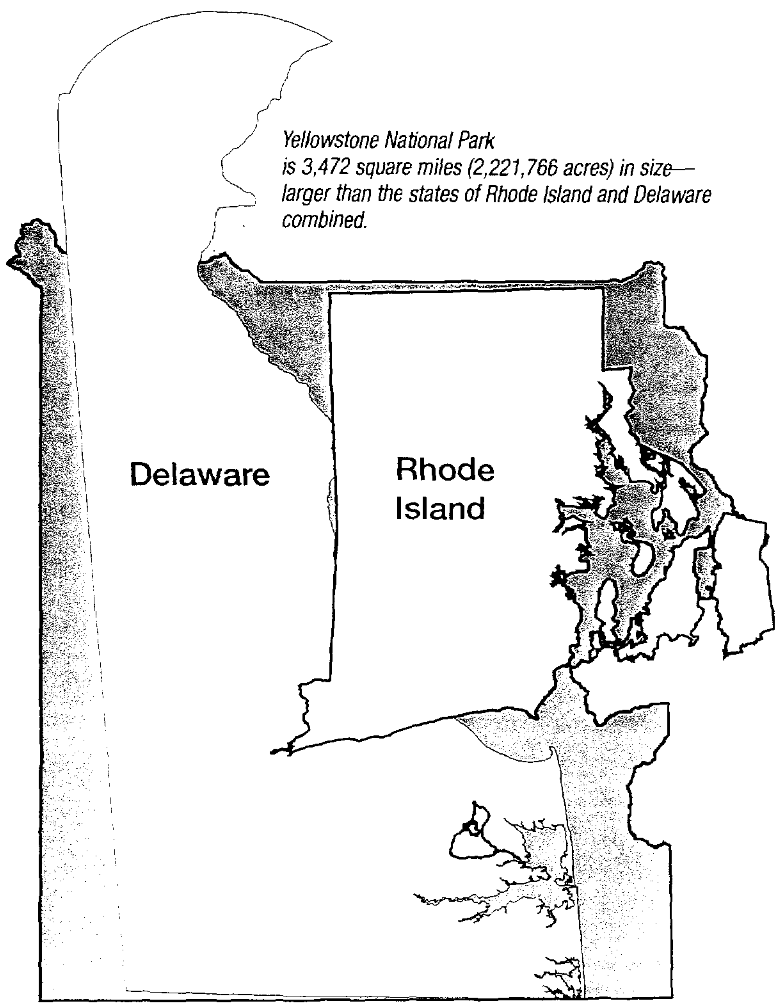
Precipitation ranges from 10 inches (26 cm) at the north boundary to 80 inches (205 cm) in the southwest corner

Temperatures
Average: 9°F in January to 80°F in July at Mammoth Hot Springs
Records:
High: 98°F (Lamar 1936)
Low: –66°F (Madison 1933)

Frequently Asked Questions

Why is Yellowstone National Park significant?

- World's first national park.
- International symbol of natural preservation.
- A Biosphere Reserve and a World Heritage Site *(see page 15)*.
- Contains approximately half of the world's hydrothermal features— more than 10,000—including the world's largest concentration of geysers—more than 300.
- Home of the world's tallest active geyser, Steamboat, which erupts to more than 300 feet.
- One of the few places in the world with active travertine terraces.
- Hydrothermal features support microbes that are providing links to primal life, origins of life, and astrobiology; plus they are proving useful in solving some of our most perplexing medical and environmental problems *(see Chapters 3 & 8)*.
- With the restoration of the gray wolf in 1995, the park now contains all the large mammal species known to be present when European Americans first arrived.
- Protects two federally listed endangered species, the gray wolf (designated experimental and non-essential in YNP) and the whooping crane; and three threatened species, the grizzly bear, the bald eagle, and the lynx.
- Home to the largest concentration of elk in the world.
- Only place in the U.S. where bison have existed in the wild since primitive times. The early legislation that protected these bison, the Lacey Act, is one of the precursors to the Endangered Species Act.
- Core of the Greater Yellowstone Ecosystem —one of the largest intact temperate zone ecosystems remaining on the planet *(see Chapter 2)*.
- Site of one of the largest volcanic eruptions in the world, which left behind one of the largest calderas.
- Site of the spectacular Grand Canyon of the Yellowstone River.
- Location of largest lake above 7,000 feet in North America—Yellowstone Lake.
- Source of many great North American rivers: two of the three forks of the Missouri; headwaters of the Snake, which flows into the Columbia and eventually into the Pacific. The Yellowstone River, which begins just south of the park, is the longest free-flowing river in the U.S.
- Yellowstone is also a refuge for the human soul. People have come here to recreate and to rest for centuries.

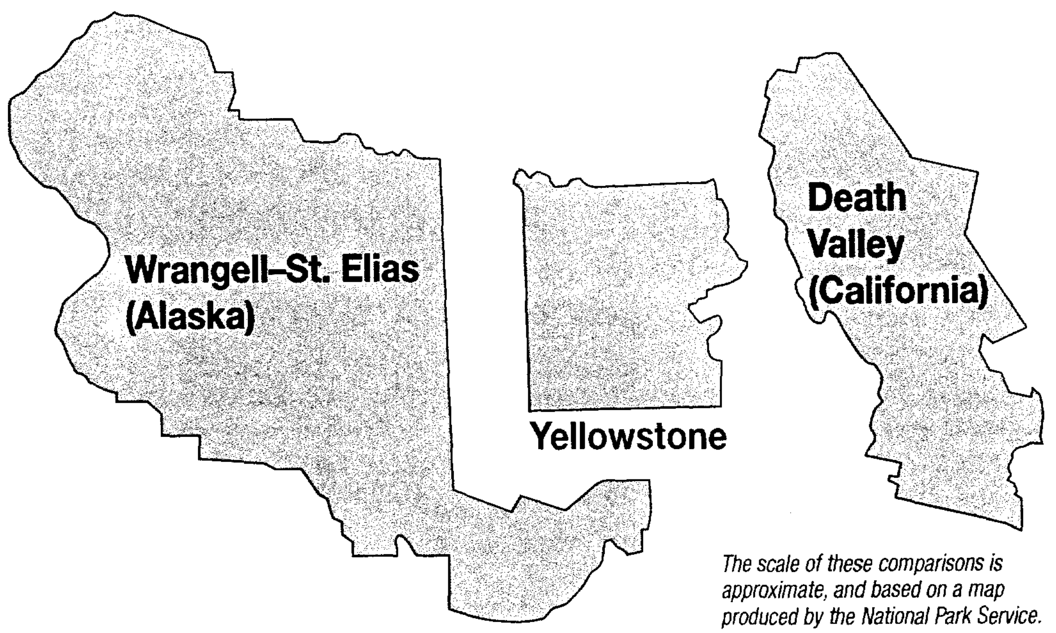


Yellowstone National Park

How did Yellowstone get its name?

The name does not come from the brightly colored, thermally altered rhyolite in the Grand Canyon of the Yellowstone. Its origin goes back to when French-Canadian trappers encountered the Minnetaree tribe along this river in what is today eastern Montana. When asked about the name of the river, the Minnetaree responded "Mi tse a-da-zi," which translates as "Rock Yellow River." The trappers translated this into French—"Roche Jaune" or "Pierre Jaune." In 1797, explorer-

geographer David Thomson translated the name into English—"Yellow Stone." Lewis and Clark called the Yellowstone River by the French and English forms. Subsequent usage formalized the name as "Yellowstone."



The scale of these comparisons is approximate, and based on a map produced by the National Park Service.

Is Yellowstone the largest national park in the country?

No. More than half of Alaska's national park units are larger, including Wrangell–St. Elias National Park and Preserve, which is the largest unit in the National Park System (13 million acres). Until recently, Yellowstone (at 2.2 million acres) was the largest national park in the contiguous states. But, in 1994, Death Valley National Park was established when Death Valley National Monument was expanded; this park has more than 3 million acres.

Were there other national parks before Yellowstone?

Some sources list Hot Springs in Arkansas as the first national park—it was set aside in 1832, forty years before Yellowstone was established—but was actually the nation's oldest national *reservation,* and the purpose for its creation was different from that of Yellowstone. Hot Springs was set aside to preserve and equitably distribute a utilitarian resource (hot water), much like our present national forests. In 1921, an act of Congress established Hot Springs as a national park.

Other sources argue Yosemite was the first national park, but it was actually a state park. In 1864, Congress set aside the area surrounding the Yosemite Valley and the Mariposa Grove of Big Trees and gave them to the state of California to administer for public use and recreation. In 1890, Congress established Yosemite as a national park 18 years after it established Yellowstone National Park.

Where are the bears?

People who visited Yellowstone prior to the 1970s often remember seeing bears along roadsides and within developed areas of the park. Although observing these habituated bears was very popular with park visitors, it was not good for the people or the bears *(see Chapters 6 & 8)*. In 1970, the park initiated an intensive bear management program to return the grizzly and black bears to feeding on natural food sources and to reduce bear-caused human injuries. Among the measures: garbage cans were bear-proofed and garbage dumps within the park were closed.

While bears are not commonly seen along the roadsides anymore, they may still be viewed occasionally in the wild. Grizzly bears are active primarily at dawn, dusk, and night. In spring, they may be seen around Yellowstone Lake, Fishing Bridge, and the East Entrance due to the trout spawning creeks in these areas. In mid summer, they are most commonly seen in the open meadows between Tower–Roosevelt and Canyon, and in the Lamar Valley. Black bears are most active at dawn and dusk, sometimes during

the middle of the day. Look for black bears in open spaces within or near forested areas. Black bears are most commonly observed between Mammoth, Tower, and the Northeast Entrance.

Where can I see wildlife?

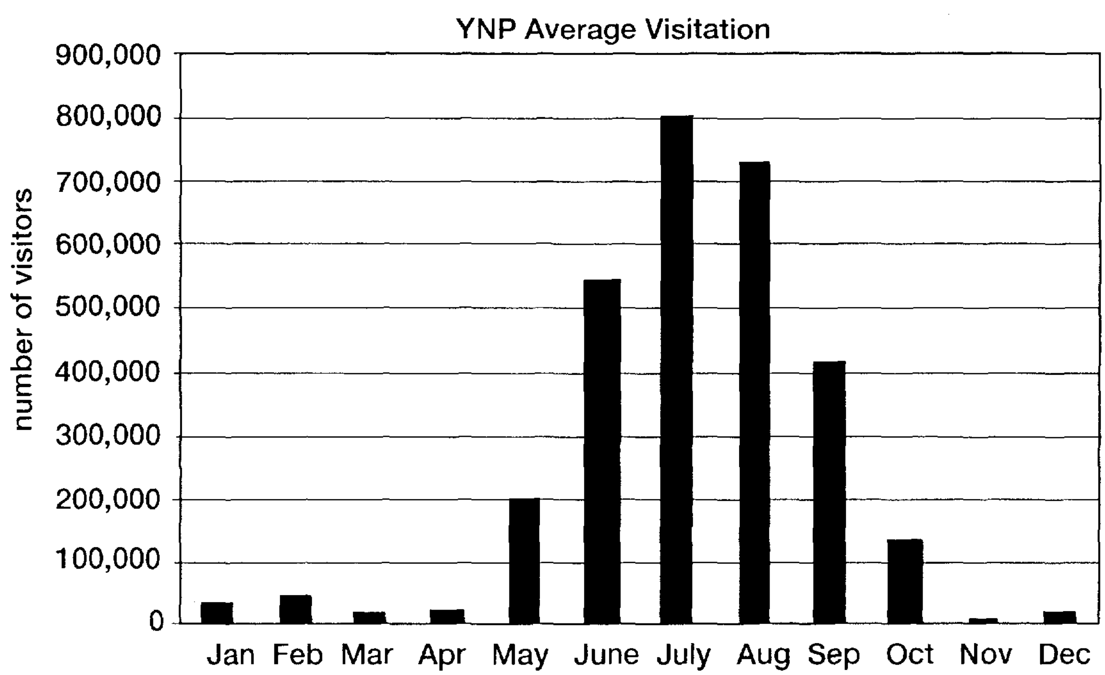
To see wildlife, it helps to know the habits of the animals you want to see and the habitats in which they live. For example, bighorn sheep eat plants and are adapted to live on steep terrain; so you could look for them on cliffs that line the Yellowstone River in the Tower area. Osprey eat fish, so you would expect to see them along rivers. Look in the park newspaper for general guidelines; ask at visitor centers for local details.

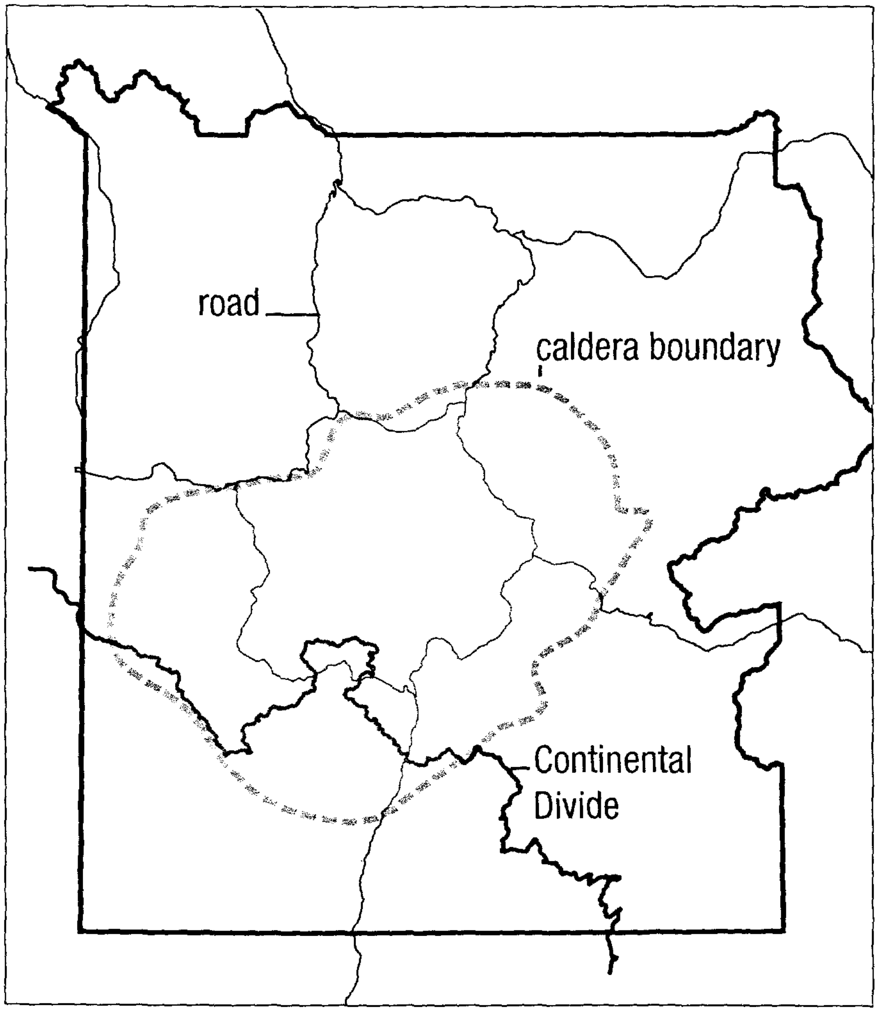
What is the difference between a bison and a buffalo?

None. In North America, both terms refer to the American bison; the scientific name is *Bison bison.* Early European explorers called this animal by many names. Historians believe that the term "buffalo" grew from the French word for beef, "boeuf." Some people insist that the term "buffalo" is incorrect because the "true" buffalo exist on other continents and are only distant relatives. However, "buffalo" is used for less formal, everyday use; "bison" is preferred for scientific use. In this book, we use "bison."

Why is fishing lead-free in Yellowstone?

Scientific evidence continues to mount regarding the dangers of lead concentrations in aquatic environments. Wildlife, such as loons, waterfowl, cranes, and shorebirds, are vulnerable to lead poisoning. Of particular concern in Yellowstone are the alarmingly low populations of trumpeter swans and loons. We strive to maintain viable breeding populations of these sensitive birds. While we can do little about natural hazards, we can minimize the effects of lead on these species. Yellowstone National Park bans most lead tackle. (Terminal tackle must be lead-free; sinkers used to fish for deep-dwelling lake trout are permissible because they are too large to be ingested.)





What is the caldera line on the park map ?
The caldera line marks the rim of a crater, or caldera, created by a massive volcanic eruption in Yellowstone approximately 640,000 years ago. (This date changes as scientists fine-tune their ability to determine events in geologic time.) Subsequent lava flows filled in the crater, and it is now measured at 30 x 45 miles. Its rim can be seen from these areas in the park: Mt. Washburn, Gibbon Falls, Lewis Falls, and Flat Mountain Arm of Yellowstone Lake.

What is the Continental Divide?
Think of the Continental Divide as the crest of the continent. Theoretically, when precipitation falls on the west side of the Divide, it eventually reaches the Pacific Ocean. When it falls on the east side of the Divide, it eventually reaches the Atlantic Ocean. In Yellowstone (as elsewhere), this ridgeline is not straight. It follows the twists and turns of the mountains through the southwestern part of the park. Therefore, you cross the Continental Divide three times while traveling from the South Entrance over Craig Pass to Old Faithful.

Why are geysers in Yellowstone?
Yellowstone's volcanic geology provides the three components for geysers and other hydrothermal features: heat, water, and a "plumbing" system. Within the past two million years, many volcanic eruptions have occurred in the Yellowstone area; three of them major. Today, Yellowstone National Park sits on top of an active volcano. Molten rock, or magma, may be as close as 3–8 miles (5–13 km) underground. This magma provides the first ingredient: heat. Ample rain and snowfall supply the second ingredient: water. The water seeps several thousand feet (more than a kilometer) below the surface where it is heated. Underground cracks and fissures form the third ingredient: plumbing. Hot water rises through the plumbing to produce the hydrothermal features in Yellowstone. Geysers occur when that plumbing is constricted *(see Chapter 3).*

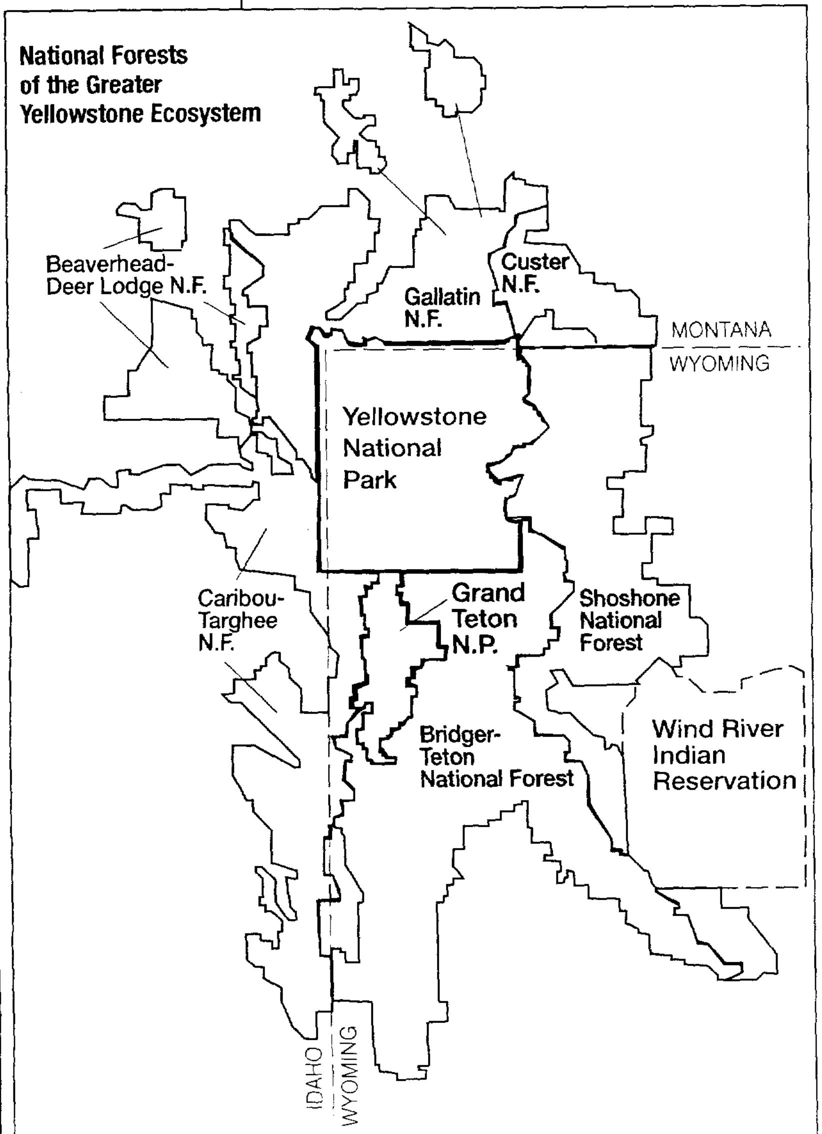
What exactly is a geyser basin?
A geyser basin is a geographically distinct area that contains a "cluster" or array of hydrothermal features that may include geysers, hot springs, mudpots, and fumaroles. These distinct areas often (but not always) occur in topographically low areas because hydrothermal features tend to be concentrated around the margins of lava flows and in areas of faulting.

Why can't I bring my dog on geyser basin trails?

Dogs do not seem to recognize the difference between hot and cold water. Dogs have died diving into hot springs. They also disturb wildlife and are prohibited from all park trails. Pets must be kept on a leash at all times. Ask at a visitor center where you can safely and legally walk a pet.

Is it really dangerous to walk off the boardwalks in geyser basins?

YES! Geyser basins are constantly changing. Boiling water surges just under the thin crust of most geyser basins, and many people have been severely injured (second and third degree burns) when they have broken through the fragile surface. Some people have died from falling into hydrothermal features.



Why can't I smoke in the hydrothermal areas?

Litter of any kind is a problem in these fragile areas, and cigarette butts quickly accumulate if smoking is allowed. Also, sulfur deposits exist in these areas, and they easily catch fire, producing dangerous—sometimes lethal—fumes.

Were Native Americans afraid of geysers?

Not at all. The affiliated tribes of Yellowstone state their people have used the park as a place to live, to collect food and other resources, and as a passage through to the bison hunting grounds of the Great Plains. Archeologists and historians have also uncovered ample evidence that people lived in and visited Yellowstone for thousands of years before historic times *(see Chapter 1)*.

What is the difference between a national park and a national forest?

Though visitors often perceive them as similar, there are notable differences between national parks and national forests. National parks are administered by the Department of the Interior and national forests by the Department of Agriculture. The National Park Service is mandated to preserve resources unimpaired, while the U.S. Forest Service is mandated to wisely manage resources for a variety of sustainable uses.

How many rangers work in Yellowstone?

Approximately 180 rangers work in Yellowstone National Park during the peak summer season; less than 100 year-round. Park rangers perform duties in interpretation, education, resource management, law enforcement, emergency medical services, and backcountry operations. Many other people work here too, in the fields of research, maintenance, management, administration, trail maintenance, fire management, and fee collection. In total, approximately 800 people are employed by the National Park Service in Yellowstone (300 permanent, 500 seasonal). The park's concessioners employ about 3,500 people who manage and staff the hotels, campgrounds, gift shops, recreational and educational activities, and service stations.

What is the highest peak in Yellowstone?

Eagle Peak in the southeastern part of the park is the highest at 11,358 feet.

How cold does it get in Yellowstone in the winter?

The record low temperature was –66°F (–54°C), at Madison, on February 9, 1933. This was also the national record for low temperatures until it was broken by a temperature of –80°F (–62°C) on January 23, 1971, at Prospect Creek Camp, Alaska. Average winter highs range between 20ºF and 30ºF, and average lows are in the single digits above 0ºF.

Why is Yellowstone called a Biosphere Reserve and a World Heritage Site, and what does this mean?

The United Nations has designated Yellowstone National Park as both a Biosphere Reserve and a World Heritage Site because of the worldwide significance of its natural and cultural resources. These designations have nothing to do with how Yellowstone is managed—the United Nations does not have any authority to dictate federal land-management decisions in the United States—nor do they change the fact that Yellowstone is under the legal authority of the United States of America.

The October 26, 1976, United Nations designation of Yellowstone as a Biosphere Reserve stated: "Yellowstone National Park is recognized as part of the international network of biosphere reserves. This network of protected samples of the world's major ecosystem types is devoted to conservation of nature and scientific research in the service of man. It provides a standard against which the effect of man's impact on the environment can be measured."

The September 8, 1978, United Nations designation of Yellowstone as a World Heritage Site, which was requested by U.S. President Richard Nixon and Congress, stated: "Through the collective recognition of the community of nations . . . Yellowstone National Park has been designated as a World Heritage Site and joins a select list of protected areas around the world whose outstanding natural and cultural resources form the common inheritance of all mankind."

How much of the park burned in 1988?

The 1988 fires affected approximately 793,880 acres or 36 percent of the park. Most of these acres sustained ground surface burns. Five fires burned into the park that year from adjacent public lands. The largest, the North Fork fire, started from a discarded cigarette. It burned more than 410,000 acres.

Could the fires have been predicted? How were weather conditions different than in previous years?

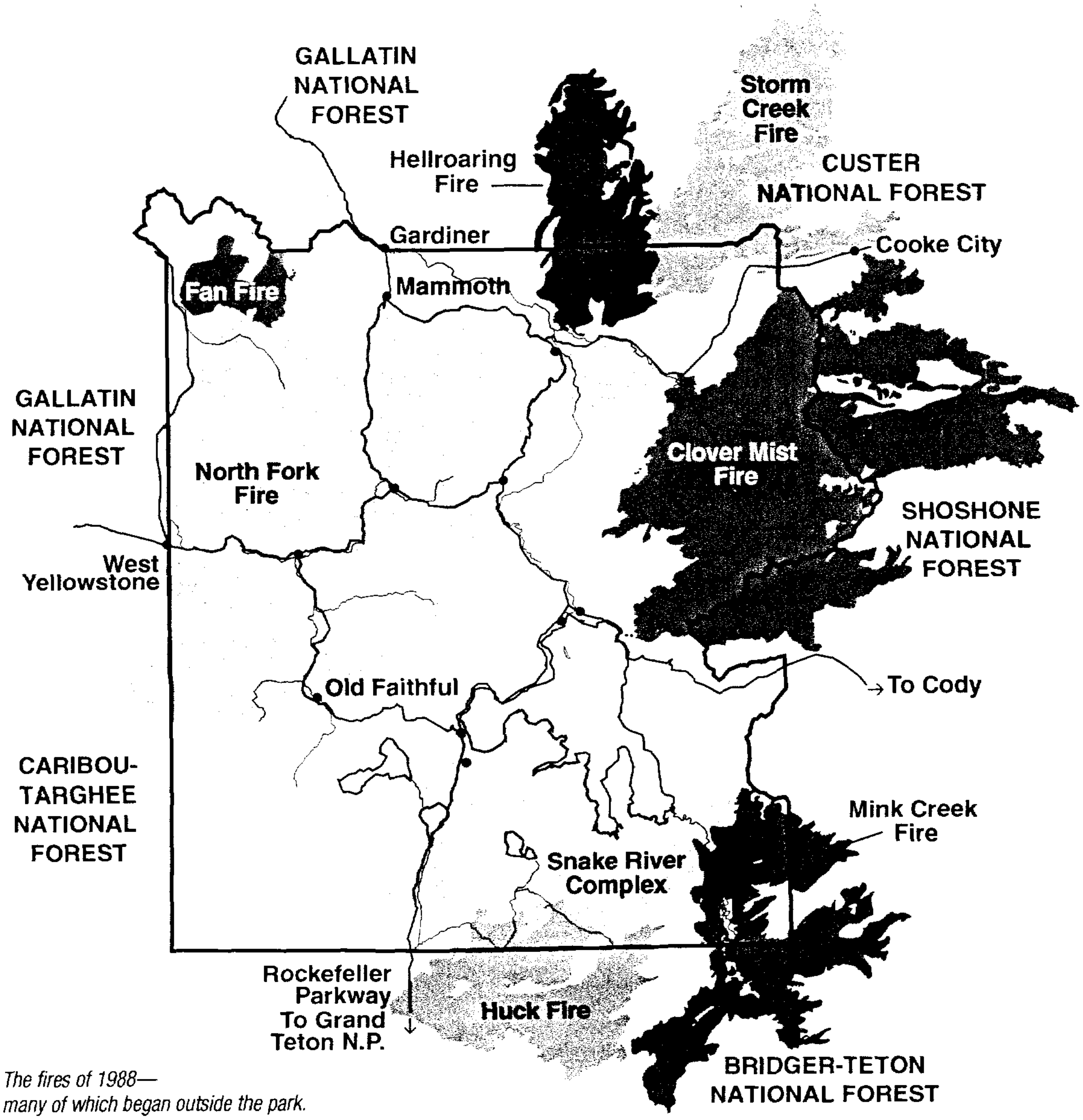
Yellowstone usually experiences afternoon showers three or four days each week during the summer, but in 1988 no rain fell for almost three months. The most severe drought in the park's recorded history occurred that summer. Also, a large number of lightning strikes came with a series of dry storm fronts. This lightning started many of the fires and storm fronts stoked them with particularly high and sustained winds.

Could the fires have been put out?

It is possible that the few fires that started in early June might have been extinguished. However, between 1972 and 1987, the average fire had gone out naturally after burning only one acre. So, while the early fires were monitored closely and some were contained from going out of the park, the history of fire behavior in the park coupled with the abnormally wet spring suggested that these fires would go out as previous fires had. After July 15, all fires were fought aggressively from the moment they were detected. Despite the largest firefighting effort in the history of the nation, weather finally contained the fires when snow fell in September.

Did Yellowstone's fire policy change after the fires of 1988?

After 1988, the fire policy underwent extensive review and a revised Fire Management Plan was implemented in 1992. As before, fires that threaten life and property and fires that are human-caused will be suppressed immediately. Plus, even naturally ignited (lightning-caused) fires may be put out if they do not meet all the criteria to be allowed to burn. The National Fire Plan 2000 was implemented late in 2000 in response to the extensive fire season that summer *(see Chapter 5)*.



The fires of 1988—
many of which began outside the park.

How does fire benefit Yellowstone?

Fires are a natural part of the Northern Rockies ecosystem. Vegetation in the Greater Yellowstone Ecosystem has adapted to fire and in some cases may be dependent on it. Fire promotes habitat diversity by removing the forest overstory, allowing different plant communities to become established, and preventing trees from becoming established in grassland. Fire increases the rate that minerals become available to plants by rapidly releasing these nutrients from wood and forest litter and by hastening the weathering of soil minerals. This is especially important in a cold and dry climate like Yellowstone's, where decomposition rates are slower than in more hot and humid areas.

In addition, the fires of 1988 provided a rare laboratory for scientists to study the effects of fire on an ecosystem.

See Chapter 5 for more information about fire ecology, management, and the fires of 1988.

History of the Park

1

HIGHLIGHTS OF YELLOWSTONE'S HISTORY

- People have been in Yellowstone more than 11,000 years, as evidenced by archeological sites, trails, and oral histories.
- Although Sheep Eaters are the most well-known group of Native Americans to use the park, many other tribes and bands lived in and traveled through what is now Yellowstone National Park prior to European American arrival.
- European Americans began exploring Yellowstone in the late 1700s.
- First organized expedition explored Yellowstone in 1870.
- Yellowstone National Park established in 1872.
- The U.S. Army managed the park from 1886 through 1918.
- First boundary adjustment of the park made in 1929.
- "Leopold Report" released in 1963; its recommendations changed how wildlife is managed in the park.
- 1970: First bear management plan.
- 1988: "Summer of Fire."
- 1995: Wolves restored to the park.

The human history of the Yellowstone region goes back more than 11,000 years. How far back is still to be determined, but the geology of the park tells us that humans probably were not here when the entire area was covered by ice caps and glaciers. The last period of ice coverage ended 14,000 years ago—and sometime after that, humans arrived here.

The Earliest Humans in Yellowstone

Human occupation of the greater Yellowstone area seems to follow environmental changes of the last 15,000 years. Glaciers and a continental ice cap covered most of what is now Yellowstone National Park. They receded about 14,000 B.P. (before present) and left behind rivers and valleys that people could follow in pursuit of Ice Age mammals such as the mammoth and the giant bison.

Knife point (9350 B.P.) from the Yellowstone National Park Museum Collection

The first people arrived in this region sometime before 10,000 B.P. Archeologists have found little physical evidence of their presence except for their distinctive stone tools and projectile points. From these artifacts, scientists surmise that they hunted mammals and ate berries, seeds, and roots.

As the climate in the Yellowstone region warmed and dried, the animals, vegetation, and human lifestyles also changed. Large Ice Age animals that were adapted to cold and wet conditions became extinct. The glaciers left behind layers of sediment in valleys in which grasses and sagebrush thrived and pockets of exposed rocks that provided protected areas for aspens and fir to grow. The uncovered volcanic plateau sprouted lodgepole forests. People adapted to these changing conditions. They could no longer rely on large mammals for food. Instead, smaller animals such as deer and rabbit became more important in their diet as did plants such as bitterroot and prickly pear. They may have also established a distinct home territory in the valleys and surrounding mountains.

Paleolndian Period — **Archaic Period**

Folsom people were in the greater Yellowstone area as early as 10,900 B.P—the date of an obsidian Folsom projectile point found near Pinedale, Wyoming.

Sites along the Canyon to Lake Road yielded Paleolndian artifacts.

10,000 B.P.

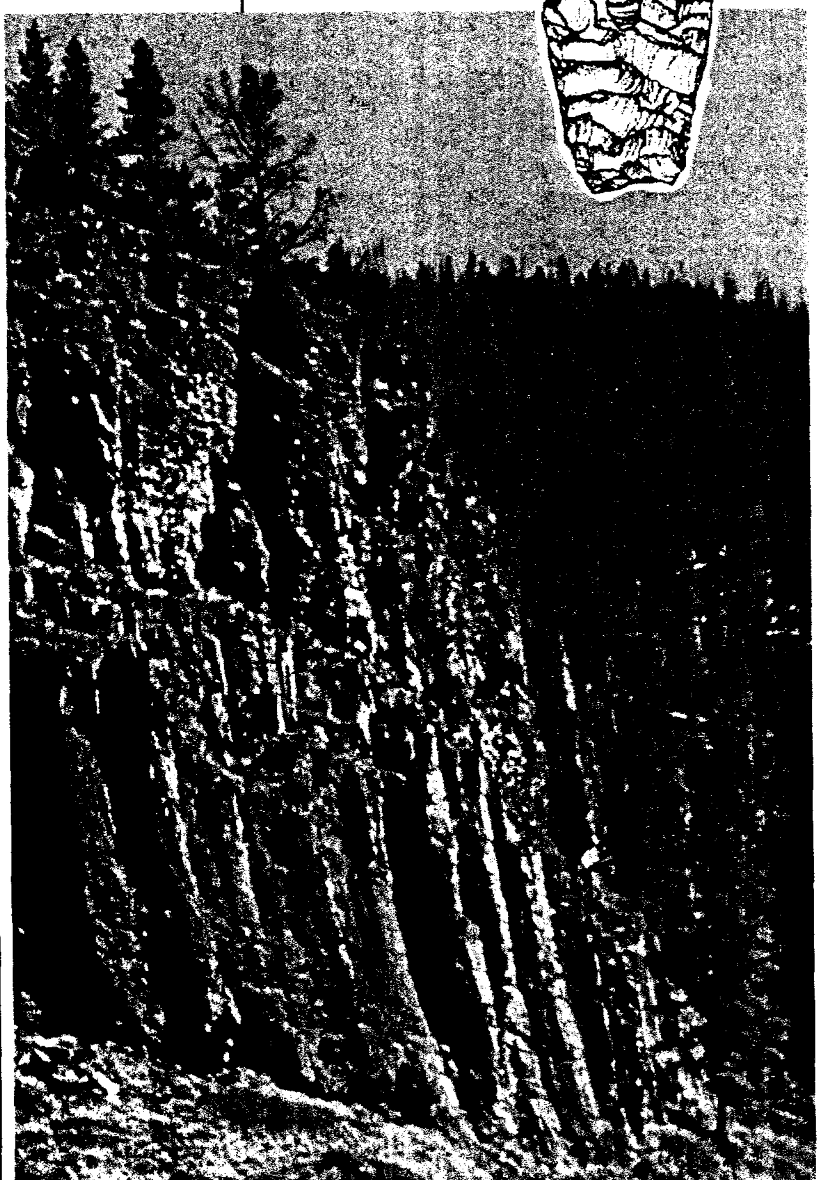
9350 B.P.

A site on the shore of Yellowstone Lake was investigated in 2000 and dated to 9350 B.P. The points had traces of blood from rabbit, dog, deer, and bighorn. People seem to have occupied this site for short, seasonal periods.

9000 B.P.

Vegetation similar to what we find today begins to appear. Sites reveal earth ovens used for preparing food. Food used included meat, roots, seeds. Projectile points begin to be notched.

Hell Gap Point, 9600–10,000 B.P.



Obsidian Cliff, a major source of obsidian for western North America, was designated a National Historic Landmark in June 1996.

This favorable climate would continue more than 9,000 years. Evidence of these people in Yellowstone remained uninvestigated, even long after archeologists began excavating sites elsewhere in North America. Archeologists used to think high regions such as Yellowstone were inhospitable to humans and thus, did little exploratory work in these areas. However, park superintendent Philetus W. Norris (1877–82) found artifacts in Yellowstone and sent them to the Smithsonian Institution in Washington, D.C. Today, archeologists study environmental change as a tool for understanding human uses of areas such as Yellowstone.

About 1,100 sites have been documented in Yellowstone National Park, with the majority from the Archaic period. Sites contain evidence of successful hunts for bison, sheep, and elk. During this period, earth ovens began to be used. These ovens were dug into the ground then were filled with hot rocks to cook food like giant "crock pots."

Campsites and trails in Yellowstone *(see map next page)* also provide evidence of early use. Some of these trails have been used by people more or less continuously since the PaleoIndian period.

No scientific evidence conclusively connects prehistoric tribes with historic people such as the Crow and Sioux, but oral histories provide links. For example, the oral tradition of the Confederated Salish & Kootenai Tribes places their Salish-speaking ancestors in the this region several thousand years ago.

Increased Use

People seem to have increased their use of the Yellowstone area beginning about 3,000 years ago. They developed the bow and arrow, which replaced the atlatl, or spear-thrower, that had been used for thousands of years. With the bow and arrow, people hunted more efficiently. They also developed sheep

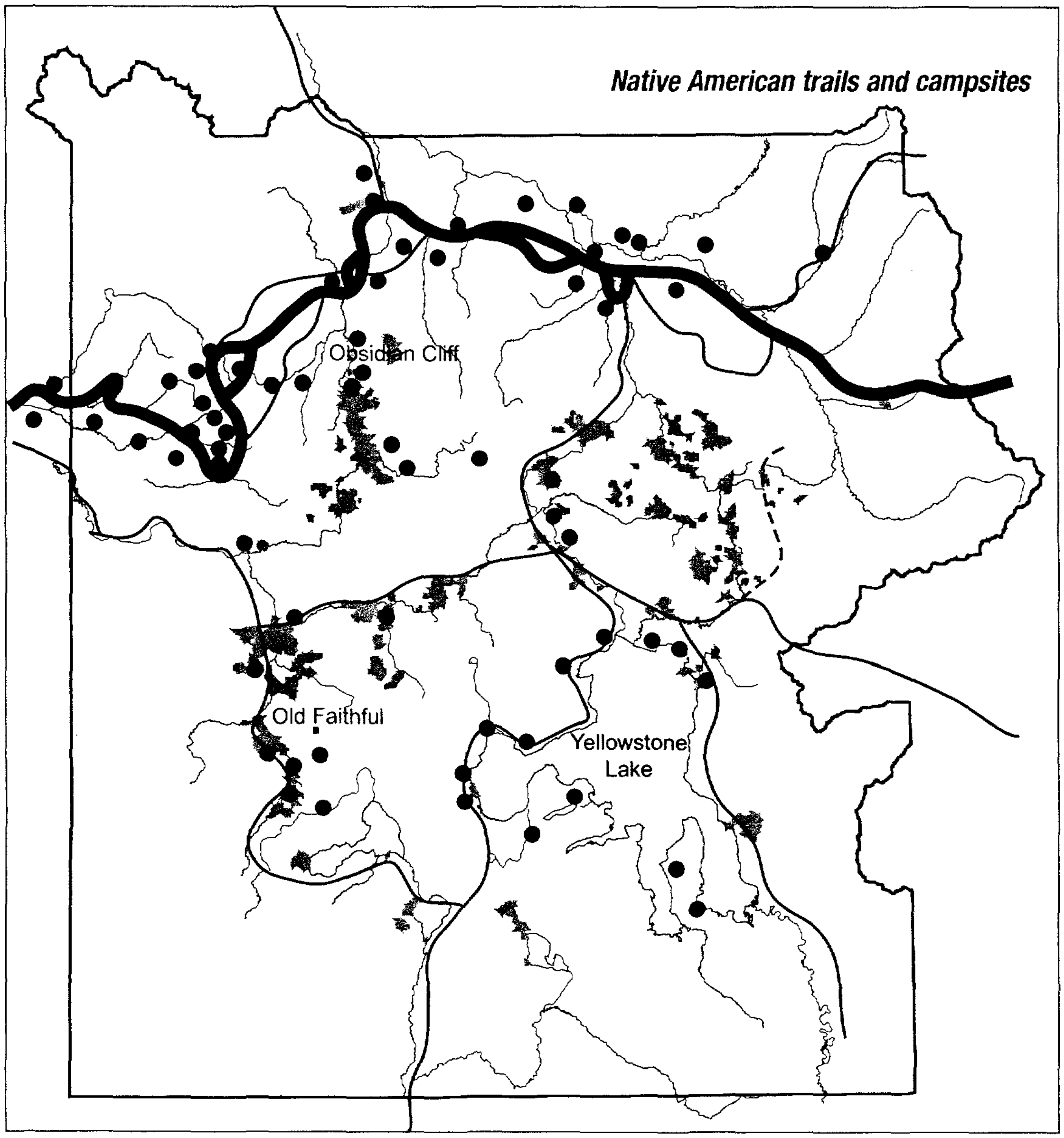
continued on page 20

Archaic Period — **Prehistoric Period**

4000 B.P. — *During this time span, early people leave traces of camps on shores of Yellowstone Lake.*

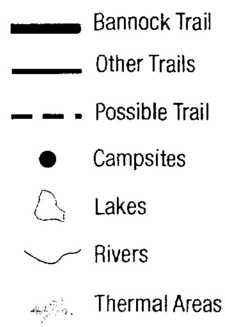
3000 B.P. — *Oral histories of the Salish place their ancestors in the Yellowstone area.*

1500 B.P. — *After 1500 B.P., bow and arrow replaces atlatl (throwing spear); sheep traps (in the mountains) and bison corrals (on the plains) begin to be used in the Rocky Mountain region.*



Bannock Ford

Upstream from where Tower Creek enters the Yellowstone River, the Bannock Ford was used by the Bannock as they crossed the Yellowstone Plateau to access the plains east of the park to hunt bison after the animal had been exterminated from the tribe's homeland, the Snake River Plains. Archeological investigations in 2001 found no evidence of repeated, long-term use of this ford by earlier people, even though the Bannock Trail itself was used off and on for centuries. Ethnographic consultations with the tribes remain to be done to discover if their traditions include information on the ford. (For more on archeological and ethnographic approaches to cultural resources, see Chapter 7.)



Map adapted from "Fear or Reverence? Native Americans and the Geysers of Yellowstone," by Joseph Weixelman, Yellowstone Science, Fall 2001.

Determining Dates

Archeologists in this region commonly use two techniques to date their findings: ***Radiocarbon dating*** *measures the amount of carbon 14 remaining in an organic sample, usually charcoal or bone. Atmospheric radiocarbon enters the life cycle of plants and animals during respiration. After death, carbon 14 no longer enters the organism and begins to decay at a known rate. Sophisticated equipment measures the amount of remaining carbon 14, which is used to calculate the time since death.* ***Obsidian hydration*** *measures the rate obsidian absorbs water at its surface, which is dependent on temperature. Measuring the thickness of the hydration layer determines an artifact's date of manufacture.*

A.D. 1000

1400 — Oral histories of the Kiowa place their ancestors in the Yellowstone area from this time through the 1700s.

1450 — Little Ice Age begins.

1600 — North American tribes begin acquiring horses in the mid to late 1600s.

traps and bison corrals during this period. Remains of sheep traps existed in the mountains of Yellowstone at least prior to the 1988 fires; bison corrals were used in the Yellowstone River valley north of the park.

This increased use of Yellowstone may have occurred when the environment was warmer, favoring extended seasonal use on and around the Yellowstone Plateau. Archeologists and other scientists are working together to study evidence such as plant pollen, landforms, and tree rings to understand how the area's environment changed over time.

The Little Ice Age

Climatic evidence has already confirmed the Yellowstone area experienced colder temperatures during what is known as the Little Ice Age—mid 1400s to mid 1800s. Archeological evidence indicates that fewer people may have used this region during this time. Campsites appear to have been used by smaller groups of people, mostly in the summer. Such a pattern of use would make sense in a cold region where hunting and gathering were practical for only a few months each year.

Tribes used hydrothermal sites ceremonially and medicinally. The Mud Volcano area was especially significant for the Kiowa. Their tradition says that a hot spring in that area called Dragon's Mouth (below) is the site of their origin.

Historic Tribes

Tribal oral histories indicate more extensive use during the Little Ice Age. Kiowa stories place their ancestors here from around A.D. 1400 to A.D. 1700. Ancestors to contemporary Blackfeet, Cayuse, Coeur d'Alene, Bannock, Nez Perce, Shoshone, and Umatilla, among others, continued to travel the park on the already established trails. They visited geysers, conducted ceremonies, hunted, gathered plants and minerals, and engaged in trade. Some tribes used Fishing Bridge as a rendezvous site.

The Crow occupied the country generally east of the park, and the Blackfeet occupied the country to the north. The Shoshone, Bannock, and other tribes of the plateaus to the west traversed the park annually to hunt on the plains to the east. Other Shoshonean groups hunted in open areas west and south of Yellowstone.

In the early 1700s, some tribes in this region began to acquire the horse. Some historians believe the horse fundamentally changed lifestyles because tribes could now travel faster and farther to hunt bison and other animals of the plains. However, the horse does not seem to have changed the tribes' traditional use of the Yellowstone area.

The "Sheep Eaters"

Some groups of Shoshone who adapted to a mountain existence chose not to acquire the horse. These included the Sheep Eaters, or Tukudika, who used their dogs to transport food, hides, and other provisions.

Sheep Eaters acquired their name from the bighorn sheep whose migrations they followed. Bighorn sheep were a significant part of their diet, and they crafted the carcasses into a wide array of tools and implements. For example, they made bows from sheep horn made pliable from soaking in hot

- late 1700s — Fur trappers travel the rivers into the Yellowstone region.
- 1804–1805 — The Lewis and Clark Expedition.
- 1807–1808 — John Colter explores part of Yellowstone.
- 1812 — The War of 1812.
- 1820s — Trappers return to Yellowstone area.
- 1834–1835 — Trapper Osborne Russell encounters Sheep Eaters in Lamar Valley.
- 1840s — Trapper era ends.
- 1850s — Little Ice Age ends, climate warms.

springs. They traded these bows, plus clothing and hides, to other tribes.

European Americans Arrive

In the late 1700s, fur trappers traveled the great tributary of the Missouri River, the Yellowstone, in search of beaver. They called the river by its French name, "Roche Jaune." As far as we know, none of the early trappers observed the hydrothermal activity in this area but they probably learned of these features from Native American acquaintances.

The Lewis and Clark Expedition, sent by Thomas Jefferson to explore the newly acquired lands of the Louisiana Purchase, bypassed Yellowstone. They had heard descriptions of the region, but did not explore the Yellowstone River beyond what is now Livingston, Montana.

A member of the Lewis and Clark Expedition, John Colter, left that group during its return journey to join with trappers in the Yellowstone area. During his travels, Colter probably skirted the northwest shore of Yellowstone Lake and crossed the Yellowstone River near Tower Fall, where he noted the presence of "Hot Spring Brimstone."

Not long after Colter's explorations, the United States became embroiled in the War of 1812, which drew men and money away from exploration of the Yellowstone region. The demand for furs resumed after the war and trappers returned to the Rocky Mountains in the 1820s. Among them was Daniel Potts, who also published the first account of Yellowstone's wonders as a letter in a Philadelphia newspaper *(see quote at right).*

Jim Bridger also explored Yellowstone during this time. Like many trappers, Bridger spun tall tales as a form of entertainment around the evening fire. His stories served to inspire future explorers determined to discover their truth.

Wickiups provided shelter for some Native Americans while they were in Yellowstone. A few, probably built in the 1800s, remain standing in the park.

As quickly as it started, the trapper era ended. Beaver became scarce and fashions changed. By the mid 1840s, trappers were turning to guiding or other pursuits.

Expeditions "Discover" Yellowstone

Although Yellowstone had been thoroughly tracked by trappers and tribes, in the view of the nation at large it was really "discovered" by formal expeditions. The first organized attempt came in 1860 when Captain William F. Raynolds led a military expedition, but it was unable to explore the Yellowstone Plateau because of late spring snow. The Civil War preoccupied the government during the next few years. During this time, however, gold was discovered west of the park. Thousands of prospectors flocked to the area, and many searched for gold in Yellowstone. Afterward, several explorations were planned but none actually got underway.

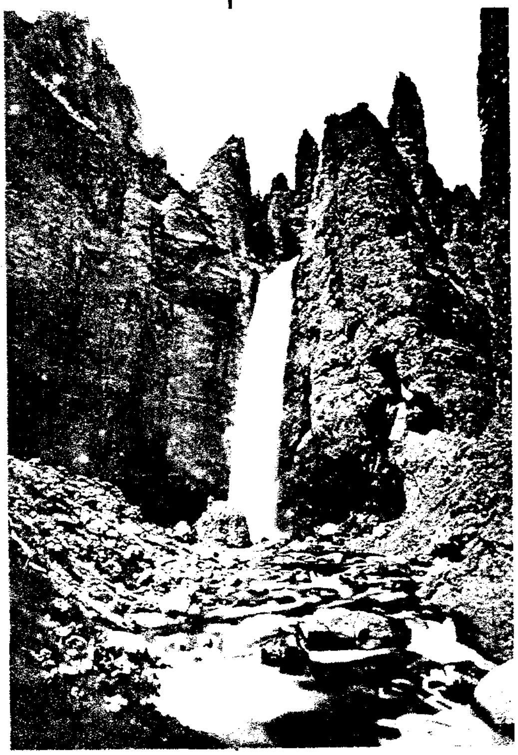
On the south border of this lake is a number of hot and boiling springs some of water and others of most beautiful fine clay and resembles that of a mush pot and throws its particles to the immense height of from twenty to thirty feet in height.

—from Daniel Potts' letter in a Philadelphia newspaper, 1827

1 History of the Park

The 1860s

- **1860** — First organized expedition attempts but fails to explore the Yellowstone Plateau.
- **1861** — *Civil War begins.*
- **1862** — *Gold strike west of Yellowstone.*
- **1865** — *Civil War ends.*
- **1869** — *Folsom–Cook–Peterson expedition.*



This photo of Tower Fall was one of many taken by W.H. Jackson during the 1871 expedition. His photos helped to bring public attention to the wonders of Yellowstone. Both the 1870 and 1871 expeditions spread the word through newspaper and magazine articles, speaking tours, and other publicity.

The 1869 Folsom-Cook-Peterson Expedition

In 1869, three members of one would-be expedition set out on their own. David E. Folsom, Charles W. Cook, and William Peterson ignored the warning of a friend who said their journey was "the next thing to suicide" because of "Indian trouble" along the way. From Bozeman, they traveled down the divide between the Gallatin and Yellowstone rivers, crossed the mountains to the Yellowstone and continued into the present park. They observed Tower Fall, the Grand Canyon of the Yellowstone—"this masterpiece of nature's handiwork"—continued past Mud Volcano to Yellowstone Lake, then south to West Thumb. From there, they visited Shoshone Lake and the geyser basins of the Firehole River. The expedition updated an earlier explorer's map (DeLacy, in 1865), wrote an article in *Western Monthly* magazine, and refueled the excitement of scientists who decided to see for themselves the truth of the party's tales of "the beautiful places we had found fashioned by the practiced hand of nature, that man had not desecrated."

The 1870 Washburn-Langford-Doane Expedition

In August 1870, a second expedition set out for Yellowstone, led by Surveyor-General Henry D. Washburn, politician and businessman Nathaniel P. Langford, and attorney Cornelius Hedges. Lt. Gustavus C. Doane provided military escort from Fort Ellis (near present-day Bozeman, Montana). The explorers traced the general route of the 1869 party to Yellowstone Lake, then traveled its eastern and southern shores, and explored the Upper, Midway, and Lower geyser basins (where they named Old Faithful). They climbed several peaks, descended into the Grand Canyon of the Yellowstone, and attempted measurements and analyses of several of the prominent natural features.

The 1871 Hayden Expedition

Ferdinand V. Hayden, head of the U.S. Geological and Geographical Survey of the Territories, led the next scientific expedition in 1871, simultaneous with a survey by the U.S. Army Corps of Engineers.

The Hayden Survey brought back scientific corroboration of the earlier tales of thermal activity. The expedition gave the world an improved map of Yellowstone and visual proof of the area's unique curiosities through the photographs of William Henry Jackson and the paintings of Henry W. Elliot and Thomas Moran. The expedition's reports excited the scientific community and aroused even more national interest in Yellowstone.

1872—Birth of a National Park

The crowning achievement of Yellowstone's explorers was helping to save Yellowstone from private development. They promoted a park bill in Washington in late 1871 and early 1872 that drew upon the precedent of the Yosemite Act of 1864, which reserved Yosemite Valley from settlement and entrusted it to the care of the state of California. To permanently close to settlement an expanse of the public domain the size of Yellowstone would depart from the established policy of transferring public lands to private ownership. But the wonders of Yellowstone—shown through Jackson's photographs, Moran's paintings, and Elliot's

The 1870s

- 1870 — Washburn–Langford–Doane expedition.
- 1871 — Hayden expedition.
- 1872 — Yellowstone National Park Act establishes the first national park.
- 1877 — Nee-me-poo (Nez Perce) flee U.S. Army through Yellowstone.

sketches—had caught the imagination of both the public and Congress. On March 1, 1872, President Ulysses S. Grant signed the Yellowstone National Park Act into law. The world's first national park was born.

The Formative Years

The park's promoters envisioned Yellowstone National Park would exist at no expense to the government. Nathaniel P. Langford, member of the Washburn expedition and advocate of the Yellowstone National Park Act, was appointed to the unpaid post of superintendent. Because he received no salary, he earned his living elsewhere and entered the park only twice during five years in office—as part of the second Hayden expedition in 1872 and to evict a squatter in 1874. His task was made more difficult by the lack of laws protecting wildlife and other natural features.

Political pressure forced Langford's removal in 1877. Congress authorized a salary for the next superintendent and appropriations "to protect, preserve, and improve the Park."

Philetus W. Norris was appointed the second superintendent. He constructed roads, built a park headquarters at Mammoth Hot Springs, hired the first "gamekeeper," and waged a difficult campaign against poachers and vandals. Much of the primitive road system he laid out remains today as the Grand Loop Road. Through constant exploration, Norris also added immensely to geographical knowledge of the park.

Norris's tenure occurred during an era of warfare between the United States and many Native American tribes. To reassure the public that they faced no threat from these conflicts, he promoted the idea that Native Americans shunned this area because they feared the hydrothermal features, especially the geysers. This idea belied evidence to the contrary that had been documented by trappers and early explorers, but the myth spread.

Norris fell victim to political maneuvering and was removed from his post in 1882. He was succeeded by three powerless superintendents who could not protect the park. Even when ten assistant superintendents were authorized to act as police, they failed to stop the destruction of wildlife. Poachers, squatters, woodcutters, and vandals ravaged the park.

Touring the Park

During the early years of the park, visitation remained low because access to the park and travel within the park were difficult. They either had to transport themselves or patronize one of the transportation enterprises that carted them to the park. Once in the park, they found only a few concessioners providing food and minimal sleeping accommodations. Access improved in 1883 when the Northern Pacific Railroad reached Cinnabar, Montana, a new town near the north entrance of the park.

A typical tour of Yellowstone began when visitors descended from the train in Cinnabar, boarded large "tally ho" stagecoaches (above), and headed up the scenic Gardner River Canyon to Mammoth Hot Springs. After checking into the large hotel, they spent the afternoon touring the hot springs. For the next four days, tourists bounced along in passenger coaches called "Yellowstone wagons," which had to be unloaded at steep grades. Each night visitors enjoyed a warm bed and a lavish meal at a grand hotel.

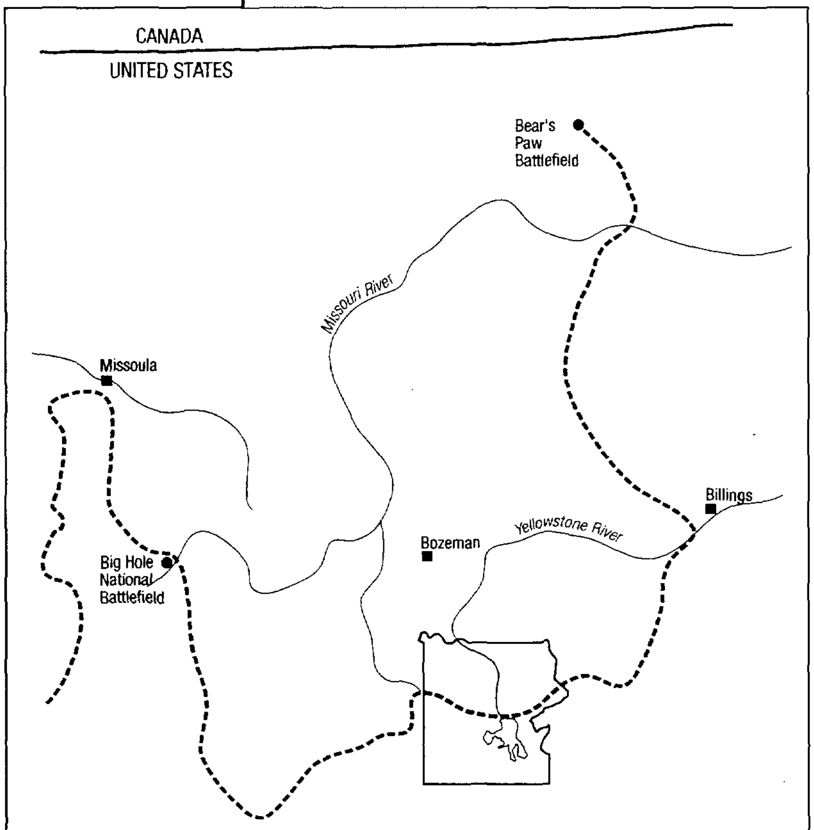
The visitors carried home unforgettable memories of experiences and sights. They recommended the tour to their friends, and each year more of them came to Yellowstone to see its wonders themselves. When the first automobile entered the park in 1915, Yellowstone became a truly national park, accessible to anyone who could afford a car.

1

History of the Park

The 1880s & 1890s

- **1883** — Northern Pacific Railroad reaches the North Entrance of the park.
- **1886** — The U.S. Army arrives to administer the park. They stay until 1918.
- **1894** — Poacher Ed Howell captured; Lacey Act passed.



1886—The Army Arrives

In 1886 Congress refused to appropriate money for ineffective administration. The Secretary of the Interior, under authority previously given by the Congress, called on the Secretary of War for assistance. On August 20, 1886, the U.S. Army took charge of the administration and protection of Yellowstone.

The Army strengthened regulations, posted them around the park, and enforced them. Troops guarded the major attractions and evicted troublemakers, and cavalry patrolled the vast interior of the park.

The most persistent menace came from poachers, whose activities threatened to exterminate animals such as the bison. In 1894, soldiers arrested a man named Ed Howell for slaughtering bison in Pelican Valley. The maximum sentence possible was banishment from the park. A prominent journalist was present and wired the story to his Chicago editor who published it. The report created a national outcry. Within two months

Flight of the Nez Perce

South of Madison Junction, on the west side of the park, the main road crosses Nez Perce Creek, which is named for the tribe that followed the creek as they crossed the park in 1877. Settlers had displaced the Nee-me-poo (the preferred name for the tribe) from their homeland west of the park, and the U.S. Government was trying to force them onto a reservation. A band of 800 men, women, and children—plus almost 2000 horses—fled toward Canada. At Big Hole, Montana, many of their group, including women and children, were killed in a battle with the Army. The remainder of the group entered Yellowstone National Park on the evening of August 23rd. During the two weeks they crossed the park, the Nee-me-poo bumped into all 25 known people visiting the new park at that time, some more than once. Still angry from the deaths at Big Hole, warriors took hostage or attacked several of these tourist parties. The group continued traveling through the park and over the Absaroka Mountains into Montana. The Army stopped them in the foothills of the Bear Paw Mountains, less than 40 miles from the Canadian border. Some Nee-me-poo slipped into Canada, but the remaining 350 tribal members surrendered after a six-day battle. This is where Chief Joseph spoke these famous words, "From where the sun now stands, I will fight no more forever." The 1,700-mile flight had ended.

Today, Nez Perce National Historic Park commemorates their flight at 38 sites in Idaho, Oregon, Washington, and Montana. The sites include Big Hole National Battlefield and Bear's Paw Battlefield, a National Historic Landmark. Congress has recognized the trail's national significance by designating it as the Nez Perce (Nee-me-poo) National Historic Trail. This designation includes the portion traversing the park, which today crosses or approaches the main park road in four places: Nez Perce Creek, Otter Creek, Nez Perce Ford, and Indian Pond.

The 20th Century

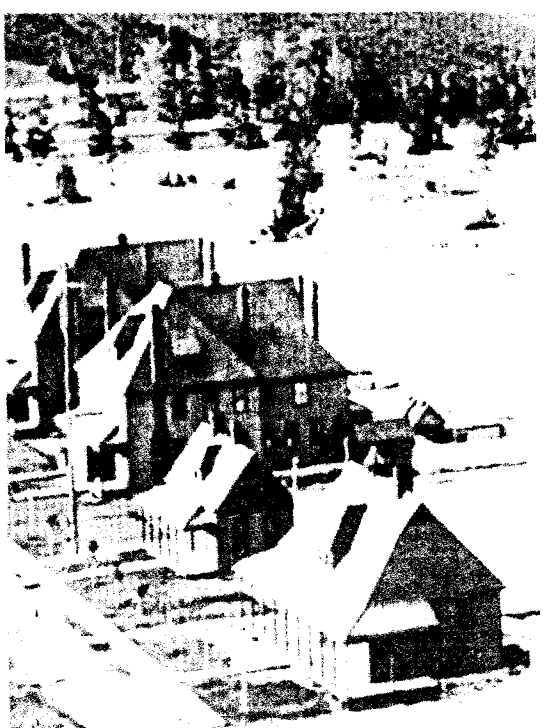
- **1903** — President Theodore Roosevelt dedicates arch at North entrance in Gardiner.
- **1906** — 1906: The Antiquities Act provides for the protection of historic, prehistoric, and scientific features on and artifacts from federal lands.
- **1908** — Union Pacific train service begins at West Yellowstone.
- **1915** — Private automobiles are officially admitted to the park.
- **1916** — The National Park Service Act establishes the National Park Service.
- **1918** — U.S. Army turns over park management to the National Park Service.

Soldiers pose with bison heads captured from poacher Ed Howell. When Howell returned to the park later that year, he was the first person arrested and punished under the new National Park Protection Act, passed in 1894.

Congress acted—the National Park Protection Act (the Lacey Act) was passed, finally providing teeth for protecting Yellowstone's treasures.

Running a park was not the Army's usual line of work. The troops could protect the park and ensure access, but they could not fully satisfy the visitor's desire for knowledge. Moreover, each of the 14 other national parks established during this period was separately administered, resulting in uneven management, inefficiency, and a lack of direction.

Fort Yellowstone at Mammoth Hot Springs as it looked in the early years. Some of its buildings remain today and serve as park headquarters.



1916: The National Park Service Begins

National parks clearly needed coordinated administration by professionals attuned to the special requirements of these preserves. Accordingly, in 1916, Congress passed the National Park Service Act, which created the National Park Service.

Yellowstone's first ranger force, which included veterans of Army service in the park, assumed responsibility for Yellowstone in 1918. The park's first superintendent under the new National Park Service was Horace M. Albright, who served simultaneously as assistant to Stephen T. Mather, Director of the National Park Service. Albright established a framework of management that guided administration of Yellowstone for decades.

The National Park Service Act

Passed in 1916, this law created the National Park Service and established its mission: "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."

The 20th Century

1929 President Hoover signs first law changing park's boundary.

1932 Present Hoover expands the park again.

1933 Civilian Conservation Corps established, works in Yellowstone through 1941.

1934 NPS Director's Order prohibits killing predators.

1935 The Historic Sites Act sets a national policy to "preserve for future public use historic sites, buildings, and objects."

1948 Park receives one million visitors.

1949 Nineteen snowplane trips carried 49 passengers into the park in winter.

The Park Adjusts

Almost as soon as the park was established, people began suggesting that the boundaries be revised to conform more closely to natural topographic features, such as the ridgeline of the Absaroka Range along the east boundary. Although these people had the ear of influential politicians, so did their opponents—which at one time also included the United States Forest Service. Eventually a compromise was reached and in 1929, President Hoover signed the first bill changing the park's boundaries: The northwest corner now included a significant area of petrified trees; the northeast corner was defined by the watershed of Pebble Creek; the eastern boundary included the headwaters of the Lamar River and part of the watershed of the Yellowstone River. (The Yellowstone's headwaters remain outside the park in Bridger-Teton National Forest.)

When Frances Pound applied for a law enforcement position in 1926, Superintendent Albright suggested she use her nickname, "Jim," because she would be the first woman hired to do law enforcement in Yellowstone.

In 1932, President Hoover added more than 7,000 acres between the north boundary and the Yellowstone River, west of Gardiner. These lands provided winter range for elk, pronghorn, and other ungulates.

Efforts to exploit the park also expanded during this time. Water users from the town of Gardiner to the potato farmers of Idaho wanted the park's water. Proposals included damming the southwest corner of the park—the Bechler region. The failure of these schemes confirmed that Yellowstone's wonders were so special that they should be forever preserved from exploitation.

The 1940s

World War II drew away employees, visitors, and money from all national parks, including Yellowstone. The park's employees, who at this time were mostly men, were pulled away for military service. Visitors were few due to gasoline and other commodity rationing. The money needed to maintain the park's facilities, much less construct new ones, was directed to the war effort. Among other projects, the road from Old Faithful to Craig Pass was left unfinished.

