Yellowstone National Park

Resources & Issues Handbook 2000

Through the years, various individuals have contributed articles for use in this collection of park information; we appreciate their contributions. This year's handbook contributors:

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Why is Yellowstone significant?

Yellowstone is the world's first national park and has become an international symbol of natural preservation. Due to the worldwide significance of its natural and cultural resources, it has been designated by the United Nations as both a Biosphere Reserve and a World Heritage Site.

With more than 10,000 thermal features, Yellowstone contains half of the known geothermal features in the world. It also has the largest concentration of geysers in the world. Its more than 300 geysers make up 1/2 of all the geysers on the planet. It is home to the world's tallest geyser, Steamboat, that (when active) erupts to a height of 385 feet. It is one of the few places in the world where travertine terraces are found. The microbes found in Yellowstone's thermal features are proving useful in solving some of our most perplexing medical and environmental problems.

Yellowstone protects the largest number and greatest variety of animal species in the lower 48 states. It protects two federally listed endangered species, the gray wolf and the whooping crane, and three threatened species, the grizzly bear, the bald eagle, and the lynx. It is home to the largest concentration of elk in the world. At the turn of the century, the last remnant of the vast bison herds of the Great Plains was saved from extinction in Yellowstone, which is the 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, served as one of the precursors to the Endangered Species Act. And, in 1995, the gray wolf, which had been extirpated from Yellowstone by 1930, was restored to the park. Finally, all the large mammal species known to be in Yellowstone when Euro-Americans had arrived were together again, making the ecosystem complete.

Yellowstone is the core of the greater Yellowstone ecosystem—the largest intact temperate ecosystem remaining on the planet. The ecosystem occupies 28,000 square miles in two national parks, seven national forests, three national wildlife refuges, and various private lands. The ecosystem preserves acres of wilderness where natural processes proceed largely uninterrupted.

Yellowstone is the site of one of the largest volcanic eruptions known to have occurred in the world, leaving behind one of the largest calderas. The park contains the world's largest petrified forest and the spectacular Grand Canyon of the Yellowstone.

Yellowstone Lake is the largest lake above 7,000 feet in North America. Many of the great North American rivers originate in the park. Situated astride the Continental Divide, park waters flow east to the Atlantic and west to the Pacific. Yellowstone gives birth to two of the three forks that form the Missouri River, the Madison and the Gallatin. The Yellowstone River is the longest free-flowing river in the United States, flowing into the Missouri, then the Mississippi, and eventually into the Gulf of Mexico. The Snake River flows into the Columbia and eventually into the Pacific. .

Yellowstone is a refuge not only for wildlife, but also for the human soul. It is a place of great beauty, where people have come to recreate and to rest for more than 125 years.

How did Yellowstone get its name?

Many people are under the mistaken impression that the name "Yellowstone" comes from the brightly colored, thermally altered rhyolite in the Grand Canyon of the Yellowstone. This is not the case. When French-Canadian trappers encountered the Minnetaree tribe along a river in what is today eastern Montana, they asked them about the name of that river. The Minnetaree responded that is was called "Mi tse a-da-zi," which translates literally as "Rock Yellow River." The trappers then called the river by the French translation, "Roche Jaune" or "Pierre Jaune." The first translation of the river's name into English, "Yellow Stone," was made by David Thomson, an explorer-geographer, in 1797. Lewis and Clark referred to the Yellowstone River both by the French and two-word English form. Subsequent usage formalized the name as a single word, "Yellowstone."

FAQ

How big is Yellowstone?

It is 3,472 square miles (2,221,766 acres) in size. It is larger than the states of Rhode Island and Delaware combined, or roughly the size of the state of Connecticut. Ninety-six percent of the park lies in Wyoming, 3 percent in Montana, and 1 percent in Idaho.

Was Yellowstone the first national park?

Yellowstone was established in 1872 as the world's first national park. Some sources list the Hot Springs in Arkansas as the first national park as it was set aside in 1832, forty years before Yellowstone was established. Hot Springs is the nation's oldest national reservation, but the purpose for its creation was quite different from that of Yellowstone. The intent at Hot Springs was to assure preservation and equitable distribution of a utilitarian resource, much like our present national forests. In 1921, an act of Congress established Hot Springs as a national park.

Others will argue that Yosemite preceded Yellowstone as the first national 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 the purpose of public use and recreation. In 1890, Congress established Yosemite as a national park. Yellowstone, 18 years after it established Yellowstone National Park.

Where are the bears?

People who visited Yellowstone prior to the 1970s often fondly remember seeing bears along roadsides and within developed areas of the park. Bears were attracted to these areas primarily due to the availability of human foods in the form of handouts, unsecured stored food, and garbage. Although observing these habituated bears was very popular with park visitors, it was neither good for the people nor the bears. Between the years of 1930 and 1969, an average of 48 bear-caused injuries occurred to people every year. Many nuisance bears were destroyed during this period.

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. Regulations that prohibited the feeding of bears were strictly enforced as were those requiring that human food be kept secured from bears. In addition, 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, grizzly bears may be seen in the Yellowstone Lake, Fishing Bridge, and the East Entrance areas 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. Black bears are most active at dawn and dusk, but may also be seen during mid-day. Look for black bears in open spaces within or near forested areas. Black bears are most commonly observed on the northern range between Mammoth, Tower, and the Northeast Entrance. Black bears may also be seen in the Old Faithful, Madison, and Canyon areas as well as in the Bechler region.

Where can I see wildlife?

Animals choose habitat based on what it provides: food, shelter, and space. Different animals are seen at different times of day, depending on their type of foraging strategy. See the park's site bulletin on this topic, "Mammals of Yellowstone National Park," for specific locations.

How often does Old Faithful erupt; how high is it; how long does it last?

The current average interval between eruptions of Old Faithful is 86 minutes, with intervals ranging from 45 to 110 minutes. Most eruptions occur within 10 minutes of the predicted time. Old Faithful can vary in height from 100 to 180 feet, averaging 130 to 140 feet. Eruptions normally last between 1 to 5 minutes.

Is Old Faithful as "faithful" as it has always been?

Yes. While the interval of Old Faithful's eruptions has lengthened by a few minutes through the years, particularly after the 1959 Hebgen Lake and 1983 Borah Peak earthquakes, it is still predictable within plus or minus 10 minutes.

Why are there geysers in Yellowstone?

Three components are needed for geysers to occur: heat, water, and a "plumbing" system. Yellowstone has a volcanic past. The most recent large eruption was about 630,000 years ago. This eruption was caused by a hot spot (magma chamber) under the center of what we now call Yellowstone. The hot spot is still there and radiates heat into the surrounding rock. Water, in the form of rain and snow, penetrates the ground through fractures, comes into contact with the hot rock, and rises to the surface. The hot ash from the volcanic eruption now exists as a rock called rhyolite that is rich in silica. The hot water rises through the rhyolite rock and dissolves the silica. The silica then lines the crevices in the rock and makes a water-tight seal that holds in pressure, creating the plumbing system of the geysers. This combination of heat, water, and strong rock allows for the geysers to occur in Yellowstone.

Why is smoking not allowed in geyser basins?

Geyser basins are fragile places. Litter of all types is a problem, but cigarette butts can become especially numerous if smoking is allowed in an area. Also, most thermal areas have sulfur deposits lying on the ground surface. When sulfur catches fire, dangerous, sometimes lethal fumes are given off.

Why are dogs not allowed on geyser basin trails?

Dogs do not seem to recognize the difference between hot and cold water. Dogs have lost their lives diving into hot springs. Dogs also disturb wildlife; they are prohibited from all park trails.

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

YES! Geyser basins are constantly changing and there are hollow areas that may have only a thin layer of rock over them. Boiling water surges just under most of the geyser basins, and many people have been severely injured (second and third degree burns) when they have broken through the thin crust. Some people have died from falling into thermal features.

What is the "caldera" line on the park map?

When a volcano erupts, as one did in Yellowstone 630,000 years ago, it rapidly expels most of its magma, and the roof of the magma chamber collapses. The crater formed by this collapse is called a "caldera," which is Spanish for "caldron." The Yellowstone caldera is more than 35 miles wide. The crater was filled in by subsequent lava flows after the eruption, but the rim of the caldera can still be seen in several areas of the park, including Mt. Washburn, Gibbon Falls, Lewis Falls, and the Flat Mountain Arm of Yellowstone Lake.

What is the Continental Divide?

Think of the Continental Divide as the roof-top 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 ridge line is not straight. It follows the twists and turns of the mountains through the southwestern side of the park. Therefore, it is possible to cross the Continental Divide several times while traveling between the South Entrance, Grant Village, and Old Faithful.

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 handbook, we use “bison.”

Why is fishing lead-free in Yellowstone?

Lead-headed jigs were banned in Yellowstone in 1990. Lead is a severe environmental contaminant and a toxic substance that has no known beneficial biological function. The scientific evidence continues to mount regarding the dangers of lead concentrating in aquatic environments. Wildlife, such as loons, waterfowl, cranes, and shorebirds, are vulnerable to lead poisoning. Of particular concern to Yellowstone is the alarmingly low population of trumpeter swans and loons. We are trying to maintain a viable breeding population of these sensitive birds in Yellowstone. While there is little we can do about natural hazards, we can minimize the effects of lead on these species. Between 120,000 and 160,000 people fish each year in Yellowstone. Non-toxic alternatives to lead fishing tackle are available to the consumer. In 1994, a non-toxic fishing program was implemented in Yellowstone.

How many rangers are there in Yellowstone?

There are approximately 250 rangers in Yellowstone. One hundred of these are permanent employees, and 150 are seasonal employees. Rangers perform duties in law enforcement, backcountry management, fee collection, and interpretation. There are approximately 750 employees of the National Park Service in Yellowstone (350 permanent, 400 seasonal).

What is the highest peak in Yellowstone?

Eagle Peak in the Absaroka Mountain range in the park’s southeastern corner is the highest peak in the park at 11,358 feet in elevation.

How cold does it get in Yellowstone in the winter?

The record low temperature was -66°F (-54°C), measured at the Riverside Station near the West Entrance of the park, 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.

What’s the difference between a national park and a national forest?

Though visitors often perceive them as quite 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 the resources under their administration for a variety of sustainable uses.

Is Yellowstone the largest national park in the country?

No. Wrangell-St. Elias National Park and Preserve in Alaska 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 lower 48 states. But, in 1994, Death Valley National Park was established when Death Valley National Monument was expanded; this park is more than 3 million acres in size.

How many visitors come to Yellowstone in a year?

Slightly more than three million visitors come to Yellowstone in the course of a year. Around 140,000 of those visit the park in the winter.

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

Because of the worldwide significance of its natural and cultural resources, the United Nations has designated Yellowstone National Park as both a Biosphere Reserve and a World Heritage Site. These designations have nothing to do with how Yellowstone is managed 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 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?

Approximately 793,880 acres or 36 percent of the park was affected by the 1988 fires. However, only 15 percent of this was a "canopy" burn—the type of burn that consumes every needle on a tree. Much of the other affected areas included grasslands and other types of vegetation that regenerates very quickly.

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

The summer of 1988 was different from previous summers as there was no rain and there were many dry storms with high winds. While Yellowstone usually experiences afternoon showers three or four days each week during the summer, but in 1988 there was no rain for virtually three months. The most severe drought in the park's history occurred that summer. Also, an unprecedented number of lightning strikes came with a series of dry storm fronts. This lightning started many of the fires and then stoked them with particularly high and constant 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, since Yellowstone was established as a national park in 1872, 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 in the park coupled with the abnormally wet spring suggested that the fires would go out as previous fires had. The fires that began in mid-July and August were fought aggressively from the moment they were detected. Despite the largest firefighting effort in the history of the nation, the weather finally contained the fires when snow fell in September.

Was Yellowstone's fire policy changed after the fires of 1988?

The park's fire policy in 1988 was to put out any fires that threatened human life and property. Naturally caused fires were allowed to burn because fire is a natural and necessary process in natural ecosystems and prior fire history indicated that these fires would be naturally contained or extinguished quickly.

After the fires of 1988, the fire policy underwent extensive review. While affirming the positive role of natural fire in the ecosystem, the review team recommended additional safeguards for the new Fire Management Plan, which was implemented in 1992. As before, fires that threaten life and property and fires that are human-caused will be suppressed immediately. However, now, even naturally ignited (lightning-caused) fires must meet additional specific fire prescription guidelines before being allowed to burn. Also, a certification must be prepared daily stating that

a natural fire is within prescription (a series of climatic parameters under which a fire should be able to be controlled), and that adequate suppression resources are available to ensure that the fire will remain “in prescription” through the next 24-hour period.

The Earliest Human Visitors

For more than 10,000 years, people have passed through and lived in the region that would become Yellowstone National Park. While we have evidence of their presence in the remnants of their homes and discarded tools, we have no idea how these peoples viewed this fantastic place. We can only imagine what their emotions and thoughts were with regard to the seething mudpots, hissing vents, periodic earthquakes, and suddenly erupting geysers.

The first people arrived in the Yellowstone region during the decline of the last Ice Age. Their small and highly mobile population possessed a limited material culture and left little physical evidence of their presence except for their distinctive stone tools and projectile points, now classified with such terms as "Folsom" and "Clovis." They traveled along rivers and down major valleys in pursuit of Ice Age mammals, such as the mammoth, the ancestral horse, and the giant bison, as well as the familiar animals of today. They supplemented the game with berries, seeds, and roots. Though they were few in number, their weapons and tools made them comparatively efficient, and their hunting, combined with the warming of the climate, may have contributed to the disappearance of many prehistoric mammals. When the last glacial stage ended about 8,500 years ago, many animals that were adapted to colder, wetter conditions became extinct. This environmental change also altered the habits of people.

As the climate in the Yellowstone region warmed up, the surrounding plains grew extremely hot and dry, but mountainous areas remained cool and well watered. The populations in the region increased steadily as a new lifestyle—hunting for small game and foraging for plants in a distinct home territory—replaced the endless wandering of the original hunters. By about AD 1600, Yellowstone was occupied by semi-nomadic populations that left many stone tools and projectile points, domestic utensils, and campsites.

When the horse arrived in the high country of the West in the late 1600s, it upset old patterns of life and, in some places, produced entirely new cultures. The Native Americans could now follow the bison herds and other game of the plains. The Crow occupied the country generally east of the park and the Blackfeet that to the north. The Shoshonean Bannock and probably other tribes of the plateaus to the northwest traversed the park annually to hunt on the plains to the east. Other Shoshonean groups pushed northward along the eastern edge of the Great Basin (west and south of the park), and the acquisition of horses both intensified this movement and scattered them into diverse bands. Most of these Shoshone hunted in the open areas west and south of Yellowstone. But some, either through conservatism of their culture or the lack of opportunity, did not acquire horses. They continued to forage on foot in the mountains of Yellowstone where there was little competition. Because of the importance of mountain sheep in their diet, they became known as "Sheepeaters."

The First White Visitors

During the late 1700s, fur trappers filtered into the upper Missouri country in search of a broad-tailed promise of fortune—the beaver. The early trappers and traders were mostly French-Canadian, and the great tributary of the Missouri, the Yellowstone, first became known to white people by its French label, "Roche Jaune." None of the early trappers, however, seem to have observed the thermal activity in the area that would one day become a national park, although they probably learned of some of its wonders from their Native American acquaintances.

The Lewis and Clark Expedition passed just north of Yellowstone in 1806. Though Native Americans told them of the great lake to the south, they remained unaware of the area's hot springs and geysers. About that same time, a trader appeared in St. Louis with a rude sketch drawn on a buffalo hide showing the region of the upper Yellowstone and indicating the presence of what appeared to be "a volcano . . . on Yellow Stone River." After his return to St. Louis, Clark interviewed a Native American who had been to the area and reported: "There is frequently heard a loud noise like Thunder, which makes the earth Tremble. . . ."

In 1807, Manual Lisa's Missouri Fur Trading Company constructed Fort Raymond at the confluence of the Bighorn and Yellowstone rivers as a center for trading with the Native Americans. To attract clients, Lisa sent John Colter on a 500-mile journey through untracked country. Aveteran of

the Lewis and Clark Expedition, Colter was a man born "for hardy endurance of fatigue, privation and perils." Part of his route in 1807-08 is open to conjecture, but he is believed to have skirted the northwest shore of Yellowstone Lake and crossed the Yellowstone River near Tower Fall, where he noted the presence of "Hot Spring Brimstone." (Although many have used the term, "Colter's Hell," to describe Yellowstone, trappers of Colter's era actually had given this name to a thermal area near present-day Cody, Wyoming.) The privations of a trapper's life and a narrow escape from the Blackfeet in 1808 prompted Colter to leave the mountains forever in 1810. But, he was the pioneer, and for the next three decades a procession of beaver hunters followed in his footsteps.

Though most of the trappers who entered Yellowstone were Americans working for various companies or as free traders, some Canadians also visited the region in the early days. At least one party of Hudson's Bay Company men left a cache of beaver traps within the park. By 1824, Yellowstone seems to have been fairly well known to most trappers, judging by the casual note of one in his journal: "Saturday 24th— we crossed beyond the Boiling Fountains. The snow is knee deep." In 1827, a Philadelphia newspaper printed a letter from a trapper who described his experience hunting furs and fighting Blackfeet in Yellowstone. The letter was the first published description of the region:

> On the south borders 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. The clay is white and pink and water appears fathomless as it appears to be hollow underneath. There is also a number of places where the pure sulphor is sent forth in abundance—one of our men visited one of these whilst taking his recreation at an instant made his escape when an explosion took place resembling that of thunder. During our stay in that quarter I heard it every day. . . .

After 1826, American trappers apparently hunted within the future park every year. Joe Meek, one of the best known of the early beaver men, expressed the surprise of some of these early visitors: "Behold! the whole country beyond was smoking with the vapor from boiling springs, and burning with gasses."

Trappers had little for entertainment but talk; as a class they were the finest of storytellers. Verbal embellishment became a fine art as they related their experiences fighting Indians or visiting strange country. Perhaps the greatest of yarn spinners was Jim Bridger. Though it is doubtful he told them all, tradition links his name with many of Yellowstone's tall tales. In 1856, a Kansas City newspaper editor rejected as "patent lies" Bridger's lucid description of the Yellowstone wonders. Perhaps this sort of refusal to believe the truth about "the place where Hell bubbled up," as Bridger called Yellowstone, led him and other trappers to embellish their accounts with false detail. They related their visits to the petrified forest, carpeted with petrified grass, populated by petrified animals, and containing even birds petrified in flight. They told of the shrinking of Alum Creek, the banks of which were frequented by miniature animals. Fish caught in cold water at the bottom of a curious spring were cooked passing through the hot water on top. Elk hunters bumped into a glass mountain. Such stories gave the features of Yellowstone the reputation of fantasies concocted by trappers, but a few people wondered whether some fact might not lie behind the fancy.

By about 1840, the extirpation of the beaver and the popularity of the silk hat had combined to end the era of the trapper. For almost 20 years, Yellowstone was rarely visited by white men. By the time of the Civil War, however, the expanding American civilization and the relentless quest for gold had drawn many people west. Arich gold strike in southwestern Montana Territory in 1862 resulted in thousands of men coming to the region and staking claims around Virginia City, Bannock, and other new, young towns. The lust for gold was such that these prospectors searched every gulch and stream of the region, including the area that would become Yellowstone National Park. One enterprising gold seeker, a civil engineer and soldier of fortune named Walter W. DeLacy, published the first reasonably accurate map of the Yellowstone region in 1865. By the time the gold rush had died out in the late 1860s, the future park had been thoroughly examined by prospectors. While no gold was found there, the tales the prospectors told of the wondrous land they had seen planted a seed of curiosity in some Montanans that compelled them to journey to the area to see for themselves the uncommon sights.

Yellowstone Is "Discovered"

Although Yellowstone had been thoroughly tracked by trappers and miners, in the view of the nation at large it was really "discovered" when penetrated by formal expeditions. The first such organized attempt to explore Yellowstone came in 1860. Captain William F. Raynolds, an astute Army engineer, led a military expedition (guided by Jim Bridger) that accomplished much, but failed to penetrate the future park because of poor scheduling and early snow. The Civil War preoccupied the government during the next few years. During the late 1860s, however, stories of the area's wonders so excited many of Montana's leading citizens and officials that several explorations were planned. None actually got underway.

Trouble with Native Americans and lack of military escort caused the abandonment of the last such expedition in the summer of 1869. Determined that they would not be deprived of a look at the wondrous region, three members of that would-be venture—David E. Folsom, Charles W. Cook, and William Peterson—decided to make the trek anyway. Folsom and Cook brought with them a sensitivity to nature attained through a Quaker upbringing, while Peterson displayed the hardy spirit that came from years as a seafarer. All three, furthermore, had become experienced while prospecting for Montana gold. They acquired a store of provisions, armed themselves well, then set out on an enterprise, which a friend warned was "the next thing to suicide."

That caution could not have been more wrong. From Bozeman, they traveled down the divide between the Gallatin and Yellowstone rivers, eventually crossing to the Yellowstone and ascending that stream into the present park by way of Yankee Jim Canyon. They observed Tower Fall and nearby thermal features and the Grand Canyon of the Yellowstone—"this masterpiece of nature's handiwork"—then continued past the Mud Volcano to Yellowstone Lake. They pushed east to Mary Bay, then backtracked across the north shore and south to West Thumb. On their way home, the explorers visited Shoshone Lake and the Lower and Midway geyser basins. The Folsom-Cook-Peterson exploration produced an updated version of DeLacy's 1865 map, an article in the *Western Monthly* magazine in Chicago, and a fever of excitement among some of Montana's leading citizens, who promptly determined 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."

By August 1870, a second expedition had been organized, however, rumors of "Indian trouble" reduced the expedition members to less than half the original number. Among those that went were prominent government officials and financial leaders of Montana Territory, led by Surveyor-General Henry D. Washburn; politician and business promoter Nathaniel P. Langford; and attorney Cornelius Hedges. Obtaining a military escort from Fort Ellis under an experienced soldier, Lt. Gustavus C. Doane, the explorers traced the general route of the 1869 party. They followed the river to the lake; passed around the eastern and southern sides of the lake; inspected the Upper, Midway, and Lower geyser basins; and paused at Madison Junction—the confluence of the Gibbon and Firehole rivers—before returning to Montana. By the end of the expedition, the party had climbed several peaks, made numerous side trips to see fabled features, descended into the Grand Canyon of the Yellowstone, and attempted measurements and analyses of several of the prominent natural features.

Some of the members of the 1870 expedition lacked extensive experience as frontiersmen, and their wilderness education came hard. At times they went hungry because, according to Doane, "Our party kept up such a racket of yelling and firing as to drive off all game for miles ahead of us." One of the expedition's members, Truman Everts, became separated from the rest of the party near the southern edge of Yellowstone Lake. He lost his glasses and his horse and nearly starved to death before he was rescued 37 days later in the northern portion of the park.

The 1870 expedition proved that ordinary men, as well as hardened frontiersmen, could venture into the wilderness of Yellowstone. Far more important, however, was their enchantment and wonder at what they had seen, and their success in publicizing these feelings. Their reports stirred intense interest in Montana and attracted national attention. Members of the expedition wrote articles for several newspapers and *Scribner's Monthly* magazine. Langford made a speaking tour in the East. Doane's official report was accepted and printed by the Congress. All this publicity resulted in a congressional appropriation for an official exploration of Yellowstone—the 1871 Hayden Expedition.

Ferdinand V. Hayden, physician turned geologist, energetic explorer, and accomplished naturalist, was head of the U.S. Geological Survey of the Territories. Hayden had been with the Raynolds expedition in 1860, and the failure of that party to penetrate Yellowstone had stimulated his desire to investigate the region. Aside from being a leading scientific investigator of the wilderness, he was an influential publicist of the scientific wonders, scenic beauty, and economic potential of the American West. He saw the interest stirred by the Washburn-Langford-Doane Expedition as an opportunity to reveal Yellowstone in an orderly and scientific manner. Drawing on the support of the railroad interest—always proponents of Western exploration and development—and favorable public reaction to the reports of the 1870 expedition, Hayden prepared for a scientific survey of Yellowstone. His expedition was supplemented by a simultaneous survey by the U.S. Army Corps of Engineers.

The Hayden Survey was more thorough than previous expeditions, and it brought back scientific corroboration of the earlier tales of thermal activity. Although a lot of the material collected in Yellowstone was destroyed in the Chicago fire of 1871, the expedition gave the world a much 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. Elliott and Thomas Moran. The expedition's reports excited the scientific community and aroused intense national interest in this previously mysterious region.

Members of all three expeditions were overwhelmed by what they had seen. The singular features of the area evoked similar reactions in all the explorers. One must remember that this was the day of the "robber barons" and of rapacious exploitation of the public domain. It was also a time of dynamic national expansion, when the nation conceived its mission to be the taming and peopling of the wilderness. But most of this region's explorers sensed that division and exploitation, through homesteading or other development, were not appropriate for Yellowstone. Its natural curiosities impressed them as being so valuable that the area should be reserved for all to see. Their crowning achievement was that they persuaded others to their view and helped to save Yellowstone from private development.

Hayden, assisted by members of the Washburn party and other interested persons, promoted a park bill in Washington in late 1871 and early 1872. Working earnestly, the sponsors 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, and the persuasive magic of Jackson's photographs, Moran's paintings, and Elliott's sketches. To permanently close to settlement such an expanse of the public domain would be a departure from the established policy of transferring public lands to private ownership. But the proposed park encompassing the wonders of Yellowstone had caught the imagination of both the public and the Congress. After some discussion—but surprisingly little opposition—the measure passed both houses of Congress, and, on March 1, 1872, President Ulysses S. Grant signed it into law. Yellowstone would forever be preserved from private greed and "dedicated and set apart as a public park or pleasureing-ground for the benefit and enjoyment of the people." The world's first national park was born.

"To conserve the scenery and the objects therein"

The Yellowstone Park Act was essentially directed at preventing private exploitation; it contained few positive measures for administering the new preserve. The park's promoters envisioned that it would exist at no expense to the government. The costs of maintenance and administration were to be borne by fees charged concessioners, who would provide the facilities that the public needed. For a long time, therefore, Yellowstone enjoyed little protection from pillagers. It took almost half a century of trial and error to develop a practical approach to administration and to discover what a "national park" should be.

While there was no congressional appropriation for the protection or administration of the park, the Secretary of the Interior did have the power to appoint a superintendent. In May 1872, Nathaniel P. Langford, member of the Washburn Expedition and advocate of the Yellowstone Park Act, was appointed to the post. Because he received no salary, he had to earn his living elsewhere and entered the park only twice during his five years in office, once as a member of the second Hayden Expedition in 1872 and again in 1874 to evict a particularly egregious squatter. When he was there, his task was made more difficult by the lack of statutory protection for wildlife and

other natural features.

Because there were no appropriations for administration or improved access, the park remained inaccessible to all but the hardiest travelers. Some of the visitors who did make their way to the new park displayed a marked propensity to go about, according to an observer, "with shovel and axe, chopping and hacking and prying up great pieces of the most ornamental work they could find."

Political pressure stemming partly from accusations of neglect of duty forced Langford's removal from the superintendency in April 1877. He was replaced by Philetus W. Norris. At this time Congress also revisited the issue of appropriations for the new park, and, consequently, Norris received an annual salary as well as appropriations "to protect, preserve, and improve the Park." Bringing skill and industry to the task, he constructed numerous physical improvements, built a monumental "blockhouse" on Capitol Hill at Mammoth Hot Springs for use as park headquarters, hired the first "gamekeeper" (Harry Yount, an experienced frontiersmen), and waged a difficult campaign against poachers and vandals. Much of the primitive road system he laid out still endures as part of today's Grand Loop Road. Through constant exploration and identification of the physical features, Norris added immensely to the geographical knowledge of the park. Despite the physical improvements he made in the park and his contributions to scientific knowledge, Norris fell victim to political maneuvering and was removed from his post in February 1882.

The removal of Norris was indicative of Yellowstone's plight. During its formative years, the park was fought over by interests that, for political or financial reasons, hoped to claim it as a prize and control it totally. Without legal protection against such exploitation or against poaching and vandalism, the park suffered greatly during its first two decades. Even an active and conscientious superintendent such as Norris was unable to fully protect the park. After his dismissal, promoters of schemes to build railroads and toll roads in the park and to monopolize accommodations usually blocked the appointment of capable superintendents and harassed any who showed signs of honestly striving for the benefit of the park. Asuccession of powerless and mediocre superintendents took office.

Attempts were made in the early 1880s to bring law and order to Yellowstone. Ten assistant superintendents were authorized to act as a police force. However, they failed to check the rising tide of destruction and the slaughter of game. For two years the laws of Wyoming Territory were extended into the park, but the practice of enforcement that allowed "informers" and magistrates to split the fines degraded the hoped-for protection almost to the level of extortion. After the repeal of the act authorizing such "protection" was announced in March 1886, the obviously defenseless park attracted a new plague of poachers, squatters, woodcutters, and vandals.

The Army in Yellowstone

The inability of the superintendents to protect the park appeared to be a failure to perform their duty, and in 1886 Congress refused to appropriate money for such ineffective administration. Because no superintendent was willing to serve without pay, Yellowstone now lacked even the pretense of protection. These circumstances, however, proved fortunate as 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.

Military administration greatly benefitted Yellowstone. Regulations were established and conspicuously posted around the park, and constant patrols enforced them. For the protection of visitors as well as park features, detachments guarded the major attractions. No law spelled out offenses, but the Army handled problems effectively by evicting troublemakers and forbidding them to return. Cavalry, better suited than infantry to patrol the vast land, usually guarded the park. Army headquarters was at Mammoth Hot Springs, first in Camp Sheridan and after the 1890s in Fort Yellowstone, which still today houses the park headquarters. Ascattering of "soldier stations" around the park served as outposts. One of these posts remains today at Norris.

When appropriations for improvements were finally authorized, the Corps of Engineers lent its talents to converting the primitive road network into a system of roads and trails that still endures. The soldier who left the greatest mark on Yellowstone was one of the engineers, Hiram M.

Chittenden. He not only supervised much of the development of the road system, but also wrote the first history of the park.

The most persistent menace to the park came from poachers. Their ceaseless attempts to make petty gains from the wildlife threatened to exterminate some animals. In 1894, soldiers arrested a man named Ed Howell for slaughtering bison and took him to Mammoth. The maximum sentence the Army commander could impose was banishment from the park. However, the presence in Mammoth of Emerson Hough, a prominent journalist, helped to generate national interest in the problem. Hough wired the story to his New York editor who published it, and within two months Congress acted—the National Park Protective Act (the Lacey Act) was passed, finally providing teeth for the protection of Yellowstone's treasures. Howell re-entered the park later that year, and, appropriately, he became the first person arrested and punished under the new law.

The Army compiled an admirable record during its three decades of administration. But something more than competent protection was needed. 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 great lack of direction.

The National Park Service Arrives

It was generally agreed by 1916 that the national parks needed coordinated administration by professionals attuned to the special requirements of such preserves. The creation of the National Park Service that year eventually gave the parks their own force of trained men who were ordered by the Congress "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."

APark Service ranger force, including several veterans of Army service in the park, assumed responsibility for Yellowstone in 1918. The appointment of Horace M. Albright to the post of superintendent in 1919 portended a broader approach to the management of the park than just protection of its features. Serving simultaneously in that office and as assistant to Stephen T. Mather, the Director of the National Park Service, Albright established a tradition of thoughtful administration that gave vitality and direction to the management of Yellowstone for decades. An innovation that the new Park Service brought to Yellowstone was "interpretation." Professional naturalists were hired to perform research and to use the results of their studies to give campfire talks or conduct nature walks for the public to explain the park's natural features.

But the greatest contribution of the Park Service was a sense of mission that viewed a national park as an entity valuable for its own sake. This attitude signaled that the new protectors of Yellowstone would not function merely as caretakers, but would see that the park was managed and defended according to the best principles of natural conservation. During the 1920s and 1930s the park's boundaries were adjusted to conform more closely with natural topographic features. Lands were also added to protect petrified tree deposits and increase the winter grazing range for elk and other wildlife. An offshoot of the boundary revision campaign was the establishment of Grand Teton National Park to protect the magnificent Teton Range—a movement in which the superintendent of Yellowstone, Horace Albright, played a crucial role. During the same period the Park Service helped to marshal the advocates of conservation to prevent the impoundment of Yellowstone's waters for irrigation and hydroelectric projects—reminding the nation that Yellowstone's founders considered its wonders so special that they should be forever preserved from exploitation.

Touring the Park

The experiences tourists had in Yellowstone before the days of the family automobile were quite unlike that of modern visitors. The natural features that have always attracted people to the park appear much the same today, but the manner of traveling to the park and making the "Grand Tour" in the early days would now seem utterly foreign.

One of the greatest attractions of old Yellowstone was the opportunity to bathe in the hot springs. In a day when a hot bath was a luxury and people were less sophisticated about their medical needs, hot mineral baths were popularly believed to have curative powers—not to mention the simple pleasure of soaking in hot water. Hot springs around the world have long been enjoyed as "spas" for the well-to-do and resorts for health seekers. Similarly, it was the hot waters of Yellowstone that attracted many of its first pleasure-seekers. Bathhouse enterprises offering springs of various temperatures and presumed medicinal powers, sprouted in the several thermal areas. These facilities did a brisk business well into the 20th century, when changing modes of leisure reduced their popularity.

Fewer than 500 people a year came to Yellowstone before 1877, but thereafter the number of visitors increased steadily. Getting there in the first few years was a great problem. Tourists either transported themselves or patronized one or more of the intermittent transportation enterprises that carted them from Montana towns to the park. Once in the park, they were on their own, finding sustenance during the early years only from a few concessioners or squatters who provided rude fare and minimal sleeping accommodations. Some early tourists were wealthy aristocrats, including a few titled Europeans who came well prepared to tour in grand style. But most of the earlier visitors were frontier people accustomed to roughing it—and they had to.

During the 1880s, a visit to Yellowstone became easier. Access improved when the Northern Pacific Railroad reached Gardiner, on the north edge of the park. The Bozeman Toll Road Company, later known as the Yankee Jim Toll Road in honor of its colorful owner, also facilitated travel. The railroads, particularly the Northern Pacific, took an increasing interest in the tourist business of Yellowstone. Anumber of large, ornate hotels were built in Yellowstone with railroad financing.

Yellowstone was not yet a park for all of the people. Because of the expense of transportation in the late 19th and early 20th centuries, the travel industry in general was patronized mainly by the upper middle class—the affluent leaders of the industrial revolution. People accustomed to spending summers in Europe or at rich resorts like Saratoga Springs, New York, were the principal patrons of the Yellowstone package tours and "See America First" campaigns of the railroads. Though some people of lesser means did visit Yellowstone in the stagecoach days, the concessioners were dependent mainly on the "carriage trade." The difficulty of cross-country transportation and the expense of such a vacation generally put the enjoyment of Yellowstone's wonders out of reach for those who could not go first class.

The typical tour of Yellowstone began when the tourists descended from the train in Gardiner, boarded large stagecoaches, and headed up the scenic Gardner River canyon to Mammoth Hot Springs. After checking into the large hotel, they were free to spend the afternoon touring the hot spring terraces or bathing in the waters. For the next four days, the tourists bounced along in four-horse, 11-passenger coaches called "Yellowstone wagons." The coaches frequently had to be unloaded at steep grades, giving the passengers an opportunity to stretch their legs and breathe in the cool air while following the vehicles uphill. During the several halts at important natural features, the drivers amazed their passengers with exceedingly imaginary explanations of the natural history. Each night there was a warm bed and a lavish meal at another grand hotel. After the late 1890s, people enjoyed the nightly spectacle of bears being fed hotel garbage (some even helped with the feeding), few worrying about the effect on the bears or the danger to themselves. Altogether, touring Yellowstone was a pleasant, if arduous, experience. The visitors carried home memories of experiences and sights that were unforgettable. They recommended the tour to their friends, and each year more of them came to Yellowstone to see the wonders themselves.

As increasing wealth and technological progress enabled more of the public to travel, Yellowstone could not remain an idyllic resort for the few. The first automobile entered Yellowstone in 1915. Although the autos were severely regulated and a permit was expensive, their numbers increased steadily, forcing the concessioners to replace their horse-drawn stages with buses. Horses were relegated to the backcountry, and they were replaced with paved roads, parking areas convenient to scenic attractions, service stations, and public campgrounds to accommodate the growing number of motorized visitors.

The automobile changed more than just the mode touring the park. No longer just a vacation spot for the wealthy, Yellowstone became a truly *national* park, accessible to anyone who could

afford a car. Without resorting to the concessioners, visitors could now pick their own way around the park, see what they wanted, take side trips, and camp in one place as long as they liked. But never again would a visitor be a pioneer explorer, facing an unknown wilderness, leaving his name on the map. For better or worse, a new day was beginning. Yellowstone was now truly a "pleasuring-ground" for the people—all of them.

The Legacy of Yellowstone

The generation that set aside Yellowstone National Park created more than anyone could have foreseen at the time. The establishment of the park was initially a negative reaction to the prospect that this wondrous region might be divided and exploited for private ends, thereby denying it to others. The founders determined that Yellowstone should be reserved for the "benefit and enjoyment" of all. Through the next half century, the practicalities of what such a national park should be were worked out.

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 the wilderness to be the inheritance of all the people, who gained 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, 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 persons who could claim and plunder it. 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 trusteeship in national forests and other reserves so that the country's natural wealth—in the form of lumber, grazing, minerals, and recreation—should not be consumed at once by the greed of a few, but should perpetually bestow its rewards.

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 in it. Of all the benefits resulting from the establishment of Yellowstone National Park, this may be the greatest.

A Brief History of the National Park Service

Yellowstone National Park was established in 1872. For 18 years thereafter, Yellowstone was "the national park." Then in a single year (1890), Sequoia, General Grant (now part of Kings Canyon National Park), and Yosemite national parks were established by Congress. Mount Rainier followed in 1899. In 1906, Congress passed the Antiquities Act, which gave the President authority to establish national monuments. By 1914 there were 30 national parks and monuments, each managed separately and administered by three different federal departments—Interior, Agriculture, and War. There was no unified policy or plan for the protection, administration, and development of these parks and monuments.

Creation of the National Park Service

Since Yellowstone's creation, different individuals had voiced the opinion that an agency specifically dedicated to the welfare of the national parks was necessary. But, the Department of Agriculture's Forest Service had always opposed the idea of a national parks bureau in the Department of the Interior. Forest Service officials saw such a bureau as a competitor that would weaken its power over federal lands.

In 1914, Secretary of the Interior Franklin K. Lane was looking for someone to fill the job of his Chief Assistant when he received a letter from Stephen Tyng Mather, an able conservationist and self-made millionaire, bluntly decrying the deplorable conditions prevalent in many parks at the

time. Lane's answer was brief: "Dear Steve: If you don't like the way the national parks are run, why don't you come down to Washington and run them yourself?" Mather accepted the challenge and brought with him to Washington a young assistant, Horace M. Albright.

Mather and Albright lobbied skillfully to overcome opposition to a national parks bureau. They gathered support from influential journalists, railroads likely to profit from increased park tourism, and members of Congress. Mather and Albright drafted legislation calling for the creation of a National Park Service in the Department of the Interior to "promote and regulate the use of the Federal areas known as national parks, monuments, and reservations . . . [and] 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 National Park Service Act was authorized by Congress and approved by President Woodrow Wilson on August 25, 1916.

Basic Policies of the National Park Service

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. In many instances these two principal objectives are incompatible and difficult choices must be made.

National Park Service policy directs that natural resources (plants, animals, water, air, soils, topographic features, paleontologic resources, and aesthetic values such as scenic vistas, natural quiet, and clear night skies) be managed to maintain, rehabilitate, and perpetuate their inherent integrity. This management strategy provides the American people the opportunity to enjoy and benefit from natural environments evolving through natural processes minimally influenced by human actions. Policy also directs that if a native species has been exterminated from a park, the species should be reintroduced, if possible. Any exotic species that has become established in a park will be eliminated, if it is possible to do so. With rare exceptions, grazing of domestic livestock and hunting are prohibited in National Park System areas.

National Park Service policy also directs that cultural resources (prehistoric and historic structures and resources, landscapes, archaeologic resources, ethnographic resources, and museum collections) be preserved and that their understanding and appreciation be fostered through appropriate programs.

Each park prepares a General Management Plan/Master Plan that outlines management zoning in the park. In natural zones (most of Yellowstone National Park), the primary objective is the protection of natural resources and values. Managers will not attempt solely to preserve individual species (except threatened or endangered species) or individual natural processes; rather they will try to maintain all the components and processes of naturally evolving park ecosystems, including the natural abundance, diversity, and ecological integrity of the plants and animals. Change is recognized as an integral part of functioning natural systems. Interference with natural processes in park natural zones will be allowed only when directed by Congress, in some emergencies when human life and property are at stake, or to restore native ecosystem functioning that has been disrupted by past or ongoing human activities.

In cultural or historic zones, the primary objective is to preserve and foster appreciation of the cultural resources; management of natural resources in these zones will support cultural resource objectives. Where compatible with cultural resource objectives, the policies for natural zones will be followed. Any action that will affect cultural resources adversely 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, as appropriate.

Park development zones (such as around the park's major developed areas) are managed and maintained for intensive visitor use. Accordingly, 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 and when a park manager determines that a resource is or would become impaired by public use or development, the manager may close a specific area or place limitations on public use.

The Largest National Parks

About 63 percent of the land area under jurisdiction of the NPS is in national parks. While Hot Springs NPis only 5,839 acres in size, most parks are much larger.

National Parks > 1 million acres

Rank	Name, Location	Acres
1.	Wrangell-St. Elias NP, AK	8,331,604
2.	Gates of the Arctic NP, AK	7,523,888
3.	Denali NP, AK	4,741,910
4.	Katmai NP, AK	3,716,000
5.	Death Valley NP, CA	3,267,628
6.	Glacier Bay NP, AK	3,225,284
7.	Lake Clark NP, AK	2,636,839
8.	Yellowstone NP, WY	2,221,773
9.	Kobuk Valley NP, AK	1,750,736
10.	Everglades NP, FL	1,506,499
11.	Grand Canyon NP, AZ	1,217,158
12.	Glacier NP, MT	1,013,572

Other NPS areas > 1 million acres

Noatak National Preserve, AK	6,574,481
Wrangell-St. Elias N. Pres., AK	4,856,721
Bering Land Bridge N. Pres., AK	2,784,960
Yukon-Charley Rivers N. Pres., AK	2,523,509
Lake Mead N. Rec. Area, AZ-NV	1,495,666
Lake Clark N. Preserve, AK	1,407,293
Denali National Preserve, AK	1,334,618
Glen Canyon N. Rec. Area, AZ-UT	1,236,880

The National Park System

Today, the National Park Service manages approximately 81 million acres in 49 states, the Virgin Islands, Puerto Rico, Guam, and American Samoa. Delaware is the only state without a Park Service unit. Vermont's sole contribution is a unit it shares with 13 other states, the Appalachian National Scenic Trail.

The 378 areas in the National Park Service (as of November 1998) are comprised of 74 national monuments, 74 national historic sites, 55 national parks, 38 national historical parks, 26 national memorials, 19 national recreation areas, 15 national preserves, 11 national battlefields, 10 national seashores, 11 parks (these areas are under NPS jurisdiction, but carry no other designation), 9 national military parks, 9 national wild and scenic rivers, 5 national rivers, 4 national lakeshores, 4 national parkways, 3 national battlefield parks, 3 national scenic trails, 2 national reserves, 1 national battlefield site, 1 national mall, and 1 international historic site.

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 that are established by Presidential proclamation. National historical parks and national historic sites are both set aside to commemorate some facet of the history of some past 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 NM and Vietnam Veterans NM. Most other types of national park system units are well defined by their titles.

Yellowstone may be the most famous park, but it is not the most visited. Annually, Blue Ridge National Parkway has more than 17 million visits, Golden Gate National Recreation Area has more than 14 million visits; around 3 million people come to Yellowstone. Of the national parks, Great Smoky Mountains, Grand Canyon, and Yosemite are all more visited than Yellowstone.

Archeology of Yellowstone National Park

Many myths exist about Yellowstone. However, none is more persistent than the notion that Native American groups rarely ventured into the area because of their fear of the numerous geysers. This is not the case. Current understanding suggests that Native Americans have called the area that was to become Yellowstone National Park home for more than 10,000 years.

Archeologists have only begun to investigate and understand how prehistoric groups used upland and mountain environments; only a short while ago it was believed by many researchers that these areas were too harsh to support a significant number of people. And, as such, the mountains were considered marginal and somewhat unimportant to the major cultural developments that were occurring in the basins and on the plains.

Contemporary archeological investigations use a number of researchers from various disciplines to piece together the puzzle of prehistoric societies. Palynology, the study of plant pollen, is important for understanding the various plant communities that occupied the region in the past and how the climate has changed through time. Geomorphology, the study of past landforms, provides information on how landforms have changed through time, usually in relation to shifting climatic patterns. Paleoethnobotany, the study of past uses of plants, provides the understanding of what plants were used by prehistoric groups. Through the results of these studies, a story of a very dynamic relationship between humans and their environment is emerging. While the environment does not determine specifically how people settle and what foods they eat, it does set limits in which people can operate, and understanding these limits is a major focus of archeology.

Absolute dating of cultural deposits is an important interpretive tool for archeologists. Two techniques commonly employed by archeologists working in the region are radiocarbon dating and obsidian hydration. Radiocarbon dates are determined by measuring 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 is used to measure the remaining Carbon 14, the amount of which is used to calculate the age since death. Obsidian hydration dating is based on the rate at which obsidian absorbs water at its surface, which is dependent on temperature. By measuring the thickness of the "hydration layer," a date for manufacture of the artifact can be obtained.

Past Climatic Patterns

Possibly as early as 40,000 years ago, a series of mountain glaciers moved downslope carving out many valleys. During full glaciation, an icecap as thick as 3,000 feet covered most of what is now Yellowstone. These glaciers retreated 14,000 years ago. In a short period of time, plants, animals, and humans colonized the landscape. Following deglaciation, the climate was still colder and more moist than present conditions. High-altitude subalpine and alpine vegetation communities dominated the area with mixed conifer forests at lower elevation basins. Trees appeared 11,500 years ago, beginning with Engelmann spruce, followed by lodgepole pine, Douglas-fir, whitebark pine, and limber pine. Between 9,500 and 5,000 years ago, a period of increased warmth and aridity occurred resulting in an increase of Douglas-fir, aspen, and other drought-resistant species. Fire frequency may also have increased during this time. By about 5,000 years ago, vegetation similar to that of today flourished.

Paleoindian Period (12,000 to 8,000 years before present)

The earliest evidence of humans living in Yellowstone is provided by a Folsom projectile point discovered in the Bridger-Teton National Forest. The point, dating about 10,900 years ago, was manufactured from obsidian geochemically sourced to Obsidian Cliff in Yellowstone. This landform is the remnant of the last violent eruption of the Yellowstone caldera 630,000 years ago and is the predominant resource for tool manufacture in the park, a resource which was recognized very early in the course of human habituation of the area.

These large, fluted spear points have been found in the surrounding basins in association with extinct bison bones. Seasonal forays by small groups of people to hunt bison, mountain sheep, and

deer and to collect plant foods were made during this time.

More substantial evidence of occupation is provided by numerous projectile point types, such as Agate Basin and Hell Gap, dating to about 10,000 years ago. About 9,000 years ago, a mountain-oriented lifestyle developed. This archeological tradition is characterized by lanceolate spear points with contracting stems and concave bases. These people subsisted on a more diverse array of plant species as well as numerous large and small mammals. It has been suggested that a climatic shift to warmer and more arid conditions may have caused this increased utilization of the mountains.

Archaic Period (8,000 to 1,500 years before present)

Continuation of the broad-based economy begun during late Paleoindian times is a hallmark of the Archaic Cultures. Achange in projectile point technology from lanceolate points to a side-notched and corner-notched points is also characteristic of this archeological tradition. During this period, evidence of semi-subterranean structures, called pithouses, appear in the archeological record of the region. Other innovations include earth ovens for preparing foods. People constructed these cooking hearths by digging a pit in the ground and filling it with heated rocks. They cooked numerous foods in these hearths, such as meat; roots from camas, bitterroot, yampa, or prickly pear; and the seeds of plants such as goosefoot and waterleaf.

Late Prehistoric/Protohistoric-Historic Period (1,500 to 100 years before present)

Radiocarbon dates derived from cultural deposits suggest an increase in use of the area by native groups during the last 1,500 years. This period is best characterized by the development of the bow and arrow, which replaced the earlier atlatl, or spearthrower, of Paleoindian and Archaic times. Innovations in hunting, through the use of sheep traps in the mountains and bison corrals on the plains, also occurred. The use of steatite (soapstone) vessels and the development of pottery probably also increased the efficiency of these groups in preparing and storing foods.

During historic times, a number of tribes are known to have used the Yellowstone area. However, the one group most closely associated with the park is the Shoshone. Trappers and early explorers of the region provide first-hand accounts of small bands of Shoshone in the park. However, it is uncertain when the Shoshone entered the region. Linguistic evidence from the Great Basin suggests a recent migration of Numic-speaking peoples about AD 1500, although some scholars suggest that archeological evidence indicates the Shoshone are the descendants of people who lived in the mountains for thousands of years. Stone circles possibly representing tepee sites, wickiup, and lean-to structures still exist in the park today and are haunting evidence of the people who called Yellowstone their home for thousands of years.

The story of the prehistory of Yellowstone National Park is slowly coming together. To date, only about 1 percent of the park has been surveyed for archeological sites and only a few exploratory excavations have been conducted. Archeologists are now finding evidence of groups of people who intimately knew the treasures of our first national park thousands of years prior to the arrival of Europeans.