During the war, the park withstood neglect. But visitation jumped as soon as the war ended. By 1948, park visitation reached one million people per year. The park's budget did not keep pace, and the neglect of the war years quickly caught up with the park.

Mission 66

In 1955 the National Park Service initiated a program to address backlogged construction and maintenance and to provide modern facilities for the traveling public. The program was targeted for completion by 1966, the golden anniversary of the National Park Service, and was called Mission 66.

In Yellowstone, the Canyon Area was redeveloped as part of Mission 66. Visitor facilities were designed to reflect American attitudes of the 1950s: Anything "old" had no value or relevance in "modern" times, and convenience was paramount. Visitor services were arranged around a large parking plaza with small cabins a short distance away. Canyon Village opened in July 1958, the first Mission 66 project completed by the National Park Service.

1955 — Mission 66 begins. The first concession-run snowcoach trips carry more than 500 people into the park in winter.

1959 — Magnitude 7.5 earthquake strikes on August 17 west of Yellowstone, killing campers in Gallatin National Forest and affecting geysers and hot springs in the park.

1963 — The Leopold Report is issued.

1966 — Thermus aquaticus discovered in a Yellowstone hot spring (see Chapter 8, "Bioprospecting").

1970 — First bear management plan implemented (see Chapter 6, page 85).

1971 — Overnight winter lodging opens in park.

1975 — Grizzly bear listed as threatened species in the lower 48 states.

Changing Management Ideas

Until the mid 1960s, park managers actively managed the elk and bison of Yellowstone. Elk population limits were determined according to formulas designed to manage livestock range. When elk reached those limits, park managers "culled" or killed the animals to reduce the population. Bison were likewise heavily managed.

In 1963, a national park advisory group, comprised of prominent scientists, released a report recommending parks "maintain biotic associations" within the context of their ecosystem, and based on scientific research. Known as the Leopold Report, this document established the framework for park management still in use today throughout the National Park System. By moving into this new management philosophy, Yellowstone went from an unnatural managing of resources to "natural regulation"—today known as Ecological Process Management.

Complex Times

Although change and controversy have occurred in Yellowstone since its inception, the last three decades have seen many issues arise. Most involve natural resources, and those still current are described elsewhere in the book *(see list at right).*

In an effort to resolve park management issues throughout the system, Congress passed the The National Parks Omnibus Management Act in 1998. This law mandates the use of high quality science from inventory, monitoring, and research to understand and manage park resources.

One issue resolved was the threat of water pollution from a gold mine outside the northeast corner of the park. Among other concerns, the New World Mine would have sited waste storage along the headwaters of Soda Butte Creek, which flows into the Lamar River and then the Yellowstone River. In 1996, after years of public debate, President Clinton authorized a federal buyout of the mining company. The buyout is not complete, but the pollution from the mine is no longer a threat.

Park facilities, underfunded for decades, are seeing some improvements due to a change in how such projects can be funded. In 1996, as part of a national pilot program, Yellowstone National Park was authorized to increase its entrance fee and retain more than half of the fee for park projects. (Previously, none of the entrance fees specifically funded projects in Yellowstone.) Projects being funded, in part, by this pilot program include a major renovation of Canyon Visitor Center, replacement of outdated audiovisual equipment at Old Faithful Visitor Center, and various resource studies.

A Decade of Environmental Laws

Beginning in the late 1960s, the U.S. Congress passed an unprecedented suite of laws to protect the environment. The laws described here particularly influence the management of our national parks.

***The National Environmental Policy Act,** passed in 1969, establishes a national policy "to promote efforts which will prevent or eliminate damage to the environment...stimulate the health and welfare of man...and enrich the understanding of ecological systems..." It requires detailed analysis of environmental impacts of any major federal action that significantly affects the quality of the human environment. Environmental assessments (EAs) and environmental impact statements (EISs) are written to detail these analyses and to provide forums for public involvement in management decisions.*

***The Endangered Species Act** (1973) requires federal agencies to protect species that are (or are likely to become) at risk of extinction throughout all or a significant part of their range. It prohibits any action that would jeopardize their continued existence or result in the destruction or modification of their habitat.*

***The Clean Water Act** (1977) is enacted to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" by prohibiting the discharge of pollutants.*

***The Clean Air Act** (1977) mandates protection of air quality in all units of the National Park System; Yellowstone is classified as Class 1, the highest level of clean air protection.*

For Information on Current Issues

Fire Management (and the fires of 1988): Chapter 5

Bioprospecting, bison management, lake trout and other aquatic concerns, and winter use: Chapter 8.

1

History of the Park

The Twentieth Century

- **1988** — *Public Law 100-443 protects hydrothermal features in national parks from geothermal development on adjacent federal lands.*

  Summer of Fire: more than 790,000 acres affected by fires in Yellowstone.
- **1991** — *Clean Air Act Amendments require air quality monitoring at specified sites including Yellowstone, a Class I airshed— one of the purest in the nation.*
- **1994** — *The Appropriation Act allows a percentage of park entrance fees to be retained in the parks.*
- **1995** — *Wolves are restored to Yellowstone.*
- **1996** — *President Clinton authorizes federal buy-out of the New World Mine on Yellowstone's northeast border.*
- **1998** — *The National Parks Omnibus Management Act.*

The Legacy of Yellowstone

The years have shown that the legacy of those who worked to establish Yellowstone National Park in 1872 was far greater than simply preserving a unique landscape. This one act has led to a lasting concept—the national park idea. This idea conceived wilderness to be the inheritance of all people, who gain more from an experience in nature than from private exploitation of the land. In time, the idea blossomed in the form of many new national parks worldwide, set aside in the same spirit as Yellowstone.

The national park idea was part of a new view of the nation's responsibility for the public domain. By the end of the 19th century, many thoughtful people no longer believed that the wilderness should be fair game for the first person who could claim and plunder it. They believed its fruits were the rightful possession of all the people, including those yet unborn. Besides the areas set aside as national parks, still greater expanses of land were placed into national forests and other reserves so that the country's natural wealth—in the form of lumber, grazing, minerals, and recreation lands—should not be consumed at once by the greed of a few, but should perpetually benefit all people.

The preservation idea, born in Yellowstone, spread around the world. Scores of nations have preserved areas of natural beauty and historical worth so that all humankind will have the opportunity to reflect on their natural and cultural heritage and to return to nature and be spiritually reborn. Of all the benefits resulting from the establishment of Yellowstone National Park, this may be the greatest.

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Greater Yellowstone Ecosystem

2

Yellowstone National Park forms the core of the Greater Yellowstone Ecosystem (GYE)—one of the largest intact temperate zone ecosystems on the earth today. This 28,000-square-mile region of mainly federal lands preserves and nurtures a variety of wildlife species and the natural processes that sustain them.

Each of Yellowstone National Park's separate parts—the hydrothermal features, the wildlife, the lakes, the Grand Canyon of the Yellowstone River, and the petrified trees—could easily stand alone as a national park. That they are all at one place is testimony to Greater Yellowstone's diversity and natural wealth.

GYE BASICS

- 12–18 million acres; 18,750–28,125 square miles *(see map, next page, for why it varies)*
- States: Wyoming, Montana, Idaho
- Encompasses state lands, two national parks, portions of six national forests, three national wildlife refuges, Bureau of Land Management holdings, private and tribal lands
- Managed by state governments, federal government, tribal governments, and private individuals
- Largest elk herd in North America
- Largest free-roaming, wild herd of bison in U.S.
- One of two grizzly populations in contiguous U.S.
- Home to the rare wolverine and probably to the lynx

In Yellowstone National Park:

60 mammals
315 bird species; 148 species nest here
18 fishes: 12 native, 6 non-native
10 reptiles and amphibians
12,000+ insect species, including 128 species of butterflies
1,280+ species of vascular plants

Geoecosystem

Geological characteristics form the foundation of an ecosystem. In Yellowstone, the interplay between volcanic, hydrothermal, and glacial processes and the distribution of flora and fauna are intricate and unique.

The topography of the land from southern Idaho northeast to Yellowstone results from millions of years of hotspot influence. Some scientists believe the Yellowstone Plateau itself is a result of uplift due to hotspot volcanism. Today's landforms channel westerly storm systems eastward onto the plateau where they drop large amounts of snow.

The distribution of rocks and sediments in the park also influences the distributions of flora and fauna. The volcanic rhyolites and tuffs of the Yellowstone Caldera are rich in quartz and potassium feldspar, which form nutrient-poor soils. Thus, areas of the park underlain by rhyolites and tuffs generally are characterized by extensive, monotypic stands of lodgepole pine, which are drought tolerant and have shallow roots that take advantage of the nutrients in the soil. In contrast, andesitic volcanic rocks that underlie the Absaroka Mountains are rich in calcium, magnesium, and iron. These minerals weather into soils that can store more water and provide better nutrients than rhyolitic soils. This allows for more vegetative growth, which adds organic matter to the soils and results in much more fertile soils. You can see the result when you drive over Dunraven Pass or through other areas of the park with Absaroka rocks. They have a richer flora, including mixed forests interspersed with meadows. Lake sediments such as those underlying Hayden Valley, which were deposited during glacial periods, form clay soils that allow meadow communities to outcompete trees for water. The patches of lodgepole pines in Hayden Valley grow in areas of rhyolite rock outcrops.

These whitebark pine grow in the andesitic soils on Mount Washburn.

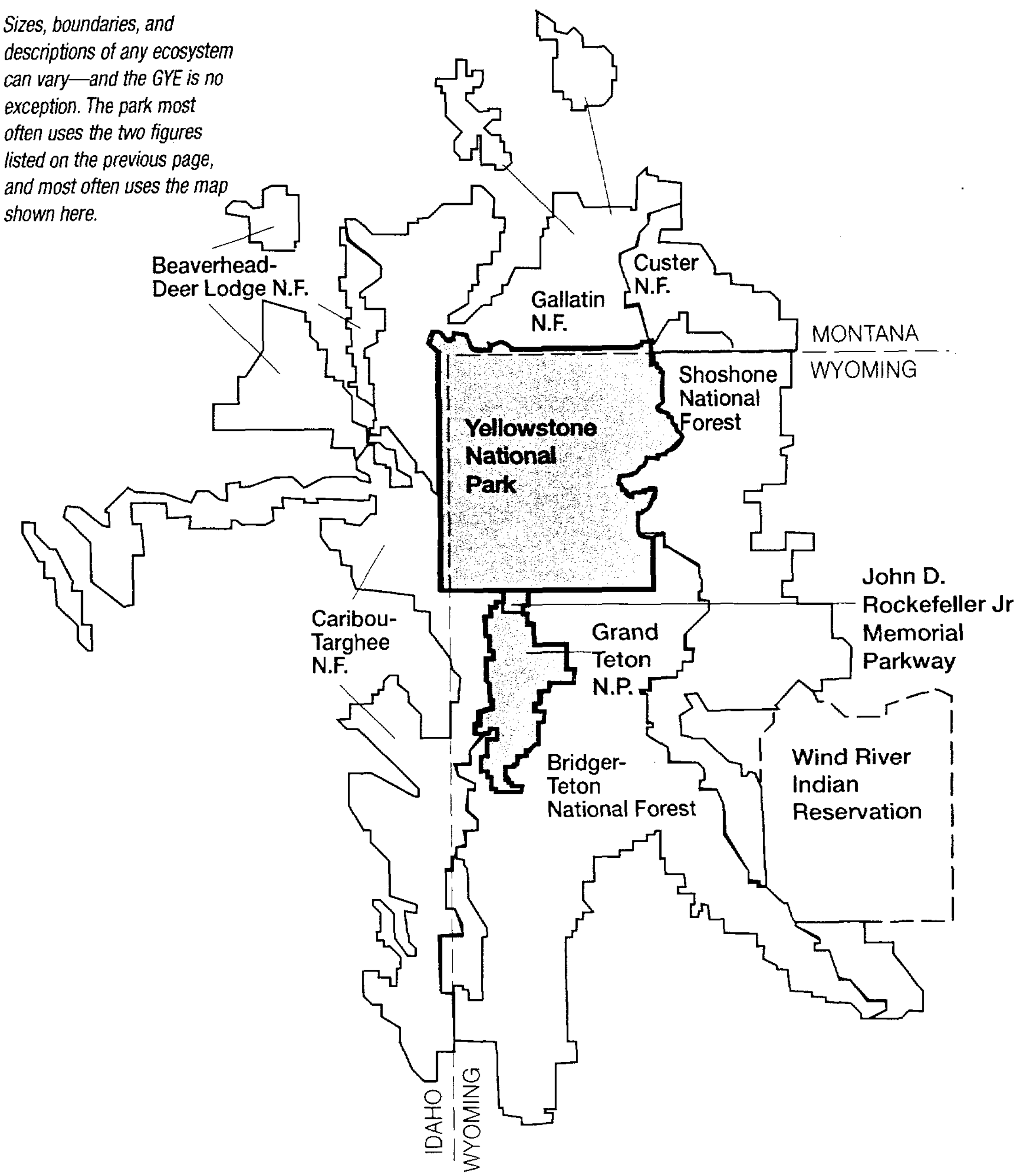
2

Greater Yellowstone Ecosystem

Because of the influence rock types have on plant distribution, some scientists theorize that geology also influences wildlife distributions and movement. Whitebark pine is an important food source for grizzly bears during the autumn. The bears migrate to the whitebark pine areas such as the andesitic volcanic terrain of Mt. Washburn. Grazing animals such as elk and bison are found in the park's grasslands, which grow best in sedimentary soil of valleys such as Hayden and Lamar. And the many hydrothermal areas of the park, where grasses and other food remain uncovered, provide a haven for animals during the winter.

How big is the Greater Yellowstone Ecosystem?

Sizes, boundaries, and descriptions of any ecosystem can vary—and the GYE is no exception. The park most often uses the two figures listed on the previous page, and most often uses the map shown here.



Biological Diversity

Biological diversity is one of the benchmarks measuring the health of an ecosystem. Biodiversity can be measured two ways: the number of different species (also called richness) and the abundance of each species (also called eveness). The diversity of animals within the greater Yellowstone ecosystem is as great as that found anywhere in the lower 48 states.

Significantly, Greater Yellowstone's natural diversity is still essentially intact. With the exception of the black-footed ferret, the region appears to have retained or restored its full historic complement of vertebrate wildlife species—something truly unique in the wildlands of the contiguous 48 states.

The extent of wildlife diversity is due in part to the different habitats found in the region, ranging from high alpine areas to sagebrush country, hydrothermal areas, forests, meadows, and other habitat types. All of these are connected, including linkages provided by streams and rivers that course through the changing elevations.

Other unique lifeforms are protected here, too. Various species of microorganisms are the living representatives of the primitive lifeforms now recognized as the beginnings of life on this planet. The original atmosphere on earth was anoxic (without oxygen), and cyanobacteria were the first organisms capable of photosynthesis (the process by which plants use sunlight to convert carbon dioxide to oxygen and other byproducts). Consequently, these organisms began to create an atmosphere on earth that would eventually support plants and animals.

Cycles and Processes

Cycles and processes are the building blocks in the foundation of any ecosystem. Photosynthesis, predation, decomposition, climate, and precipitation facilitate the flow of energy and raw materials. Living things absorb, transform, and circulate energy and raw materials and release them again. Cycles and processes provide the essential connections within the ecosystem.

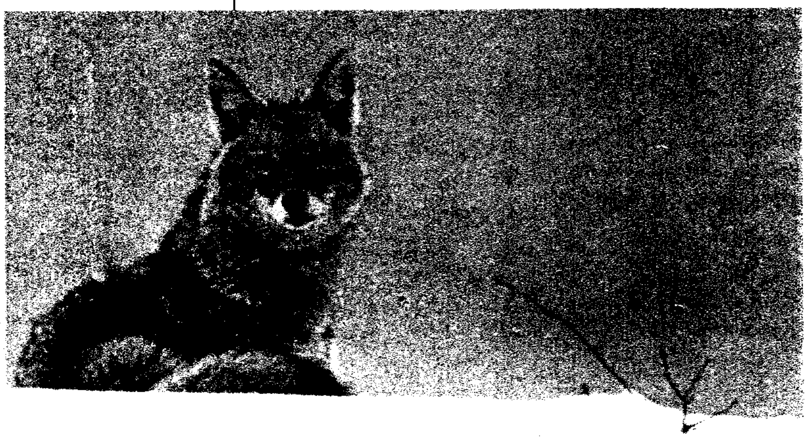
The Lamar Valley's thick grasses grow in nutrient-rich sedimentary soil laid down by glaciers. This and other Yellowstone grasslands provide habitat for bison, elk, deer, pronghorn, coyote, wolf, grizzly and black bear, golden and bald eagles, ravens, osprey, and many other species.

Lifeforms are active at all levels. Microbes beneath Yellowstone Lake thrive in hydrothermal vents where they obtain energy from sulfur instead of the sun. Plants draw energy from the sun and cycle minerals such as carbon, sulfur, and nitrogen through the system. Herbivores, ranging from ephydrid flies to elk, feed on the plants and, in turn, provide food for predators like coyotes and hawks. Decomposers—bacteria, fungi, other microorganisms—link all that dies with all that is alive.

The ecosystem is constantly changing and evolving. A forest fire is one example of such an integral, dynamic process. Fires rejuvenate forests on a grand scale. Some species of plants survive the intense burning to resprout. The serotinous cones of lodgepole pines pop open in heat generated by fires, spreading millions of seeds on the forest floor. After fire sweeps through an area, mammals, birds, and insects quickly take advantage of the newly created habitats. Fires recycle and release nutrients and create dead trees or snags that serve a number of ecological functions, such as the addition of organic matter to the soil when the trees decompose *(see Chapter 5)*.

2

Greater Yellowstone Ecosystem



Winter in the Yellowstone Ecosystem

Deep snow, cold temperatures, and short days characterize winter in the Greater Yellowstone Ecosystem, and all the plants and animals here live with these conditions. For example, all of the conifers retain their needles through the winter, which extends their ability to photosynthesize. Deciduous trees like aspens and cottonwoods contain chlorophyll in their bark, enabling them to photosynthesize before they produce leaves. Animals exhibit a variety of physical, physiological, and behavioral adaptations.

Animal Behavioral Adaptations

- Red squirrels and beavers cache food before winter.
- Some birds roost with their heads tucked into their back feathers to prevent heat loss.
- Chickadees roost in small cavities.
- Deer mice huddle together to stay warm.
- Ungulates like deer, elk, and bison sometimes follow each other through deep snow to save energy.
- Small mammals find insulation, protection from predators, and ease of travel by living beneath the snow.
- Grouse roost overnight by burrowing into the snow for insulation.

Animal Morphological/Physical Adaptations

- Mammals molt their fur in fall. Incoming guard hairs are longer and protect the underfur. Colorless guard hairs are hollow, containing trapped air that provides insulation. Additional underfur grows each fall and consists of short, thick, often wavy hairs designed to trap air. A sebaceous (oil) gland, adjacent to each hair canal, secretes oil to waterproof the fur. Mammals have muscular control of their fur, fluffing it up to trap air when they are cold and sleeking it down to remove air when they are warm.
- River otters' fur has long guard hairs with interlocking spikes that protect the underfur, which is extremely wavy and dense to trap insulating air. Oil secreted from sebaceous glands prevents water from contacting the otters' skin. After emerging from water, they replace air in their fur by rolling in the snow and shaking their wet fur.
- Snowshoe hares, long-tailed weasels, and short-tailed weasels turn white for winter. White color provides camouflage but may have evolved primarily to keep these animals insulated as hollow white hairs contain air instead of pigment.
- Snowshoe hares have large feet to spread their weight over the snow; martens and lynx grow additional fur between their toes to give them effectively larger feet.
- Moose have special joints that allow them to swing their legs over snow rather than push through snow as elk do.
- Bison have a large hump of shoulder muscles powering their massive heads as they sweep snow aside in search of food.
- Chickadees' half-inch-thick layer of feathers keeps them up to 100 degrees warmer than the ambient temperature.

Bison can reach food beneath three feet of snow, as long as the snow is not solidified by melting and refreezing. A bison's hump is made of elongated vertebrae to which strong neck muscles are attached, which enable the animal to sweep its massive head from side to side. After the bison moves on, other animals such as elk can find food in the craters.

Biochemical/physiological

- Mammals and waterfowl exhibit counter-current heat exchange in their limbs that enables them to stand in cold water: Cold temperatures cause surface blood vessels to constrict, shunting blood into deeper veins that lie close to arteries. Cooled blood returning from extremities is warmed by arterial blood traveling towards the extremities, conserving heat.
- At night, chickadees undergo regulated hypothermia. Their body temperature drops from 108°F to 88°F, which lessens the sharp gradient between the temperature of their bodies and the external temperature, resulting in a 23 percent decrease in the amount of fat burned each night.
- Chorus frogs tolerate freezing by becoming severely diabetic in response to cold temperatures and the formation of ice within their bodies. At this point the liver quickly converts glycogen to glucose, which enters the blood stream and serves as an antifreeze. Within eight hours, blood sugar rises 200–fold. When a frog's internal ice content reaches 60–65 percent, the frog's heart and breathing stop. Within one hour of thawing, the frog's heart resumes beating.

Types of Snow

Temperature Gradient Snow
or "depth hoar," forms through snow metamorphosis during cold air temperatures when water moves from warmer snow near the ground to colder snow near the surface. Snow crystals grow in size, forming sugar snow where small mammals burrow.

Equitemperature Snow
forms as new crystals of snow become rounded and snowpack settles.

Rime Frost
forms when supercooled water droplets contact an object and freeze in place.

Hoar Frost
forms when water vapor sublimates onto a surface. Formation of surface hoar occurs when nighttime temperatures are very low.

2

Greater Yellowstone Ecosystem

Ecosystem Management Challenges

Despite the size of the ecosystem, Greater Yellowstone's biodiversity is in jeopardy. Many of its plant and animal species are considered to be rare, threatened, endangered, or of special concern. This includes more than 100 plants, hundreds of invertebrates, at least six fish species, several species of amphibians, at least 20 bird species, and 18 species of mammals. The numbers are estimates because, even in this vital region, comprehensive inventories have not been completed. Carnivorous mammals represent more than half of the mammals in danger, including the grizzly bear, wolverine, and lynx.

Habitat modification—beyond the levels of natural disturbance—poses a serious threat to both biodiversity and to ecosystem processes. Such modifications fragment habitats and isolate populations of plants and animals from each other, which cuts them off from processes necessary for survival.

Ecosystem management is gaining support among conservationists and resource managers who recognize that most protected parks and reserves represent fragments of much larger ecosystems. Ecosystem management addresses the whole ecosystem, including preserving individual components and the relationships and linkages between them. Maintaining healthy, functioning ecosystems more effectively preserves species than do emergency measures to bring back threatened species from the brink of extinction.

Ecosystem management includes human activities as part of management and protection of ecosystems. Development proposals are evaluated using methods such as "cumulative effects analysis," which considers combined effects of all development—not just one activity—on an entire area, not just a few species.

In the past, GYE has been managed as individual units drawn along political lines. The result has been fragmented, inconsistent, and sometimes contradictory management. Since the 1980s, however, the ecosystem management approach has been gaining support. For example, the supervisors, superintendents, and regional officials for the two national parks and six of seven national forests in the ecosystem meet periodically as the Greater Yellowstone Coordinating Committee to discuss common issues and seek solutions.

GYE is included in the Yellowstone to Yukon Conservation Initiative, or "Y2Y." More than 170 organizations, institutions, and foundations based in Canada and the United States are working together to ensure the long-term survival of wildlife in the Northern Rockies from the Greater Yellowstone Ecosystem to the Yukon Highlands—a distance of 1,900 miles. Ecosystem management on this scale is needed for wide-ranging wildlife species such as grizzly bears and wolves; Y2Y seeks to build and maintain a life-sustaining system of core reserves and connecting wildlife corridors. Existing national, state, and provincial parks and wilderness areas will anchor the system, while the creation of new protected areas and cooperation of land-owners will provide the additional reserves and corridors.

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GEOLOGY

3

Yellowstone National Park is a unique physical landscape that provides insight into myriad geological processes. The fact that Yellowstone is an area of active volcanic, seismic, and hydrothermal processes is what makes this national park a unique treasure. This area has a history of catastrophic volcanic eruptions and will continue to have earthquakes (some large), dynamic geothermal processes, and perhaps even eruptions of lava.

YELLOWSTONE'S GEOLOGIC SIGNIFICANCE

- One of the most geologically dynamic areas on earth due to a rare continental hotspot that causes volcanic activity
- One of the largest volcanic eruptions known to have occurred in the world, leaving behind one of the largest known calderas
- More than 10,000 hydrothermal features, including more than 300 geysers
- The largest concentration of active geysers in the world—approximately half of the world's total
- Most of the undisturbed geyser basins left in the world (Kamchatka Peninsula has the others; the rest have been modified or destroyed by human development)
- One of the few places in the world where active travertine terraces are found, in Mammoth Hot Springs
- Site of many layers of petrified trees resulting from repeated volcanic eruptions over the ages

Yellowstone National Park was established for its unique array of geological features and processes. While those geological processes may impart risk, the volcanic and seismic energy powers the geysers and related hydrothermal features also creates the mountains and canyons, and generates the unique ecosystems that support Yellowstone's diverse wildlife.

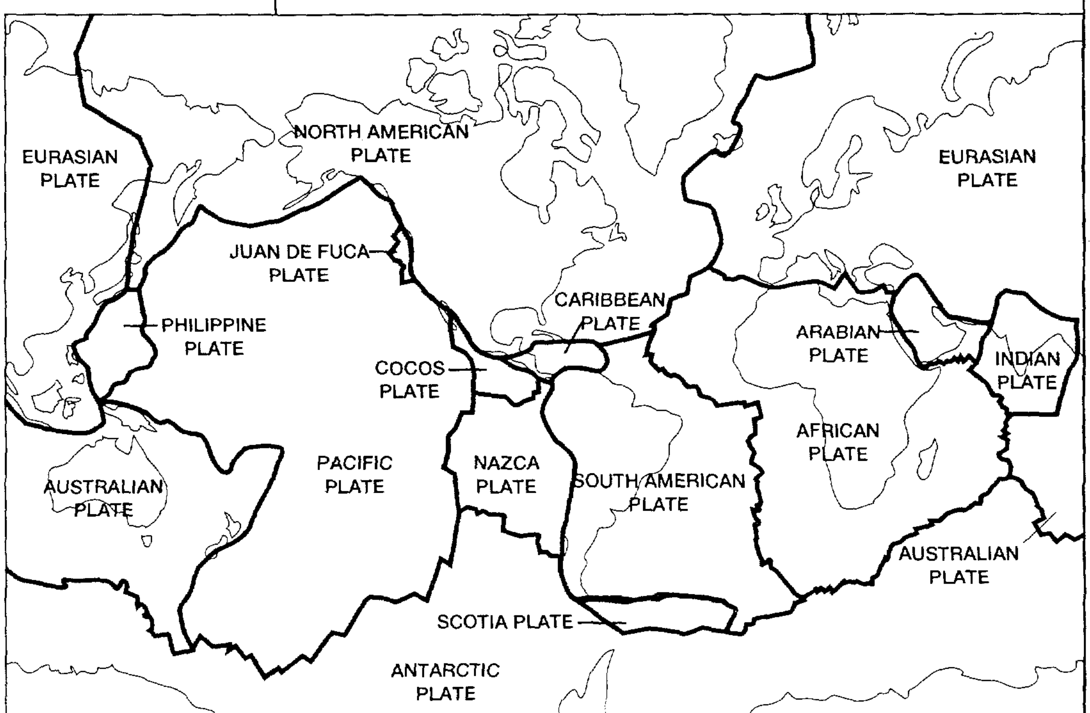


Plate Tectonics

Plate tectonics is an all-encompassing theory of geology that begins with the idea that the lithosphere of the earth is divided into many plates *(see illustration at right).*

Continental plates are of distinctively different composition than oceanic plates; they are made of less dense materials (granitic rocks as opposed to basaltic rocks) and, thus, "ride" higher than the oceanic plates. All of the earth's plates move constantly and, where the edges meet, one plate may slide past another (transform boundary) or one plate can be driven below the other (subduction). At other plate edges, upwelling of volcanic material pushes the plates apart (mid ocean ridges). Several hypotheses have been advanced to explain what drives the crustal plate movement, the most likely being that convection currents in the partially molten asthenosphere exert pressure on the rigid lithospheric plates, thus, causing them to move.

Volcanoes in Yellowstone

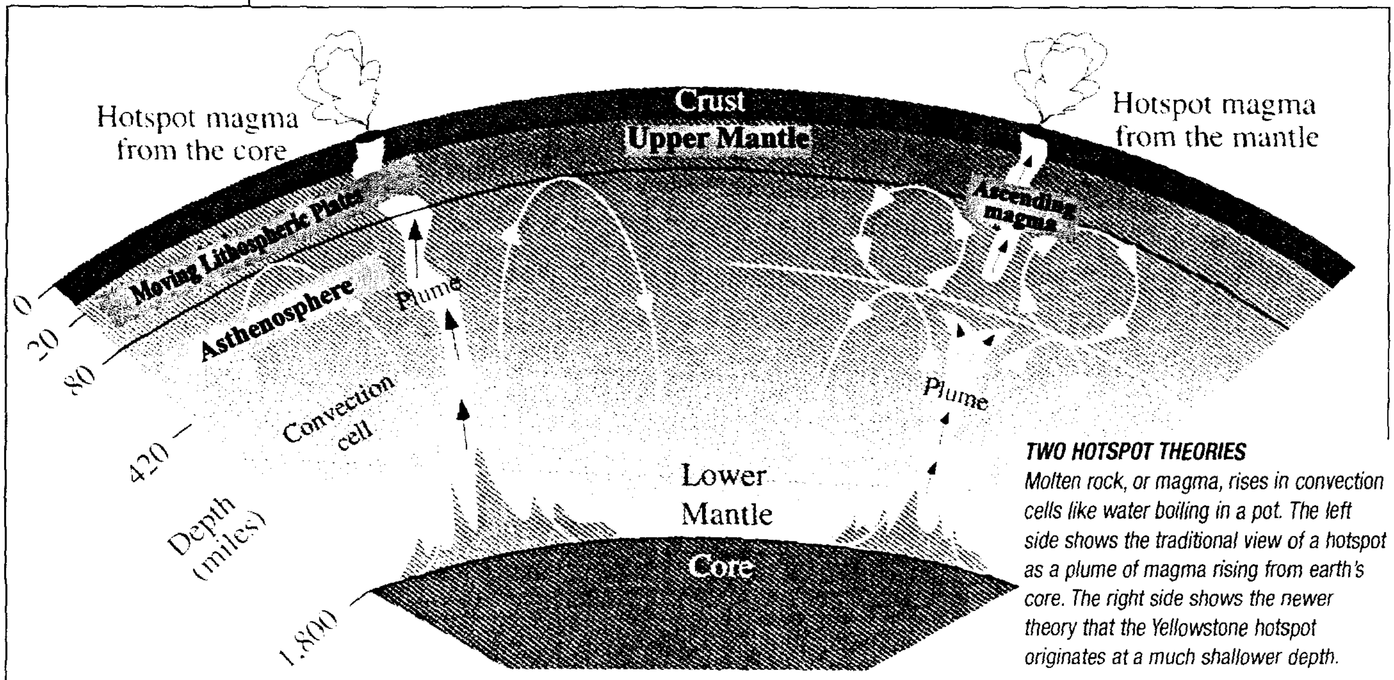
Volcanism in the Yellowstone area began about 50 million years ago during a period of extensive mountain building throughout the northern Rocky Mountains as subduction occurred along plate boundaries. The Absaroka Mountains, which lie along the eastern side of Yellowstone and north of the park, were formed during this period, which ended about 40 million years ago.

About 16 million years ago, a series of volcanic eruptions began in what is now western Idaho and northern Nevada. A rare continental hotspot causes this activity. Scientists theorize that as the crustal plate has moved southwest over the hotspot, the volcanic activity has moved northeast.

About 2.1 million years ago, the track of this volcanic activity had neared present-day Yellowstone. The volcano was under the southwestern portion of Yellowstone, extending into the Island Park area of Idaho. The volume of material ejected during the volcanic explosion that occurred is difficult to imagine; it is estimated to be 2,400 times the size of the 1980 Mount St. Helens explosion; ash from this eruption has been found as far away as Missouri. The resulting collapse of this volcano is called the Huckleberry Ridge Caldera. Subsequent caldera explosions have destroyed much evidence of this event, but geologists can still trace many areas of the caldera rim. The yellow rocks in the Golden Gate area of northern Yellowstone are Huckleberry Ridge tuff (welded ash).

Approximately 800,000 years later, a smaller volcanic eruption occurred on the western edge of the Huckleberry Ridge Caldera. The Henry's Fork Caldera, near Island Park, Idaho, is dated to 1.3 million years of age by the Mesa Falls tuff left from this explosion. The next large volcanic event occurred 640,000 years ago. It was centered in what is now Yellowstone National Park, and resulted in the Yellowstone Caldera. The caldera rim is still visible in many areas of the park (for example, Gibbon Falls, Lewis Falls, and Lake Butte). The caldera is about 30 x 45 miles in size.

Yellowstone remains atop the hotspot and the pressure of the rising fluids and magma has created two bulges on the earth's surface. These bulges, called resurgent domes, lie within the caldera, one near LeHardys Rapids north of Yellowstone Lake and the other east of Old Faithful near Mallard Lake. Since the Yellowstone Caldera formed, lava has flowed onto the landscape numerous times. An additional caldera-forming event occurred about 150,000 years ago, which resulted in a smaller caldera that now is filled by the West Thumb of Yellowstone Lake.



TWO HOTSPOT THEORIES
Molten rock, or magma, rises in convection cells like water boiling in a pot. The left side shows the traditional view of a hotspot as a plume of magma rising from earth's core. The right side shows the newer theory that the Yellowstone hotspot originates at a much shallower depth.

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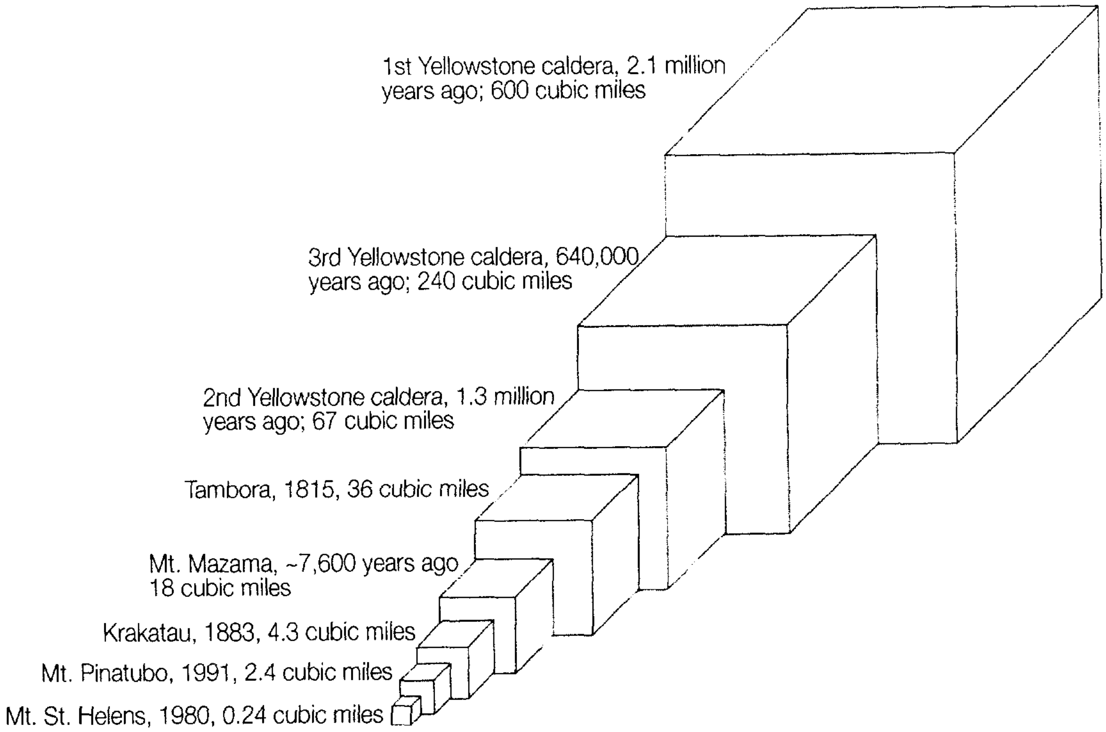
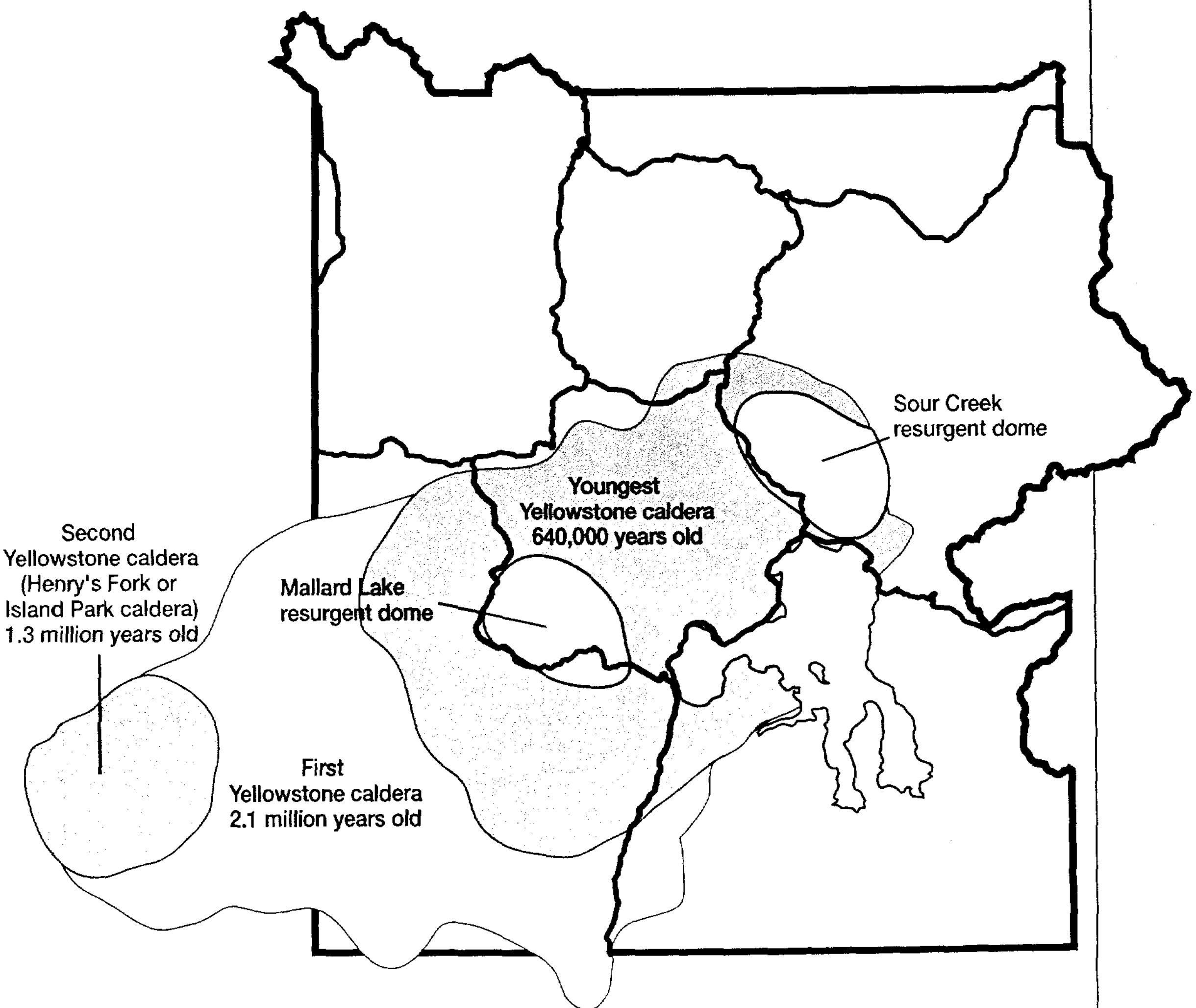
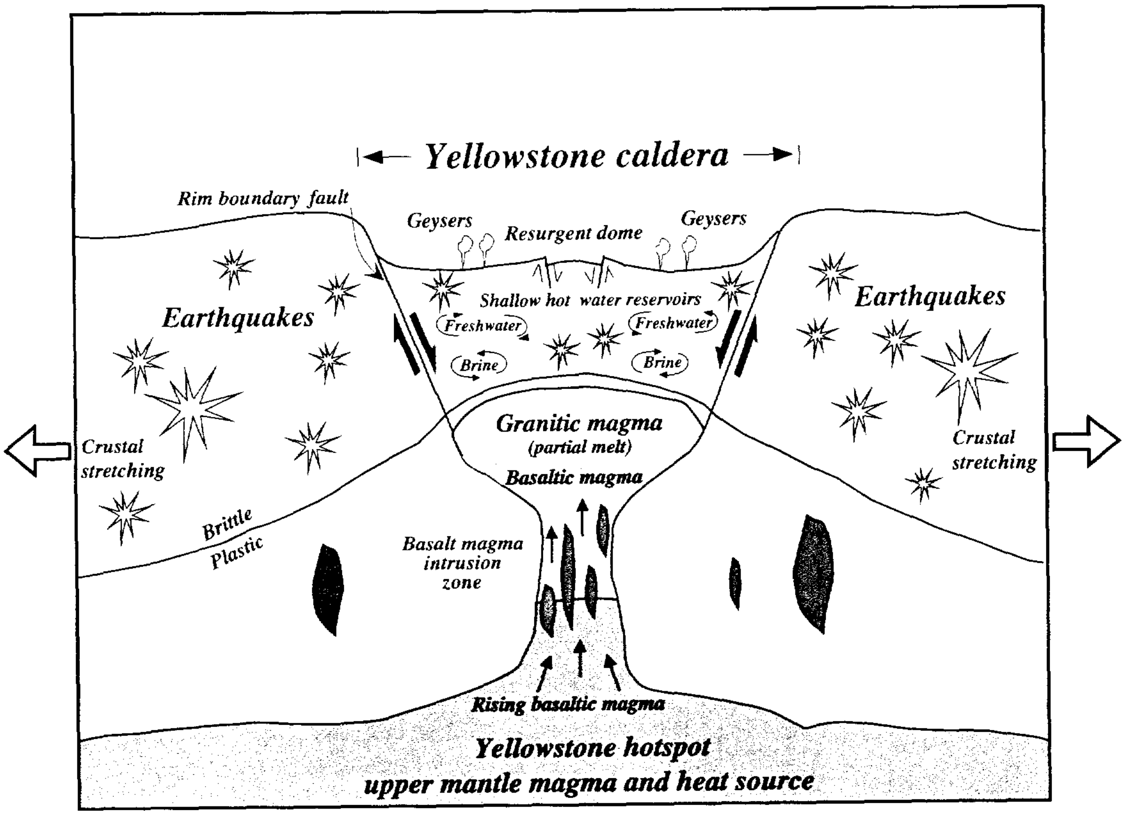
Geology: Volcanics



Illustrations on pages 36–38 are courtesy of Dr. Robert Smith, from his book,* Windows Into the Earth *(co-authored with Lee J. Siegel; 2000; Oxford Press). Those on pages 37 and 38 have been adapted for better readability in this book's format.





At Yellowstone and some other volcanoes, some scientists theorize that earth's crust fractures and cracks in a concentric or ring-fracture pattern. At some point these cracks reach the magma "reservoir," release the pressure, and the volcano explodes. The huge amount of material released causes the volcano to collapse into a huge steaming crater—a caldera.

The Hydrothermal System of Geyser Basins

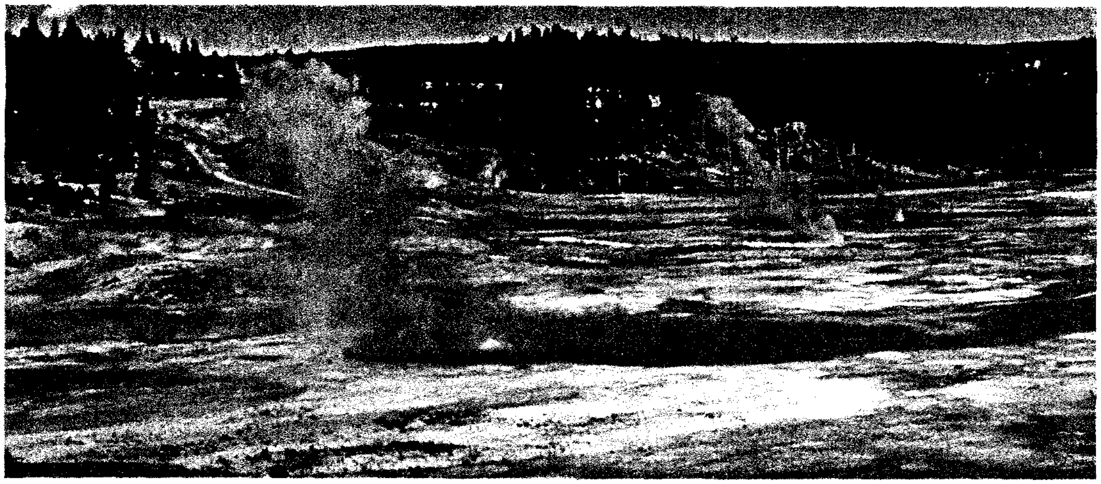
Yellowstone's hydrothermal features would not exist without the underlying volcanics of the region. They also depend on sources of water, such as in the mountains surrounding the Yellowstone Plateau. There, snow and rain slowly percolate through layers of porous rock riddled with cracks and fissures. Some of this cold water meets hot saline brine that is directly heated by the shallow magma body beneath the surface. The water's temperature rises well above the boiling point and becomes superheated. The water, however, remains in a liquid state due to the great pressure and weight pushing down on it from overlying rock and water. The result is superheated water with temperatures in excess of 400°F.

The superheated water is less dense than the colder, heavier water sinking around it. This creates convection currents that allow the lighter, more buoyant, superheated water to begin its slow journey back to the surface following the cracks, fissures, and weak areas through rhyolitic lava flows. As the hot water travels through the rock, the high temperatures dissolve some of the silica in the rhyolite.

While in solution underground, some of this silica deposits as geyserite, coating the walls of the cracks and fissures to form a nearly pressure-tight seal. This locks in the hot water and creates a "plumbing system" that can withstand the great pressure needed to produce a geyser. At the surface, silica precipitates to form a rock called geyserite, or sinter, creating the massive geyser cones, the scalloped edges of hot springs, and the light colored, seemingly barren landscape of geyser basins *(see photo top of next page)*.

3

Geology: Hydrothermal Features



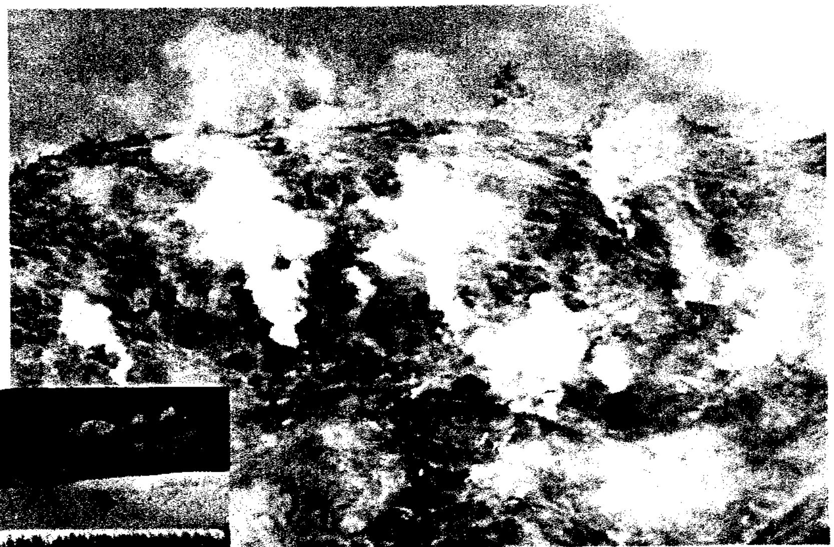
Geysers *are hot springs with constrictions in their plumbing, usually near the surface, that prevent water from circulating freely to the surface where heat would escape. The deepest circulating water can exceed the surface boiling point (199°F/93°C). The surrounding pressure also increases with depth, much as it does with depth in the ocean. Increased pressure exerted by the enormous weight of the overlying rock and water prevents the water from vaporizing. As the water rises, steam forms. Bubbling upward, steam expands as it nears the top of the water column until the bubbles are too large and numerous to pass freely through the tight spots. At a critical point, the confined bubbles actually lift the water above, causing the geyser to splash or overflow. This decreases pressure on the system, and violent boiling results. Tremendous amounts of steam force water out of the vent, and the eruption begins. Water is expelled faster than it can enter the geyser's plumbing system, and the heat and pressure gradually decrease. The eruption stops when the water reservoir is depleted or when the system cools.*

Geyser basin landscapes, *as at Norris (above), owe their light, barren appearance to a rock called sinter.*
Cone geysers, *such as Riverside in Upper Geyser Basin (center) erupt in a narrow jet of water, usually from a cone.*
Fountain geysers, *such as Echinus in Norris Geyser Basin (left) shoot water in various directions, often from a pool.*

3

Geology: Hydrothermal Features

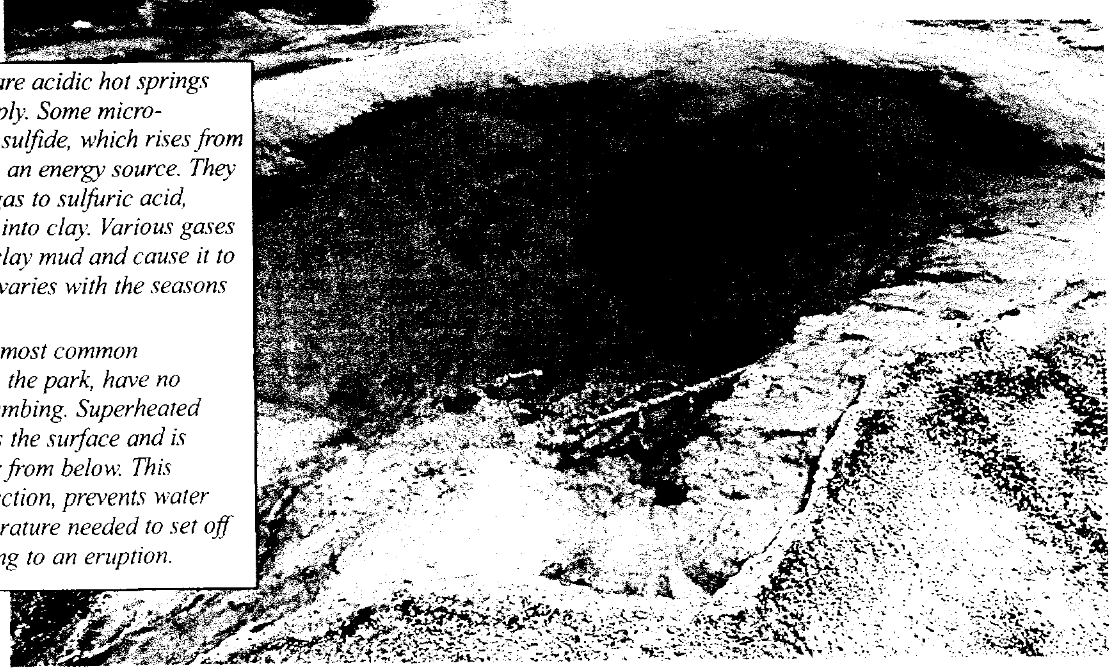
Fumaroles *or steam vents, are the hottest hydrothermal features in the park. They have so little water that it all flashes into steam before reaching the surface. At places like Roaring Mountain (right), the result is a loud hissing of steam and gases.*



Travertine terraces, *found at Mammoth Hot Springs (right), are formed from limestone, which is comprised of calcium carbonate. Thermal waters that rise through the limestone carry high amounts of dissolved carbonate. At the surface, pressure is released and calcium carbonate is deposited as travertine, the chalky white rock of the terraces. Due to the rapid rate of deposition, these features change quickly and constantly.*

Mudpots *(center, right) are acidic hot springs with a limited water supply. Some microorganisms use hydrogen sulfide, which rises from deep within the earth, as an energy source. They help convert the smelly gas to sulfuric acid, which breaks down rock into clay. Various gases escape through the wet clay mud and cause it to bubble. Mudpot activity varies with the seasons and precipitation.*

Hot Springs *(right), the most common hydrothermal features in the park, have no constrictions in their plumbing. Superheated water cools as it reaches the surface and is replaced by hotter water from below. This circulation, called convection, prevents water from reaching the temperature needed to set off the chain reaction leading to an eruption.*



Color & Life In Hydrothermal Areas

The colors in hot springs and runoff channels result mostly from light refraction, suspended mineral particles, and large communities of microscopic organisms. These organisms are primitive lifeforms—algae, bacteria, and *Archaea*—that have inhabited the earth for almost four billion years. (*Archaea* were once considered a type of bacteria, but their DNA is now known to be completely different.) They grow in water too hot—even boiling—for most life on earth. After water cools below 160°F (70°C), the organisms grow in thick, living layers of color in many different hues.

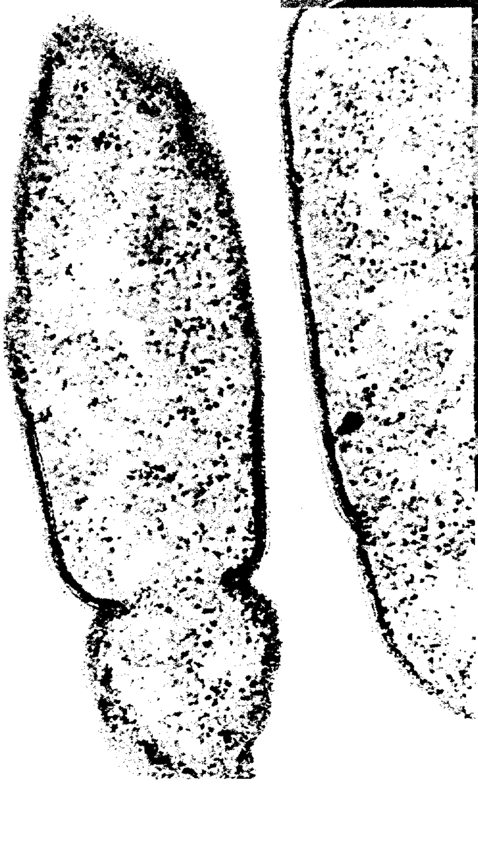
The chemistry of the hydrothermal pools also influences the kinds and abundance of life. Cyanobacteria grows in alkaline hot water. Its colors often follow a sequence from hottest to coolest: yellow, then green, red/orange, and brown. These different pigments gather solar energy or sunlight for photosynthesis. Cyanobacteria are one of the first organisms to evolve that used the energy of sunlight for life and produced free oxygen as a byproduct. They played a major role in creating an atmosphere that could support other lifeforms, including humans.

In acidic hydrothermal areas, such as Norris and Mud Volcano, different organisms grow. For example, the neon green mats in the cooler features are often due to the alga *Cyanidium.* The purple color is often *Zygogonium.*

The acidic features of Norris and Mud Volcano are also colored by minerals, such as the gray of sinter (a hydrated form of silica); the yellow of sulfur; and the red, orange, and black of iron and arsenic compounds. The color of the mudpots may be due to a single mineral or to a mixture, such as the red, muddy pools in which particles of silica or clay are coated with iron oxides. The shades of gray and black of the muds are often a result of iron sulfides.

In neutral areas, look for *Phormidium,* the organism causing orange "shag carpet" areas; *Synechococcus* and *Chloroflexus,* which form yellow and yellow-green color mats; and *Calothrix,* which appears as a brown organism in cool, neutral runoff channels such as those of Castle Geyser (Upper Geyser Basin), and Grand Prismatic Spring (Midway Geyser Basin).

These bizarre life forms are still largely a mystery to scientists. For more about thermophiles and the issues surrounding them, see "Bioprospecting," Chapter 8.

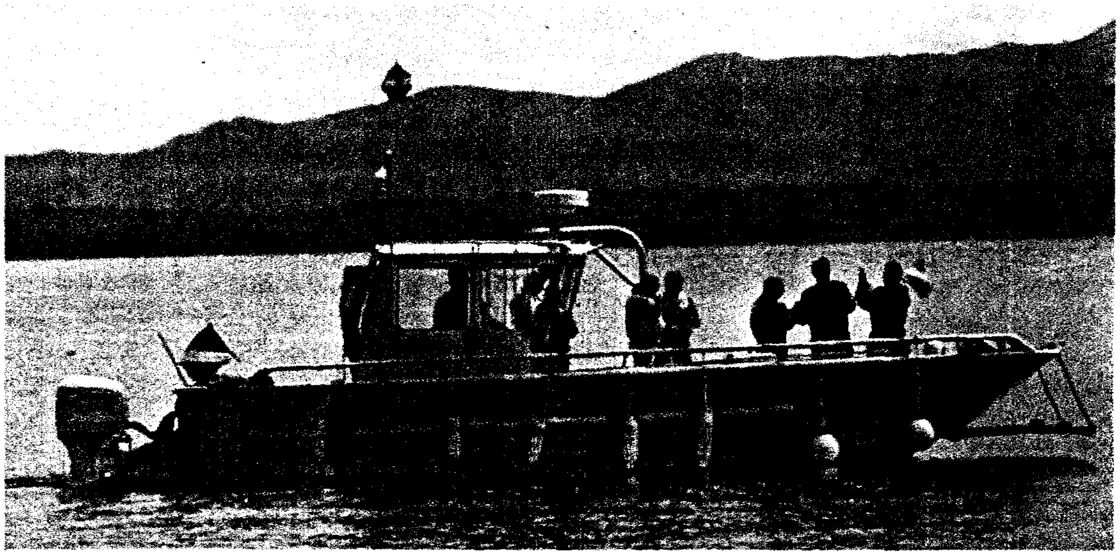


Thermus aquaticus

Above: Even in black and white, the patterns caused by thermophiles can be seen. The colors of runoff channels change with the water temperature and pH—which varies with hot spring and geyser activity and also with the seasons. Left: Thermus aquaticus, *the thermophile that sparked scientific and medical change* (see Chapter 8, "Bioprospecting").

3

Geology: Underwater Hydrothermal Features



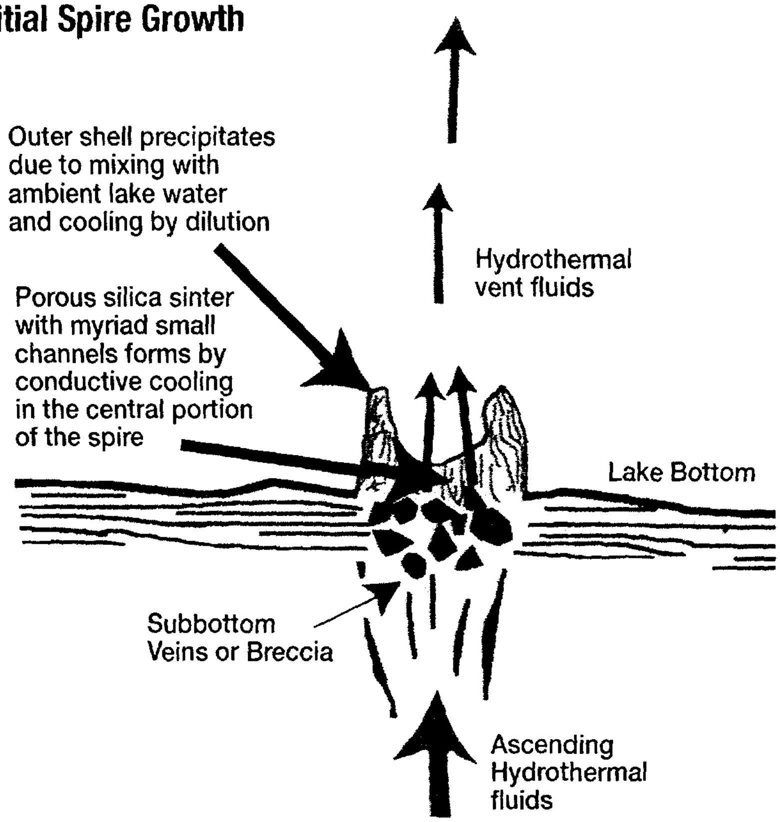
Beneath Yellowstone Lake

In 1999, archeologists who were exploring for sites in Bridge Bay saw anomalies on the bay's bottom on the sonar. They discussed their findings with geologists, who then took a look and found an area of tall spires *(photo at right)*. Since then, a team of scientists from the U.S. Geological Survey and a private company, Eastern Oceanics, have been surveying the bottom of Yellowstone Lake and discovering many underwater hydrothermal features and obtaining geologic data. Using high-resolution multi-beam bathymetric and seismic reflection surveys, they have mapped the northern and central parts of the lake and the West Thumb basin. In summer 2002, they plan to survey the lake's Southeast Arm.

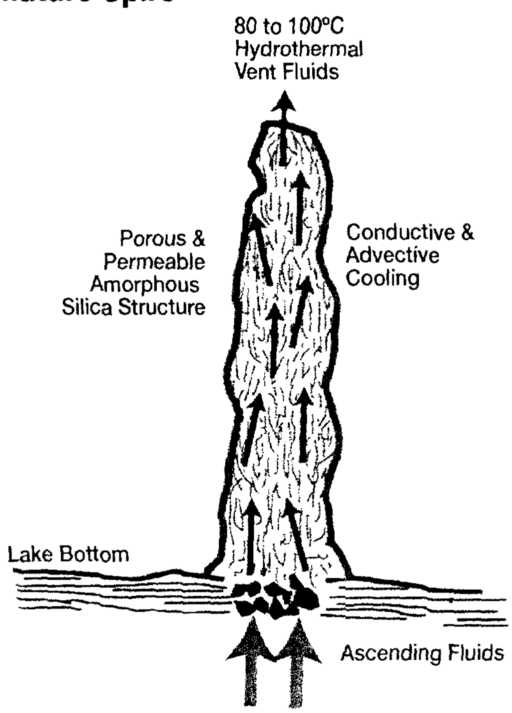
Most of the mapped area to date is inside the 640,000-year-old Yellowstone Caldera. Features revealed include circular, steep-walled depressions interpreted as hydrothermal explosion craters; siliceous spires composed primarily of diatoms, bacteria, and amorphous silica; domal features containing gas pockets, deformed sediments, and hydrothermal vents; and recent, previously unmapped faults, slump structures, and submerged older lake shorelines. These features are draped above an undulating surface of rhyolitic lava flows and active fissures. Further research on these features will improve understanding of their interrelationship, their causes, and influences by deeply circulating hydrothermal fluids.

Divers on this boat (above) descended the lake's cold waters to photograph and collect specimens from spires (below) that no one knew existed a decade ago. Scientists think these structures may be very old hydrothermal vents.

Initial Spire Growth



Mature Spire



Formation of circular depressions and siliceous spires is related to deep-seated hydrothermal processes. Hydrothermal explosions result from water flashing to steam often accompanied by failure and fragmentation of overlying caprock. Spires, composed of siliceous sinter, may be similar in formation to black smoker chimneys, well-documented hydrothermal features associated with oceanic plate boundaries.

Recent studies show the Yellowstone Caldera has cycles of inflation and deflation. The underwater geologic history integrated with the exposed shoreline history will help define the chronology and shape of these cycles. Further analysis of the data and direct investigations using a submersible remotely operated vehicle (ROV) may identify the relationship of fish and other fauna to these important hydrothermal influences on the ecosystem, including locations of lake trout spawning sites.

The research goal is to obtain a high resolution bathymetric map of Yellowstone Lake and unequivocally characterize many lake bottom features such as faults, fissures, slumps, hydrothermal deposits, explosion craters, domes, submerged shorelines, and glacial deposits. These surveys will give an accurate picture of the geologic forces shaping Yellowstone Lake, identify potential geologic hazards located in the lake, and determine geologic influences affecting the present-day aquatic biosphere.

Illustrations on this page are courtesy of Dr. Lisa A. Morgan, U.S.G.S. Research Geologist

3

Geology: Earthquakes

The Richter Scale

An earthquake's strength is measured by a scale of magnitude called the Richter scale, which is a measure of ground motion (amplitude) caused by an earthquake and measured by a seismograph. The scale is logarithmic; therefore, an increase of one whole number on the scale represents a 10-fold increase in measured amplitude or 32 times more energy.

An Earthquake Year In Yellowstone

This map shows the number of earthquakes occurring in a one-year period. Anyone can access real-time data about earthquakes in Yellowstone from a website maintained by the University of Utah Seismograph Stations: www.seis.utah.edu

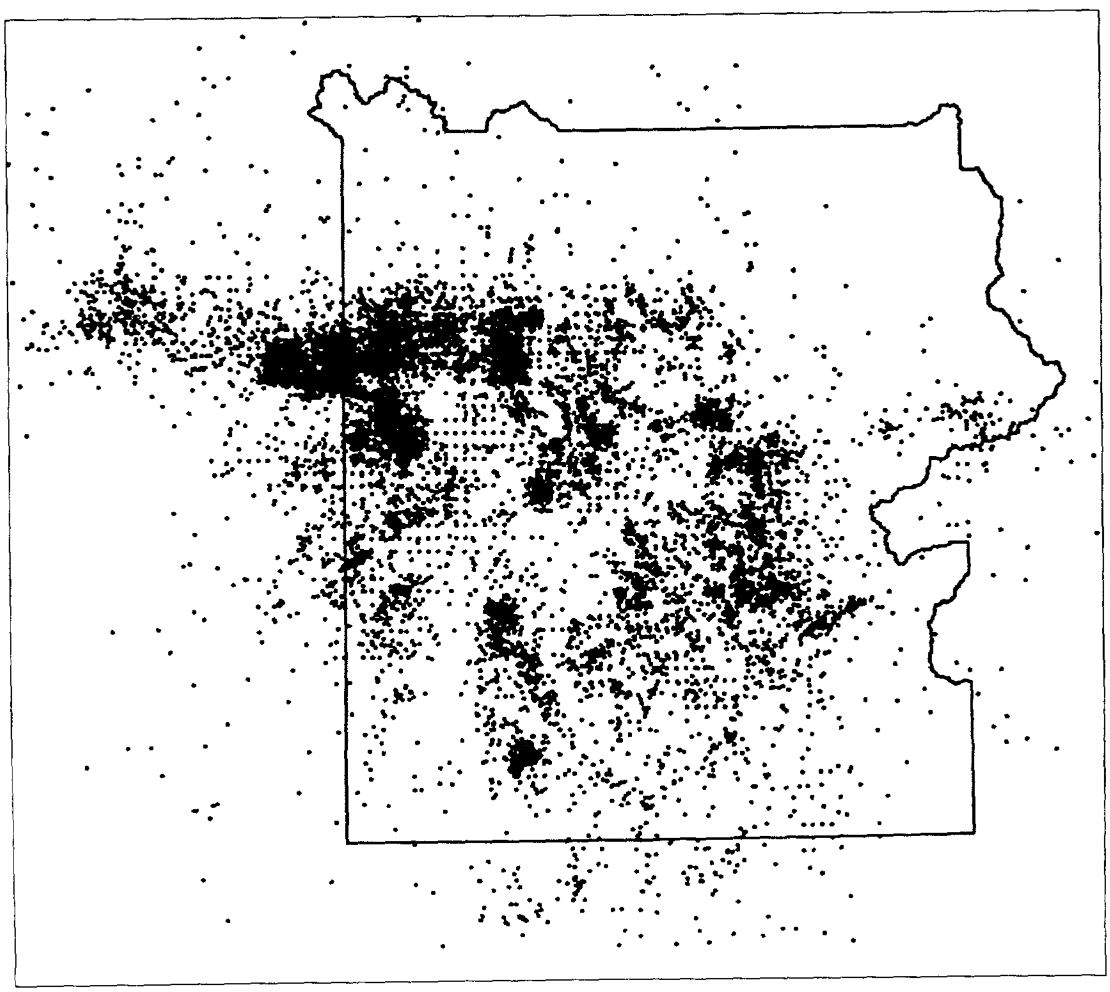
Earthquakes

Earthquakes occur along fault zones in the crust where forces from crustal plate movement build to a significant level. The rock along these faults becomes so stressed that eventually it slips or breaks. Energy is then released as shock waves (seismic waves) that reverberate throughout the surrounding rock. Approximately 2,000 earthquakes occur each year in the Yellowstone area—most are not felt.