Suggested Reading

Bartlett, Richard. *Nature's Yellowstone.* University of Arizona Press, Tucson. 1974.

Bartlett, Richard. *Yellowstone: A Wilderness Besieged.* University of Arizona Press, Tucson. 1985.

Chittenden, Hiram. *The Yellowstone National Park.* University of Oklahoma Press, Norman. 1964.

Clary, David. *The Place Where Hell Bubbled Up: A History of Yellowstone National Park.* Homestead Publishing, Moose, WY. 1993.

Cook, Charles W., David E. Folsom, and William Peterson. *The Valley of the Upper Yellowstone: An Exploration of the Headwaters of the Yellowstone River in the Year 1869.* Aubrey Haines, editor. University of Oklahoma Press, Norman. 1965.

Everhart, W.C. *The National Park Service.* Westview Press, Boulder, CO. 1983.

Haines, Aubrey. *The Yellowstone Story: A History of Our First National Park.* 2 vols. Yellowstone Library and Museum Association, Yellowstone NP, WY. 1977.

Haines, Aubrey. *Yellowstone National Park: Its Exploration and Establishments.* National Park Service. 1974.

Janetski, Joel C. *Indians of Yellowstone Park.* University of Utah Press, Salt Lake City. 1987.

Langford, Nathaniel P. *The Discovery of Yellowstone Park.* University of Nebraska Press, Lincoln. 1972.

Milstein, Michael. *Yellowstone: 125 Years of America's Best Idea.* Billings Gazette, Billings, MT. 1996.

Russell, Osborne. *Journal of a Trapper.* MJF Books, New York, NY. 1997.

Schullery, Paul, editor. *Old Yellowstone Days.* Colorado Associated University Press, Boulder. 1979.

Strong, W.E. *A Trip to Yellowstone National Park in July, August, and September of 1875.* University of Oklahoma Press, Norman. 1968.

Whittlesey, Lee H. *Yellowstone Place Names.* Montana Historical Society, Helena. 1988.

Whittlesey, Lee H. and National Park Service Staff. *A Yellowstone Album.* Roberts Rinehart Publishers, Boulder, CO. 1997.

An Interpretive Geology of Yellowstone

There are few more impressive manifestations of the power and mystery of the earth than Yellowstone. The park is the site of some of the largest volcanic eruptions in history—a display of the energy and potential lying just beneath the earth's surface. Today, this power is seen in myriad geothermal features, the likes of which are found in only a few other places on the planet..

First and foremost, Yellowstone is a geologic park. Geology is the foundation upon which all plant and animal life exists, and it is the stage on which the human drama unfolds. When the first exploring parties surveyed the Yellowstone territory, they were impressed by many of the sights they encountered: the wildlife, mountain scenery, and fast-flowing headwater streams of the region. However, none captured their imagination more than the geologic wonders they found here. The "natural curiosities" of the geysers, hot springs, mudpots, and fumaroles inspired members of these early expeditions, and it is for these treasures that Yellowstone was ultimately dedicated and set apart as the world's first national park in 1872.

The Yellowstone Hotspot

At the center of Yellowstone's geologic story is the Yellowstone Plateau. "This good fire mountain," as naturalist John Muir called it, is a large volcanic plateau that dominates the Yellowstone landscape. Situated at about 8,000 feet in the heart of the northern Rocky Mountains, it is a vast wilderness, encompassing more than 1,000 square miles and characterized by a rolling terrain of lava flows. The poor volcanic soils yield thick forests of lodgepole pine, the park's dominant tree.

Like the Hawaiian islands, Yellowstone owes its origins to a geologic "hotspot" of molten rock, or magma. Hotspots are found throughout the world, mostly underlying the thin crust of the ocean floors. Continental hotspots, like the one found under Yellowstone, are rare. On continents, the crust of the earth is typically 25 to 30 miles thick, below which is found the hot molten material of the earth's mantle. Yellowstone is the exception. Here, it is believed that a plume of magma rises through the mantle into the crust where it forms a shallow magma chamber near the earth's surface, perhaps as little as one to three miles beneath Yellowstone.

This hotspot of magma remains stationary as the North American Plate, or continental crust, moves southwestward, like a sheet of paper moving over a burning candle. About two million years ago, the hot spot emerged from Idaho's Snake River Plain in what is considered the largest volcanic eruption ever recorded in the history of the earth. As the continental crust continued its slide in a southwesterly direction, the center of volcanic activity slowly shifted in the opposite direction, trending toward the northeast and farther into Yellowstone. The result is a series of three calderas tracking from beyond the park's southwest boundary to the northeast into the center of the park.

Occurring at approximately 600,000 year intervals, the second volcano exploded about 1.3 million years ago, just outside the park's southwest boundary in the area of Island Park, Idaho. Although small in comparison to the other eruptions, it still ranks among the greatest volcanic episodes in history.

Centered under the park, the last and most recent volcano erupted about 630,000 years ago and set the stage for much of the story of Yellowstone today. Magma rising from deep within the earth, accumulated in the upper reaches of the earth's crust. As it did, the ground above the magma chamber stretched and expanded, becoming thinner as it was forced upward in a doming effect, much like a blister forming on the surface of the earth. Ultimately, as the continual uplift caused by the rising magma expanded across an extensive land area, "ring fractures" or concentric cracks begin to form around the base of the dome, like the circular cracks in a pie crust as it heats and rises. These cracks then spread down toward the magma chamber. When they breached this highly pressurized chamber, they set in motion yet another of the world's largest volcanic explosions.

The volcano blasted phenomenal quantities of hot molten rock, ash, and gases upward and outward in a large cataclysmic event. In total, more than 240 cubic miles of volcanic material erupted, an explosion approximately 1,000 times more powerful than the Mount Saint Helens explosion in 1980. Volcanic ash flows spewed forth from the ring fractures at temperatures in excess of 1,500°F, spreading across thousands of square miles of land in a matter of moments, destroying all life in its

wake. Likewise, ash and dust flew across much of North America, clouding the skies and most likely affecting the world's weather patterns in profound ways.

As volcanic debris continued to erupt from the earth, the upper portion of the magma chamber emptied. In this void, with nothing left to hold up the roof of the chamber, a great collapse ensued as the ground slumped and caved in on itself along the ring fractures, resulting in the present-day Yellowstone caldera. In forming the caldera, the mountain ranges and other surface landforms were either blown away by the erupting volcano or consumed in the collapse of the caldera. The caldera is immense. Measuring approximately 47 miles long and 23 miles wide, this huge volcanic depression likely reached several thousand feet deep at the time of its formation.

For most visitors to Yellowstone today, trying to visualize this giant caldera is a challenging task, because it is so big and because subsequent lava flows masked its appearance. Shortly after the collapse of the magma chamber roof, more magma resurged in two areas within the caldera, doming the earth near Old Faithful and also north of Yellowstone Lake near LeHardy Rapids. Almost immediately after the formation of the caldera, magma rose from this renewed chamber, flowing quietly out of the earth as a type of lava known as rhyolite. These intermittent flows of rhyolite oozed from the magma chamber until about 70,000 years ago. They filled in and covered much of the caldera basin, burying most of its rim in the process and giving rise to the Yellowstone Plateau.

Today, evidence indicates a shallow magma chamber lies just beneath Yellowstone in the northeast portion of the present caldera. Uplift, often associated with rising magma, has been recorded in this area, most notably at the LeHardy Rapids on the Yellowstone River, north of Yellowstone Lake. During a 50-year period ending in 1985, benchmarks have revealed that the ground here has risen a total of three feet, at a rate of approximately one-half inch per year. Since 1985, the earth here has experienced a period of sinking, or subsidence, also at the rate of half an inch each year. With volcanoes erupting approximately every 600,000 years, is Yellowstone poised for another massive explosion? Scientists say "Yes," but no one knows how many hundreds or thousands of years from today that will happen.

One thing is certain: regardless of what happens in the future, much of Yellowstone's breathtaking scenery today owes its origins to this recent volcanic past. Yellowstone Lake lies in a basin bounded by the rim of the 600,000-year-old caldera to the east and subsequent flows of lava to the west. Recent underwater explorations of the lake have revealed deep canyons along with geysers, hot springs, and associated thermal activity on the bottom of this big, cold, mountain lake. Lying in the heart of the park, Yellowstone Lake characterizes the beauty of a landscape that has emerged in stark contrast to the violent volcanic activity of the last two million years.

Stories in Stone

The park's geologic chronology spans much of the earth's history. Surrounding the Yellowstone caldera are stories of more ancient times that yield remarkable geologic treasures. The oldest rocks revealed in Yellowstone date back 2.7 billion years. These rocks are found in the northern mountains of the park and represent the very foundation of North America. Later, 500 million years ago, Yellowstone was a far different place than it is today. Covered by shallow inland seas, ocean sediments built up layer upon layer to form the common sedimentary rocks found in the park—limestone, sandstone, and shale. And the story continues with the latest deposits of travertine on the terraces of Mammoth Hot Springs. Standing in one place in Mammoth, a visitor can see some of the oldest and newest rocks on earth at the same time.Between the time of ancient seas and the caldera-forming volcanoes of the recent past, a great period of mountain building began as the North American Plate collided with the Pacific Plate 100 to 50 million years ago. A time of tremendous upheaval, this powerful tectonic activity folded, faulted, and compressed the earth, leading to the uplift and creation of the Rocky Mountain chain.

In this unstable landscape, even more ancient volcanoes arose about 50 million years ago to form the Absaroka and Washburn mountains. Lying across Yellowstone Lake and bounding the park's east side, the Absarokas are an imposing mountain range that formed from erupting volcanoes during a 15-million-year period. Today, they provide a wonderful backdrop to the waters of Yellowstone Lake. At the time of their creation, they ejected silica-rich lava and ash, which mixed with water to form mudflows. These mudflows surrounded redwoods, sycamores, magno-

lias, dogwoods, and other trees, preserving the world's largest petrified forest as a record of an earlier climatic period. Today, these forests of stone can best be seen on Specimen Ridge near Lamar Valley.

Fire and Ice

Yellowstone is a land of contrasts and extremes. Just as the internal fires of the earth bring boiling water to the surface as geysers and hot springs, the park's high elevation and northern latitude also make it a land of deep snows and long winters. When more snow falls in winter than can melt in summer, ice begins to form under the weight of the snow and eventually begins to flow as a glacier. Though there are no active glaciers in Yellowstone today, such conditions have occurred here intermittently during the last two million years.

Like any good sculptor working in stone, these giant glaciers left their imprint on Yellowstone in many ways, both subtle and harsh. The region's most recent period of glaciation began about 50,000 years ago in the high mountains of the Absaroka-Beartooth Wilderness, northeast of Yellowstone. With time, vast sheets of ice, thousands of feet thick, flowed from the mountains to converge over Yellowstone Lake, covering the Yellowstone Plateau and virtually all of the park and surrounding area. While thermal basins continued to seethe beneath the ice, this land of fire and brimstone was in a deep freeze for thousands of years. At the peak of this glacial era, roughly 25,000 years ago, prominent peaks like Mount Sheridan lay hidden underneath this icy blanket, while the tip of Mount Washburn and the thin ridgeline of the Absaroka Mountains barely peeked above this unrelenting sea of ice. For thousands of years, ice flowed in all directions from this immense ice field, carving, scouring, and sculpting the land.

As this ice age slowly ended nearly 15,000 years ago, it left behind ample evidence of the transforming power of ice. Among the broad hills and benches of Hayden Valley, lake sediments of silt, sand, and gravel, covered in glacial till, remain from a time when the valley was covered by an ancient lake formed by an early ice dam. Large river valleys like the Firehole, Madison, and Lamar were broadened and scoured by accompanying rivers of ice. Retreating glaciers and their meltwaters gradually dropped their load of rock debris. Having carried massive stones from high, far-off mountains like the Beartooths, the ice melted and left behind fields dotted with large granite boulders, called glacial erratics, at places where granite is not found, like Canyon's Inspiration Point and near Lamar Valley. Glacial ponds, striated hillsides, chiseled peaks, and polished mountain faces, all fashioned by the hand of ice, create some of the finishing touches on the spectacular landscape we see today.

The Grand Canyon of the Yellowstone River

Nowhere else have the combined powers of fire and ice come together to create so beautiful and so sublime a work of nature as the Grand Canyon of the Yellowstone. This deep, colorful canyon of many hues and moods has been celebrated in paintings and in photographs since the time it was first captured on canvas by landscape painter Thomas Moran.

This stunning display of nature's handiwork began when the last volcano laid down rhyolitic lava flows shortly after the caldera's collapse. In carving the canyon, the Yellowstone River was first aided by the action of a geyser basin that formed within the lava flow. The hot water, steam, and gases of these thermal features altered the normally hard rhyolite, weakening the rock and making it susceptible to erosion and further downcutting by the river. Later, it is believed that 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. This huge volume of water flowing through the soft canyon rock further eroded and defined the canyon's present appearance.

Today, remnants of the area's thermal activity are still visible within the canyon. The chemical alteration of the rhyolite due to these hot waters has caused a variety of iron compounds in the rock to oxidize, or rust, releasing a palette of yellow, red, and orange colors on the canyon walls.

Yellowstone is indeed a spectacular and beautiful place. How it came to be and the forces that are still at work on the landscape make the geologic story a fascinating tale and a current events chronicle.

2

An Introduction to Geothermal Resources

Nowhere else in the world can we find the array or number of geysers, hot springs, mud pots, and fumaroles as are found in Yellowstone. More than 50 percent of the world's geysers, including the world's largest and tallest, are here in seven major basins. Combine this with more than 10,000 thermal features comprised of brilliantly colored hot springs, bubbling mudpots, and steaming fumaroles, and you have a place like no other. The park's thermal features lie in one of two essentially undisturbed geyser basins left worldwide. (Kamchatka Peninsula, in Siberia, contains the other.) Iceland and New Zealand, geothermal drill holes and wells have reduced geyser activity and hot spring discharge. Yellowstone offers visitors an opportunity to appreciate thermal features in their natural, changing state.

Geysers . . . current activity as of March 2000

Geyser Activity

Geyser and Location	*Average Interval; Duration; and Height*
Upper Geyser Basin	
Old Faithful	80 minutes; 1–5 minutes; 105–84 feet
Aurum	2 hours, 31 minutes; 70 seconds; 20 feet
Beehive	13 hours, 12 minutes; 5 minutes; 150+ feet
Castle	11 hours, 42 minutes; 15–20 minutes; 75 feet
Daisy	111 minutes; 3 minutes; 80 feet
Giant	Irregular (last eruption: 10/15/98); 1 hour; 200+ feet
Giantess	Irregular (last full eruption: 10/31/97); 12–48 hours; 150 ft
Grand	7 hours, 48 minutes; 10 minutes; 160 feet
Lion	6 hours, 15 minutes; 1–7 minutes; 60 feet
Little Cub	109 minutes; 10 minutes; 5 feet
Plume	38 minutes; 1 minutes; 20 feet
Riverside	5 hours, 45 minutes; 20 minutes; 75 feet
Midway Geyser Basin	
Flood	45 minutes; 7 minutes; 10 feet
Till	9 hours; 30 minutes; 20 feet
Lower Geyser Basin	
Great Fountain	10 hours; 45 minutes; 70–200+ feet
White Dome	10 minutes–2 hours; 1 minutes; 25 feet
Clepsydra	Almost continuous eruption; 20–33 feet
Norris Geyser Basin	
Steamboat	Irregular (last eruption: 5/2/00); 10+ minutes; 300+ feet
Echinus	Irregular; 10+ minutes; 80 feet
Porkchop	Destroyed 9/5/89 by hydrothermal explosion; had erupted between 10–36 feet

All geyser activity changes with time. Check at the Old Faithful Visitor Center for current information. For information on Echinus Geyser, ask at the Norris Geyser Basin Museum.

The "Plumbing" System

In the high mountains surrounding the Yellowstone Plateau, water falls as snow or rain and slowly percolates through layers of porous rock, finding its way through cracks and fissures in the earth's crust created by the ring fracturing and collapse of the caldera. Sinking to a depth of nearly 10,000 feet, this cold water comes into contact with the hot rocks associated with the shallow

magma chamber beneath the surface. As the water is heated, its temperatures rise well above the boiling point to become superheated. This superheated 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 something akin to a giant pressure cooker, with water temperatures in excess of 400°F.

The highly energized 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 toward the surface through rhyolitic lava flows, following the cracks, fissures, and weak areas of the earth's crust. Rhyolite is essential to geysers because it contains an abundance of silica, the mineral from which glass is made. As the hot water travels through this "natural plumbing system," the high temperatures dissolve some of the silica in the rhyolite, yielding a solution of silica within the water.

At the surface, these silica-laden waters form a rock called geyserite, or sinter, creating the massive geyser cones; the scalloped edges of hot springs; and the expansive, light-colored, barren landscape characteristic of geyser basins. While in solution underground, some of this silica deposits as geyserite on the walls of the plumbing system forming a pressure-tight seal, locking in the hot water and creating a system that can withstand the great pressure needed to produce a geyser.

Hot Springs and Fumaroles

With the rise of superheated water through this complex plumbing system, the immense pressure exerted over the water drops as it nears the surface. The heat energy, if released in a slow steady manner, gives rise to a hot spring, the most abundant and colorful thermal feature in the park. Hot springs with names like Morning Glory, Grand Prismatic, Abyss, Emerald, and Sapphire glisten like jewels in a host of colors across the park's harsh volcanic plain.

Fumaroles, or steam vents, are hot springs with so little water that it all boils away before reaching the surface. At places like Roaring Mountain, the result is a loud hissing of steam and gases.

Mudpots

Where hot water is limited and hydrogen sulfide gas is present (emitting the "rotten egg" smell common to thermal areas), sulfuric acid is generated. The acid dissolves the surrounding rock into fine particles of silica and clay that mix with what little water there is to form the seething and bubbling mudpots. The sights, sounds, and smells of areas like Artist and Fountain paint pots and Mud Volcano make these curious features some of the most memorable in the park.

The Mammoth Hot Springs Terraces

At Mammoth Hot Springs, a more rare kind of spring is born when the hot water ascends through the ancient limestone deposits of the area instead of the silica-rich lava flows common elsewhere in the park. The results are strikingly different. They invoke a landscape that resembles a cave turned inside out, with its delicate features exposed for all to see. The flowing waters spill across the surface to sculpt magnificent travertine limestone terraces.

The Great Geysers

Sprinkled amid the hot springs are the rarest fountains of all, the geysers. What makes them rare and distinguishes them from hot springs is that somewhere, usually near the surface in the plumbing system of a geyser, there are one or more constrictions. Expanding steam bubbles generated from the rising hot water build up behind these constrictions, ultimately squeezing through the narrow passageways and forcing the water above to overflow from the geyser. The release of water at the surface prompts a sudden decline in pressure of the hotter waters at great depth, triggering a violent chain reaction of tremendous steam explosions in which the volume of rising, now boiling, water expands 1,500 times or more. This expanding body of boiling superheated water bursts into the sky as one of Yellowstone's many famous geysers.

There are more geysers in Yellowstone than anywhere else on earth. Old Faithful, certainly the most famous geyser, is joined by numerous others big and small, named and unnamed. Though

born of the same water and rock, what is enchanting is how differently they play in the sky. Riverside Geyser shoots at an angle across the Firehole River, often forming a rainbow in its mist. Castle erupts from a cone shaped like the ruins of some medieval fortress. Grand explodes in a series of powerful bursts, towering above the surrounding trees. Echinus spouts up and out to all sides like a fireworks display of water. And Steamboat, the largest in the world, pulsates like a massive steam engine in its rare but remarkably memorable eruptions, which reach heights of 300 to 400 feet. (Steamboat erupted on May 2,2000—the first time since October 1991.)

Fragile and Subject to Harm

Park features have always been subject to some influence from human vandalism. In the park's early years it was common for visitors to use thermal features as "wishing wells," and this practice, unfortunately, continues to some degree today. Coins, rocks, trash, logs or stumps, and other paraphernalia are found in the narrow vents of geysers and hot springs. Features have been plugged up, and little can be done to repair the damage. Radical attempts to siphon surface water and induce eruptions have occasionally been tried on famous features such as Morning Glory Pool, with varying degrees of success. Damage also occurs when people leave walkways and climb on features or when they break pieces of sinter or travertine off for souvenirs.

Features can also be affected by nearby ground-disturbing activities. Construction and maintenance activities in the park must be carefully designed and monitored so that geothermal features are not altered. Because we do not yet understand the faulting system under Yellowstone, no one knows if drilling outside the park to tap into geothermal water there would harm the features in Yellowstone. Known geothermal resource areas (KGRAs) are located west of the park in Island Park, Idaho, and north of the park at Corwin Springs, Montana.

Yellowstone is constantly changing because of natural volcanic and seismic processes. Thermal features and basins respond, sometimes violently, to these forces. Anetwork of seismic monitoring stations in the park provides data to help understand overall seismicity in the region and to gauge the magnitude of earth tremors.

A Primer on Color in the Thermal Areas

Visitors often inquire about the colors in the thermal features. The colors in the hot springs and runoff channels are mostly from light refraction, suspended mineral particles, and large communities of microscopic organisms. These organisms are primitive life forms—algae, bacteria, and archaea—that have inhabited the earth for almost four billion years. (Archaea were once considered a type of bacteria, but their DNAis completely different.) They grow in water too hot for most kinds of life familiar to us on Earth. Life even occurs in boiling water, but as it cools to about 160 degrees F (70 C), the organisms become thick, living layers of color in many different hues.

The chemistry of the thermal pools also influences the kinds and abundance of life. The boiling hot springs of Norris, some of which are more acidic than battery acid, sustain algae, bacteria, and archaea far different from those living in the alkaline springs in the Old Faithful area.

In alkaline areas, cyanobacteria are one type of organism that grows in the hot water. Its colors often follow a color sequence from hottest to coolest: yellow and orange, then green, red, and brown. Cyanobacteria are one of the first organisms to evolve that used the energy of sunlight for life (photosynthesis) and produced free oxygen as a byproduct. In this way, these primitive organisms played a major role in creating an atmosphere that could support human life.

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

Minerals also play a role in the acid features: the gray color of sinter (a hydrated form of silica); the yellow color of sulfur; and the red, orange, and black color of the iron compounds to name a few. 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 orange color mats; and *Calothrix,* which appears as a brown organism in cool, neutral runoff.

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

Suggested Reading

Brock, Thomas. *Life at High Temperatures.* Yellowstone Association for Natural Science, History, and Education, Yellowstone NP, WY. 1994.

Bryan, T. Scott. *Geysers: What They are and How They Work.* Roberts Rinehart Publishers, Niwot, CO. 1990.

Bryan, T. Scott. *The Geysers of Yellowstone.* Colorado Associated University Press, Boulder. Third Edition, 1995.

Cottrell, Dr. William H. *Born of Fire: The Volcanic Origin of Yellowstone National Park.* Roberts Rinehart Publishers, Boulder, CO. 1987.

Ehrlich, Gretel. *Land of Fire and Ice.* Harper Collins Publishers, New York, NY. 1987.

Fritz, William J. *Roadside Geology of the Yellowstone Country.* Mountain Press Publishing Company, Missoula, MT. 1985.

Good, John M. and Kenneth L. Pierce. *Interpreting the Landscapes of Grand Teton and Yellowstone National Parks: Recent and Ongoing Geology*. Grand Teton Natural History Association, Moose, WY. 1996.

Marler, George D. *The Story of Old Faithful.* Yellowstone Library and Museum Association, Yellowstone NP, WY. 1969. (Out of print; available in Research Library)

Marler, George D. *Inventory of Thermal Features of the Firehole River Geyser Basins and Other Selected Areas of Yellowstone National Park.* U.S. Department of Commerce, National Technical Information Service, Publication PB221 289. 1973.

Rinehart, John S. *Guide to Geyser Gazing.* Hyper Dynamics, Santa Fe, NM. 1976.

Smith, Robert B. and Robert L. Christiansen, "Yellowstone Park as a Window on the Earth's Interior." *Scientific American,* Vol. 242, No. 2, pp 1004-117, February. 1980.

Smith, Robert B. and Lee J. Siegel. *Windows Into the Earth: The Geologic Story of Yellowstone and Grand Teton National Parks.* Oxford University Press. 2000.

Tuttle, Sherwood D. *Geology of National Parks.* Chapter 41, "Yellowstone National Park." Kendal-Hunt Publishing Company, Dubuque, IA. 1997.

The Greater Yellowstone Ecosystem

An ecosystem is a place where plants, animals, and their physical environment interact. Plants grow by drawing energy from the sun and nutrients from soils or decaying matter. Animals eat plants and each other. When animals die, their decomposing carcasses cycle nutrients back onto the system. Within an ecosystem, all forms of life are inextricably linked in a self-sustaining process. Many call this a "web of life." Pull a string on one end of that web, and you will find it attached to everything else.

An ecosystem can be as small as a pond or as large as the planet. The 18-million acre greater Yellowstone ecosystem is one of the largest, relatively intact temperate zone ecosystems left on earth. Situated in Wyoming, Montana, and Idaho, the greater Yellowstone ecosystem includes Yellowstone and Grand Teton national parks, portions of seven surrounding national forests, three national wildlife refuges, and state and private lands.

Most of the region surrounding the core ecosystem has been radically altered, with much of the historical flora and fauna eliminated. Greater Yellowstone, in contrast, still contains nearly all of the living organisms found in pre-Columbian times, though generally not in the same numbers.

At the heart of the ecosystem is Yellowstone National Park. The magnificence of Yellowstone cannot be overstated. Each of its separate parts—the geothermal features, the wildlife, the lakes, the Grand Canyon of the Yellowstone, and the petrified forest—could easily stand alone as a national park. That they are all at one place is testimony to greater Yellowstone's abundant diversity and its natural wealth.

Biological Diversity

Biological diversity refers to the diversity of life in all its forms and at all levels, including diversity of species, landscape, habitats, and genes. It is one of the benchmarks that can be used to measure the health of an ecosystem. Biodiversity can be measured two ways. The "richness" of an ecosystem, or the number of different species, is one way. The other is "evenness" or abundance of each species. The diversity of plants and animals within the greater Yellowstone ecosystem is as great as that found anywhere in the lower 48 states. Some 60 mammals, 303 bird species, 17 fishes, and ten reptiles and amphibians live in or pass through the ecosystem. Some 12,000 insect species exist here, including 128 species of butterflies. There are more than 1,700 species of vascular plants.

The greater Yellowstone ecosystem is host to the largest elk herd in all of North America, one of only two remaining populations in the lower 48 states of the majestic grizzly bear, the only U.S. wintering ground for the rare trumpeter swan, and the largest herd of free-ranging bison in the country. Wolverine and cougar still roam the mountains here, bighorn sheep scramble among its cliffs, and bald eagles commonly grace the skies. The paucity of diverse vegetation is striking, however; more than 40 percent of greater Yellowstone is dominated by one tree species, lodgepole pine.

What is significant about the area's biological diversity is the fact that all of greater Yellowstone's natural diversity is still essentially intact. With the exception of the black-footed ferret, the region appears to retain its full historic complement of vertebrate wildlife species—something truly unique in the context of 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, geothermal areas, forests, meadows, and myriad other habitat types. All of these are connected, including linkages provided by streams and rivers that course through the changing elevations.

Despite the size of the ecosystem, the biodiversity of greater Yellowstone 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 135 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, fisher, and lynx.

Aserious threat to both biodiversity and to ecosystem processes is habitat modification beyond the levels of natural disturbance—modifications that fragment or break up habitats in such a way that populations of plants and animals become isolated from each other and cut off from processes necessary for survival.

Cycles and Processes

The foundation of any ecosystem is constructed of cycles and processes. They are the building blocks that facilitate the flow of energy and raw materials. In all ecosystems, living things absorb, transform and circulate energy and raw materials and release them again. These processes and cycles include photosynthesis, predation, decomposition, climate, and precipitation, among others.

The cycles and processes provide the connections within the ecosystem. Without them, the system would collapse. Geologic forces shape the landscape. Ground water flows to replenish geothermal system. Weather wears down rock and helps dictate the type of vegetation. Nutrients such as carbon and nitrogen cycle through the system.

Lifeforms are active at all levels, including lichens that break down rock into soils. Plants draw energy from the sun and cycle minerals such as carbon, sulfur, and nitrogen through the system. Herbivores, ranging from grasshoppers to elk, feed on the plants and, in turn, provide food for predators like coyotes and hawks. The unsung heroes of the ecosystem are the hundreds of species of bacteria, fungi, and other microorganisms that constantly work to decompose matter. They link all that dies with all that is alive.

The ecosystem is constantly changing and evolving. The very character of greater Yellowstone has been shaped by millions of years of natural disturbance, ranging from the periods of volcanism to insect infestations to fire. The processes and cycles keep the ecosystem in dynamic balance.

The burning of forest fires is one example of such an integral, dynamic process. Fires are the way the forest rejuvenates itself on a grand scale. Some species of plants survive the intense burning and 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 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.

While biological diversity of greater Yellowstone is largely intact today, many species are threatened, mostly by geographic isolation created by encroaching development. The smaller and more isolated a population, the more likely extinction is in a given period. That so many of the species are now threatened or are otherwise in jeopardy demonstrates that people influence the system in very critical ways.

Ecosystem Management

Though still evolving, the concept of “ecosystem management” is gaining support among conservationists and resource managers worldwide. The foundation of the concept is that most protected parks and reserves represent fragments of much larger ecosystems. Effective protection can be achieved only if ecosystems are treated as a unit. Ecosystem management must be concerned with the whole, including preserving individual components and the relationships and linkages between them. Maintaining intact ecosystems is also the best way to preserve species. It is more efficient to protect and maintain healthy, functioning ecosystems than to initiate “emergency room” measures to yank threatened species from the brink of extinction.

In the last few years, a coalition of more than 170 organizations, institutions, and foundations based in Canada and the United States have worked together to ensure the long-term survival of wildlife in the Northern Rockies. This effort is called the Yellowstone to Yukon Conservation Initiative, or “Y2Y.” Because wide-ranging wildlife species, such as grizzly bears and wolves, need much more territory than any one park or preserve can provide, Y2Y seeks to build and maintain a life-sustaining system of core protected reserves and connecting wildlife corridors. This effort

extends from the greater Yellowstone ecosystem to the Yukon Highlands—a distance of 1,900 miles. Existing national, state, and provincial parks and wilderness areas will anchor the system while the creation of new protected areas will provide the additional cores and corridors needed to complete it.

Ecosystem management can result in protection of key components of an ecosystem, while permitting activities in other parts in such a manner that ecological integrity is not damaged. Human health and welfare depends directly on the services and goods provided by healthy ecosystems. When ecosystems are fragmented or degraded, these goods and services may be destroyed. When development exceeds levels that can be sustained over a long period of time, future economic activities are threatened. Methods are available for assessing the impact developments will have on an ecosystem. "Cumulative effects analysis" considers combined effects of all development in an area on a species and a system, rather than just one activity.

As an ecosystem, greater Yellowstone is defined by topographical and biological boundaries between the more than 25 federal, state, and local government entities that manage ecosystem lands in units drawn along political lines. The result is fragmented, inconsistent, and sometimes contradictory management of adjacent lands. The concept of the greater Yellowstone ecosystem is gaining support. 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. In 1987, the Committee published a report titled the "Aggregation of Park and Forest Service Management Plans," which provided a snapshot of current resources and their uses in the ecosystem. While this document did not analyze resource management problems, since then a growing awareness of the various ecosystem threats has led to a more holistic view of decisions.

Greater Yellowstone is a rare and extraordinary place. And, unlike many other places, the opportunity to protect wildlands, restore some of the damage that has been done by the careless use of resources, and maintain healthy, sustainable economies is still possible here.

3

Threatened and Endangered Species In Yellowstone

The list below names federally listed threatened or endangered species known to reside or occur in Yellowstone National Park.

Endangered

- Gray wolf *(Canis lupus)*
- Whooping crane *(Grus americana)*

Threatened

- Grizzly bear *(Ursus arctos horribilis)*
- Bald eagle *(Haliaeetus leucocephalus)*—the eagle was down listed from endangered to threatened in four of five regions, including the one containing Yellowstone, in July 1995.
- Lynx *(Felis lynx canadensis)*—listed in March 2000.

  Note: The peregrine falcon *(Falco peregrinus)*—formerly endangered, was delisted in August 1999.

Other Species of Concern

Category 1 species are candidates for listing on the federal list of threatened or endangered species.

- Mountain plover *(Charadrius montanus)*—Migrant
- Arctic grayling *(Thymallus arcticus)*—in 1994, listing was determined to be warranted but precluded at that time.

In August 1995, the U.S. Fish and Wildlife Service issued new policy indicating Category 2 species are no longer considered candidates for listing. The list below of formerly classified Category 2 species indicates species about which we lack good information. These species are not all confirmed to be in Yellowstone, but may occur or reside here.

- Wolverine *(Gulo gulo luscus)*
- Spotted bat *(Euderma maculatum)*
- Preble's shrew *(Sorex preblei)*—only one recorded specimen from Yellowstone
- Long-billed curlew *(Numenius americanus)*—Migrant
- Burrowing owl *(Athene cunicularia)*—Migrant
- Ferruginous hawk *(Buteo regalis)*—Migrant
- Trumpeter swan *(Cygnus buccinator)*
- Harlequin duck *(Histrionicus histrionicus)*
- Black tern *(Chlidonias niger)*—Occasional
- Loggerhead shrike *(Lanius ludovicianus)*—Migrant
- Northern Goshawk *(Accipiter gentilis)*
- Western boreal toad *(Bufo boreas boreas)*
- Spotted frog *(Rana pretiosa)*
- Ross' bentgrass *(Agrostis rossiae)*—Endemic to Yellowstone
- Yellowstone sand verbena *(Abronia ammophila)*

Mammals of Yellowstone National Park

Yellowstone National Park is home to the largest concentrations of large and small mammals in the lower 48 states. While some species are rare or occasional visitors to the park, 60 different mammals are listed as present here. Seven species of ungulates are native to the park—elk, mule deer, bison, moose, bighorn sheep, pronghorn, and white-tailed deer. Non-native mountain goats appear to be colonizing the park.

Numerous carnivores roam the area, including grizzly and black bears. The grizzly is listed as "threatened" on the Endangered Species List, and it is estimated that a minimum of at least 200 grizzly bears live in the greater Yellowstone area. Black bears are common. The gray wolf was native to the Yellowstone area, but was eliminated in the 1930s. In 1995, it was restored to the ecosystem. Mountain lions, bobcats, coyotes, and red fox also live here. Awide variety of small mammals, from chipmunks to marmots to squirrels to weasels to voles and mice inhabit the park. Beaver live here, too, but they are rarely seen. Park regulations prohibit feeding any animal, and visitors must stay at least 100 yards away from a bear and at least 25 yards away from all other wildlife (often it is advisable to stay even farther away).

The list below includes the name, common habitat, and, where available, the most recent population estimates of mammals found in Yellowstone. Even though a species is listed as "common," you are not assured of seeing that animal. Apark site bulletin, "Mammals of Yellowstone National Park," is available at visitor centers and lists popular viewing areas for many large mammals.

Mammals of Yellowstone

ORDER Carnivora	**Habitat**	***Estimated* Population**
Family Ursidae		
Black Bear	forests, meadows	500–600
Grizzly Bear	forests, meadows	350–400
Family Canidae		
Coyote	forests, meadows, grasslands	common
Gray Wolf	forests, meadows	115
Red Fox	meadows	occasional
Family Felidae		
Bobcat	forests, meadows	uncommon
Mountain Lion (cougar, puma)	mountains, rocky areas	18–24
Lynx	sub-alpine forests	rare, if present
Family Procyonidae		
Raccoon	rivers, cottonwoods	occasional
Family Mustelidae		
Badger	sagebrush	common
Fisher	forests	rare, if present
Marten	coniferous forests	common
Mink	riparian forests	occasional
River Otter	rivers, lakes, ponds	common
Striped Skunk	riparian to forest	occasional
Long-tailed Weasel	willows to spruce/fir forests	common
Short-tailed Weasel (ermine)	willows to spruce/fir forests	common
Wolverine	coniferous forests	rare
ORDER Artiodactyla		
Family Cervidae		
Elk (Wapiti)	meadows, forests	35,000
Moose	riparian, forests	300–500
Mule Deer	forests, grasslands, shrub lands	2,500
White-tailed Deer	forests, grasslands, shrub lands	occasional
Family Bovidae		

Bison	meadows, grasslands	2,200–2,500
Bighorn Sheep	alpine meadows, cliffs	150–225
Mountain Goat (non-native)	rocky slopes	rare
Family Antilocapridae		
Pronghorn	sagebrush, grasslands	200–250
ORDER Chiroptera		
Family Vespertilionidae		
Big Brown Bat	roost in cliffs, attics; feed around water	rare
Little Brown Bat	roost in cliffs, attics; feed around water	common
Long-eared Bat	roost in cliffs, attics; feed around water	common
Big-eared Bat	roost in cliffs, attics; feed around water	common
ORDER Lagomorpha		
Family Leporidae		
Snowshoe Hare	forests, willows	common
White-tailed Jackrabbit	sagebrush, grasslands	common
Desert Cottontail	shrub lands	common
Mountain Cottontail	shrub lands	common
Family Ochotonidae		
Pika	rocky slopes	common
ORDER Insectivora		
Family Soricidae		
Dusky Shrew	moist meadows, forests	common
Masked Shrew	moist meadows, forests	common
Water Shrew	moist meadows, forests	common
Preble's Shrew	moist meadows, forests	rare, if present
Dwarf Shrew	moist meadows, forests	rare
ORDER Rodentia		
Family Castoridae		
Beaver	ponds, streams	300–350l
Family Sciuridae		
Least Chipmunk	forests	common
Uinta Chipmunk	forests	common
Yellow Pine Chipmunk	forests	common
Yellow-bellied Marmot	rocky slopes	common
Golden-mantled Ground Squirrel	forests	common
Northern Flying Squirrel	forests	occasional
Red Squirrel	forests	common
Uinta Ground Squirrel	sagebrush, meadows	common
Family Geomyidae		
Northern Pocket Gopher	sagebrush, meadows, forests	common
Family Cricetidae		
Deer Mouse	grasslands	common
Western Jumping Mouse	riparian	occasional
Muskrat	streams, lakes, ponds	common
Heather Vole	sagebrush to forests	occasional
Long-tailed Vole	moist meadows	common
Meadow Vole	moist meadows	common
Montane Vole	moist meadows	common
Red-backed Vole	dense forests	common
Water Vole	riparian	occasional
Bushy-tailed Woodrat	rocky slopes	common
Family Erethizontidae		
Porcupine	forests, sagebrush, willows	occasional

Wolves

As of March 2000 . . .

Number in Yellowstone

- 11 packs
- 115 individuals

Where to see

Lamar Valley at dawn and dusk.

Food

- 90% of a wolf's diet consists of elk. Wolf packs on the northern range kill about 9 elk in a 30 day period in early winter and about 14 elk in a 30 day period in late winter.

Mortality

- High pup mortality in 1999 was probably due, in part, to parvo virus.
- Approximately 75 wolves have died since they were reintroduced. Anumber of pups did not survive the first few weeks, some wolves were legally destroyed due to livestock predation, some died of natural causes, some were killed by motor vehicles, and some were shot illegally.

Other Info

- The Defenders of Wildlife has spent $54,450 to compensate ranchers for livestock lost to wolves from 1996–1999.
- Livestock predation by wolves since reintroduction: 100 sheep, 12 cattle

Current Management

- See "Wolf Restoration" in Chapter 8.

Wolves are highly social animals and live in packs. Most packs number 2 to 8 animals, with the largest ever recorded being 36 (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 are carnivores and 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.

Male wolves generally average 95 to 100 pounds, measure 5 to 6-1/2 feet from nose to tail-tip (tails are 13 to 20 inches), and stand about 3 feet tall at the shoulder. Females are somewhat smaller. The largest wolf on record was an Alaskan male which weighed 175 pounds. Pups are born blind, deaf, furred, and weighing about a pound. While gray is the predominate color, wolves range in color from white to buff to brown to reddish to gray to black.

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. Based upon certain observable differences, however, biologists differentiate wolves into subspecies. 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.

Early Management of Wolves

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 its 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, mountain lions, 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 eliminated from the 48 states (except for northern Minnesota and Michigan's Isle Royale), even in places where there was no livestock, like Yellowstone.

Today, it is difficult for many to understand why early park managers would have participated in the extermination of wolves. After all, the Organic Act (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 game, and those 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 Organic Act.

Restoration

The last wolves were killed in Yellowstone in 1923. Within two decades, biologists were aware of the lack of foresight shown by that act. With an increasing understanding of the complex relationships that exist in nature, it was recognized that elimination of a species could upset a delicate natural balance that had evolved through centuries. For example, while wolves will kill any large animal they can bring down, the nature of predator-prey relationships means that wolves will kill more of the very young, the very old, and the sick than of healthy, prime animals. Thus, wolves will help keep a prey population fit. 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, 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. 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.)

The long, complex, and difficult process of wolf restoration began in earnest in the latter 1970s. An extensive and lengthy research and public review process culminated in an environmental impact statement being approved in 1994 that established guidelines for wolf recovery in three areas of the Rocky Mountains, including the greater Yellowstone ecosystem. It contained special management rules to aid the wolf recovery process in Yellowstone while recognizing the importance of the livestock industry to the region's economy.

The recovery process began when a small number of gray wolves were captured in western Canada and transported to Yellowstone and central Idaho in early 1995. In Yellowstone, the wolves were placed in large acclimation pens for a period of time to allow them to adjust to their new surroundings before being set free. In January 1996 another shipment of wolves from Canada was brought to Yellowstone, acclimated, and then released.

The greater Yellowstone ecosystem is now home to about 115 gray wolves. While the reintroduction has not been without problems, researchers consider the effort to date a great success. They credit both the supreme adaptability of the wild wolves and the fact that the region contains some of the best wolf habitat in the world. The goal of Yellowstone's restoration project is to establish a self-sustaining gray wolf population of 10 breeding pairs of wolves in the greater Yellowstone ecosystem.

Black Bears

As of March 2000 . . .

Number in Yellowstone

- 500–600

Where to see

Tower and Mammoth areas.

History

- Along with grizzlies, used to be fed at dumps within the park.
- For years, black bears would be fed from vehicles.
- Both of these actions resulted in bears losing fear of humans, pursuing human food, which resulted in visitor injuries, property damage, and having 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.
- No research since the 1960s, but black bears have benefited from management efforts aimed at recovering the grizzly bear.
- Because they are not seen as often as in the past, many visitors believe the population of black bears has declined. However, bear sighting reports suggest that black bear numbers are good.

The smallest and most widely distributed bear in North America is the black bear, *Ursus americanus,* which was once abundant in most wooded and mountain areas of the continent. Today the animal is not as numerous as it used to be, especially in the East and Midwest.

The "black" in the name refers to a type of bear rather than a color. The bluish glacier bear of Alaska, the white Kermode's bear of coastal British Columbia, and many bears ranging from black to brown, cinnamon, and blonde are all black bears. In Yellowstone, about 50 percent of black bears are black, with others mostly brown and cinnamon. Black bears stand about 3 feet high at the shoulder. Boars (males) weigh about 210 to 315 pounds, sows (females) 135 to 160 pounds; an exceptional male can weigh 500 pounds. Life expectancy is about 15 to 20 years in the wild. Black bears have fair eyesight and an exceptional sense of smell.

Bears are omnivorous—that is, they eat almost anything, including grass, berries, fruits, tree bark, roots, bird eggs, nuts, insects, fish, and carrion. Their short, curved claws enable them to climb trees with great agility, but do not allow them to dig for roots or ants as well as a grizzly bear can (grizzlies have longer, stronger claws).

Black bears are less aggressive than grizzly bears. When faced with a threat, they are more likely to retreat up a tree or flee outright and less likely to be aggressive as a response. However, "less likely" means just that as any bear, particularly a female with cubs, may attack when surprised at close range. Always give bears a wide berth.

During fall and early winter, bears become fat and sleek. They look for a cave or den where they hibernate until spring. There is some discussion among scientists as to what constitutes true hibernation. Some animals experience an extreme drop in metabolism with a cooling of body temperature and near stoppage of respiration and circulation. Bears undergo these changes but to a less dramatic extent than some other species like marmots or ground squirrels. A bear can be easily roused from its hibernation. Most scientists today consider bears to be true hibernators.

For the better part of the year, males and females without cubs are solitary, living individually on home ranges of 6 to 124 square miles for males and 2 to 45 square miles for females. The exception is during the mating season, the height of which is late June to early July. Promiscuity is common, although pairs will occasionally stay together for the entire period. For both genders, the usual first breeding season is at age 4 . 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 take place.

Birth occurs in mid-January; the female becomes semiconscious during delivery. Usually there are two cubs in a litter, though there may be one or three; four are rare. The new cubs are blind, toothless, and practically naked of hair. 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 den and sleep wherever they happen to be. In the fall, the cubs den with their mother. During the next summer’s mating season, the mother is no longer interested in these cubs and separates from them (they are about 16 months old).

Grizzly Bear

As of March 2000 . . .

Number in Yellowstone

- Estimated 350–400 bears

Where to see

- Grizzly bears are most commonly seen during the summer at dawn and dusk in the Hayden Valley and the Antelope Creek/Lamar Valley areas.

Food

- Elk calves, cutthroat trout, small rodents, ants, moths, vegetation

Status

- Although grizzly bears once roamed from Mexico to the Arctic Ocean, Yellowstone is one of only two major areas south of Canada still inhabited by grizzly bears.
- e In July, 1975, the grizzly bear was listed as a threatened species under the authority of the Endangered Species Act (ESA).

Current Management

- A recovery plan and conservation strategy have been produced. See Chapter 8.
- See "Bear Management History" in this chapter, and related articles in Chapter 8.

Brown bears *(Ursus arctos)* crossed the Bering Land Bridge from Asia about 50,000 years ago and spread into North America. 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.

Grizzly bears are larger than black bears and can usually be distinguished by longer, curved claws, humped shoulders, and a "dished-in" face. Their coats range in color from light brown to nearly black. 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.

In greater Yellowstone, male grizzly bears average 400 to 600 pounds and females 250 to 350 pounds in size. An occasional male may exceed 800 pounds. Adults stand 3 to 4 at the hump when standing on all four legs. They may rear up on their hind legs to more than 8 feet in height; standing up improves their opportunity to see and smell. Grizzlies have adapted to be fast sprinters—running up to 45 miles per hour for short distances. There is a record in the greater Yellowstone area for a wild grizzly bear living to at least 28 years.

It is commonly said that grizzly bears cannot climb trees. This is not strictly true, especially when the bears are small. As grizzlies increase in size and as their claws grow longer, it becomes more difficult for them to climb. Stories that bears cannot swim or run downhill are also persistent—and incorrect.

Bears are generally solitary, although they may tolerate other bears being nearby when food is not a limiting resource. 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 expe-

rience “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. Two or three cubs is common, but several times in recent years observers in greater Yellowstone have seen females with litters of four cubs. Male bears take no part in raising cubs and in fact may pose a threat to younger bears. Amother grizzly will usually keep her cubs with her for two winters following their birth, after which time she (or a prospective suitor) chases the 2 -year-old subadult bears away so she can mate again.

The grizzly’s need for space is large. Their individual home range must contain food, water, and cover throughout all seasons of the year. Although the size of home ranges varies greatly, research shows that males in greater Yellowstone use from 520,392 to 1.3 million acres. Female ranges are considerably smaller, from 133,681 to 343,716 acres. Female cubs frequently establish their home range in the vicinity of their mother, but male cubs must disperse farther in search of a home.

Grizzly bears are omnivorous. 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 or from road-killed wildlife. They eat small mammals (such as pocket gophers) and insects (such as ants and army cutworm moths that summer on high-elevation talus slopes). Amazingly, despite their small size, insects are important, high-protein foods for grizzly bears. Grizzly bears have long, straight claws and a large shoulder muscle mass, which makes them quite efficient at digging for food items in the soil such as roots, bulbs, corms, and tubers, as well as rodents and their caches. They eat a wide variety of plants, including white-bark pine nuts, berries, tubers, roots, sedges, and grasses. They eat glacier lilies and dandelions, yampas and biscuitroots, horsetails and thistles. And, of course, they will eat human food and garbage where they can get it; that is why managers have emphasized 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, those just learning to live on their own away from mother’s protection, are the 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, often becoming “habituated”—an unacceptable tolerance for humans that 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 pre-denning period in autumn. Bears enter their winter dens between mid-October and early December. Dens are usually dug on steep slopes where deep snow will accumulate, providing an added layer of insulation for the sleeping bear(s).

Bear Management History

Feeding Bears

- As early as 1889, bears were gathering at night to feed on garbage piles behind park hotels.
- The first incidents of bears panhandling for food along park roads were reported in 1910.
- The first confirmed bear fatality occurred in 1916.

Early Management

- In 1931, the park began keeping detailed records of bear-inflicted human injuries, property damage, and bear control actions.
- From 1931–1969, an average of 48 bear-inflicted human injuries and 138 incidents of property damage occurred annually in Yellowstone.

Changes in Management

- In 1970, Yellowstone implemented a new bear management program with the objectives of restoring the grizzly and black bear populations to subsistence on natural foods and reducing the number of injuries and property damage.
- Regulations prohibiting the feeding of bears were strictly enforced, as were regulations that required human food and garbage be kept secured from bears.
- All garbage cans in the park were converted to a bear-proof design, and garbage dumps within and adjacent to the park were closed.