Different kinds of seismic waves are released inside the earth during an earthquake. Primary waves ("P-waves") travel quickly back and forth horizontally, compressing and stretching the rock. Secondary waves ("S-waves") move up, down, and sideways through rock in a rolling motion. Once a seismic wave reaches the surface of the earth, it may be felt. Surface waves affect the ground, which can roll, crack open, or be vertically and/or laterally displaced. Structures are susceptible to earthquake damage because the ground motion is usually horizontal.

Earthquakes in Yellowstone help to maintain hydrothermal features by keeping the "plumbing" system open. Without the periodic disturbance of relatively small earthquakes, the small fractures and conduits that supply hot water to geysers and hot springs might be sealed by deposition of minerals. Some earthquakes generate changes in Yellowstone's hydrothermal systems. The 1959 Hebgen Lake and 1983 Borah Peak earthquakes caused measurable changes in Old Faithful and many other hydrothermal features.

Earthquakes help us understand the subsurface geology around and beneath Yellowstone. The energy from earthquakes travels through the earth in much the same way that CAT scans are conducted on humans. We can "see" the subsurface and make images of the hotspot and the caldera by "reading" the energy emitted during earthquakes because energy travels at different rates through hard and molten rock. An extensive geological monitoring system is in place to aid in that interpretation.



Glaciers

Glaciers result when, for a period of years, more snow falls in an area than melts. Once the snow reaches a certain depth, it turns into ice and begins to move under the the force of gravity or the pressure of its own weight. During this movement, rocks are picked up and carried in the ice, and these rocks grind the earth's surface, eroding and carrying material away. Large U-shaped valleys, ridges of debris (moraines), and out-of-place boulders (erratics) are evidence of a glacier's passing.

Yellowstone and much of North America have experienced numerous periods of glaciation during the last two million years. Succeeding periods of glaciation have destroyed most surface evidence of previous glacial periods, but scientists have found evidence of these glacial periods in sediment cores taken on land and in the ocean. Oceanic sediments contain the shell remains of one-celled animals called foraminifera. These shells are constructed using oxygen, and the ratio of oxygen isotopes in oceanic water at the time of shell formation remains a signature in the shells. One type of oxygen isotope (^{18}O) occurs in higher concentrations in colder water (i.e., when there is greater ice volume), and, thus, will be found in higher concentration in the foraminifera shells.

The Bull Lake Period glaciers covered the region about 140,000 years ago. Evidence exists that this glacial episode extended farther south and west of Yellowstone than the subsequent Pinedale Glaciation *(described in the next paragraph)*, but no evidence of it is found to the north and east. This indicates that the Pinedale Glaciation destroyed surface evidence of Bull Lake Glaciation in these areas.

The last (and most studied) glacial period, the Pinedale, began about 80,000 years ago and was over by 14,000 years ago. At the peak of the Pinedale Glaciation 25,000 years ago, nearly all of today's Yellowstone National Park was covered by a huge ice sheet 4,000 feet thick (at a point above present-day Yellowstone Lake). Mount Washburn and Mt. Sheridan were both completely covered by ice. This ice field was not part of the continental ice sheet extending south from Canada. The ice field occurred here, in part, because the hotspot beneath Yellowstone had pushed up the area to a higher elevation with colder temperatures and more precipitation than the surrounding land.

***The Porcupine Hills,** (below) at the northeast edge of the Lower Geyser Basin, formed when the hot water and steam from a hydrothermal vent melted a hole in the glacier above it. Glacial meltwater deposited rocks, gravel, and sand being carried by the glacier into these holes in the ice. When the glacier melted or receded, the piles of debris—called kames—remained. Subsequent hydrothermal activity cemented them into resistant hills. Other kames exist at Mammoth Hot Springs.*

3

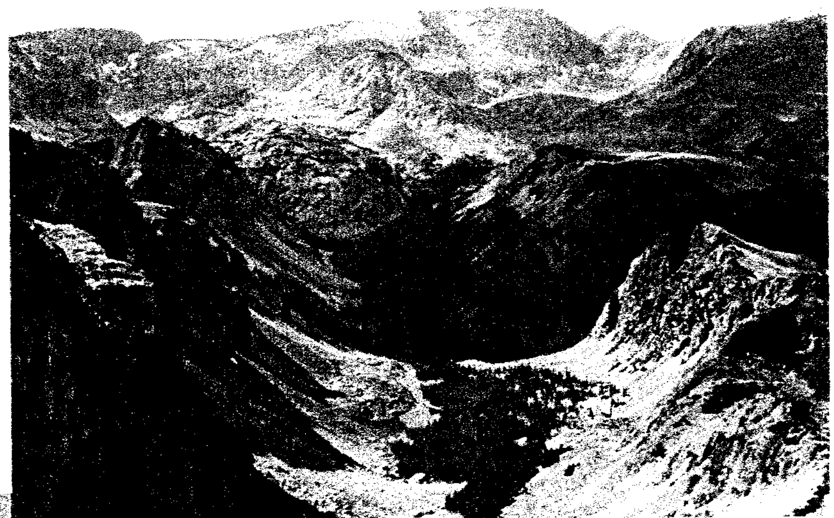
Geology: Sedimentation & Erosion

Sedimentation & Erosion

Not all the rocks in Yellowstone are of "recent" volcanic origin. Precambrian igneous and metamorphic rock in the northeastern portion of the park are at least 2.7 billion years old. These rocks are very hard and erode slowly.

Sedimentary sandstones and shales, deposited by seas during the Paleozoic and Mesozoic eras (570 million to 67 million years ago) can be seen in the Gallatin Range and Mount Everts. Sedimentary rocks in Yellowstone tend to erode more easily than the Precambrian rocks of the Beartooth Mountains.

Erosion can occur as a result of wind, water, glaciation, the freeze/thaw action of ice, or gravity. All rock formations will erode, some just do so more quickly. When erosion takes place, sedimentation—the deposition of material—also eventually occurs. Through time, sediments are buried by more sediments and the material hardens into rock. This rock is eventually exposed (through erosion, uplift, and/or faulting), and the cycle repeats itself. Sedimentation and erosion are the "reshapers" and "refiners" of the landscape—and they are also the exposers of Yellowstone's past life as seen in fossils like the petrified trees.



The Beartooth Mountains northeast of Yellowstone (right) are actually an uplifted block of Precambrian rock. Mt. Everts, near Mammoth, (below) exposes sedimentary rock which erodes easily and often tumbles into Gardner Canyon.

Fossils

Paleobotany

Nearly 150 species of fossil plants (exclusive of fossil pollen specimens) from Yellowstone have been described, including ferns, horsetail rushes, conifers and deciduous plants such as sycamores, walnuts, oaks, chestnuts, maples, and hickories. Sequoia is abundant, and other species such as spruce and fir are also present.

The first fossil plants from Yellowstone were collected by the early Hayden Survey parties. In his 1878 report of the Hayden Survey, Holmes made the first reference to Yellowstone's fossil forests. The report identified the petrified trees located on the north slope of Amethyst Mountain opposite the mouth of Soda Butte Creek, about eight miles southeast of Junction Butte.

Around 1900, F.H. Knowlton identified 147 species of fossil plants from Yellowstone, 81 of them new to science. He also believed that the petrified trees on the northwest end of Specimen Ridge were forests petrified in place. Most of the trees project above the surface *(photo right),* including hundreds of trunks from 1 to 8 feet in diameter and from 1 to 20 feet high, with the tallest more than 40 feet. Fossilized bark is also preserved at this location.

Another theory is that volcanic debris flows uprooted trees and transported them to lower elevations. The 1980 eruption of Mount St. Helens supported this idea. Mud flows not only transported trees to lower elevations, they also deposited the trees upright.

Most petrified wood and other plant fossils come from Eocene deposits about 50 million years old, which occur in many northern parts of the park, including the Gallatin Range, Specimen Creek, Tower, Crescent Hill, Elk Creek, Specimen Ridge, Bison Peak, Barronette Peak, Abiathar Peak, Mount Norris, Cache Creek, and Miller Creek. Petrified wood is also found along streams in areas east of Yellowstone Lake. The most accessible fossil forest is the one on Specimen Ridge.

Mount Everts provides a Cretaceous exposure of marine and nonmarine sediments. The area is under study; fossil leaves, ferns, clam-like fossils, shark teeth, and several species of vertebrates have been found. In 1994 fossil plants were discovered in Yellowstone during the East Entrance road construction project, which uncovered areas containing fossil sycamore leaves and petrified wood.

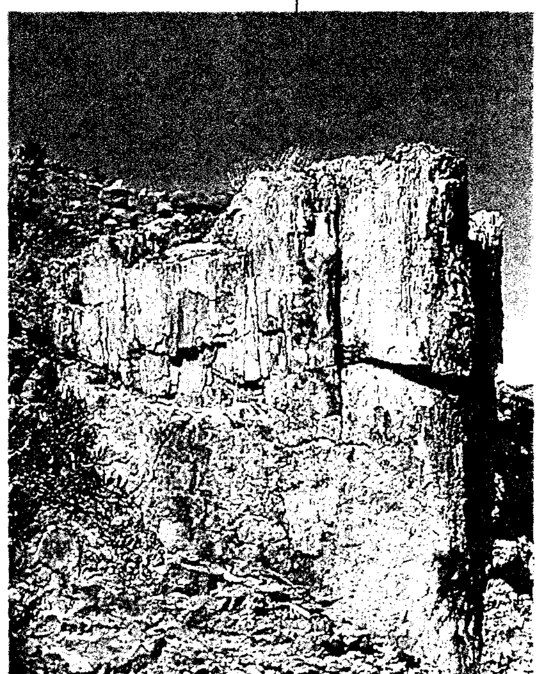
Fossil Invertebrates

Fossil invertebrates are abundant in Paleozoic rocks, especially the limestones associated with the Madison Group in the northern and south-central parts of the park. They include corals, bryozoans, brachiopods, trilobites, gastropods, crinoids, ammonites, and Pleistocene insects. Trace fossils, such as channeling and burrowing of worms, are found in some petrified tree bark.

Fossil Vertebrates

Fossil remains of vertebrates are rare, but perhaps only because of insufficient field research. A one-day survey led by paleontologist Jack Horner, of the Museum of the Rockies, Bozeman, Montana, resulted in the discovery of the skeleton of a Cretaceous vertebrate. Other vertebrate fossils found in Yellowstone include:

- Fish: A crushing tooth plate; phosphatized fish bones; fish scales; fish teeth.
- A possible Pleistocene horse, *Equus nebraskensis,* was reported in 1939.
- A possible *Bison occidentalis* skull, which was discovered in northeast Wyoming and dated to 6470 B.P. Other reports of bison from the park include McCartneys Cave.
- Holocene subfossil mammals recovered from Lamar Cave.
- Titanothere (type of rhinocerus) tooth and mandible found on Mt. Hornaday in 1999.



In Yellowstone, many layers of petrified trees can be seen. Resulting from repeated volcanic eruptions, these layers present questions that scientists continue to ponder: Were the trees petrified in place and thus represent layers of forest? Or were they scattered before and after petrification, which means the number of forests cannot be determined?

Dr. Robert Smith and assistant set up a seismographic station. It is one of dozens throughout the Greater Yellowstone Ecosystem sending seismic data to researchers at the University of Utah.

Yellowstone As a Geologic Laboratory

Yellowstone is a unique outdoor laboratory for scientists who conduct research. Many of these scientific studies have ramifications far beyond Yellowstone National Park. Current research examples:

- Earthquake monitoring stations detect the numerous daily tremors occurring in the Yellowstone region, and the patterns are studied to develop an understanding of the geodynamics of Yellowstone's hotspot.
- Studies on the location of previously unmapped geologic structures should help us understand what controls subsurface fluid flow and recharge in the geothermal systems.
- Baseline geochemical studies help distinguish between human and natural influences on the underground water network in the region.
- Underwater studies in Yellowstone Lake have identified hydrothermal vents where organisms that survive on sulfur emissions and that resemble life found under the ocean near similar hydrothermal vents have been found; comparison studies continue.
- The deposition of sinter around hydrothermal springs is being studied to understand how early life developed on earth and to look for these clues on other planets, particularly Mars.
- Thermophiles, microorganisms that can live in extreme environments, are being collected from the park's hydrothermal features, identified, and their heat-resistant enzymes are being studied. Some already are being used in a variety of medical and forensic processes.

All scientists in Yellowstone work under special permits and are closely supervised by National Park Service staff.

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Videos

The Complete Yellowstone

Yellowstone: Imprints of Time

Yellowstone Revealed

Yellowstone: A Symphony of Fire and Ice

VEGETATION

4

Major Types

Two main forces determine vegetation in the park: precipitation and rock type. Most precipitation in Yellowstone is snow, which is held on top of the soil for much of the year and then released in a short period during spring and early summer. The two major types of bedrock in Yellowstone—the Absaroka volcanics (andesites) and the Yellowstone volcanics (rhyolites)—differ in their mineral content, especially in the amount of calcium. Andesites contain two to eight times more calcium than rhyolites. Rhyolites are low in some of the other minerals essential to plant growth. Glacial activity has also blurred the boundaries, causing deposits of one type to be well within the boundaries of another *(see Chapter 2, "Greater Yellowstone Ecosystem," for more information).*

MAJOR VEGETATION TYPES

Sagebrush/Steppe
- Dominant species: sagebrush & grass
- In Northern Range, underlain by glacial till and Absaroka volcanics
- In Hayden & Pelican valleys, underlain by lakebed sediments

Lodgepole pine forest
- Dominant species: lodgepole pine
- Often underlain by rhyolite
- Dominates recently burned areas

Spruce-fir forest
- Dominant species: Englemann spruce and subalpine fir
- Underlain by Absaroka volcanics
- Commonly encountered at higher elevations

Subalpine/Alpine
- Dominant species: whitebark pine and forbs adapted to alpine/tundra-like turf
- Includes treeline region

Aspen groves
- Interspersed with sagebrush–steppe vegetation
- Also found along Snake River and in Bechler region

Dry Sagebrush/Steppe
- Dominant species: sagebrush and other shrubs
- Less than 15 inches precipitation annually
- Adjacent to the North Entrance and the town of Gardiner, Montana

Sagebrush/Steppe dominates the dry (less than 20 inches of precipitation annually) grasslands of the Northern Range, which is underlain by glacial till and Absaroka volcanics. Sagebrush, other shrubs, forbs, and grasses grow here, with pockets of forest where geology and rock type allow such growth. This vegetation type also dominates Hayden and Pelican valleys, which are underlain by lake beds and support slightly different plants.

Lodgepole pine forest dominates areas of the park underlain by rhyolite, such as around Norris and Old Faithful. Few other trees grow in these areas except as young trees in the understory. For example, whitebark pines may grow in small groups. In regions with better soil, such as Yellowstone Lake, lodgepole forests can include spruce and fir.

Spruce-fir forest increases with elevation in the park, where andesitic rock is more prevalent than rhyolite and precipitation is heavier.

Subalpine/Alpine vegetation dominates some higher elevations, such as Mount Washburn. Whitebark pine is the most common tree; above treeline the turf is similar to alpine/tundra and supports various plants—such as moss campion and mountain avens—adapted to these conditions.

Aspen grow in scattered stands in the Northern Range, along the lower Madison and Gallatin rivers, near the Snake River, and in the Bechler region.

Dry Sagebrush/Steppe vegetation types occur in a limited area around the North Entrance of the park where annual precipitation is less than 15 inches. Saltbush, greasewood, winterfat, prickly pear cactus, and other such species grow here. The heavy soils are derived from shales.

4

Vegetation: Trees

Conifers Lodgepole pine Limber pine Whitebark pine Englemann spruce Subalpine fir Douglas-fir Rocky Mountain juniper Common juniper **Deciduous** Cottonwood, various species Quaking aspen Willow, various species	**Most numerous** Lodgepole pines comprise 80% of trees in Yellowstone. **Concerns** • Whitebark pine nuts provide important food for grizzly bears in fall. Potential threats to the whitebark pine stands could have a grave impact on the survival of the threatened grizzly bear. • The condition of the aspen and cottonwood populations is the subject of some debate *(see Chapter 8, "The Northern Range")*.

Limber pine and whitebark pine both have five needles and are found in similar habitats, including the understory of lodgepole pine forests. Even for experienced botanists, they are almost impossible to tell apart except by their cones. Red squirrels and other animals consume most whitebark cones before they mature.

The **lodgepole pine** *(Pinus contorta)* is by far the most common tree in Yellowstone; 80 percent of all trees in the park are lodgepole. Various Native American tribes used this tree to make the frames of their tipis or lodges, hence the name "lodgepole" pine. Its scientific name derives from a similar pine that grows on the Pacific Coast, where it grows into a twisted tree. In Yellowstone, lodgepole pine grows very straight and is seldom more than 75 feet tall. The species is shade intolerant; any branches left in the shade below the canopy will wither and fall off the tree. Lodgepoles growing by themselves will often have branches all the way to the base of the trunk because sunlight can reach the whole tree.

Lodgepoles are the only tree in Yellowstone whose needles grow in groups of two. The bark is pale yellow on any section of the tree that gets sufficient sunlight; elsewhere, the bark will appear dark. A grayish-black fungus often grows on the shady parts of the bark, giving the tree a dark cast.

Like all conifers, lodgepole pines have both male and female cones. The male cones produce huge quantities of yellow pollen in June and July. This yellow pollen is often seen in pools of rainwater around the park or at the edges of lakes and ponds. The lodgepole's female cone takes two years to mature. In the first summer, the cones look like tiny, ruby-red flowers out near the end of the branches. The next year, the cone looks more "cone-like." There are two types of female cones: one that opens at maturity, and a serotinous type that opens after it has been heated by a forest fire (these cones remain closed and hanging on the tree for years until the right conditions allow them to open). Serotinous cones ensure a ready seed source for establishment of new trees immediately after a fire. Trees without serotinous cones (like Engelmann spruce, subalpine fir, and Douglas-fir) must rely on wind, animals, or other agents to carry seeds into recently burned areas.

Lodgepole pine seedlings grow quickly in mineral soils that have been disturbed, either by fire or by humans (such as a road cut). The tree prefers a slight amount of acidity in the soil. Reproduction is generally vigorous. The reverse takes much longer: in the dry, cold conditions of Yellowstone, lodgepole pines decay at a rate of about one percent each year; consequently, it can take a century for a tree to rot away. Their roots spread out sideways and do not extend deeply—an advantage in Yellowstone where the soil is only about 6 to 12 inches deep, but a disadvantage in high winds. Lodgepole pines can fall over easily in the slightest windstorm.

The **limber pine** *(P. flexilis)* is a five-needled pine. It is seldom found in pure stands, and is more often growing in groups of a few individuals, such as at Mammoth Hot Springs. It grows 25–50 feet high, and can be 200–300 years old at maturity. The bark is thin and light in color. The tree has a strong taproot. The young branches of the limber pine are very flexible and can be tied into knots without breaking. This peculiar

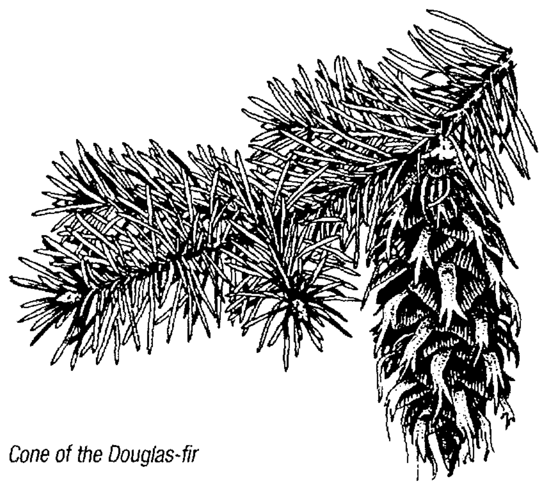
characteristic is responsible for both the common and the scientific names of the tree.

Whitebark pine *(P. albicaulis)* also has five needles in each cluster and is almost indistinguishable from the limber pine except for its very characteristic purplish brown cones, which are 1½ to 3½ inches long and nearly that wide. The cones are rarely found at or after maturity because the seeds are an important food item for animals such as red squirrels, Clark's nutcrackers, and bears. Whitebark pine grow mainly at higher elevations (7,000–10,000 feet) and have a distorted branched appearance. The tree seldom grows more than 40 feet high and 3 feet in diameter.

The needles of **Engelmann spruce** *(Picea engelmannii)* are sharp, square, and grow singly (characteristics of all spruces). This tree can grow 60–120 feet high and be up to 3 feet in diameter; such trees can be 350–500 years old. Engelmann spruce prefer shade and are often seen growing under larger lodgepole pine trees. The tree grows slowly and has a shallow spreading root system. Some of the trees in the northeast portion of the park approach white spruce in appearance, indicating some hybridization between Engelmann spruce and white spruce.

Subalpine fir *(Abies lasiocarpa)* is a true fir: its needles are blunt tipped (usually referred to as "friendly," because they are not sharp), flat in cross-section (they won't roll easily in your fingers), and the cones stand straight up on the branches. This is the only true fir in the park. However, the cones disintegrate on the branches a short time after forming, so it is only around August that this can be used to distinguish the species. The tree usually grows 20–100 feet high and has a diameter of 1–2 feet. The bark is gray, often with lateral serrations and scars near the bottom because of browsing by moose and other ungulates. The crown is steeple-shaped. Shade tolerant, it is often found growing with Engelmann spruce in the shade of lodgepole pines. In winter, if the lower branches sag to the ground under the weight of snow, they will occasionally root and form a small ring of trees, called a "snow mat," around the parent. Native Americans used the balm obtained from pitch blisters to heal sores and burns, breathed the smoke of burning needles to relieve colds, and chewed the tree gum to clear their throats. Subalpine firs grow in areas between 7,000 feet and treeline.

Douglas-fir *(Pseudotsuga menziesii)* is the largest tree in the park. Although it is not a true fir, it nevertheless has needles that are flat and friendly. It resembles the fir and the hemlock, hence its generic name *Pseudotsuga,* which means "false hemlock." The Douglas-fir's thick bark enables it to resist forest fires. The cones hang down (unlike the true fir, which bears its cones upright), and they do not disintegrate on the tree (as they do on the true fir). The best distinguishing feature of the Douglas-fir is the female cone: it has prominent, 3–pronged bracts (which look like tridents) coming off the cones. The same tree also has male cones (bright red, appearing in early spring), but they fall off as soon as the pollen is shed. Few Douglas-firs grow above 7,000 feet in Yellowstone.



Cone of the Douglas-fir

Two species of **juniper** grow in Yellowstone. Junipers belong to the Cypress family and are often called "cedars." **Rocky Mountain juniper** *(Juniperus scopulorum)* has scale-like or awl-shaped needles that grow in groups of 3, and are ⅛–½ inch long. The fruits are actually little cones, but they are so fleshy that they look like berries. These berries are used to flavor gin, and they were used by Native Americans as an important source of medicine, food, and dye. The Rocky Mountain juniper is a tree; the **common juniper** *(J. communis)* is a low, spreading shrub.

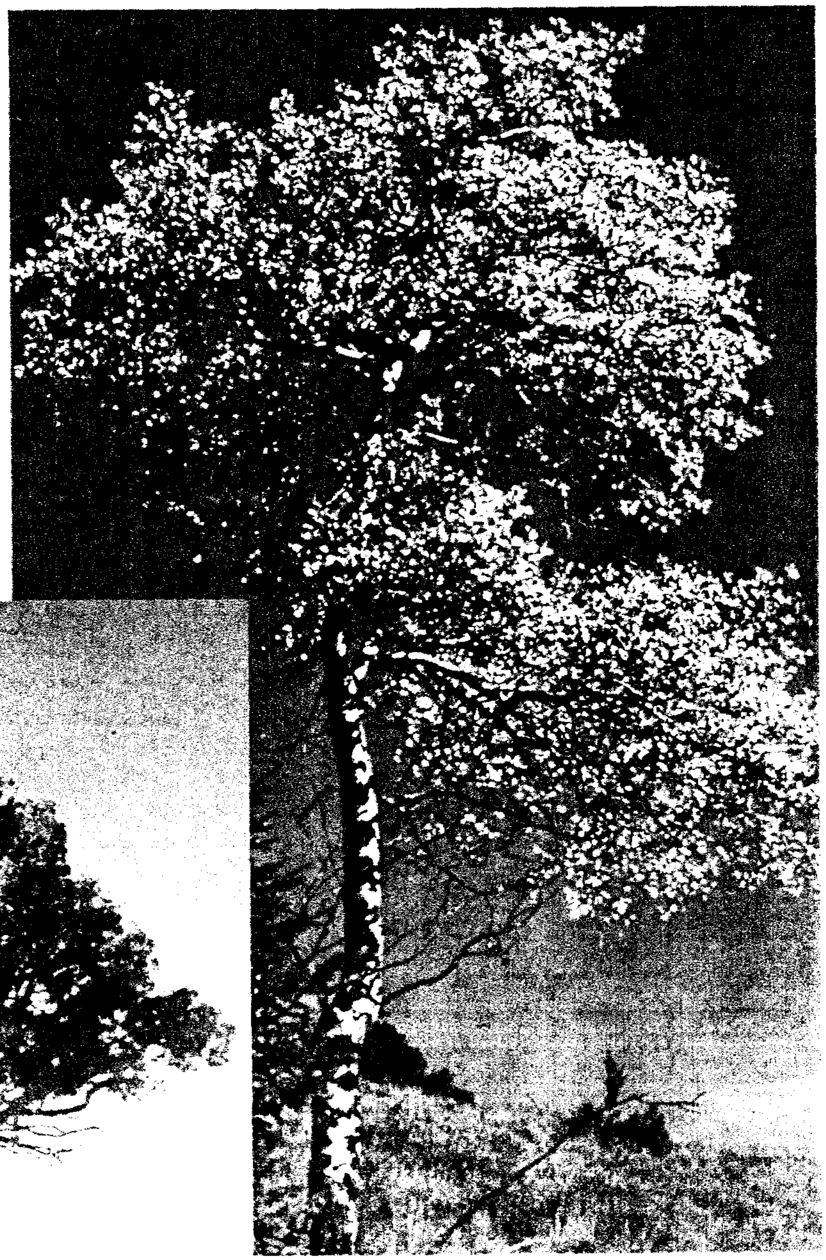
Eight conifers grow in Yellowstone National Park. Ponderosa pine, prevalent in the state of Montana, does not grow in either Yellowstone or Grand Teton national parks.

4

Vegetation: Trees

Deciduous Vegetation

- 24 species of willows (*Salix* spp.) grow in the park—most grow along streams and look shrubby. Some species on the alpine tundra gorw only a couple of inches tall.
- Several cottonwood species (*Populus* spp.) and their hybrids grow in riparian areas. Cottonwoods grow tall and broad, and have thick, furrowed bark. Their seeds are attached to fluffy fibers for efficient wind dispersal. Distinguishing among them is difficult.
- Quaking aspen (*P. tremuloides*) grows in scattered stands around the Northern Range, along the Snake, Gallatin, and Madison rivers, and in the Bechler region. Its flexible stems allow leaves to quake and shiver in the slightest breeze, hence its name. The bases of larger trees are often roughened and black due to browsing by elk or other animals *(see Chapter 5 for more about aspen and fire).*



Right: Quaking aspen
Below: Juniper

Yellowstone is home to two endemic species—plants that grow no where else. Endemics often occur in unusual or specialized habitats such as thermal areas. Several other species are unique to the Greater Yellowstone Area: warm springs spike rush, which grows in warm water; and Tweedy's rush, sometimes the only vascular plant growing in acidic thermal areas.

Ross's bentgrass

Ross's bentgrass *(Agrostis rossiae)* only occurs on thermal ground along the Firehole River and near Shoshone Lake. It seems to require locations that provide the right combination of moisture and warmth that create a natural greenhouse. The temperature within an inch of the surface under a population of this grass is usually roughly 100°F. As a result, this grass is one of the first species to green up in warm nooks and crannies of the geyserite—sometimes as early as January. Its flowers may be present in February and March, but typically do not produce viable seed that early. It is in full bloom in late May and early June. As soon as the temperatures rise in the early summer, this grass dries out due to the summer sun above and the thermal heat beneath. Ross's bentgrass is already dead and hard to find by July when most of the park's wildflowers are in full bloom.

Other closely related species of grass also occur in the geyser basins. Tickle grass *(A. scabra)* is common all through the interior of the park. This species is much more frequently encountered in the geyser basins than Ross's bentgrass and looks similar. Ross's bentgrass is shorter, rarely growing taller than six inches and more typically only 2–3 inches. Another diagnostic characteristic of Ross's bentgrass is that the inflorescence never completely opens up.

Any plant growing in thermal areas must be able to deal with the constant change in these areas. A successful plant in the geyser basins must be able to shift location relatively easily as one major thermal change or a group of changes could eradicate the entire population. Apparently, Ross's bentgrass deals with this problem efficiently. Its seed dispersal mechanism has not been investigated, but probably includes traveling on the muddy hooves of bison and elk who inhabit thermal areas during the winter. There are no known threats to the health of this species However, several exotic species are spreading aggressively throughout the thermal areas. It is probably only a matter of time before some exotic species begins to outcompete Ross's bentgrass.

Ross's bentgrass

Yellowstone Sand Verbena

Yellowstone sand verbena *(Abronia ammophila)* occurs along the shore of Yellowstone Lake. Taxonomists debate about the relationship of this population of sand verbena to other sand verbenas. Recent work suggests that Yellowstone sand verbena is distinct at least at the subspecific level, and is certainly reproductively isolated from the closest sand verbena populations in the Bighorn Basin of Wyoming.

Sand verbenas are a member of the four o'clock family, which is primarily a tropical family of flowering plants. Very few members of the family grow this far north. Little is known about the life history of Yellowstone sand verbena. It was described as an annual in the only monograph that has examined this genus in recent years, but it is a perennial. It grows prostrate on the sand surface. Some

individuals occur near warm ground, so the thermal activity in Yellowstone may be helping the survival of this species. The flowers are white and the foliage is sticky. Apparently, the sand verbena flowers from roughly mid June until killing frosts in early September.

Yellowstone Sand Verbena, an endemic of the park

4

Vegetation: Exotics

The full extent and impact of exotic plants in Yellowstone is not known. Many are found in disturbed areas such as developments, road corridors, and thermal basins; they also are spreading into the backcountry. Several exotics, such as the common dandelion, have spread throughout the park. Exotic plants can displace native plant species and change the nature of the vegetation communities, thus changing the available forage for grazers such as elk and bison. They also undoubtedly impact native invertebrate communities.

Controlling more than 195 species, some of which have been well-established for decades, is unrealistic. Due to the large number of exotic species, the park prioritizes them into several categories, thereby focusing control action on species posing the most serious threat or are most likely to be controlled.

The park has made some progress in monitoring, mapping, and control of high priority target species. Using Integrated Pest Management—chemical, biological, sociological, and mechanical methods—the park can control some of the exotic plants. The park also cooperates with adjacent state and county Weed Control Boards to share knowledge and technology related to exotic plant detection and control.

Number in Yellowstone
More than 195 species

Problems
- Displace native plant species.
- Change the nature of native plant communities, thus change available forage for ungulates such as elk and bison.
- Knapweeds (four species in park) can displace almost all other species in an area.

Management
- Target species posing the most serious threats and areas offering best prospects for successful control.
- Educate staff and visitors.
- Prevent establishment of exotic plants.
- Control by hand-pulling, mowing, and applying approved herbicides.


Dalmatian toadflax

The Biggest Threats

Dalmatian toadflax *is prominent in northern portions of the park. Intense biological and chemical control efforts during the late 1960s and early 1970s were largely unsuccessful. Dalmatian toadflax has since spread throughout the Mammoth area and is migrating into the park interior.*

Spotted knapweed *is an aggressive species that, once established, can result in a virtual monoculture. It threatens to displace native grasses on the ungulate winter and summer ranges, which will have a major impact on wildlife. Aggressive control efforts target this species every year to prevent a catastrophic change in park vegetation.*

Canada thistle *grows throughout the park and adjacent national forests. Its airborne seed enables this plant to spread widely throughout the park, invading wetlands and causing radical changes in the vegetation.*

Ox-eye daisy *infestations were originally discovered in the Mammoth and Madison areas. Control efforts have substantially curtailed infestations in these two areas, but monitoring and evaluation continue. This exotic is unpalatable to wildlife; it becomes dominant in meadows.*

Houndstongue *has become increasingly widespread. It appears to have been originally introduced in the park by contaminated hay used by both the National Park Service and concessioners in their horse operations. The seeds act like Velcro, easily attaching to the coats of animals, and thus has spread along animal corridors.*

Leafy spurge *poses another potential threat. Although it has only been found in small infestations so far, it is extremely hard to control because of deep roots and dense vegetation. It becomes a monoculture, forcing out native forbs and grasses.*

4

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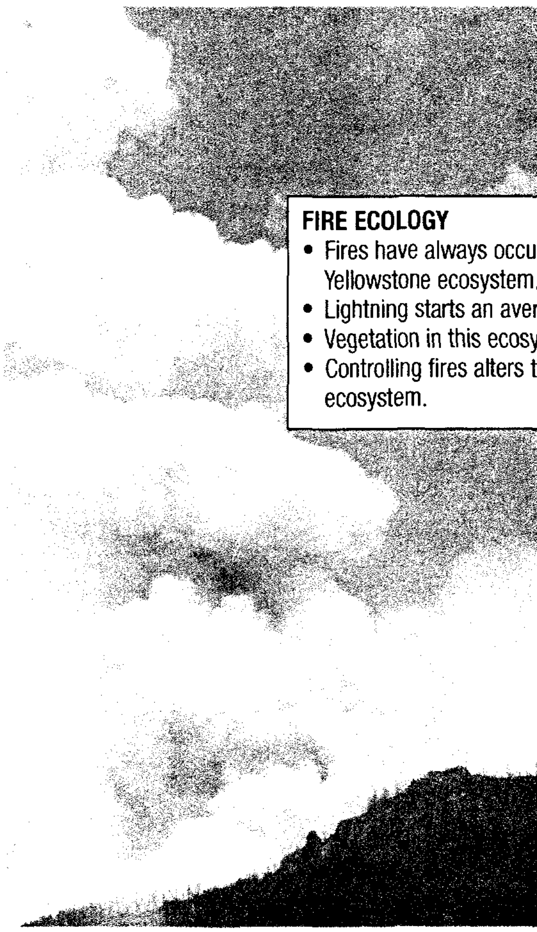
FIRE IN YELLOWSTONE



FIRE ECOLOGY

- Fires have always occurred periodically in the Yellowstone ecosystem.
- Lightning starts an average of 22 fires annually.
- Vegetation in this ecosystem is adapted to fire.
- Controlling fires alters the dynamics of the ecosystem.

Fire is a natural force operating in the Yellowstone ecosystem since the beginning of time. Fire scars on old Douglas-fir trees in the Lamar River valley indicate an average frequency of one fire every 25 to 60 years. Other indicators of past fires showing intervals of 200 years or more exist in the even-aged stands of lodgepole pine throughout the park and charcoal in the soil. Records kept since 1931 show that lightning starts an average of 22 fires each year.

The vegetation in the Greater Yellowstone Ecosystem has adapted to fire and in some cases is dependent on it. Some plant communities depend on the removal of the forest overstory to become established; they are the first to inhabit sites after a fire. Other plants growing on the forest floor are adapted to survive at a subsistence level for long periods of time until fires open the overstory.

Fire can limit trees in grassland areas. Microhabitats suitable for tree seedling establishment are rare in a grassland, but if a seed reaches such a microhabitat during a favorable year, a tree may grow. Once the tree is growing, it begins to influence the immediate environment. More tree habitat is created and a small forest island eventually appears. Periodic fire kills the small trees before they have a chance to become islands, thus maintaining the grassland.

Older Douglas-fir trees are adapted to fire by having thick bark that resists damage by ground fires. In the past, in areas like the park's Northern Range, frequent ground fire kept most young Douglas-fir trees from becoming part of the overstory. The widely scattered, large, fire-scarred trees in some of the dense Douglas-fir stands in the valleys of the Lamar and Gardner rivers are probably remnants of these communities.

Lodgepole pines produce two types of cones, one of which opens after being heated to at least 113°F. These fire-dependent cones—called serotinous—ensure seedling establishment after a fire. Lodgepole seedlings also need an open canopy that allows plenty of sun through. This happens only if mature trees in a lodgepole stand are periodically thinned by disease, fire, or other natural agents. Such disruption creates a landscape more diverse in age, which reduces the probability of disease or fire spreading through large areas.

Fire influences the rate that minerals become available to plants by rapidly releasing these nutrients from wood and forest litter. Fire's heat may also hasten the weathering of soil minerals, releasing more mineral elements. Following a fire, plants rapidly absorb this abundant supply of soluble minerals.

Fire control alters these natural conditions. Landscape diversity diminishes, forest size increases, and plant community structure and composition change. Species susceptible to fires become prominent; diseases spread over

Effects of Fire Control

- *Landscape becomes primarily older communities, decreasing diversity.*
- *Structure and composition of many communities favors species that do not benefit from fire.*
- *Insects and diseases are more likely to spread over larger areas.*
- *Litter and dead-fall continue to accumulate, increasing the chances of extreme fire behavior over larger areas.*

5

Fire Management

History

- For most of the park's history, managers believed that preservation of its resources meant that fires had to be extinguished.
- Scientific research revealed:
  - —fires have occurred in Yellowstone for as long as there has been vegetation to burn
  - —fire plays a role in creating the landscape
  - —fire is a part of the ecosystem that park managers want to preserve
  - —suppressing fires actually alters the natural landscape and diminishes diversity.
- 1972, Yellowstone began using natural fire management.
- Between 1972 and 1987, 234 fires burned nearly 35,000 acres—mostly in two dry years, 1979 and 1981.
- The fires of 1988 brought about management changes *(see next section)*.

Current Fire Management Policy

The National Fire Plan, based on a report after the 2000 fire season, emphasizes interagency cooperation in fire management. Appropriations for the plan include $101 million for National Park Service projects and activities identified in plan.

greater areas; litter and deadfall accumulate; and minerals remain locked up or are more slowly released.

The expanses of even-aged lodgepole pine forests in Yellowstone are a good example of how fire—or lack of fire—affects this forest community.

Fire suppression began with the arrival of the U.S. Army, which was placed in charge of protecting the park in 1886. The Army, which was in Yellowstone until 1918, successfully extinguished some fires, though it is difficult to determine what effect their efforts had on overall fire frequency or extent of fires. During this period, fire suppression was most effective on the grasslands, shrub lands, and savannas of the park's Northern Range. Throughout the rest of the park, which is largely covered by forest, reliable and consistent fire suppression began when modern airborne firefighting techniques became available after World War II.

On most public and private lands, maintaining wild processes is not as high a priority as other activities, and controlling wildfires may be appropriate. But in natural areas such as Yellowstone, preserving a state of wildness and its associated processes is a primary goal of management.

Evolution of Fire Management Plans

In 1972, Yellowstone was one of several national parks that initiated programs allowing some natural fires to run their courses. Two backcountry areas in the park (340,000 acres) were designated as locations where natural fires could burn.

That year, 340,000 acres in two backcountry areas were designated as appropriate for naturally caused fires.

In 1974, after the initial successes of the program, plans were made to expand the acreage and an environmental assessment (EA) was prepared in 1975. The EA recommended allowing fires to burn on about 1,700,000 acres in the park; it was approved early in 1976. Shortly thereafter Yellowstone National Park and the Bridger–Teton National Forest entered into a cooperative program to involve the Teton Wilderness in the fire plan so naturally caused fires could burn across the boundary between the two federal units.

Between 1972 (the first fire management plan) and 1988, Yellowstone's fire management plan was gradually revised and updated in accordance with National Park Service guidelines and as research provides new information:

- Tens of thousands of lightning strikes simply fizzled out with no acreage burned.
- 140 lightning-caused fires burned only a small area.
- More than 80 percent of the lightning starts went out by themselves.
- A total of 34,175 acres burned in the park as a result of natural fires.
- The largest natural fire burned about 7,400 acres (prior to this, the largest natural fire in the park's written history was in 1931 at Heart Lake where about 18,000 acres burned).
- No human lives were lost, and no significant human injuries occurred due to fires.

- No park structures or special features were affected.

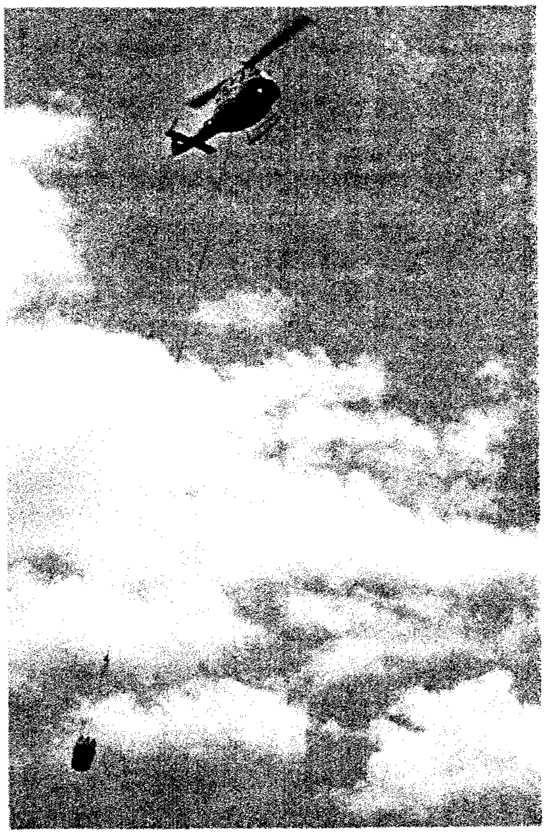
Based on these facts, a fire plan revision was begun in late 1986 and was in the final stages of approval by the spring of 1988. The plan's goals:

- To permit lightning-caused fires to burn under natural conditions.
- To prevent wildfire from destroying human life, property, historic and cultural sites, special natural features, or threatened and endangered species.
- To suppress all human-caused fires (and any natural fires whose suppression is deemed necessary) in as safe, cost-effective, and environmentally sensitive ways as possible.
- To resort to prescribed burning when and where necessary and practical to reduce hazardous fuels, primarily dead and down trees.

The plan was reviewed again after the fires of 1988 *(see next section)* when the Secretaries of the Departments of the Interior and Agriculture appointed a Fire Management Policy Review Team. Its final report, issued in May 1989, reaffirmed the basic soundness of natural fire policies in national parks and wilderness areas and offered 15 recommendations to improve federal fire management programs. These recommendations were incorporated into the National Park Service's Wildland Fire Management Policy Guideline that was revised in June 1990 and in the 1992 fire management plan revision in Yellowstone National Park.

National fire management plans continue to be reviewed after major fire seasons. For example, a major review of federal policies and programs followed the 1994 fire season when 34 people were killed in the western United States (none in Yellowstone, though). That review, completed in 1995, directs federal agencies to achieve a balance between suppression to protect life, property, and resources and "fire use" (the new term for natural fires that replaces prescribed natural fire) to regulate fuels and maintain healthy ecosystems. The report provides nine guiding principles and 13 policies to be incorporated into all wildland fire management actions. The principles include:

- Firefighter and public safety is the first priority.
- The role of wildland fire is an essential ecological process and a natural change agent and will be incorporated into the planning process. These principles and policies were incorporated into wildland fire management activities for the 1996–2000 fire seasons.



The National Fire Plan

During the 2000 fire season, almost 93,000 wildland fires burned more than 7 million acres in the United States and destroyed numerous structures. President Clinton asked the Secretaries of Agriculture and the Interior to develop recommendations on how to reduce the impacts of fire on rural communities and ensure sufficient firefighting resources for the future. A report was presented to the President in September 2000 and came to be known as the "National Fire Plan." The plan identified five points that continue to emphasize interagency approaches:

- *Firefighting: Continue to fight fires and be adequately prepared for next year.*
- *Rehabilitation and Restoration: Restore landscapes and rebuild communities damaged by the wildfires of 2000.*
- *Hazardous Fuel Reduction: Invest in projects to reduce fire risk.*
- *Community Assistance: Work directly with communities to ensure adequate protection.*
- *Accountability: Be accountable and establish adequate oversight, coordination, program development, and monitoring for performance.*

The House and Senate approved an appropriations bill that funded most of the actions. The bill contains about $2.8 billion in funding for the five land management agencies involved in wildland fire management. Of this sum, $101 million is for National Park Service projects and activities identified in the National Fire Plan.

5

The Fires of 1988

Statistics

- 9 fires caused by humans.
- 42 fires caused by lightning.
- 36% (793,880 acres) of the park was affected, mostly by surface burns.
- Fires begun outside of the park burned 63% or approximately 500,000 acres of the total acreage.
- About 300 large mammals perished as a direct result of the fires: 246 elk, 9 bison, 4 mule deer, 2 moose.
- $120 million spent fighting the fires.
- 25,000 people employed in these efforts.

Fighting the Fires

- Until July 15, naturally-caused fires allowed to burn.
- After that, all fires were fought, regardless of their cause.
- Single largest fire-fighting effort in the history of the United States.
- Effort saved human life and property, but probably had little impact on the fires themselves.
- Rain and snow in September finally stopped the advance of the fires.

Results of the Fires

- Extensive review, some revision of fire management policy *(see previous section)*
- Extensive research on fire ecology *(see next section)*

Moisture Content

When the moisture content of vegetation is:

- *8 to 12%, lightning will start lots of fires & many will burn freely*
- *12 to 16%, some fires will burn up to 200 to 300 acres*
- *>16%, fires may start but few will burn any significant acreage*
- *24%, few fires start*

THE YEAR THE RAINS FAILED
Percent of Normal Rainfall

	April	May	June	July	Aug.
1977	10	96	63	195	163
1978	91	126	42	99	46
1979	6	17	42	115	151
1980	33	152	55	143	199
1981	49	176	102	103	25
1982	169	74	89	118	163
1983	22	29	69	269	88
1984	44	84	66	297	121
1985	42	93	44	160	84
1986	145	47	64	212	75
1987	42	144	75	303	122
1988	155	181	20	79	10

The spring of 1988 was wet until June, when hardly any rain fell. Park managers and fire behavior specialists expected that July would be wet, though, as it had been historically *(see chart below left)*. About 20 lightning-caused fires were allowed to burn after evaluation according to the fire management plan. Eleven of these fires burned themselves out, behaving just like many fires had in previous years.

Rains did not come in July as expected. By late July, after almost two months of little rain, moisture content of grasses and small branches reached levels as low as 2 or 3 percent, downed trees were as low as 7 percent (kiln-dried lumber is 12 percent). A series of unusually high winds fanned flames that even in the dry conditions would not have moved with great speed.

Because of the extremely dry conditions, after July 15 no new natural fires were allowed to burn (exceptions were made for natural fires that started adjacent to existing fires, when the new fires were clearly going to burn into existing fires). Even so, within a week the perimeter of the fires in the park doubled to about 17,000 acres. After July 21, all fires were subjected to full suppression efforts as staffing would allow. (Human-caused fires had been vigorously suppressed from the beginning.) On July 27, during a visit to Yellowstone, the Secretary of the Interior reaffirmed that the natural fire program had been suspended, and all fires would be fought.

Fighting the Fires

An extensive interagency fire suppression effort was initiated in mid July in the greater Yellowstone area in an attempt to control or contain the unprecedented series of wildfires. The extreme weather conditions and heavy, dry fuel accumulations presented even the most skilled professional firefighters with conditions rarely observed.

Accepted firefighting techniques were frequently ineffective because fires spread long distances by "spotting," a phenomenon in which wind carries embers from the tops of the 200-foot flames far out across unburned forest to start spot fires well ahead of the main fire. Regular spotting up to a mile and a half away from the fires made the widest bulldozer lines useless and enabled the fires to jump rivers, roads, and even the Grand Canyon of the Yellowstone River.

Fires often moved two miles per hour, with common daily advances of five to ten miles, consuming even very light fuels that would have been unburnable during an average season. The fast movement, coupled with spotting, made frontal attacks on the fires impossibly dangerous, as fire crews could easily be overrun or trapped between a main fire and its outlying spot fires. Even during the night, fires could not be fought. Normally, wildfires "lie down" at night as increased humidity and decreased temperature quiet them. But in 1988, the humidity remained low at night, and fire fighting was further complicated by extreme danger from falling trees.

Firefighting efforts were directed at controlling the flanks of fires and protecting lives and property in their paths. The fire experts on site generally agreed that only rain or snow could stop the fires. They were right: one-quarter inch of snow on September 11 stopped the advance of the fires.

By the last week in September, about 50 lightning-caused fires had occurred in or burned into the park, but only eight were still burning. More than $120,000,000 had been spent in control efforts on fires in the greater Yellowstone area, and most major park developments—and a few surrounding communities—had been evacuated at least once as fires approached within a few miles. The fire suppression efforts involved many different federal and state agencies, including the armed forces. At the height of the fires, ten thousand people were involved. This was the largest such cooperative effort ever undertaken in the United States.

Confusion In the Media

The Yellowstone area fires of 1988 received more national attention than any other event in the history of national parks. Unfortunately, many media reports were inaccurate or misleading and confused the public. The reports tended to lump all fires in the Yellowstone area together as the "Yellowstone Park Fire"; they referred to these fires as part of the park's natural fire program, which was not true; and they often contained oversimplification of events and exaggeration of how many acres had burned. In Yellowstone National Park itself, the fires affected—but did not "devastate"—793,880 acres or 36 percent of the park's total acreage.

The North Fork Fire threatened Old Faithful, Madison, Canyon, Norris, West Yellowstone, Mammoth Hot Springs, and the Tower–Roosevelt area.

A number of major fires, most notably the North Fork Fire, the Hellroaring Fire, the Storm Creek Fire, the Huck Fire, and the Mink Fire started outside the park. These fires accounted for more than half of the total burn in the greater Yellowstone area, and included most of the ones that received intensive media attention. The North Fork Fire began in the Targhee National Forest and suppression attempts began immediately. The Storm Creek Fire started as a lightning strike in the Absaroka– Beartooth Wilderness of the Custer National Forest northeast of Yellowstone; it eventually threatened the Cooke City–Silver Gate area, where it received extended national television coverage.

Additional confusion resulted from the mistaken belief that managers in the Yellowstone area let park fires continue burning unchecked because of the natural fire plan—long after such fires were being fought. Confusion was probably heightened by misunderstandings about how fires are fought: if crews were observed letting a fire burn, casual observers might think the burn was merely being monitored. In fact, in many

Burned Area Within Yellowstone National Park

Burn Type	Acres	Percent of Park
• Crown fire: consuming the forest canopy, needles, and ground cover and debris	323,291	15%
• Mixed: mixture of burn types in areas where most of ground surface was burned	281,098	13%
• Meadows, sagebrush, grassland	51,301	2%
• Undifferentiated: variety of burn types	37,202	2%
• Undelineated: surface burns not detectable by satellite because under unburned canopy	100,988	4%
Total Burned Area	**793,880**	**36%**
Total Unburned Area	**1,427,920**	**64%**

Data from the Geographic Information Systems Laboratory, Yellowstone National Park, 1989; Table adapted from Yellowstone in the Afterglow: Lessons From the Fires, *Mary Ann Franke, 2000.*

instances, fire bosses recognized the hopelessness of stopping fires and concentrated their efforts on the protection of buildings and developed areas.

The most unfortunate public and media misconception about the Yellowstone firefighting effort may have been that human beings can always control fire. These fires could not be controlled; their raw, unbridled power cannot be overemphasized. Firefighters were compelled to choose their fights very carefully, and they deserve great praise for working so successfully to save all but a few of the buildings in the park.

Post-fire Response and Ecological Consequences

By late September, as the fires were diminishing, plans were underway in Yellowstone to develop comprehensive programs for all aspects of post-fire response. These included replacement, rehabilitation, or repair of damaged buildings, power lines, firelines, trails, campsites, and other facilities. Similarly, programs were developed to interpret the fires and their effects for visitors and for the general public. The park also cooperated with other agencies and state and local governments in promoting the economic recovery of communities near the park that were affected by the fires.

The same scene, in 1988 after the fires (left) and in 1989 (right)

Scientists wanted to monitor the ecological processes following these major fires. The National Park Service cooperated with other agencies and independent researchers and institutions in developing comprehensive research directions for this unparalleled scientific opportunity.

Observations began while the fires were still burning, when it was apparent that the fires did not annihilate all life forms in their paths. Burning at a variety of intensities, sometimes as ground fires, sometimes as crown fires, the fires killed many lodgepole pines and other trees, but did not kill most other plants; they merely burned the tops off of them, leaving roots to regenerate.

Temperatures high enough to kill seeds occurred in less than one-tenth of one percent of the park. Only under logs and in deep litter accumulations, where the fire was able to burn for several hours, did lethal heat penetrate more deeply into the soil. Where water was available, new plant growth began within a few days. In dry soils, the rhizomes, bulbs, root crown, seeds, and other reproductive tissues had to wait until soil moisture was replenished the following spring.

The fires of 1988 created a mosaic of burns, partial burns, and unburned areas that are now the new habitats of plants and animals. This mosaic actually provides natural firebreaks, reducing the number of fire starts and limiting fire size over time while sustaining a greater variety of plant and animal species. Vegetation capable of sustaining another major fire will be rare for decades, except in extraordinary situations.

Though animal movements were sometimes affected dramatically by the passage of fires, relatively few animals died. However, portions of the Northern Range burned, which affected winter survival of grazing animals when coupled with summer drought conditions. In this and many other ways, fires dramatically altered the habitat and food production of Yellowstone for the short term.

Yellowstone Fires 1988–2000

	Number of Fires		
Year	**Prescription**	**Suppressed**	**Acres Burned**
1988	*	45	793,880
1989	*	24	10
1990	*	43	247
1991	*	29	270
1992	15	14	485
1993	5	5	<1
1994	4	60	16,238
1995	9	7	<2
1996	13	11	3,261
1997	12	1	<1
1998	11	2	125
1999	11	4	10
2000	2	31	7,209

* After the natural fire policy was suspended on July 15, 1988, all fires in the park were suppressed until the revised policy was approved in 1992.

Table adapted from Yellowstone in the Afterglow: Lessons From the Fires, *Mary Ann Franke, 2000.*

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Results of Fire Research Since 1988

In 2000, The Yellowstone Center for Resources published *Yellowstone in the Afterglow: Lessons from the Fires,* by Mary Ann Franke. Some findings are summarized on the next four pages.

What Has Changed

Although some long-term consequences of the fires remain to be seen, these changes have been caused entirely or in part by the fires of 1988:

- ✓ The replacement of thousands of acres of forest with standing or fallen snags and millions of lodgepole pine seedlings.
- ✓ The establishment of aspen seedlings in areas of the park where aspen had not previously existed.
- ✓ A decline in the moose population because of the loss of old growth forest.
- ✓ Shifts in stream channels as a result of debris flows from burned slopes.
- ✓ An increase in the public understanding and acceptance of the role of fire in wildland areas.
- ✓ A stronger program to reduce hazardous fuels around developed areas.

This list indicates the relatively small number of documented changes that might be apparent or of interest to the average park visitor.

What Has *NOT* Happened Since 1988

Whether you agree that Yellowstone became "a blighted wasteland for generations to come," as announced by one U.S. Senator in 1988 is a matter of personal opinion. But of the more quantifiable predictions that were made about the fires' long-term consequences, there is not yet any evidence that the following have come to pass:

- ✗ A long-term drop in park visitation.
- ✗ Flooding downstream of the park because of increased runoff on bare slopes.
- ✗ A decline in fish populations because increased erosion silts up the water.
- ✗ An increase in fish populations in smaller streams where deforestation and loss of shade could result in warmer water and higher nutrient levels.
- ✗ More rapid invasion of non-native plants into burned areas and corridors cleared as fire breaks.
- ✗ An increase in lynx following a boom in snowshoe hares as a result of changes in forest structure.
- ✗ Increased willow vigor and production of the defense compounds that deter its browsing by elk and moose.
- ✗ An increase in the elk population because of improved forage.
- ✗ A decline in the endangered grizzly bear population because of smaller whitebark pine seed crops.
- ✗ Another big fire season in Yellowstone because of all the fuel provided by so many dead and downed trees.
- ✗ Adoption of a program of prescribed burning to reduce the likelihood of future large fires in Yellowstone.

Soils

Fertile soils with good water-holding capacity that had a dense, diverse vegetation before the fire were likely to respond quickly after the fire with a variety of species and nearly complete cover. Some soils in Yellowstone supported little vegetation before the fires and have continued to have little since then. Areas that appear barren and highly erosive did not necessarily become that way because of fire.

Vegetation

As root systems of standing dead trees decay and lose their grip on the soil, the trees are gradually falling down, often with the help of a strong wind. However, many will remain upright for another decade or more.

Many of the forests that burned in 1988 were mature lodgepole stands, and this species is now recolonizing most burned areas. Lodgepole pine grow slowly in Yellowstone's current climate, and 30 years after the post-fire seedlings have taken root, many may still be less than 10 feet tall. The first seedlings of Engelmann spruce, subalpine fir, and Douglas-fir are also beginning to emerge.

The density of lodgepole pine seedlings that sprouted in burned areas after the 1988 fires varied, depending on factors such as fire severity, elevation, abundance of serotinous cones, and seedbed characteristics. Density ranged from 80 seedlings per hectare in a high-elevation stand with no serotinous cones to 1.9 million seedlings per hectare in a low-elevation stand in which nearly half the trees had serotinous cones. (One hectare is approximately 2.5 acres.)

About 28 percent of the park's whitebark pine forest burned in 1988. This affects grizzly bears, for which whitebark pine seeds are an important food in fall. Seeds not consumed by grizzlies remain in caches of red squirrels and Clark's nutcracker. These buried seeds and the hardiness of whitebark pine seedlings on exposed sites give this tree an initial advantage in large burned areas over conifers that depend on the wind to disperse their seeds. However, this slow-growing and long-lived tree is typically more than a century old before it begins producing cones. The young trees may die before reproducing if the interval between fires is too short or if faster-growing conifers overtake them. By 1995, whitebark pine seedlings had appeared in all 275 study plots, though density was not significantly different between burned and unburned sites.

Some grasses and flowers, such as fireweed (above) and dragon's head, thrived only in the first years after the fires, while others such as pinegrass and showy aster have slowly but steadily increased.

About one-third of the aspen in the Northern Range burned in the 1988 fires—but the aspen stands were not destroyed. Fire that killed individual adult trees also enhanced aspen reproduction. Like other disturbances, fire stimulates the growth of suckers from the aspen's extensive underground root system. (Suckers and root shoots produce clones of the "parent" aspen.) Fire also leaves behind bare mineral soil devoid of taller plants—perfect conditions for aspen seedlings. After the fires of 1988, aspen seedlings appeared throughout the park in burned areas. All the young trees, whether clones or seedlings, can be heavily browsed by elk and may not grow much beyond shrub height. But the fires indirectly helped protect some of these young trees: the trunks of fallen trees keep elk from reaching some of the young aspen.

Like trees, most other types of vegetation in the park were not killed by the fires; the portion above ground may have been burned off, but the roots were left to regenerate. The regrowth of plant communities began as soon as the fire was gone and moisture was available, which in some sites was within days. In

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Results of Fire Research Since 1988

Twelve years after the fires, the moose is the only large mammal whose population appears to have declined because of the fires. Willow and subalpine fir—which moose depend on for winter food—were reduced by the fires. Dense forest canopies were also gone, which resulted in deeper snow accumulations. The combination of less food and more snow contributed to winter moose mortality.

dry soils, the seeds had to wait until moisture was replenished the following spring. New seedlings grew even in the few areas where the soil had burned intensely enough to become sterilized. Within a few years, grasslands had largely returned to their pre-fire appearance, and sagebrush areas may be next, in another 20 to 30 years.

Plant growth was unusually lush in the first years after the fires because of the mineral nutrients in the ash and increased sunlight on the forest floor. Moss an inch or more thick became established in burned soils, and may have been a factor in moisture retention, promoting revegetation and slowing erosion.

Wildlife

Most ungulate (hoofed) species were more affected by the drought and the relatively severe winter that followed than by the fires themselves. Although none of their winter range burned, mule deer declined 19 percent and pronghorn 29 percent during the winter of 1988.

Elk mortality rose to about 40 percent in the winter of 1988–89, but scientists are unsure how much of this was due to reduced forage because of the fires. (At least 15 percent of the deaths were due to the hunting season.) Even without the fires, several factors would probably have led to high elk mortality that winter; summer drought, herd density, hunting harvest, and winter severity. The greatest impact of the fires would therefore be on the quantity and quality of forage available to elk in subsequent years. A two-year study following the fires found that the forage quality of three types of grasses was better at burned sites than unburned sites.

Of the 38 grizzly bears wearing radio transmitters when the fires began, 21 had home ranges that were hit by one or more of the fires: 13 of these bears moved into burned areas after the fire front had passed, three bears (adult females without young) stayed within active burns as the fire progressed, three bears remained outside the burn lines at all times, and two adult females could not be located (one of which was found in Hayden Valley in the summer of 1990). In a study from 1989–92, bears were found grazing more frequently at burned than unburned sites, especially on clover and fireweed. Even though bear feeding activity in some whitebark pine areas decreased as much as 63 percent, the fires have had no discernable impact on the number of grizzly bears in greater Yellowstone.

Rodents probably had the highest fire-related mortality of any mammals. Although many could escape the fires in burrows, others died of suffocation as the fires came through. They also were more exposed to predators because they had lost the cover of grasses and other plants. But if the number of small mammals did temporarily decline while their predators multiplied, the increased number of predators would soon face a food shortage themselves, continuing the ongoing adjustment in the predator-prey ratio.

Most birds were not directly harmed by the fires and some benefited. For example, raptors hunted rodents fleeing the fires. But osprey young that were still in their nests perished. Post-fire habitat changes have helped some birds and not others. Cavity-nesting birds, such as Barrow's goldeneye, flickers, and bluebirds, had many dead trees for their nests. Robins and flickers found ants and worms more easily. Boreal owls, however, lost some of the mature forests they need.

Aquatic Resources

In general, the amount of soil loss and sediment deposits in streams varied greatly, but in most cases was within the normal range of variation.

About a quarter of the Yellowstone Lake and Lewis Lake watersheds and half of the Heart Lake watershed burned to some extent, but no significant changes have been observed in nutrient enrichment, plankton production, or fish growth as a result. There was no apparent increase in streambank erosion or change in substrate composition or channel morphology that would affect cutthroat trout spawning habitat, nor does there appear to have been a decline in the number of spawning streams. No discernable fire-related effects have been observed in the fish populations or the angling experience in the six rivers that have been monitored regularly since 1988.

In other park watersheds, such as the Gibbon River, massive erosion and mudslides occurred during and after the heavy rains of the summer of 1989. However, by 1991, growth of plants had slowed this erosion.

Conclusion

In the years that have passed since the fires, visitors have marveled at the new vistas, the wildflower blooms, and the lush growth of new, young trees. Some visitors still feel that the Yellowstone they knew and loved is gone forever. But Yellowstone is not a museum; it is a living functioning ecosystem in which fire plays an important role.

Lodgepole seedling

5

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www.fire.nps.gov for information about the National Fire Plan

WILDLIFE

MAMMALS

- Yellowstone National Park is home to the largest concentration of mammals in the lower 48 states.
- 60 different mammals live here, including a wide variety of small mammals.
- Several hundred grizzly bears live in the greater Yellowstone area.
- Black bears are common.
- Gray wolves were restored in 1995; more than 100 live in the park now.
- Wolverine, a predator requiring large expanses of undisturbed habitat—lives here; lynx, which also requires such habitat, may also be here.
- Seven native species of ungulates—elk, mule deer, bison, moose, bighorn sheep, pronghorn, and white-tailed deer—live here, including one of the largest herds of elk in the United States.
- Non-native mountain goats may be colonizing the park.

ORDER Carnivora	Habitat	Estimated Population
Family Ursidae		
*Black Bear *(Ursus americanus)*	forests, meadows	500–650
*Grizzly Bear *(Ursus arctos horribilis)*	forests, meadows	280–610
Family Canidae		
*Coyote *(Canis latrans)*	forests, meadows, grasslands	common
*Gray Wolf *(Canis lupus)*	forests, meadows	132
*Fox *(Vulpes vulpes)*	meadows	occasional
Family Felidae		
*Bobcat *(Lynx rufus)*	forests, meadows	may be widespread
*Cougar *(Puma concolor)*	mountains, rocky areas	20–35
*Lynx *(Lynx canadensis)*	subalpine forests	rare, if present
Family Procyonidae		
Raccoon *(Procyon lotor)*	rivers, cottonwoods	rare, if present
Family Mustelidae		
Badger *(Taxidea taxus)*	sagebrush	common
Fisher *(Martes pennanti)*	forests	rare, if present
**Marten *(Martes martes)*	coniferous forests	common
Mink *(Mustela vison)*	riparian forests	occasional
**River Otter *(Lutra canadensis)*	rivers, lakes, ponds	common
Striped Skunk *(Mephitus mephitus)*	riparian to forest	rare
**Long-tailed Weasel *(Mustela frenata)*	willows to spruce/fir forests	common
**Short-tailed Weasel (ermine) *(Mustela erminea)*	willows to spruce/fir forests	common
**Wolverine *(Gulo gulo)*	alpine, coniferous forests	rare

**indicates a species described in the species accounts that begin on page 81, following "Small Mammals."*

***indicates a species described on pages 74–80 under "Small Mammals."*

Species described under "Small Mammals" are alphabetized by their common name on this list.