Current Status

- In 1975, the grizzly bear population in the Yellowstone ecosystem was listed as a Threatened Species under the authority of the Endangered Species Act.
- Human injuries have decreased to an average of 1 injury per year in the 1990s from 45 injuries per year in the 1960s.
- Property damage claims have decreased to an average of 7 per year in the 1990s from 219 per year in the 1960s.
- Bears that must be killed or removed from the park have decreased to an average of .2 black bear and .3 grizzly bear per year in the 1990s from 33 black bears and 4 grizzlies per year in the 1960s.
- Bear relocations from away from the frontcountry have decreased to and average of .4 black bear and .9 grizzly bear per year in the 1990s, from more than 100 black bears and 50 grizzlies per year in the 1960s.
- For more detailed information on current management, see Chapter 8.

Grizzlies have always been a part of the history of greater Yellowstone. Native Americans hunted bears and invoked their spirits in ceremonies and dances. Early European explorers into the region noted seeing bears on the Great Plains and in the mountainous regions where they were hunting and trapping. After Yellowstone became a national park in 1872, increasing numbers of visitors came into the region, and they developed an early interest in the area's wildlife—especially the bears.

As early as 1889, bears were gathering nightly at the first park hotels, feeding on garbage discarded in open pits. Dumps as bear-viewing sites quickly became a primary tourist attraction, and this situation continued for decades in Yellowstone National Park and in the surrounding towns of

Gardiner, Cooke City, and West Yellowstone, Montana. At the height of the bear-feeding era, hundreds of people sat nightly in bleachers and watched as grizzly and black bears came to feed on specially built garbage platforms.

Despite the official prohibition in 1902 against hand-feeding the bears, Yellowstone National Park became known as the place to see and interact up-close with the popular animals. Roadside bears, often receiving handouts from enthusiastic park visitors, caused a common experience: "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.

As park visitation and the number of bear-human conflicts began to increase, park managers became more concerned about the situation. By 1931, the park was keeping detailed records of bear-caused human injuries, property damages, and subsequent nuisance bear control actions. During the 29-year period from 1931 to 1969, an average of 48 people were injured by bears within the park each year. In addition, bears caused an average of 98 incidents of property damage each year. As a result, park personnel removed an average of 3 nuisance grizzly bears and 22 nuisance black bears each year. The second known bear-caused fatality occurred during this period when an unknown species of bear killed a woman in the Old Faithful campground in 1942. (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.) After the 1942 fatality, Congress criticized the park for failing to solve its bear problems.

In 1959 and continuing through 1971, a pioneering ecological study of grizzly bears occurred in Yellowstone under the direction of Dr. John Craighead and his brother, Frank. Their research provided the first scientific data about grizzlies in greater Yellowstone. From the time the park was established through the 1950s, bear management had been somewhat informal, with little biological understanding of the species. Most management efforts were directed at the bears that were causing problems and not at the underlying causes leading to bear-human conflicts. Overly troublesome bears were simply removed as necessary. The Craigheads'study as well as other studies elsewhere provided park managers with data about bears and their habitat requirements.

In 1960, a National Park Service bear management program was implemented. The program was designed to reduce the number of bear-caused human injuries and property damages that occurred within the park and to re-establish bears in a natural state. The program included expanded efforts to educate visitors about bear behavior and the proper way to store food, garbage, and other bear attractants; more prompt removal of garbage to reduce its availability to bears and the development and use of bear-proof garbage cans; stricter enforcement of regulations that prohibited the feeding of bears; and, the removal of potentially hazardous bears, habitual beggar bears, and those bears that damaged property in search of food. These guidelines were directed primarily at the management of black bears and were largely in response to public complaints of personal injury and property damage caused by roadside and campground bears.

After 10 years of this bear management program, 332 nuisance black bears and 30 nuisance grizzly bears had been removed from the population. However 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 with the objectives of restoring the grizzly bear and black bear populations to subsistence on natural forage and reducing bear-caused injuries to humans. As part of this management program, a controversial decision was made to eliminate the unsanitary open-pit garbage dumps inside the park (eventually the garbage dumps adjacent to the park in West Yellowstone, Gardiner, and Cooke City, Montana, were also closed). The long-term goal was to wean bears away from the unnatural concentrations of food and back to a natural distribution and a diet of plant and animal foods available throughout the ecosystem.

The Craigheads objected to this plan and predicted that it would cause bears to range more widely, resulting in more bear-human conflicts and subsequent bear mortalities. This indeed occurred in the short-term as the bears were forcibly weaned away from an easy food source that many of them had come to rely on. During the first three years of the program, 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 as well as the number of bear management control actions declined significantly.

In 1983, the park implemented a new grizzly bear management program. The 1983 program was similar to the 1970 program, but with greater emphasis on habitat protection in backcountry areas. As part of the 1983 bear management plan, the park established "bear management areas" where recreational use was restricted in areas with seasonal concentrations of grizzly bears. The goals behind these restrictions 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.

Analysis of the data indicates that most bear-human conflicts before 1983 involved food-conditioned bears aggressively seeking human foods. In contrast, from 1983 to 1993, most bear-human conflicts involved habituated, but not food-conditioned, bears seeking natural foods within developed areas or along roadsides. Since 1983, bear-caused human injuries have declined to an average of 1 per year, and the number of nuisance bears translocated has also declined (for grizzly bears to 2 per year and for black bears to 1 per year). The number of incorrigible bears removed from the population has also declined significantly from earlier periods. The long-term goal of forcing bears to relearn how to be "natural bears" appears to have been a success.

The Grizzly Is Listed as a Threatened Species

The grizzly bear in the lower 48 states was listed as "threatened" under the Endangered Species Act in 1975. Although grizzlies originally ranged throughout western North America from the Arctic Ocean to central Mexico, at the time of listing, the species was reduced to living in only about 2 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 by the mid-1970s.

The listing of the grizzly for protection under the Endangered Species Act resulted in cessation of grizzly bear hunting, as well as 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 and the John D. Rockefeller, Jr. Memorial Parkway as well as significant portions of Grand Teton National Park and the Bridger-Teton, Shoshone, Gallatin, Targhee, Custer, and Beaverhead 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. Because of the IGBST and the earlier Craighead studies, greater Yellowstone managers have amassed the longest continuous database for any grizzly bear population in the lower 48 states.

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. The IGBC includes the heads of state wildlife management agencies, regional national park and forest managers, and representatives of the U.S. Fish and Wildlife Service, which has primary responsibility for implementing the Endangered Species Act. Twice each year, these managers have met to discuss common challenges related to grizzly bear recovery. They have supervised the implementation of public education programs, sanitation initiatives, and research studies to benefit the grizzly bear populations in Yellowstone and the other recovery areas in the lower 48 states.

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. Indications are that bears are reproducing well and raising cubs in nearly all portions of the recovery area. 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. 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 that these are not "park bears" leaving Yellowstone for places beyond, but previously unmarked bears and offspring 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, it is not possible to count wide-ranging and fairly solitary animals like bears with any degree of accuracy.

Bison

As of March 2000 . . .

Number in Yellowstone

- 2,200–2,500 estimated
- Three primary herds: the Mary Mountain herd that migrates between Hayden Valley and Fountain Flats, the Northern herd in Lamar Valley, and the Pelican herd in Pelican Valley.

Where to see

Hayden and Lamar valleys year-round; plus Firehole Valley and thermal areas in winter.

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 American 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 overgrazing the park.
- By 1968, 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.

More than 60 million bison *(Bison bison)* may have roamed North America in the 1800s. Their historic range spread from the Pacific to the Appalachians. They were once found in what is now western New York, Pennsylvania, and Virginia, but, as a result of over hunting, they disappeared from 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 as the animals were herded/chased into traps or run over cliffs. The acquisition of the horse from the Spanish in the 1600s fundamentally changed many tribes'way of life as bison could now be hunted more easily, and many tribes prospered.

But Euro-American settlers moving west changed the balance. Starting about 1855, bison were hunted by the new settlers in large numbers for their hides and tongues, the latter considered a delicacy. About the time Yellowstone was established as a national park in 1872, superior methods for processing bison leather were developed by a New York tanner. Shortly thereafter, huge orders for hides from the eastern states and Europe resulted in hide hunters flocking to the plains by the thousands. By 1885, only isolated herds of bison were left, mostly captive animals on ranches.

Yellowstone is the only place in the lower 48 states where a population of wild bison persisted. Primarily because of poaching, Yellowstone bison numbers declined significantly. The poaching of these last bison was interrupted by the U.S. Army. The near loss of bison in the wild resulted in a large public outcry and the swift passage of the Lacey Act, which prohibits hunting in national parks. The story of the near extinction of bison in the U.S. and their protection in Yellowstone is one of the great triumphs of the American conservation movement.

In 1902, fearing the demise of the wild herd (only 23 were counted), the U.S. Army brought 21 bison from ranches to Yellowstone, and the Buffalo Ranch in Lamar Valley was constructed where these bison were managed as on a ranch. During the next several decades, these bison and the park's remaining wild ones flourished. For many years it was believed that Yellowstone's bison were not the plains bison but a different subspecies known as the mountain bison. However, biologists now believe that there is no distinction between these two types of bison. The slight differences in appearance of Yellowstone bison, the larger size and hump, are likely an adaptation to the deep snows and harsh environment of the high mountain plateau.

When domestic bison were brought to Yellowstone and actively managed at the Lamar Buffalo Ranch, the goal was to increase the herd size. National Park Service policy began to shift in the 1930s to the preservation of bison in a more natural state with less artificial manipulation. Consequently, the fences at the Buffalo Ranch were removed, and the ranched bison were allowed to intermingle with the native bison; however, bison were still periodically culled until the late 1960s. Culling was based on carrying-capacity studies conducted from a range management perspective, which suggested a maximum population that Yellowstone's northern range could sustain. Bison were rounded up or hay-baited in the Lamar Valley, and numbers were controlled by regular reductions (this was also done with elk). In 1966, NPS management policy changed to one of allowing natural regulation management to occur to the maximum extent possible. Since artificial regulation of numbers was stopped in the 1960s, the bison population has risen steadily, reaching about 4,200 animals in 1994. Today, there are between 2,200 and 2,500 bison in Yellowstone.

As members of the cattle family, the bison is the largest land mammal in North America. Large bulls commonly weigh up to 2,000 pounds and cows about 1,000 pounds. Both sexes have horns, those of the cow being slightly more curved and slender than the bull's. The bison's pelt is thicker on the forward part of its body, especially in winter. Bulls are more massive in appearance toward the front of their bodies than cows, and more bearded. Bison are sexually mature at age 3 and fully mature at age 8. Life span averages 12 to 15 years, but occasional individuals live as long as 40 years. For their size, bison are remarkably agile and quick, capable of speeds in excess of 30 mph. Ill tempered overall, their docile appearance results in several injuries to park visitors each summer, for bison will often gore those who approach them closely. Grasses and, especially, sedges are their chief food, accounting for about 96 percent of their diet. During winter, bison use their massive head to plow snow side to side as they forage.

Overall, large herds of bison will be composed of cows, calves, and perhaps 1/4 to 1/3 bulls. Most bulls, however, spend the majority of the year by themselves or in small groups. Breeding (the "rut") occurs in late July and August. Furious fighting for cows precedes the actual mating; injuries are common but fatalities rare. After a gestation period of 9 to 9-1/2 months, single reddish-brown calves are born in late April and May. Calves can keep up with the herds about 2-3 days after birth, and predation of calves by bears and mountain lions has been almost non-existent; the extent to which wolves will prey on bison calves is not yet known. Calves nurse through most of their first year. Because of this, yearlings facing their second winter have a lower survival rate than calves facing their first winter.

Adult bison have had no large predators for many decades, although the restoration of wolves in Yellowstone is changing that. Many insects prey upon the bison, and bison will rub against trees, rocks, or in dirt wallows in an attempt to rid themselves of insect pests. Sometimes birds (most notably the brown-headed cowbird) "ride" a bison in order to feed on insects in its coat. While not subject to much predation, as carrion the bison is an important source of food for scavenger species (in winter) and bears just out of their dens in spring.

For information on bison management, brucellosis, and the EIS, see Chapter 8.

Elk

As of March 2000 . . .

Number in Yellowstone

- Summer: Approximately 35,000 elk in seven different herds

Winter: Approximately 10,000–20,000 that winter here

- 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

Winter: migrate south to the Jackson Hole Elk Refuge in Jackson, Wyoming, or north around Gardiner, Montana. A few winter in thermal areas.

Management

- See the article on the Northern Range in Chapter 8.

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

Elk are grazers and prefer grasses. An average, mature bull elk weighs about 700 pounds and is about 5 feet tall at the shoulder. Cows weigh about 550 pounds and are slightly shorter. Calves are usually 30 to 40 pounds at birth (most are born around June 1st). Calves are born light brown with white spots and have little scent, providing them with good camouflage from predators. While they can walk within an hour of birth, they spend much of their first week to ten days bedded down between nursings. The first year is a difficult one for elk calves. Summer losses due to predators average 1/3—and can exceed 1/2—of the calf population. Elk calves are food for black and grizzly bears, wolves, coyotes, mountain lions, and golden eagles. Elk that reach maturity commonly live about 12 to 15 years; rare individuals may live to 25 years.

The mating season (rut) generally occurs around early September to mid-October. At this time, elk gather in mixed herds—lots of females and cows, 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 engage in battle for possession of the cows. The battle involves a crashing together of antlers accompanied by intense pushing and wrestling for dominance. While loud and extremely strenuous, only rarely does any serious injury befall a participant. The weaker bull ultimately gives up and wanders off. The end of the rut coincides with the coming of cold weather and the migration to wintering grounds.

Yellowstone's elk live in an environment characterized by long winters that range in severity of temperature and snowfall. 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 35,000 elk (in 7 herds), winter snowfalls force elk and other ungulates to leave most of the park. The number of elk that winter in the park averages between 10,000 to 20,000.

The northern, lower-elevation portion of Yellowstone, where temperatures are more moderate and snowfall less than in the park interior, can support large numbers of wintering elk. In fact, the northern Yellowstone herd is the largest herd 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.

Only one herd lives both winter and summer in the interior of the park in the valleys of the Madison and Firehole rivers. The Madison-Firehole elk herd has been the focus of a research study since November 1991. This herd numbers from 650 to 850 animals. The population appears to be naturally regulated 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 and high reproduction rates. Information gained in this study will be useful in comparing unhunted and hunted elk populations.

These same researchers have also examined elk use of areas burned in the wildfires of 1988. Observations indicate that elk made extensive use of burned trees; tests showed that fires 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 select burned bark because it is readily available above the snow cover in winter.

Other findings show that high quality forages growing throughout the winter in association with thermal features are apparently significantly lower in digestibility than expected. Also, arsenic from geothermal water accumulates in aquatic plants growing in the Firehole River. Although arsenic is extremely toxic, radio-collared elk commonly feed on the aquatic plants throughout the winter, with no apparent ill effects.

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, as well as on cattle, are a two-part structure. An interior portion of bone (also 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.

Antler growth is triggered in spring by a combination of two factors: a depression of testosterone levels and a lengthening photoperiod. The first result of this change is the casting or shedding of the previous year's "rack." New growth begins shortly thereafter. 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 growth, and the animal begins scraping the velvet off, polishing and sharpening the antlers in the process.

The 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 2/3 of an inch each day. A typical healthy bull will have antlers 55 to 60 inches in length with a spread of just under six feet and a weight of about 30 pounds.

An average, mature, healthy bull elk will bear antlers that are symmetrical, each with six tines. There is great variation among individuals, of course, including asymmetry, malformations, and occasional racks on females. The mature bull is usually referred to as a "six-point" or a "six by six." The latter style of reference refers to left antler points by right antler points and is convenient especially when referring to elk with asymmetric antlers.

Bull elk begin growing their first set of antlers when they are (about) one year old. Commonly, these antlers will consist of simple spikes ranging in length from 10 to 20 inches and occasionally forked at their tips. The second set of antlers will usually possess four to five points, although the antlers themselves will be quite slender compared to an older bull's. The third set will also be four to five points (on average), and will begin to approach the thickness and breadth of a more mature bull. The fourth set and beyond will typically bear the six-point configuration, although they will continue to thicken and lengthen each year. As a percentage of the animal's body weight, the finest antlers produced are the 11th or 12th set. After this time, as the animal approaches senility, antler mass and size will begin to diminish.

Elk 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. Moose and deer are not as gregarious an animal as elk. Retaining antlers during the winter is costly from an energy standpoint, and moose and deer do not usually carry their antlers very long after their rutting season.

With the rut behind them, testosterone levels in bull elk drop during the winter. When they have reached a certain low level and combined with the lengthening day, the antlers are shed in preparation for growing new ones. While there is variation, most bulls drop their antlers between mid-February to late March. Bulls that frequent mixed herds for the winter will usually drop their antlers about 10 days later than those in "bachelor clubs," while aged bulls often drop theirs earlier than those in their prime.

3

Moose

As of March 2000 . . .

Number in Yellowstone

- 300–500

Where to see

- Look in riparian areas around Yellowstone Lake and along the Madison, Gallatin, Snake, and upper Yellowstone rivers.

Other Info

- Population of moose on the northern range has decreased since 1960s.
- One factor may be burning of winter spruce-fir habitat in 1988.
- Other factors may be competitive exclusion by elk, the loss of old growth forests, and mortality from hunting outside the park.

Moose *(Alces alces shirasi)*, the largest member of the deer family, were reportedly very rare in northwest Wyoming when Yellowstone National 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 as moose are dependent on mature fir forests for winter survival. By the 1970s, an estimated 1,000 moose inhabited the park.

Like most deer family members, bull moose are antlered and the cows are not. The antlers are flat and palmate (shaped like a hand). Bulls average about 900 pounds, the largest can be as much as 1,400 pounds. Cows average about 675 pounds. Moose are a chocolate brown, often with tan legs and muzzle, and possess a waggle or bell, a 6- to 10-inch growth of skin and hair that hangs from the throat. Its purpose or function is unknown. The moose is an excellent swimmer and is as likely to cross a lake as walk around it. Moose mature at about 2 to 3 years of age; the average life span for moose is 18 to 20 years. Despite its size, a moose can slip through the woods without a sound. Moose, especially cows with calves, are unpredictable and often belligerent.

Moose are well known for feeding while standing in water, where they seek aquatic plants like water lilies, duckweed, and burweed. But the principle staple of the moose diet are the leaves and twigs of the willow, followed by other woody browse species such as balsam, birch, maple, and mountain ash. An adult moose consumes at least 40 to 50 pounds of browse per day.

On-going research with radio-collared moose has revealed some interesting insights into moose migration in winter. 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 (to as high as 8,500 feet) to winter in mature stands of subalpine fir and Douglas-fir. They browse almost exclusively on the twigs and needles of these conifers. In thick fir stands, much of the snow builds up on the branches of the trees, meaning there is less snow on the ground beneath the trees, which facilitates easier movement for the moose.

Moose are solitary creatures for most of the year, except during the rut, which lasts from mid-September until the end of November. Both genders are vocal at this time: the cows may be heard bellowing in search of a mate, and bulls challenge one another with low grunts before clashing with their antlers. Abull moose 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. Such a thrust may puncture the ribs and drive one of the several short prongs on the outer edges of the antlers into a vital organ. Normally before such a thing happens, however, the weaker animal gives up. The victor stays for a week to ten days with the cow that it has won before going on to do battle

again for another cow.

In December, shortly after the rut is finished, bulls will shed their antlers. This conserves energy, thereby promoting easier winter survival. Cows are pregnant through the winter; gestation is 7 to 7 months. In early May, the cow will drive off any previous year's offspring that may have wintered with her and seek out a thicket to drop her new calf. A cow's first-born is a single calf; thereafter twins are often born, with triplets a rarity.

Calves are born covered with hair and with their eyes open. The muzzle is black and there are dark spots over each eye. Acalf walks a few hours after birth and stays close to its mother. It is often the prey of bears or wolves and less frequently of mountain lions, coyotes, or wolverines. An adult moose can usually outrun these predators or trample them to death.

During the summer, the bulls grow new antlers to replace those shed in December. In April or May small bumps on each side of the forehead start to swell, then enlarge until they are knobs covered with a black fuzz and fed by blood which flows through a network of veins. Finally the knobs change into antlers: spikes 6 to 8 inches long for a yearling; a fork-horn for a two-year old; and narrow palmate antlers with 3 or 4 irregular points for a three-year old. By August antlers are fully developed. As a bull rubs and polishes his antlers on small trees without low branches the antlers become hard and brown. When a bull reaches maturity at 12 to 15 years, the antlers may be as wide as 5 feet from tip to tip. Beyond maturity, the antlers and bell of a bull moose become smaller.

Recent research on the northern range indicates that the moose calf crop has been declining since the fires of 1988. During that summer there was also high predation of moose by grizzly bears in small patches of surviving timber. The winter following the fires many old moose died, 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, which continue to be monitored. Moose are more commonly observed in the park's southwestern corner and in the Soda Butte Creek, Pelican Creek, Lewis River, and Gallatin River drainages.

3

Pronghorn

As of March 2000 . . .

Number in Yellowstone

- 200–250

Where to see

- Summer: Lamar Valley.
  Spring, Fall, Winter: near the North Entrance near Gardiner, Montana

History

- Prior to European-American settlement of the West, pronghorn population estimated to be 35 million.
- Prior to the 19th century, pronghorn abundant in river valleys radiating from Yellowstone.
- Settlement and hunting in 19th century reduced their numbers.
- Park management also culled pronghorn during the first have of the 20th century due to overgrazing concerns.
- By 1967, fewer than 200 pronghorn were counted.

Research Concerns

- 1991, 594 counted; decline may be due to predations, in-breeding depression, and loss of winter range.
- Research began in 1998 to study mortality of this small population, which contains more genetic diversity than any other North American herd studied. Biologists believe that is the herd drops below 200 animals, it will be in jeopardy of extinction.

The North American pronghorn *(Antilocapra americana)* is not a true antelope (like gazelles), which are found in Africa and southeast Asia. The pronghorn is the only 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. Clark wrote, "He is more like the Antilope or Gazella of Africa than any other species of Goat [sic]."

The pronghorn has true horns, similar to those of 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. First, the sheaths are shed and regrown every year; second, they are the only horns which have a fork (the prong) in them. (Anumber of other horned mammals occasionally shed their horns, but not annually.) Adult males (bucks) typically have 10- to 16-inch horns, which are curved at the tips. About 70 percent of the females (does) also have horns, but they are considerably smaller than those of males, averaging 1 to 2 inches long. The males usually shed the horny sheaths in November or December and begin growing the next year's set in February or March. The new horns grow for 9 to 10 months, reaching their maximum development in August or September. Females are quite variable as to when their unbranched horns are shed and regrown.

Even without their unusual horns, pronghorns are easy to distinguish from all other North American hoofed animals. Their deer-like bodies are reddish-tan on the back and white underneath, and they have a large white rump patch. They have very large and protruding eyes, which provide the animal with an extraordinarily large field of vision. Males have a black cheek patch, which is absent in the females. Pronghorns usually measure about 45 to 55 inches from the nose

tip to tail and are 35 to 40 inches tall at the shoulder. Males weigh about 100 to 125 pounds, and females weigh around 90 to 110 pounds.

During winter, pronghorns form herds that may contain dozens, or even hundreds, of animals of both sexes and all age classes. When spring arrives these congregations split into smaller bands of females, bachelor groups of males between 1 and 5 years old, and solitary older males. Yearling or older females that bred the previous fall commonly deliver a set of twins in May or June. The newborn kids are a uniform grayish-brown color and weigh between 6 and 9 pounds. They are able to 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 kids turn three weeks old they begin following the females during daily foraging. At this time several females and their youngsters join together in nursery herds along with yearling females.

Most likely, pronghorns form groups for increased protection against predators. Whenever one individual detects danger it flares its white rump patch, signaling the others to flee. The pronghorn is well adapted for outrunning its enemies, having an oversized windpipe and heart that allow large amounts of oxygen and blood to be carried to its unusually large lungs. Pronghorn can sustain sprints of 45 to 50 mph. Such speed, together with a keen visual "advance warning system," make the adults difficult prey for any natural predator. Kids, however, are taken fairly often by coyotes, bobcats, and golden eagles. If adults are weakened by severe winter weather, they too will fall prey to these predators as well as to free-ranging dogs.

While the pronghorn's speed frustrates most predators, running is no match for a tight fence. Pronghorns can jump over fences, but most are reluctant to do so. Instead, they would rather crawl under or through the barrier. Fences made of woven wire or four to five tight strands of barbed wire often will corral pronghorns and enable predators to capture them—especially if the antelope is slowed by deep snow. Also, such obstacles prevent pronghorns from moving readily to new food supplies or from migrating to sheltered areas during severe winters.

The pronghorn breeding season, or "rut," commences in mid-September and extends through early October. During the rut the older males defend territories in areas having 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 the horns meet, which is followed by vigorous twisting and shoving. Eventually, the weaker individual will retreat. Although the fights may be bloody, fatalities are rare. Males reigning over the choicest territories may attract the largest number of female visitors and, thus, do most of the breeding.

A pronghorn's day is divided between feeding, resting, and ruminating ("chewing its cud"), and includes trips to water holes if forage is very dry. The most important foods throughout the year are various shrubs like sagebrush and rabbitbrush; these shrubs become critical during winter when lower-growing plants are covered by snow. Succulent forbs are consumed during spring and summer. Pronghorns may actually benefit some rangelands by eating vegetation that is poisonous or unpalatable to livestock. They seem to relish plants like locoweed, lupine, and poisonvetch. It is thought that the pronghorn's very large liver (proportionately, almost twice the size of a domestic sheep's liver) is used to remove forage toxins, including selenium and various alkaloids, 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 of high nutritional value.

During summer, 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). In winter, home ranges are generally smaller. Pronghorns, including some in Yellowstone, also may migrate many miles between different winter and summer ranges, allowing them to more fully utilize forage within broad geographic areas.

During the early part of the nineteenth 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 erroneously believed that pronghorns were competing with livestock for forage. By the 1920s, it was estimated that only 15,000 to 20,000 individuals were left on the entire continent. Today, due to transplant programs and careful management, pronghorns again roam the sagebrush prairies in herds totaling nearly one-half million animals.

Between 200 and 250 pronghorns live in Yellowstone National Park and adjoining lands. The best places to see them year-round are the grassy flats just south of Gardiner, Montana, and the area east of the park's horse corrals, 3 miles north of Gardiner along the county gravel road. In summer, pronghorns may be seen in Lamar Valley south of the Lamar Ranger Station. Historically, pronghorn migrated to the Hayden Valley during summers, but since the 1940s pronghorn are rarely seen in the park's interior.

There has been some concern that large declines in pronghorn numbers in the park, especially between the 1960s and 1980s, were caused by poor (overgrazed) range conditions. In 1991, park researchers began collaring pronghorn kids to monitor their movements and survival. Nearly all collared pronghorn kids were apparently killed by coyotes. The average kid life span in 1991 was about 35 days. This mortality rate closely followed the decline in total kid numbers measured during weekly surveys of the entire park. At least from this small sample, it appeared that natural predation, not range conditions, caused the loss of most the annual kid crop. Pronghorn population numbers have continued to decline, and in late 1998 another study was initiated to determine what the fawn productivity and mortality rates are.

There is also concern that the park's antelope herd is too small and too isolated to ensure its viability. In the winter of 1995-96, the park initiated weekly winter surveys of pronghorn between Mammoth and Cinnabar Mountain (north of Gardiner, Montana) in order to help track the trend in the pronghorn herd and its relationship, if any, to bison management-related activities near Stephens Creek. There was no bison control activity in the area in 1995-96. During 1996-97, significant bison management operations occurred, and preliminary data suggest that increased human activity may influence pronghorn distribution on their winter range.

Bighorn Sheep

As of March 2000 . . .

Number in Yellowstone

- 150–225
- Summer: slopes of Mount Washburn, along Dunraven Pass. Year-round: Gardner Canyon, between Mammoth and the North Entrance.

Management

- Bighorns in Gardner Canyon exhibit some habituation to humans. Be alert to them along the road.
- Researchers from Montana State University are studying bighorn sheep habitat use and the effect of human activity along the Gardner–Mammoth corridor. About 65% of all sheep observations in this winter range were atop McMinn Bench, 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.
- 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.
- The northern range population has not recovered to levels recorded before a Chlamydia (pinkeye) epidemic that broke out in the winter of 1982, resulting in the loss of about 60% of the herd. Since no sign of the disease is currently present, other factors are believed to be limiting the bighorn sheep population, such as over-hunting outside the park, introduction of other domestic livestock diseases, and difficulty in re-colonizing previous habitats.
- The cliffs in the Gardner Canyon, between Mammoth Hot Springs and the park's north entrance, are closed to human entry to protect the sheep, which use these cliffs for shelter, security, water, and minerals.

Bighorn sheep *(Ovis canadensis)* once numbered in the millions in the western United States. But, by 1900, bighorn numbers were reduced to a few hundred due to intense market hunting. The bighorn was the principal food of the “Sheepeaters,” a band of the Shoshone tribe who lived year-round in Yellowstone until 1880. The Sheepeaters also made their bows from sheep horns.

In 1897 naturalist Ernest T. Seton spent several months roaming the upper ranges of Yellowstone National Park and did not see any sheep, although about 100 to 150 were estimated to be present. Later, in 1912, Seton reported that despite a disease (scab) contracted from domestic sheep, bighorns in the park had increased to more than 200, and travelers could find them with fair certainty by devoting a few days to searching around Mt. Everts or Mt. Washburn. In the winter of 1981-82, an outbreak of pinkeye occurred among bighorns in the Mt. Everts area. Many sheep were blinded and/or killed on the adjacent park road or by falling from cliffs. No evidence of the disease, a natural occurrence, has been found since. The current population of bighorn sheep is estimated to be 150-225 animals.

Bighorn sheep inhabit high, rocky country. Both males (rams) and females (ewes) have horns, but they are shaped differently. Those of the male are large and curved while those of the female are slightly curved, slender, and much smaller. The body hair is straight, not woolly. Bighorn sheep are tan brown in summer and much lighter in winter.

Mating season 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 loudly crashing their heads and horns together. Their extra thick skull protects their brain during these jarring

encounters. Occasionally one male butts another one over a cliff. By the time the two-month mating season is over, males are often battered and bruised.

One or two lambs are born in late spring and grow rapidly. When first born, lambs can walk under a standing ewe, but within a month they must kneel to nurse. All bighorn sheep are extremely sure-footed. The bottoms of their feet are concave, enabling them to walk and run over rocks very easily.

For the first two years of its life, the horns of a male are similar to the small horns of a female. But by the time a male is five years old the horns have grown until they reach the bottom of the downward swing. When 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. Broken or splintered tips are never replaced, and the horn continues to grow from the base throughout the animal's life.

Forage consists of mountain grasses, herbs, and some woody plants. As the animals 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 go or passed to the other side of the mountain. The bighorn swims well and often plunges into rivers or lakes to move from a summer feeding ground to a wintering area.

In summer, sheep are found in the Gallatin, Washburn, Absaroka, and Red mountain ranges. On Dunraven Pass, between Canyon and Tower Junction, a band of ewes and lambs has become somewhat habituated to summer traffic. These bighorns cause numerous traffic jams and are sometimes illegally fed by visitors, posing traffic hazards and danger to the sheep.

Mountain Goats

Visitors occasionally inquire about the presence of the mountain goat *(Oreamnos americanus)* in Yellowstone. This distinctive, snow-white mammal has been sighted in the northwestern and northeastern corners of the park and in the Gibbon River Canyon in recent years. Goats are not native to Yellowstone, but no decision has been made about what to do if goats become established here.

Mountain Lions

As of March 2000 . . .

Number in Yellowstone

- 18– 24 on the northern range; others in park seasonally.
- Mountain lions occupied Yellowstone since the park's establishment in 1872. Populations were significantly reduced by predator control measures during the early 1900s. It is reported that 121 lions were removed from the park by 1925, at which time the population was estimated at 12 individuals.

Where to see

- Seldom seen.

Research

- In 1987, the first study on mountain lions in Yellowstone documented population dynamics in the northern Yellowstone ecosystem. In 1998, research began to assess effects of wolf restoration on mountain lions.

Other Info

- Preferred terrain: rocky breaks near prey.
- Prey: primarily elk and deer; sometimes moose, bighorn sheep, porcupine, other small animals.
- Bears frequently displace cougars from their kills.
- In the winter of 1999-2000, wolves apparently killed or caused the abandonment of 4 kittens in one litter.
- Mountain lions, especially males, kill other cougars within their territory.

Interaction with humans

- No documented lion-human confrontations have occurred in Yellowstone.
- Report all sightings.
- Preventive and defensive measures: grouping together or - carrying small children; and making noise, waving arms, throwing rocks or sticks if necessary to scare off a big cat if close or stalking humans.

The mountain lion *(Felis concolor)*, also called the cougar, is the largest member of the cat family living in Yellowstone. Mountain lions can weigh up to 200 pounds, although park lions are thought to range between 140 and 160 pounds for males and around 100 pounds for females. Two to three kittens may be born at any time of year, although most arrive in summer and fall. For reasons that are not clear, only about 50 percent of kittens survive their first year. The current population of lions in Yellowstone is estimated at 18–24 animals and is thought to be increasing.

Mountain lions are rather secretive, consequently, most visitors are unaware of their existence in Yellowstone. Lions probably live throughout the park in summer. In winter, difficulty of movement and lack of available prey causes most lions to move to lower elevations. Lions are territorial and will kill other lions. The dominant animals reside in the northern range areas of the park where prey is available year-round. Mountain lions prey chiefly upon elk and deer, although their diet probably varies based upon opportunity. In winter, porcupines provide an important supplement to the lion’s diet.

Mountain lions were significantly reduced by predator control measures during the early 1900s. It is reported that 121 lions were removed from the park between the years 1904 and 1925. At that

time, the remaining population was estimated to be 12 individuals. Mountain lions apparently existed at very low numbers between 1925 and 1940. Reports of lions 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 mountain lion ecology was initiated in Yellowstone National Park. The research documented population dynamics of mountain lions in the northern Yellowstone ecosystem inside and outside the park boundary, determined home ranges and habitat requirements, and assessed the role of lions as a predator in the ecosystem. In recent years in other areas of the West, mountain lions have occasionally attacked humans. No documented lion/human confrontations have occurred in Yellowstone.

Coyotes

As of March 2000 . . .

Number in Yellowstone

- Numerous. However, since wolves were reintroduced to Yellowstone in 1995, the coyote population has decreased 30–50% through direct mortality and changes in coyote denning behaviors and success.

Where to see

- Meadows, fields, other grassland areas

Management

- Like other predators, coyotes were often destroyed in the early part of the 20th century because they were thought to prey 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 and opened a niche that coyotes could occupy in Yellowstone.
- In 1989, researchers began investigating the basic ecological role of coyotes in Yellowstone. The park is one of the few places where the natural behavior of coyotes is not strongly influenced by trapping or predator-control programs. Yellowstone is one of the few places in North America where coyotes live in packs.
- Coyotes can lose their wariness of humans if they are conditioned to accept human food.
- Several instances of coyote aggression toward humans have occurred in the park.
- NPS staff monitors coyotes and use cracker-shell rounds, bear spray, or other negative stimuli to aversively condition them.

Coyotes *(Canis latrans)* are intelligent and adaptable. The coyote is respected by many Native American tribes and is often portrayed in their various legends as a teacher and/or trickster. For the Euro-American settler, however, coyotes were viewed as a serious problem. Like the wolf, when the wild game in an area was gone, domestic animals became prey. However, owing to its greater adaptability, coyotes were—and continue to be—successful in resisting efforts to exterminate them. The coyotes of Yellowstone were originally blamed for serious wildlife losses until the results of careful research in the 1940s proved differently. This research showed that the chief foods of the coyote are marmots, voles, mice, rabbits, and other small animals as well as carrion.

The coyote is a rather small, slender animal resembling a shepherd dog in general appearance. While most appear rather tan in pelage, coats are sometimes buffy, grayish and black, or yellowish in some individuals, with underparts lighter, and a large and bushy tail. Males are slightly larger than females. Adults average about 35 to 45 pounds, total length is 3 to 4 feet, and height at the shoulder is 16 to 18 inches. Yellowstone's coyotes are among the largest coyotes in the United States, and visitors frequently mistake them for wolves. Five to seven pups are born in April in a small cave, cavity among rocks, or ground burrow. By August, they appear full grown and are hunting in family groups.

In 1989, research was undertaken to investigate the basic ecological role of coyotes in Yellowstone. The park is one of the few places where the natural behavior of coyotes is not strongly influenced by trapping or predator-control programs. Yellowstone is one of the few places in North America where coyotes live in packs; 85 to 90 percent of coyotes on the northern range belong to packs. Researchers captured and radio-collared coyotes, mainly on Yellowstone's northern range, in order to study movements and behavior. Males and females were sampled from at

least 16 different resident packs. Average pack size during the winters of 1990-93 was 6 to 7 animals, and the pack typically consisted of a dominant, mated “alpha-pair” and subordinate “beta” individuals. The betas are pups from previous litters that remain in the area where they were born. Evidence strongly indicates that coyote territories are traditional.

Wolf extirpation probably resulted in high coyote population densities, and coyotes, at least partially, slid into the niche left vacant by the removal of wolves. The northern Yellowstone coyote population has characteristics similar to those of gray wolves: low productivity, a highly structured social system, non-overlapping year-round territories, and an old age structure. Adult mortality is very low and is primarily due to vehicles and mountain lions. Dozens of fatal wolf-coyote interactions have been documented in the first years of wolf restoration to the park. On the northern range, researchers estimate that wolves have caused up to a 50 percent reduction is the resident coyote population through direct mortality and changes in coyote denning behaviors and success.

Coyotes occasionally lose their wariness of humans and frequent roadsides or developed areas, becoming conditioned to human food by receiving handouts or picking up food scraps. They can quickly learn bad habits like roadside begging behavior. This leads to potential danger for humans and coyotes. Several instances of coyote aggression toward humans have occurred here, including one that involved an actual attack. Habituation most likely played a role in this unusual coyote behavior.

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 translocated to other areas of the park or removed from the park ecosystem. 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.

Beaver

As of March 2000 . . .

Number in Yellowstone

- Approximately 300

Where to see

- Beaver are distributed throughout Yellowstone, though not uniformly. They are concentrated in the southeast (Yellowstone River delta), southwest (Bechler River), and northwest (Madison and Gallatin rivers) areas in the park. However, since they are most active at night, beaver are not commonly seen

Other Info

- By the early 1800s, fur trappers had nearly decimated beaver populations in the American Northwest to supply pelts for men's beaver hats in Europe. Since Yellowstone was hard to get to and there was not an abundant quantity of beaver in the area, Yellowstone's beaver were never "trapped out."
- In recent years, some park critics have insisted that beaver have been extirpated from the park. Park records show beaver present throughout Yellowstone's history.

Current Management

- Since 1989, park staff has periodically surveyed riparian habitats for beaver. A1998 survey flight counted 51 lodges with an associated food cache, and offered an estimated population of about 300 beaver. A1999 flight documented even more active colonies; results from this and a corresponding 1998 ground survey are still being analyzed.

While Yellowstone National Park has many rare and wonderful forms of wildlife, none has been as important to the human history of this continent as the beaver, *Castor canadensis.* Afad in European men's fashion in the 1700s and early 1800s led to the era of the fur trapper/mountain man in the North American West. The introduction of silk in the late 1830s brought about a change of fashion—and likely saved the beaver from extinction. While Yellowstone's beaver were trapped on occasion, they received nowhere near the attention that beaver in other mountainous regions did. Yellowstone was a difficult place to get to in those early days, and trappers quickly found out that there was not an abundant quantity of pelts in this area, as Yellowstone is near the limits of beaver range. Because of these two reasons, Yellowstone's beaver were never "trapped out" (extirpated).

Beaver live in groups, or colonies, and they are almost always found in or near water. Beaver are about 35 to 40 inches long, with the last 10 inches being a paddle-shaped tail. When startled or surprised, beaver slap their tail on the water before submerging and seeking safety. With an average weight of 30 to 60 pounds, the beaver is the largest rodent of North America. Arich brown in color, beavers have no sexual dimorphism; that is, male and female appear exactly alike in all respects. Because beaver are most active at night, it is not likely that visitors will see beaver in Yellowstone.

While famous as "dam builders," not all beaver colonies build dams. 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 Yellowstone River, Lamar River, or the Snake River in the park) do not build dams on the main waterways; however, beaver persist in these major rivers, often denning in holes in the riverbank rather than in the well-known lodges.

Beaver are distributed throughout Yellowstone National Park, although not uniformly. Beaver 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 due to the amount of water present, the meadow-type flatlands, and the associated extensive willow communities present. In the lower Madison and Gallatin river drainages, aspen communities are more extensive than elsewhere in Yellowstone.

While willows, aspens, and/or cottonwoods are generally preferred beaver foods, there is wide regional variation in the number and composition of woody plant species utilized by the animal, and it should be noted that beaver are not restricted to riparian types of habitat. Essentially no aspen exists in some areas where beaver sign is most abundant, such as in the Bechler River and Boundary Creek areas. The same is true in other areas where beaver appear to persist, although sign is less abundant and/or more dispersed. These areas include 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 areas of this nature, beaver appear to use lodgepole pine and some Douglas-fir for construction purposes and/or for food. Beaver are known to eat the cambium from pines. The beaver's digestive system allows it to digest the most nutritious parts of a large amount of woody, fibrous plants. In areas where preferred woody plants are only present in very small densities or are absent, beavers may feed solely on submerged vegetation.

Since 1989, park staff have periodically surveyed riparian habitat in Yellowstone to determine current presence and distribution of beaver. These surveys encompassing more than 250 miles of riparian habitat, including more than 75 lakes and stream segments in the five major drainages of Yellowstone. During the 1994 survey, 113 beaver dams were observed as were 78 lodges, of which 44 (56 percent) appeared to be active. Researchers have long known that areas that appear to be marked by "old" beaver activity may still be active, and beaver often reoccupy lodges that were abandoned in past years. An example of this was seen at Slide Lake, near Mammoth. Alodge that was occupied during the 1988-89 survey appeared partially collapsed and abandoned during initial observations in 1994. About one month later, however, a large adult beaver was seen using this lodge.

Beaver do not necessarily avoid areas that received moderate to high levels of human use. Several occupied lodges in Yellowstone are in close proximity to popular backcountry trails and/ or campsites. Also, several beaver sightings occur along main park roadways every year. The nocturnal habits of beaver seem to be enough to separate them from human use of the same area.

Birds

As of March 2000 . . .

Number in Yellowstone

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

Other Info

- One endangered bird species occurs in Yellowstone; the whooping crane. The peregrine falcon, formerly an endangered species, was de-listed in August, 1999.
- One threatened bird species occurs in Yellowstone; the bald eagle.
- Other species of concern include: peregrine falcons, American white pelicans, trumpeter swans, ospreys, common loons, harlequin ducks, great blue herons, great gray owls, and colonial nesting birds.

Current Management

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

Records of bird sightings have been kept in Yellowstone since its establishment in 1872; these records document 303 species of birds, of which 148 are known to nest. This is quite remarkable, especially when one considers the harsh environmental conditions that characterize the area. Winters are long in Yellowstone, and snow can fall in any month of the year. Although elevations range from about 5,300 feet to more than 11,000 feet, the majority of the park is a high plateau lying between 7,000 and 8,000 feet.

Habitats vary considerably in the park, from low elevation sagebrush grasslands to high alpine tundra. However, the majority of the park is forested, mainly with lodgepole pine. There are many lakes and streams in Yellowstone that afford riparian habitat as well as areas of spruce-fir and Douglas-fir forest. Many birds, such as robins and common ravens, are found throughout the park. Other species are localized in particular habitats. For example, belted kingfishers are found near rivers and streams while Steller's jays are found in coniferous forests.

Spring migration brings many birds back to Yellowstone from their winter journeys south. This is a good time to look for birds. Birds are singing now to establish and defend their territories, and they are in their distinctive, 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. Some birds do stay in Yellowstone year-round, including the common raven, Canada goose, blue grouse, gray jay, red-

breasted nuthatch, and American dipper.

There are a number of interesting birds that many visitors may see while in Yellowstone. American white pelicans are often seen along the shores of Yellowstone Lake and in the Yellowstone River. These large white birds are often mistaken for trumpeter swans until their huge yellow beak and throat pouch is seen. In flight, the black tips of their wings are easily visible. A common visitor question is,"What is the black and white bird with the long tail?" It is the black-billed magpie, a gregarious bird seen throughout the West, often along the highway. The osprey, or "fish hawk," is often seen along rivers and at the Grand Canyon of the Yellowstone (where six to ten pairs have nested since the mid-1980s). 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, few do. These secretive birds are found in dense forests. Many sightings in Yellowstone have been in the Canyon area.

With steaming geysers, shining mountains, tremendous herds of bison and elk, the celebrated grizzly bear, and, now, the wolf to attract one's attention, Yellowstone's birds are often overlooked. But, the rewards for the birder in Yellowstone are great. From the common to the unusual, Yellowstone's birds draw your eye to places and scenes that might be missed without the motion and color of these feathered residents. The park's bird list (Field Checklist of Birds of Yellowstone National Park 1996) is available at park visitor centers.

Bald Eagles

The bald eagle *(Haliaeetus leucocephalus)* is a large, brown-bodied bird with a completely white head and tail. Females are larger than males, which is true with most predatory birds. Eagles form long-term pair bonds. Immature eagles will appear mostly brown although nearly full-sized by their first winter. They change their coloration several times before achieving their adult colors when about five years old. Immature bald eagles are often mistaken for golden eagles. (Sometimes a good way to determine which bird is being observed is to note the habitat the bird is seen in. Bald eagles feed on fish and waterfowl and are almost always observed near water while golden eagles hunt in open country.)

Bald eagles reside in Yellowstone throughout the year, nesting in large trees in close proximity 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 it is available. During severe winter weather, some eagles may move to lower elevations where food is more available. On these wintering areas, resident eagles may be joined by migrant bald eagles as well as golden eagles.

By late winter, eagles are returning to their nesting sites; eagles are extremely sensitive to human disturbance when nesting. One to three eggs (usually two) are laid in late March 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 fly from the nest. Radio-tagging studies have shown that all 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, there were 22 active eagle territories in 1998, and 15 eaglets fledged. Some eagle territories are experiencing nest instability due to the large number of trees that are falling as a result of the 1988 wildfires. Collectively however, bald eagles are doing very well in the park and throughout the greater Yellowstone ecosystem.

Peregrine Falcons

In 1962, Rachel L. Carson sounded an alarm concerning the irresponsible use of pesticides in our environment with the 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. Among those birds that were affected was the peregrine falcon *(Falco peregrinus)*. The peregrine was on the Endangered Species List, but it has made a comeback in much of its former range and was delisted in 1999. The most damaging pesticides were banned, and a program of reintroduction by groups such as the non-profit Peregrine Fund of Boise has led to this success.

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 April through October, nesting on large cliffs that overlook rivers or valleys where prey is abundant. Their food is mostly songbirds and waterfowl. Peregrines winter as far south as South America; none of them spend the winter in Yellowstone.

The peregrine is difficult to observe. Because of their great speed and low population numbers, sightings in Yellowstone are rare. 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 in dives after prey.

In Yellowstone, known peregrine nesting sites (eyries) increased from 1 in 1984 to 13 in 1998. In 1998, 22 young peregrines fledged from 13 eyries. Biologists believe that the peregrine falcon is ecologically recovered in Yellowstone, as elsewhere. However, because peregrines are highly prized by falconers, the locations of nesting sites are not revealed.

Trumpeter Swans

The trumpeter swan *(Cygnus buccinator)* is the largest wild fowl in North America. The long-necked swan is all-white and has a black bill. Both males and females are about equally sized; on average, an adult male weighs 25 to 30 pounds and a female about 20 to 25 pounds. They are most often observed swimming in slow-moving rivers or placid lakes. While their normal life span is not known, there is a record for one individual living 23 years and 10 months.

Common in North America at one time, trumpeter swans in the lower 48 states neared extirpation in the early 1900s as a result of human encroachment, habitat destruction, and the commercial swan-skin trade. Asmall population of swans survived in Yellowstone and in other isolated areas of the country. Swans received protection when the Migratory Bird Act of 1918 was passed. Red Rock Lakes National Wildlife Refuge, the country's largest 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 10,000 trumpeters exist in North America.

In Yellowstone, the resident population of swans rarely exceeds 30, and winter numbers vary between 60 to several hundred swans. Swan reproduction rates are low, and populations have fluctuated dramatically in Yellowstone. Predation and weather appear to be the primary factors influencing production here. Lack of recruitment from outside the park is also of concern. Overall, in the greater Yellowstone area, the number of resident swans is low perhaps 300 to 400 year-round residents and in excess of 2,000 winter migrants, and each location occupied by swans has its own set of inherent problems.

Non-native swans (mute swans), especially those in the Paradise Valley of Montana (north of the park), are a potential threat to the trumpeters in Yellowstone. In cooperation with specific local landowners, mute swans on private lands are replaced with captive-raised trumpeter swans to reduce the threat of non-native birds.

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. In order to try to mitigate the effects of human interference, a floating nesting platform exists out 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 1998, there were nine nest attempts but only three cygnets were counted in the fall along with 20 adult birds.

3

Number in Yellowstone

- Natives—12
- 3 sport fish: cutthroat trout (3 races), Arctic grayling, mountain whitefish
- 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: brook trout, brown trout, lake trout, rainbow trout, lake chub

History

- Many waters in Yellowstone were fishless when the park was established.
- Stocking of native and non-native fish occurred for decades to accommodate the growing popularity of sport-fishing.
- Problems with stocking:

1) Changed the ecology of many Yellowstone waters, especially as non-native fish displaced or interbred with native species, diluting their genetic makeup.
2) Affected the quality of the fishing experience, because the abundance of fish attracted so many anglers that, even with continual restocking, the annual trout harvest could not be sustained.