ORDER Artiodactyla		
Family Cervidae		
*Elk (Wapiti) *(Cervus elaphus)*	meadows, forests	30,000 in summer
*Moose *(Alces alces shirasi)*	riparian, forests	<1,000
*Mule Deer *(Odocoileus hemionus)*	forests, grasslands, shrub lands	2,500
*White-tailed Deer *(O. virginianus)*	forests, grasslands, shrub lands	occasional
Family Bovidae		
*Bison *(Bison bison)*	meadows, grasslands	3,500
*Bighorn Sheep *(Ovis canadensis)*	alpine meadows, cliffs	150–225
Mountain Goat (non-native) *(Oreamnus americanus)*	rocky slopes	rare
Family Antilocapridae		
*Pronghorn *(Antilocapra americanus)*	sagebrush, grasslands	200–250
ORDER Chiroptera		
Family Vespertilionidae		
Big Brown Bat *(Eptesicus fuscus)*	roost in cliffs, attics; feed around water	rare
Little Brown Bat *(Myotis lucifugus)*	roost in cliffs, attics; feed around water	common
Long-eared Bat *(M. evotis)*	roost in cliffs, attics; feed around water	common
Big-eared Bat *(Plecotus townsendi)*	roost in cliffs, attics; feed around water	common
ORDER Lagomorpha		
Family Leporidae		
**Snowshoe Hare *(Lepus americanus)*	forests, willows	common
White-tailed Jackrabbit *(Lepus townsendii)*	sagebrush, grasslands	common
Desert Cottontail *(Sylvilagus audubonii)*	shrub lands	common
Mountain Cottontail *(S. nuttallii)*	shrub lands	common
Family Ochotonidae		
**Pika *(Ochotona princeps)*	rocky slopes	common
ORDER Insectivora		
Family Soricidae		
Dusky Shrew *(Sorex monticolus)*	moist meadows, forests	common
Masked Shrew *(S. cinereus)*	moist meadows, forests	common
Water Shrew *(S. palustris)*	moist meadows, forests	common
Preble's Shrew *(S. preblei)*	moist meadows, forests	rare, if present
Dwarf Shrew *(S. nanus)*	moist meadows, forests	rare
ORDER Rodentia		
Family Castoridae		
*Beaver *(Castor candensis)*	ponds, streams	300–350

Family Sciuridae		
**Least Chipmunk *(Tamius minimus)*	forests	common
Uinta Chipmunk *(T. umbrinus)*	forests	common
Yellow Pine Chipmunk *(T. amoenus)*	forests	common
**Yellow-bellied Marmot *(Marmota flaviventris)*	rocky slopes	common
**Golden-mantled Ground Squirrel *(Spermophilus lateralis)*	forests, rocky slopes	common
Northern Flying Squirrel *(Glaucomys sabrinus)*	forests	occasional
**Red Squirrel *(Tamiasciurus hudsonicus)*	forests	common
**Uinta Ground Squirrel *(Spermophilus armatus)*	sagebrush, meadows	common
Family Geomyidae		
**Northern Pocket Gopher *(Thomomys talpoides)*	sagebrush, meadows, forests	common
Family Cricetidae		
Deer Mouse *(Peromyscus maniculatus)*	grasslands	common
Western Jumping Mouse *(Zapus princeps)*	riparian	occasional
Muskrat *(Ondatra zibethicus)*	streams, lakes, ponds	common
Heather Vole *(Phenacomys intermedius)*	sagebrush to forests	occasional
Long-tailed Vole *(Microtus longicaudus)*	moist meadows	common
Meadow Vole *(M. pennsylvanicus)*	moist meadows	common
**Montane Vole *(M. montanus)*	moist meadows	common
Red-backed Vole *(Clethrionomys gapperi)*	dense forests	common
Water Vole *(M. richardsoni)*	riparian	occasional
Bushy-tailed Woodrat *(Neotoma cinerea)*	rocky slopes	common
Family Erethizontidae		
Porcupine *(Erethizon dorsatum)*	forests, sagebrush, willows	common

6A

Small Mammals

*Species accounts appear in alphabetical order by their **common name.***

Numerous small mammals live in Yellowstone National Park. The park's interpretive rangers chose the following species to describe because visitors are likely to see them or inquire about them. Descriptive photos and illustrations exist in numerous books about these species; see "For More Information" on pages 120–121 for suggested titles.

GOLDEN-MANTLED GROUND SQUIRREL

Spermophilus lateralis

Identification

- 9–12 inches; 7.4–11 ounces.
- In the adults the head and shoulders are reddish-brown color, their "mantle."
- **Often mistaken for a least chipmunk (described below);** distinguished by larger size, more robust body, shorter tail, and lateral stripes that do not extend onto the sides of the head.

Habitat

- Found throughout Yellowstone at all elevations in rocky areas, edges of mountain meadows, forest openings, tundra.
- 87% of diet consists of fungi and leaves of flowering plants; other foods include buds, seeds, nuts, roots, bird eggs, insects, and carrion.
- Predators include coyotes, weasels, badgers, hawks.

Behavior

- Hibernate from October to March or April.
- Breeding occurs shortly after both males and females emerge from hibernation; one litter of 5 young per year.

LEAST CHIPMUNK

Tamius minimus

Identification

- 7.5–8.5 inches long, 1.2 ounces.
- Smallest member of the squirrel family; one of three chipmunk species in the park.
- Alternating light and dark stripes on its back and sides, with the outermost stripe on the sides being dark; underside tends to be white and its tail has black-tipped hairs with a reddish undertone.
- **Often mistaken for golden-mantled ground squirrel (described above);** distinguished by smaller size, longer tail, and lateral stripes that extend onto the sides of the head.

Habitat

- Prefers sagebrush valleys, shrub communities, and forest openings.
- Eats primarily plant material, especially seeds and other fruits, but will also eat conifer seeds and some insects.
- Preyed on by various hawks and probably foxes and coyotes.

Behavior

- In YNP this species hibernates but also stores some food and probably arouses frequently during the winter.
- Breeding begins as snowmelt occurs usually late March until mid May; one litter of 5–6 young per year.
- Little is known about their vocalizations but they do have "chipping" (which may be an alarm) and "clucking" calls.
- Can be identified by quick darting movements and it seems to carry its tail vertically when moving.

LONG-TAILED WEASEL

Mustela frenata

Identification

- 13–18 inches long, 4.8–11 ounces.
- Light to dark brown dorsally; belly is buff to rusty orange; chin white, tail makes more than 40% of its body length.
- Males 40% larger than females.

Compare to marten (below) and short-tailed weasel, page 78.

Habitat

- Found in forests, open grassy meadows and marshes, and near water.
- Eat voles, pocket gophers, mice, ground and tree squirrels, rabbits; to a lesser degree birds, eggs, snakes, frogs, and insects.

Behavior

- Breeding occurs in early July and August; one litter of 6–9 young per year.
- Solitary animals except during breeding and rearing of young.

MARTEN

Martes americana

Identification

- 18–26 inches long, 1–3 pounds.
- Weasel family; short limbs and long bushy tail; fur varies from yellow to brown to black; irregular, yellowish to bright orange throat patch.
- Smaller than a fisher; lighter in color, orange bib rather than white.

Compare to long-tailed weasel (above) and short-tailed weasel, page 78.

Habitat

- Found in conifer forests with dense canopy and understory of fallen logs and stumps; will use riparian areas, meadows, forest edges and rocky alpine areas.
- Eat primarily small mammals such as red-backed voles, red squirrels, snowshoe hares, flying squirrels, chipmunks, mice and shrews; also to a lesser extent birds and eggs, amphibians and reptiles, earthworms, insects, fruit, berries, and carrion.

Behavior

- Solitary except in breeding season (July & August); delayed implantation; 1–5 young born in mid March to late April.
- Active throughout the year; hunt mostly on the ground.
- Rest or den in hollow trees or stumps, in ground burrows or rock piles, in excavations under tree roots.

MONTANE VOLE

Microtus montanus

Identification

- 5–7.6 inches long, 1.2–3.2 ounces.
- Brownish to grayish-brown, occasionally grizzled; ventral side is silvery gray; relatively short tail is bi-colored.

Habitat

- Found at all elevations in moist mountain meadows with abundant grass and grassy sagebrush communities; also common in riparian areas.
- Grass is their primary food.
- Probably the most important prey species in the park; eaten by coyotes, raptors, and other animals.

Behavior

- Typically breeds from mid February to November; up to 4 litters of 2–10 young per year.
- Active year-round maintaining tunnels in the winter; also dig shallow burrows.

PIKA

Ochotona princeps

Identification

- 7–8.4 inches long; 5.3–6.2 ounces (about the size of a guinea pig).
- Tailless, gray to brown with circular ears.

Habitat

- Found on talus slopes at nearly all elevations in the park.
- Eat plant foods such as grasses, sedges, aspen, lichen, and conifer twigs.
- Predators include coyotes, martens, and hawks.

Behavior

- Active during the day; darts around on rocks.
- Often heard but not seen; makes a distinct shrill whistle call or a short "mew."
- Breeds in spring; two litters per year.
- Scent marks by frequently rubbing cheeks on rocks.
- Late summer they gather mouthfuls of vegetation to build "haystacks" for winter food; defends haystacks vigorously.
- Haystacks often built in same place year after year; have been known to become three feet in diameter.
- Like rabbits and hares, pika eat their own feces.

POCKET GOPHER

Thomomys talpoides

Identification

- 6–10 inches long, 2.6–6.3 ounces.
- Very small eyes and ears; brown or tan smooth fur; short tail; long front claws for burrowing; large external pouches for carrying food.

Habitat

- Only restriction in range seems to be topsoil depth, which limits burrowing.
- Preyed upon by owls, badgers, grizzly bears, coyotes, weasels, and other predators.
- Snakes, lizards, ground squirrels, deer mice, and other animals use their burrows.
- In the top 6–8 inches below the surface they forage for forbs, some grasses and underground stems, bulbs and tubers.
- Transport food in their cheek pouches to underground cache.

Behavior

- Breed in May and April; one litter of 5 young per year.
- Burrow systems are elaborate and often bi-level; can be 400–500 feet long.
- Very territorial; only one per burrow.
- Grizzly bears will sometimes dig up these caches, including an unsuspecting gopher.
- Do not hibernate, but instead burrow into the snow; often fill tunnels with soil forming worm-like cores that remain in the spring after snow melts.

RED SQUIRREL

Tamiasciurus hudsonicus

Identification

- 11–15 inches long, 6.7–7 ounces.
- Brownish-red on its upper half; dark stripe above white ventral side; light eye ring; bushy tail.
- Quick, energetic.
- Loud, long chirp to advertise presence; much more pronounced in the fall.

Habitat

- Spruce, fir, and pine forests; young squirrels found in marginal aspen habitat.
- Eat conifer seeds, eat terminal buds of conifer trees, fungi, some insects; sometimes steal young birds from nests.
- Preyed on by coyotes, grizzly bears, hawks.

Behavior

- Breeds February–May, typically March and April; one litter of 3–5 young.
- One of the park's most territorial animals; territorialism ensures winter food supply.
- In fall, cuts cones from trees and caches them in middens, which are used for years and can be 15 by 30 feet; grizzlies search out these middens in whitebark pine habitat to obtain the nuts.

RIVER OTTER

Lutra canadensis

Identification

- 40–54 inches long, 10–30 pounds.
- Sleek, cylindrical body; small head; tail nearly one third of the body and tapers to a point; feet webbed; claws short; fur is dark dense brown.
- Ears and nostrils close when underwater; whiskers aid in locating prey.

Habitat

- Most aquatic member of weasel family; rarely found far from water.
- Eats crayfish and fish; also frogs, turtles, sometimes young muskrats or beavers.

Behavior

- Breeds in late March through April; one litter of two young per year.
- Females and offspring remains together until next litter; may temporarily join other family groups.
- Can swim underwater up to 6 miles per hour and for 2–3 minutes at a time.
- Not agile or fast on land unless they find snow or ice, then can move rapidly by alternating hops and slides; can reach speeds of 15 miles per hour.
- Mostly crepuscular but have been seen at all times of the day.
- Active year-round.

SHORT–TAILED WEASEL (ERMINE) *Mustela erminea*

Identification

- 8–13 inches long, 2.1–7 ounces.
- Typical weasel shape, a very long body, short legs and pointed face: tail makes up 40% of its body.
- Males about 40% larger than females.
- Fur is light brown in summer and white in winter; tail is black-tipped all year.

Compare to long-tailed weasel and marten, page 75.

Habitat

- Eat voles, shrews, deer mice, rabbits, rats, chipmunks, grasshoppers, and frogs.
- Found in willows and spruce forests.

Behavior

- Breeding takes place in early to mid summer; 1 litter of 6–7 young per year.
- Can leap repeatedly three times their length.
- Will often move through and hunt in rodent burrows.

SNOWSHOE HARE

Lepus americanus

Identification

- 14.5–20 inches long, 3–4 pounds.
- Large hind feet enable easy travel on snow; white winter coat offers camouflage; gray summer coat.
- Transition in seasonal fur color takes about 70–90 days; seems to be triggered in part by the day length.

Habitat

- Found throughout YNP in coniferous forests with dense understory of shrubs, riparian areas with many willows, or low areas in spruce-fir cover.
- Rarely ventures from dense forest cover except to feed in forest openings.
- Eats plants.
- Preyed upon by lynx, bobcats, coyotes, foxes, some hawks, and great horned owls.

Behavior

- Breed from early March to late August.
- Young are born with hair, grow rapidly and are weaned within 30 days.
- Mostly nocturnal; their presence in winter is only advertised by a network of well-worn trails in the snow.
- Docile except during the breeding season when they chase each other, drum on the ground with the hind foot, leap into the air, and occasionally battle each other.

UINTA GROUND SQUIRREL

Spermophilus armatus

Identification

- 11–12 inches long, 7–10 ounces.
- Grayish back and rump with fine white spots on back; nose and shoulders are tan to cinnamon; tail is grayish underneath.

Habitat

- Found in disturbed or heavily grazed grasslands, sagebrush meadows, and mountain meadows up to 11,000 feet.
- Eats grasses, forbs, mushrooms, insects, and carrion (including road-killed members of its own species).
- Preyed on by long-tailed weasels, hawks, coyotes, badgers.

Behavior

- Hibernate mid July through March.
- Breeds in early spring; one litter of 6–8 young per year.
- Young, after they leave the burrow, are vulnerable to long-tailed weasels and hawks.
- During cool spring weather, Uinta ground squirrels active at all times of day, as the weather warms activity more limited to morning, late afternoon, and evening.

WOLVERINE

Gulo gulo

Identification

- 28–42 inches long, 30–60 pounds.
- Largest member of weasel family; compact and strongly built, broad head, short legs; black to dark brown with white on chest may extend as bands onto sides; shaggy appearance due to long guard hairs.

Habitat

- Found in undisturbed conifer forests and alpine tundra; wolverines considered an indicator of true wilderness.
- Eats burrowing rodents, birds, eggs, beavers, squirrels, marmots, mice, and vegetation; has also been known to take large prey such as deer or elk when snow is deep.

Behavior

- Breeds April to October; 1 litter of 2–4 young each year.
- Den under log jams, uprooted trees, caves.
- Solitary except when breeding.
- Primarily nocturnal, active year-round.

YELLOW-BELLIED MARMOT

Marmota flaviventris

Identification

- 20–28 inches long; 3.5–11 pounds.
- One of the largest rodents in Yellowstone.
- Reddish-brown upper body; yellowish belly; small ears; prominent active tail.

Habitat

- Found from lowest valleys to alpine tundra, usually in open grassy communities and almost always near rocks.
- Feed on grasses and forbs in early summer; switch to seeds in late summer, occasionally will eat insects.
- Preyed on by coyotes, grizzlies, and golden eagles.

Behavior

- Hibernate up to 8 months, emerging from February to May depending on elevation; may estivate in June in response to dry conditions and lack of green vegetation and reappear in late summer.
- Breeds within two weeks of emerging from hibernation; average 5 young per year.
- Active in morning, late afternoon, and evening.
- Colonies consist of one male, several females, plus young of the year.
- Vocalizations include a loud whistle (early settlers called them "whistle pigs"), a "scream" used for fear and excitement; a quiet tooth chatter that may be a threat.
- Males are territorial; dominance and aggressiveness demonstrated by waving tail slowly back and forth.

Bear, Black

In Yellowstone, about 50 percent of black bears *(Ursus americanus)* are black in color, others are brown and cinnamon. Black bears stand about 3 feet high at the shoulder. Males weigh 210–315 pounds; females weigh 135–160 pounds. They have fair eyesight and an exceptional sense of smell.

Black bears eat almost anything, including grass, berries, fruits, tree cambium, bird eggs, nuts, insects, fish, and carrion. Their short, curved claws enable them to climb trees, but do not allow them to dig for roots or ants as well as a grizzly bear can (grizzlies have longer, less-curved claws).

During fall and early winter, bears spend most of their time feeding, in a predenning period known as "hyperphagia." In November they locate or excavate a den on north-facing slopes between 5,800–8,600 feet. There, they hibernate until late March.

Most scientists consider bears to be true hibernators. Some hibernating animals experience an extreme drop in metabolism with a cooling of body temperature and near stoppage of respiration and circulation. Bears undergo these changes to a less dramatic extent than some other species, and they can be easily roused from hibernation.

Males and females without cubs are solitary, except during the mating season, which is May to early July. They may mate with a number of individuals, but occasionally a pair stays together for the entire period. Both genders usually begin breeding at age four.

After fertilization, the barely developed blastocyst (egg) does not immediately implant in the uterus, a process called "delayed implantation." If the bear is healthy when she dens for the winter, implantation and development will begin; if not, her body will abort the blastocyst. Total gestation time is 200 to 220 days, but only during the last half of this period does fetal development occur.

As of March 2002 . . .

Number in Yellowstone
500–650, estimate

Where to see
Tower and Mammoth areas, most often

Behavior & Size
- Males weigh 210–315 pounds, females weigh 135–160 pounds; adults stand about 3 feet at the shoulder.
- May live 15–20 years.
- Home range: male, 6–124 square miles, female, 2–45 square miles.
- Can climb trees; adapted to life in forest and along forest edges.
- Food includes rodents, insects, elk calves, cutthroat trout, pine nuts, grasses and other vegetation.
- Mates in spring; gives birth the following winter to 1–4 cubs.

History
- Like grizzlies, used to be fed at dumps within the park.
- For years, black bears were fed by visitors from vehicles.
- Both of these actions resulted in bears losing fear of humans, pursuing human food, which resulted in visitor injuries, property damage, and the need to destroy "problem bears."

Management Status
- 1960, black bear management program implemented, which has reduced the number of bear-caused human injuries and property damage; and has re-established black bears in a natural state.
- 2000, new study begun to find out how black bears fit into the mix of Northern Range predators; three black bears have been radio-collared.

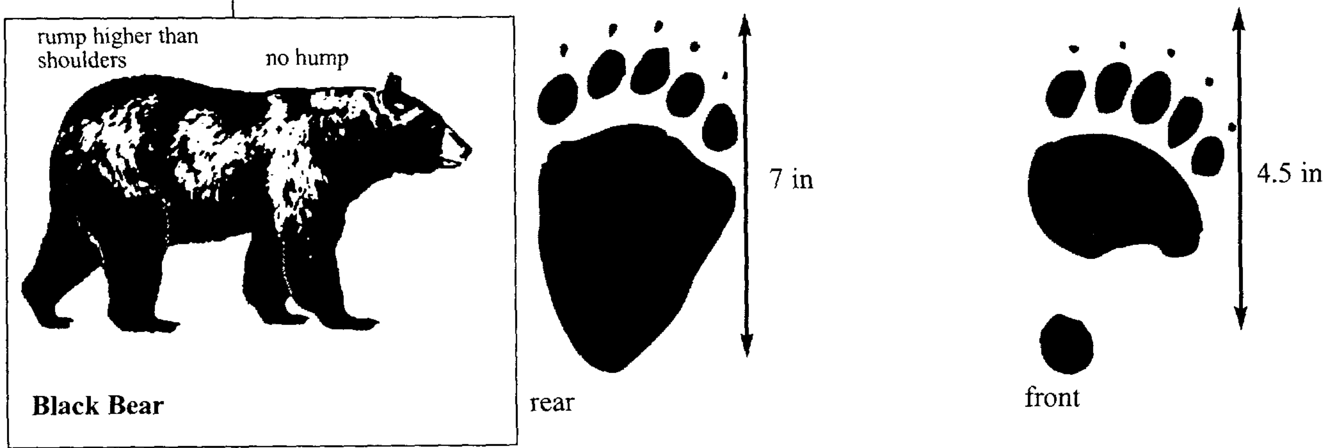
Birth occurs in mid January to early February; the female becomes semiconscious during delivery. Usually two cubs are born, though there may be one or three; four are rare. At birth, the cubs are blind, toothless, and almost hairless. After delivery the mother continues to sleep for another two months, during which time the cubs alternately suckle and sleep.

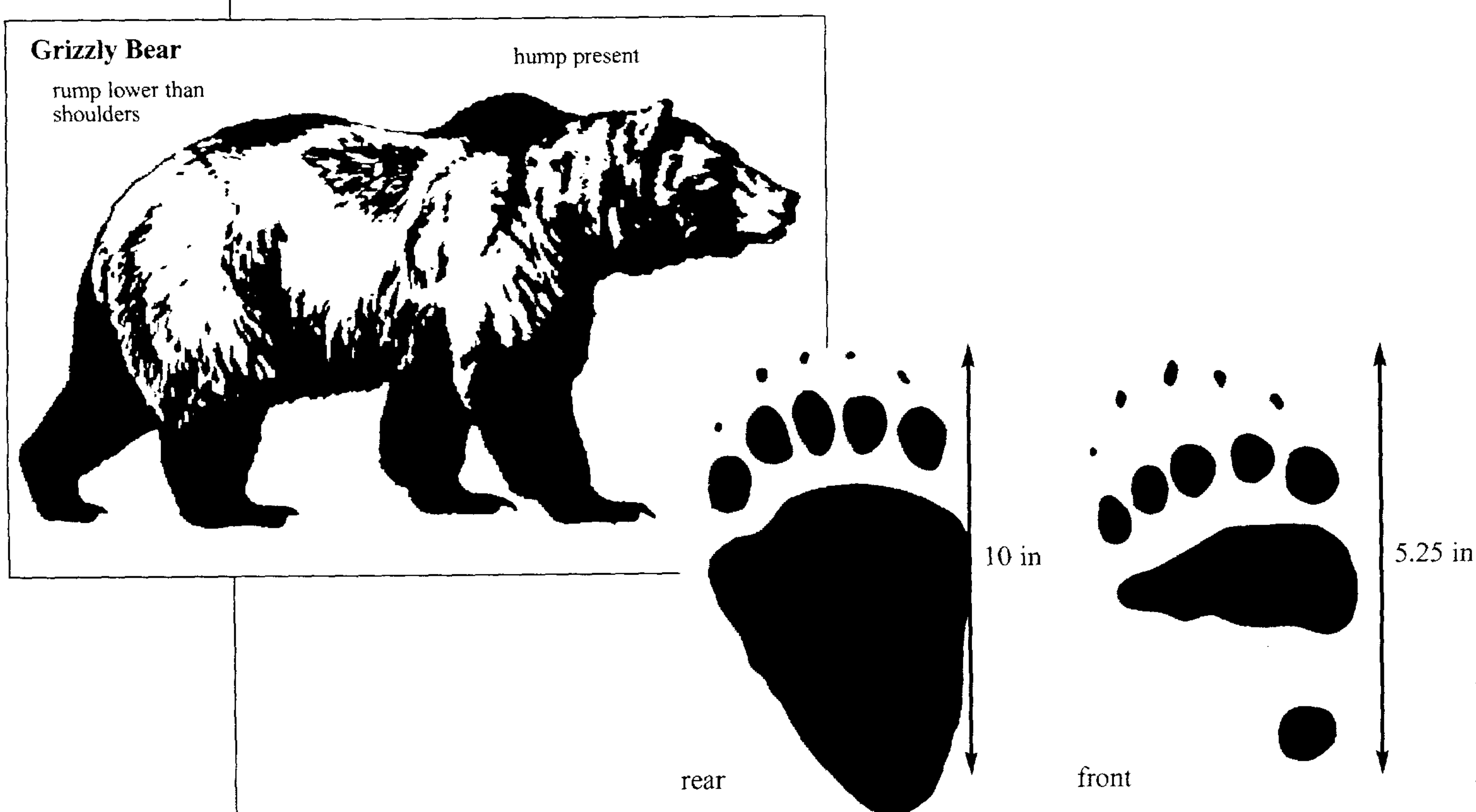
After emerging from the den, the cubs and their mother roam over her home territory. The animals have no regular summer den, but they often dig shallow depressions—day beds—near abundant food sources. In the fall, the cubs den with their mother. The following spring, the cubs and mother separate.

When faced with a threat, black bears are likely to retreat up a tree or flee outright, rather than reacting aggressively. However, any bear, particularly a female with cubs, may attack when surprised at close range. And black bears are more likely than grizzlies to stalk a human—although this is rare. Whether it's a grizzly or a black bear, always give these animals a wide berth.

6A

Bears, Comparison





As of March 2002 . . .

Number in Yellowstone
Estimated 280–610 bears

Where to see
Most commonly seen at dawn and dusk in the Hayden and Lamar valleys, on the north slopes of Mt. Washburn, and from Fishing Bridge to the East Entrance.

Behavior & Size
- Males weigh 300–700 pounds, females weigh 200–400 pounds; adults stand about 3½ feet at the shoulder.
- May live 15–20 years.
- Home range: male, 813–2,075 square miles, female, 309–537 square miles
- Agile; can run up to 45 miles per hour.
- Can climb trees but curved claws and weight make this difficult.
- Adapted to life in forest and meadows.
- Food includes rodents, insects, elk calves, cutthroat trout, roots, pine nuts, grasses, and large mammals.
- Mates in spring; gives birth the following winter; 2–3 cubs, rarely 4.

Status
- Yellowstone is one of only two major areas south of Canada still inhabited by grizzly bears.
- In July, 1975, the grizzly bear was listed as a threatened species under the Endangered Species Act.

Current Management
See "Bear Management History" in this chapter & related articles in Chapter 8.

The grizzly bear *(Ursus arctos horribilis)* is a subspecies of brown bear that once roamed the mountains and prairies of the American West. Today, the grizzly bear remains in a few isolated locations in the lower 48 states, including Yellowstone.

The name "grizzly" comes from the frequent presence of silver-tipped or "grizzled" hairs on the animals' coats. However, the coloration of black and grizzly bears is so variable that it alone is not a reliable means of telling the two bears apart. Particularly when bears are not fully grown or when seen only briefly or at a long distance, it can be difficult to correctly identify one bear species from another.

It is commonly said that grizzly bears cannot climb trees. This is not true, especially when the bears are small. As grizzlies increase in size and as their claws grow longer, they have a harder time climbing. Stories that bears cannot swim or run downhill are also persistent—and incorrect. Grizzlies can sprint up to 45 miles per hour.

Bears are generally solitary, although they may tolerate other bears when food is not limited. Mating season occurs from mid May to mid July, and bears may mate with multiple partners during a single season. Females do not breed until at least age 4 or 5. Bears experience "delayed implantation," meaning that the embryos do not begin to develop until late November or December. This appears to be a strategy allowing the mother bear to save up energy until entering her winter den, where the cubs are born in late January or February. A litter of two or three cubs is common, litters of four cubs occur occasionally. Male bears take no part in raising cubs and may pose a threat to younger bears. A mother grizzly will usually keep her cubs with her for two winters following their birth, after which time she (or a prospective suitor) chases the subadult bears away so she can mate again. Female cubs frequently establish their home range in the vicinity of their mother, but male cubs must disperse farther in search of a home.

They can be effective predators, especially on such vulnerable prey as elk calves and spawning cutthroat trout. They also scavenge meat when available, such as from winter-killed carcasses of elk and bison, from road-killed wildlife, and from wolves and cougars. They eat small mammals (such as pocket

gophers) and insects (such as ants and army cutworm moths that summer on high-elevation talus slopes), both of which provide important, high-protein food. A grizzly's long claws and strong shoulders make it an efficient digger for roots, bulbs, corms, and tubers, and rodents and their caches. They also eat a wide variety of plants, including whitebark pine nuts, berries, sedges, grasses, glacier lilies, dandelions, yampas and biscuit-roots, horsetails and thistles. And, of course, they will eat human food and garbage where they can get it. This is why managers emphasize that keeping human foods secure from bears increases the likelihood that humans and bears can peacefully co-exist in greater Yellowstone.

Grizzlies have a social hierarchy in which adult male bears dominate the best habitats and food sources, generally followed by mature females with cubs, then by other single adult bears. Subadult bears, who are just learning to live on their own away from mother's protection, are lowest on the social ladder and most likely to have to make a living in poor-quality habitat or in areas nearer roads and developments. Thus, young adult bears are most vulnerable to danger from humans and other bears, and to habituation. Habituation often results in a bear being transferred or ultimately removed from the wild population.

Bears spend most of their time feeding, and this effort increases during "hyperphagia," the predenning period in autumn. They locate or excavate dens on densely vegetated, north-facing slopes between 6,562–10,000 feet. Bears enter their winter dens between mid October and early December. Although grizzlies are considered true hibernators *(see black bear description for more on this),* they do sometimes awaken and leave their dens during the winter.

6A

Bears: Management History

Early visitors to Yellowstone National Park developed an interest in the area's wildlife—especially the bears. Dumps as bear-viewing sites quickly became a primary tourist attraction. At the height of the bear-feeding era, hundreds of people sat nightly in bleachers and watched as bears fed on garbage.

Despite the official prohibition in 1902 against hand-feeding bears, Yellowstone National Park became known as the place to see and interact with bears. Roadside bears, often receiving handouts from enthusiastic park visitors, caused "bear jams"—a traffic jam resulting from the presence of one or more photogenic park bears, black or grizzly, often with a park ranger standing by to direct traffic, answer questions, and even pose for pictures.

In 1931, as park visitation and the number of bear-human conflicts began to increase, park managers began keeping detailed records of bear-caused human injuries, property damages, and subsequent nuisance bear control actions. Between 1931 and 1969 an average of 48 bear-inflicted human injuries and more than 100 incidents of property damage occurred annually in Yellowstone.

In 1959 and continuing through 1971, Drs. John and Frank Craighead, who are brothers, conducted a pioneering ecological study of grizzly bears in Yellowstone. Their research provided the first scientific data about grizzlies in this ecosystem, which enabled park managers to manage bears based on science and solve the underlying causes leading to bear-human conflicts.

In 1960, the park implemented a bear management program—directed primarily at black bears—designed to reduce the number of bear-caused human injuries and property damages that occurred in the park and to re-establish bears in a natural state. It included expanded efforts to educate visitors about bear behavior and the proper way to store food, garbage, and other bear attractants; prompt removal of garbage to reduce its availability to bears, and the development and use of bear-proof garbage cans; stricter enforcement of regulations prohibiting the feeding of bears; and removal of potentially hazardous bears, habituated bears, and bears that damaged property in search of food.

After 10 years of this bear management program, the number of bear-caused human injuries decreased only slightly, to an average of 45 each year. Consequently, in 1970, Yellowstone initiated a new, more intensive bear management program that included the controversial decision to eliminate the unsanitary open-pit garbage dumps inside the park. The long-term goal was to wean bears away

Feeding Bears

- 1889: Bears gathered at night to feed on garbage behind park hotels.
- 1910: First incidents of bears seeking human food along park roads.
- 1916: First confirmed bear-caused human fatality.

Early Management

- 1931: Park began keeping detailed records of bear-inflicted human injuries, property damage, and bear control actions.
- 1931–1969: average of 48 bear-inflicted human injuries and more than 100 incidents of property damage occurred annually in Yellowstone.

Changes in Management

- 1970: Yellowstone implemented a new bear management program to restore bears to subsistence on natural foods and to reduce the human injuries and property damage.
- Strict enforcement of regulations prohibiting the feeding of bears, and requiring proper storage of human food and garbage.
- All garbage cans in the park converted to a bear-proof design.
- Garbage dumps closed within and adjacent to the park.

Current Status

- In 1975, the grizzly bear population in the Yellowstone ecosystem was listed as a threatened species under the Endangered Species Act.
- Decrease in human injuries from 45 injuries per year in the 1960s to 1 injury per year in the 1990s.
- Decrease in property damage claims from 219 per year in the 1960s. to an average of 7 per year in the 1990s.
- Decrease in number of bears that must be killed or removed from the park from 33 black bears and 4 grizzlies per year in the 1960s to an average of 0.2 black bear and 0.3 grizzly bear per year in the 1990s.
- Decrease in bear relocations away from the front country from more than 100 black bears and 50 grizzlies per year in the 1960s to an average of 0.4 black bear and 0.9 grizzly bear per year in the 1990s.
- *For more detailed information on current management, see Chapter 8, pages 143–148.*

The first bear-caused human fatality within Yellowstone occurred in 1916 when a grizzly bear killed a wagon teamster in a roadside camp. At the time, park managers considered this bear's behavior to be completely out of the ordinary.

Bears: Management History

Reductions in Conflict

Most bear-human conflicts before 1983 involved habituated bears aggressively seeking human *foods. From 1983 to 1993, most bear-human conflicts involved habituated bears seeking* natural *foods near humans.*

Since 1983, bear-caused human injuries have declined to an average of one per year.

The number of bears removed from the population has also declined from earlier periods.

Because of the IGBST and the earlier Craighead studies, greater Yellowstone managers have the longest continuous database for any grizzly bear population in the lower 48 states.

The rate of cubs surviving to adulthood is high (about 33 percent), and the average litter size has increased from 1.9 observed in the mid 1970s to 2.15 in the mid 1990s.

from unnatural concentrations of food and back to a natural distribution and a diet of plant and animal foods available throughout the ecosystem.

The Craigheads predicted bears would range more widely, resulting in more bear-human conflicts and subsequent bear mortalities. This indeed occurred in the short-term. During the program's first three years, an average of 38 grizzly bears and 23 black bears were trapped each year and translocated from roadsides and developed areas to backcountry areas. In addition, an average of 12 grizzly bears and 6 black bears were removed from the population each year. However, bear-caused human injuries decreased significantly to an average of 10 each year. After 1972, the number of bear-human conflicts and bear management control actions declined significantly.

In 1983, the park implemented a new grizzly bear management program. The 1983 program emphasized habitat protection in backcountry areas. The park established "bear management areas" where recreational use was restricted in areas with seasonal concentrations of grizzly bears. The goals were to minimize bear-human interactions that might lead to habituation of bears to people, to prevent human-caused displacement of bears from prime food sources, and to decrease the risk of bear-caused human injury in areas with high levels of bear activity. This program continues today.

Listing as a Threatened Species

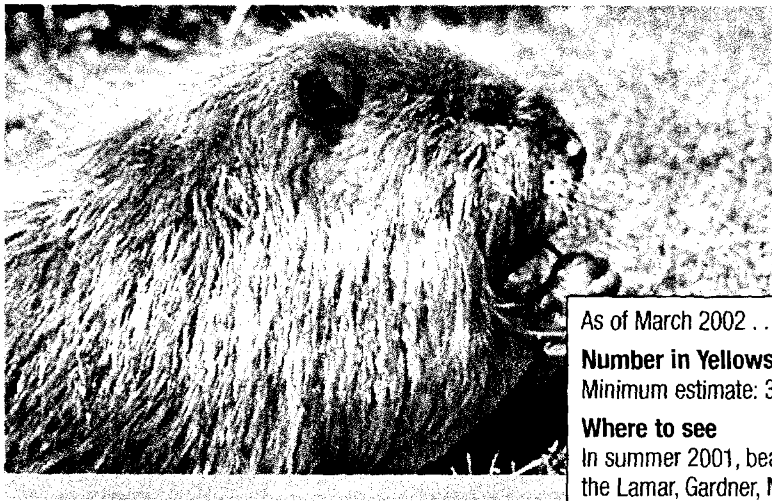
In 1975, the grizzly bear in the lower 48 states was listed as threatened under the Endangered Species Act, in part, because the species was reduced to only about two percent of its former range south of Canada. Five or six small populations were thought to remain, totaling 800 to 1,000 bears. The southernmost—and most isolated—of those populations was in greater Yellowstone, where some 250 to 300 grizzly bears were thought to have remained the mid 1970s.

The listing of the grizzly for protection under the Endangered Species Act resulted in cessation of grizzly bear hunting, and the development of numerous plans and guidelines to protect the remaining bears and their habitat within an identified recovery area. The Yellowstone grizzly bear recovery area is approximately 9,500 square miles in size and includes all of Yellowstone National Park, the John D. Rockefeller, Jr. Memorial Parkway, significant portions of Grand Teton National Park and the Bridger-Teton, Shoshone, Gallatin, Caribou–Targhee, Custer, and Beaverhead–Deer Lodge national forests. It also includes Bureau of Land Management lands and state and private lands in Idaho, Montana, and Wyoming.

Research and management of grizzlies in greater Yellowstone intensified after the 1975 establishment of the Interagency Grizzly Bear Study Team (IGBST). The team, in cooperation with state wildlife managers in Idaho, Montana, and Wyoming, have monitored bears, estimated the number and trend of the population, and enhanced our understanding of grizzly bear food habits and behavior in relation to humans and to other wildlife species.

In 1983, the Interagency Grizzly Bear Committee (IGBC) was created in order to increase the communication and cooperative efforts among managers of grizzly bears in all recovery areas. Twice each year, managers meet to discuss common challenges related to grizzly bear recovery. They supervise the implementation of public education programs, sanitation initiatives, and research studies to benefit the grizzly bear populations in Yellowstone and the other recovery areas.

Scientists and managers believe that, despite the continuing growth in human use of greater Yellowstone, the grizzly population has been stable to slightly increasing since 1986. The bears seem to be reproducing well and raising cubs in nearly all portions of the recovery area. More and more frequently, bears have been seen well outside Yellowstone National Park, south into Wyoming's Wind River Range, north throughout the Gallatin Range, and east of the Absarokas onto the plains. By tracking radio-collared bears, we know previously unmarked bears and offspring are dispersing into new and vacant but suitable habitats. In 1996, scientists estimated with 90 percent confidence that the Yellowstone grizzly population was between 280 and 610 bears. While many people may wish for a more precise estimate, at this time it is not economically possible to count wide-ranging and fairly solitary animals like bears with complete accuracy.



As of March 2002 . . .

Number in Yellowstone
Minimum estimate: 300

Where to see
In summer 2001, beavers had lodges in the Lamar, Gardner, Madison, and Gallatin rivers, Trout Creek (Hayden Valley), Willow Park (between Mammoth and Norris), Beaver Ponds (Mammoth area), and Harlequin Lake (Madison area) in the front country; upper Yellowstone River (Thorofare region) and Bechler River in the backcountry.

Behavior & Size
- Active at night; seldom seen during day.
- If live on rivers, may build bank dens instead of lodges.
- One lodge may support 1–6 beavers that are usually related; this group is called a colony.
- 35–40 inches long, including tail.
- Weighs 30–60 pounds.

Other Info
- Beaver are native to Yellowstone.
- Yellowstone's beaver escaped most of the trapping that occurred in the 1800s due to the region's inaccessibility.
- Park biologists periodically survey the park for beaver; the most recent survey was conducted in 2001.

Since 1989, park staff have periodically surveyed riparian habitat in Yellowstone to determine current presence and distribution of beaver *(Castor canadensis)*. These surveys confirm that beaver live throughout Yellowstone National Park but are concentrated in the southeast (Yellowstone River delta area), southwest (Bechler area), and northwest portions (Madison and Gallatin rivers) of the park. These areas are likely important habitat because of their waterways, meadows, and the presence of preferred foods such as willow, aspen, and cottonwood.

Beaver, however, are not restricted to areas that have their preferred foods. Essentially no aspen exist in some areas where beaver sign is most abundant, such as in the Bechler River. The same is true in other areas where beaver periodically live, such as Heart Lake, Grizzly Lake, the lower Lamar River and Slough Creek area, the Beaver Ponds near Mammoth, Slide Lake, and the lower Gardner River. In these areas, beaver appear to use lodgepole pine and some Douglas-fir for construction purposes and/or for food. In areas where preferred woody plants are only present in very small densities or are absent, beavers may feed solely on submerged vegetation such as pond lilies.

Beaver are famous as dam builders, and examples of their work can be seen from the roads in the park. An old dam is visible at Beaver Lake between Norris and Mammoth, and a newer dam is located on Trout Creek in Hayden Valley. Most dams are on small streams where the gradient is mild, and the current is relatively placid during much of the year. Colonies located on major rivers or in areas of frequent water level fluctuations, such as the Lamar River, den in holes in the riverbank.

Male and female beaver look alike—thick brown fur, paddle-shaped tail, weigh 30–60 pounds, and are about 35 to 40 inches long, including tail. When hunched over their food, beaver can resemble round river rocks.

Because beaver are most active at night, visitors seldom see them. But these animals do not necessarily avoid areas of moderate to high levels of human use. Several occupied lodges in Yellowstone are close to popular backcountry trails and/or campsites. Every year, beaver are seen along main park roadways. The nocturnal habits of beaver seem to be enough to separate them from human use of the same area.

People who wait near known beaver activity areas may be rewarded with the sight of them swimming smoothly along or clambering onto the bank to gnaw at trees and willows. But they may just as likely hear the sound of a startled or surprised beaver—the sharp sound of the beaver slapping its tail on the water before it submerges to seek safety.

6A

Bighorn Sheep

As of March 2002 . . .

Number in Yellowstone
150–225

Where to See
- Summer: slopes of Mount Washburn, along Dunraven Pass.
- Year-round: Gardner Canyon, between Mammoth and the North Entrance. Also: On cliffs along the Yellowstone River opposite Calcite Springs; above Soda Butte; in backcountry of eastern Absarokas.

Behavior and Size
- Adult male (ram) up to 300 pounds, including horns that can weigh 40 pounds.
- Adult female (ewe) up to 200 pounds.
- Both sexes have horns.
- Feed primarily on grasses; forage on shrubby plants in fall and winter.
- Mating season begins in November.
- One to two lambs born in May or June.

Management
- Bighorns in Gardner Canyon and on Mount Washburn exhibit some habituation to humans; be alert to them along the road; never feed them.
- Early accounts that reported large numbers of bighorn sheep in Yellowstone have led to the speculation that they were more numerous before the park was established.
- A chlamydia (pinkeye) epidemic in 1982 reduced the northern herd by 60%.
- Other factors that may be limiting the population now: over-hunting outside the park, introduction of other domestic livestock diseases, difficulty in re-colonizing previous habitats.

Bighorn sheep *(Ovis canadensis)* once numbered in the millions in the western United States. By 1900, though, bighorn numbers were reduced to a few hundred due to market hunting. In 1912, naturalist Ernest T. Seton reported bighorns in the park had increased to more than 200, and travelers could find them around Mt. Everts or Mt. Washburn.

Bighorn sheep inhabit high, rocky country. The bottoms of their feet are concave, enabling them to walk and run over rocks very easily. Their tan-colored fur camouflages them against cliff rocks.

As bighorns feed, one acts as a sentinel. At any hint of danger, all take off after the leader, generally a female, and do not stop until they have climbed as high as they can or passed to the other side of the mountain.

Both males and females have horns. For the first two years of its life, the horns of a male are similar to the small, slightly curved horns of a female. By the time a male is six or seven years old, the horns form the better part of a circle. The bone interior of the horn does not extend out very far; the outer parts of the horns are hollow and may be damaged during the rut (mating season). Broken or splintered tips are never replaced, and the horn continues to grow from the base throughout the animal's life.

The rut begins in November. Males challenge one another in dramatic battles, snorting and grunting and rising onto their hind legs, then racing toward each other and crashing their heads and horns together. Their extra thick skull protects their brain during these jarring encounters. At the end of the two-month rut, males are often battered and bruised.

Although they are sure-footed in a steep and rocky environment, bighorns do have accidents. They fall off cliffs, slip on ice, and can become caught in avalanches. In Yellowstone, they also have been struck by lightning and hit by automobiles.

Population and Management

After a chlamydia (pinkeye) epidemic in 1982, the population of bighorns on the Northern Range has not recovered to previous levels. Because no sign of the disease is present, other factors are believed to be limiting the population, such as over-hunting outside the park, introduction of other domestic livestock diseases, and difficulty in re-colonizing previous habitats.

Researchers have also studied bighorn sheep habitat use and the effect of human activity along the Gardiner–Mammoth road. About 65 percent of all sheep observations occur atop McMinn Bench of Mt. Everts, which has been proposed as an alternate route for the road. Moving the road to this location would affect at least 2 ewe groups and 2–3 ram groups. Studies and evaluations of data are continuing.

6A

Bison

For many years scientists considered Yellowstone's bison to be a subspecies known as the mountain bison. Most scientists no longer make this distinction, and consider bison to be one species, *Bison bison.*

The bison is the largest land mammal in North America. Bulls are more massive in appearance than cows, and more bearded. For their size, bison are agile and quick, capable of speeds in excess of 30 mph. Each summer, bison injure park visitors who approach too closely.

Bison are sexually mature at age 3. Although female bison may breed at younger ages, older males (>7 years) participate in most of the breeding. Life span averages 12–15 years, few individuals live as long as 20 years in the wild. Both sexes have horns, those of the cow being slightly more curved and slender than the bull's.

Bison are animals of the grasslands; they eat primarily grasses and sedges. Their massive hump supports strong muscles that allow the bison to use its head as a snowplow in winter, swinging side to side to sweep aside the snow.

Cows, calves, and some younger bulls comprise a herd. Mature bulls, however, spend most of the year alone or with other bulls. The exception is during the rut, or mating season. At this time, in late July and August, bulls seek out females. They display their dominance by bellowing, wallowing, and engaging in fights with other bulls. Once a bull has found a female who is close to estrus, he will stay by her side until she is ready to mate. Then he moves on to another female, and the cow may accept other bulls.

After a gestation period of 9 to 9½ months, single reddish-brown calves are born in late April and May. Calves can keep up with the herds about 2–3 hours after birth and they are well protected by their mothers and other members of the herd. However, some wolves have succeeded in killing bison calves.

As of March 2002 . . .

Number

3,500 estimated

Where to see

- Year-round: Hayden and Lamar valleys.
- Summer: grasslands of the park.
- Winter: hydrothermal areas and along the Madison River.

Behavior & Size

- Male (bull) weighs up to 2,000 pounds, female (cow) weighs up to 1,000 pounds.
- Three fairly distinct herds: Northern (Lamar Valley), Mary Mountain (Hayden-Firehole valleys), Pelican Valley.
- Feed primarily on grasses and sedges.
- Mate in late July through August; give birth to one calf in late April or early May.
- Can be aggressive, are very agile, and can run up to 30 miles per hour.

History

- Yellowstone is the only place in the lower 48 states to have a continuously free-ranging bison population since prehistoric times.
- In the 1800s, market hunting, sport hunting, and a U.S. Army campaign nearly resulted in the extinction of the bison.
- By 1902, poachers reduced Yellowstone's small herd to about two dozen animals.
- The U.S. Army, who administered Yellowstone at that time, protected these bison from further poaching.
- Bison from private herds augmented the native herd.
- For decades, bison were intensively managed due to belief that they, along with elk and pronghorn, were over-grazing the park.
- By 1968, intensive manipulative management (including herd reductions) of bison ceased and natural ecological processes began.
- In 1994, the population reached its peak at 4,200 animals.

Current Issues

See Chapter 8 for articles on management & brucellosis.

Adult bison have had no large predators for many decades, although the restoration of wolves in Yellowstone is changing that—wolves in the Pelican Valley successfully kill a few adult bison each winter. Many insects feed upon the bison, and bison will rub against trees, rocks, or in dirt wallows in an attempt to rid themselves of insect pests. Birds such as the magpie "ride" a bison in order to feed on insects in its coat. The cowbird will also follow close behind a bison, feeding on insects disturbed by its steps. Dead bison provide an important source of food for scavenger species and bears just out of their dens in spring.

In North America, both "bison" and "buffalo" refer to the American bison (Bison bison). *Generally, "buffalo" is used informally; "bison" is preferred for more formal or scientific purposes.*

6A

Bison

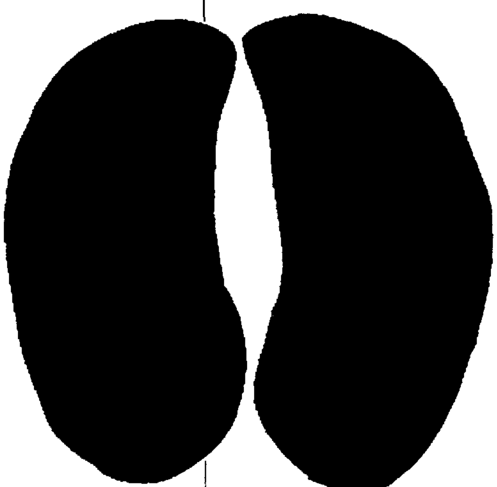
History

From 30 to 60 million bison may have roamed North America in the 1800s. Their historic range spread from the Pacific to the Appalachians. As a result of over-hunting, they disappeared east of the Mississippi by 1832.

While bison were found throughout the country, their main habitat was the Great Plains. For millennia bison had roamed there in herds that often numbered three to five million animals. Plains tribes developed a culture that depended on bison. Almost all parts of the bison provided something for the Native American's way of life—food, tools, shelter, or clothing. No part of the animal was wasted; even the dung was burned for fuel. Hunting bison required skill and cooperation to herd and capture the animals. After tribes acquired horses from the Spanish, in the 1600s, they could travel farther to find bison and hunt the animals more easily.

But European American settlers moving west during the 1800s changed the balance. Market hunting, sport hunting, and a U.S. Army campaign in the late 1800s nearly caused the extinction of the bison.

Yellowstone was the only place in the lower 48 states where a population of wild, free-ranging bison persisted. The U.S. Army, which administered Yellowstone at that time, protected these few dozen bison from further poaching. The protection of bison in Yellowstone and their subsequent recovery is one of the great triumphs of the American conservation movement.



Management History

Despite protection, Yellowstone's bison were reduced to less than two dozen animals in 1902. Fearing the demise of the wild herd, the U.S. Army brought 21 bison from ranches to Yellowstone. In 1906–07, the Buffalo Ranch in Lamar Valley was constructed and began operation as a bison ranch. Various management techniques were used in the park until the mid 1930s in order to increase the herd size, and they were successful: The herd grew to more than 1,000 animals. During that period, little attention was given to the park's surviving native bison herd in Pelican Valley.

Policy began to shift in the 1930s to the preservation of bison in a more natural state with less artificial manipulation. The introduced bison were released and allowed to move freely throughout the park and intermingle with the native bison. However, bison were still managed, albeit sporadically, through culling.

In January 1954, an aerial survey of the entire park placed the number of bison at 1,477. Subsequent management reductions were carried out, and an aerial count in March 1967 indicated there were 397 bison in the entire park.

In 1968, manipulative management of bison ceased, allowing intensive research on natural ecological processes to begin. Their population subsequently grew and bison began to seek new ranges inside and outside the park. Because humans now occupy much of what used to be bison habitat, conflicts inevitably occur. Bison can be a threat to human safety and can cause considerable damage to fences, crops, landscaping, and other private property. And, of significant concern to livestock producers, bison can be infected with the disease brucellosis.

Because of brucellosis, the bison are not welcome outside the park even though all other ungulates that may also harbor the brucellosis organism are. Through the 1980s and 1990s, this issue has grown steadily into one of the most heated and complex of Yellowstone's resource controversies. For more information about brucellosis and the bison management plan, see Chapter 8, "Bison Management."

6A

Cats: Bobcat & Lynx

The cats of Yellowstone are seldom seen and little known. Of the three living in the park, cougars are better studied and are discussed in their own section. The little information available on bobcats and lynx is summarized below.

Lynx *(Lynx canadensis)*

Number in Yellowstone

Unknown; less than 70 observations in entire park history.

Where to see

- Rarely seen; most reports from southern half of the park.
- Typical habitat: dense conifer forests.

Behavior and Size

- Adult: 15–30 pounds, 26–38 inches long.
- Gray brown fur with white, buff, brown on throat and ruff; tufted ears; short tail; hind legs longer than front.
- Distinguish from bobcat: tail tip solid black; longer ear tufts; larger track.
- Wide paws with fur in and around pads; allows lynx to run across snow and approach silently.
- Solitary, nocturnal; usually beds during the day.
- Eats primarily snowshoe hares, especially in winter; also rodents, rabbits, birds, and other small mammals.

Research

In January 2001 research began attempting to document the number and distribution of lynx in the park.

Bobcat *(Lynx rufus)*

Number in Yellowstone

Unknown, but probably widespread.

Where to see

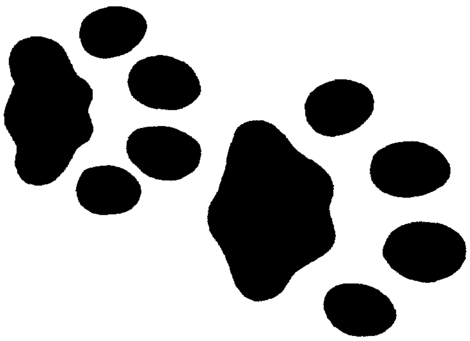
- Rarely seen; most reports from northern half of the park.
- Typical habitat: rocky areas, conifer forests, and sagebrush.

Behavior and Size

- Adult: 12–35 pounds; 21–46 inches long.
- Color ranges from red-brown fur with indistinct markings to light buff with dark spotting; short tail; ear tufts.
- Distinguish from lynx: black rings discontinuous around tail, shorter ear tufts, smaller track.
- Solitary, nocturnal.
- Eats rabbits, hares, voles, mice, red squirrels, birds such as wrens, sparrows, grouse; may take young deer and adult pronghorn.

6A

Cougar



As of March 2002 . . .

Number in Yellowstone
20–35 on the Northern Range; others in park seasonally.

Where to see
Seldom seen.

Behavior and size
- Adult males weigh 140–165 pounds; females weigh about 100 pounds; length, including tail, 6.5–7.5 feet.
- Preferred terrain: rocky breaks near prey.
- Prey primarily on elk and mule deer, plus porcupines and other small mammals.
- Bears frequently displace cougars from their kills.
- Male cougars will kill other male cougars within their territory.
- In the winter of 1999–2000, wolves apparently killed or caused the abandonment of 4 kittens in one litter.
- Litters range from 2–3 kittens; 50% survive first year.

Research
Research is underway to assess effects of wolf restoration on cougars.

Interaction with humans
- Few documented cougar–human confrontations have occurred in Yellowstone.
- Preventive/defensive measures: grouping together or carrying small children; making noise, waving arms, throwing rocks or sticks if necessary to scare off a big cat if close or stalking humans.

The cougar *(Puma concolor)*, also called the mountain lion, is the largest member of the cat family in North America. Cougars live throughout the park in summer, but their secretive nature results in few sightings. In winter, most cougars move to lower elevations where they can move more easily and find more prey. The Northern Range of Yellowstone is prime habitat for cougars—snowfall is light and prey always available. Cougars probably live at higher elevations in summer and move to lower elevations in the winter.

Cougars are territorial, but male territories may overlap with several females. However, males will not tolerate other adult males in their home range and may kill them.

A cougar preys chiefly upon elk (mostly calves) and deer. It stalks the animal then attacks, aiming for the animal's back and killing it with a bite to the base of the skull or the throat area. It then eats until full, and will cache the carcass for later use. Cougars catch other animals—from red squirrels to moose—if the opportunity arises. Porcupines supplement their winter diet.

Cougars are solitary hunters who face competition for their kills from other large mammals. In Yellowstone, black and grizzly bears will take over a cougar's kill. Coyotes will try, but can be killed by the cougar instead. Wolves displace cougars from their kills less than 5 percent of the time according to recent observations.

Management History

In the early 1900s, cougars were killed as part of predator control in the park. By 1925, the remaining population was estimated to be 12 individuals. Reports of cougars in Yellowstone have increased steadily from 1 each year between 1930 and 1939 to about 16 each year between 1980 and 1988. However, increases in visitor travel in Yellowstone and improvements in record keeping during this period probably contributed to this trend.

In 1987, the first study of cougar ecology began in Yellowstone National Park. The research documented population dynamics of cougars in the northern Yellowstone ecosystem inside and outside the park boundary, determined home ranges and habitat requirements, and assessed the role of cougars as a predator in the ecosystem.

In 1998, the second phase of cougar research began. Researchers collared 21 cougars in areas used by three wolf packs in northern Yellowstone. Between 1998 and 2000, researchers documented 96 known or probable cougar kills. Their prey included 66 elk, 17 mule deer, 1 bighorn, 4 coyotes, 4 porcupines, 3 marmots, and 1 red squirrel. One cougar was responsible for killing and eating 4 coyotes. Most of the elk killed were calves; 23 percent were cows, 12 percent were bulls. They averaged one elk or deer every 7.4 days and spent almost 4 days at each kill.

Very few cougar/human confrontations have occurred in Yellowstone. However, observations of cougars, particularly those close to areas of human use or residence, should be reported.

6A

Coyote

wolf coyote

Coyotes *(Canis latrans)* are intelligent and adaptable. Like wolves, coyotes have been killed because they sometimes preyed on livestock and, in the park's early days, they were perceived as threats to ungulate populations. Unlike wolves, however, coyotes were successful in resisting efforts to exterminate them. Up until the 1940s, wildlife managers in Yellowstone also considered the coyote a threat to survival of elk and other ungulates. Since then, research has shown the chief foods of the coyote are voles, mice, rabbits, other small animals, and carrion. Coyotes do hunt for elk calves in the spring, but only when the calves are young.

The coyote is a small, slender animal resembling a shepherd dog in general appearance. Its coat colors range from tan to buff, sometimes gray, and with some orange on its tail and ears. Males are slightly larger than females. Yellowstone's coyotes are among the largest coyotes in the United States, and visitors frequently mistake them for wolves. Coyotes, however, are much smaller with a slighter build.

Wolf extirpation in the early part of the 20th century probably resulted in high coyote population densities, and coyotes, at least partially, slid into the niche left vacant by the removal of wolves. Coyotes are more social in Yellowstone National Park than elsewhere. Most of the coyotes on the Northern Range live and hunt in packs of 6–7 animals, with an alpha male and female, and subordinate individuals (usually pups from previous litters). They defend their territories by vocalization and scent-marking with their urine and feces. They also use scent-marking to communicate with each other about their location and breeding status.

Until recently, coyotes faced few predators in Yellowstone other than cougars, who will kill coyotes feeding on cougar kills. Since wolves were restored, however, dozens of coyote pups and adults have been killed by wolves. On the Northern Range, wolves have caused a 25–50 percent reduction in the resident coyote population through direct mortality and changes in coyote denning behaviors and success.

As of March 2002 . . .

Number in Yellowstone
Total unknown, but numerous. In the Northern Range, scientists know the coyote population has decreased 30–50% since wolves were reintroduced to Yellowstone due to direct mortality and changes in coyote denning behaviors and success.

Where to see
Meadows, fields, other grassland areas.

Behavior & Size
- Weigh 25–35 pounds, 16–20 inches high at the shoulder.
- Average life span 6 years; up to 13 years in Yellowstone National Park.
- Home range:6–42 square miles.
- Primarily eat mice, voles, ground squirrels, pocket gophers, birds, carrion, elk calves, some adult elk.
- 5–7 pups are born in May in dens.

Management
- Like other predators, coyotes were often destroyed in the early part of the 20th century because they sometimes preyed on livestock.
- Coyotes continued to thrive because their adaptability enabled them to compensate for the destruction efforts.
- Elimination of wolves probably resulted in high coyote population densities; wolves' absence opened a niche that coyotes could occupy in Yellowstone.
- NPS staff monitors coyotes and uses cracker-shell rounds, pepper spray, or other negative stimuli to discourage coyotes that have lost their wariness of humans.

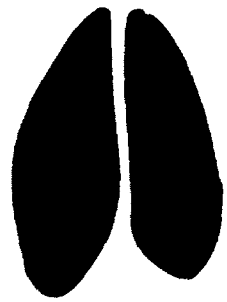
Coyotes also face threats from humans. They quickly learn habits like roadside feeding. This may lead to aggressive behavior toward humans and can increase the risk of the coyote being poached or hit by a vehicle. Several instances of coyote aggression toward humans have occurred here, including one that involved an actual attack.

Beginning in 1988, park staff increased monitoring of coyotes along park roadsides and began to experiment with scaring unwary coyotes from visitor-use areas with cracker-shell rounds, bear repellent spray, or other negative stimuli. Those animals that continue to pose a threat to themselves or to humans are moved to other areas of the park or killed. Signs, interpretive brochures, and park staff continue to remind visitors that coyotes and other park wildlife are wild and potentially dangerous and should never be fed or approached.

6A

Deer, Mule & White-tailed

Mule deer are common in Yellowstone, living throughout the park in almost all habitats; white-tailed deer are uncommon, restricted to streamside areas of the Northern Range.



Mule deer and white-tailed deer can be told apart by their size, coloration, antler shape, tail, behavior, and where they live.

All species of deer use their hearing, smell, and sight to detect predators such as coyotes or cougars. They probably smell or hear the approaching predator first; then may raise their heads high and stare hard, rotating ears forward to hear better. If a deer hears or sees movement, it flees.

Mule deer *(Odocoileus hemionus)*

Number in Yellowstone

Varies with seasonal migration: in winter, may be less than 100; in spring and summer, as many as 2,500.

Where to see

- Summer: throughout the park.
- Winter: Northern Range and sometimes in the Upper Geyser Basin.

Behavior and Size

- Male (buck): 150–250 pounds; female (doe): 100–175 pounds; 3½ feet at the shoulder.
- Summer coat: reddish; winter coat: gray-brown; white rump patch with black-tipped tail; brown patch on forehead; large ears.
- Males grow antlers from April or May until August or September; shed them in late winter and spring.
- Mating season (rut) in November and December; fawns born in late June to early August.
- Lives in brushy areas, coniferous forests, grasslands.
- Bounding gait, when four feet leave the ground, enables it to move more quickly through shrubs and rock fields.
- Eats shrubs, forbs, grasses; conifers in spring.
- Predators include wolf, coyote, cougar, bear.

White-tailed Deer *(O. virginianus)*

Number in Yellowstone

Scarce

Where to see

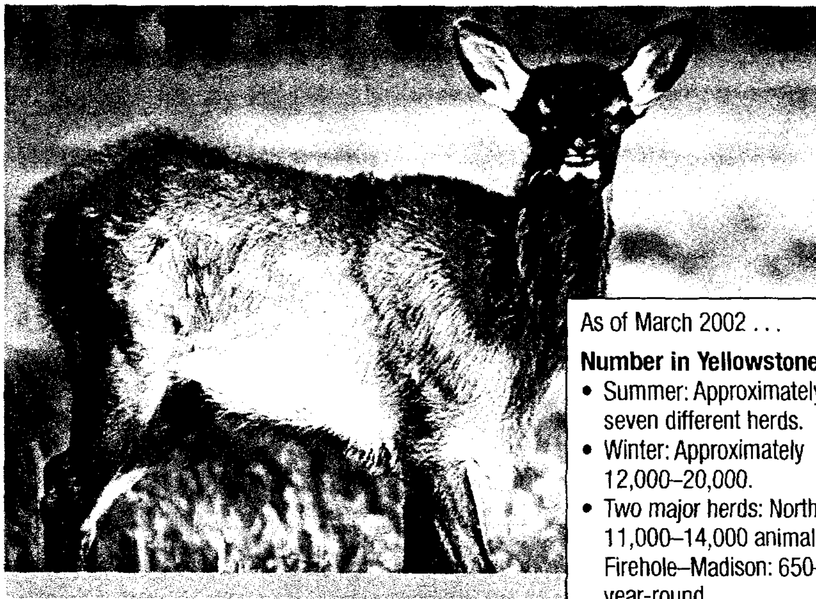
Along streams and rivers in northern part of the park.

Behavior and Size

- Adults up to 300 pounds; 3½ feet at the shoulder.
- Summer coat: red-brown; winter coat: gray-brown; throat and inside ears with whitish patches; belly, inner thighs, and underside of tail white.
- Waves tail like a white flag when fleeing.
- Males grow antlers from May until August; shed them in early to late spring.
- Mating season (rut) peaks in November; fawns born usually in late May or June.
- Eats shrubs, forbs, grasses; conifers in spring.
- Predators include wolf, coyote, cougar, bear.

6A

Elk



As of March 2002 . . .

Number in Yellowstone

- Summer: Approximately 30,000 elk in seven different herds.
- Winter: Approximately 12,000–20,000.
- Two major herds: Northern Range: 11,000–14,000 animals in winter; Firehole–Madison: 650–850 animals, year-round.

Where to see

Summer: Gibbon Meadows, Elk Park, and Lamar Valley.

Autumn, during "rut" or mating season: Mammoth Hot Springs, Norris, Madison River.

Winter: migrate south to the Jackson Hole Elk Refuge in Jackson, Wyoming, or north to the Northern Range and around Gardiner, Montana; 600–800 along the Firehole and Madison Rivers; a few in hydrothermal areas.

Behavior and Size

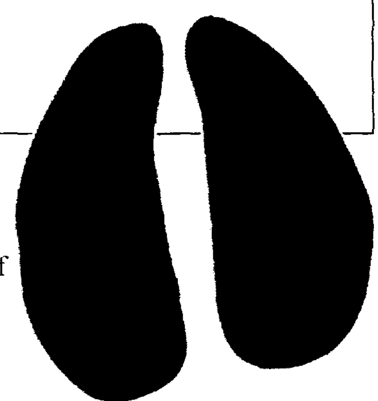
- Male (bull) weighs about 700 pounds and is about 5 feet high at the shoulder; female (cow) weighs about 500 pounds and is slightly shorter; calf is about 30 pounds at birth.
- Only bulls have antlers, which they begin growing in the spring and drop in March or April.
- Feed on grasses, sedges, other herbs and shrubs, bark of aspen trees, conifer needles, burned bark, aquatic plants.
- Mating season (rut) in September and October; calves born in May to late June.
- *See article on the Northern Range, Chapter 8, page 149.*

Elk *(Cervus elaphus)* are the most abundant large mammal found in Yellowstone. European American settlers used the word "elk" to describe the animal, which is the word used in Europe for moose (causing great confusion for European visitors). The Shawnee word "wapiti," which means "white deer" or "white-rumped deer," is another name for elk. The North American elk is considered the same species as the red deer of Europe.