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, Yellowstone's native trout had recovered under angling restrictions that still provide opportunities for visitors to catch wild fish in a natural setting, but discourage the killing of fish.
- Threats to the fisheries:

1) Three species at risk of extinction: fluvial Arctic grayling, upper Missouri morph of the westslope cutthroat trout, finespotted cutthroat trout.
2) Lake trout illegally introduced into Yellowstone Lake, creating a new threat to the Yellowstone cutthroat trout.
3) Whirling disease is now present in Yellowstone Lake, posing another threat to the native cutthroat.
4) New Zealand mud snail disturb fish populations and the natural functioning of the ecosystems.

More than 220 lakes comprise approximately 107,000 surface acres in Yellowstone—94 percent of which can be attributed to Yellowstone, Shoshone, Lewis, and Heart lakes. Some 1,000 streams make up more than 2,650 miles of running water. When explorers first visited the park, about 17 lakes contained endemic fish populations and 135 were barren. It is believed that about 40 percent of all waters in Yellowstone were barren when the area was made a national park, including the upper Firehole River, Shoshone Lake, and Lewis Lake. Early in the park's history fish were transplanted into new locations, intensively managed at hatcheries, and non-native species introduced. Between 1881 and 1980, more than 310 million fish were stocked in Yellowstone. Today, about 40 lakes have fish populations; the remainder were either not planted or have restored themselves to an original barren condition.

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. Thus, Yellowstone contains one of the most significant, near-pristine aquatic ecosystems found in the United States. Predators on fish include threatened grizzly bears, endangered bald eagles, black bears, otters, mink, ospreys, pelicans, loons, grebes, mergansers, diving ducks, terns, gulls, kingfishers, and herons.

There are 12 species of fish native to the park, including Arctic grayling, westslope and Yellowstone cutthroat trout, mountain whitefish, three species of suckers (Utah, longnose, and mountain), four species of minnows (longnose dace, speckled dace, redside shiner, and Utah chub), a hybrid minnow (redside shiner/speckled dace), and the mottled sculpin. Their ranges and densities have been substantially altered during the past century due to exploitation, introduction of exotic species, and natural factors. Non-native species in the park include rainbow trout, brown trout, brook trout, lake trout, and lake chub. All non-native trout have become very important to the angler experience.

The history of fisheries management in Yellowstone began in the 1880s when non-native fishes were introduced into fishless waters (1881-1909). This period was followed by "put, grow, and take" practices for both native and non-native species (1920-1955). After 1955, the emphasis was on restoration and preservation of native species, subspecies, and genotypes, and there were major revisions in fisheries regulations and management. For about 30 years until 1996, the U.S. Fish and Wildlife Service maintained an office and staff in the park for the purpose of providing assistance with aquatic research and monitoring programs. For many years, the objectives of fisheries management in the park have been 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.

About three million visitors come to Yellowstone each year; approximately 17 percent of these visitors are anglers. Although about 100 waters are commonly fished, 96 percent of the angling is concentrated on 9 waters. Angling is an obvious anomaly in a park where the primary purpose is to preserve natural environments and native species in ways that maintain natural conditions. As in many other parks, it is often pointed out that consumptive use of the fishery resource contradicts policies that prevent harvest of other animals, trees, or minerals. Yet fishing has been a major visitor activity here for more than 100 years. Fly 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 obviously a popular activity even for non-anglers. Park staff monitored non-consumptive use of aquatic resources for about a decade (ending in 1992) at Fishing Bridge and LeHardy Rapids. The total number of visitors each year to LeHardy 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.

Cutthroat Trout

The cutthroat trout *(Salmo clarki)* is a relative of the salmon. Indeed, the flesh of the cutthroat is a pinkish-orange color. The fish is native to the Rocky Mountains, and, in Yellowstone, it occurs as three subspecies: the Yellowstone cutthroat, the Snake River cutthroat, and the westslope cutthroat

(see section below for details about this subspecies). The difference between the first two subspecies is in the size and number of the black spots on the fish. The Yellowstone cutthroat originally occurred in the Yellowstone, Madison, and Gallatin river drainages, but has since been planted in the southern part of the park. The Snake River cutthroat is limited to the Snake River drainage in the southern third of the park.

While the cutthroat 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 at Two Ocean Pass (just south of the park in the Teton Wilderness Area). 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 Ocean to the Atlantic Ocean via the Snake and Yellowstone rivers. Two Ocean Pass was discovered (probably) by Jim Bridger around 1830. lt was widely considered just a fable until it was rediscovered in 1873 by Captain W.A. Jones.

Cutthroat trout are abundant in Yellowstone Lake, and, for many years, intensive monitoring and research studies of the fish have been done on Yellowstone Lake. In the 1960s, it was determined that angler harvest was excessive and was having a negative impact on 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 taken from Yellowstone Lake weighs one pound and is about 14 inches long.

Cutthroats 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. Yellowstone Lake and Yellowstone River together contain the largest population of native cutthroat trout in this hemisphere. The recent discovery of the illegally introduced lake trout in Yellowstone Lake now poses a significant threat not only to the future of the cutthroat trout population, but also to the bird and mammal species that depend on cutthroats as a food resource.

Westslope Cutthroat Trout

Westlope cutthroat trout *(Salmo clarki lewisi)* were historically distributed throughout the Madison and Gallatin river drainages, but have since been reduced to small headwater populations as a result of habitat loss, overfishing, and competition from non-native fish. In an attempt to re-establish westslope cutthroat trout populations, candidate streams within their historic range were surveyed. Among those sites selected as potentially viable was Canyon Creek, a tributary of the Gibbon River that enters approximately 1/2 mile below Gibbon Falls.

Initial work began in July 1997 and focused on the removal of non-native fish from Canyon Creek through electrofishing methods. Introduced non-natives appear to be most responsible for the decline in range of westslope cutthroats as other factors such as habitat loss and pollution appear negligible in the park. From mid-July through October, approximately 5,000 brown, brook, and rainbow trout were removed from Canyon Creek and placed in the Gibbon River drainage. Additionally, 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 attempted to ascend over the barrier, none were successful.

As part of the restoration program, park staff are also searching for genetically pure populations of westslope cutthroat trout that remain within park boundaries. The presence of non-native fish (namely rainbow trout) and transplanted Yellowstone cutthroat trout have resulted in interbreeding of the three species and in the isolation of populations of unknown genetic structure. Fish surveys were conducted in small headwater streams in the northwestern portion of the park, including Fan, Specimen, and Grayling creeks. Tissue samples will be used for DNAanalysis to identify genetically pure or hybrid individuals. If a genetically pure population is identified, information will be gathered to determine if those populations are a viable source of fish for current and future restoration efforts within the park.

Arctic Grayling

The fluvial (riverine) Arctic grayling *(Thymallus arcticus)* is a rare and protected species in the

park. In 1993, the park began a cooperative program with the state of Montana to restore fluvial grayling to park waters by releasing 800 young fish. This restoration effort continued in 1994 and 1995, but has not been successful due to low over-winter survival, probably a result of poor quality habitat. Other ways to try to restore fluvial grayling in the upper Gallatin River drainage are being discussed.

Problems

Lake Trout. In July 1994, non-native lake trout were discovered in Yellowstone Lake. Despite the extensive human influence on the Yellowstone Lake fishery during the past century, the native cutthroat trout population had never before been threatened by a larger predatory fish. Because of their size and voracious nature, lake trout, if left unchecked, could easily decimate the cutthroat trout population in Yellowstone Lake. Lake trout also threaten to disrupt the lake ecosystem because they are deep water spawners and spend much more of their life in deeper waters out of reach of the ecosystem predators that depend on cutthroat trout. Please see Chapter 8 for more information.

The New Zealand mud snail (native to New Zealand) was discovered in park waters in 1995. At present, the tiny (< inch), black, conical-shaped snail occurs in the Firehole, Gibbon, Madison, and Snake rivers, sometimes in extremely high numbers. The mud snail often 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.

Whirling disease is a parasitic infection of fish caused by a microscopic protozoan that destroys the cartilage of juvenile trout, causing them to swim in a whirling pattern (as if chasing their tail) when startled. Seriously infected fish have a reduced ability to feed or escape from predators, and mortality is high. Please see Chapter 8 for more information.

The zebra mussel poses another potential threat. It was first discovered in the United States in 1988. It is not now known to be in Yellowstone, but has been found in 18 states and 2 Canadian provinces. This jelly bean-sized animal is moving up the Missouri River drainages and may hitchhike on dirty boat hulls.

Fishing in Yellowstone National Park

In national parks where native plants and animals and natural environments are protected, there has been discussion of prohibiting fishing. Because fishing in Yellowstone is historically entrenched (since 1870) and not easily eliminated, it is allowed under strict regulations. These regulations are designed to allow ecological processes to function without interference from humans and to preserve fish populations first for the birds and animals that depend on them. Fish-eating birds (for example, pelicans, osprey, bald eagles, kingfishers, mergansers, gulls, terns, herons) on Yellowstone Lake consume approximately 200,000 pounds of fish each year. Other creatures that eat fish include river otter, mink, and bear.

Prior to 1994, a non-fee permit was required to fish in Yellowstone. Since 1994, a special-use permit is required to fish. A7-day permit currently costs $10 for anglers aged 16 and over, or anglers can purchase a season permit for $20. Anglers 12 to 15 years of age must still obtain a non-fee permit, and those anglers under the age of 12 may fish without a permit when accompanied by an adult with a permit. The revenue generated from the fishing fees remains in Yellowstone to support the park's fisheries program.

Regulations are generally species-specific, however, they vary from lake to lake, creek to creek, and river to river. Certain waters may be closed to protect rare or endangered species, nesting birds, or to provide vistas for viewing scenic landscapes and undisturbed wildlife. Some waters are catch-and-release fishing only while other areas have size limits and/or fish type or creel limits or gear restrictions (such as fly-fishing only). Bait fishing is strictly prohibited (except that children under 12 may fish with worms in some areas) and only fly fishing or lure fishing is allowed. Bait

fishing is prohibited in the park to prevent the introduction of non-native fish into park waters, to prevent overharvest, and because hooking mortality studies have shown an increased risk of death to fish caught with bait. Fishing is allowed only during certain seasons (usually late May through October).

In 1994, the National Park Service implemented a lead-free fishing program in Yellowstone. Fishing tackle such as leaded split-shot sinkers, weighted jigs, and soft weighted ribbon for nymph fishing are no longer permitted. This new policy was instituted in order to remove lead from the aquatic environment. Lead is known to cause poisoning in waterfowl when ingested.

Fish Species Changes in Yellowstone Waters

Because of the fish stocking activities that occurred in the park in its early years, native and non-native fish now live in waters that were once barren. In most cases, the non-native fish cannot be removed by any known or feasible method. Park policy today manages these fisheries while promoting native species recovery, where possible.

Historically, Yellowstone Lake was populated by only Yellowstone cutthroat trout and longnose dace. Today, these two species are still present, and the longnose sucker, lake chub, redside shiner, and the illegally introduced lake trout also live in the lake's waters.

The Firehole River is famous for its world-class fishery. Historically, though, the river was fishless because of waterfalls blocking fish movement upstream. Today, anglers can fish for rainbow trout, brown trout, Yellowstone cutthroat trout, and brook 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, 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. Early fisheries managers added lake trout to Heart Lake.

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 added to the drainage.

Reptiles and Amphibians

Number in Yellowstone

- Cool, dry conditions limit Yellowstone's reptiles to six species and amphibians to four species.
- Reptiles: prairie rattlesnake, bull snake, common garter snake, wandering garter snake, rubber boa, sagebrush lizard.
- Amphibians: boreal toad, chorus frog, spotted frog, tiger salamander.

Status

- None listed as threatened or endangered.
- 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.

Visitors to Yellowstone often see the larger animals of the park—bison, elk, mule deer, moose and bears. But Yellowstone is also a home for many other animals, including a small variety of snakes and amphibians. There are six species of reptiles found in Yellowstone (prairie rattlesnake, bullsnake, common garter snake, wandering garter snake, rubber boa, and sagebrush lizard) and four species of amphibians (boreal toad, chorus frog, spotted frog, and tiger salamander). Cool and dry conditions are likely responsible for the relatively low number of reptiles and amphibians 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. The relatively undisturbed nature of the park and our 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, and/or predation.

Although there are no Yellowstone reptile or amphibian species currently listed as threatened or endangered, several—including the spotted frog—are thought to be declining in the West. Reptiles live on land and have scaly, dry skin. Amphibians have moist glandular skins, lack claws, and lay their eggs in water. The young must pass through a larval stage before changing into adults. Amphibious means "living a double life," and salamanders, toads, and frogs indeed do that, living in water as larvae and near water for the rest of their lives.

Wandering Garter Snake

The most common reptile in the park is the wandering garter snake. It is usually found near water in all areas of the park; it can range from 18 to 30 inches in length; and it may be brown, brownish green, or grey. It usually has a well-defined light stripe down its back. The garter snake eats fish, frogs, tadpoles, salamanders, earthworms, slugs, and leeches. When threatened, a garter snake may discharge musk from glands at the base of the tail, resulting in an unpleasant, sweet odor. These snakes give birth to as many as 20 live young during mid-summer.

Bullsnake

Yellowstone's largest reptile is the bullsnake, ranging from 50 to 72 inches long. Bullsnakes prefer lower altitudes; drier, warmer climates; and open areas, which accounts for their being found mostly near Mammoth within the park. This yellowish snake is marked with a series of black,

brown, or reddish-brown blotches down the back; the darkest, most contrasting colors are near the head and tail. A bullsnake's head resembles a turtle's in shape, with a dark band extending from the top of the head through the eye to the lower jaw. The bullsnake is sometimes called a gopher snake because it lives in burrows and its favorite food is small rodents. When disturbed, a bullsnake will coil up, hiss loudly, and vibrate its tail against the ground, producing a "rattling" sound. This behavior causes people to think that it is a rattlesnake, and the bullsnake is often killed for this reason. This is unfortunate because these reptiles are especially effective in controlling rodents.

Rubber Boa

The rubber boa is the least common of all snakes in the park. It is one of two species of snakes in the United States that is related to tropical boa constrictors and pythons. Adult rubber boas reach a maximum of two feet in length. The snake's back is uniformly grey or greenish-brown, and its belly is lemon yellow. Its scales are small and smooth, making this snake almost velvety to the touch. The rubber boa is a secretive animal, and very little is known about its life history. It is believed that the snake spends a great deal of time partially buried under leaves and soil in heavily wooded areas around the Lower Geyser Basin. Rodents make up most of its diet.

Prairie Rattlesnake

The only venomous snake in the park is the prairie rattlesnake. It is found in the Reese Creek, Stephens Creek, and Rattlesnake Butte areas of northern Yellowstone where the habitat is drier and warmer than elsewhere in the park. It is a blotched rattlesnake that ranges from 35 to 45 inches in length. Colors may vary from greenish grey to olive green, greenish brown, light brown, or yellowish. The dark brown splotches down its back are bordered in white. This snake is supposed to live in harmony with rodents and burrowing owls, but these animals also make good meals for the snake.

Blotched Tiger Salamander

The only species of salamander known to live in Yellowstone is the blotched tiger salamander. Adults reach a maximum length of seven to eight inches. This salamander's head is broad and dark olive in color with irregular dark spots. The back and tail are black with olive-green to yellow-green blotches. The belly is a dull lemon yellow with irregular black spots. In Yellowstone, the salamander's distribution depends on the presence of adequate water and favorable temperatures between 60 and 75 degrees Fahrenheit; in the Lamar Valley, several sizable populations exist. In late April and early May, the adult salamanders come out from hibernation and migrate in large numbers to breeding ponds where they lay their eggs. They then return to their moist homes under rocks and logs.

Strictly carnivorous, salamanders feed on adult insects, insect nymphs and larvae, small aquatic invertebrates, and frogs, tadpoles, and small snakes. They are in turn preyed upon by snakes and some birds (like sandhill cranes). Commonly, these harmless creatures are found in cellars in the winter. Many people incorrectly believe they are poisonous and kill them needlessly.

Boreal Toad

Another of Yellowstone's amphibians is the boreal toad, the most common toad in the park. Adults reach a body length of 2-1/4 to 5 inches and are brown, grey, or olive green with irregular black spots. They always have a white or cream colored stripe down the back. Toads can easily be distinguished from frogs by their warty bodies, thick waists, and prominent glands behind their eyes. These toads can be found at elevations of more than 8,000 feet when water is adequate but are more often found at lower elevations. Though adults can tolerate dry conditions for some time, their eggs must be laid in water. As tadpoles, these animals eat aquatic plants. In contrast, the adult toad eats insects, worms, and small invertebrates. Toads are usually most active at night and can be commonly found throughout the park. Acommon misconception about toads is that handling them causes warts. Atoad does secrete irritating fluids from glands on its back as a defense against predators, but this fluid does not affect the hands of people. Despite this protection, many toads are eaten by snakes and large wading birds.

Spotted Frog

Because of its size and abundance, the spotted frog is probably the best known amphibian in Yellowstone. It can be found all summer in cold rivers, streams, smaller lakes, marshes, ponds, and rain pools. Adults reach a maximum length of 3-1/2 inches. The upper surface of the body is greyish-brown to dark olive or even green with irregular black spots. The underside is white splashed with brilliant orange on the thighs and arms. (Young frogs do not usually show this.) Breeding begins in late spring or early summer depending on temperatures. The eggs are laid on the surface of the breeding ponds in compact jelly-like masses and hatch after a few weeks. The tadpoles mature and change into adults between July and September. Like toad tadpoles, spotted frog tadpoles feed strictly on aquatic plants, and the adults eat insects, aquatic invertebrates, and sometimes tadpoles. In the winter, the spotted frog, like all amphibians, burrows into moist mud that won't freeze and doesn't come up for air until spring. They can do this because they are able to absorb oxygen from the water directly through their skin.

Western Chorus Frog

The western chorus frog is another common amphibian in Yellowstone, but due to its small size and secretive habits, people rarely see it. The adults may range in size from 1 to 1-1/2 inches in length, and females are usually larger than males. Chorus frogs are small, slender creatures that are brown, olive, or green with a prominent black stripe from the nostril through the eye and over the arm. They also have three dark stripes down the back. These frogs may be found in grassy pools, lakes, and marshes. They usually breed in shallow temporary pools during the late spring. You can easily find them by following their calls, which resemble the sound of a thumb running along the teeth of a comb. The chorus frog lays its eggs in loose irregular clusters attached to submerged vegetation in quiet water. The eggs hatch in about two weeks, and the tiny tadpoles mature within 40 to 50 days. The chorus frog's food preferences are similar to the spotted frog's. Western spotted frogs, garter snakes, and wading birds are the chorus frog's natural enemies.

Suggested Reading—Wildlife

General

Burt, W.H. and R.P. Grossenheimer-illus. *A Field Guide to the Mammals.* Houghton Mifflin, Boston, MA. 1964.

Craighead, Karen. Large *Mammals of Yellowstone and Grand Teton National Parks.* Yellowstone Association for Natural Science, History, and Education, Yellowstone NP, WY. 1991.

Despain, Don, et al. *Wildlife in Transition: Man and Nature on Yellowstone's Northern Range.* Roberts Rinehart Publishers, Boulder, CO. 1986.

Harry, Bryan and Willard E. Dilley. *Wildlife of Yellowstone and Teton National Parks.* Wheelwright Lithographing Co., Salt Lake City, UT. 1972.

Wolves

Bass, Rick. *The Ninemile Wolves.* Clark City Press, Livingston, MT. 1992.

Ferguson, Gary. *The Yellowstone Wolves: The First Year.* Falcon Press, Helena, MT. 1996.

Fischer, Hank. *Wolf Wars.* Falcon Press, Helena, MT. 1995.

Halfpenny, James C. and Diann Thompson. *Discovering Yellowstone Wolves: Watcher's Guide.* A Naturalist's World, Gardiner, MT. 1996.

Lopez, Barry. *Of Wolves and Men.* Scribners, New York, NY. 1978.

Mech, L. David. *The Wolf: The Ecology and Behavior of an Endangered Species.* University of Minnesota Press, Minneapolis. 1981.

McIntyre, Rick. *A Society of Wolves: National Parks and the Battle over the Wolf.* Voyageur Press, Stillwater, MN. 1993.

McIntyre, Rick, ed. *War against the Wolf: America's Campaign to Exterminate the Wolf.* Voyageur Press, Stillwater, MN. 1995.

McNamee, Thomas. *The Return of the Wolf to Yellowstone.* Henry Holt and Company, New York, NY. 1997.

Phillips, Michael K. and Douglas W. Smith. *The Wolves of Yellowstone.* Voyageur Press, Stillwater, MN. 1996.

Schullery, Paul, ed. *The Yellowstone Wolf: A Guide and Sourcebook*. High Plains Publishing Co., Worland, WY. 1996.

U.S. Fish and Wildlife Service. *Final Environmental Impact Statement: The Reintroduction of Gray Wolves to Yellowstone National Park and Central Idaho.* 1994.

Varley, John D. and Paul Schullery. *Wolves for Yellowstone? A Report to the United States Congress.* 1992.

Bears

Biel, Mark. "Potential Interactions between Black Bears, Grizzly Bears, and Gray Wolves in Yellowstone National Park." *Bear Management Office Information Paper* June 1995: Number BMO-9.

Cole, G. F. "Management Involving Grizzly Bears and Humans in Yellowstone National Park, 1970-1973." *BioScience* 1974: Volume 24, Number 6.

Craighead Jr., Frank C. *Track of the Grizzly.* Sierra Club Books, San Francisco, CA. 1979.

Gunther, Kerry. "Grizzly Bears and Cutthroat Trout: Potential Impact of the Introduction of Non-native Trout to Yellowstone Lake." *Bear Management Office Information Paper.* May 1995: Number BMO-9.

Gunther, Kerry. "Yellowstone National Park Bear Management Summary," 1996.

Gunther, Kerry and Roy Renkin. "Grizzly Bear Predation on Elk Calves and other Fauna of Yellowstone National Park." *International Conference Bear Research and Management* 8:329-334. 1990.

Harting, A.L. *Relationships Between Activity Patterns and Foraging Strategies of Yellowstone Grizzly Bears.* M.S. Thesis, Montana State University. 1985.

Herrero, Steven. "AComparison of Some Features of the Evolution, Ecology, and Behavior of Black and Grizzly/Brown Bears." *Carnivore* 1978: Volume 1, Number 1.

Kieter, Robert B. "Observations on the Future Debate over 'Delisting'the Grizzly Bear in the Greater Yellowstone Ecosystem." *The Environmental Professional* 1991: Volume 13.

Knight, Richard, D. Mattson, and B.M. Blanchard. "Movements and Habitat use of the Yellowstone Grizzly Bear." NPS Unpublished Report, 1984.

Mack, J.A. *Ecology of Black Bears on the Beartooth face, South Central Montana.* M.S. Thesis, Montana State University. 1988.

Schleyer, B.O. *Activity Patterns of Grizzly Bears in the Yellowstone Ecosystem and their Reproductive Behavior, Predation, and the use of Carrion.* M.S. Thesis, Montana State University. 1983.

Schullery, Paul. *The Bears of Yellowstone.* Roberts Rinehart Publishers, Boulder, CO. 1986.

Schullery, Paul. "Yellowstone Grizzlies: The New Breed." *National Parks* November/December 1989.

Bison

Dary David. *The Buffalo Book: The Full Saga of an American Animal.* Sage Books, Chicago, IL. 1974.

McHugh, Tom with Victoria Hobson. *The Time of the Buffalo*. University of Nebraska Press, Lincoln. 1972.

Price, David and Paul Schullery. "The Bison of Yellowstone and the Challenge of Conservation." *Bison World*, November/December 1993.

Meagher, Mary. "The Bison of Yellowstone National Park." National Park Service, Scientific Monograph Series No. 1. 1973.

Sample, Michael. *The Bison: Symbol of the American West.* Falcon Press, Billings, MT. 1987.

Elk

Boyce, M.S. "Natural Regulation or the Control of Nature?" *The Greater Yellowstone Ecosystem: Balancing People and Nature on America's Wildlands.* Eds. R.B. Kieter and M.S. Boyce. Yale University Press, New Haven, CT. 1990.

Cole, G.F. *The Elk of Grand Teton and Southern Yellowstone National Parks.* Yellowstone Library and Museum Association, Yellowstone NP, WY. 1969.

Evanoff, R. and F.J. Singer, eds. *Effects of Grazing by Wild Ungulates in Yellowstone National Park. National Park Service*, Natural Resource Program Center, Natural Resource Information Division, Denver, CO. 1996.

Houston, D.B. *The Northern Yellowstone Elk: Ecology and Management.* Macmillan Publishing Co., New York, NY. 1982.

Murie, Olaus J. *The Elk of North America.* Stackpole Co., Harrisburg, PA. 1957.

Singer, F.J. and N.A. Bishop. *Ungulate Grazing Effects on Yellowstone's Northern Winter Range—A Provisional Digest.* National Park Service. 1991.

Thomas, Jack Ward, and Dale E. Toweill, eds. *Elk of North America.* Stackpole Books, Harrisburg, PA. 1982.

Yellowstone National Park. *Northern Yellowstone Elk: Complexity and Change in Wildland Ecosystems.* AReport to the Director, Yellowstone National Park, 1997.