Bull elk are probably the most photographed animals in Yellowstone, due to their huge antlers. Bull elk begin growing their first set of antlers when they are about one year old. Antler growth is triggered in spring by a combination of two factors: a depression of testosterone levels and lengthening daylight. The first result of this change is the casting or shedding of the previous year's "rack." Most bulls drop their antlers from late March to early April. New growth begins by mid to late May.

Growing antlers are covered with a thick, fuzzy coating of skin (the blood vessels of which are depositing the bone that makes up the antler) commonly referred to as "velvet." Usually around early August, further hormonal changes signal the end of antler growth, and the animal begins scraping the velvet off, polishing and sharpening the antlers in the process.

The antler growing period is shortest for yearlings (about 90 days) and longest for healthy, mature individuals (about 140 days). Roughly 70 percent of the antler growth takes place in the last half of the period, when the antlers of a mature elk will grow ⅔ of an inch each day. The antlers of a typical healthy bull are 55–60 inches long, just under six feet wide, and weigh about 30 pounds per pair.



Bulls retain their antlers through the winter. When antlered, bulls usually settle disputes by wrestling with their antlers. When antlerless, they use their front hooves (as cows do), which is more likely to result in injury to one of the combatants. Because elk spend the winter in herds with other bulls or with gender-mixed herds, retention of antlers means fewer injuries sustained overall. Also, bulls with large antlers that are retained longer are at the top of elk social structure, allowing them preferential access to feeding sites.

6A

Elk Antler Details

- *Antlers usually symmetrical, but asymmetry and malformations occur.*
- *The average, healthy, mature bull has six tines on each antler, and is known as a "six point" or "six by six."*
- *Can occur on female elk.*
- *One-year-old bulls grow simple spikes 10–20 inches, sometimes forked.*
- *Two-year-old bulls usually have four to five points on slender antlers.*
- *Three-year-old bulls have the same number of points, but thicker antlers.*
- *Four-year-old and older bulls typically have six points; antlers are thicker and longer each year.*
- *Eleven- or twelve-year old bulls often grow the heaviest antlers; after that age, the size of antlers generally diminishes.*

Mating Season

The mating season (rut) generally occurs from early September to mid October. Elk gather in mixed herds—lots of females and calves, with a few bulls nearby. The bulls bugle to announce their fitness and availability to females and to warn and challenge other bulls. When answered, bulls move toward one another and sometimes engage in battle for access to the cows. The battle involves a crashing together of antlers accompanied by intense pushing and wrestling for dominance. While loud and extremely strenuous, fights rarely cause serious injury. The weaker bull ultimately gives up and wanders off.

Calves are born in May and June. They are brown with white spots and have little scent, providing them with good camouflage from predators. They can walk within an hour of birth, but they spend much of their first week to ten days bedded down between nursings. Soon thereafter they begin grazing with their mothers, and join a herd of other cows and calves. Up to one half of each year's calves may be killed by predators. Elk calves are food for black and grizzly bears, wolves, coyotes, cougars, and golden eagles. Elk that reach maturity can live 12 to 15 years; rare individuals may live to 25 years.

Habitat

Climate is the most important factor affecting the size and distribution of elk herds here. While nearly the entire park provides summer habitat for approximately 30,000 elk, winter snowfalls force elk and other ungulates to leave most of the high elevation grasslands of the park. The number of elk that winter in the park averages between 12,000 to 20,000.

The Northern Range, with more moderate temperatures and less snowfall than the park interior, can support large numbers of wintering elk. The northern Yellowstone herd is one of the two largest herds of elk in the United States. The herd winters in the area of the Lamar and Yellowstone river valleys from Soda Butte to Gardiner, Montana. It also migrates outside of the park into the Gallatin National Forest and onto private lands.

Only one herd lives both winter and summer in the interior of the park. The Madison–Firehole elk herd, 650–850 animals that live in these river valleys, has been the focus of a research study since November 1991. The population appears to be naturally regulated because of severe winter conditions to a degree not found in other, human-hunted elk herds. Researchers are examining the effects of environmental variability on ungulate reproduction and survival. This herd has both high survival of animals older than calves and high reproduction rates. Information gained in this study will be useful in comparing unhunted and hunted elk populations.

Researchers have also examined elk use of areas burned in the wildfires of 1988. They found that elk ate the bark of burned trees. Fires had altered the chemical composition of lodgepole pine bark, making it more digestible and of higher protein content than live bark. While the burned bark was not the highest quality forage for elk, it is comparable to other low-quality browse species. The researchers speculate that elk selected burned bark because it was readily available above the snow cover in winter.

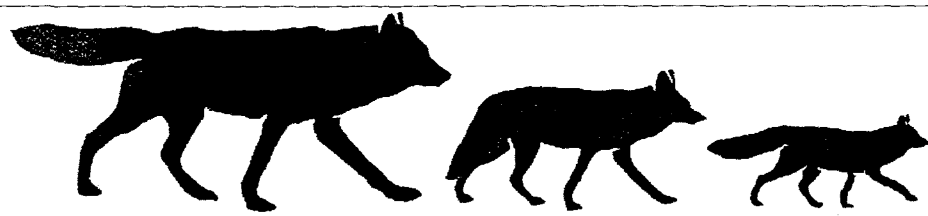
See also Chapter 8, "Northern Range Issue."

Horns vs. Antlers

Antlers, found on members of the deer family, grow as an extension of the animal's skull. They are true bone, are a single structure, and, generally, are found only on males. Horns, found on pronghorn, bighorn sheep, and bison, are a two-part structure. An interior portion of bone (an extension of the skull) is covered by an exterior sheath grown by specialized hair follicles (similar to human fingernails). Antlers are shed and regrown yearly while horns are never shed and continue to grow throughout an animal's life. However, one exception is the pronghorn, which sheds and regrows its horn sheath each year.

6A

Fox



As of March 2002 . . .

Number in Yellowstone
Unknown

Where to see
- Lamar Valley, Canyon Village
- Typical habitat: edges of sagebrush/grassland and forests

Behavior and Size
- Adult: 9–12 pounds; average 43 inches long
- Several color phases; usually red fur with white-tipped tail, dark legs; slender, long snout
- Rarely howls or sings
- Distinguish from coyote by size and color
- Solitary or in mated pairs
- Prey: voles, mice, rabbits, other small animals
- Other food: carrion and some plants
- Predators include coyotes

The red fox *(Vulpes vulpes)* has been documented in Yellowstone since the 1880s. In relation to other canids in the park, red foxes are the smallest. Adult foxes weigh 9-12 pounds; coyotes average 28 pounds in Yellowstone; and adult wolves weigh closer to 100 pounds. Red foxes occur in several color phases, but they are usually distinguished from coyotes by their reddish yellow pelage that is somewhat darker on the back and shoulders, with black "socks" on their lower legs. "Cross" phases of the red fox (a dark cross on their shoulders) have been reported a few times in recent years near Canyon and Lamar Valley. Also, a lighter-colored red fox has been seen at higher elevations.

Foxes feed on a wide variety of animal and plant materials. Small mammals such as mice and voles, rabbits, and insects comprise the bulk of their diet. Carrion seems to be an important winter food source in some areas. The many miles of forest edge and extensive semi-open and canyon areas of the park seem to offer suitable habitat and food for foxes. They are widespread throughout the northern part of the park with somewhat patchy distribution in the remainder of the park. Foxes are much more abundant than were previously thought in Yellowstone, yet they are not often seen. They are nocturnal, usually solitary, and travel along edges of meadows and forests.

Although occasionally active in daylight hours, foxes are mainly nocturnal. This behavior changes when a fox becomes habituated to humans usually due to being fed. One fox in the summer of 1997 was trapped and relocated three times from the Tower Fall parking area because visitors fed it human food. The fox was relocated between 10 and 60 miles away from Tower but twice the fox returned to the area. Finally the fox came to Mammoth where it was fed again and as a result was destroyed. While this story gives us interesting information about the homing instinct of fox, it also points out the importance of obeying rules to avoid inadvertently causing the death of one of Yellowstone's animals.

A little known fact about red foxes is that most of them in the Lower 48 states, especially in the eastern and plains states, were introduced from Europe in the 18th and 19th centuries for fox hunts and fur farms. The foxes that survived the hunt or escaped the fur farms proliferated and headed westward. In addition to this subspecies of red fox, there exists three subspecies at high elevations in the Sierra *(V. v. necatar)*, Cascade *(V. v. cascadensis)*, and Rocky *(V. v. macroura)* Mountains and are collectively called mountain foxes. Little is known about any of these subspecies.

A research project conducted between 1994–1998 determined at least two

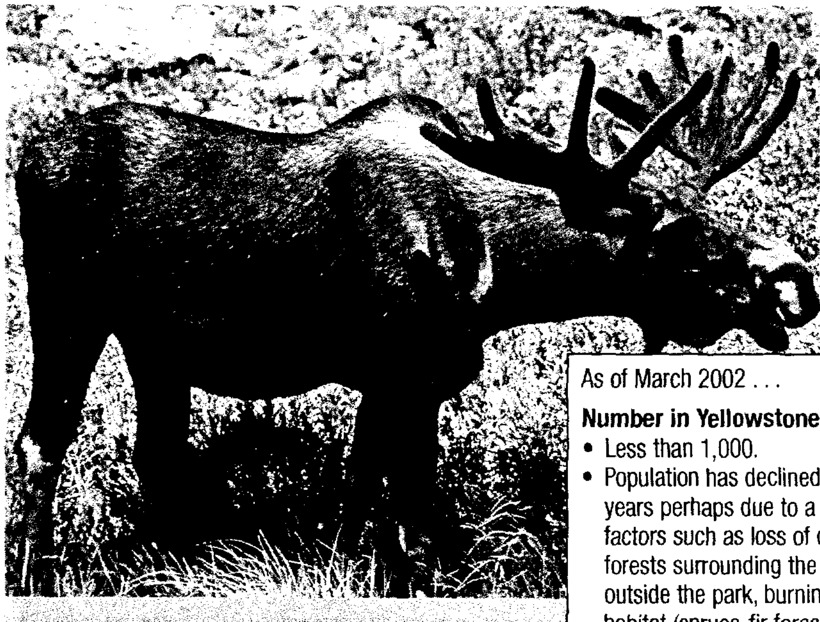
subpopulations of foxes living in the Yellowstone ecosystem. At about 7,000 feet in elevation, there seemed to be a dividing line with no geographical barriers separating these foxes. The genetic difference between these foxes was similar to mainland and island populations of foxes in Australia and their habitat use was different as well. In addition, their actual dimensions such as ear length and hind foot length were adapted to some degree for colder environments with deep snow and long winters.

Ever since red fox sightings were first recorded in Yellowstone National Park, a novel coat color has been seen at high elevations. This yellowish or cream color most often occurs above 7,000 feet in areas such as Cooke City and the Beartooth Plateau.

Across the past century, especially within the past few decades, the number of fox sightings has increased greatly. This could be due to better documentation of sightings through the rare animal sighting reports that began in 1986. In addition, an increase in visitors means more chances to see foxes. There may also be a gradual increase in the number of foxes now that the wolf has returned to Yellowstone. Because wolves and coyotes are more closely related both genetically and physically than wolves and foxes, wolves compete with coyotes, thus the coyote population has decreased in core areas of wolves. It appears this has caused an increase in the number of fox sightings in these core wolf areas.

6A

Moose



As of March 2002 . . .

Number in Yellowstone
- Less than 1,000.
- Population has declined in last 40 years perhaps due to a number of factors such as loss of old growth forests surrounding the park, hunting outside the park, burning of winter habitat (spruce-fir forests) in 1988.

Where to see
- Marshy areas of meadows, lake shores, and along rivers.

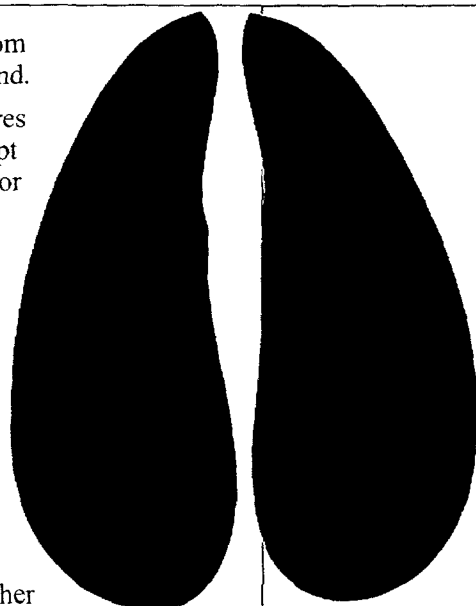
Behavior & Size
- Largest member of deer family.
- Adult male (bull) weighs close to 1,000 pounds; female (cow) weighs up to 900 pounds; 5½ to 7½ feet at the shoulder.
- Browses on willows and aquatic plants in summer; willows where available in winter or on conifers above 8,500 feet.
- Usually alone or in small family groups
- Mating season peaks in late September and early October; one or two calves born in late May and June.
- Lives up to 18–20 years.

Moose *(Alces alces shirasi)* are the largest members of the deer family in Yellowstone. A male (bull) moose can weigh more than 900 pounds and stand more than 7 feet at the shoulder. Both sexes have long legs that enable them to wade into rivers and through deep snow, to swim, and to run fast. Despite its size, a moose can slip through the woods without a sound. Moose, especially cows with calves, are unpredictable and have chased people in the park.

Both sexes are chocolate brown, often with tan legs and muzzle. Bulls can be distinguished from cows by their antlers. Adults of both sexes have "bells"—a pendulous dewlap of skin and hair that dangles from the throat and has no known function.

In summer, moose eat aquatic plants like water lilies, duckweed, and burweed. But the principle staples of the moose diet are the leaves and twigs of the willow, followed by other woody browse species such as gooseberry and buffaloberry. An adult moose consumes approximately 10–12 pounds of food per day in the winter and approximately 22–26 pounds of food per day in the summer.

Some moose that summer in the park migrate to lower elevations west and south of Yellowstone in winter where willow remains exposed above the snow. But many moose move to higher elevations (as high as 8,500 feet) to winter in mature stands of subalpine fir and Douglas-fir. Moose can also move easily in these thick fir stands because the branches prevent snow from accumulating on the ground.



Moose are solitary creatures for most of the year, except during the mating season or rut. During the rut, both bulls and cows are vocal: the cows may be heard grunting in search of a mate, and bulls challenge one another with low croaks before clashing with their antlers. A bull on the offensive tries to knock its opponent sideways. If such a move is successful, the challenger follows through with another thrust of its antlers. The weaker animal usually gives up before any serious damage is done; occasionally the opponent's antlers inflict a mortal wound.

Bulls usually shed their antlers in late November or December, although young bulls may retain their antlers as late as March. Shedding their heavy antlers helps them conserve energy and promote easier

6A

Moose

winter survival. In April or May, bulls begin to grow new antlers. Small bumps on each side of the forehead start to swell, then enlarge until they are knobs covered with a black fuzz (called velvet) and fed by blood which flows through a network of veins. Finally the knobs change into antlers and grow until August. The antlers are flat and palmate (shaped like a hand). Yearlings grow six to eight inch spikes; prime adult bulls usually grow the largest antlers—as wide as 5 feet from tip to tip. Then the bull rubs and polishes his antlers on small trees in preparation for the rut.

Cows are pregnant through the winter; gestation is approximately eight months. When ready to give birth, the cow will drive off any previous year's offspring that may have wintered with her and seek out a thicket. She gives birth to one or more calves, each weighing 25–35 pounds.

A calf walks a few hours after birth and stays close to its mother. Even so, a moose calf often becomes prey for bears or wolves and less frequently of cougars, or coyotes. An adult moose can usually outrun these predators or trample them to death.

History

Moose were reportedly very rare in northwest Wyoming when the park was established in 1872. Subsequent protection from hunting and wolf control programs may have contributed to increased numbers, but suppression of forest fires probably was the most important factor in their population increase. Moose depend on mature fir forests for winter survival. By the 1970s, an estimated 1,000 moose inhabited the park.

The moose population declined following the fires of 1988. Many old moose died during the winter of 1988–89, probably as a combined result of the loss of good moose forage and a harsh winter. Unlike moose habitat elsewhere, northern Yellowstone does not have woody browse species that will come in quickly after a fire and extend above the snowpack to provide winter food. Therefore, the overall short-term effect of the fires was probably detrimental to moose populations. Their current population and distribution are unknown.

Today, moose are most likely seen in the park's southwestern corner and in the Soda Butte Creek, Pelican Creek, Lewis River, and Gallatin River drainages.

6A

Pronghorn

The North American pronghorn *(Antilocapra americana)* is not a true antelope, which are found in Africa and southeast Asia. The pronghorn is the surviving member of a group of animals that evolved in North America during the past 20 million years. Use of the term "antelope" seems to have originated when the first written description of the animal was made during the 1803–1805 Lewis and Clark Expedition.

The pronghorn has true horns, similar to bison and bighorn sheep. The horns are made of modified, fused hair that grows over permanent bony cores, but they differ from those of other horned animals in two major ways: the sheaths are shed and grown every year and they are pronged. (A number of other horned mammals occasionally shed their horns, but not annually.) Adult males (bucks) typically have 10–16 inch horns that are curved at the tips. About 70 percent of the females (does) also have horns, but they average 1–2 inches long and are not pronged. The males usually shed the horny sheaths in November or December and begin growing the next year's set in February or March. The horns reach maximum development in August or September. Females shed and regrow their horns at various times.

Pronghorns are easy to distinguish from the park's other ungulates. Their deer-like bodies are reddish-tan on the back and white underneath, with a large white rump patch. Their eyes are very large, which provides a large field of vision. Males also have a black cheek patch.

Females that bred the previous fall commonly deliver a set of twins in May or June. The newborn fawns are a uniform grayish-brown and weigh 6–9 pounds. They can walk within 30 minutes of birth and are capable of outrunning a human in a couple of days. The young normally stay hidden in the vegetation while the mother grazes close by. After the fawns turn three weeks old they begin to

As of March 2002 . . .

Number in Yellowstone
200–250

Where to see
- Summer: Lamar Valley; some may be near the North Entrance near Gardiner, Montana.
- Spring, Fall, Winter: between the North Entrance and Reese Creek.

Behavior and Size
- Male (buck) weighs 100–125. pounds; female (doe) weighs 90–110 pounds; adult length is 45–55 inches and height is 35–40 inches at the shoulder.
- Young (fawns) born in late May–June.
- Live in grasslands.
- Eat sagebrush and other shrubs, forbs, some grasses.
- Both sexes have horns; males are pronged.

History
- Prior to European American settlement of the West, pronghorn population estimated to be 35 million.
- Early in the 19th century, pronghorn abundant in river valleys radiating from Yellowstone; settlement and hunting reduced their range and numbers.
- Park management also culled pronghorn during the first half of the 20th century due to overgrazing concerns.

Research Concerns
- Since 1991, the population has dropped approximately 50%; research is underway to determine why; possible causes include predation, in-breeding depression, and loss of winter range.
- This small population, which contains more genetic diversity than any other North American herd studied, could face extinction if the herd drops below 200.

follow the females as they forage. Several females and their youngsters join together in nursery herds along with yearling females.

Pronghorns form groups most likely for increased protection against predators. When one individual detects danger, it flares its white rump patch, signaling the others to flee. The pronghorn is well adapted for outrunning its enemies—its oversized windpipe and heart allow large amounts of oxygen and blood to be carried to and from its unusually large lungs. Pronghorn can sustain sprints of 45–50 mph. Such speed, together with keen vision, make the adults difficult prey for any natural predator. Fawns, however, can be caught by coyotes, bobcats, and golden eagles. If adults are weakened by severe winter weather, they too will fall prey to predators.

The pronghorn breeding season begins mid September and extends through early October. During the rut the older males defend territories that have the best food supplies. They warn any intruding males with loud snorts and wheezing coughs. If this behavior does not scare off the opponent, a fight may erupt. The contenders slowly approach one another until their horns meet, then they twist and shove each other. Eventually, the weaker individual will retreat. Although the fights may be bloody, fatalities are rare.

The most important year-round foods are shrubs like sagebrush and rabbitbrush; they eat succulent forbs during spring and summer. They can eat plants like locoweed, lupine, and poisonvetch that are toxic to some ungulates. Their large liver (proportionately, almost twice the size of a domestic sheep's liver) may be able to remove plant toxins from the blood stream. Grasses appear to be the least-used food item, but may be eaten during early spring when the young and tender shoots are especially nutritious.

During winter, pronghorns form mixed-sex and -age herds. In spring, they split into smaller bands of females, bachelor groups of males between 1–5 years old, and solitary older males. The small nursery and bachelor herds may forage within home ranges of 1,000 to 3,000 acres while solitary males roam smaller territories (60 to 1,000 acres in size). Pronghorns, including most in Yellowstone, migrate between different winter and summer ranges to more fully utilize forage within broad geographic areas.

History

During the early part of the 19th century, pronghorns ranked second only to bison in numbers, with an estimated 35 million throughout the West. The herds were soon decimated by conversion of rangeland to cropland, professional hunters who sold the meat, and ranchers who believed that pronghorns were competing with livestock for forage. Today, due to transplant programs and careful management, pronghorns again roam the sagebrush prairies in herds totaling nearly one-half million animals.

Pronghorn in Yellowstone have not fared as well. The park's pronghorn population has been declining since the 1960s. Research in 1991 found that the average fawn life span in 1991 was about 35 days and nearly all collared pronghorn fawn were apparently killed by coyotes. This mortality rate closely followed the decline in total fawn numbers measured during weekly surveys of the entire park. Pronghorn population numbers have continued to decline, and in late 1998 another cooperative study was initiated to determine fawn productivity and mortality rates.

In the winter of 1995–96, the park began weekly winter surveys of pronghorn between Mammoth and Cinnabar Mountain (north of Gardiner, Montana) to help track the trend in the pronghorn herd and its relationship, if any, to the bison capture facility at Stephens Creek. During 1996–97, significant bison management operations occurred, and increased human activity and the presence of wing fences designed to channel bison may have kept pronghorn from their winter range beyond Stephens Creek. The wing fences had been designed with gaps at the bottom to allow pronghorn to pass (they often prefer to go under a fence rather than over one), plus gates were kept open to allow pronghorn to pass. However, the wing fences also seem to have made pronghorn easier prey for coyotes. The wing fences were removed in 2000.

Research continues to search for answers to the population decline. This small, genetically unique population has a great chance of extinction if it drops below 200 animals.

As of March 2002 . . .

Number in Yellowstone area

- Almost 216 wolves live in 24 packs in the greater Yellowstone area.
- 10 of those packs with 132 individuals live in the park.

Where to see

They inhabit most of the park now, look at dawn and dusk.

Behavior & Size

- 26–36 inches high at the shoulder, 4–6 feet long from nose to tail tip; males weigh 70–130 pounds, females weigh 80–110 pounds.
- Home range: 18–540 square miles; varies with pack size, food, season.
- Live 10–12 years in wild.
- Three color phases: gray, black, and white; gray is the most common; white is only in the high arctic; and black is common only in the Rockies.
- Prey primarily on hoofed animals. In Yellowstone, 90% of their diet is elk; also eat a variety of smaller mammals like beavers.
- Mate in February; give birth to average of five pups in April after a gestation period of 63 days.; young emerge at 10–14 days; pack remains at the den for 3–10 weeks unless disturbed.
- Human-caused death is the highest mortality factor for wolves; the leading natural cause is wolves killing other wolves.

Current Management

See Chapter 8, "Wolf Restoration."

Wolves ranged widely throughout North America in pre-Columbian times. Worldwide, all wolves, except the red wolf *(Canis rufus)* of the southeastern United States, are the same species *(Canis lupus)*. Formerly, scientists recognized as many as 24 subspecies of wolves as native to the continent; current thought suggests that 5 is probably a more correct number.

Wolves are highly social animals and live in packs. In Yellowstone, the average pack numbers ten animals; some are more than twice that size. (In areas of abundant wolves, about 25 percent of the packs will have more than 8 members.) The pack is a highly evolved and complex social family, with leaders (the alpha male and alpha female) and subordinates, each having individual personality traits. Packs generally command territory that is marked by urine scenting and defended against intrusion by other wolves (individuals or packs).

Wolves consume a wide variety of prey, large and small. However, the evolution of packs and their structure allows efficient hunting of large prey while still competing with coyotes (and, to a lesser extent, foxes) for smaller meals. In Yellowstone, 90 percent of their prey is elk: 40 percent calves, 30–35 percent cows, 10–22 percent bulls. (Wolves kill older cows; the average age is 14. Hunters kill cows that average six years of age.) In winter, a wolf pack will kill an average of 9–14 elk per month. Wolves in the Pelican Valley also occasionally kill adult bison.

On the other hand, wolves have provided a bounty of food for a variety of animals in Yellowstone. When wolves kill an elk, ravens arrive almost immediately. Coyotes arrive soon after, waiting nearby until the wolves are sated. Bears are not so patient and will attempt to chase the wolves away, and are usually successful. Many other animals—from magpies to foxes—dine on the remains.

From their confined beginnings in a few pens, the wolves have expanded their population and range, and now are found throughout the Greater Yellowstone Ecosystem.

History

In the 1800s, westward expansion brought settlers and their livestock into direct contact with native predator and prey species. Much of the wolves' prey base was destroyed as agriculture flourished. With the prey base removed, wolves began to prey on domestic stock, which resulted in humans removing wolves from most of their historic range. (Other predators such as bears, cougars, and coyotes were also killed to protect livestock and "more desirable" wildlife species, such as deer and elk.) By the early 1900s, wolves had been almost entirely eliminated from the 48 states.

Wolves will kill each other and other carnivores, such as coyotes and cougars, usually because of territory disputes or competition for carcasses. In 2000, however, the subordinate female wolves of the Druid pack exhibited behavior never seen before: they killed their pack's alpha female; they then carried her pups to a central den and raised them with their own litters.

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Wolf

As wolf numbers increase, they will encounter more humans. Wolves are not normally a danger to humans, unless humans habituate them by providing them with food. Like coyotes, wolves can quickly learn to associate campgrounds, picnic areas, and roads with easy food. This may lead to aggressive behavior toward humans and can increase the risk of the wolf being poached or hit by a vehicle.

Maps of wolf pack territories can be found in the "Yellowstone Tracker" insert of the park newspaper, and on the park's web site: www.nps.gov/yell

Today, it is difficult for many people to understand why early park managers would have participated in the extermination of wolves. After all, the Yellowstone National Park Act of 1872 stated that the Secretary of the Interior "shall provide against the wanton destruction of the fish and game found within said Park." But this was an era before people, including many biologists, understood the concepts of ecosystem and the interconnectedness of species. At the time, the wolves' habit of killing prey species was considered "wanton destruction" of the animals. People who poisoned every carcass they passed in the backcountry (loading strychnine into carcasses was the easiest way to kill wolves) did so believing they were supporting the Yellowstone National Park Act. Between 1914 and 1926, at least 136 wolves were killed in the park; by the 1940s, wolves were rarely reported.

In the 1960s, National Park Service policy regarding human management of Yellowstone's wildlife populations changed to a policy of allowing those populations to manage themselves. Many suggested at the time that for such regulation to succeed, the wolf had to be a part of the picture.

Also in the 1960s and 1970s, a national awareness of environmental issues and consequences led to the passage of many laws that were designed to correct the mistakes of the past and help prevent similar mistakes in the future. One such law was the Endangered Species Act, passed in 1973. The U.S. Fish and Wildlife Service is required by this law to restore endangered species that have been eliminated, if possible. (National Park Service policy also calls for restoration of native species where possible.)

See Chapter 8, "Wolf Restoration," for more details.

6A

Birds

From the common to the unusual, Yellowstone's birds draw your eye to places and scenes that might be missed without their motion and color of these feathered residents.

Records of bird sightings have been kept in Yellowstone since its establishment in 1872; these records document 312 species of birds, of which approximately 148 are known to nest. This is remarkable considering the harsh environmental conditions that characterize the area.

Many birds, such as American robins and common ravens, are found throughout the park. Other species live in particular habitats. For example, belted kingfishers are found near rivers and streams while Steller's jays are found in coniferous forests.

Spring is a good time to look for birds. Migration brings many birds back to the park from their winter journeys south; other birds are passing through to more northern nesting areas. Neotropical songbirds are singing to establish and defend their territories; and many ducks are in their colorful breeding plumages, which makes identification easier.

Watch for birds on early morning walks from mid May through early July. At all times, but especially during the nesting season, birds should be viewed from a distance. Getting too close can stress a bird (as it can any animal) and sometimes cause the bird to abandon its nest.

Most birds migrate to lower elevations and more southern latitudes beginning in September. At the same time, other birds pass through Yellowstone. Transients include tundra swans and ferruginous hawks. Some birds do stay in Yellowstone year-round, including the common raven, Canada goose, blue grouse, gray jay, red-breasted nuthatch, American dipper, and mountain chickadee. And a few species, such as rough-legged hawks and northern shrikes, migrate here for the winter.

Brief descriptions of some of Yellowstone's significant bird species follow on the next few pages.

As of March 2002 . . .

Number in Yellowstone

- 315 bird species have been documented in Yellowstone.
- Approximately 148 of these species nest in the park.

Other Info

- One endangered bird species occurs in Yellowstone: the whooping crane.
- One threatened bird species occurs in Yellowstone: the bald eagle.
- The peregrine falcon, formerly an endangered species, was delisted in August 1999. No longer considered threatened or endangered, the species is still closely monitored.
- Other species of concern include American white pelicans, trumpeter swans, ospreys, common loons, harlequin ducks, great gray owls, and colonial nesting birds.

Current Management

Yellowstone is an active participant in the Western Working Group of Partners in Flight, an international effort to protect migrant land birds in the Americas, because more than 100 bird species spend the winter in Mexico and Central America. There, they are threatened by loss of habitat, pesticide use, and increasing human development and pressure.

Visitors often ask, "What is the black and white bird with the long tail?" They have seen the black-billed magpie, a gregarious bird found throughout the West. In the right light, its dark feathers appear a shiny blue-black.

Bald Eagle

The bald eagle *(Haliaeetus leucocephalus)* is a large, dark bird with a completely white head and tail. Females are larger than males, which is true with most predatory birds. Immature bald eagles are often mistaken for golden eagles; their coloration changes several times before achieving adult colors when four or five years old. Habitat can determine which you are likely to see: bald eagles almost always are near water where they feed on fish and waterfowl; golden eagles hunt in open country for rodents and other small mammals. Both, however, may be found on carcasses in the winter, sometimes together.

Bald eagles reside in Yellowstone throughout the year, nesting in large trees close to water. In winter, fish stay deeper in water and are more difficult for eagles to catch. Waterfowl then comprise more than half an eagle's diet; carrion is used whenever available. During severe winter weather, some eagles may move to lower elevations such as Paradise Valley, north of the park, where food is more available. On these wintering areas, resident eagles may be joined by migrant bald eagles and golden eagles.

Eagles form long-term pair bonds. Some remain on their territories year-round, while others return to their nesting sites by late winter. Two to three eggs (usually two) are laid from February to mid April. Both eagles incubate the eggs, which hatch in 34 to 36 days. At birth, eaglets are immobile, downy, have their eyes open, and are completely dependent upon their parents for food. By 70 to 98 days after hatching, they are capable of flying from the nest. Radio-tagging studies have shown that young produced in a given summer leave the park in fall although most of the adults stay in the park. Some young Yellowstone eagles migrate to western Oregon and Washington their first fall.

The bald eagle is listed as threatened on the endangered species list, but recovery appears to be well underway. As of 1989, recovery objectives had been reached in the Greater Yellowstone Ecosystem as well as in the Pacific Northwest region. In 1995, the U.S. Fish and Wildlife Service downlisted the bald eagle from endangered to threatened in four of five regions, including the one containing Yellowstone, due to the significant population gains made.

In Yellowstone, 31 active eagle nests successfully produced 15 eaglets in 2001. Some eagle territories are experiencing nest instability due to the large number of trees that are falling as a result of the 1988 fires. Collectively however, bald eagles are doing very well in the park and throughout the Greater Yellowstone Ecosystem.

Peregrine Falcon

In 1962, Rachel L. Carson sounded an alarm concerning the irresponsible use of pesticides in our environment with her landmark book, *Silent Spring.* Among other dangers, she pointed out the adverse effects of chemicals on the reproductive capacity of some birds, especially predatory species such as the bald eagle and peregrine falcon *(Falco peregrinus).* Her book raised public awareness of this issue, and was one of the catalysts leading to the banning of the most damaging pesticides.

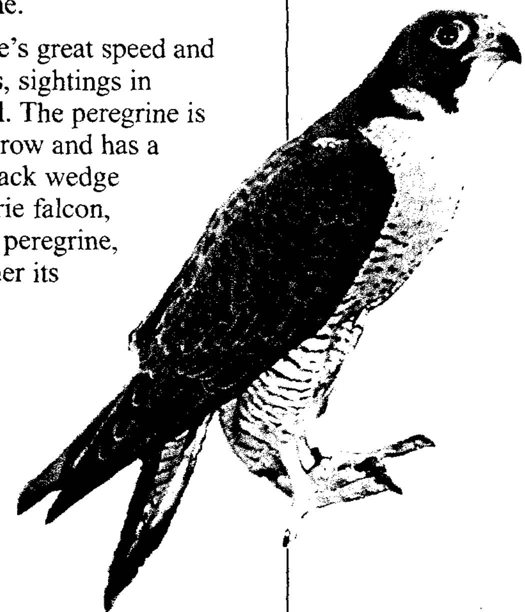
The peregrine falcon was among the birds most affected by the toxins. It was listed on the endangered species list and a reintroduction program was spearheaded by groups such as the non-profit Peregrine Fund of Boise, Idaho. Subsequently, the peregrine has made a comeback in much of its former range and was delisted in 1999.

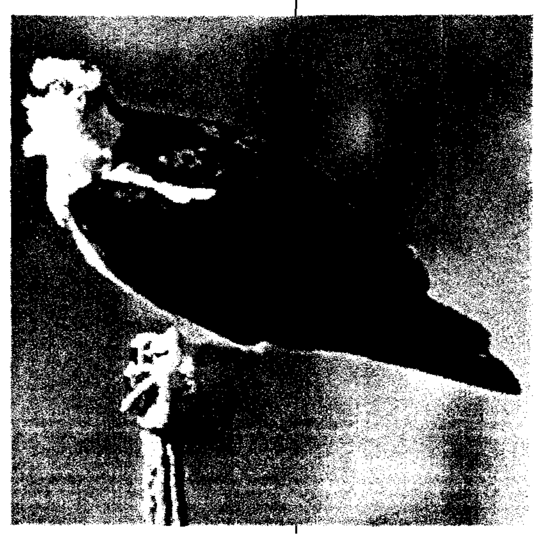
Young peregrine falcons were released in Yellowstone between 1983 and 1988. The reintroductions were discontinued after 1988 when it became evident that the population of peregrines was increasing on its own.

Peregrine falcons reside in Yellowstone from March through October, nesting on large cliffs that overlook rivers or valleys where prey is abundant. In 2001, 16 nesting pairs fledged 31 young.

Peregrines eat mostly songbirds and water-fowl—prey that are uncommon in winter in Yellowstone. Peregrines from the park winter as far south as Mexico; none of them spend the winter in Yellowstone.

Because of the peregrine's great speed and low population numbers, sightings in Yellowstone are unusual. The peregrine is slightly smaller than a crow and has a black "helmet" and a black wedge below the eye. The prairie falcon, often confused with the peregrine, has black "armpits" under its wings. Peregrines are expert hunters and have been clocked at speeds exceeding 200 mph when diving after prey.





The osprey, or "fish hawk," (above) is often seen at the Grand Canyon of the Yellowstone, where six to ten pairs nest. In flight, the osprey's white underparts, narrow wings with a bend and dark patch at the wrist are good identifiers.

While many people hope to see the elusive great gray owl (left), few do. These secretive birds are found in dense forests. Many sightings in Yellowstone have been in the Canyon area.

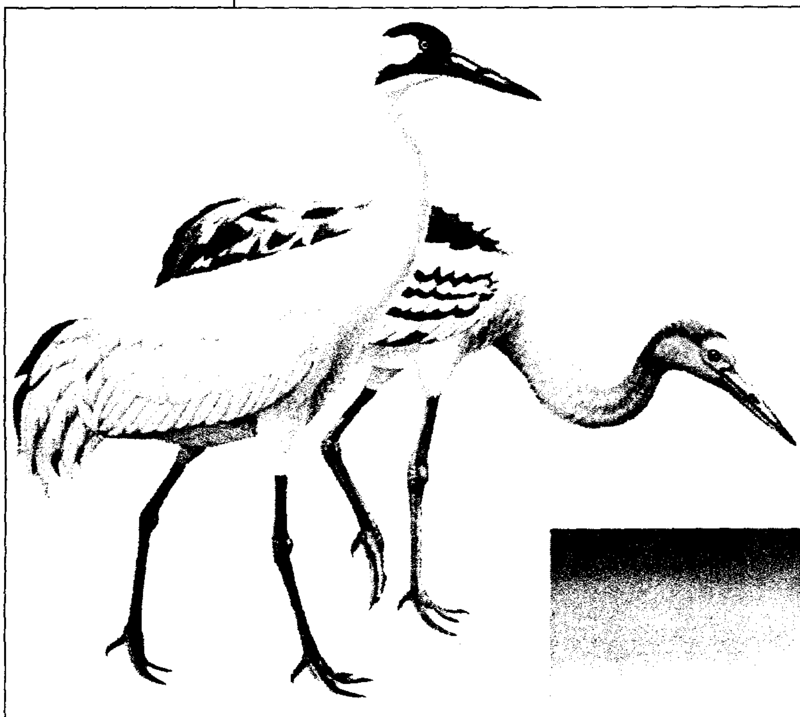
Whooping Crane

For a brief time in 1998, you might have been lucky enough to see the rarest crane in the world, the whooping crane *(Grus americana)*, here in Yellowstone. Two whoopers were living near Slough Creek, where they fed on aquatic animals and plants, and the occasional frog or snake. They were part of one of several experiments trying to establish new migratory flocks of whooping cranes in this region.

The two birds that were here in 1998 were part of a group of four whoopers that had been trained on a ranch in eastern Idaho to follow an ultralight aircraft. In 1997, they had followed the aircraft to wintering grounds at Bosque del Apache National Wildlife Refuge in New Mexico. Two of their group died along the way, but these two survived. During their journey north in the spring of 1998, they encountered problems with powerlines and fences. Scientists decided to recapture them and then released them in Yellowstone National Park. Both returned safely to their wintering grounds, but one died the following spring during the migration. Only one remains, but it has not returned to Yellowstone National Park.

A longer running project involved placing whooping crane eggs under incubating sandhill cranes on Gray's Lake National Wildlife Refuge in Idaho. The hope was that sandhill cranes would lead immature whoopers on migration to Bosque del Apache NWR. The project was never a complete success. The only survivor of this project resides in the Centennial Valley of the greater Yellowstone area.

Yellowstone's ornithologist is not optimistic about the long-term return of whooping cranes to Yellowstone National Park. He says, "The prognosis for the whooping crane in the greater Yellowstone area does not appear promising, and whooping cranes are expected to disappear from the area in the near future."



While the whooping crane (left) is rare in this region, its relative, the sandhill crane (below) nests in Yellowstone each summer. Sandhills' warbling calls announce their presence long before most people see them—their gray and brown feathers blend in well with their grassland habitat.

Trumpeter Swan

The trumpeter swan *(Cygnus buccinator)* is the largest wild fowl in North America. This native swan is white; its bill is black with a pink stripe at the base of the upper mandible. On average, an adult male weighs 25–30 pounds and a female 20–25 pounds. They are most often observed swimming in slow-moving rivers or placid lakes where they feed on submerged vegetation. While their average life span is not known, records exist of individuals living more than 25 years in the wild.

Once common in North America, trumpeter swans in the lower 48 states neared extirpation in the early 1900s due to human encroachment, habitat destruction, and the commercial swan-skin trade. A small population of swans survived in isolated areas such as Yellowstone. The Migratory Bird Act of 1918 protected these and other birds at risk. Red Rock Lakes National Wildlife Refuge, which is west of Yellowstone and is a very large mountain marsh ecosystem, was set aside in the 1930s specifically for the trumpeter. In the 1950s, a sizeable population of swans was discovered in Alaska. Today, some 20,000 trumpeters exist in North America.

In Yellowstone, the resident population of swans rarely exceeds 30 individuals, and winter numbers vary between 60 to several hundred. Swan reproduction rates are low, and populations have fluctuated dramatically in Yellowstone. Weather and winter predation by coyotes appear to be the primary factors influencing production here. Lack of recruitment from outside the park is also of concern. Even in greater Yellowstone, resident swans number perhaps 300 to 400 individuals. Swan numbers increase in winter when more than 2,000 swans reside in the region.

Non-native swans (mute swans), especially those in the Paradise Valley of Montana (north of the park), were a potential threat to the trumpeters in Yellowstone. However, through a cooperative effort with local landowners, this threat has been eliminated by replacing mute swans on private lands with captive-raised trumpeter swans.

Trumpeter swans are most often seen on the Madison River at Seven Mile Bridge on the West Entrance Road and occasionally at Swan Lake. Human disturbance of a nesting site is a common cause of failure to hatch cygnets, and signs at the Madison River site warn visitors to keep a respectful distance. To try to mitigate the effects of human interference, a floating nesting platform exists in the reeds at Seven Mile Bridge. Although this platform is used by swans, the status of the swan population in the park is precarious. In 2001, there were two nest attempts and no cygnets. An autumn 2001 survey tallied only 17 resident adult swans in Yellowstone National Park.

American white pelicans (left) spend the summer in the waters of Yellowstone Lake and the Yellowstone River. These large white birds are often mistaken for trumpeter swans (above) until their huge yellow beak and throat pouch is seen. In flight, the black tips of their wings are visible.

6C

Fish

Yellowstone contains one of the most significant, near-pristine aquatic ecosystems found in the United States. More than 220 lakes comprise approximately 107,000 surface acres in Yellowstone—94 percent of which can be attributed to Yellowstone, Lewis, Shoshone, and Heart lakes. Some 1,000 streams make up more than 2,650 miles of running water. This may appear to be prime fish habitat, but waterfalls and other physical barriers prevented fish from colonizing the smaller headwaters streams and isolated lakes. When Yellowstone became a national park, almost 40 percent of its waters were barren of fish—including Lewis Lake, Shoshone Lake, and the Firehole River above Firehole Falls. That soon changed.

Early park managers transplanted fish into new locations, produced more fish in hatcheries, and introduced *non-native* species. By the mid 20th century, more than 310 million fish had been stocked in Yellowstone. Today, about 40 lakes have fish; the remainder were either not planted or have reverted to their original fishless condition.

The ranges and densities of the park's 12 native fish species have been substantially altered during the past century due to exploitation and introduction of exotic species. Non-native species in the park include rainbow trout, brown trout, brook trout, lake trout, and lake chub.

Despite changes in species composition and distribution, large-scale habitat degradation has not occurred in the park. Water diversions, water pollution, and other such impacts on aquatic ecosystems have rarely occurred here. Consequently, fish and other aquatic inhabitants continue to provide important food for grizzly and black bears, bald eagles, river otters, mink, ospreys, pelicans, loons, grebes, mergansers, diving ducks, terns, gulls, kingfishers, and herons.

As of March 2002 . . .

Number in Yellowstone
- Natives: 12
  —3 sport fish: cutthroat trout (3 races), Arctic grayling, mountain whitefish
  —9 non-game fish: 5 minnows: longnose dace, speckled dace, redside shiner, Utah chub, redside shiner/speckled dace hybrid; 3 suckers: longnose sucker, mountain sucker, Utah sucker; mottled sculpin
- Non-native: 5 species & 1 hybrid—brook trout, brown trout, lake trout, rainbow trout, lake chub, cutthroat/rainbow trout hybrid

History
- When the park was established, many of its waters were fishless.
- Park waters were stocked with native and non-native fish for decades.
- Stocking changed the ecology of many Yellowstone waters as non-native fish displaced or interbred with native species.

Status
- By the 1960s, Yellowstone's fish populations were in poor condition and the angling experience had declined, prompting a major change in fisheries management.
- By the late 1980s,native trout had recovered in some areas under restrictions that allow catching wild fish in a natural setting but prohibit killing native sport fish.
- In 2001, fishing regulations changed to require the release of all native sport fishes caught in park waters.
- Four native fish at risk: fluvial form of Arctic grayling, westslope cutthroat trout, Yellowstone cutthroat trout, Snake River cutthroat trout.
- Threats to the fisheries:
  1) Lake trout illegally introduced into Yellowstone Lake and its tributaries *(see Chapter 8, page 139).*
  2) Whirling disease now present in Yellowstone Lake and the Firehole River*(see Chapter 8, page 141).*
  3) New Zealand mud snails *(see next page).*

For about 30 years until 1996, the U.S. Fish and Wildlife Service maintained an aquatic research and monitoring program in the park. Current fisheries managers focus on the same objectives: to manage aquatic resources as an important part of the park ecosystem, preserve and restore native fishes and their habitats, and provide anglers with the opportunity to fish for wild fish in a natural setting.

The Voluntary Angler Report

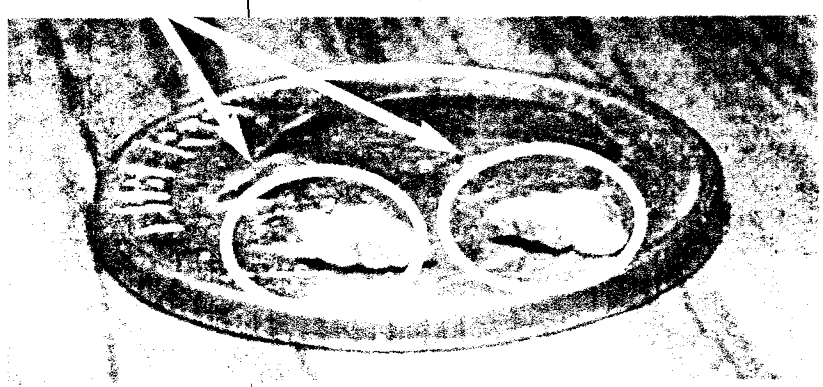
Anglers contribute to the park's fisheries database by filling out the Voluntary Angler Report card, which is issued with each fishing license. For some park waters, these reports are the only data available. This information helps managers monitor the healthy of the fisheries throughout the park.

6C

Fish

Snail Invasion

The New Zealand mud snail has invaded park waters. About one-quarter inch long (see below), this snail forms dense colonies on aquatic vegetation and rocks along streambeds, crowding out native aquatic insect communities, which are a primary food source for fish. Strategies for dealing with this invader are being developed. In the meantime, anglers and other water users should rinse mud, plants, and debris from all angling gear, footwear, boats, pets, and other items used in the water before entering Yellowstone and after leaving each water body within the park. All gear should be thoroughly inspected for the mud snail.



Fishing in Yellowstone National Park

About 75,000 of the park's three million visitors fish each year. Angling is an anomaly in a park where the primary purpose is to preserve natural environments and native species in ways that maintain natural conditions. Yet fishing has been a major visitor activity here for more than 100 years. Fishing is a major industry in the Greater Yellowstone Ecosystem, and park anglers spend more than $4 million annually. Angler groups have supported management actions, such as closing the Fishing Bridge to fishing in the early 1970s, and have helped fund research on aquatic systems.

Observing fish in their natural habitat is also a popular activity for anglers and non-anglers. Park staff monitored non-consumptive use of aquatic resources for about a decade (ending in 1992) at Fishing Bridge and LeHardys Rapids. The total number of visitors each year to LeHardys Rapids, where spawning cutthroat can be observed jumping the rapids, was about 134,000. Visitors at Fishing Bridge, where fish can be seen in the waters below the bridge, was nearly 290,000 in 1988.

Fishing Regulations

Strict regulations allow ecological processes to function with minimal interference from humans and preserve fish populations for the animals that depend on them. Complete regulations are at all ranger stations and visitor centers. In summary:

- Fishing is allowed only during certain seasons (usually late May through October).
- A permit is required (revenue stays in the park to support park programs).
- Terminal tackle must be lead-free (lead poisoning remains a serious threat to waterfowl).
- Bait fishing is prohibited, except for children under 12 in some areas (to prevent the introduction of non-native fish into park waters, because of an increased risk of death to fish caught with bait).
- All native sport fish—cutthroat trout, Arctic grayling, and mountain whitefish—must be released.
- Lake trout must be killed if caught in Yellowstone Lake and its tributaries.
- Certain waters may be closed to protect rare or endangered species, nesting birds, or to provide undisturbed vistas.

Changes in Yellowstone Waters

- Historically, Yellowstone Lake was populated by only Yellowstone cutthroat trout and longnose dace. Today, these two species are still present. The longnose sucker, lake chub, redside shiner, and the lake trout also live in the lake.
- Most of the Firehole River historically was fishless because Firehole Falls blocked fish from moving upstream. Today, anglers can fish for rainbow trout, brown trout, brook trout, and Yellowstone cutthroat trout in the thermally influenced stream.
- Historically, the Madison and Gibbon rivers (below Gibbon Falls) were inhabited by westslope cutthroat trout, Arctic grayling, mountain whitefish, mottled sculpin, mountain sucker, and longnose dace. Today, some of those species survive (some in extremely depleted numbers) and brown trout, rainbow trout, and brook trout have been added to the mix.
- When Heart Lake was first sampled for fish, Yellowstone cutthroat trout, mountain whitefish, speckled dace, redside shiner, Utah sucker, Utah chub, and the mottled sculpin were found.
- Lewis and Shoshone lakes were historically fishless because of waterfalls on the Snake River. Today, the lakes support lake trout, brown trout, brook trout, Utah chub, and redside shiner.
- The lower Lamar River and Soda Butte Creek historically were home to Yellowstone cutthroat trout, longnose dace, longnose sucker, and mountain sucker. Today, those species survive, and rainbow trout was stocked in the drainage.

Cutthroat Trout

The cutthroat trout *(Oncorhynchus clarki)* is native to the Rocky Mountains, and in Yellowstone occurs as three subspecies: the Yellowstone cutthroat, the Snake River cutthroat, and the westslope cutthroat (described below). The primary difference between the first two subspecies is the size and number of black spots on the fish. The Yellowstone cutthroat originally occurred in the Yellowstone River, its tributaries, and in the Falls River. The Snake River cutthroat is limited to the Snake River drainage.

While the cutthroat trout is essentially a Pacific drainage species, it has (naturally) traveled across the Continental Divide into the Atlantic drainage. One possible interconnection between the two oceans in the Yellowstone area is Two Ocean Pass, south of the park in the Teton Wilderness. Here, a fish can literally swim across the Continental Divide at the headwaters of Pacific Creek and Atlantic Creek and, thus, swim from the Pacific to the Atlantic via the Snake and Yellowstone rivers.

Cutthroat trout spawn in rivers or streams in late May through mid July, and spawners are an important food resource for other Yellowstone wildlife species, including the grizzly bear. Adult cutthroat trout consume smaller fish, fish eggs, small rodents, frogs, algae and other plants, and plankton. Their most important food are aquatic insects such as mayflies, stoneflies, caddisflies, plus any terrestrial insects unlucky enough to fall into the stream. They require cold, clear, clean water in streams or lakes. Deep waters found in even small lakes provide a winter refuge.

Yellowstone Lake and Yellowstone River together contain the largest population of native cutthroat trout in the world. For many years, the fish in Yellowstone Lake have been intensively monitored and studied. In the 1960s, fisheries managers determined that angler harvest was excessive and negatively impacting the fishery. In the 1970s and 1980s, increasingly restrictive angling regulations were put into place. Cutthroat trout population numbers and the age structure of the population were restored. The average fish caught in Yellowstone Lake weighs one pound and is about 14 inches long.

The recent discovery of the illegally introduced lake trout in Yellowstone Lake now poses a significant threat to the cutthroat trout population. *(See Chapter 8, "Fisheries: Lake Trout.")*

A Cutthroat Problem
Lake trout are large and voracious fish that, if left unchecked, could easily decimate the cutthroat trout population in Yellowstone Lake, which would also impact predators that depend on cutthroats for food. See Chapter 8 for details.

Westslope Cutthroat Trout

Westslope cutthroat trout *(Oncorhyncus clarki lewisi)* evolved independently of other cutthroat trout species, but share their food and habitat requirements *(see above).*

The westslope cutthroat trout originally was distributed throughout the Madison and Gallatin river drainages, but now is reduced to small headwater populations due to overfishing, competition, and interbreeding with non-native fish. Introduced non-natives appear to be most responsible for the decline in range of westslope cutthroat trout as other factors such as habitat loss and pollution appear negligible in the park.

In 1997, fisheries biologists identified Canyon Creek, a tributary of the Gibbon River that enters approximately one-half mile below Gibbon Falls, as a potential restoration site. Through electrofishing, they have removed nearly 13,800 brown, brook, and rainbow trout since 1997. Many of these fish have been placed in the Gibbon River. An existing artificial fish barrier was improved to prevent non-natives from re-entering the stream. Following completion of the barrier, fish—particularly brown trout—were observed congregating below the barrier in an attempt to spawn in Canyon Creek. Although fish have attempted to ascend over the barrier, biologists do not believe any have succeeded.

Park staff are also searching for genetically pure populations of westslope cutthroat trout within the park. Fish surveys were conducted in small headwater streams in the northwestern portion of the park, including Fan, Specimen, and Grayling creeks. DNA analysis identified one genetically pure population in North Fork Fan Creek. Information is being gathered to determine if this population is a viable source of fish for current and future restoration efforts within the park.

Because the westslope cutthroat trout has interbred with rainbow trout and transplanted Yellowstone cutthroat trout, its genetics cannot be assumed pure, even in isolated populations.

The park's fishing regulations include illustrations of these fish and additional information about fishing in Yellowstone.

Whirling disease is a parasitic infection of fish caused by a microscopic protozoan that destroys the cartilage of juvenile trout. Seriously infected fish have a reduced ability to feed or escape from predators and mortality is high. See Chapter 8 for details.

Musseling In?
The zebra mussel was first discovered in the United States in 1988. This mollusk clogs water intakes, crowds out bottom invertebrates, and reduces lake productivity. It is not known to be in Yellowstone, but it is moving up Missouri River drainages and may hitchhike on dirty boat hulls.

Arctic Grayling

The fluvial (riverine) Arctic grayling *(Thymallus arcticus)* is a rare and protected species in the park. Before European Americans arrived, grayling shared the rivers and streams of the Yellowstone region with cutthroat trout and whitefish. Because these species share similar food and habitat needs, they must have developed niches that allowed them to co-exist. We may never know, now that the grayling is for the most part gone from these streams and rivers. They were displaced from their historic waters mainly by introduced non-native species; grayling do not compete well with these species.

However, because of stocking in the 1920s, grayling do live in some lakes within the park—particularly Grebe Lake, where you may see them spawning in June. The waters of this and other lakes provide grayling with shelter in winter. Grayling, like trout, eat insects and other fish.

Current efforts on behalf of the grayling include sampling and tagging in Grebe and Wolf lakes and downstream in the Gibbon River. Park staff hopes to determine if grayling captured in the Gibbon River are simply downstream migrants displaced from the lakes or a distinct subpopulation of the fluvial form. Genetic sampling of grayling handled during the Gibbon River surveys will also provide insight to this question.

Mountain Whitefish

A slender silver fish, the mountain whitefish *(Prospium williamsoni)* is found in the rivers and streams of Yellowstone. It requires deep pools, clear and clean water, and is very sensitive to pollution. Unlike other native fish, the whitefish spawns in the fall. It generally feeds from the bottom, eating aquatic insect larvae, and does not seem to compete with trout for food. It is a strong and powerful fish that will take flies. The whitefish has survived in its native waters for more than 100 years, unlike native trout and grayling.

Nongame native fish

Nongame fish usually are less studied than sport fish, even though they are integral to the aquatic environment.

Suckers: longnose, mountain, and Utah
Using ridges on their jaws, these bottom-dwelling fish scrape aquatic flora and fauna from rocks. In turn, they are eaten by birds, bears, and brown trout. These fish can be distinguished by their habitat. **Mountain suckers** *(Castostomus platyrhynchus)* live in cold, fast, rocky streams and some lakes. **Longnose suckers** *(C. castostomusgriseus)* are native to the Yellowstone River drainage below the Grand Canyon, and have been introduced to Yellowstone Lake and are now in its surrounding waters. The longnose sucker is equally at home in warm and cold waters, streams and lakes, clear and turbid. The least known of the three, the **Utah sucker** *(C. ardens)* lives in the Snake River drainage.

Mottled sculpin *(Cottus bairdi)* resembles small catfish (less than four inches). It lives in shallow, cold water throughout Yellowstone, eating small insects and some plants and other fish. Sculpin are eaten by trout.

Minnows: longnose dace, speckled dace, redside shiner, Utah chub, redside shiner/speckled dace hybrid
These small fish live in a variety of habitats and eat a variety of foods; all five are eaten by trout. The **Utah chub** *(Gila atratria)* is the largest at 12 inches; it is native to the Snake River drainage, and seems to prefer slow, warm waters with abundant aquatic vegetation. The **longnose dace** *(Rhinichthys cataractae)* is most often found behind rocks and in eddies of the cold, clear waters of the Yellowstone and Snake river drainages.
A minnow of lakes, the **redside shiner** *(Richarsonius balteatus hydrophlox)* is native to the Snake River drainage but has been introduced to Yellowstone Lake, where it might compete with native trout because its diet is similar to that of young trout. Large shiners will also eat young trout. **Speckled dace** *(Rhinichthys osculus)* live in the Snake River drainage. The **redside shiner/speckled dace hybrid** is of scientific interest because the hybrid has occurred between two native fish. Hybridization is more common between native and non-native species. The hybrids inhabit the same waters as their purebred relatives and exhibit similar habits and behavior.

Yellowstone is home for a small variety of reptiles and amphibians. Glacial activity and current cool and dry conditions are likely responsible for their relatively low numbers in Yellowstone.

In 1991 park staff began cooperating with researchers from Idaho State University to sample additional park habitats for reptiles and amphibians. This led to establishment of long-term monitoring sites in the park *(map, page 119)*. The relatively undisturbed nature of the park and the baseline data may prove useful in testing hypotheses concerning the apparent declines of several species of toads and frogs in the western United States. Reptile and amphibian population declines may be caused by such factors as drought, pollution, disease, predation, habitat loss and fragmentation, introduced fish and other non-native species.

As of March 2002 . . .

Number in Yellowstone

- Cool, dry conditions limit Yellowstone's reptiles to six species and amphibians to four species.
- Population numbers for these species are not known.
- Reptiles: prairie rattlesnake, bull snake, valley garter snake, wandering garter snake, rubber boa, sagebrush lizard.
- Amphibians: boreal toad, chorus frog, spotted frog, tiger salamander.

Status

- The spotted frog may be declining in the West.
- Some researchers suspect that there are more amphibians in Yellowstone than are currently known, but this has not been documented yet.

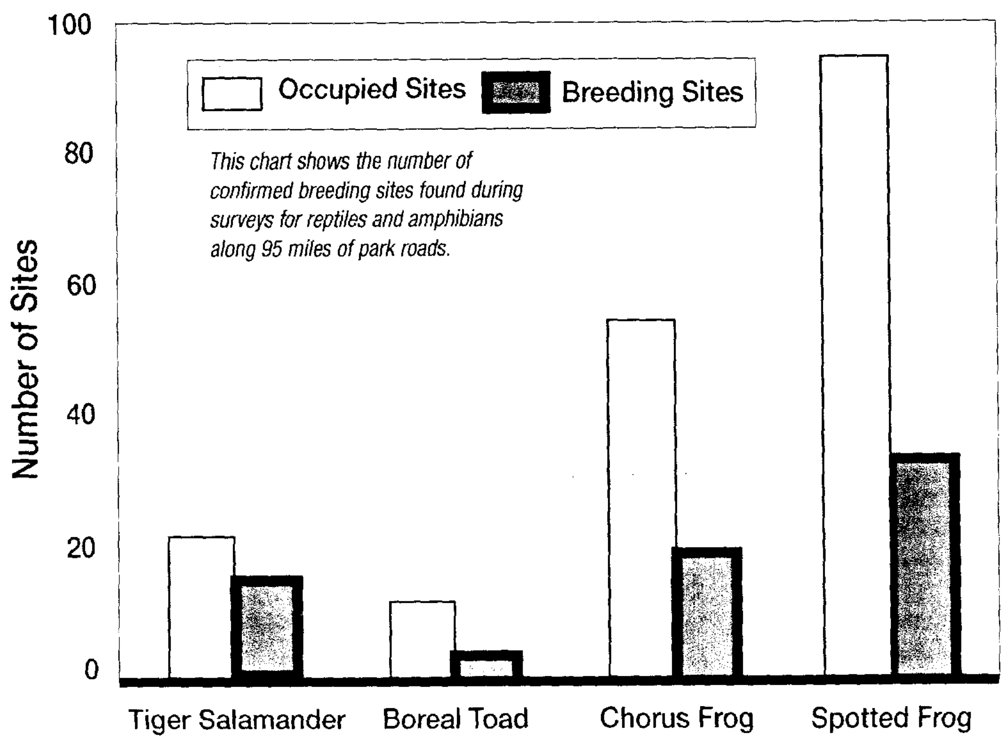
Current Research

In 1991, NPS staff began cooperating with Idaho State University to sample park habitats for reptiles and amphibians.

Although no Yellowstone reptile or amphibian species are currently listed as threatened or endangered, several—including the boreal toad—are thought to be declining in the West. Surveys and monitoring are underway to try to determine if amphibian populations are declining in Yellowstone National Park

Species descriptions follow.

Both reptiles and amphibians are ectothermic ("cold-blooded"), meaning they derive body heat from outside sources rather than generate it internally. Reptiles have scaly, dry skin. Some lay eggs; others bear live young. Amphibians have thin, moist glandular skin permeable to water and gases. The young must pass through a larval stage before changing into adults. Amphibious means "double life" and reflects the fact that salamanders, toads, and frogs live in water as larvae and on land for much of the rest of their lives.



From Yellowstone Science, *Winter 1999.*

6D

Reptiles & Amphibians

VALLEY GARTER SNAKE

Thamnophis sirtalis fitchi

Identification

- Subspecies of the common garter snake.
- Medium sized snake reaching total length of up to 34 inches.
- Nearly black background color with three bright longitudinal stripes running the length of the body, underside is pale yellow or bluish gray.
- Most distinguishing characteristics of this subspecies in our region are the irregular red spots along the sides.

Habitat

- Thought to be common in the past, now in decline for no apparent reason.
- Closely associated with permanent surface water.
- In Yellowstone observed only in the Falls River drainage in the Bechler region and three miles south of the south entrance along the Snake River.

Behavior

- Generally active during the day.
- In the Yellowstone area it eats mostly toads, chorus frogs, fish remains, and earthworms; can eat relatively poisonous species.
- Predators include fish, birds, and carnivorous mammals.

WANDERING GARTER SNAKE

Thamnophis elegans vagrans

Identification

- Most common reptile in the park.
- 6 to 30 inches in length.
- Brown, brownish green, or gray with three light stripes—one running the length of the back and a stripe on each side.

Habitat

- Usually found near water in all areas of the park.
- Eats small rodents, fish, frogs, tadpoles, salamanders, earthworms, slugs, snails, and leeches.

Behavior

- May discharge musk from glands at the base of the tail when threatened.
- Gives birth to as many as 20 live young in late summer or fall.

BULLSNAKE

Pituophis catenifer sayi

Identification

- A subspecies of the gopher snake, is Yellowstone's largest reptile, ranging from 50 to 72 inches long.
- Yellowish with a series of black, brown, or reddish-brown blotches down the back; the darkest, most contrasting colors are near the head and tail; blotches are shaped as rings around the tail.
- Head resembles a turtle's in shape, with a protruding scale at the tip of the snout and a dark band extending from the top of the head through the eye to the lower jaw.

Habitat

- In Yellowstone, found at lower elevations; drier, warmer climates; and open areas such as near Mammoth.

Behavior

- Lives in burrows and eats small rodents—behavior that gave the gopher snake its name.
- Often mistaken for a rattlesnake because of its appearance and its defensive behavior: when disturbed, it will coil up, hiss loudly, and vibrate its tail against the ground, producing a rattling sound.

Descriptive photos and illustrations exist in numerous books about these species; see "For More Information" on pages 120-122 for suggested titles.

RUBBER BOA

Charina bottae

Identification

- Infrequently encountered in Yellowstone, perhaps due to its nocturnal and burrowing habits.
- One of two species of snakes in the United States related to tropical boa constrictors and pythons.
- Maximum length of 24 inches.
- Back is gray or greenish-brown, belly is lemon yellow; scales are small and smooth, making it almost velvety to the touch.

Habitat and Behavior

- Eats rodents.
- May spend great deal of time partially buried under leaves and soil, and in rodent burrows.
- Usually found in rocky areas near streams or rivers, with shrubs or trees nearby.
- Recent sightings have occurred in the Bechler region and Gibbon Meadows.

PRAIRIE RATTLESNAKE

Crotalis viridis viridis

Identification

- More than 48 inches in length.
- Greenish gray to olive green, greenish brown, light brown, or yellowish with dark brown splotches down its back that are bordered in white.

Habitat

- Only dangerously venomous snake in the park.
- Lives in the lower Yellowstone River areas of the park, including Reese Creek, Stephens Creek, and Rattlesnake Butte, where the habitat is drier and warmer than elsewhere in the park.

Behavior

- Usually defensive rather than aggressive.
- Only two snake bites are known during the history of the park.

SAGEBRUSH LIZARD

Sceloporus graciosus graciosus

Identification

- Only lizard in Yellowstone.
- Maximum size of five inches from snout to tip of the tail; males have longer tails and may grow slightly larger than females.
- Gray or light brown with darker brown stripes on the back set inside lighter stripes on the sides, running the length of the body; stripes not always prominent and may appear as a pattern of checks down the back; underside usually cream or white.
- Males have bright blue patches on the belly and on each side, with blue mottling on the throat.

Habitat

- Usually found below 6,000 feet but in Yellowstone lives up to 8,300 feet.
- Populations living in thermally influenced areas are possibly isolated from others.
- Most common along the lower portions of the Yellowstone River near Gardiner, Montana and upstream to the mouth of Bear Creek; also occurs in Norris Geyser Basin, Shoshone and Heart Lake geyser basins, and other hydrothermal areas.

Behavior

- Come out of hibernation about mid May and active through mid September.
- Diurnal, generally observed during warm, sunny weather in dry rocky habitats.
- During the breeding season males do push-ups on elevated perches to display their bright blue side patches to warn off other males.
- Feed on various insects and arthropods.
- Eaten by bull snakes, wandering garter snakes, rattlesnakes and some birds.
- May shed tail when threatened or grabbed.

In the winter in Yellowstone, some amphibians go into water that does not freeze (spotted frogs), others enter underground burrows (salamanders and toads), and others (boreal chorus frog) actually tolerate freezing and go into a heart-stopped dormancy for the winter in leaf litter or under woody debris.

Toad or Frog?
Toads can easily be distinguished from frogs by their warty bodies, thick waists, and prominent glands behind their eyes.

BLOTCHED TIGER SALAMANDER

Ambystoma tigrinum melanostictum

Identification

- The only salamander in Yellowstone.
- Adults range up to about 9 inches, including the tail.
- Head is broad, with a wide mouth.
- Color ranges from light olive or brown to nearly black, often with yellows blotches or streaks on back and sides; belly is dull lemon yellow with irregular black spots.
- Larvae, which are aquatic, have a uniform color and large feathery gills behind the head; they can reach sizes comparable to adults but are considerably heavier.

Habitat

- Breeds in ponds and fishless lakes.
- Widespread in Yellowstone in a great variety of habitats, with sizable populations in the Lamar Valley.

Behavior

- Adult salamanders come out from hibernation in late April to June, depending on elevation, and migrate to breeding ponds where they lay their eggs.
- Mass migrations of salamanders crossing roads are sometimes encountered, particularly during or after rain.
- After migration, return to their moist homes under rocks and logs and in burrows.
- Feed on adult insects, insect nymphs and larvae, small aquatic invertebrates, frogs, tadpoles, and even small vertebrates.
- Preyed upon by a wide variety of animals, including mammals, fish, snakes, and birds such as sandhill cranes and great blue herons.

BOREAL TOAD

Bufo boreas boreas

Identification

- Yellowstone's only toad.
- Adults range up to about 4 inches, juveniles just metamorphosed from tadpoles are only one inch long.
- Stocky body and blunt nose.
- Brown, gray, or olive green with irregular black spots, lots of "warts," and usually a white or cream colored stripe down the back.
- Tadpoles are usually black and often congregate in large groups.

Habitat

- Once common throughout the park, now appears to be much rarer than spotted frogs and chorus frogs; scientists fear this species has experienced a decline in the Greater Yellowstone Ecosystem.
- Adults can range far from wetlands because of their ability to soak up water from tiny puddles or moist areas.
- Lay eggs in shallow, sun-warmed water, such as ponds, lake edges, slow streams, and river backwaters.

Behavior

- Tadpoles eat aquatic plants; adults eat insects, especially ants and beetles, worms and other small invertebrates.
- Sometimes active at night.
- Defends itself against predators by secreting an irritating fluid from numerous glands on its back and behind the eyes.
- Eaten by snakes, mammals, ravens, and large wading birds.

COLUMBIA SPOTTED FROG

Rana petiosa

Identification

- Abundant and best known amphibian in Yellowstone.
- Maximum length is 3.2 inches, newly metamorphosed juveniles less than one inch long.
- Upper surface of the adult is gray-brown to dark olive or even green, with irregular black spots; skin is bumpy; underside is white splashed with brilliant orange on the thighs and arms on many but not all individuals.
- Tadpoles have long tails and may grow to 3 inches long.

Habitat

- Found all summer along or in rivers, streams, smaller lakes, marshes, ponds, and rain pools.
- Lay eggs in stagnant or quiet water, in globular masses surrounded by jelly.

Behavior

- Breeds in May or early June, depending on temperatures.
- Tadpoles mature and change into adults between July and September.
- Tadpoles eat aquatic plants, adults mostly eat insects but are highly opportunistic in their food habits (like many other adult amphibians).

BOREAL CHORUS FROG

Pseudacris triseriata maculata

Identification

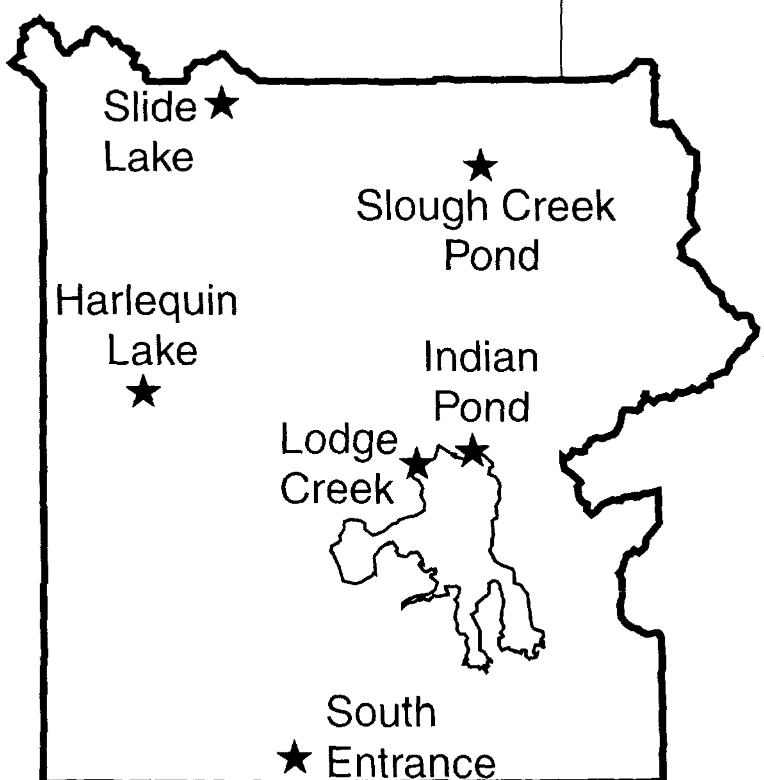
- Adults reach 1 to 1½ inches in length, and females are usually larger than males; newly metamorphosed froglets are less than one inch long.
- Brown, olive, tan, or green (sometimes bi-colored) with a prominent black stripe on each side from the nostril through the eye and down the sides to the groin; three dark stripes down the back, often incomplete or broken into blotches.

Habitat

- Common, but seldom seen due to its small size and secretive habits.
- Live in moist meadows and forests near wetlands.
- Lays eggs in loose irregular clusters attached to submerged vegetation in quiet water.

Behavior

- Breeds in shallow temporary pools or ponds during the late spring.
- Calls are very conspicuous, resembles the sound of a thumb running along the teeth of a comb.
- Males call and respond, producing a loud and continuous chorus at good breeding sites, from April to early July, depending on elevation and weather.
- Usually call in late afternoon and evening.
- Tadpoles eat aquatic plants; adults mostly eat insects.
- Eaten by fish, predacious aquatic insect larvae, other amphibians, garter snakes, mammals, and birds.



This map shows six amphibian breeding sites monitored since 1991; each site has two to four species.

From Yellowstone Science, *Winter 1999.*

6

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CULTURAL RESOURCES

Cultural resources are material evidence of past human activities. In the National Park Service, specialists in this field:

- Identify, evaluate, document, establish basic information about, and in some cases register cultural resources
- Identify people associated with a park for two or more generations whose interests in the park's resources began prior to the park's establishment
- Plan to ensure that management decisions and priorities integrate cultural resources needs and provide for consultation and collaboration with outside entities
- Preserve and protect cultural resources, and make those resources available for public understanding and enjoyment.

The types of cultural resources are related to disciplines such as archeology, curation, ethnography, history, and historical architecture. Although each type is closely associated with a particular discipline, an interdisciplinary approach is often used to document and evaluate cultural resources.

YELLOWSTONE'S CULTURAL RESOURCES

- More than 55 ethnographic resources; many provided by the more than two dozen affiliated tribes
- More than 1,100 prehistoric and historic Native American archeological sites and historic European American archeological sites
- 6 National Historic Landmarks
- 4 National Register Historic Districts
- Museum collection of more than 200,000 cultural objects and natural science specimens available to researchers
- Archives containing thousands of irreplaceable historic documents
- Thousands of books and periodicals available to the public; plus manuscripts and rare books available to historians and other researchers
- 90,000 historic photographs for use by staff, scholars, authors, and filmmakers

Archeology: Resources In the Ground

From the discarded points of 10,000 years ago to the trash heaps of hotels, humans leave behind evidence of their presence. These pieces of evidence and the sites where they are found comprise the archeological resources of Yellowstone.

Archeologists have identified more than 1,100 prehistoric sites in Yellowstone—many more may exist. About two percent of the park has been surveyed for archeological sites, mostly along road corridors prior to construction or along the shores of Yellowstone Lake where erosion is uncovering and destroying sites.

The oldest known site is a shoreline site at risk from erosion. Rather than stopping that natural process, archeologists began testing the site in 2000.

This photo, from 1933, conveys a wealth of historic information. It shows Max Big Man and his daughter, Myrtle, of the Crow Tribe. Max made presentations about how the Crow lived at the time of fur trappers. The tribe ceded part of its territory to the park in 1868. The photo also shows how interpretive signs once looked, and provides a visual record of Giant Geyser's appearance at the time.

That summer also saw archeologists working at a contemporary site of historic significance. The Lake Hotel is the oldest hotel still existing in the park. For decades, hotel workers disposed of trash in pits behind the hotel. One of those sites was uncovered during maintenance and evaluated by the cultural resources staff. They found a large variety of materials from the early 20th century, including a key chain, old bricks, a vaseline jar with top made after 1908, and a lot of beverage bottles. No one story reveals itself in these artifacts; instead, a more general picture emerges of life at that time.

7

Cultural Resources

Cultural Landscapes

A cultural landscape is a geographic area associated with a historic event, activity, or person or it exhibits other cultural or esthetic values. Cultural landscapes can be formally nominated as historical districts on the National Register of Historic Places.

Yellowstone doubtless contains dozens of cultural landscapes, both Native American and European American, but few have been studied so far. Tribes have identified sacred sites (considered ethnographic landscapes) but none have yet been formally evaluated. Fort Yellowstone and the Old Faithful area are other known cultural landscapes. Two cultural landscapes have been officially recognized: the road system, and Apollinaris Spring, a site between Mammoth and Norris.

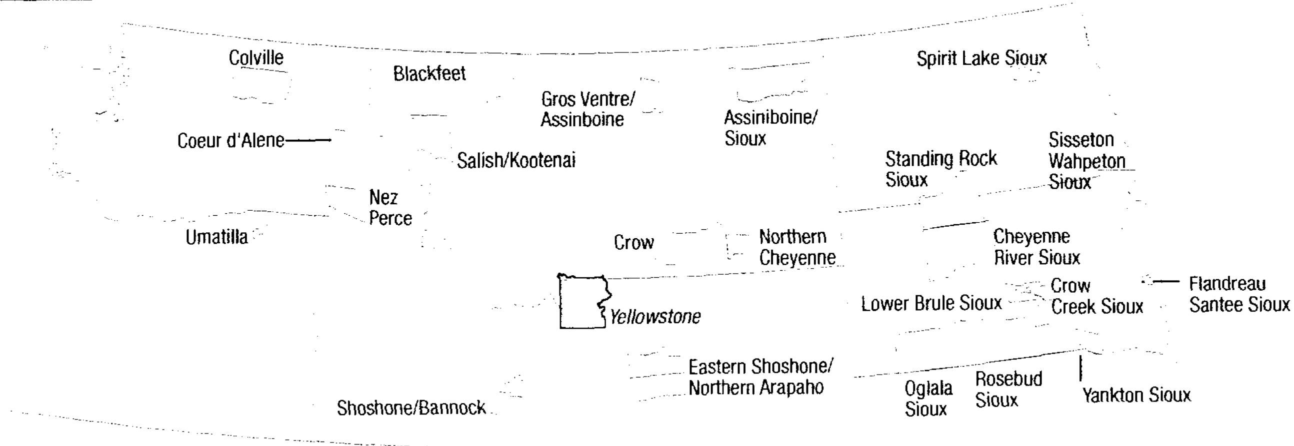
Ethnography: Resources of the People

Ethnographic resources are the natural and cultural features of a park that are significant to people traditionally associated with the park. These places are closely linked with the development and maintenance of their identity as a community. Ethnographic resources may be sites identified by oral history as where a tribe began. They may be sites that support ceremonial activities, are hunting or gathering places, or are associated with migration routes and histories. Preservation of these resources is mandated by laws and executive orders, some of which are described on page 129.

Tribal Affiliates

Yellowstone's traditionally associated groups are the park's affiliated tribes *(see below).* Their ancestral presence is shown through archeological documentation, ethnohistoric documentation, interviews with tribal elders, and ongoing consultations *(see Chapter 1).* Some tribes lived here through a few seasons at least, if not year-round. Others came for ceremonial reasons, and almost all have hunted and gathered, traded and raided here. Certain places and resources remain important to these tribes' sense of themselves and in maintaining their traditional practices.

Right now Yellowstone National Park has more than 55 ethnographic resources identified by tribal peoples. These include animals such as bison, plants, hydrothermal areas, mineral paints from hydrothermal areas, Yellowstone Lake, vision questing sites, obsidian, rendezvous sites, and hunting sites.



Affiliated Tribes of Yellowstone National Park

as of March 2002

\+ Kiowa & Comanche in Oklahoma

Assiniboine & Sioux
Blackfeet
Cheyenne River Sioux
Coeur d'Alene
Comanche
Confederated Tribes of the Colville Reservation
Confederated Tribes of the Umatilla Reservation
Confederated Salish & Kootenai Tribes
Crow
Crow Creek Sioux
Eastern Shoshone
Flandreau Santee Sioux
Gros Ventre and Assiniboine
Kiowa
Lower Brule Sioux
Nez Perce
Northern Arapaho
Northern Cheyenne
Oglala Sioux
Rosebud Sioux
Shoshone-Bannock
Sisseton-Wahpeton Sioux
Spirit Lake Sioux
Standing Rock Sioux
Yankton Sioux

Tribes and Yellowstone National Park have a mutual interest in cultural preservation. Tribes want traditions to survive and the National Park Service wants to assist such preservation as part of its commitment to protecting cultural resources. In addition, tribes are sovereign nations whose leaders have a legal relationship with the federal government that is not shared by the general public. Consequently, representatives of Yellowstone's affiliated tribes participate in periodic consultation meetings with park managers. They bring tribal perspectives to current issues such as bison management. (Bison in Yellowstone are a precious resource of all affiliated tribes.) Tribes also comment on park projects that could affect tribal ethnographic resources.

By Word of Mouth

Oral histories provide information to help with resource management, interpretation, and documentation. They also can provide evidence of human use where scant archeological evidence and little or no written information exists.

Native American tribes relate their histories through the oral tradition, and in recent years some of Yellowstone's affiliated tribes have been willing to be interviewed about their history. For example, the Kiowa of Oklahoma spoke of their people being in Yellowstone from the 1400s to the 1700s. They also told the heroic story of their creator giving Yellowstone to the Kiowa as their homeland. The site where this occurred is Dragon's Mouth, a hot spring in the Mud Volcano area. Elders of the Nez Perce have also visited sites in Yellowstone, especially those associated with their people's flight through the park in 1877 *(see page 24)*. They spoke emotionally about this trek, adding a different and valuable dimension to our understanding of this historic event.

Together with archeology and history, oral tradition enriches our understanding about Yellowstone's complex history. This knowledge also assists with the management of Yellowstone's heritage resources in a way that strengthens the ability of indigenous peoples to perpetuate their culture and to enrich parks with a deeper sense of place.

The history of park management is also being documented through oral histories conducted with former and current employees. The first project was a history of the Northern Range, in which dozens of former employees were interviewed about elk management in the 1950s and 60s. The employees contributed stories of what it was like to round up elk, how they felt about participating in this operation, and how the public reacted. Other projects include an oral history of the Civilian Conservation Corps, in which surviving workers have been interviewed, and an ongoing oral history of scientists and rangers involved in bear management over the years.

These interviews now reside on CDs, in written transcripts, and—in some cases—as videos in the park's archives.

Above: Nez Perce tribal representatives sit at Nez Perce Ford and relate the story of their people's flight through Yellowstone (see page 24).
Right: The late historian Aubrey Haines documented Yellowstone history through careful research and conversations with the "old timers."

Historic Park Buildings still in use

1891	1903	1903-04	1906	1908	1909	1918-28
Lake Hotel part of Lake Fish Hatchery Historic District.	*Roosevelt Memorial Arch.*	*Old Faithful Inn, National Historic Landmark; part of Old Faithful Historic District.*	*Lamar Buffalo Ranch, National Historic District.*	*Norris Soldier Station, now the Museum of the National Park Ranger.*	*Albright Visitor Center, part of the Mammoth Hot Springs Historic District.*	*Old Faithful Lodge, part of Old Faithful Historic District*

Historic Structures & Districts

Historic buildings provide opportunities for visitors to learn about the region's last 130 years through exhibits, publications, and tours led by park and concession interpreters.

Mammoth Hot Springs/Fort Yellowstone

In March 2002, Mammoth Hot Springs Historic District was listed on the National Register of Historic Places. It includes Fort Yellowstone, a proposed Historic Landmark, where thirty-five structures remain from the 1890s and early 1900s when the U.S. Army administered the park *(see pages 24–25)*. Significant developments occurred here in national conservation policies that led to the origin of the National Park Service.

Above: Albright Visitor Center, above, part of the newly registered Mammoth Hot Springs Historic District, housed the first "information office" (visitor center).
Right: Lake Hotel

Lake Hotel

The Lake Hotel is the oldest operating hotel in the park. At the time it was opened, in 1891, the building resembled any other railroad hotel financed by the Northern Pacific Railroad. But in 1903, the architect of the Old Faithful Inn, Robert Reamer, masterminded the renovation of the hotel, designing the ionic columns, extending the roof in three places, and adding the 15 false balconies, which prompted it to be known for many years as the "Lake Colonial Hotel." By 1929, number of additional changes—addition of the dining room, porte-cochere (portico), sunroom, plus the refurbishing of the interior—created the landmark we see today. The hotel was placed on the National Register of Historic Places in 1991.

Roosevelt Arch

Visitors who enter Yellowstone at the North Entrance pass through the Roosevelt Arch. This soaring stone structure was designed in 1903 by Robert Reamer. President Theodore Roosevelt placed the cornerstone for the arch, which was later named for him. The top of the arch is inscribed with a line from the Yellowstone National Park Act of 1872: "For the benefit and enjoyment of the people."

Roosevelt Lodge & Area

Diners at Roosevelt Lodge (where Roosevelt never stayed) view much the same landscape seen by visitors when the lodge first opened in 1920. The area surrounding and including the lodge is registered as The Roosevelt National Historic District.

The Buffalo Ranch

The Lamar Buffalo Ranch Historic District overlooks Lamar Valley. The

Historic Park Buildings still in use

- **1919–20; 1925–26** — *Lake Lodge, part of Lake Fish Hatchery Historic District.*
- **1920** — *Roosevelt Lodge, listed on the National Register of Historic Places as part of the Roosevelt Lodge Historic District.*
- **1929** — *First trailside museum opens at Old Faithful. Three more built at Madison, Norris, and Fishing Bridge—they are still in use and are National Historic Landmarks.*
- **1937** — *Mammoth Hot Springs Hotel, part of the Mammoth Hot Springs Historic District.*
- **1958** — *Canyon Visitor Center, part of the Mission 66 building program.*

Left: Lamar Buffalo Ranch
Below: Old Faithful Inn

ranch, which operated from 1906 until the 1950s, was the focal point of an effort to increase the herd size of the few remaining bison in Yellowstone. Remnants of irrigation ditches, fencing, and water troughs can still be found, and four buildings from the original ranch compound remain *(photo above)*—two residences, the bunkhouse, and the barn. New cabins, which blend with the historic buildings, house students at the Yellowstone Association Institute or the National Park Service's residential environmental education program.

Old Faithful Inn & Historic District

Most people who step into the Old Faithful Inn *(photo right)* for the first time stop as their eyes follow thick rustic logs up to the soaring peak of the ceiling. Robert Reamer designed this National Historic Landmark, which opened in 1904. It is the centerpiece of the Old Faithful Historic District.

The Old Faithful Lodge, part of the historic district, is a result of numerous changes dating back to the early days of tent camps. In 1918, a laundry was built on the site and construction continued until 1928 when the lodge reached its present configuration.

Trailside Museums

Four trailside museums were built in Yellowstone as part of a national idea that a national park is itself a museum and an interpretive structure should blend in with its surroundings and its exhibits explain but not substitute for the park experience. The museums here are well-known examples of the architectural style, National Park Rustic (also called "parkitecture").

The Old Faithful Museum was the first trailside museum in Yellowstone. It opened in 1929 to acclaim for its quality materials and construction, and for the way it blended into its surroundings. It was replaced by a new visitor center in 1972.

The Norris Museum, built in 1930 and still in use, is a gateway to the Norris Geyser Basin. Visitors first glimpse the area's hydrothermal features from an open foyer; they learn about the features from exhibits that flank the foyer.

7

Cultural Resources

6 National Historic Landmarks: Fishing Bridge Trailside Museum, Madison Junction Trailside Museum, Norris Geyser Basin Trailside Museum, Northeast Entrance Station, Obsidian Cliff, Old Faithful Inn

4 National Register Historic Districts: Lake Fish Hatchery, Mammoth Hot Springs, Old Faithful, Roosevelt Lodge

5 National Historic Sites: Lake Hotel, Lamar Buffalo Ranch, Obsidian Cliff Kiosk, Queen's Laundry Bath House, U.S. Post Office at Mammoth Hot Springs

The Madison Museum *(photo right),* overlooking the junction of the Gibbon and Firehole rivers, features many elements associated with National Park Rustic: stone and wood-shingled walls, and rafters of peeled logs. Built in 1930, it now serves as an information station and bookstore.

The Fishing Bridge Museum, built in 1932, retains many of its original exhibits as an example of early National Park Service displays. On the lake side of the museum, visitors can cross a flagstone terrace overlooking the lake and descend steps to the shore.

Canyon Village

The Canyon Village development is eligible for listing in the National Register of Historic Places because of its place in Mission 66 history *(see page 26)*. The visitor center *(photo below)* was designed to deliver information to visitors in a fast and efficient manner. In-depth interpretive exhibits were minimal; films quickly presented the park's "story." The Canyon Visitor Center no longer meets the needs of visitors and has serious structural problems. An extensive renovation is planned to solve these problems and reflect a combination of this building's original architectural style—"National Park Service Modern"—and the that of the original hotel, which was Arts and Crafts style.

National Register of Historic Places

The National Register of Historic Places is the Nation's official list of cultural resources worthy of preservation. Authorized under the National Historic Preservation Act of 1966, the National Register is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archeological resources. Properties listed in the Register include districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, engineering, and culture. The National Register is administered by the National Park Service. Currently 73,000 listings have been nominated by governments, organizations, and individuals because they are important to a community, a state, or the nation.

National Historic Landmarks

National Historic Landmarks are nationally significant historic places designated by the Secretary of the Interior because they possess exceptional value or quality in illustrating or interpreting the heritage of the United States. Today, fewer than 3,500 historic places bear this national designation. Working with citizens throughout the nation, the National Historic Landmarks program draws upon the expertise of National Park Service staff who evaluate potential landmarks and provide assistance to existing landmarks.

Lodging No Longer Standing

Marshall House, which stood near the present-day intersection of Fountain Flats Drive and Grand Loop Road, was built in 1880 and was the second hotel in the park. Later renamed the Firehole Hotel, it was torn down between 1892 and 1895.

Fountain Hotel opened in 1891 north of Fountain Paint Pot. This was one of the first Yellowstone hotels to feed bears for the entertainment of guests. The hotel closed after 1916 and was torn down in 1927.

Three lodging facilities were built at Norris. The first, built in 1886, burned before it opened. The second, Larry's Lunch Station, provided lodging for 10–20 people who "wanted to tarry." The final hotel at Norris served the public from 1901 through 1916.

Three hotels were built in succession at Canyon, the last being the largest hotel in the park. Sited where the horse stables are now, the Canyon Hotel was closed in 1958 due to financial and/or maintenance problems and burned in 1960.

These and other sites of former park facilities are historic archeologic sites. They are studied and documented for what they reveal about the history of visitor use in the park.

More Than a Century of Collecting

The basement of the Albright Visitor Center and a warehouse in Gardiner contain a unique and valuable collection of prehistoric and historic artifacts, documents, and specimens that reflects the unique resources and history of Yellowstone National Park. Among the items tucked away: paintings and pencil sketches by Thomas Moran; photographs by William H. Jackson; historic hotel furnishings; historic vehicles; park souvenirs; archeological objects; and fossil and plant specimens.

Historic photographs document European American explorations of the region and the history of the park. Historians consult these photos for visual information; the park's landscape architects consult them to plan historically accurate renovations. Documentary filmmakers request photos of people and the park to visually tell the story of Yellowstone.

The park maintains archives through an agreement with the National Archives and Records Administration. Irreplaceable documents include manuscripts and diaries by N.P. Langford and Thomas Moran, logs from park patrols and management, and field notes from researchers who have studied Yellowstone's cultural and natural resources.

The park's collections are in inadequate storage. Plans are underway to build a new collections facility in Gardiner; construction is due to begin in 2003.

Cultural Resource Laws

These laws guide the management of historic and cultural resources in national parks.

***The Antiquities Act** (1906) provides for the protection of historic, prehistoric, and scientific features on and artifacts from federal lands.*

***The Historic Sites Act** (1935) sets a national policy to "preserve for future public use historic sites, buildings, and objects."*

***The National Historic Preservation Act** (1966) authorizes the creation of the National Register of Historic Places and gives extra protection to national historic landmarks and properties on the national register. National parks established for their historic value automatically are registered; others, such as Yellowstone, must nominate landmarks and properties to the register.*

***The Archeological and Historic Preservation Act** (1974) provides for the preservation of significant scientific, historic, and archeological material and data that might be lost or destroyed by federally sponsored projects. For example, federal highway projects in Yellowstone now must include archeological surveys.*

***The Archeological Resources Protection Act** (1979) provides for the preservation and custody of excavated materials, records, and data.*

***The Native American Graves Protection and Repatriation Act** (1990) assigns ownership or control of Native American human remains, funerary objects, and sacred objects of cultural patrimony to culturally affiliated Native American groups.*

***American Indian Religious Freedom Act** (AIRFA) protects and preserves American Indian access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites.*

***Executive Order 13007** guarantees access to and ceremonial use of Indian sacred sites by Indian religious practitioners and that these sites not be adversely affected.*

7

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Controversial Park Issues

8

Bioprospecting & Benefits-Sharing

When you look into Yellowstone's deep and colorful hydrothermal pools, it is as though you are looking through a window into the earth's past to the beginnings of life itself. The original atmosphere of the earth was so anoxic (without oxygen) that it would not support human life. The brightly colored bacteria that form the yellow, orange, and green mats found in and around the hot springs were the among the first organisms capable of photosynthesis—the process by which plants use sunlight to convert carbon dioxide to oxygen and other byproducts. In this way, these colorful lifeforms, called cyanobacteria, began to create an atmosphere that would eventually support human life.

The Issue
Should the potential scientific and economic benefits resulting from collaboration with scientists be used to support and strengthen the National Park Service's primary mission of resource preservation?

Definitions
Bioprospecting is the search for useful organic compounds in nature.
Benefits–sharing is an agreement between researchers, their institutions, and the National Park Service that returns benefits to the parks when results of research have potential for commercial development.

History
1966: the microorganism *Thermus aquaticus* was discovered in a Yellowstone hot spring.
1985: an enzyme from *T. aquaticus,* which is synthetically reproduced, contributed to the DNA fingerprinting process that has earned hundreds of millions of dollars for the patent holder.
1997: the park signed a benefits-sharing agreement with Diversa Corporation, which ensures a portion of their future profits from research in Yellowstone National Park will go toward park resource preservation.
1999: a legal challenge put a hold on implementing this agreement until an environmental analysis (EA or EIS) is completed.

Current Status
- NPS is conducting an environmental impact statement (EIS) to decide whether benefits-sharing should be a part of NPS policy for parks nationwide. Through a public process, the EIS will examine the potential impacts of implementing and not implementing benefits-sharing agreements.
- Each year, approximately 50 research permits are granted to scientists to study microbes in Yellowstone. Regulations governing these permits provide that the research project may be authorized only if it is appropriate in Yellowstone. By law, appropriate projects must not impair natural or cultural resources or visitor use and enjoyment of the park.
- Research microbiologists continue to find microorganisms in Yellowstone that provide insights into evolution, aid in the search for life on other planets, and reveal how elements are cycled through ecosystems.

History

Careful scientific study of these curious lifeforms began in earnest in 1966, when Dr. Thomas Brock discovered a way to grow one of the microorganisms that lived in the extraordinary hot waters (more than 70°C) of Mushroom Pool in the Lower Geyser Basin. This bacterium, *Thermus aquaticus,* proved essential to one of the most exciting discoveries in the 20th century *(see photo on page 133).*

Two decades ago, the study of DNA was barely possible. Things we take for granted today such as DNA fingerprinting to identify criminals, DNA medical diagnoses, DNA-based studies of nature, and genetic engineering were unimaginable. But in 1985, the polymerase chain reaction (PCR) was invented. PCR is an artificial technique for something that living things do every day—replicate DNA. PCR is the rocket ship of replication, since it allows scientists to multiply a piece of DNA billions of times in a few hours. Without PCR, scientists could not get enough DNA to work with. An enzyme discovered in *T. aquaticus*—called Taq polymerase—made PCR practical. Because it came from a thermophile (heat-loving organism), Taq polymerase can withstand the heat of the PCR process without breaking down like ordinary polymerase enzymes. Use of a synthetically re-created enzyme discovered in *T. aquaticus* and now made in a laboratory allowed DNA studies to be practical and affordable.

Many other species of microbes have been found in Yellowstone since 1966. Each of these thermophiles produces thousands of uncommon, heat-stable proteins. Researchers estimate more than 99 percent of the species actually present in Yellowstone's hydrothermal features have yet to be identified.

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Bioprospecting & Benefits-Sharing

Dr. Thomas Brock

Science

Because much of modern biotechnology is based on the use of enzyme catalysts for biochemical reactions—including genetic engineering, fermentation, and bioproduction of antibiotics—these heat-stable proteins are becoming increasingly important in the advancement of science, medicine, and industry. Yellowstone preserves one of the planet's greatest concentrations of thermophilic biological diversity and, thus, is a strategic repository of unique genetic resources.

Yellowstone's geology provides a variety of physical and chemical habitats that support a wide spectrum of early life forms. Hot springs with pH readings ranging from 2 to 10 are typical, and they have geochemical substrates ranging from igneous and metamorphic to sedimentary. According to DNA sequencing analysis, the organism most closely related to the primordial origin of life—the earth's most primitive species—resides in a mineral spring in Hayden Valley. It is a member of the domain *Archaea* and for now is known as PjP78.

Ongoing Research

Nearly 50 research studies are being done on microorganisms from the park today. For example, NASA is studying thermophiles that might help determine if life exists on Mars. Cyanobacteria that influence the growth of hot springs terraces impart a biogeochemical signature that can be seen from overhead satellite imagery. Scientists are searching this imagery for the same signature in Mars' ancient volcanoes and suspected hot springs. Other microbes have been found that are useful in producing ethanol, treating agricultural food waste, bioremediating chlorinated hydrocarbons, recovering oil, biobleaching paper pulp, improving animal feed, increasing juice yield from fruits, improving detergents, and a host of other processes.

Controversy

Along with this exciting new dimension to the park and to science, some questions have been raised about whether or not bioprospecting of microbes should be allowed in the park. Long-standing laws and regulations instruct parks to allow scientific research as long as it does no harm to park resources or values. Park managers do not allow the commercial use of park specimens or "extraction" of microbes beyond the tiny samples required for scientific analysis. Thus, only information and insight gained from research on Yellowstone specimens may be commercialized—not the specimens collected from the park. In addition, bioprospectors are not the only ones who may get ideas from their research that can be applied to commercial uses. Any Yellowstone scientist may accidentally learn something that leads to a commercial success. Nonetheless, some people question the appropriateness of allowing scientists to perform research in a national park if they are avowed bioprospectors even if they are looking for a way to reduce greenhouse gas emissions or cure cancer.

Benefits-Sharing

The issue of benefits-sharing from approved research projects with bioprospecting outcomes came to the forefront when Yellowstone recognized that the development of the polymerase chain reaction (PCR) had resulted in a multi-million dollar business.

Hoffman–La Roche, a Swiss pharmaceutical company, purchased the U.S. patents for the PCR process and Taq polymerase from Cetus Corporation in 1991 for an alleged $300 million. Since then, PCR has become one of the cornerstones of modern medical diagnostics, and annual sales of Taq polymerase have grown to an estimated $100 million. Yellowstone National Park and the United States public have received nothing from this commercial use of a product developed using science based upon a Yellowstone resource. Hoffman–La Roche and the researchers acted lawfully throughout the development and sales of Taq polymerase. At issue is whether the NPS should insist that research institutions and companies share any benefits they may acquire from their scientists' research results or whether the NPS should relinquish any claim to a portion of such benefits.

Benefits-Sharing Agreements

In 1997, Yellowstone National Park became the first U.S. national park to enter into an agreement called a Cooperative Research and Development Agreement (CRADA). Other federal agencies, including the National Institutes of Health and the Department of Energy routinely use CRADAs to conduct collaborative research and development with private researchers. At Yellowstone, these agreements could allow the park to collaborate with researchers and receive equitable benefits, such as equipment, research, or funding for conservation projects, when research on biological material from the park leads to commercially successful inventions. Similar benefits-sharing agreements are increasingly used in other countries to protect biodiversity by allowing the host nation to benefit from commercial discoveries that depended on its national parks and other protected areas.

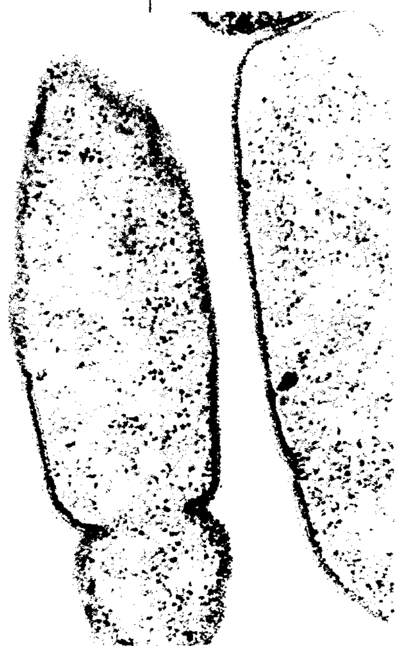
Under this particular CRADA, Diversa Corporation would pay the park $100,000 over five years and, if profits result from research on Yellowstone microbes, royalty payments. The up-front payment would be creditable against any royalties Diversa might owe Yellowstone, so additional royalty payments would not be received by the park until the up-front amount had been exceeded. The agreement did not enable Diversa to do anything that was not already allowed under the NPS research permit system; it simply provided compensation to the park for collaborative assistance provided by park personnel and for the preservation of the microbial habitat.

Diversa, which has research sites in Costa Rica, Iceland, Antarctica, and at the bottom of the Pacific and Atlantic oceans, collects DNA from hydrothermal habitats and screens the genes for the ability to produce useful compounds such as enzymes. They genetically engineer the most useful genes into "microbial livestock" for commercial production of the compound or enzyme. As with all NPS research specimens, the Yellowstone microbes themselves remain in federal ownership. None of Yellowstone's natural resources are ever sold. Specimens used by all bioprospectors remain federal property.

Into Court

Four entities, including two organizations opposed to bio-technology and an environmental group, sued the National Park Service in 1998, alleging the agreement was a commercialization of public resources without public input. In April 2000 the judge ruled in favor of the National Park Service but let stand a previous order requiring NPS to complete an environmental analysis of the impacts of the agreement according to National Environmental Policy Act procedures. The CRADA between Diversa and Yellowstone is suspended until such an analysis has been completed.

As global biodiversity declines, national parks and other preserves become increasingly important as sources of genetic diversity for scientific study as well as products that may benefit humanity. Between 25–30 percent of the medicines in use today are based on natural products derived from nature.



Thermus aquaticus, *magnified*

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Issues: Bison Management

The Issue

About half of Yellowstone's bison test positive for exposure to brucellosis, a disease that can cause susceptible domestic cattle to abort their first calf. Because Yellowstone bison migrate into Montana, their exposure to brucellosis concerns the cattle industry in that state.

History/Background

- Bison probably contracted the disease from domestic cattle that were raised in the park to provide milk and meat for park visitors in the early 1900s.
- Brucellosis has had no apparent impact on the health of the bison population.
- Cattle may contract the disease by coming in contact with infected tissue and birth fluids of other cattle.
- The human form of the disease, called undulant fever, was once a public health threat but is no longer.
- An effective brucellosis vaccine for cattle (strain 19) provides little protection for bison. Another vaccine used in cattle, RB51, is still being studied for its potential use in bison.
- No cases exist of wild, free-ranging Yellowstone bison transmitting brucellosis to cattle.
- The State of Montana, like other states, has spent much time, effort, and money attempting to eradicate brucellosis in cattle.
- Elk also carry brucellosis.

Current Status

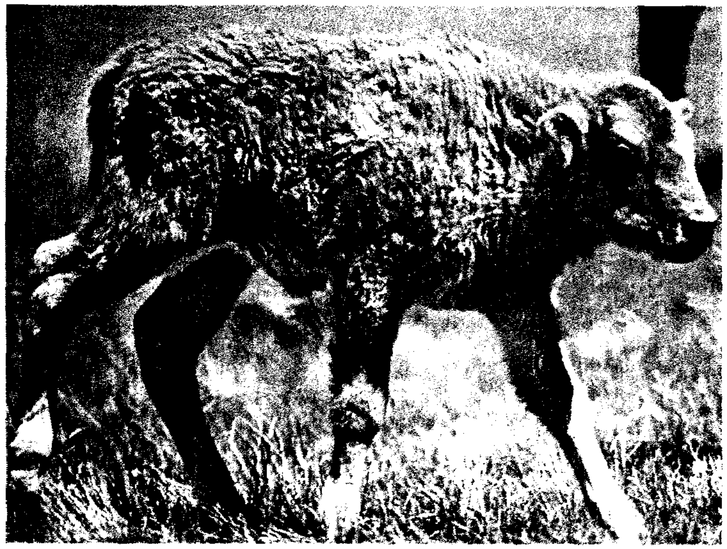
In December 2000, the federal government and the state of Montana released Records of Decision that, while separate documents, support essentially the same management plan for bison.

About Brucellosis

Brucellosis, caused by the bacterium *Brucella abortus,* can cause pregnant cattle to abort their calves. The disease is transmitted primarily when uninfected, susceptible animals come into direct contact with infected birth material. No cure exists for brucellosis in animals. According to recent research, however, a vaccine (RB51) used in cattle can be used in bison calves and yearlings.

Although rare, humans can contract brucellosis (through unpasteurized, infected milk products or contact with infected birth tissue) and develop a disease called undulant fever. With milk pasteurization, which is required by law, humans have virtually no risk of contracting the disease. And if they do, antibiotics can treat the disease.

Brucellosis was discovered in Yellowstone bison in 1917. They probably contracted the disease from domestic cattle raised in the park to provide milk and meat for visitors staying at the hotels. Now about 50 percent of the park's bison test positive for exposure to the brucella organism. However, testing positive for exposure (seropositive) does not mean the animal is infected with the disease and capable of transmitting brucellosis. (For example, adult humans who received a smallpox immunization shot during their childhood will test positive for



So far, research shows that bison calves poses no risk to cattle. The risk of brucellosis transmission in the wild occurs only during the time that the afterbirth and its residue remain on the ground. Bison typically consume these materials; any bacteria left behind lives less than two weeks.

antibodies to smallpox even though they are not infected with the disease and cannot transmit it.) Research indicates less than half of seropositive female bison actually carry *Brucella abortus.* Male bison do not transmit the disease in the wild because they do not produce birth materials and they are not near the females during birthing season. It has never been documented that wild bison can transmit the disease to domestic cattle under natural conditions, although this has been achieved under laboratory conditions.

Many other issues about brucellosis are not yet fully resolved. Scientific data on brucellosis in cattle may not necessarily apply to bison. Likewise, the disease may manifest itself differently in the two species. For example, a recent review of published and unpublished data shows that infected bison differ from infected cattle in the way they respond to vaccines, and even standard testing for the disease. Until additional research is completed on wild bison, understanding of the bison host/brucella organism relationship will remain limited.

Elk in the Greater Yellowstone Ecosystem also test positive for the brucella organism, and this reservoir for the disease might be able to reinfect a bison herd. A variety of research projects are currently underway to examine these questions.

Cattle–Bison Conflicts

Federal and state agencies and the livestock industry have spent much time and money to eradicate brucellosis from cattle. States that have accomplished this task receive "brucellosis class-free" status and can export livestock without restrictions and costly disease testing. Montana received this status in 1985.

Brucellosis infections in Montana cattle herds can threaten the state's status and the finances of the rancher involved. When a single cow in a livestock herd becomes infected with brucellosis, the entire herd is quarantined and slaughtered. Federal and state indemnity funds partially compensate the livestock producer for this loss. If the disease spreads to another livestock herd or if a herd is found to be infected and the state does not address the problem, the state could lose its brucellosis class-free status. Such a loss could be costly to Montana livestock producers.

To protect cattle from brucellosis, ranchers may vaccinate their herds. Approximately 95 percent of cattle grazing in the Yellowstone area during summer are vaccinated; under the new management plan *(described on page 137),* 100 percent will be vaccinated. A safe and effective brucellosis vaccine has not yet been developed for wildlife.

Because of concern over losing brucellosis class-free status, some people have wanted bison to be subjected to the same management protocols as livestock in order to achieve the goal of brucellosis eradication. Others believe brucellosis eradication is not possible in wildlife, and bison and livestock can be managed in ways to reduce the risks of transmission.

1985
Montana receives brucellosis-free status; institutes public hunts for bison.

1989
Almost 600 bison killed in public hunt.

1990
Public outcry over hunt causes Montana to end it. NPS prepares environmental assessment enabling park staff to haze and shoot bison outside the park.

1995
Montana files lawsuit against NPS; settlement requires EIS preparation.

Recent History

In 1985, Montana initiated a public hunt as the method to control bison migrating from Yellowstone National Park to areas along the north boundary near Reese Creek and areas along the west boundary near West Yellowstone. The control hunts continued with little notice until the severe winter following the fires of 1988 when 569 bison were killed. The resultant nationwide public controversy about the hunt caused the Montana Legislature to rescind authorization for the hunt.

Beginning in 1990, while Montana and the federal agencies were preparing a long-term plan, Montana needed an interim management plan to protect private property, to provide for human safety, and to protect the state's brucellosis class-free status. NPS complied with an environmental assessment (EA) that provided for limited NPS management of bison through hazing and monitoring, and shooting outside of park boundaries at the request and under the authority of the Montana Department of Fish, Wildlife and Parks. In 1992, the State of Montana entered into an agreement with NPS, the U.S. Department of Agriculture (USDA) Forest Service (USFS) and the USDA Animal Protection Health Inspection Service (APHIS) to develop a long-term management plan and environmental impact statement (EIS) for managing bison migrating from Yellowstone into Montana.

Lawsuit Filed

In January 1995, the state of Montana filed a lawsuit against NPS and APHIS because it believed the federal agencies were not doing enough to protect the state from losing its brucellosis-free status. In the settlement, APHIS agreed that it would not downgrade Montana's brucellosis class-free status based on the presence of exposed bison migrating from Yellowstone into Montana as long as certain actions were taken, including completing another Interim Bison Management Plan.

The Interim Management Plan

The new plan called for NPS to build a facility to capture bison inside Yellowstone National Park at Stephens Creek, along the northern boundary. All bison captured in the facility would be tested for brucellosis; seropositive animals would be shipped to slaughter. Any bison migrating north of the park into the Eagle Creek/Bear Creek area (east of the Yellowstone River) would be monitored and not captured. The Montana Department of Livestock (which, in 1995, had been given state authority to manage bison in Montana) was to capture all bison migrating out of the park at West Yellowstone and test them for brucellosis. All seropositive bison and seronegative pregnant females would be sent to slaughter. Other seronegative bison were to be released on public land. At their discretion, Montana could shoot any untested bison in the West Yellowstone area.

The new Interim Bison Management Plan began during the winter of 1996–97, the most severe winter since the 1940s. Large numbers of bison migrated out the north and west boundaries. By the end of the winter, 1,084 bison had been shot or sent to slaughter. Public outcry was much louder than in 1989.

The winter of 1997–98 was mild, and the state of Montana shot only 11 bison on the west side of the park, and no bison exited the park in the Stephens Creek area. The winter of 1998–99 was also mild, but in April, 94 bison were shipped to slaughter or died during capture operations from the western boundary area of the park.

Draft EIS Released

The draft long-term bison management plan and EIS was released in June 1998. The state was a lead agency along with the NPS and the U.S. Forest Service. APHIS was a cooperating agency. As with any EIS, lead agencies must come to agreement on the alternatives presented and analyzed. In this case, the management objectives of the federal agencies and the state complicated the process.

1996 — *Interim Bison Management Plan begins.*

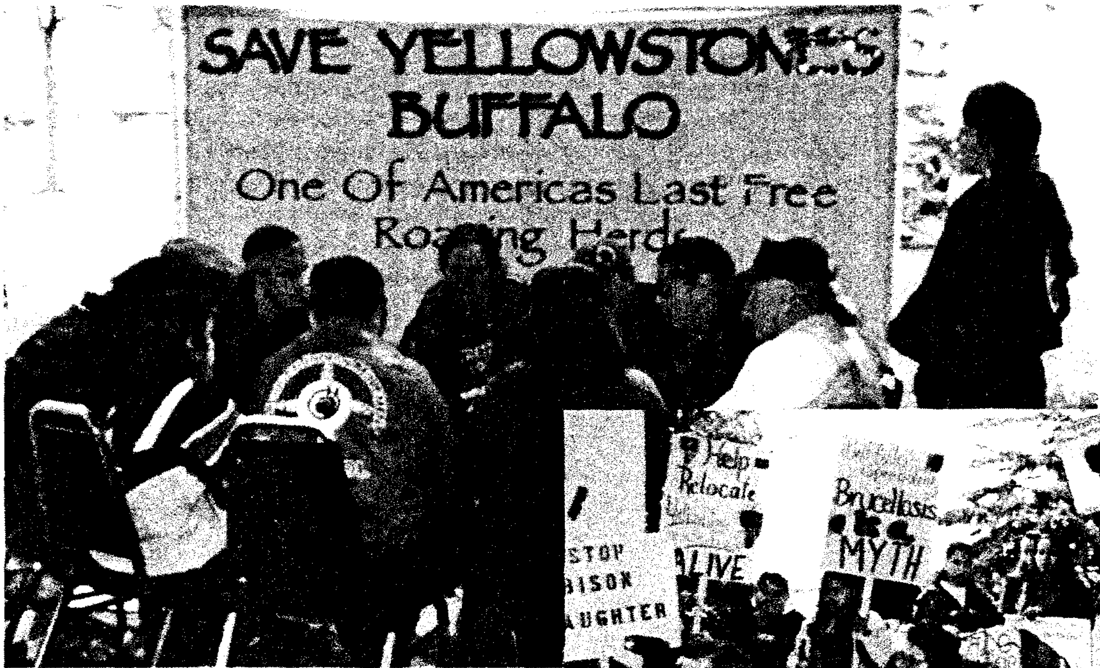
1997 — *Unusually severe winter. More than 1,000 bison shot or shipped to slaughter.*

1998 — *Draft EIS released. More than 67,500 public comments received, most supported less intrusive management.*

1999 — ***August,** almost 8,000 acres of additional winter wildlife habitat acquired by federal government or put under easement. **December,** federal agencies withdraw from a Memorandum of Agreement with the State of Montana to jointly produce an EIS.*

2000 — ***February,** a federal judge orders state and federal agencies into mediation to work out their differences. **August,** Final EIS released and receives several thousand comments. **December,** Records of Decision signed by federal and state governments.*

2002 — *First year of operation for the Bison Management Plan. More than two dozen bison are shipped to slaughter or killed.*



Public hearings on the draft EIS were held around the country. The last one, held in Minneapolis, was preceded by a public rally organized by area tribes.

Seven alternatives with a full range of management techniques were presented for maintaining a wild, free-ranging bison population and minimizing the risk of transmitting the disease brucellosis from bison to domestic cattle on public and private lands in Montana. The alternatives ranged from capturing all bison that leave the park and sending those that test positive to slaughter, to the use of public hunting to control bison, to establishing tolerance zones outside the park boundaries.

The plan received more than 67,500 public comments, the majority of which favored an alternative plan that emphasized protection of bison. Subsequently, the federal agencies developed a modified preferred alternative that minimized the risk of transmission of brucellosis from bison to cattle, worked towards the eradication of brucellosis from the bison herd, and decreased the unnecessary killing of bison.

The Final EIS and Management Plan

During development of the final EIS, further conflicts arose between the lead agencies. The State of Montana was concerned that other states would impose testing requirements on cattle that would increase costs for livestock producers. Montana also wanted all bison to be vaccinated immediately, although no safe vaccine has been found for pregnant female bison, the vaccine effectiveness has not yet been determined, and a safe and effective delivery method currently does yet not exist. Montana was also unwilling to allow seronegative pregnant bison outside park boundaries.

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Bison Management

NPS objectives in the Final EIS and Bison Management Plan:

- *Maintain genetic integrity of the bison population.*
- *Maintain a wild, free-ranging bison population.*
- *Maintain and preserve the ecological function that bison provide in the Yellowstone area, such as their role as grassland grazers and as a source of food for scavengers.*
- *Reduce risk of brucellosis transmission from bison to cattle.*

The lead agencies reached an impasse and in December 1999, the federal agencies withdrew from a Memorandum of Agreement with the State of Montana to jointly produce an EIS. The State challenged this action and a federal judge upheld the federal agencies' withdrawal from the MOU in February 2000. Before formal dismissal of the lawsuit, the state and federal agencies agreed to work out their differences using a court-appointed mediator to facilitate the process beginning in late April 2000. That mediation process lasted until early December 2000.

In August 2000, the *Final Environmental Impact Statement for the Interagency Bison Management Plan for the State of Montana and Yellowstone National Park* was released. After a public comment period, which lasted until mid October, the final management plan was further refined in consultation with the State of Montana and is a slightly altered version of the federal agencies' modified preferred alternative presented in the FEIS. In December 2000, the federal government and the state of Montana released Records of Decision that, while separate documents, support essentially the same plan.

The final management plan uses adaptive management to phase in greater tolerance of bison outside Yellowstone during the next five years. Some bison would be tolerated on public lands during winter, up to 100 along the park's north boundary near Reese Creek and up to 100 along the west boundary of the park. The joint bison management plan provides that some bison outside the park in the western boundary area or near the northern boundary area may be captured and removed regardless of disease status if the late winter or early spring bison population inside the park is above 3,000. Cattle will be vaccinated and monitored in specific areas near Yellowstone National Park. Techniques for bison management could include additional monitoring of bison on public lands outside the park, hazing onto appropriate public lands or back into the park in the spring to avoid lethal removal, and control on public lands outside the park through capture and slaughter or agency shooting. The plan also includes provisions for continued research.

Both state and federal officials describe the plan as being "test driven" and open to refinement as managers and scientists learn more about brucellosis and managing bison and cattle.

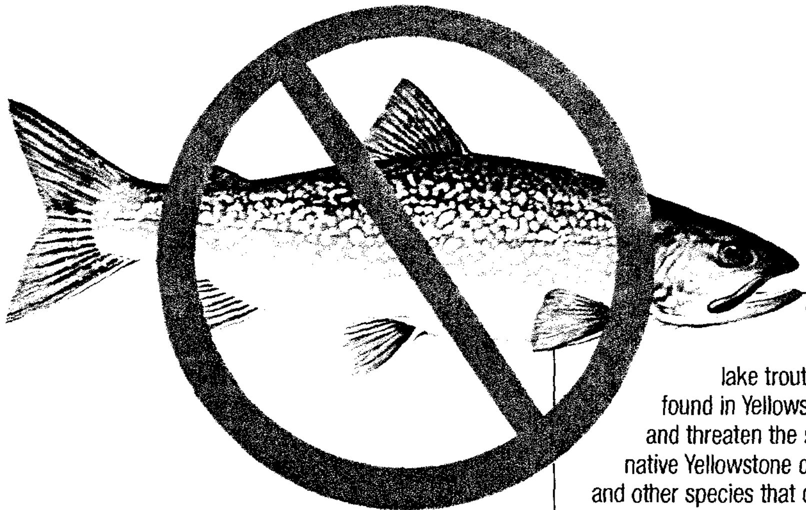
Other Management Efforts

NPS participates in the Greater Yellowstone Interagency Brucellosis Committee (GYIBC), whose goal is to "protect and sustain the existing free-ranging elk and bison populations in the Greater Yellowstone Area (GYA) and protect the public interests and economic viability of the livestock industry in Wyoming, Montana and Idaho." The mission of GYIBC is to develop and implement brucellosis management plans for elk and bison. Objectives include maintaining viable elk and bison populations; maintaining the brucellosis-free status of Wyoming, Montana, and Idaho; aggressively seeking public involvement in the decision making process; and planning for the elimination of Brucella abortus *from the Yellowstone area by the year 2010.*

An NPS–Natural Resources Preservation Program project began research and collection of data on bison ecology and how Brucella abortus *survives and functions in a wild environment. This project involved Grand Teton and Yellowstone national parks, and the information gathered from the research will help managers make sound defensible decisions for the future management of bison and elk in the two parks.*

NPS is also working with the Biological Resources Division of the U.S. Geological Survey in an ongoing research effort to examine the ecology and carrying capacity of bison in Yellowstone National Park. Preliminary results about bison movement in the park suggest that the animals do not travel on groomed roads as much as expected, but tend to follow rivers and other natural corridors.

More results for the various research projects are expected in 2002.



The Issue

Non-native lake trout have been found in Yellowstone Lake and threaten the survival of native Yellowstone cutthroat trout and other species that depend on the native trout.

History/Background

- During the time that the park stocked fish, lake trout were introduced to Lewis and Shoshone lakes.
- In 1994, an angler caught the first verified lake trout in Yellowstone Lake.
- No one knows how lake trout were introduced into Yellowstone Lake, but it probably occurred 10–30 years ago.
- One lake trout can consume up approximately 50–60 cutthroat trout per year.
- If no action is taken, cutthroat trout in Yellowstone Lake would likely decline by 50% in 20–50 years.
- Many wildlife species, including the grizzly bear and bald eagle, may depend on the cutthroat trout for a portion of their diet.
- Lake trout are not a substitute food because they live at much greater depths than cutthroat trout and spawn in the lake rather than in shallow tributaries.

Current Status

- The fisheries staff is removing lake trout by gill-netting: more than 40,000 lake trout have been removed this way since 1994 (almost 16,000 in 2001 alone).
- Regulations encourage anglers to catch lake trout; 1,500 per year are caught.
- Biologists are researching the abundance and distribution of lake trout in Yellowstone Lake.
- With continued aggressive control efforts, lake trout numbers can be reduced and the impacts to cutthroat trout lessened.

During the late 1880s when the Army administered Yellowstone National Park, the U.S. Fish Commission (a predecessor of today's U.S. Fish and Wildlife Service) was invited to stock non-native fish in some of the park's waters. Lake trout (also called Mackinaw) were brought from their native Great Lakes and planted in Lewis Lake.

Lake trout were never officially stocked in Yellowstone Lake, which had a healthy population of Yellowstone cutthroat trout. However, on July 29, 1994, a young girl fishing on Yellowstone Lake reeled in a fish that was a lake trout. The species must have been introduced—there is no natural way for lake trout to have gotten into the lake.

The lake trout is a large and aggressive predatory fish that has decimated cutthroat trout in other western waters. If its population is not controlled in Yellowstone Lake, the impacts will reach far beyond the cutthroat trout population. It has the potential to be an ecological disaster.

In early 1995, a group of experts convened to review the situation, exchange information, and make recommendations. They recommended gill-netting for lake trout at areas of steep drop-offs where lake trout are thought to concentrate.

Netting Lake Trout

Lake trout gill-netting begins in late May or early June after ice is gone from the lake, and continues into October. Three different netting strategies are employed: control, distribution, and spawning. Control netting is primarily comprised of small-mesh (less than two-inch) gill nets strategically placed to capture small lake trout while minimizing cutthroat trout bycatch. Distribution netting means nets are set at the same sites each year to monitor the distribution of both adult and immature lake trout. Both large- and small-mesh nets are used to capture all sizes of lake trout. Distribution netting has shown that most adult lake trout are in the West Thumb Basin and Breeze Channel areas. Spawning net strategy targets spawning grounds during the fall spawn.

Since lake trout control operations began in 1994, more than 43,000 lake trout have been caught. Gill net operations not only remove lake trout from Yellowstone Lake, but also provide valuable population data on this non-native species. Information on population size, age structure, maturity, and potential new spawning areas all lead to more effective control of this species. For example, during 1996, a lake trout spawning area was discovered in the West Thumb region of Yellowstone Lake at Carrington Island.

The Role of the Cutthroat Trout

Cutthroat trout may be an important food source for more than 40 animal species in the ecosystem, including the threatened bald eagle and grizzly bear. Native Yellowstone cutthroat trout are available to predators because they spend most of their lives at or near the surface of the water in the lake. Cutthroat trout also spawn in the lake's tributaries in the spring. Grizzly bears seek this high protein food. Lake trout are not available as prey because they spend most of their lives in deep water and spawn in the lake.

Scientists radio-tagged and released fish here to learn more about lake trout movements. They also found a second spawning area in West Thumb between Breeze Point and the mouth of Solution Creek. Hydroacoustic work (using sonar-based fish finders) done in 1997 confirmed lake trout were concentrated in the western portion of Yellowstone Lake. These surveys also revealed medium-sized (12–16 inches) lake trout tended to reside in deep water (greater than 130 feet). This is deeper than the Yellowstone cutthroat reside and now scientists can more easily target lake trout without harming cutthroat trout. Hydroacoustic data also provides minimum abundance estimates of both cutthroat and lake trout, which is invaluable information for long-term evaluation of our efforts.

Anglers are also an important component in the lake trout management program. They have had the most success in catching lake trout that are between 15 and 24 inches long. These fish are found in shallow, near-shore waters in June and early July. To date, anglers have taken approximately 4–5 percent of the lake trout removed from Yellowstone Lake. Fishing regulations require anglers to kill all lake trout caught in Yellowstone Lake and its tributaries. In 2001, regulations were further refined to restrict all cutthroat trout fishing to catch-and-release only.

About 80 percent of a lake trout's diet consists of cutthroat trout. Based on lake trout predation studies in Yellowstone Lake, fisheries biologists estimate that approximately 50 to 60 cutthroat trout are saved for every lake trout caught.

Lake trout cannot be eliminated from Yellowstone Lake. However, ongoing management of the problem can control lake trout population growth, maintain the cutthroat trout population, and, thus, maintain this incredible ecological link between Yellowstone Lake and its surrounding landscape.

Above: Two lake trout held up by a fisheries biologist.
Left: Lake trout caught in gill nets.

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Issues: Fisheries, Whirling Disease

The Madison River in western Montana has long been considered a stable, world-class trout fishery. However, beginning in 1991, studies in a section of the river outside Yellowstone National Park indicated this was changing. The population of rainbow trout in the study section was declining dramatically. Testing completed in late 1994 confirmed the presence of whirling disease, which scientists believe is one of the factors in the decline.

The Issue

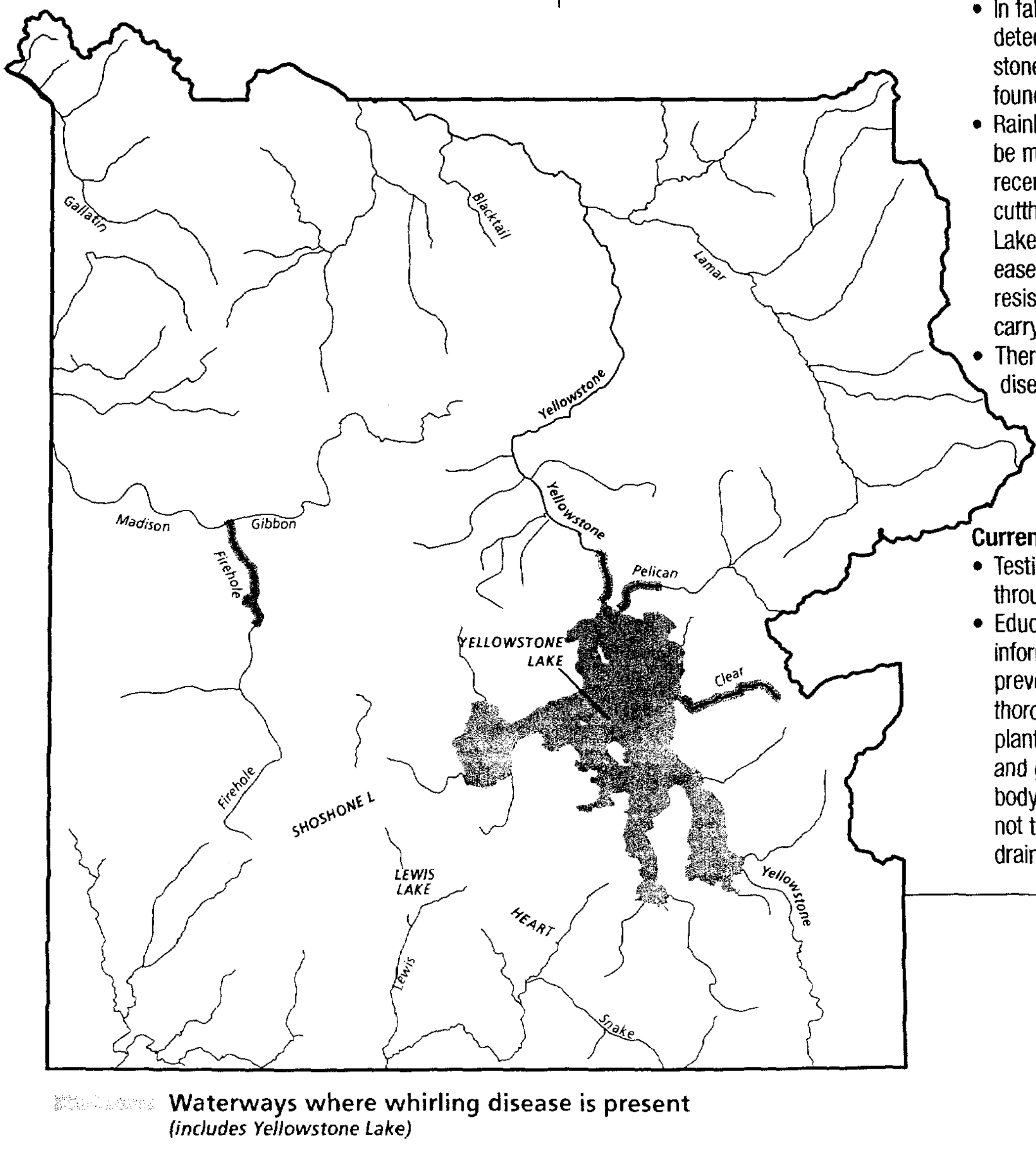
Whirling disease is caused by a parasite that attacks the developing cartilage of young fish, resulting in skeletal deformities and may cause a whirling behavior. Affected fish cannot feed normally and are vulnerable to predation.

History/Background

- The disease was first described in Europe more than 100 years ago. It was detected in the U.S. in the mid 1950s.
- It most likely came to the U.S. in frozen fish products.
- Whirling disease has been confirmed in 20 states and appears to be rapidly spreading throughout the western United States.
- In fall of 1998, whirling disease was detected in cutthroat trout in Yellowstone Lake; in 2000, the parasite was found in the Firehole River.
- Rainbow trout populations appear to be most susceptible to the disease; recent laboratory tests suggests that cutthroat trout are also susceptible. Lake trout appear immune to the disease, and brown trout are highly resistant, but can be infected and can carry the parasite.
- There is no treatment for the disease.

Current Status

- Testing for whirling disease continues throughout the park.
- Education efforts are ongoing to inform the public how to help prevent the spread of the disease by thoroughly cleaning mud and aquatic plants from all equipment, clothes, and gear before moving to another body of water or watershed; and by not transporting fish between drainages.



Waterways where whirling disease is present
(includes Yellowstone Lake)

8

Fisheries, Whirling Disease

Whirling disease is caused by a microscopic parasite that can infect trout and salmon; it does not infect humans. The parasite attacks the developing cartilage of fish between 1–6 months old and causes deformities of the bony structures. An infected fish may have a deformed head and tail, blackened areas of the tail, and whirling swimming behavior. It may be unable to feed normally and is vulnerable to predation.

State-to-state transmission has often been attributed to the transport of hatchery fish. More recently, rigorous testing and strict policies have targeted both state and private hatcheries to reduce this threat. Little information exists on how the parasite moves from one drainage to another in the wild.

In Montana, in addition to the Madison River, the disease has been found in the Gallatin and Yellowstone rivers. A Whirling Disease Task Force has been formed to find solutions to the problem. In a June 1996 report, the task force stated that whirling disease is "the most significant threat to wild, native and nonnative naturally reproducing trout populations in Montana." The report went on to state, "the relevant question appears no longer to be if whirling disease will spread, but how long it will take to happen." The task force has recommended an aggressive program of research, management, communication, and education in an effort to find workable solutions to protect, preserve, and restore self-sustaining native wild trout populations in Montana.

In Yellowstone National Park, multi-year surveys for whirling disease have been completed for variety of sites, including Soda Butte Creek and the Bechler, Firehole, Gibbon, Gallatin, and Gardner rivers; all except the Firehole have tested negative for the parasite. Whirling disease is also present in Yellowstone Lake.

No effective treatment exists for wild trout infected with this disease or for the waters containing infected fish. Therefore, anyone participating in water-related activities, including anglers, boaters, or swimmers, are encouraged to take steps to help prevent the spread of the disease. This includes thoroughly cleaning mud and aquatic vegetation from all equipment and inspecting footwear before moving to another drainage. Anglers should not transport fish between drainages and should clean fish in the body of water where they were caught.

8

Issues: Grizzly Recovery Plan

The Issue

The grizzly bear is listed as a threatened species; the management goal is to recover the species to self-sustaining, viable population that no longer needs protection.

History/Background

- Debates on grizzly recovery center on variations of two points of view:
1. The animal is doomed to extinction.
2. The population has recovered and should be removed from the threatened and endangered list.
- The current population is estimated to be 280–610 animals.
- Habitat loss and development on land outside the park continue to threaten the survival of the grizzly bear.
- 40–80 radio-collared grizzlies are monitored to track population trends and habitat use.
- The Draft Conservation Strategy has been released for public comment. *See the next section for more information.*

Current Status

- Three goals must be achieved before the grizzly bear population is considered recovered:
1. To have an average of 15 adult females with cubs of the year on a 6-year running average inside the recovery zone and within a 10-mile area surrounding the recovery zone.
2. To have 16 of 18 recovery zone Bear Management Areas occupied by females with young from a running 6-year sum of observations; no two adjacent areas shall be unoccupied.
3. To have the known human-caused mortality below 4% of the population estimate based on the most recent three-year sum of females with cubs minus known, adult female deaths. In addition, no more than 30% of the known human-caused mortality shall be females. These mortality limits cannot be exceeded during any two consecutive years.
- The goals were met in 1994, 1998, 1999, 2000, and 2001; they were not met in 1995, 1996, and 1997.

On July 28, 1975, under the authority of the Endangered Species Act (ESA), the U.S. Fish and Wildlife Service listed the grizzly bear as a threatened species. A primary goal of the ESA is to recover threatened or endangered species to self-sustaining, viable populations that no longer need protection. As part of this goal, recovery parameters for the grizzly bear were established in the 1993 Grizzly Bear Recovery Plan. Under this plan, three population recovery goals must be achieved before the grizzly bear is considered recovered.

Parameter 1: Females With Cubs

Adult female grizzly bears with cubs-of-the-year (COY) are the most reliable segment of the population to count. Since 1975, more than 400 grizzly bears have been radio-marked. Using aerial and ground observations by reliable observers (determined by the leader of the Interagency Grizzly Bear Study Team [IGBST], and a committee of agency biologists), a minimum number of unduplicated females with cubs is recorded each year. The number of cubs per litter and pelage color combinations of different family groups (and the presence of radio-collars marking some individual bears) aid in identifying individual adult females. Adult female grizzly bears in the Yellowstone ecosystem generally have a three-year breeding interval. Therefore, 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.

Recovery Goal: To have an average of 15 adult females with COY on a 6-year running average both inside the recovery zone and within a 10-mile area immediately surrounding the recovery zone.

Rationale: The purpose of this goal is to estimate an average minimum population size and to demonstrate that a known minimum number of adult females are alive so that reproduction is sufficient to sustain existing levels of human-caused bear mortality in the ecosystem. The target number of 15 unduplicated females with COY must be attained as a running 6-year average. A running 6-year average accounts for two breeding cycles and will allow at least two years when each live adult female can be reported with cubs. The 6-year average number of unduplicated females with cubs is not intended to

determine precise population size or trend but to derive a minimum population estimate.

Current Status: The annual average number of unduplicated females with COY (1996–2001, 6-year average) is 35. This recovery goal is currently being achieved.

Parameter 2: Distribution of Females With Cubs

To monitor grizzly bear population trends and to analyze the consequences of human activities and development on bears, grizzly bear habitat within the recovery zone has been divided into 18 habitat units called Bear Management Units (BMUs). Ideally, each unit should contain complete spring, summer, and fall habitat for grizzly bears. For most of the units, there is substantial evidence that the habitat contains adequate food sources to support grizzly bears in these three seasons.

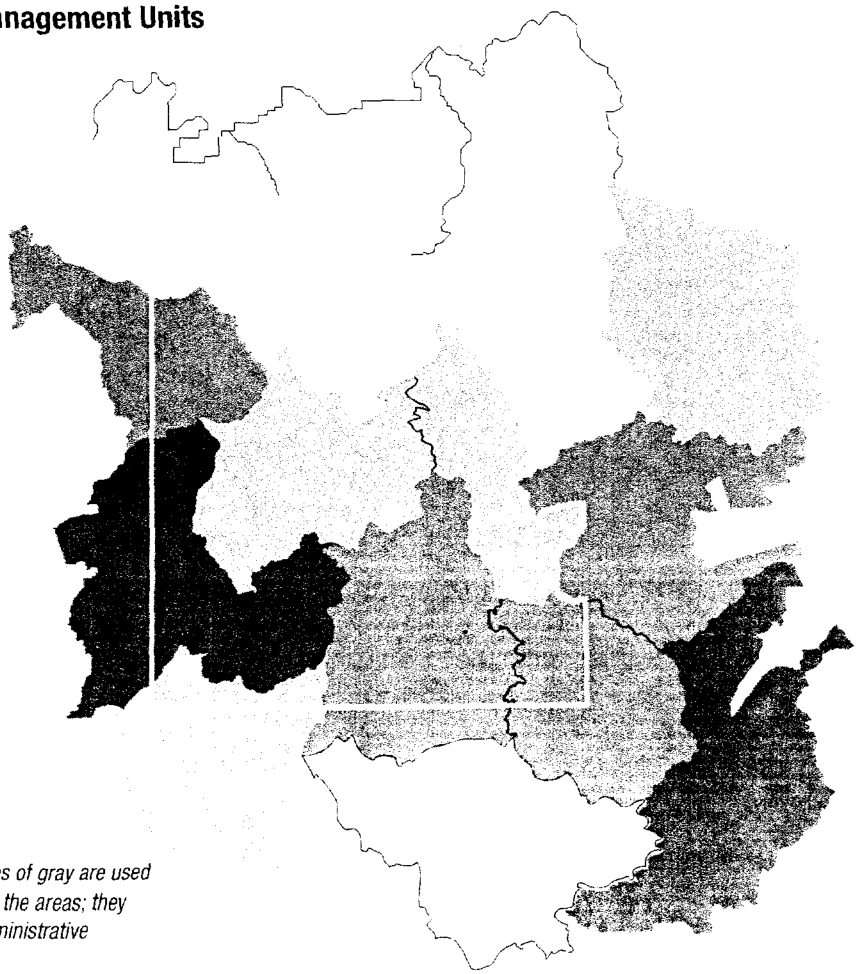
Recovery Goal: To have 16 of 18 BMUs occupied by females with young from a running 6-year sum of observations, and no two adjacent BMUs shall be unoccupied. Occupancy requires verified evidence (sightings or tracks) of at least one female with young (COY, yearling, or two-year-old) at least once in each of 16 BMUs during a 6-year period.

Rationale: The purpose of this parameter is to demonstrate an adequate distribution of reproductive females within the recovery zone. Adult female grizzlies have a strong affinity for their home range. Distribution of family groups of bears indicates a likelihood of continued occupancy of each BMU, because grizzly bear offspring, especially females, tend to occupy habitat within or near the home range of their mother after being weaned. This parameter assumes that successful reproduction is an indicator of sufficient habitat being available to bears and provides evidence that available habitat is being managed adequately.

Current Status: From 1996 through 2001 (6-year running sum), all 18 BMUs were occupied at least once with family groups. This recovery goal is being achieved.

In addition to these three biological goals, habitat-based recovery parameters must be established and there must be a demonstration that "adequate regulatory mechanisms" are in place to ensure conservation of the species if and when it should be removed from the special protections granted by the ESA. (See next section for information on the conservation strategy.) When all these goals have been met, the grizzly bear may be considered for delisting from its threatened status.

Bear Management Units



Note: Shades of gray are used to delineate the areas; they have no administrative meaning.

Parameter 3: Mortality

The rate of human-caused grizzly bear mortality, especially of adult females, is a key factor influencing the potential recovery of the population in the Yellowstone ecosystem. Known human-caused mortalities in excess of the level sustainable at a given number of females with cubs could result in population decline, while mortalities below this level would likely result in population increase.

Recovery Goal: The known human-caused mortality shall not exceed 4 percent of the population estimate based on the most recent three-year sum of females with cubs minus known, adult female deaths. In addition, no more than 30 percent of the known human-caused mortality shall be females. These mortality limits cannot be exceeded during any two consecutive years for recovery to be achieved.

Rationale: The level of sustainable mortality is directly related to the number of females with cubs. Grizzly bear populations probably can sustain 6 percent human-caused mortality without population decline. To facilitate recovery and account for unknown, unreported, human-caused mortality, the mortality goal is set at no more than 4 percent of the minimum population estimate, with no more than 30 percent of this mortality being females. The most recent 3-year sum of unduplicated females with cubs is used to calculate a minimum population estimate. This method applies the proportion of adult females in a population to the minimum number of adult females known to be alive. Mortality limits are recalculated annually based on population monitoring.

Current Status: The allowable, known human-caused mortality limit for 1999 was 14 bears (4 percent of the population estimate of 348 bears). The annual average of known, human-caused grizzly bear deaths (1994–1999) was 8 bears per year or two percent of the present minimum population estimate of 348 bears. This total mortality goal was achieved. The allowable human-caused mortality of adult females for the period was 4 bears (30 percent of the total allowable of 14). The 6-year average of annual, known human-caused female mortality was 3 female bears per year. This portion of the mortality goal is currently being achieved.

Status of Grizzly Recovery Goals

	94	95	96	97	98	99	00	01
Goal 1 Average of 15 adult females with COY for 6 years in and around the recovery zone.	✔	✔	✔	✔	✔	✔	✔	✔
Goal 2 16 Bear Management Units occupied by females with young for 6 years.	✔	✔	✔	✔	✔	✔	✔	✔
Goal 3 4% or less human-caused mortality; female bears comprise 30% or less of mortalities.	✔				✔	✔	✔	✔

8

Issues: Grizzly Conservation Strategy

The Issue

If the threatened grizzly bear is delisted, a conservation strategy would ensure that population and habitat parameters continue to be achieved.

History/Background

- A team of biologists and managers from the USFS, NPS, USFWS and the states of Idaho, Wyoming, and Montana completed the Draft Conservation Strategy for the Grizzly Bear in the Yellowstone Ecosystem in March 2000.
- Public meetings were held in the three surrounding states (Montana, Wyoming, and Idaho) to obtain comments on the strategy.
- 16,794 public comments were received.
- The strategy contains population and habitat triggers that initiate relisting of the species if the population or habitat fall below certain threshold levels.
- The strategy plans to secure habitat and to monitor:
  1. changes in genetic diversity in the Yellowstone grizzly population
  2. four major food sources (cutthroat trout, army cutworm moths, ungulate carcasses, and whitebark pine cones)
  3. bear predation of livestock
  4. development of private land inside the recovery area
  5. numbers of elk hunters and hunter-related bear deaths
  6. cub production, mortality, and distribution

Current Status

The team is writing responses to significant comments.

The Strategy's Role in Recovery

Habitat-based recovery criteria and a conservation strategy define measures needed to ensure that the Yellowstone grizzly bear population remains at or above the recovery levels described in the Recovery Plan *(see previous section).* They also demonstrate and reaffirm the commitment of the state and federal agencies to continue maintaining the Yellowstone grizzly bear and its habitat.

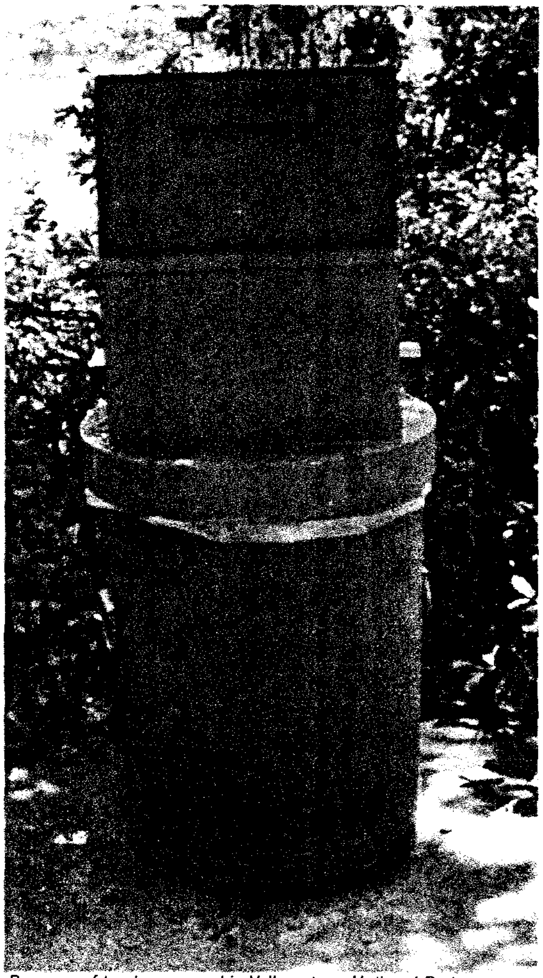
The conservation strategy is the primary long-term guide for managing and monitoring the grizzly bear population and assuring sufficient habitat to maintain recovery. It emphasizes the importance of continued coordination and cooperative working relationships among management agencies, landowners, and the public to ensure public support, continue application of best scientific principles, and maintain effective actions to benefit the continued coexistence of grizzlies and humans in the ecosystem. It incorporates existing laws, regulations, policies, and goals such as those already outlined in the Grizzly Bear Recovery Plan.

Flexibility In the Strategy

Under the proposed strategy, management of the grizzly and its habitat would have increased flexibility in several key areas:

- The existing recovery zone would be a Primary Conservation Area (PCA) in which grizzly/human conflict management and bear habitat management would be high priorities. Decisions would favor the bear population when grizzly habitat and other land uses are incompatible. In developed areas, grizzly bears will be actively discouraged and controlled.
- State wildlife agencies have primary responsibility to manage grizzly bears outside of national parks. National forests and parks will continue to manage habitat within their jurisdictions.
- The goal remains to sustain a grizzly bear population in the Greater Yellowstone Ecosystem, with an average of at least 15 unduplicated female bears with cubs distributed in 18 Bear Management Units (BMUs) across the ecosystem and with no more than 4 percent known mortality of bears on average. The goal is to maintain or improve habitat conditions for grizzly bears within the PCA.
- State and federal wildlife managers will continue to monitor the grizzly population and habitat conditions using the most feasible and accepted professional techniques. These include the maintenance of a marked (radio-collared) sample of bears and scientific methods to assess habitat conditions and changes on a broad geographic scale; this will require a long-term interagency commitment of professional wildlife biologists.

- Removal of nuisance bears will be conservative, consistent with mortality limits outlined above, and removal of female grizzly bears will be minimized. Managers will emphasize removal of the human cause of conflict rather than removal of a bear when possible.


Bear-proof trash can used in Yellowstone National Park

- Managers will continue to meet periodically to share information, implement coordinated management actions, assure data collection, and identify research and financial needs across state and federal jurisdictions.
- Managers have more flexibility to manage nuisance grizzlies, particularly male bears. Bears may be relocated as many times as judged prudent by management authorities. However, no bears may be removed without at least one relocation unless involved in unnatural aggression toward humans.
- Management areas, previously used to delineate differences in land-management strategies, are eliminated. No distinction is made across the PCA as to management zones or "situation lines." Decisions affecting grizzly bears and/or their habitat would be made based on existing and future management plans incorporating input from biologists, other professional land managers, and affected publics.
- Outside the PCA and areas currently occupied by grizzly bears, state and federal land management plans will define where grizzly bear occupancy will be acceptable. These decisions will be made through planning processes that involve affected groups and individuals.

What Is Next

If the grizzly bear population goals outlined in the Grizzly Bear Recovery Plan continue to be met and habitat goals are established, consideration will be given to delisting the greater Yellowstone grizzly bear population. Completion of a conservation strategy does not in itself propose or accomplish a change in status of the grizzly bear population. The conservation strategy is a commitment by the responsible agencies to long-term management of grizzly bears and their habitat in ways that are compatible with human occupation and enjoyment of greater Yellowstone.

Management reviews will be conducted when conditions deviate from the desired long-term goals for the grizzly bear population and/or its habitat. If a change occurs in the protected status of the grizzly bear population, such reviews may result in a recommendation for a formal status review by the U.S. Fish and Wildlife Service. If and when conditions warrant, a delisted population could be relisted for protection under the Endangered Species Act.

Non-Debatable Topics

The Interagency Grizzly Bear Committee and the U.S. Fish and Wildlife Service view some of the topics discussed in the conservation strategy as non-debatable. These include:

- The continued population goal to have at least 15 unduplicated female bears with cubs distributed in 18 Bear Management

Units (BMUs) across the ecosystem. Continuation of this requirement maintains a minimum level and distribution of grizzly bears that has allowed us to achieve the positive trend in the population as seen during the past decade.

- The size of the existing recovery zone, which would be managed as a Primary Conservation Area (PCA). The existing zone has been sufficient to achieve the population growth seen during the past decade.
- The legally established jurisdiction for wildlife management (primarily vested in the states, except on lands of exclusive federal jurisdiction such as Yellowstone National Park.)

However, public involvement will be important to managers as they finalize this statement of long-term management goals and guidelines. Topics on which public input is desired include:

- How should nuisance bears be managed to allow desired multiple land uses while meeting mortality goals necessary to maintain a healthy grizzly population?
- Where and under what conditions should grizzly bears be tolerated outside the existing recovery zone/PCA?
- How should habitat conditions needed to sustain a healthy grizzly bear population be monitored and maintained?
- How should the continued costs of monitoring and managing a grizzly bear population across the greater Yellowstone area be paid for?

8

Issues: Northern Range

The Northern Range refers to the broad grassland that borders the Yellowstone and Lamar rivers in the northern quarter of the park *(map next page)*. This area sustains one of the largest and most diverse populations of free-roaming large animals seen anywhere on earth. Many of the park's ungulates spend the winter here. Elevations are lower and the area receives less snow than elsewhere in the park. Often the ridge tops and south-facing hillsides here are clear of snow, a result of wind as well as snowmelt during the many sunny winter days. Animals take advantage of this lack of snow, finding easy access to forage.

History

From the time the U.S. Army arrived in 1886 until the 1930s, wildlife management in Yellowstone was mainly seen as protecting the ungulates from poachers, natural predators, and other threats. Wildlife biology was in its infancy, and management practices encouraged the attitude that wildlife was either "good" or "bad." This view led to the elimination of many predators from most of the western United States, including Yellowstone. In the park, protection from

The Issue

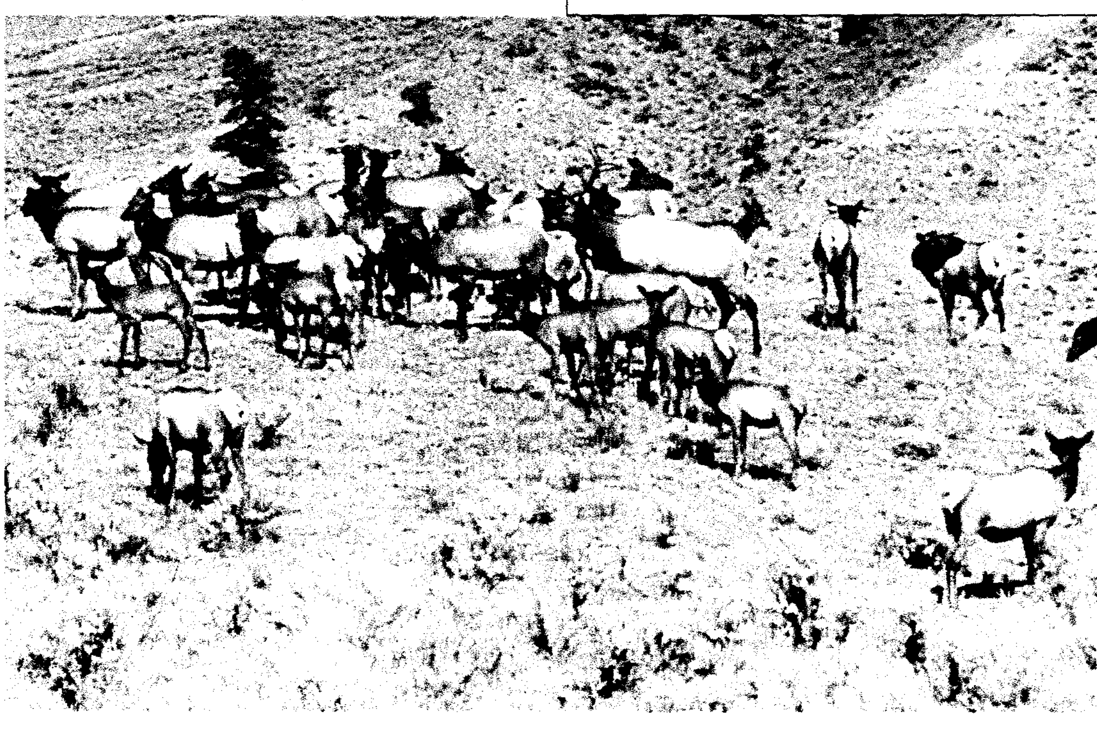
Some scientists believe the park has more ungulates (hoofed mammals) than the Northern Range can sustain. Elk, bison, and pronghorn are blamed for overgrazing, and for increased erosion and declines in willows, aspen, and beaver. Other scientists have found no evidence that the park's grasslands are overgrazed.

History/Background

- For decades, the park intensively managed elk, bison, and pronghorn.
- The park discontinued wildlife reductions in 1968 due to the growing belief that wildlife populations can self-regulate.
- In the 1970s and early 1980s, scientific and public concerns grew about the increasing population of ungulates on the Northern Range.
- In 1986, Congress mandated a major research initiative to answer these concerns. Results found that the Northern Range was healthy and that elk did not adversely affect the overall diversity of native animals and plants.
- The interaction of ungulates, climate, hydrology, beaver and aspen or woody shrubs such as willows is equivocal and more scientific research is needed.

Current Status

- Despite scientific conclusions to the contrary, some people continue to claim that the Northern Range is overgrazed.
- In 1998, Congress called for the National Academy of Sciences to review management of the Northern Range. Results were released in March 2002.
- In March 2000, in response to new controversy about the impact of wolves on the elk herds of the Northern Range, three independent researchers began a 5-year investigation of this elk population and the impact of wolf restoration.



predators caused an increase in ungulate numbers.

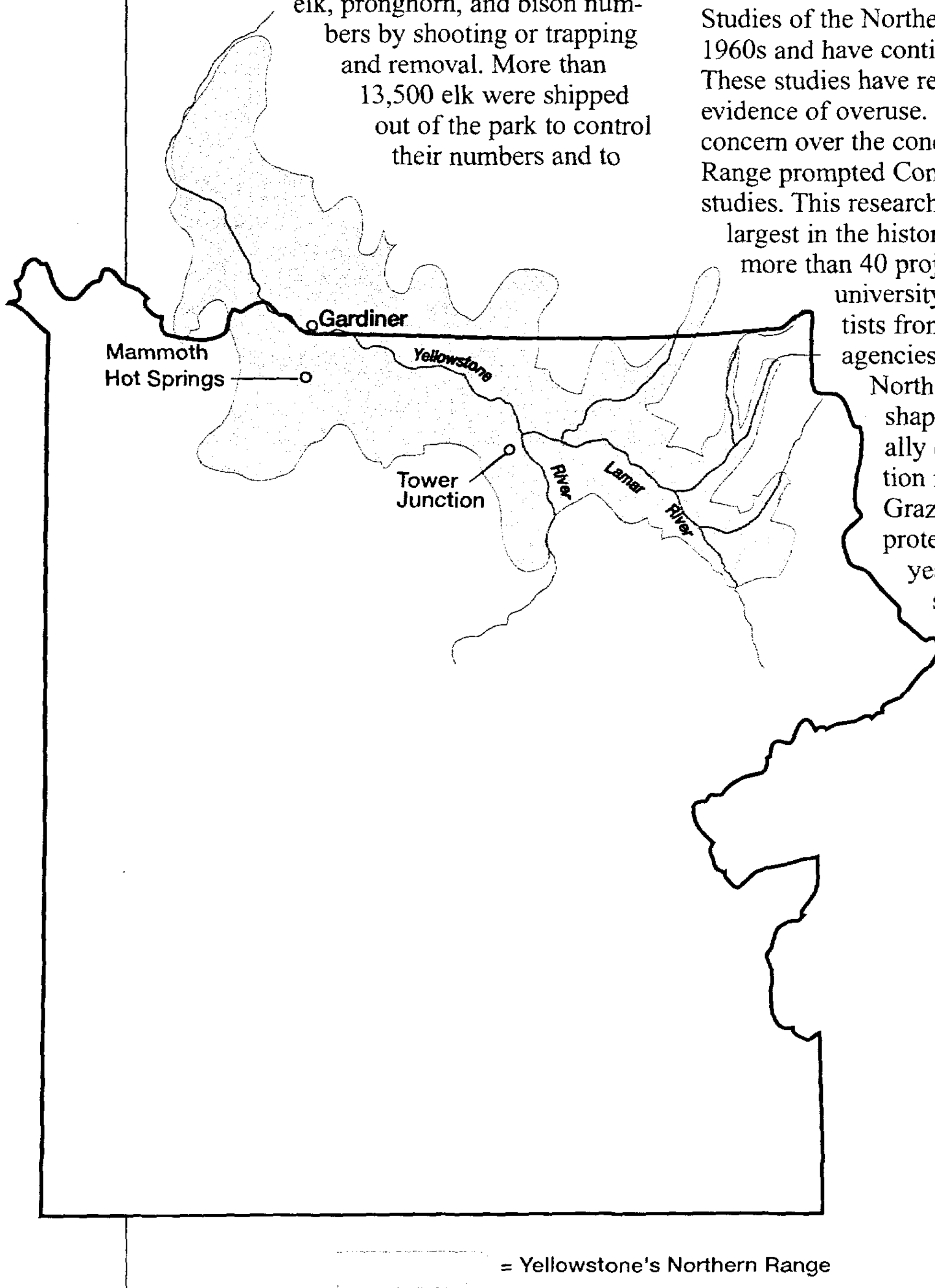
Early censuses of the elk in the park, especially on the Northern Range, are highly questionable. By the early 1930s, scientists and managers believed that grazing and drought in the early part of the century had reduced the range's carrying capacity and that twice as many elk were on the range in 1932 as existed there in 1914.

From 1935 to 1968, park rangers controlled elk, pronghorn, and bison numbers by shooting or trapping and removal. More than 13,500 elk were shipped out of the park to control their numbers and to repopulate areas where over-harvesting or poaching had eliminated elk.

By the 1960s, scientists and wildlife managers had begun to understand complex interconnections existed among and between living and non-living components of ecosystems. In Yellowstone, scientists suggested that ungulate populations could be self-regulating, and, as a result, wildlife reductions were discontinued in 1968.

Research Results

Studies of the Northern Range began in the 1960s and have continued to the present. These studies have revealed no clear evidence of overuse. In 1986, continuing concern over the condition of the Northern Range prompted Congress to mandate more studies. This research initiative, one of the largest in the history of NPS, encompassed more than 40 projects by NPS biologists, university researchers, and scientists from other federal and state agencies. Results found that the Northern Range was in good shape. Ungulate grazing actually enhances plant production in all but drought years. Grazing also enhances protein content of grasses, yearly growth of big sagebrush, and seedling establishment of sagebrush. No reductions in root biomass or increase in dead bunchgrass clumps were observed. However, studies on aspen and willows and their relationship to ungulates on the Northern Range are not so clear-cut and are continuing. Despite these results, the belief that elk grazing is damaging Northern Range vegetation and that grazing accelerates erosion persists among many people, including some scientists.



Continuing Controversy

In 1998, Congress again intervened in the controversy. It called for the National Academy of Sciences to review management of the Northern Range. This two-year study began in 1999; results were released in March 2002 *(see sidebar at right)*. Another study began in March 2000 to investigate elk population responses to wolf restoration.

In part, the controversy is likely due to the personal or scientific background of each person. Many urban dwellers live among intensively managed surroundings (community parks and personal gardens and lawns) and are not used to viewing wild, natural ecosystems. Livestock managers and range scientists tend to view the landscape in terms of maximizing the number of animals that a unit of land can sustain. Range science has developed techniques that allow intensive human manipulation of the landscape for this goal, which is often economically based. Many ecologists and wilderness managers, on the other hand, have come to believe that the ecological carrying capacity of a landscape is different from the concept of range or economic carrying capacity. They believe that the only constant in a naturally functioning wilderness ecosystem is variability and change. What may look bad, in fact, may be normal.

Change on the Northern Range

During the 1990s, the ecological carrying capacity of the Northern Range increased as elk colonized new winter ranges north of the park that had been set aside for this purpose. Summers were also wet (resulting in better plant production) while winters were (generally) mild. The fires of 1988 also had opened many forest canopies, allowing more grasses to grow.

Many scientists believe that winter is the major factor influencing elk populations. Mild winters allow many more elk to survive until spring, but severe winters result in significant levels of winter kill for many animals, not just elk. In severe winters (like the winter of 1988–89 or 1996–97), up to 25 percent of the herd can die. The northern Yellowstone elk herd demonstrates the ecological principle of density-dependence: overwinter calf mortality, yearling mortality, and adult bull mortality all increase with higher elk population densities. Elk are also continuously subjected to predation by other species in the ecosystem, including bears, wolves, coyotes, and mountain lions. The complex interdependence of these relationships results in fluctuations in the elk population—when there are lots of elk, predator numbers increase, which, in part, helps to reduce elk numbers.

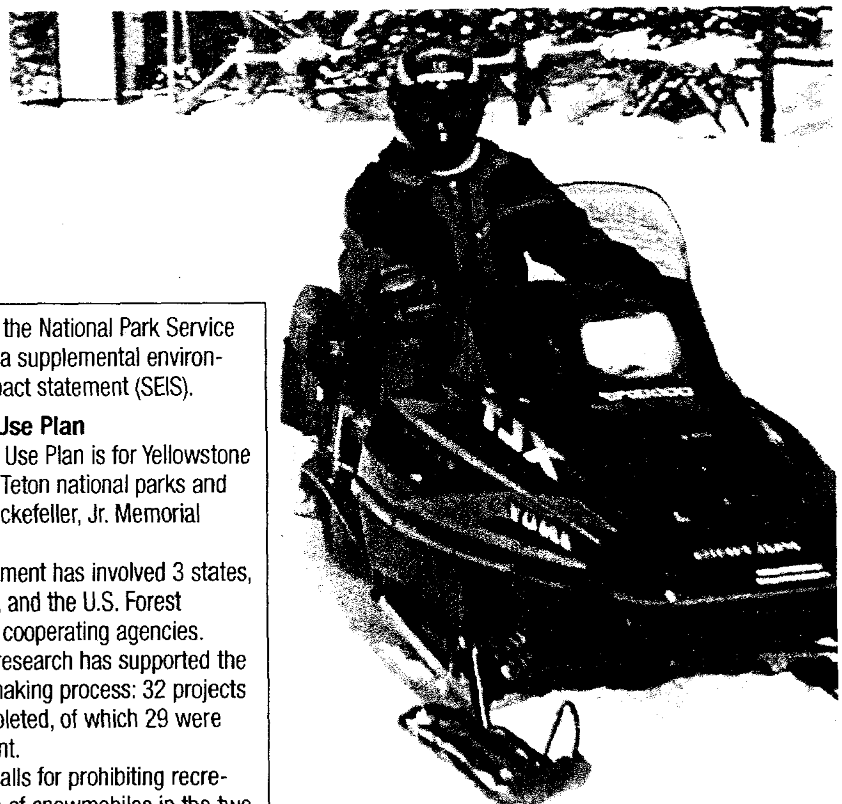
National Park Service policies not only protect native species but also protect the ecological processes that occur naturally across the landscape. Whenever possible, human intervention is discouraged. While controversy continues about the Northern Range and NPS management practices, a myriad of research projects continue in an effort to more accurately describe what is happening on Yellowstone's Northern Range.

Northern Range Report Released

The National Research Council's report, Ecological Dynamics on Yellowstone's Northern Range, *is now available on the internet at www.nationalacademies.org or through a link with Yellowstone's website, www.nps.gov/yell. The report will be published in book form later this year.*

8

Issues: Winter Use



The Issue

Winter recreation in Yellowstone National Park proceeded for 37 years without compliance with the applicable laws and executive orders, thus, with little thought about its appropriateness and impact on the ecosystem.

History

1949, winter: 35 visitors entered the park by snowplane

1955, winter: 507 entered by snow-coach

1963, winter: six snowmobiles entered the park.

1992, winter: visitation exceeded threshold of 140,000 people, which was projected in a 1990 winter use plan.

1993: In accordance with the 1990 plan, a Visitor Use Management process began and resulted in an interagency evaluation of winter recreation in the Greater Yellowstone Area (GYA), completed in 1999.

1997: Fund for Animals filed lawsuit; resulted in NPS signing an agreement requiring the development of a new winter use plan and environmental impact statement (EIS).

1999: The draft EIS was released in July; it received more than 48,000 public comments.

2000, October: The final EIS was released and received about 11,000 public comments.

2000, November: A record of decision (ROD) was signed on the 22nd.

2000, December: The Secretary of the Interior, et al., were named as defendants in a lawsuit brought by the International Snowmobile Manufacturers Association, et al

2001, January: The final rule was published in the Federal Register.

2001, June: Settlement agreement was reached; The Department of Interior committed the National Park Service to prepare a supplemental environmental impact statement (SEIS).

The Winter Use Plan

- The Winter Use Plan is for Yellowstone and Grand Teton national parks and John D. Rockefeller, Jr. Memorial Parkway.
- Its development has involved 3 states, 5 counties, and the U.S. Forest Service as cooperating agencies.
- Extensive research has supported the decision-making process: 32 projects were completed, of which 29 were independent.
- The ROD calls for prohibiting recreational use of snowmobiles in the two national parks and the parkway in the winter of 2003–2004.
- The final rule provides for interim actions to reduce the impacts of snowmobile use during the winter use season of 2002–2003. The following winter, only oversnow motorized recreation access by NPS-managed snowcoach, with limited exceptions for snowmobile access to other public and private lands adjacent to or within Grand Teton National Park.

Current Status

The existing rule remains in effect during the supplemental EIS process.

- Draft SEIS on the Internet February 19, 2002.
- Printed copies of the draft SEIS available March 29.
- Proposed modifications or changes to existing regulations published in the Federal Register on March 29.
- Comment period through May 29.
- Final SEIS available October 2002.
- ROD and promulgate a final rule (if necessary) November 2002.

Winter use has increased dramatically from virtually none 30 years ago to more than 140,000 visits per season since the early 1990s. This winter use had received no systematic planning up until 1990. In that year, the National Park Service (NPS) completed the *Winter Use Plan Environmental Assessment* for Yellowstone and Grand Teton national parks and the John D. Rockefeller, Jr. Memorial Parkway that included a commitment to establish a Visitor Use Management (VUM) process if winter visitation exceeded certain thresholds. That happened in 1992–1993, when winter use exceeded the projection for the year 2000 (140,000 visitors), and the VUM process began in 1993.

As part of the VUM process, scientific studies and visitor surveys were undertaken and analyzed. Letters were accepted during a public comment period, and a series of eight public meetings were held around the region from February through May 1996. Members of the public expressed concerns regarding a number of issues *(see sidebar next page)*. An interagency planning team produced a draft report in the summer of 1997, *Winter Use Management: A Multi-Agency Assessment*, which was available for public comment in 1997 and approved for final publication in 1999.

Lawsuit Filed

During the severe winter of 1996–97, more than 1,000 bison were shot or shipped to slaughter in addition to a large natural winterkill. As a result, concern arose that groomed roads increased the number of bison leaving the park and being killed. In May 1997, the Fund for Animals and other organizations and individuals filed lawsuit in Washington, D.C., against NPS. The lawsuit identified three primary complaints:

- NPS had failed to prepare an environmental impact statement concerning winter use in Yellowstone and Grand Teton national parks and the Rockefeller Parkway
- NPS had failed to consult with the U.S. Fish and Wildlife Service on the effects of winter use on threatened and endangered species
- NPS had failed to evaluate the effects of trail grooming in the parks on wildlife and other park resources.

On October 27, 1997, the plaintiffs, Department of Justice, and NPS signed a settlement agreement. Under the terms of this agreement, NPS agreed to prepare a new winter use plan and corresponding environmental impact statement, and to consult with the U.S. Fish and Wildlife Service on the effects of winter use on threatened and endangered species. NPS also agreed to immediately prepare an environmental assessment (EA) evaluating the effects of temporarily closing one or more segments of winter snowmobile road in Yellowstone to study wildlife movements on groomed roads within the park. (An EA was necessary because closing road segments within the park to grooming could potentially impact park visitors and, subsequently, local and regional economies.)

The *Environmental Assessment–Temporary Closure of a Winter Road, Yellowstone National Park* was released to the public in October 1997. During the 45-day public comment period, the park received 2,742 letters. Of primary concern to members of the public were the negative and positive impacts of road grooming on bison, the negative and positive aspects of snowmobiling, and the importance of snowmobiling and winter use on local economies. About 500 letters contained comments addressing research concerns, suggesting a lack of scientific evidence existed to justify a temporary road closure.

After completing analysis of the comments in January 1998, Yellowstone National Park officials decided a road closure would not be put into effect in the winter of 1997–98 nor during the next two winters. The rationale was the lack of scientific evidence that clearly showed a road closure was necessary. To answer these questions, NPS identified areas of additional research. During the next three winters, biologists would research and monitor wildlife movements (particularly bison) in the Gibbon, Firehole, and Madison river areas and Hayden Valley. Monitoring of other road segments to determine seasonal use by bison and the significance of that use in bison population movements and dynamics would also be conducted. The following are complete: five years of monitoring in Hayden Valley plus four years on the west side and two research projects.

Concerns Raised at Public Meetings

overcrowding

visitor impacts on natural resources

noise & air pollution

availability of facilities and services

use restrictions

user group conflicts

importance of winter visitation to the local and regional economy

wildlife use of groomed surfaces

wildlife displacement

health & human safety

1990 — *Winter use plan released.*

1992 — *Winter visitation exceeds threshold of 140,000 people per year, which was projected in a 1990 winter use plan.*

1993 — *In accordance with the 1990 plan, a Visitor Use Management process began and resulted in an interagency evaluation of winter recreation in the Greater Yellowstone Area (GYA), completed in 1999.*

1997 — *Fund for Animals files lawsuit; results in NPS signing an agreement requiring the development of a new winter use plan and environmental impact statement (EIS).*

Another Lawsuit

On February 18, 1998, the Fund for Animals and other organizations filed suit against the National Park Service alleging that NPS did not have the necessary data to make the decision to defer closing a road segment in the park. In addition, the plaintiffs alleged that the unlimited road grooming and the alleged lack of winter use management practices were continuing to harm the plaintiffs' short- and long-term interests in recreating and in protecting and observing and studying the environment and wildlife in the park. On March 31, 1999, the U.S. District Court for the District of Columbia ruled in favor of NPS. The court found that the park's decision to not close one or more segments of groomed road during the next three years did not violate the October 1997 settlement agreement and that the park had presented an adequate range of alternatives in the EA as required under the law.

Planning Continued

Meanwhile, preparing for a new winter use plan and environmental impact statement began in early 1998. The purpose of this plan is to provide future winter visitors to the parks with a range of quality winter experiences and settings from primitive to developed. The recreational experiences must be offered in an appropriate location or setting that does not impact sensitive natural resources, wildlife, cultural areas, or the experiences of other park visitors. In order to ensure the safety of all park visitors and employees, conflicts between different types of user groups and conflicts with wildlife must be minimized. Finally, winter recreation within Yellowstone and Grand Teton national parks and the John D. Rockefeller, Jr. Memorial Parkway should complement the unique aspects of each landscape within the ecosystem.

While Yellowstone and Grand Teton national parks and the John D. Rockefeller, Jr. Memorial Parkway were the lead agencies preparing the document, nine cooperating agencies joined the effort: the U.S. Forest Service, the states of Idaho, Montana, and Wyoming; and the counties of Gallatin and Park, Montana, and Park and Teton, Wyoming, and Fremont, Idaho. To develop the scope of the winter use plan, scoping brochures were mailed to about 6,000 interested parties, 12 public meetings were held in the greater Yellowstone area, 4 public meetings were held in other parts of the country, and about 2,000 public comments were considered.

In July 1999, NPS published a draft EIS for public comment. The alternatives addressed the issues of visitor access, sound, emissions, wildlife concerns, and affordability. The preferred alternative called for, among other things, plowing the road from West Yellowstone to Old Faithful and allowing snowmobile use on other park roads. Five public hearings were held in the region, and one in Colorado. More than 48,000 public comments were received.

Looking At Snowmobiles System-wide

Separately, in January 1999, the Bluewater Network and some 60 other conservation organizations requested that NPS begin immediate rulemaking to prohibit snowmobile use within the 44 units of the National Park System in which it is allowed, including Yellowstone, Grand Teton, and the Parkway. That petition prompted an agency review of policies and practices on snowmobile use in parks. As part of that review, NPS conducted a survey of parks in which snowmobile use is currently allowed. The survey gathered information from each relevant park on such matters as the basis for the original decision to allow snowmobile use in that park; extent of that use; what is known about the impacts of that use on park resources and values, including the enjoyment of other visitors; and what monitoring is conducted to determine impacts.

1999

The draft EIS released in July; it receives more than 48,000 public comments.

2000

October, the final EIS released and receives about 11,000 public comments. **November:** A record of decision (ROD) signed. **December:** International Snowmobile Manufacturers Association files lawsuit against the Secretary of the Interior.

2001

January: The final rule published in the Federal Register. **June:** Settlement agreement reached; The Department of Interior directs the National Park Service to prepare a supplemental EIS (SEIS). **December:** Park begins experimental program to reduce impacts of snowmobiles and to educate snowmobilers.

2002

Draft SEIS released in February.

NPS also held a two-day snowmobile summit in February 2000 at which officials from the DOI (including the Office of the Solicitor) and NPS (including all but one of the 44 affected parks) reviewed the snowmobile use now occurring in the National Park System. The officials learned through the survey and the snowmobile summit that much of the snowmobile use in the national park system is not consistent with management objectives or the protection of park resources and values and is not in compliance with the requirements of the two executive orders and NPS general regulations on snowmobile use.

In March 2000, NPS met with cooperators on the plan (state and county representatives) to review public comments, studies and additional information gathered since preparation of the draft EIS. NPS indicated a tentative direction for a preferred alternative for the final EIS that would move towards using snowcoaches as the only mechanized means to access the interior of Yellowstone. The Environmental Protection Agency (EPA) stated that based on impacts to human health, air quality, water quality and visibility, this alternative (snowcoach only) was the "environmentally preferred alternative."

In April 2000, the Department of the Interior and the National Park Service announced an intention to propose changes in the snowmobile use allowed in all national parks to protect park resources and values, to meet management objectives for the parks, and to come into compliance with the legal requirements applying to that use.

Finalizing Yellowstone's Winter Use Plan

During the next ten months, the winter use plan was finalized. The final EIS was released in October 2000. Although there was no requirement for public review, commitments were made to the cooperating agencies that there would be a public comment period. About 11,000 public comments were received. A record of decision was signed on November 22; it called for prohibition of recreational use of snowmobiles in Yellowstone and Grand Teton national parks and the Parkway in the winter of 2003–2004. On December 18, draft regulations were published in the Federal Register to amend rules for snowmobile use in Grand Teton, Yellowstone, and the Parkway and thus

implement the ROD. The regulations were available for comment until January 17, 2001, and more than 5,200 public comments were received.

On January 22, 2001, the final rule was published in the *Federal Register*. The rule provides for interim actions to be implemented to reduce the impacts of snowmobile use during the winter use season of 2002–2003; and effective at the end of the 2002–2003 winter use season, it allows for oversnow motorized recreation access by NPS-managed snowcoach only, with limited exceptions for snowmobile access to other public and private lands adjacent to or within Grand Teton National Park. The rule went into effect April 22, 2001.

Implementing the Plan

Several actions are being taken to implement the plan. For winter 2000–2001, NPS allowed existing snowcoach and snowmobile outfitters to add snowcoaches to their fleet. NPS issued a prospectus for new snowcoach contracts and awarded new two-year contracts to 11 outfitters. NPS has also partnered with the U.S. Department of Energy through their Idaho Operation Office (the Idaho National Engineering and Environmental Laboratory, INEEL) to conduct an evaluation of vehicles for all seasons and to develop alternative fueled vehicles. Through INEEL, the park is working with a consortium of private companies to develop a prototype of a new multi-season, multi-passenger, multi-fueled, fully accessible vehicle. Also, Yellowstone National Park has begun working with its neighbors to develop a marketing strategy for visiting Yellowstone by snowcoach.

Legal Framework for Snowmobiles in National Parks

National Park Service Act of 1916: *To conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same and by such means as will leave them unimpaired for the enjoyment of future generations.*

NPS Management Policies—2001: *Impairment is an impact that, in the professional judgement of the responsible NPS manager, would harm the integrity of the park resources or values, including the opportunities that would otherwise be present for the enjoyment of those resources and values.*

General Authorities Act—1978: *The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided for by Congress.*

National Parks and Recreation Act—1978: *Directs that management plans be prepared for all units of the National Park System that include, but are not limited to: (3) identification of and implementation commitments for visitor carrying capacities for all areas of the unit.*

Clean Air Act: *Section 160 states one of the purposes of the act is "to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value."*

Section 162 mandates the designation of national park areas greater than 6,000 acres and wilderness areas greater than 5,000 acres as Class I. Yellowstone and Grand Teton national parks are mandatory Class I areas.

Section 169(A) states that "Congress hereby declares as a national goal the prevention of any future, and the remedying of any existing impairment of visibility in mandatory Class I Federal areas which impairment results from any manmade air pollution."

E.O. 11644—2/8/72 (President Nixon) "Use of Off-Road Vehicles on the Public Lands": *Areas and trails shall be located in areas of the National Park System only if the respective agency head determines that off-road vehicle use in such locations will not adversely affect their natural, esthetic or scenic values.*

E.O. 11989—5/24/77 (President Carter): *The respective agency head shall, whenever he determines that the use of off-road vehicles will cause or is causing considerable adverse effects on the soil, vegetation, wildlife, wildlife habitat or cultural or historic resources of the particular areas or trails of the public lands, immediately close such areas or trails to the type of off-road vehicle causing such effects, until such time as he determines that such adverse effects have been eliminated and that measures have been implemented to prevent future recurrences.*

Departmental Implementation of Executive Order 11644, as amended by E.O. 11989, *pertaining to use of off-road vehicles on the public lands (DOI prepared EIS, 1976): Clearly defines use of snowmobiles on roads as off-road vehicles.*

36 CFR 2.18: *The use of snowmobiles is prohibited, except where designated and only when their use is consistent with the park's natural, cultural, scenic, and esthetic values, safety considerations, park management objectives, and will not disturb wildlife and damage park resources.*

Consolidated Appropriation Act—2001, Section 128: *None of the funds provided in this or any other Act may be used prior to July 31, 2001, to promulgate or enforce a final rule to reduce during the 2000–2001 or 2001–2002 winter seasons the use of snowmobiles below current use patters at a unit of the National Park System; Provided, That nothing in this section shall be interpreted as amending any requirement of the Clean Air Act: Provided further, That nothing in this section shall preclude the Secretary from taking emergency actions related to snowmobile use in any national park based on authorities which existed to permit such emergency actions as of the date of enactment of this Act.*

Another Lawsuit

On December 6, 2000, the Secretary of the Interior, et al., were named as defendants in a lawsuit brought by the International Snowmobile Manufacturers Association, et al. A settlement agreement was reached on June 29, 2001. The Department of Interior has directed the National Park Service to prepare a SEIS. Additional information from the International Snowmobile Manufacturers Association will be considered, as well as any other new or updated information not available at the time of the earlier decision, along with more public input.

The states of Wyoming, Montana and Idaho, five affected counties, the U.S. Forest Service, and the Environmental Protection Agency are cooperating agencies.

The existing rule will remain in effect during the SEIS process. In accordance with the settlement agreement, rulemaking will occur concurrently with the SEIS process. (Normally, rulemaking would follow the process set out in the National Environmental Policy Act.) Because there was no preferred alternative in the draft SEIS, the proposed rule suggests a one-year delay to the rule currently in effect. If a new decision is made at the completion of the SEIS process, a new rulemaking process would begin. The Department of Interior may modify the existing rule with additional limits or exceptions.

Supplemental EIS

The SEIS includes four alternatives but does not designate a preferred alternative. Briefly, the four alternatives are:

Alternative 1a: No Action alternative that allows for implementation of the current rule allowing access to the parks via snowcoaches only in the future. A phase-out of snowmobiles would begin the winter of 2002–3 with a full ban on snowmobiles effective the winter of 2003–4.

Alternative 1b: Also a No Action alternative, but implementation of the current rule would be delayed until the winter of 2003–4 with a full ban on snowmobiles effective the winter of 2004–5. Both of the no action alternatives provide for access by a NPS-managed, mass transit snowcoach system.

Alternative 2: Provides for non-guided snowmobile access. It phases in proposed EPA 2010 emission standards by 2005 for cleaner snowmobiles and limits decibel levels to 75 (current limits are at 78 decibels). It also provides for a daily cap on numbers of snowmobiles and calls for increased National Park Service management of winter use.

Alternative 3: Provides for access by guided snowmobile tours with snowmobiles that must be the best available technology for sound and emissions. Snowmobile numbers would be limited, and visitors would be encouraged to shift to snowcoach services.

The NPS position on these alternatives is neutral.

Winter 2001/2002 Pilot Program

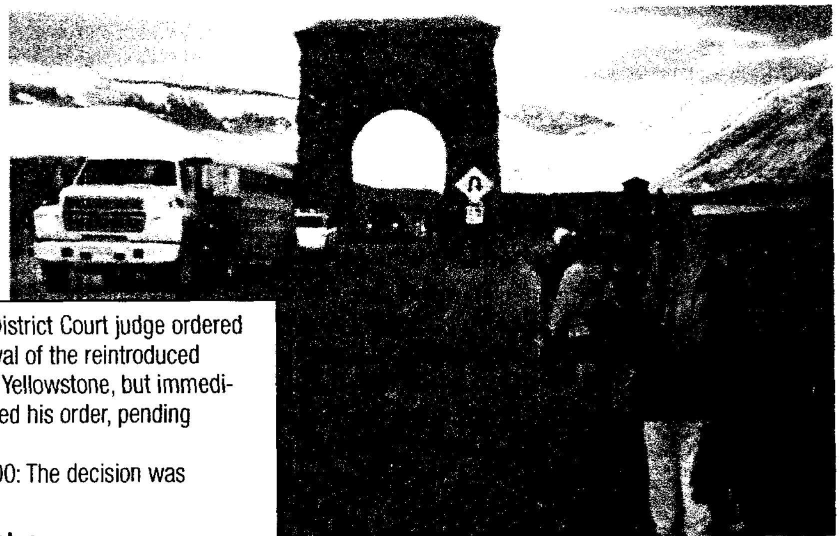
At the beginning of the 2001/2002 winter season, an experimental plan was announced to address some of the concerns raised during the winter use process. Serious issues related to human/animal conflicts, employee health and safety, air quality, noise, and deteriorating visitor experiences required action now, while the planning process continues. The plan was implemented on the road segment between West Entrance and the Old Faithful area, a 30-mile segment of road out of the 180 miles that are open for snowmobile use, and provided for:

- *Additional grooming of park snow roads to improve safety of snowmobilers, including park employees who must travel the roads daily*
- *Additional interpretive staff to educate visitors in the park and in West Yellowstone about low-impact snowmobiling*
- *Preselling all West Entrance permits at the Public Lands Desk in the West Yellowstone Chamber of Commerce and not at the gate (to reduce idle time at the gate and, it is hoped, the accompanying tremendous build-up of fumes)*
- *Lower speed limit between West Entrance and Old Faithful from 45 mph to 35 mph to attempt to reduce conflicts between snowmobiles and wildlife.*

NPS is testing new multi-season vehicles, such as this van.

8

Issues: Wolf Restoration



The Issue

The wolf is a major predator that had been missing from the Greater Yellowstone Ecosystem for decades until its restoration in 1995.

History

Late 1800s–early 1900s: predators, including wolves, were routinely killed in Yellowstone.

1926: The last wolf pack in Yellowstone was killed, although reports of single wolves continued.

1973: The gray wolf was listed as endangered; recovery is mandated under the Endangered Species Act.

1975: The long process leading to wolf restoration in Yellowstone began.

1991: Congress appropriated money for an EIS for wolf recovery.

1994: EIS completed for wolf reintroduction in Yellowstone and central Idaho. More than 160,000 public comments were received—the largest number of public comments on any federal proposal.

1995 and 1996: 31 gray wolves from western Canada were relocated to Yellowstone.

1997: U.S. District Court judge ordered the removal of the reintroduced wolves in Yellowstone, but immediately stayed his order, pending appeal.

January 2000: The decision was reversed.

Current Status

- As of December 2002, 210–220 wolves live in 24 packs in the greater Yellowstone area—including at least 14 breeding pairs.
- 100 documented wolf deaths have occurred since the beginning of reintroduction. More than half of the mortalities are human caused with the rest being natural. The leading natural cause of mortality is wolves killing other wolves.
- Livestock predation was expected to be 40–50 sheep and 10–12 cows per year, but has been much lower: 146 sheep, 19 cattle since 1995.
- A private non-profit group, Defenders of Wildlife, compensates livestock owners for the value of lost livestock.
- Research is underway to determine impact of wolf restoration on cougars, coyotes, and elk.

The gray wolf *(Canis lupus)* was present in Yellowstone when the park was established in 1872. Predator control, including poisoning, was practiced here in the late 1800s and early 1900s. Between 1914 and 1926, at least 136 wolves were killed in the park; by the 1940s, wolf packs were rarely reported. An intensive survey in 1978 found no evidence of a wolf population in Yellowstone, although an occasional wolf probably wandered into the area. A wolf-like canid was filmed in Hayden Valley in August 1992, and a wolf was shot just outside the park's southern boundary in September 1992. However, no verifiable evidence of a breeding pair of wolves existed. During the 1980s, wolves began to reestablish breeding packs in northwestern Montana; 50–60 wolves inhabited Montana in 1994.

Restoration Proposed

NPS policy calls for restoring native species when: a) sufficient habitat exists to support a self-perpetuating population, b) management can prevent serious threats to outside interests, c) the restored subspecies most nearly resembles the extirpated subspecies, and d) extirpation resulted from human activities.

The U.S. Fish & Wildlife Service (USFWS) 1987 Northern Rocky Mountain Wolf Recovery Plan proposed reintroduction of an "experimental population" of wolves into Yellowstone. (An experimental population, under section 10(j) of the Endangered Species Act, is considered nonessential and allows more management flexibility.) Most scientists believed that wolves would not greatly reduce populations of mule deer, pronghorns, bighorn sheep, white-tailed deer, or bison; they might have minor effects on grizzly bears and cougars; and their presence might cause the decline of coyotes and increase of red foxes.

In 1991, Congress provided funds to the USFWS to prepare, in consultation with NPS and the U.S. Forest Service, an environmental impact statement (EIS) on restoration of wolves. In June 1994, after several years and a near-record number of public comments, the Secretary of the Interior signed the Record of Decision for the final EIS for reintroduction of gray wolves to Yellowstone National Park and central Idaho.

Staff from Yellowstone, the USFWS, and participating states prepared for wolf restoration to the park and central Idaho. The USFWS prepared special regulations outlining how wolves would be managed as an experimental population.

1991 — Congress appropriates money for an EIS for wolf recovery.

1994 — EIS completed for wolf reintroduction in Yellowstone and central Idaho. More than 160,000 comments received.

1995–96 — 31 gray wolves from western Canada relocated to Yellowstone.

1997 — U.S. District Court judge orders the removal of the reintroduced wolves in Yellowstone, but immediately stays his order, pending appeal.

2000 — The decision is reversed.

2002 — As of December 2001, 210–220 wolves live in 21 packs in the greater Yellowstone area—including at least 14 breeding pairs.

Park staff completed site planning and archaeological and sensitive plant surveys for three sites in the Lamar Valley that would be used in 1994–95. Later, additional sites—Blacktail Plateau, Nez Perce Creek, Fishing Bridge, Trail Creek—were prepared for potential use in 1995–97.

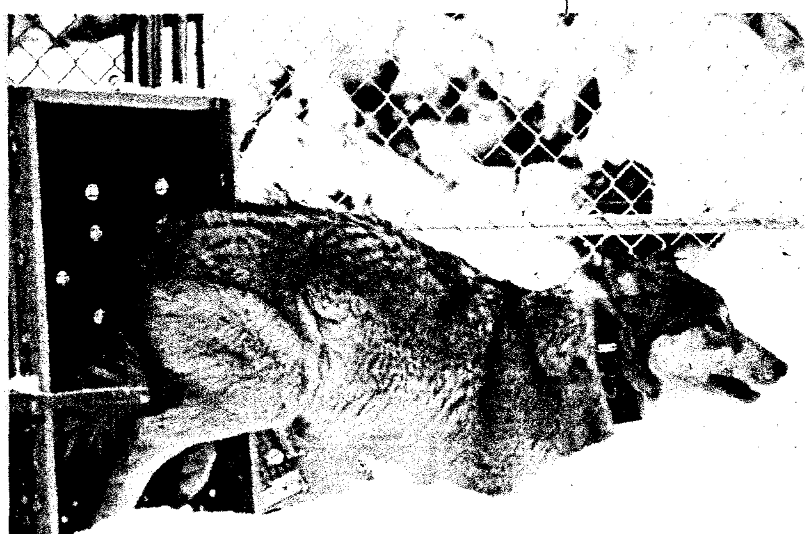
Each release site was approximately one acre enclosed with 9-gauge chain-link fence in 10 x 10 foot panels. The fences had a two-foot overhang and a four-foot skirt at the bottom to discourage climbing over or digging under the enclosure. Each pen had a small holding area attached to allow a wolf to be separated from the group if necessary (i.e., for medical treatment). Plywood boxes provided shelter if the wolves desired isolation from each other. These enclosures were built to be dismantled and reconstructed at other sites, if necessary, in future years.

Relocation & Release

In late 1994/early 1995, and again in 1996, USFWS and Canadian wildlife biologists captured wolves in Canada and relocated and released them in both Yellowstone and central Idaho. In mid January 1995, 14 wolves were temporarily penned in Yellowstone; the first 8 wolves on January 12 and the second 6 on January 19, 1995. Wolves from one social group were together in each release pen. On January 23, 1996, 11 more gray wolves were brought to Yellowstone to launch the second year of wolf restoration. Four days later they were joined by another 6 wolves. The wolves ranged from 72 to 130 pounds in size and from approximately nine months to five years in age. They included wolves known to have fed on bison. Groups included breeding adults and younger wolves from one to two years old.

Each wolf was radio-collared as it was captured in Canada. While temporarily penned, the wolves experienced minimal human contact. Approximately once a week, they were fed elk, deer, moose, or bison that had died in and around the park. They were guarded by law enforcement rangers who minimized the amount of visual contact between wolves and humans. The pen sites and surrounding areas were closed to visitation and marked to prevent unauthorized entry. Biologists checked on the welfare of wolves several times each week, using telemetry or visual observation while placing food in the pens. Due to the early success of reintroductions, no transplants occurred after 1996.

Some people expressed concern about wolves becoming habituated to humans while in captivity. However, wolves typically avoid human contact, and they seldom develop habituated behaviors such as scavenging in garbage. Captivity was also a negative experience for them and reinforced their dislike of humans.



Lawsuits

Several lawsuits were filed to stop the restoration on a variety of grounds. These suits were consolidated, and in December 1997, the judge found that the wolf reintroduction program in Yellowstone and central Idaho violated the intent of section 10(j) of the Endangered Species Act because there was a lack of geographic separation between fully protected wolves already existing in Montana and the reintroduction areas in which special rules for wolf management apply. The judge wrote that he had reached his decision "with utmost reluctance." He ordered the removal (and specifically not the killing) of reintroduced wolves and their offspring from the Yellowstone and central Idaho experimental population areas, but immediately stayed his order pending appeal. The Justice Department appealed the case, and in January 2000 the decision was reversed.

Results of the Restoration

The return of wolves has already had significant beneficial impacts to the Yellowstone ecosystem. Wolves have preyed primarily on elk and these carcasses have provided food to a wide variety of other animals, especially scavenging species. Grizzly bears have usurped wolf-kills almost at will, a finding contrary to predictions and observations from other areas where the two occur. Coyote populations have declined inside wolf territories, a finding that may benefit other smaller predators, rodents, and birds of prey. Preliminary data from studies indicate that wolf recovery will likely lead to greater biodiversity throughout the Greater Yellowstone Ecosystem.

8

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All Issues

Yellowstone Science (any issue). Yellowstone Center for Resources. www.nps.gov/yell, in the Yellowstone Library, or at Yellowstone Center for Resources

For current information on issues in Yellowstone National Park, check the official park website: www.nps.gov/yell

Major Areas of the Park

The Grand Canyon of the Yellowstone

Formation

The Grand Canyon of the Yellowstone has been celebrated in paintings, photographs, poetry, and prose since the time it was first captured on canvas by painter Thomas Moran. Its depth and colors result from the combined forces of fire and ice.

The canyon's origin goes back 640,000 years to when the last great Yellowstone caldera was doming. This action created faults where erosion could be accelerated and may have determined the ultimate site of the canyon. After the caldera erupted, a series of lava flows covered the area, including a thermal area. Steam and gases from this thermal area altered and weakened the rhyolite, making it susceptible to erosion and further downcutting by the river.

Later, glaciers assisted in the carving of the canyon, not by the brute force of ice, but through the release of torrential flood waters from melting ice dams near Yellowstone Lake. At the end of the last glacial period (about 14,000 years ago) ice dams formed at the north end of Hayden Valley. When the ice dams melted, a great volume of water was released downstream causing massive flash floods and immediate and catastrophic erosion of the present-day canyon. These flash floods probably happened more than once. The canyon's V–shape indicates river-type erosion rather than glaciation.

FREQUENTLY ASKED QUESTIONS

Where can I see the canyon/falls?
Upper Falls: North Rim, from viewing area between exit of North Rim drive and entrance to South Rim Drive; South Rim, from two viewpoints at Uncle Tom's Parking Area.
Lower Falls: North Rim at Inspiration, Lookout, & Red Rock Points, plus the brink overlook; South Rim at Artist Point, from Uncle Tom's Trail, and from a few places along the South Rim Trail.

What causes the different colors in the canyon?
The colors are caused by the oxidation of iron compounds in the rhyolite rock, which has been hydrothermally altered. You could say the canyon is "rusting."

Is there a place where I can see both falls at once?
No. The canyon bends between the Upper and Lower falls, so there is no location where they can be seen at the same time.

How tall are the falls?
Upper Falls: 109 ft; Lower Falls: 308 ft.

How big is the canyon?
The canyon is roughly 20 miles long. It varies from 800 to 1,200 feet deep, and is 1,500 to 4,000 feet wide.

How can I get to the bottom of the canyon?
Only one trail in this area leads to the bottom of the canyon—Seven Mile Hole Trail, a strenuous, steep round trip of 11 miles.

How much water goes over the falls?
The volume varies from 63,500 gallons per second at peak runoff to 5,000 gallons per second in the late fall.

What causes the green stripe in the Lower Falls?
That is the natural color of the water. A notch in the lip in the brink makes the water deeper and keeps it from becoming turbulent as it goes over the edge.

Who was Uncle Tom?
"Uncle Tom" Richardson was an early concessioner in the canyon area. He guided visitors to the canyon bottom down a steep trail using rope ladders. (This is the present Uncle Tom's Trail, which descends partway into the canyon via steep steel steps.) He lost his permit in 1906 after the Chittenden Bridge was completed.

What are the large birds that look like eagles?
They are osprey, and they nest in the canyon from late April until late August or early September. Look for nests from Grand View, Lookout, and Artist points.

About the Falls

The Upper and Lower Falls are formed by the Yellowstone River as it flows over points where the unaltered rhyolite lava meets the altered, weakened rhyolite of the thermal areas. The first falls, Upper Falls, is 109 feet high; it can be seen from the Brink of the Upper Falls Trail and from viewpoints at Uncle Tom's Parking Area. The Lower Falls is 308 feet high and can be seen from Lookout Point, Red Rock, Artist Point, Brink of the Lower Falls Trail, and from various points along the South Rim Trail. A third falls, Crystal Falls, enters the canyon between the Upper and Lower falls. It is a waterfall on Cascade Creek and can be seen from the South Rim Trail just west of Uncle Tom's parking area.

Colors in the Canyon

The colors in the canyon are a result of hydrothermal alteration of iron compounds in the rhyolite. Exposure to the elements caused the rocks to change colors as they oxidized. The colors indicate the presence or absence

of water in the individual iron compounds. Most of the yellows in the canyon also result from iron in the rock, not sulfur.

Hayden Valley

The Yellowstone River flows through Hayden Valley between Yellowstone Lake and the Grand Canyon of the Yellowstone. The valley was once filled by an arm of Yellowstone Lake and, consequently, contains fine-grained lake sediments that are now covered with glacial till left from the most recent glacial retreat 14,000 years ago. Because the glacial till contains many different grain sizes, including clay and a thin layer of lake sediments, water cannot percolate quickly into the ground. Thus, Hayden Valley is marshy and has little encroachment of trees.

Hayden Valley is one of the best places in the park to view a wide variety of large mammals. Grizzly bears are often seen in the spring and early summer when they may be eating winter-killed animals or preying upon elk calves. Large herds of bison may be viewed in the spring, early summer, and during the rut, which usually begins late July to early August. Coyotes can almost always be seen in the valley. Wolves are in the area, but seldom seen.

Birds are abundant. Shore birds feed in the mud flats at Alum Creek. A pair of sandhill cranes usually nests at the south end of the valley. Ducks, geese, and American white pelicans cruise the river. Bald eagles and osprey hunt for fish along the river; northern harriers fly low looking for rodents in the grasses. Great gray owls are sometimes seen searching the meadows for food (these birds are sensitive to human disturbance).

Mt. Washburn

Mt. Washburn, named for General Henry Dana Washburn, leader of the 1870 Washburn–Langford–Doane Expedition, is the highest peak in the Washburn Range. It rises 10,243 feet and can be seen from many locations in the park. It is a remnant of an extinct stratovolcano from the Absaroka Volcanics of about 50 million years ago. The volcano was literally cut in half by collapse of the Yellowstone Caldera 640,000 years ago. Only the northern part of the original volcano is still visible as you travel from Dunraven Pass toward Tower Fall. Bighorn sheep and wildflowers can be seen on its slopes in the summer, and black and grizzly bears are sometimes seen here. And it is an excellent place to view the Yellowstone Caldera to the southeast.

Note: Beginning early September 2002, road construction may close the road from Canyon north to Chittenden Road, including Dunraven Pass. Road construction may also cause delays from Canyon to Fishing Bridge, through Hayden Valley.

TRAILS

Canyon Rims: Numerous trails and viewpoints along both the north and south rims provide views of the canyon and falls. The Canyon Area Trail Guide, available at numerous locations along the rim, contains descriptions.

Mary Mountain: Moderately strenuous due to length; 21 miles one way. Climbs gradually up over Mary Mountain and the park's Central Plateau to the Nez Perce trailhead between Madison and Old Faithful. Can be hard to follow because bison knock down trail markers; also sometimes closed due to bear activity. Trailhead: north of Alum Creek pullout, 4 miles south of Canyon Junction.

Howard Eaton, Canyon to Norris portion: Moderately easy; little vertical rise; 3 to 12 miles one way; 2 to 8 hours, depending on how far you go. Passes through forest, meadow, and marshland to Cascade Lake (3 miles), Grebe Lake (4 ¼ miles), Wolf Lake (6 ¼ miles), Ice Lake (8 ¼ miles), and Norris Campground (12 miles). Can be very wet and muddy through July with many biting insects. Trailhead: pullout ¼ mile west of Canyon Junction on the Norris–Canyon Road. *See also Ice Lake Trail in the Norris Area.*

Cascade Lake: Easy; 5 miles round trip; 3 hours. Passes through open meadows and over small creeks. Can be very wet and muddy through July. Trailheads: pullout one-quarter mile west of Canyon Junction on the Norris–Canyon Road or Cascade Lake Picnic Area, 1 ½ miles north of Canyon Junction on the Tower–Canyon Road.

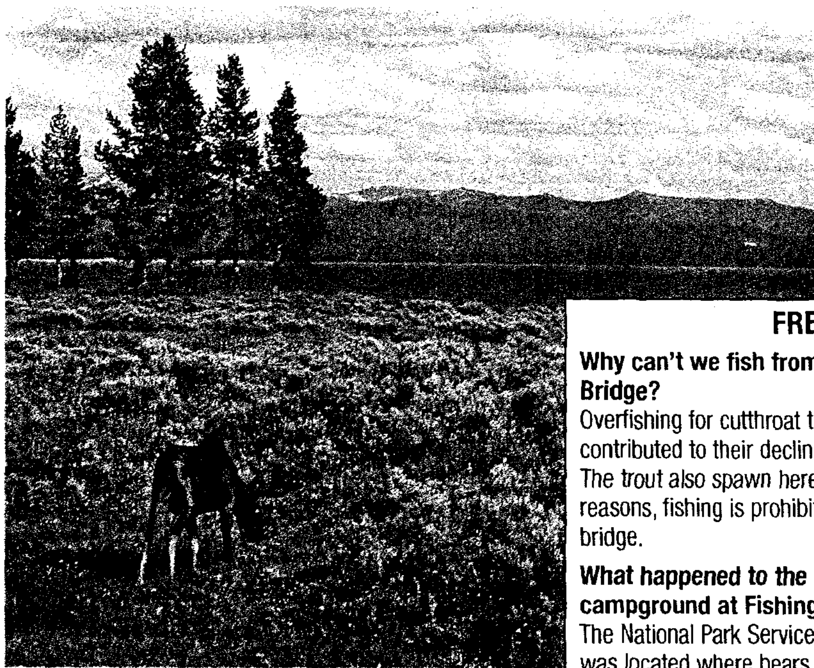
Observation Peak: Strenuous; 11 miles round trip. The trail passes through open meadows to Cascade Lake *(see above)*, then climbs 1,400 feet in three miles to a high mountain peak for an outstanding view of the Yellowstone wilderness. No water available. Not recommended for persons with heart and/or respiratory problems. Trailheads: *See Cascade Lake, above.*

Grebe Lake: Moderately easy; little vertical rise; 6 miles round trip; 3 to 4 hours. Follows old fire road through meadows and forest, some of which burned in 1988. At the lake you can connect with the Howard Eaton Trail *(see above)*. Trailhead: 3 ½ miles west of Canyon Junction on the Norris–Canyon Road.

Seven Mile Hole: Strenuous; 11 miles round trip; 6 to 8 hours. Follows the canyon rim for the first 1 ½ miles, at which point you can see Silver Cord Cascade across the canyon. After another ½ mile joins the Washburn Spur Trail; after another 3 miles, the trail drops off to Seven Mile Hole, a 1 ½ mile, 1,400 foot drop. Caution: watch your footing and conserve your energy. Be especially careful where the trail passes both dormant and active hot springs. Off-trail travel is prohibited. Not recommended for persons with heart and/or respiratory problems. Trailhead: Glacial Boulder pullout on Inspiration Point Road.

9

Major Areas: Lake & Fishing Bridge



About Yellowstone Lake

The lake area lies in a stunning setting with the Absaroka Mountains as a backdrop to the east, but this area has not always been so peaceful. The lake's basin is part of the caldera formed after the last major volcanic eruption 640,000 years ago. Originally the lake was 200 feet higher than today and extended north across Hayden Valley to the base of Mt. Washburn. The arms of the lake were formed by uplift along fault lines and sculpting by glaciers.

Geologists think Yellowstone Lake originally drained south via the Snake River into the Pacific Ocean drainage. The lake now drains north from its outlet at Fishing Bridge. The elevation of the lake's north end does not drop substantially until LeHardys Rapids, which is considered the actual northern boundary of the lake.

One of the resurgent domes from the last major eruption—Sour Creek, east of LeHardys Rapids—currently has a net uplift of about one half-inch per year. This uplift is causing the lake to tilt southward. Larger sandy beaches can now be found on the north shore of the lake, and flooded areas can be found in the southern arms.

The area of the lake known as West Thumb is a caldera within a caldera. It was formed by a volcanic explosion that occurred 128,000–140,000 years ago. The resulting caldera later filled with water forming an extension of Yellowstone Lake. *(For more about the West Thumb area, see page 178.)*

FREQUENTLY ASKED QUESTIONS

Why can't we fish from Fishing Bridge?
Overfishing for cutthroat trout here contributed to their decline in the lake. The trout also spawn here. For these reasons, fishing is prohibited from the bridge.

What happened to the old campground at Fishing Bridge?
The National Park Service campground was located where bears came to fish, and many human/bear conflicts occurred. A recreational vehicle park, operated by a concessioner, still exists in the area.

How big is Yellowstone Lake? How deep? Is it natural?
The lake is natural and has 136 square miles of surface area and 110 miles of shoreline; it is 20 miles long by 14 miles wide. Its deepest spot is in excess of 390 feet; its average depth is 140 feet. The lake's basin has an estimated capacity of 12,095,264 acre-feet of water. Because its annual outflow is about 1,100,000 acre-feet, the lake's water is completely replaced only about every eight to ten years. Since 1952, the annual water level fluctuation has been less than six feet.

Is Yellowstone Lake the largest lake in the world?
No, but it is the largest lake at high elevation (above 7,000 feet) in the Western Hemisphere.

Where does the Yellowstone River begin? Where does it end?
It begins on the slopes of Younts Peak in the Absaroka Mountains southeast of the park and completes its 671-mile run by joining the Missouri River near the Montana/North Dakota border. Its waters then travel to the Mississippi River and into the Atlantic Ocean at the Gulf of Mexico. It is the longest undammed river in the United States.

What kind of fish live in the lake?
Yellowstone cutthroat trout, longnose dace, redside shiners, longnose suckers, lake chubs, and lake trout. You can often see cutthroat trout and longnose suckers from Fishing Bridge; lake trout live in deeper waters; the others are minnows that are harder to see.

Which fish are natives?
Yellowstone cutthroat trout and possibly the longnose dace are natives.

Where can I see moose?
In marshy areas, particularly at Fishing Bridge and along Pelican Creek, and in large meadows near Bridge Bay. The best time to look is at dawn and dusk.

What's that smell at Mud Volcano?
That "rotten egg" smell comes from hydrogen sulfide gas. Sulfur, in the form of iron sulfide, gives the features their many shades of gray.

Water Temperatures

During late summer, Yellowstone Lake becomes thermally stratified with several water layers having different temperatures. The topmost layer rarely exceeds 66°F, and the lower layers are much colder. Because of the extremely cold water, survival time for anyone in the lake is estimated to be only 20 to 30 minutes. In winter, ice thickens on Yellowstone Lake, and it varies from a few inches to more than two feet with many feet of snow on top of the ice.

Wildlife

This area's abundant and diverse wildlife attracts many visitors. The lake is home to the largest population of Yellowstone cutthroat trout in North America, which are now threatened by non-native lake trout. The area around the lake is prime grizzly bear habitat. The Fishing Bridge area, including Pelican Valley to the north and east, is especially significant to bears and other wildlife because lake, river, and terrestrial ecosystems merge here to create a diverse natural complex unique inside and outside the park. Bears visit numerous streams in the spring and early summer to eat spawning trout. Hayden Valley is known for herds of bison. During the rut in August traffic can be stopped for hours by huge herds of milling bison. During the winter, Pelican Valley is another outstanding place to view bison. While river otters are elusive, they are seen with some regularity at the Bridge Bay Marina during the summer. American white pelicans, bald eagles, and osprey are commonly seen in the Lake area.

Yellowstone River

The Yellowstone River is the longest major undammed river in the lower 48 states, flowing 671 miles from its source southeast of Yellowstone National Park to the Missouri River. The river begins in the Absaroka Mountain Range on Younts Peak and flows through the Thorofare region into Yellowstone Lake. It leaves the lake at Fishing Bridge and flows north over LeHardys Rapids and through Hayden Valley. After this peaceful stretch, the river crashes over the Upper and Lower falls of the Grand Canyon. It then flows generally northwest, meeting the Lamar River at Tower Junction. The river continues through the Black Canyon and leaves the park near Gardiner, Montana. The Yellowstone River continues north and east through Montana and joins the Missouri River just over the North Dakota state line.

TRAILS

Pelican Creek: Easy; 1 mile round trip. Passes through a forest to the lake before looping back across the marsh along Pelican Creek to the trailhead. Scenic introduction to a variety of the park's habitats and a good place for birding. Trailhead: west end of Pelican Creek Bridge, 1 mile east of Fishing Bridge Visitor Center.

Natural Bridge: Easy; 4 miles round trip. Meanders through the forest for about ¼ mile, then joins the Natural Bridge service road and continues to the right (west) for 1 mile to the Natural Bridge. The bridge is a 51-foot cliff of rhyolite rock cut through by Bridge Creek. A short but steep trail to the top of the bridge starts in front of the interpretive exhibit panel. The top of the bridge is closed to hiking. Trailhead: just south of the Bridge Bay Marina parking lot near the campground entrance road. Alternate route: Begin at the Natural Bridge service road, which is also a bicycle trail, ¼ mile south of Bridge Bay junction. Inquire at Fishing Bridge Visitor Center about trail closures before hiking or bicycling these trails; they are closed from late spring to early summer due to bears feeding on spawning trout in Bridge Creek.

Storm Point: Easy; 2 miles round trip. Passes by Indian Pond before turning right (west) into the forest. Continues through the trees out to scenic, windswept Storm Point (look for yellow-bellied marmots); then follows shoreline to the west, loops through lodgepole pine forest and returns to Indian Pond. Trailhead: Indian Pond pullout, 3 miles east of Fishing Bridge Visitor Center.

Elephant Back Mountain: Moderately strenuous 3 miles. Climbs 800 feet in 1½ miles through a dense lodgepole pine forest. At one mile, splits into a loop. Left fork is the shortest and least steep route. Overlook provides a panoramic view of Yellowstone Lake and the surrounding area. Trailhead: pullout 1 mile south of Fishing Bridge Junction.

Howard Eaton, Fishing Bridge portion: Easy; 7 miles round trip. Follows the Yellowstone River from Fishing Bridge for a short distance, joins a service road for ¼ mile, then meanders for 3 miles through meadow, forest, and sagebrush flats with frequent views of the river. Wildlife and waterfowl are commonly seen here. The last mile passes through a dense lodgepole pine forest before reaching an overview of LeHardys Rapids. Trail continues 12 miles to the South Rim Drive at Canyon, but is not well maintained and such a trip requires a full day and a car shuttle. Trailhead: east side of Fishing Bridge. Inquire at the Fishing Bridge Visitor Center about trail closures before hiking; the trail is often closed due to bear activity.

Avalanche Peak: Strenuous; 5 miles round trip. Climbs 1,800 feet in 2½ miles without switchbacks. Passes through forest and into old avalanche slide area, continues through whitebark pine forest to a small meadow at the base of the bowl of Avalanche Peak, affording some of the best panoramic views in the park. Continues up a scree slope along the narrow ridgeline. An unmarked trail drops down the northeast side of the bowl and returns to the meadow. Whitebark pine cones are a favored food of grizzlies in late summer and fall, so avoid this trail at that time. Trailhead: west end of Eleanor Lake across the road east of the small creek.

Pelican Valley: Moderately difficult; 6 miles round trip. Travels through forest to Pelican Valley, then follows Pelican Creek upstream to a washed-out footbridge, which is a convenient turn-around point. Because Pelican Valley provides some of the best grizzly habitat in the lower 48 states, this trail does not open until July 4th and travel is restricted to specific times of day. Groups of four people or more are recommended but not required. Trailhead: end of a dirt road, which is 3 miles east of Fishing Bridge Visitor Center and across the road from Indian Pond.

Viewing Fish

The original Fishing Bridge was built at the lake's outlet in 1902. It was a rough-hewn corduroy log bridge with a slightly different alignment from the current bridge. The existing bridge was built in 1937. Fishing Bridge, situated over a cutthroat trout spawning area, used to be a tremendously popular place to fish, but it was closed to fishing in 1973. Since that time, the bridge has become a popular place to observe fish.

Trout can also be viewed at LeHardys Rapids, three miles north of Fishing Bridge. In spring, cutthroat trout rest in the pools before leaping up the rapids on their way to spawn under Fishing Bridge. The rapids were named for Paul LeHardy, a member of the 1873 Jones Expedition. Harlequin ducks once frequented this area in spring, but have not been seen for several years. Nevertheless, the boardwalk is closed in early spring to protect the sensitive habitat.

Mud Volcano/Sulphur Caldron

When the Washburn Expedition explored the area in 1870, Nathaniel Langford described Mud Volcano as the "greatest marvel we have yet met with." Although the Mud Volcano can no longer be heard from a mile away (as it could then) nor does it throw mud from its massive crater, the area is still intriguing. A short loop trail from the parking lot passes the Dragon's Mouth and the Mud Volcano and is wheelchair accessible. The half-mile upper loop trail via Sour Lake and the Black Dragon's Caldron is relatively steep. A trail guide is available at the beginning of the boardwalk.

The hydrothermal features at Mud Volcano and Sulphur Caldron—primarily mudpots and fumaroles—are among the park's most acidic. Hydrogen sulfide gas is present deep in the earth at Mud Volcano. As this gas combines with water and the sulfur is metabolized by cyanobacteria, a solution of sulfuric acid is formed that dissolves the surface soils to create pools and cones of clay and mud. Along with hydrogen sulfide, other gases such as steam and carbon dioxide explode through the mud. The Sulphur Caldron is among the most acidic springs in the park with a pH of 1–2.

Historic Structures & Areas

Fishing Bridge Trailside Museum

Lake Fish Hatchery Historic District including Lake Lodge

Lake Hotel

See Chapters 1 and 7 for more information on historic areas in the park.

9

Major Areas: Mammoth Hot Springs

FREQUENTLY ASKED QUESTIONS

Are the springs drying up?
No, even though they may look different from the last time you saw them. These features change constantly and sometimes overnight—but the overall activity of the entire area and the volume of water discharge remain relatively constant.

Are the elk outside the visitor center tame?
No. They are wild and unpredictable. In the spring, cows with calves can be dangerous. In the late summer and fall, which is the mating season, cows are skittish and bulls are very aggressive. Each year visitors are chased, trapped, and sometimes injured by elk. Bull elk also sometimes attack cars.

What were these old buildings?
The row of stone and wood buildings across the street from the Mammoth Hotel were the officers' quarters for the U.S. Army from 1891 to 1918. Fort Yellowstone is eligible for listing on the National Historic Landmark. A self-guiding trail takes visitors through the area.

Can we swim in the hot springs?
No. Swimming is prohibited in park hydrothermal features because it damages the resource and is unsafe. However, you may swim in bodies of water fed by runoff from hydrothermal features. An established spot is the "Boiling River" two miles north of Mammoth on the North Entrance Road. It is open only during daylight hours and is closed during times of high water.

What can we do at Mammoth during the winter?
You can take self-guided tours of Fort Yellowstone and the Mammoth Terraces, join a guided walk or tour, cross-country ski, snowshoe, ice skate (sometimes), rent a hot tub, soak in the Boiling River, watch wildlife, attend ranger programs, visit the Albright Visitor Center, and snowmobile. You can also drive the North Entrance road through to Cooke City, Montana; coyotes, bison, elk, wolves, eagles, and other wildlife are often seen.

Formation

Even though Mammoth Hot Springs lies outside the caldera boundary, the hydrothermal activity here is the result of the same magmatic system that fuels other Yellowstone hydrothermal areas. Hot water likely flows from Norris to Mammoth along a fault zone roughly associated with the Norris to Mammoth road. Shallow circulation along this corridor allows Norris's super-heated water to cool somewhat to about 170°F before surfacing at Mammoth.

While most of the hydrothermal formations you see in the park are comprised of geyserite, the hot spring terraces here are travertine due to the limestone (calcium carbonate) underlying the area. Hydrothermal waters that rise through the limestone carry high amounts of dissolved carbonate. At the surface, pressure is released and calcium carbonate is deposited as travertine, the chalky white rock of the terraces. Due to the rapid rate of deposition, these features change quickly and constantly.This rapidly shifting activity can confuse visitors, but they can be reassured the overall volume of discharged water fluctuates little.

Elk are found in Mammoth year-round, and can be especially dangerous during the autumn rut.

Mammoth shows evidence of several thousand years worth of hydrothermal activity. Terrace Mountain has a thick cap of travertine. The Mammoth Terraces extend all the way from the hillside where we see them today, across the Parade Ground, and down to Boiling River. An old terrace formation, known as Hotel Terrace, underlies all of Fort Yellowstone and the Mammoth Hotel. Several large sink holes, which are fenced off on the Parade Ground, provide visual evidence of the area's hollow foundation.

The Mammoth area also exhibits much evidence of glacial activity. The summit of Terrace Mountain is covered with glacial till, dating its travertine formation to before the end of the Pinedale Glaciation (14,000 years ago). Thermal kames, including Capitol Hill and Dude Hill, are major features of the Mammoth area. East of Mammoth, ice-marginal stream beds are in evidence in the small, narrow valleys where Floating Island Lake and Phantom Lake are found. In Gardner Canyon, the old, sorted gravel bed of the Gardner River is covered by glacial till.

Wildlife

Mammoth is lower in elevation than most of the rest of the park, and has always been used by elk during winter. Now elk are found in the Mammoth area year-round. The development offers elk an ample supply of forage and refuge from their natural predators, including bears, coyotes, mountain lions, and wolves. Rivaling the elk in numbers, Uinta ground squirrels form a large colony every summer in front of the visitor center and among the hotel cabins.

45th Parallel Bridge & Boiling River

On the road from Mammoth to Gardiner, a sign marks the 45th parallel of latitude, which is an imaginary line circling the globe halfway between the Equator and the North Pole. This same line passes through Minneapolis–St. Paul; Ottawa, Ontario, Canada; Bordeaux, France; Venice, Italy; Belgrade, Yugoslavia; and the northern tip of the Japanese islands. Here it also marks the Montana-Wyoming border.

A parking area on the east side of the road is used by visitors to the Boiling River, who must walk upstream about a half mile from the parking area to the bathing area. This spot is also marked by large clouds of vapor, especially in cold weather. Here, a large hot spring, known as Boiling River, enters the Gardner River. Soaking is allowed here because the hot and the cold water mix in pools along the river's edge. Bathers are allowed in the river during **daylight hours only.** Bathing suits are required, and no alcoholic beverages are allowed. Boiling River is closed in early summer due to hazardous high water and often does not reopen until mid summer.

Mt. Everts

Mt. Everts, 7,841 feet high, is the long ridge northeast of Mammoth. It is made up of distinctly layered sandstones and shales—sedimentary rocks deposited when this area was covered by a shallow inland sea, 70–140 million years ago. Fossils have been found here *(see Chapter 3).* Its steep cliffs are

TRAILS

Beaver Ponds: Moderately difficult; 5 miles round trip. Follows a creek up Clematis Gulch, climbs 350 feet through Douglas-fir trees, then through open meadows of sagebrush and stands of aspen to a series of beaver ponds. Elk, mule deer, pronghorn, moose, beaver dams and lodges, the occasional beaver, plus black and grizzly bears may be seen. Past the ponds, the trail travels through forest and grassland back to Mammoth. Trailheads: between Liberty Cap and the stone house (the Judge's house) next to the Mammoth Terraces or behind the end of the guest wing of the hotel.

Bunsen Peak: Moderately difficult; 4 miles round trip. Climbs 1,300 feet through forest to the summit of Bunsen Peak, which has panoramic views of the Blacktail Plateau, Swan Lake Flat, Gallatin Mountain Range, and the Yellowstone River Valley. Return by the same route or take the trail down the back side of the mountain to Osprey Falls trailhead (about 2 miles) and return via the Bunsen Peak Road (hiking/biking only; about six miles). *See below for Osprey Falls description.* Trailhead: 5 miles south of Mammoth on the Mammoth–Norris Road.

Osprey Falls: Difficult; 8 miles round trip. Follows Bunsen Peak Road (hiking/biking only) through grassland and burnt forest 2½ miles to Osprey Falls Trail, which descends switchbacks to the bottom of Sheepeater Canyon, one of the deepest canyons in Yellowstone. Trailhead: 5 miles south of Mammoth on the Mammoth–Norris Road.

Lava Creek: Moderately difficult; 3½ miles one way. Follows Lava Creek downstream past Undine Falls (60 feet), descending gradually, passes the confluence of the creek and Gardner River, and crosses the river on a footbridge to a final climb out. Trailhead: Lava Creek picnic area on Mammoth–Tower Road; ends in a pullout north of Mammoth Campground on the North Entrance Road.

Rescue Creek: Moderately difficult; 8 miles one way. Follows Blacktail Deer Creek Trail past the east end of Blacktail Pond then climbs up short hill, then veers left on the Rescue Creek Trail. Climbs gradually through aspens and meadows, then descends through forests to open sagebrush flats that lead to a footbridge across the Gardner River. Trailhead: 7 miles east of Mammoth on Mammoth–Tower Road; ends 1 mile south of the North Entrance Station

Sepulcher Mountain: Strenuous; 11 miles round trip. Follows the Beaver Ponds Trail *(see above)* to the Sepulcher Mountain Trail junction, then climbs 3,400 feet through forest and meadows to the 9,652 foot summit. Loop trail continues along the opposite side of the mountain through an open slope to the junction of Snow Pass Trail, which descends to the Howard Eaton Trail, which should be followed west to Mammoth Terraces and the trailhead. Trailhead: between Liberty Cap and the stone house (the Judge's house) next to the Mammoth Terraces.

Wraith Falls: Easy; 1 mile round trip. Travels open sagebrush and Douglas-fir forest to the foot of Wraith Falls cascade on Lupine Creek. Trailhead: pullout ¼ mile east of Lava Creek Picnic area on the Mammoth–Tower Road.

Blacktail Deer Creek–Yellowstone River: Moderately difficult; 12 miles one way. Follows Blacktail Deer Creek as it descends 1,100 feet through rolling, grassy hills and Douglas-fir forest to the Yellowstone River. Crosses steel suspension bridge spanning Yellowstone River then joins the Yellowstone River Trail, which continues downriver, passing Knowles Falls and into arid terrain until it ends in Gardiner, Montana. Trailhead: 7 miles east of Mammoth on Mammoth–Tower Road; ends in Gardiner, Montana.

Historic Structures & Areas

Mammoth Hot Springs Historic District—includes Albright Visitor Center

Fort Yellowstone Historic Landmark (proposed)

Obsidian Cliff National Historic Landmark

Obsidian Cliff Kiosk

U.S. Post Office

See Chapters 1 and 7 for more information on historic areas in the park.

Also located in this area:

Administrative Headquarters of Yellowstone National Park

Yellowstone Research Library and Archives (open to the public)

habitat for bighorn sheep, which sometimes can be seen in Gardner Canyon.

Mt. Everts was named for explorer Truman Everts, a member of the 1870 Washburn Expedition who became separated from his companions and spent the next 37 days starving, freezing, and hallucinating as he made his way through the wilderness. Everts never made it as far as Mt. Everts. He was found near what is now the Blacktail Plateau Drive and was mistaken for a black bear and nearly shot. His story remains Yellowstone's best known, lost-in-the-wilderness story.

Collecting rocks, fossils, or anything else is forbidden on Mt. Everts and throughout the park.

Bunsen Peak

Bunsen Peak is 8,564 feet high and has two popular trails, described on the previous page. It is an intrusion of igneous material (magma) that formed during the same period as the Absaroka volcanics *(see Chapter 3).* The peak burned in the 1880s and in 1988. A series of old photos shows the creep of trees up Bunsen following the 1886 fires, and the new patterns of open space created by the fires of 1988.

Bunsen Peak and the "Bunsen burner" were both named for the German physicist, Robert Wilhelm Bunsen. His students gave the burner that name because he was involved in pioneering research about geysers, and a "Bunsen burner" has a resemblance to a geyser. His theory on geysers was published in the 1800s, and it is still believed to be accurate.

Swan Lake Flat

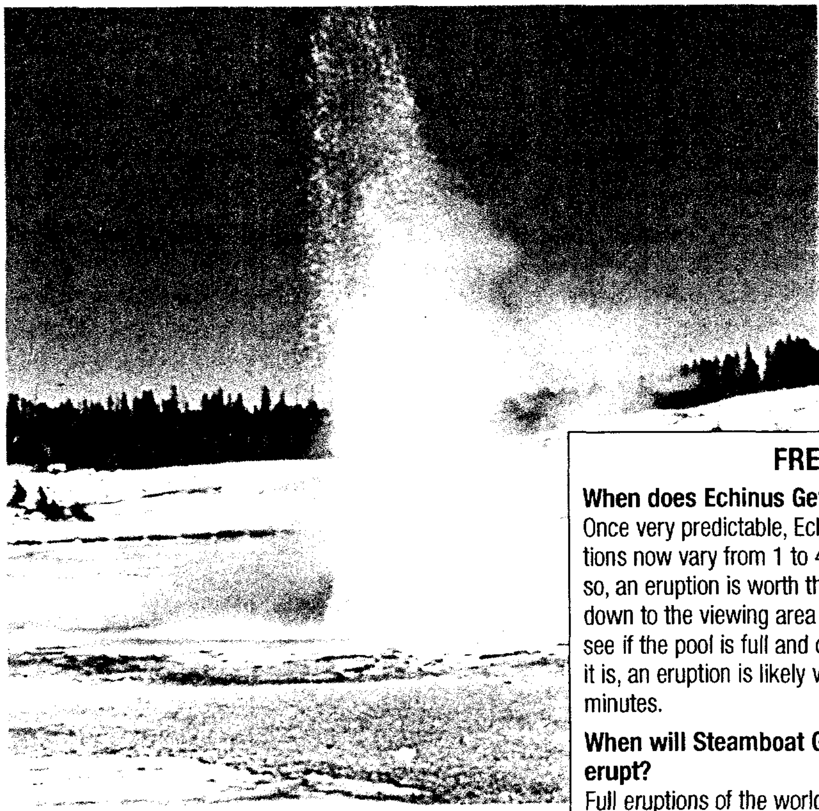
South of Bunsen Peak is Swan Lake Flat, a large glaciated area now made up of meadows where visitors often see herds of elk and bison, and sometimes grizzlies. It is also an excellent spot to see swans, ducks, herons, cranes, shore birds, and a variety of sparrows.

Obsidian Cliff

Obsidian Cliff is located 11 miles south of Mammoth Hot Springs and rises 150 to 200 feet above Obsidian Creek. Obsidian, or "volcanic glass," forms when very dry rhyolitic lava cools and hardens. Forty rhyolite flows in the park contain obsidian, but only a few contain obsidian of tool quality. A massive outcrop the size of Obsidian Cliff is rare because obsidian is usually found as small sections of other rock outcrops.

Because obsidian is so dry, it begins to absorb moisture once it is exposed to the air. By measuring the amount of moisture that has been absorbed, obsidian can be dated, and its source can be located. Obsidian was important to native peoples. The rock is dark and glassy and, when broken, fractures into round pieces with sharp edges. Consequently, for centuries Native Americans made projectile points and other tools from obsidian. Because there are so few sources of obsidian, it was a valuable trade item and is found throughout the continent, far from its source. In 1996, Obsidian Cliff was named a National Historic Landmark. The historic wayside exhibit structure here is one of the first of its kind in Yellowstone, built in the 1920s.

This area is closed to hiking, collecting, and all entry to protect the area.



9

Major Areas: Norris & Madison

FREQUENTLY ASKED QUESTIONS

When does Echinus Geyser erupt?
Once very predictable, Echinus's eruptions now vary from 1 to 4 hours. Even so, an eruption is worth the wait. Go down to the viewing area and look to see if the pool is full and overflowing. If it is, an eruption is likely within twenty minutes.

When will Steamboat Geyser erupt?
Full eruptions of the world's tallest active geyser are spectacular but entirely unpredictable —and often many years apart. The last eruption was May 2000; before that, October 1991. However, you may be able to see Steamboat ejecting water 10 to 40 feet in "minor phase" eruptions.

Why is this place so colorful?
The colors here, like in other hydrothermal areas, are due to combinations of minerals and lifeforms resistant to acidity and heat. Silica or clay minerals saturate some acidic waters, making them appear milky. Iron oxides, arsenic, and cyanobacteria create the red-orange colors. Cyanidium grows bright green. Mats of *Zygogonium* are dark purple to black. Sulfur creates a pale yellow hue.

NORRIS GEYSER BASIN

Norris Geyser Basin is the hottest, oldest, and most dynamic of Yellowstone's hydrothermal areas. The highest temperature yet recorded in any Yellowstone hydrothermal area was measured in a scientific drill hole at Norris: 459°F just 1,087 feet below the surface. Few hydrothermal features at Norris have temperatures below the boiling point (199°F). Norris shows evidence of having had hydrothermal features for at least 115,000 years. The features in the basin change daily, with frequent disturbances from seismic activity and water fluctuations.

Norris is so hot and dynamic primarily because it sits on the intersection of three major faults. One runs from Norris north through Mammoth to the Gardiner, Montana, area. The Hebgen Lake fault runs from northwest of West Yellowstone, Montana, to Norris. These two faults intersect with a ring fracture from the Yellowstone Caldera eruption 640,000 years ago.

Features

Norris Geyser Basin consists of three areas: Porcelain Basin, Back Basin, and One Hundred Spring Plain. Most of the water here is acidic, and Norris has rare acidic geysers such as Echinus (pH 3.5 or so). Echinus is found in Back Basin, a wooded area with features scattered along a 1½ mile trail of boardwalk and dirt. Steamboat Geyser, the tallest active geyser in the world (300 to 400 feet) steams on the hillside between Back Basin and the Norris Museum. On the other side of the museum, barren Porcelain Basin provides a sensory experience in sound, color, and smell along its ½ mile dirt, asphalt, and boardwalk trail. One Hundred Spring Plain is an off-trail section that is very acidic, hollow, and dangerous. Travel is discouraged without the guidance of knowledgeable staff.

Periodically, Norris Geyser Basin undergoes a large-scale basin-wide disturbance that may last a few weeks. Water levels fluctuate, temperatures and pH change, color changes, and eruptive patterns change throughout the basin. During a disturbance in 1985, Porkchop Geyser became a continuous jet of steam and water; during a disturbance in 1989, Porkchop apparently clogged with silica and blew up, throwing rocks more than 200 feet.

Geologists and chemists who have studied these disturbances have several theories about why they occur. They may be caused by a massive fluctuation in the underground reservoirs providing water to the basin. In the fall, they could be caused by less surface water mixing with water from deep underground, which holds more silica and clogs the cracks and crevices that supply water, thereby creating a "disturbance" as pressure builds.

9

Major Areas: Norris & Madison

The Ragged Hills that lie between Back Basin and One Hundred Spring Plain are thermally altered glacial moraines formed as glaciers receded. The underlying hydrothermal features melted remnants of ice and caused masses of debris to be dumped. These debris piles were then altered by steam and hot water flowing through them.

History

The area was named for Philetus W. Norris, the second superintendent of Yellowstone, who provided early detailed information about the hydrothermal features. Two historic buildings remain in this area: The Norris Geyser Basin Museum *(see Chapter 7)* and the Museum of the National Park Ranger, which is housed in the Norris Soldier Station, one of the only remaining soldier stations in the park. The building was used as a ranger station and residence until the 1959 Hebgen Lake earthquake caused structural damage. The building was restored in 1991 and adapted to its current use.

Wildlife

The Norris Campground area and meadows adjacent to the Gibbon and Madison rivers are prime elk calving areas in the spring. Fall brings bull elk to look for females to mate with. Bison frequent the same meadows in the spring, summer, and fall and use the hydrothermal areas in the winter. Both black and grizzly bears pass through the Norris area, with grizzlies using the hydrothermal areas in the spring to feed on winter-killed elk and bison.

Norris is one of the few areas in the park having lizards. The sagebrush lizard can survive here due to the influence of hydrothermal activity. Chorus frogs may be heard in the area in the spring *(see Chapter 6 for more about these animals).*

TRAILS

Norris Area

Grizzly Lake: Moderately difficult; 4 miles round trip. Passes through a lodgepole pine stand burned in 1976 and 1988, and through meadows to the long, narrow lake. Can be wet and mosquito laden before July. Trailhead: 1 mile south of Beaver Lake on Mammoth–Norris Road.

Solfatara Creek: Easy; 6.5 miles one way. Requires a car shuttle or returning the same route. Follows Solfatara Creek and soon passes the junction with the Howard Eaton (to Ice Lake, Wolf Lake, etc.). It parallels a power line for most of the way to Whiterock Springs; then climbs a short distance to Lake of the Woods (look off trail) and passes Amphitheater Springs and Lemonade Creek—small, but pretty hydrothermal areas. Trail continues to the Mammoth–Norris Road. **Caution:** Check at a visitor center for trail closures due to bear activity. Trailhead: Loop C of Norris Campground; ends ¾ miles south of Beaver Lake Picnic Area.

Ice Lake (direct route): Easy; 0.3 miles. Travels through lodgepole forest to Ice Lake, a small lake with a wheelchair accessible backcountry site. Hikers can continue on the Howard Eaton trail to Wolf Lake, Grebe Lake, Cascade Lake, and on to Canyon. *(See Canyon Area for descriptions.)* Trailhead: 3½ miles east of Norris on Norris–Canyon Road.

Wolf Lake Cut-off: easy; 6 miles round trip. Follows the Gibbon River past Little Gibbon Falls and through dense, partially burned lodgepole pine forest to Wolf Lake. Trail crosses the stream several times (no bridges) and is not regularly maintained. Trailhead: big pullout about ¼ mile east of Ice Lake Trailhead on Norris–Canyon Road.

Cygnet Lakes: Easy; 8 miles round trip. Travels through intermittently burned lodgepole pine forest and past ephemeral ponds to lush meadows surrounding the small and boggy Cygnet Lakes. Trail continues, but is not maintained. **Caution:** Due to bear activity, trail is day-use only. Trailhead: pullout on south side of Norris–Canyon road approximately seven miles from Norris Junction.

Artists' Paint Pots: Easy; 1 mile round trip. Crosses wet meadow then through partially burned lodgepole forest to colorful hot springs and small geysers. Trailhead: 4½ miles south of Norris on Norris—Madison Road.**Caution:** Due to road construction, trailhead is unmarked and parking is across the road.

Monument Geyser Basin: Strenuous; 2 miles round trip. Follows the Gibbon River, then turns sharply uphill and climbs 500 feet in one-half mile. Watch your footing; rocks are loose. *See description of geyser basin above.* Trailhead: 5 miles south of Norris just past Gibbon River Bridge. **Caution:** Active thermal features and thin crust here; do not travel beyond the end of the trail or within the geyser basin.

Madison Area

Purple Mountain: Strenuous; six miles round trip. Ascends 1,500 feet through intermittent burned lodgepole forest to views of Firehole Valley, lower Gibbon Valley, and Madison Junction area. Trailhead: ¼ mile north of Madison Junction along Mammoth–Norris Road.

Harlequin Lake: Easy; 1 mile round trip. Ascends through burned lodgepole forest to a small, marshy lake popular with mosquitoes and waterfowl (but not harlequin ducks). Trailhead: 1½ miles west of Madison Campground on West Entrance Road.

Two Ribbons: Easy; half-mile round trip. Boardwalk winds through burned lodgepole and sagebrush communities next to the Madison River, with good examples of fire recovery and buffalo wallows, interpreted by wayside exhibits. Trailhead: large pullout approximately 3 miles east of West Entrance.

Gallatin Area

Excellent long-distance hikes available in the Gallatin area north of West Yellowstone. Consult a ranger at visitor centers or one of the trail guides available from the Yellowstone Association.

Killdeer are found in the basin year-round taking advantage of the brine flies and other insects that live in the warm waters.

Thermophiles

Because Norris is acidic, some forms of life especially suited to life in extremes of heat and acid have been found here. *Cyanidium* is one of the more unusual algae found here; look for the brilliant green streak near Whirligig Geyser. Minerals such as arsenic also color the features.

Roaring Mountain

North of Norris, Roaring Mountain is a large, acidic hydrothermal area (solfatara) that contains many fumaroles. In the late 1800s and early 1900s, the number, size, and power of the fumaroles was much greater than today.

Virginia Cascades

A one-way, three-mile section of an older portion of the Grand Loop Road takes visitors past 60-foot high Virginia Cascades. The waterfall is formed by the Gibbon River as it crosses part of the rim of the Yellowstone Caldera. Lava flows formed the cliffs alongside the road. A portion of the 22-mile swath of lodgepole pine blown down by wind-shear action in 1984 can be seen just beyond the entrance to the drive. This blowdown burned during the 1988 fires, which makes the landscape look blackened and barren. A boardwalk trail takes visitors into the blowdown and a wayside exhibit tells the story.

Artists' Paint Pots

Artists' Paint Pots is a small but lovely hydrothermal area south of Norris Junction. A 1-mile round trip trail takes visitors to colorful hot springs, two large mudpots, and through a section of forest burned in 1988. **Caution:** Due to road construction, trailhead is unmarked and parking is across the road.

Monument Geyser Basin

This small basin may contain clues to recent discoveries under Yellowstone Lake. While the basin has no active geysers, its "monuments" are siliceous sinter deposits similar to the siliceous spires discovered on the floor of the lake. Scientists hypothesize that this basin's structures formed from a hot water system in a glacially dammed lake during the waning stages of the Pinedale Glaciation *(see Chapter 3)*. The basin is on a ridge reached by a very steep 1-mile trail just south of Artists' Paint Pots. **Caution:** Active thermal features and thin crust; do not travel beyond the end of the trail or in the geyser basin.

Gibbon Falls

South of Artists' Paint Pots, the 84-foot Gibbon Falls marks in spectacular fashion one of the locations of remnants from the caldera rim. The actual rim is southwest about one-quarter mile.

MADISON JUNCTION

At Madison Junction, the Gibbon River joins the Firehole River to form the Madison River. (The Gibbon River flows from Grebe Lake through the Norris area to Madison Junction. The Firehole River starts south of Old Faithful and flows through the park's major hydrothermal basins north to Madison Junction.) The Madison joins the Jefferson and the Gallatin rivers at Three Forks, Montana, to form the Missouri River.

Madison Junction lies within eroded stream channels that cut through lava flows after the last major volcanic eruption. National Park Mountain is actually part of the lava flows. The meadows are used by bison year-round, and also provide habitat for sandhill cranes, elk, and other animals.

People have camped here and at Norris for thousands of years. Archeological digs in both campground areas have found campfire remnants, obsidian flakes, and bone fragments dating back at least 10,000 years.

Terrace Spring

This hydrothermal area lies north of Madison Junction and can be reached via a short boardwalk. The runoff from the springs passes under the road and flows down a long slope to the Gibbon River. Yellow monkey flowers line the runoff channels in season.

Firehole Canyon Drive

This one-way side road, south of Madison Junction, follows the Firehole River upstream past 800-feet-thick lava flows to 40-foot Firehole Falls. The West Yellowstone Rhyolite Flow is to the west and occurred 110,000 years ago; the Nez Perce Rhyolite Flow is to the east and occurred 150,000 years ago. The unstaffed swimming area here is popular on warm summer days. Cliff diving is illegal. Swimming is usually prohibited during spring and early summer due to high water and strong current.

Historic Structures & Areas

Norris Soldier Station (now the Museum of the National Park Ranger)

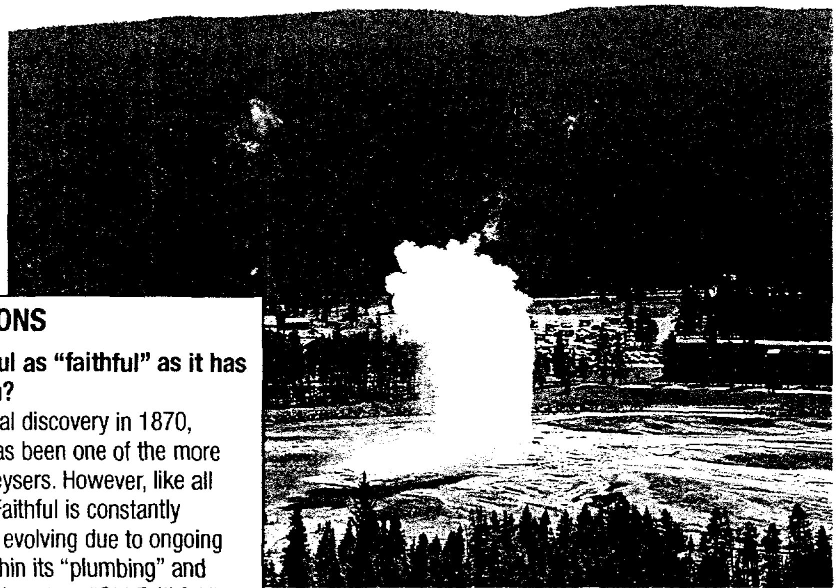
Norris Trailside Museum

Madison Trailside Museum

See Chapters 1 and 7 for more information on historic areas in the park.

9

Major Areas: Old Faithful



FREQUENTLY ASKED QUESTIONS

How often does Old Faithful erupt; how tall is it; how long does it last?
The average interval between eruptions of Old Faithful changes; currently it is 92 minutes, with intervals ranging from 45 to 120 minutes. Old Faithful can vary in height from 106 to more than 180 feet, averaging 130 feet. Eruptions normally last between 1½ to 5 minutes and expel from 3,700 to 8,400 gallons of water. At the vent, water is 204°F (95.6°C).

Is Old Faithful as "faithful" as it has always been?
Since its formal discovery in 1870, Old Faithful has been one of the more predictable geysers. However, like all geysers, Old Faithful is constantly changing and evolving due to ongoing processes within its "plumbing" and from earthquakes *(see "Old Faithful," below)*. Even so, Old Faithful remains one of the more predictable geysers.

See also the hydrothermal questions, pages 13–14 in the Introduction, and Chapter 3, Geology.

Historic Structures & Areas

Nez Perce National Historic Trail passes through the Lower Geyser Basin

Old Faithful Inn

Old Faithful Historic District; including Old Faithful Lodge

F. Jay Haynes photo studio, built in 1897; originally in front of the Old Faithful Inn, now near the cross-walk at the Grand Loop Road.

The Klamer Store, also built in 1897, is the Hamilton Store north of the Old Faithful Inn.

See Chapters 1 and 7 for more information on historic areas in the park.

THE UPPER GEYSER BASIN

Yellowstone National Park has approximately half of the world's geysers—most of them in this area. One square mile contains at least 150 of these hydrothermal wonders. Five major geysers—Old Faithful, Castle, Grand, Daisy, and Riverside—are predicted regularly by the interpretive staff. This basin contains many frequent, smaller geysers, and numerous hot springs

The hills surrounding Old Faithful and the Upper Geyser Basin are composed of rhyolite lava flows. These flows, occurring long after the catastrophic caldera eruption of 640,000 years ago, flowed across the landscape like stiff mounds of bread dough due to their high silica content.

Evidence of glacial activity also exists in the area. The glacial till deposits underlying the geyser basins provide the storage area for the water necessary for geysers to occur. Many landforms, such as the Porcupine Hills north of Fountain Flats, are comprised of glacial gravel and are reminders that as recently as 14,000 years ago, this area was buried under ice.

The Firehole River

The Firehole River originates from cold springs on the Madison Plateau and plunges over the 125–foot Kepler Cascades before reaching the Upper Geyser Basin. The river flows through three major geyser basins—Upper, Midway, and Lower—before joining the Gibbon River at Madison Junction to form the Madison River.

The epicenter of the 1959 Hebgen Lake Earthquake was located west of the park near the Madison River. This earthquake, measured at 7.5 on the Richter scale, shook up the geothermal underpinnings of the geyser basins along the Firehole River. Hundreds of geysers erupted—including hot springs never known to erupt. This hyperactivity continued for months.

Old Faithful Geyser

Predicting any geyser's eruption is difficult because of the complex interactions of constantly changing factors. Old Faithful has been analyzed for years by mathematicians, statisticians, and dedicated observers. We now know a direct relationship exists between the duration of Old Faithful's eruption and the length of the following interval. During a short eruption, less water and heat are discharged; thus, they rebuild again in a short time. Longer eruptions mean more water and heat are discharged and they require more time to rebuild.

Over time, the average interval between Old Faithful's eruptions increases, in part due to

ongoing processes within its plumbing. Changes also result from earthquakes. Prior to the Hebgen Lake Earthquake, the interval between Old Faithful's eruptions averaged more than one hour. Its intervals increased after that earthquake and again after the 1983 Borah Peak Earthquake, centered in Idaho. In 1998, an earthquake near Old Faithful lengthened the interval again; an earthquake swarm further increased intervals. As of March 2002, the average interval was 92 minutes.

Wildlife

Hydrothermal basins provide important habitat for wildlife in the Old Faithful area. Large numbers of bison and elk live here year-round. In the winter, they take advantage of the warm ground and thin snow cover. During spring and fall, moose are sometimes seen during the early morning or late afternoon. A small band of mule deer winters here too. Both black and grizzly bears are seen, especially during the spring when winter-killed carcasses are available. Yellow-bellied marmots are frequently seen in the rocks behind Grand Geyser and near Riverside Geyser. Cyanobacteria live in the runoff channels of hot springs and geysers, providing food for tiny black ephydrid flies. The flies, in turn, lay their eggs in salmon colored clumps just above the water surface where they are then preyed upon by spiders. Killdeer also feast on the adult flies.

MIDWAY GEYSER BASIN

This geyser basin, across the Firehole River from the Grand Loop Road, is smaller in size than the Upper and Lower geyser basins. Excelsior Geyser is a gaping crater 200 x 300 feet that constantly discharges more than 4,000 gallons of water per minute into the river. Grand Prismatic Spring, Yellowstone's largest hot spring, is 370 feet in diameter and more than 121 feet in depth. A bridge across the Firehole River allows access to the basin.

LOWER GEYSER BASIN

Activity of the Lower Geyser Basin can be viewed from two areas: Fountain Paint Pot (accessed by a boardwalk trail, and described at right) and Firehole Lake Drive. The latter is a 2-mile, one-way drive where you will find the sixth geyser predicted by the Old Faithful staff: Great Fountain. Its eruptions send jets of water droplets bursting 100 to 200 feet in the air, while waves of water cascade down its sinter terraces.

Hydrothermal features extend throughout this area, including sites that researchers explore for thermophiles that might be useful in medicine and science. For more on bioprospecting, see Chapter 8.

Fountain Flats Drive, a short side road immediately south of the Nez Perce picnic area, follows the Firehole River for 1½ miles to a trailhead. A hiking and biking trail continues along the old roadbed allowing access to the Sentinel Meadow and Fairy Falls trails. Also along this path is a wheelchair-accessible backcountry site at Goose Lake.

TRAILS

Upper Geyser Basin

Numerous loops or one-way walks explore the Upper Geyser Basin; a few descriptions follow. Geysers such as Castle, Grand, Riverside, and Daisy plus Morning Glory Pool, Biscuit Basin, and Black Sand Basin can be reached by other trails described in *The Old Faithful Area Trail Guide,* available at trailheads and the visitor center. Obtain geyser prediction times at the visitor center.

Geyser Hill Loop: Easy, 1⅓ mile round trip. Passes by Old Faithful, crosses the Firehole River, and then circles Geyser Hill and its variety of geysers and hot springs. Trailhead: Old Faithful Visitor Center.

Observation Point Loop: Strenuous; 1.1 miles round trip. Climbs about 150 feet to an overlook of the Upper Geyser Basin. Trailhead: just past the footbridge behind Old Faithful Geyser.

Mallard Lake: Moderately difficult; 6.8 miles round trip. Climbs through lodgepole forest and along meadows and rocky slopes to Mallard Lake. Trailhead: southeast side of the Old Faithful Lodge cabins, near the Firehole River.

Lone Star Geyser: Easy; 5 miles round trip. Open to bicycles. Follows old service road along the Firehole River through lodgepole forests to the geyser, which erupts approximately every 3 hours. Visitors record geyser times and observations in a logbook located in a box near the geyser. Trailhead: 3 miles south of the Old Faithful area, just beyond Kepler Cascades parking area.

Mystic Falls: moderately difficult; 2½ miles round trip. Follows a lovely creek through a lodgepole forest to the 70-foot falls. Turn around here or climb the switchbacks to an overlook of the Upper Geyser Basin, then loop back to the main trail. Trailhead: back of the Biscuit Basin boardwalk.

Midway and Lower Geyser Basin

Midway Geyser Basin: Easy; ½ mile. Boardwalk loops by impressive features such as Excelsior Geyser and Grand Prismatic Spring. Trailhead: 6 miles north of the Old Faithful area.

Fountain Paint Pot: Easy; less than ½ mile. Boardwalk loops past Yellowstone's four types of hydrothermal features: geysers, hot springs, mudpots, and fumaroles. Trailhead: 8 miles north of the Old Faithful area. *The Fountain Paint Pot Area Trail Guide* describes features along this trail and Firehole Lake Drive; available at the trailhead or Old Faithful Visitor Center.

Fairy Falls: Easy; 5 or 7 miles round trip. Two trails lead to this 200-foot waterfall. The shorter route approaches from the south, crossing the Firehole River then following the hiking/biking road approximately 1 mile to the Fairy Falls Trail. The longer route approaches from the north along hiking/biking road 1¾ miles to the Fairy Falls Trail. Trailheads: short route—1 mile south of Midway Geyser Basin; long route—at the end of Fountain Flats Drive, north of Fountain Paint Pot.

9

Major Areas: Tower—Roosevelt

FREQUENTLY ASKED QUESTIONS

How tall is Tower Fall?
132 feet.

How did the rock columns form in the canyon?
The formation you see across the Yellowstone River was formed by a basaltic lava flow that cracked into hexagonal columns as it slowly cooled. You can see other basalt columns at Sheepeater Cliff along the Gardner River between Mammoth and Norris.

How long is the trail to the bottom of Tower Fall?
One mile round trip from the Tower Fall Overlook to the bottom. The trail is steep—it descends about 300 feet in one-half mile. If you have heart, lung, or knee problems, you may want to enjoy the view from the overlook.

How did the petrified tree become petrified?
Two elements are required:

1. Rapid burial to minimize decay. In Yellowstone, trees were buried by volcanic deposits and mudflows 45–50 million years ago.
2. Groundwater with high concentrations of silica. The silica precipitates from ground water, filling the spaces within wood cells, and petrifies the tree.

Erosion uncovered the tree. In Yellowstone, glacial ice, running water, and wind have uncovered vast areas of petrified trees.

Historic Structures & Areas

Lamar Buffalo Ranch

Northeast Entrance Station

Roosevelt Lodge Historic District

See Chapters 1 and 7 for more information on historic areas in the park.

Formation

The geology of the Tower area is incredibly varied and its landforms are expressions of geologic events that helped shape much of the Yellowstone area. Mount Washburn and the Absaroka Range are both remnants of ancient volcanic events that formed the highest peaks in this area. Ancient eruptions 45 to 55 million years ago buried the forests of Specimen Ridge in ash and debris flows. The columnar basalt formations near Tower Fall, the volcanic breccias of the "towers" themselves, and numerous igneous outcrops all reflect the area's volcanic history. For more on these volcanic events, see Chapter 3.

Later, glaciers scoured the landscape, exposing the petrified trees and leaving evidence of their passage throughout the area. The glacial ponds and huge boulders (erratics) between the Lamar and Yellowstone rivers were left by the retreating glaciers, as were many lateral and terminal moraines.

Lamar Canyon

This canyon, east of Tower Junction, contains outcrops of granite and granitic gneiss that are among the oldest rocks known in the park—more than two billion years old. Little is known about their origin; time, heat and pressure have altered these rocks from their original state and obscured their early history. Only in the Gallatin Range are older outcrops found inside the park.

Tower Fall

Tower Creek drops 132 feet at Tower Fall, which is framed by eroded volcanic pinnacles. The idyllic setting has inspired numerous artists, including Thomas Moran, and today is a popular resting place for visitors before they begin the long climb back up.

Calcite Springs

This group of hydrothermal springs, located on a slope near river level, marks the downstream end of the Grand Canyon of the Yellowstone River. The heat driving these springs rises from a volcanic fracture zone beneath the area. Calcite Springs has been called a "natural oil refinery"—deposits of oil and other hydrocarbons lie in rocks beneath the springs. Heat forces oil out of these deeper rocks, causing it to ooze at the surface of the springs.

The canyon walls here offer a different glimpse of geologic time than do the walls near the Canyon Village area. Most of the wall is made up of sands, gravels, and cobbles deposited during volcanic eruptions nearly 50 million years ago, older than the Yellowstone Caldera volcanism. The columns of rock on top of this layer are the result of smaller basalt lava flows that covered this area about 1.5 million years ago. In between the basalt flows are gravels deposited from glaciers melting at the time of the basalt flows. At the top of the canyon are sediments from the

Pinedale Glaciation (Yellowstone's most recent), which ended about 14,000 years ago.

The gorge and cliffs provide habitat for wildlife species such as bighorn sheep, red-tailed hawks, and osprey.

Specimen Ridge

Specimen Ridge is the site of many layers of petrified trees. Located at the top of the ridge along the Northeast Entrance Road east of Tower Junction, area also includes excellent samples of petrified leaf impressions, conifer needles, and microscopic pollen from numerous species no longer growing in the park. The Petrified Tree, located near the Lost Lake trailhead, is an excellent example of an ancient redwood, similar to many found on Specimen Ridge, that is more accessible to park visitors. For more about the petrified trees in Yellowstone, see Chapter 3.

Wildlife

The (relatively) low-elevation valleys of the this area provide critical winter range to some of the largest wild herds of bison and elk found in North America. Due to the large herds of wintering bison and elk, the Lamar Valley was chosen as a primary site for restoration of gray wolves into Yellowstone in 1995 after a nearly 60 year absence *(see Chapters 6 and 8)*. Historic accounts indicate that wolves inhabited nearly all portions of the area, especially the Lamar Valley and Hellroaring Creek drainages. Multiple wolf pack territories currently exist in this prime habitat. Coyotes are also common, and an occasional bobcat, cougar, or red fox is reported.

Both grizzly and black bears are sighted throughout the area, particularly in the spring. Black bears are more commonly seen around Tower Fall and Tower Junction. Grizzlies are frequently seen on the north slopes of Mt. Washburn, particularly in the spring when elk are calving. The road pullouts provide excellent viewing platforms for wildlife watching.

Note: Beginning early September 2002, road construction may close the road from Chittenden Road south to Canyon, including Dunraven Pass.

TRAILS

Lost Lake: moderate; 4 miles round trip. Climbs 300 feet then joins the Roosevelt horse trail and continues west to Lost Lake. From Lost Lake, the trail follows the contour around the hillside to the Petrified Tree parking area, crosses the parking lot and continues up the hill, loops behind the Tower Ranger Station, across the creek, and back to the lodge. **Caution:** If you meet horses, move to the downhill side of the trail and remain still. Trailhead: behind Roosevelt Lodge.

Garnet Hill Loop: moderate; 7½ miles round trip. Trail follows the stagecoach road about 1½ miles to the cookout shelter, then follows Elk Creek almost to the Yellowstone River then turns upriver around Garnet Hill and back to the beginning. Trailhead: park in the large parking area east of the service station at Tower Junction, then walk approximately 100 yards on the Northeast Entrance Road to the trailhead on the left.

Hellroaring: Strenuous; 4 miles round trip. The trail begins with a steep descent to Yellowstone River Suspension Bridge, then crosses a sagebrush plateau and drops down to Hellroaring Creek. The Yellowstone River and Hellroaring Creek are both popular fishing areas. **Caution:** This trail can be hot and dry during the summer months so take plenty of water. Watch your footing if you go off trail and onto the smooth river boulders along the Yellowstone River. You can also access this trail from Tower Junction by following the Garnet Hill Loop Trail *(see above);* roundtrip distance is 10 miles. Trailhead: Hellroaring parking area 3.5 miles (5.6 km) west of Tower Junction.

Yellowstone River Picnic Area: moderate; 3.7 miles round trip. Climbs steeply for a short distance, then follows the rim of the Grand Canyon of the Yellowstone upriver, with views of the Narrows of the Yellowstone, the Overhanging Cliff area, the towers of Tower Fall, basalt columns, and the historic Bannock Ford. Watch your footing and beware of steep dropoffs into the canyon. Do not approach bighorn sheep; retreat or walk around them, keeping at least 25 yards between you and the animals. Above Bannock Ford, trail connects with the Specimen Ridge Trail and follows it a short distance to a left turn back to the Northeast Entrance Road. Once at the road, walk west 0.7 miles back to the picnic area. Trailhead: Yellowstone River Picnic Area.

Slough Creek: Moderately strenuous; 4 or 10 miles round trip. Actually a long-distance trail that leads far into the wilderness beyond Yellowstone, this trail is often used by anglers and hikers up to the first and second meadows. Trail follows historic wagon trail up Slough Creek, beginning with a climb up a moderately steep hill then down to the first meadow (2 miles); continues along the edge of the meadow to the second meadow (5 miles from trailhead.) Horse-drawn wagons also use this trail, they come from Silver Tip Ranch, a private ranch north of the park boundary that has a historic right of access. **Caution:** Be alert for bears; they frequent these meadows. Trailhead: Large parking area with vault toilet on the road to Slough Creek Campground.

Mt. Washburn: Strenuous; 3 miles one way. Two trails lead to the summit of Mt. Washburn; both are popular and often crowded in the summer. The north approach follows a service road and is open to bicycles and service vehicles. The south approach is hiking only. For descriptions of this area, see the Canyon area. Trailhead for north approach: Chittenden Road parking area, 8.7 miles south of Tower Junction.

9

Major Areas: West Thumb & Grant

FREQUENTLY ASKED QUESTIONS

Why is this area called West Thumb?
The name "West Thumb" comes from Yellowstone Lake's resemblance to the shape of a human hand; the large southwestern bay represents the thumb. The bay is a caldera within a caldera. It was formed by a volcanic explosion that occurred about 150,000 years ago. The resulting caldera later filled with water forming an extension of Yellowstone Lake.

Where can I see wildlife around Grant?
In summer, look for bison, elk, and mule deer around West Thumb Geyser Basin and in meadows along Big Thumb Creek; waterfowl, bald eagles, and osprey along the lake shore; ground squirrels, marmots, red squirrels, and other small mammals throughout the area. In winter, look for river otters along the shores of West Thumb where underwater hydrothermal features melt holes in the ice.

How deep is Abyss Pool?
About 53 feet; Black Pool is about 35–40 feet deep.

How hot are the springs at West Thumb?
Temperatures vary from less than 100°F to just over 200°F.

The West Thumb Paint Pots aren't like they used to be. What happened?
Like all hydrothermal features in Yellowstone, the West Thumb Paint Pots change over time. They became less active and more fluid in the 1970s. In the 1990s, they became more active; new mud cones periodically throw mud into the air.

Why doesn't Grant Campground open before late June?
Grizzly and black bears frequent this area in spring when cutthroat trout spawn in five streams here. To help prevent bear/human conflicts, the campground opens after most of the spawn is over.

What happened to the development at West Thumb?
The gas station, marina, photo shop, store, cafeteria, and cabins were removed in the 1980s to protect the fragile hydrothermal features and improve the quality of visitor experience. The development at Grant took the place of most of these facilities.

Formation

The large circular bay of West Thumb is an excellent example of a volcanic crater or caldera. A powerful volcanic explosion about 150,000 years ago caused the earth's crust to collapse, creating the West Thumb caldera. The depression produced by the volcano later filled with water to become this large bay of Yellowstone Lake.

The West Thumb caldera lies within the Yellowstone Caldera, which encompasses the central and southern portions of the park.

Fishing Cone

West Thumb Geyser Basin

The West Thumb Geyser Basin, including Potts Basin to the north, is the largest geyser basin on the shore of Yellowstone Lake. The hydrothermal features here are found on the shore and under the lake. Several underwater hydrothermal features were discovered in the early 1990s and can be seen as slick spots or slight bulges in the summer. During the winter, the underwater hydrothermal features can prevent lake ice from forming.

Walter Trumbull of the 1870 Washburn Expedition described a unique event while a man was fishing adjacent to what is now called Fishing Cone, a geyser on the lakeshore: ". . . in swinging a trout ashore, it accidentally got off the hook and fell into the spring. For a moment it darted about with wonderful rapidity, as if seeking an outlet. Then it came to the top, dead, and literally boiled." Fishing Cone erupted frequently to the height of 40 feet in 1919 and to lesser heights in 1939. One fisherman was badly burned in Fishing Cone in 1921. Fishing at the geyser is now prohibited.

Early visitors would arrive at West Thumb via stagecoach from the Old Faithful area. They had the choice of continuing on the dusty, bumpy stagecoach or boarding the steamship "Zillah" to continue the journey by water to the Lake Hotel. The boat dock was located near the south end of the geyser basin near Lakeside Spring.

Heart Lake

Lying in the Snake River watershed east of Lewis Lake and south of Yellowstone Lake, Heart Lake was named sometime before 1871 for Hart Hunney, an early hunter. Other early explorers in the region incorrectly assumed that the lake's name was spelled "Heart" because of its shape.

The Heart Lake Geyser Basin begins a couple of miles from the lake and descends along Witch Creek to the lakeshore. Five groups of hydrothermal features comprise the basin, and all of them contain geysers, although some are dormant.

The small range of mountains located just west of Heart Lake, the Red Mountains, includes 10,308-foot Mount Sheridan. Another peak, Factory Hill, was named because of the nearby steam vents, which N.P. Langford described in 1871: "Through the hazy atmosphere we beheld, on the shore of the inlet opposite our camp, the steam ascending in jets from more than fifty craters, giving it much the appearance of a New England factory village."

Craig Pass

Craig Pass, at 8,262 feet on the Continental Divide, is about eight miles east of Old Faithful on the Grand Loop Road. In 1891, U.S. Army Corps of Engineers Captain Hiram Chittenden discovered Craig Pass while he was surveying. It was probably Chittenden who named the pass for Ida M. Craig (Wilcox), one of the first visitors to cross the pass on the new road.

Isa Lake, at the pass, was also named by Chittenden. It is probably the only lake on earth that drains naturally to two oceans backwards, the east side draining to the Pacific and the west side to the Atlantic.

Shoshone Lake

Shoshone Lake, the park's second largest lake and the site of a geyser basin, is the source of the Lewis River southwest of West Thumb. Fur trapper Jim Bridger may have been the first European American to visit this lake, in 1833. Fellow trapper Osborne Russell certainly reached the lake in 1839. In 1872, Frank Bradley of the second Hayden Survey gave the lake its official name—the same name that area tribes gave the Snake River.

Shoshone Lake is thought to be the largest lake in the lower 48 states that cannot be reached by road. Its maximum depth is 205 feet and it has an area of 8,050 acres. Originally, the lake was barren of fish owing to waterfalls on the Lewis River. Lake and brown trout were planted beginning in 1890, and the Utah chub was apparently introduced by bait anglers.

The Shoshone Geyser Basin, reached by hiking or by boat, contains one of the highest

TRAILS

West Thumb Geyser Basin: Easy; ⅜ mile round trip; wheelchair accessible with assistance. Boardwalks provide access to this geyser basin and its colorful hot springs and dormant lakeshore geysers on the shores of Yellowstone Lake. Trailhead: West Thumb Geyser Basin parking lot, ¼ mile east of West Thumb Junction. *The West Thumb Trail Guide*, available at the trailhead, provides descriptions of this hydrothermal area.

Yellowstone Lake Overlook: Moderately difficult; 2 miles round trip. Follows mostly level terrain then climbs 400 feet to an overlook in a high mountain meadow with a commanding view of the West Thumb of Yellowstone Lake and the Absaroka Mountains.

Duck Lake: Moderately difficult; 1 mile round trip. Climbs a small hill to a view of Duck and Yellowstone lakes and the expanse of the 1988 fires that swept through this area. Trailhead: West Thumb Geyser Basin parking area.

Shoshone Lake (via DeLacy Creek): easy; 6 miles round trip. Follows a forest edge and passes through open meadows to the shores of Yellowstone's largest backcountry lake. Trailhead: 8.8 miles east of West Thumb Junction.

Riddle Lake: easy; 5 miles round trip. Crosses the Continental Divide and passes through small mountain meadows and forests to the shores of a picturesque little lake. Look for moose in the marshy meadows and for birds near the lake. Due to grizzly activity, this trail does not open until July 15th and groups of four people or more are recommended but not required. Trailhead: approximately 3 miles south of the Grant Village intersection, just south of the Continental Divide sign.

Lewis River Channel/Dogshead Loop: moderately difficult; 7 or 11 miles round trip. Travels through a fairly level forested and burned area to the Lewis River Channel. Look for eagles and osprey fishing for trout in the shallow waters. Turn around at this point for the shorter trip or continue on. Trail follows the channel to Shoshone Lake and returns via the Dogshead Trail. Trailhead: approximately 5 miles south of the Grant Village intersection, just north of Lewis Lake on west side of the road.

concentrations of geysers in the world—more than 80 in an area 1,600 x 800 feet. Hot springs and mudpots dot the landscape between the geyser basin and the lake.

Snake River

The Snake River is a major tributary of the Columbia River and has its headwaters just inside Yellowstone on the Two Ocean Plateau. Its source was debated for a long time. The problem was to find the longest branch in the Two Ocean Plateau, which is thoroughly crisscrossed with streams. Current maps show the head of the Snake to be about 3 miles north of Phelps Pass, at a point on the Continental Divide inside Yellowstone National Park. A number of springs gush forth upon the hillside, which is about two miles above sea level. Uniting, they form a small stream, which flows through Idaho, joins the Columbia in Washington, and then to the Pacific. The Snake River is the nation's fourth largest river; 42 miles of it are in Yellowstone National Park.

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