Moose

Houston, Douglas B. "The Shiras Moose in Jackson Hole, Wyoming." *Technical Bulletin No. 1.* Grand Teton Natural History Association. 1968

Houston, Douglas B. *Aspects of the Social Organizations of Moose.* National Park Service, Paper No. 37.

Tyres, Dan. "Winter Ecology of Moose on the Northern Yellowstone Winter Range." Yellowstone National Park, 1995. On file at the Yellowstone Center for Resources.

Mountain Lion

Hornocker, Maurice G., K. Murphy, and G. Felzien *The Ecology of the Mountain Lion in Yellowstone National Park.* Investigators Annual Report, Yellowstone National Park. 1995.

Murphy, Kerry, G. Felzien, and S. Relyea. *Ecology of the Mountain Lion in Yellowstone. Cumulative* Progress Report No. 5, Yellowstone National Park. 1992.

Murphy, Kerry, G. Felzien, and S. Relyea. *Predation dynamics of Mountain Lions in the Northern Yellowstone Ecosystem.* Progress Report, Yellowstone National Park. 1993.

Beaver

Murphy, S.L. Consolo and D.D. Hanson. "Current Distribution of Beaver in Yellowstone National Park." *Wolves for Yellowstone. A Report to the United States Congress*, National Park Service, Washington D.C. 1991.

Murphy, S.L. Consolo and Robb B. Tatum. "Distribution of Beaver in Yellowstone National Park." 1994.

Rue, Leonard Lee. *The World of the Beaver.* Lipponcott, New York, NY. 1964.

Birds

Follett, Dick. *Birds of Yellowstone and Grand Teton National Parks.* Roberts Rinehart Publishers, Boulder, CO.

Hansen, Skylar. *The Trumpeter Swan--A White Perfection.* Northland Press, Flagstaff, AZ. 1984.

Harmata, Al. "Yellowstone's Bald Eagles," in *Yellowstone Science,* Vol. 2, No. 3. 1994.

Maj, Mary. *Status of Trumpeter Swans in Yellowstone Park*. Information Paper #38, National Park Service. 1981.

McEneaney, Terry. *Birds of Yellowstone: A Practical Habitat Guide to the Birds of Yellowstone National Park,* and Where to Find Them. Roberts Rinehart Publishers, Boulder, CO. 1988.

McEneaney, Terry. "1998 Yellowstone Bird Report." Yellowstone National Park.

McEneaney, Terry, Bill Herwick, and Bob Oakleaf. "Greater Yellowstone Peregrine Falcons: Their Trials, Tribulations, and Triumphs," in *Yellowstone Science,* Vol.6, No.2. 1998.

Peterson, Roger Tory. *A Field Guide to Western Birds.* Houghton Mifflin Co., Boston, MA. 1990.

Skinner, M.P. "The Birds of Yellowstone National Park." *Roosevelt Wildlife Bulletin* Vol. 3, No. 1, Feb 1925. Roosevelt Wild Life Forest Experiment Station of the New York State College of Forestry at Syracuse University.

Fishes

Sharpe, Phillip F. *Yellowstone Fish and Fishing.* Fish color plates by Daniel Feaser. Yellowstone Library and Museum Association, Yellowstone NP, WY. 1970.

Simon, James R. *Yellowstone Fishes.* The Yellowstone Library and Museum Association, Yellowstone NP, WY. 1962.

Varley, John and Paul Schullery. *Freshwater Wilderness.* Michael Simon, illus. Yellowstone Library and Museum Association, Yellowstone NP, WY. 1983.

Reptiles and Amphibians

Koch, Edward D and Charles R. Peterson. *Amphibians and Reptiles of Yellowstone and Grand Teton National Parks.* University of Utah Press, Salt Lake City. 1995.

Major Vegetation Zones

Douglas-fir

- Dominant species: Douglas fir is dominant forest type in zone dominated by big sagebrush and grasses.
- Elevation: 6,000–7,600 feet, primarily in valleys of Lamar and Yellowstone rivers

Lodgepole pine

- Dominant species: lodgepole pines
- Forest stage: climax
- Elevation: 7,600–8,400 feet

Spruce-fir

- Dominant species: spruce-fir
- Forest stage: young to mature
- Elevation: above 8,400 feet

Smaller Zones
Great Basin or Cold Desert, near Gardiner, Montana
Alpine tundra, above 10,000 feet

The park can be divided into three major vegetation zones: the spruce-fir, the lodgepole pine, and the Douglas-fir. Two smaller zones are also present: a small area near Gardiner, Montana, supports the Great Basin, or Cold Desert, vegetation zone and the alpine tundra zone exists in areas above 10,000 feet.

There are two main forces determining the zones of vegetation in the park: precipitation and bedrock. Precipitation is closely related to elevation, and most precipitation comes in the form of snow. Thus, precipitation is held on top of the soil for much of the year and then released in a short period during the spring and early summer. The region of the park receiving the highest rainfall is the southwestern corner. This area is the first topographic rise that air masses from the west reach.

The two major types of bedrock found in Yellowstone—the Absaroka volcanics and the Yellowstone volcanics (rhyolites)—differ in their mineral content, especially in the amount of calcium that they contain. Absaroka volcanics contain between two and eight times more calcium than Yellowstone rhyolites. Rhyolites are also low in other minerals essential to plant growth. This is the main factor that accounts for the character of the vegetation and the vegetation zones. Glacial activity has blurred the boundaries between various bedrocks and caused deposits of one type to be well within the boundaries of another. Peculiarities in the moisture content of an area that are the result of glaciated terrain may also cause departures from zonal vegetation.

The spruce-fir zone is dominated by spruce-fir forests in successionally young to mature stages. The young stands are characterized by relatively fast growing lodgepole pine, with a good representation of both spruce and fir, especially in the understory. The overstory of the mature spruce-fir stands can be dominated by either spruce or fir or be a fairly even mixture of the two. Whitebark pine may also be a major component of this zone, it may even be the dominant tree species, especially near timberline. The spruce-fir zone lies above 8,400 feet and is either underlain by Tertiary andesitic bedrock (Absaroka volcanics) or receives more than 40 inches of precipitation each year, or both.

The lodgepole pine zone is dominated by climax lodgepole pine or earlier seral stages with very little or no spruce or fir in the understory. The lodgepole pine is slow growing and may reach 300 years of age or more. At older ages, the tree can have a dbh (diameter at breast height) of 12 to 20 inches. Whitebark pine may also be present in both overstory and understory. Areas that have a

more favorable moisture regime (such as pond margins, drainage ways, and north-facing slopes) may have good spruce-fir stands. The lodgepole pine zone lies between 7,600 and 8,400 feet, receives 20 to 40 inches of precipitation annually, and is underlain mostly by Quaternary rhyolite flows (Yellowstone volcanics).

The Douglas-fir zone can also be called the sagebrush zone. Douglas-fir is the dominant forest type within the zone, but more area is covered by big sagebrush and various grasses than by forest. The forest is characterized by very large, fire-scarred, well scattered trees with an understory of smaller Douglas-fir. The density of these smaller trees can range from scattered to dense. Aspen stands are also common in this zone. Individual spruce and fir trees can be found along streams, and stands of lodgepole pine can be found occasionally. The form of these forests may have changed from their original state because of effective fire suppression efforts. This zone lies between 6,000 and 7,600 feet along the Yellowstone and Lamar river valleys. Less than 20 inches of rain fall here each year. The zone is underlain by various thicknesses of glacial till derived from the granites and Absaroka volcanics upstream. There are occasional outcrops of limestone in the valley, which may add calcium to the till. The bedrock is predominantly Quaternary sediments and granite.

Asmall area near Gardiner, Montana, along the northern boundary of the park, has a vegetation type similar to that found throughout the Great Basin. Saltbush, greasewood, winterfat, blue gramma, and other such species predominate. The area usually receives less than 15 inches of precipitation annually, and the heavy soils are derived from shales.

Areas above 10,000 feet support an alpine tundra. Moss campion, mountain avens, native dandelions, and other alpine plants are found in these small islands throughout the park.

Hayden Valley and Pelican Valley, two large treeless areas, are well covered with grassland species. Both areas are lake beds from the Ice Age and are covered by thick deposits of lake sediment. This probably accounts for the treeless condition.

Trees

Conifers

- Lodgepole pine
- Limber pine
- Whitebark pine
- Englemann spruce
- Subalpine fir
- Douglas fir
- Rocky Mountain juniper
- Common junipe
- Very rare: white spruce and blue spruce

Deciduous

- Balsam cottonwood
- Narrowleaf cottonwood
- 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 deciduous populations is the subject of some debate. For more information, refer to “The Northern Range Controversy” article in this handbook.

There are ten conifers present in Yellowstone National Park; the white spruce and blue spruce are both quite rare in the park and are not discussed. Additionally, there is no ponderosa pine in either Yellowstone or Grand Teton national parks even though this tree is quite prevalent in the state of Montana.

The lodgepole pine *(Pinus contorta)* is by far the most common tree in Yellowstone; 80 percent of all trees in the park are lodgepole pines. Various Native American tribes used this tree to make the frames of their teepees or lodges, hence the name “lodgepole” pine. The lodgepole pine is a very straight tree that 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. Trees growing by themselves will often have branches all the way to the bottom because sunlight can reach the whole tree, but in the areas that are more dense, the trees will not have lower branches (making the trees look like telephone poles with Christmas trees on top).

The needles of lodgepole pine grow in groups of two, which are about two inches long. This is the only tree in Yellowstone with just two needles. The bark is pale yellow on any section of the tree that gets sufficient sunlight; elsewhere, the bark will appear dark. Agrayish-black fungus often grows on the shady parts of the bark, giving the tree a dark cast.

Most lodgepole pines have both male and female cones on them. 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 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). These serotinous cones ensure a ready seed source for establishment of new trees immediately after a fire. Seeds from trees that do not have serotinous cones (like Engelmann spruce, subalpine fir, and Douglas-fir) must be carried into recently burned areas from surrounding stands by wind, animals, or other agents.

Lodgepole pine seedlings grow very quickly in mineral soils that have been disturbed, either by a forest fire or by man (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 1 percent each year, consequently, it can take a century for a tree to rot away. Lodgepole pines can fall over quite easily in the slightest windstorm because they have no real taproot. Instead, the roots spread out sideways and do not extend very deeply into the ground. Because the soil in Yellowstone is very shallow (only about 6 to 12 inches deep), the lodgepole is perfectly suited to grow here.

The limber pine *(Pinus flexilis)* is a five-needled pine. It is seldom found in pure stands, and is more often growing in groups of a few individuals. It grows 25 to 50 feet high, and can be 200 to 300 years old at maturity. The bark is thin, light in color, and smooth. 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. In June, the tree is conspicuous because of its numerous reddish clusters of pollen-bearing cones. The 3- to 10-inch long cones are large and green in color.

Whitebark pine *(Pinus albicaulis)* also has five needles in each cluster, and it is almost indistinguishable from the limber pine except for its very characteristic purplish brown cones, which are 1-1/2 to 3-1/2 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 nutcrackers, and bears. The bark is whitish. Whitebark pine grow mainly at higher elevations (7,000 to 10,000 feet) and have a distorted branched appearance. The tree seldom grows more than 40 feet high and 3 feet in diameter.

Engelmann spruce *(Picea engelmannii)* has needles that are sharp and square and grow singly (characteristics of all spruces). This tree can grow very large (60 to 120 feet high) and be up to 3 feet in diameter; such trees can be 350 to 500 years old. Engelmann spruce prefers shade and are often seen growing under larger lodgepole pine trees. The tree grows slowly and has a shallow spreading root system. Spruce wood has the peculiar characteristic of "exploding" when a tree falls, and the wood fractures into cubes. This spruce is somewhat cylindrical in shape.

Subalpine fir *(Abies lasiocarpa)* is a true fir, meaning that its needles are blunt tipped (usually referred to as "friendly," since they will not stab you), 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 tree in Yellowstone that bears cones in this fashion, and it 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 this be used to distinguish the species. The tree usually grows 20 to 100 feet high and has a dbh of 1 to 2 feet. The bark is gray, often with lateral serrations and scars near the bottom because of browsing by moose and other ungulates. The tree has a very steeple-shaped crown at the top. 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 relieved colds, and chewed the tree gum to clear their throats. Subalpine firs grow in areas between 7,000 feet and timberline.

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 genus name Pseudotsuga which means "false hemlock." The thick bark of the Douglas-fir makes it well able 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.

Two **junipers** live in Yellowstone. Junipers belong to the Cypress family and are often called "cedars." Rocky Mountain juniper *(Juniperus scopulorum)* has needles that are scale-like or awl-shaped, grow in groups of 3, and are3/8–1/2 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 gnarled twisted trees in the Mammoth Hot Springs terrace area (just as you enter the Terrace Drive) are roughly 500 years old, and are believed to be the oldest living things in the park. The Rocky Mountain juniper is different from the common juniper (Juniperus communis) in that the former is a tree while the latter is a low, spreading shrub.

Few **deciduous trees** live in the park. There are a number of species of willow *(Salix spp.)* found in riparian areas along streams; all are quite shrubby in appearance. Quaking aspen *(Populus tremuloides*) is also in the willow family and has a very flexible stem that allows the leaves to quake and shiver in the slightest breeze, hence its name. The seeds of the aspen are scattered by wind, and the leaves may be lined with the marks of leaf-mining insects. The bases of larger trees are often roughened and black as a result of browsing by elk or other animals.

Balsam cottonwood *(Populus balsamifera)* is also in the willow family. It is the largest broad-leaved tree in the park. Some specimens reach a diameter of 3 feet. It has deeply furrowed gray bark that is quite thick, which is good protection from fire. It has large, broadly ovate leaves up to 5 inches in length that are fine-toothed at the margin, dark green on upper surfaces, and lighter underneath. The seeds have attached fluffy fibers that carry them long distances. Narrowleaf cottonwood *(Populus angustifolia)* differs from the black cottonwood in that it has narrow, lance-shaped leaves.

4

Unique Plants

As of March 2000 . . .

These plants occur ONLY in Yellowstone:

- Ross' bentgrass *Agrostis rossia*e is found in thermal areas
- Yellowstone sand verbena *Abronia ammophila* occurs along the shores of Yellowstone Lake

Ross' bentgrass only occurs on thermal ground in Yellowstone along the Firehole River and near Shoshone Lake. This grass is quite inconspicuous, but is one of the first species to green up in warm nooks and crannies of the geyserite. Ross'bentgrass can be green in January! This unique grass is an annual species, which is in full bloom in late May and early June. Reproductive culms (inflorescences) are sometimes present as early as February and March, but typically do not produce viable seed. Apparently, Ross'bentgrass is highly restricted to locations that provide the right combination of moisture and warmth, in other words "natural greenhouses." The temperature within an inch of the surface under a population of the grass is usually roughly 100 degrees Fahrenheit! As a result, as soon as the temperatures rise in the early summer, this grass dries out due to the heat from the summer sun above and the thermal heat beneath the plant. Ross'bentgrass is already dead and hard to find by July when most of the park's wildflowers are in full bloom.

There are other closely related species of grass that also occur in the geyser basins including tickle grass, Agrostis scabra, which is quite common all through the interior of the park. This species is much more frequently encountered in the geyser basins than Ross'bentgrass and looks quite similar. The diagnostic characteristic of Ross'bentgrass is that the panicle never completely opens up at anthesis (flowering time) and the overall short stature of the plant. Ross'bentgrass is rarely taller than six inches and is usually much shorter, typically about 2 to 3 inches.

Change is a basic feature of the thermal features, which suggests that 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'bentgrass deals with this problem efficiently. The seed dispersal mechanism has not been investigated, but probably one of the major methods of dispersal is on the muddy hooves of bison and elk. The favored locations of Ross' bentgrass are also locations that are habitual bedding areas for the wildlife during the winter. Some of these locations resemble a feedlot, with droppings all over the area.

There currently appear to be no known threats to the health of this species. The most dangerous possibility is the arrival of an exotic species that is capable of outcompeting this grass in its specialized habitat. Currently, there are several exotic species that are spreading aggressively throughout the thermal areas. Probably, it is only a matter of time before some exotic species begins to outcompete Ross'bentgrass. The actual distribution of Ross'bentgrass is not fully known as many of the backcountry thermal areas have never been searched for this grass.

Yellowstone Sand Verbena

Yellowstone sand verbena occurs along the shore of Yellowstone Lake. There has been a continuing debate among taxonomists about the relationship of this population of sand verbena to other populations. To date, the resolution of this problem has not occurred, though 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.

Sand verbenas are a member of the four o'clock family, which is primarily a tropical family of flowering plants. There are very few members of the family this far north, which makes the population of sand verbena at 7,700 feet along the shore of Yellowstone Lake a bit of an anomaly. There is very little information on the life history of this taxa. The plants were described as annuals in the only monograph that has examined this genus in recent years, though this particular species is a perennial. The plants are prostrate on the sand surface, and some individuals occur near warm ground, so the thermal activity in Yellowstone may be helping the survival of this species though that is merely conjecture at this time. The flowers are white and the plant is quite glandular making the foliage quite sticky. Apparently, the sand verbena flowers from roughly mid-July until killing frosts in late August or early September.

Exotic Plants

Number in Yellowstone

- Approximately 170 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 virtually all other species in an area

Management

- 1986, Exotic Vegetation Management Plan identified:

--the species that pose the most serious threats

--areas offering best prospects for successful control

- Control techniques:

--education of staff and visitors

--prevention of exotic plant establishment

--control by hand-pulling, mowing, and applying approved herbicides

- In 1998, more than 140 park staff and 100 volunteers assisted with native plant control, treating 33 species on more than 2,000 acres
- Species considered top priority: four species of knapweed in the park

Approximately 170 species of non-native plants are known to inhabit Yellowstone. This includes a few ornamentals in developed areas as well as a dozen or so species considered noxious by the adjacent states of Montana, Idaho, and Wyoming. Most exotic species in the park are found in disturbed frontcountry areas such as developments, road corridors, and thermal basins. Heightened awareness for backcountry infestations has resulted in the detection and/or treatment of a few isolated areas, but the full extent of the exotic plant situation is not fully surveyed or realized at this time.

Exotic plant species are a threat because they may displace native plant species and change the nature of vegetative communities, thus changing the available forage for grazers such as elk and bison. Because it is unrealistic to think about controlling 170 species, some of which have been well-established for decades, the park prepared an *Exotic Vegetation Management Plan* in 1986. The plan identified monitoring, control, and education efforts for species categorized by the seriousness of their threat and the likelihood that control could be effective.

Some of the most significant exotic plant species are dalmatian toadflax (Linaria dalmatica), spotted knapweed (Centaurea maculosa), Canada thistle (Cirsium arvense), ox-eye daisy (Leucanthemum vulgare), butter-and-eggs (Linaria vulgaris), St. Johnswort (Hypericum perforatum), houndstongue (Cynoglossum officinale), and sulphur cinquefoil (Potentilla recta). While there are many other exotics recorded in the park, most do not have as great a potential for widespread displacement of native plant communities as do these species.

Dalmatian toadflax was first seen in Yellowstone in 1947 and is prominent in northern portions of the park. Locally, 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 threatens to migrate into the park interior.

Spotted knapweed is a more recent invader of the park. It is a very 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 park wildlife. Aggressive con-

trol efforts target this species every year in order to prevent a catastrophic change in the vegetation of the park.

Canada thistle is found throughout the park and adjacent national forests, and has been part of the local flora for the past 100 years. Canada thistle has proliferated in burned areas since 1988 and is difficult to control.

Ox-eye daisy infestations were originally discovered in the Mammoth and Madison areas. Recent control efforts have substantially curtailed infestations in these two area, but continued monitoring and evaluation are necessary to ensure control efforts have been successful.

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, which has facilitated the spread of this species along animal corridors.

Leafy spurge poses another potential threat that has recently been found in the park. Although it has only been found in small infestations so far, because it has rhizomatous roots deep underground, it is extremely hard to control.

The park has made some progress in monitoring, mapping, and control of high priority target species using an Integrated Pest Management approach to managing exotic plant species. This means using a variety of techniques to control non-native plant species in national parks, including chemical, biological, sociological, and physical controls. The park also cooperates with adjacent state and county Weed Control Boards to share knowledge and technology related to exotic plant detection and control.

Fire

•Fire is a natural force in the Yellowstone ecosystem
–opens up closed-canopy forests to species that need sunlight
–re-seeds lodgepole pine seeds
--promotes plant decomposition
--halts advance of trees into grasslands
–controls spread of plant disease and insect infestations
–creates diverse habitats for wildlife
--increases rate of nutrient cycling on land and in water
• Vegetation is adapted to fire
• Some vegetation is dependent on fire.
Example: the lodgepole pine produces two types of cones; one that opens at maturity and a serotinous type that opens after it has been heated by fire.
• Large fires:
In the conifer forests of the Yellowstone plateau, average interval of 250–400 years
In the low-elevation grasslands, average interval of 25–60 years
• Lightning starts an average of 22 fires annually

Fire is a natural force that has been operating in the Yellowstone ecosystem since the beginning of time. Recent records (kept since 1931) show that an average of 22 fires are started each year by lightning. Fire scars on old Douglas-fir trees in the Lamar River valley indicate an average frequency of one fire every 25 to 60 years there. Other indicators of past fires are the even-aged stands of lodgepole pine throughout the park and charcoal in the soil, which occurs commonly.

The vegetation in the ecosystem has adapted to fire and, in some cases, may be dependent on it. Some plant communities are dependent on the removal of the climax forest overstory to allow them to establish. These are called pioneer communities because 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. However, these plants cannot exist forever under a forest canopy and are dependent on periodic fires to open the overstory.

Fire can prevent the invasion of trees into grassland areas. Micro-habitats suitable for tree seedling establishment are rare in a grassland community, but when a seed reaches these micro-habitats during a favorable year, a tree may become established. Once the tree is established and grows, it begins to influence the environment in the immediate vicinity. More tree habitat is created and a small island of forest is eventually created. These islands then coalesce, more grassland is converted to forest, and the process starts over. Periodic fire kills the small trees before they have a chance to become islands, thus maintaining an equilibrium between forest and 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 Lamar and Gardner rivers are probably remnants of these communities.

Lodgepole pine trees produce two types of cones: one that opens at maturity and a serotinous type that opens after it has been heated by a fire. The serotinous cones ensure a ready seed source for seedling establishment after a fire. Seeds from species without serotinous cones—such as Engelmann spruce, subalpine fir, or Douglas-fir—must be carried into the area from surrounding seed trees by wind, squirrels, or other agents.

Many lodgepole pine forests have shade-tolerant spruce and fir saplings growing in the understory. If fire is excluded long enough, these lodgepole pine forests will be replaced by spruce-fir forests. Even a climax lodgepole pine forest will change in character when fire is excluded. As trees that established immediately after the fire reach maturity and are thinned by disease or other natural agents, an understory of young lodgepoles begins to develop and the stand becomes quite diverse in age. The large expanses of even-aged lodgepole pine forests in Yellowstone are a good

example of how fire affects this forest community.

The spread of tree disease and the extent of individual forest fires are likely to be reduced when a natural fire regime prevails. Young stands are less susceptible to disease and fuel levels in them are lower. The probability of a disease or fire spreading through large areas is reduced when the area is broken into a mosaic pattern.

Mineral nutrients are very important to plants and often are limiting factors to growth. With the possible exception of nitrogen, the amount of nutrients available to a plant community is governed by what is available in the soil. The mineral nutrients of an ecosystem tend more to cycle within rather than to flow through the system. They go from the soil to the wood and leaves of the plants to the litter and back to the soil. Rainwater and weathering of minerals bring mineral elements into the system; water and animals remove them. Fire has a strong influence on the rates of some of these processes. Minerals tied up in litter and wood are released either slowly by micro-organisms or very rapidly by fire. Heat from fire may also be instrumental in hastening the weathering of soil minerals, allowing release of more mineral elements. Following a fire this abundant supply of soluble minerals is rapidly absorbed and increases plant growth. A large amount of nutrients are also removed from the system by runoff water or leaching. Grassland species have more mineral nutrients than pine forest species. Thus, leaching nutrients from forest communities may be a necessary mechanism for the maintenance of the forest ecosystem.

The extent to which fires are controlled determines the degree to which an ecosystem departs from natural conditions. Some of these departures are: more area is covered by unnatural climax communities; the natural diversity of a landscape is diminished; forest boundaries advance; the structure and composition of many communities change; open forests become closed; even-aged stands become uneven; fire-susceptible species gain an unnatural prominence; disease organisms are able to spread over greater areas; litter and deadfall accumulate to unnatural levels, which changes the mineral pool relationships; and soils change in organic matter and mineral content.

Suppression activity by man also produces unnatural results. Heavy equipment leaves behind unsightly scars, and modern retardants are fertilizers. These fertilizers produce some very unnatural plant responses, as well as find their way into streams and water courses. There have been reports of retardants causing eutrophication of some aquatic systems.

Natural events or changes in a wild area are neither good nor bad, beneficial nor detrimental. Human value systems may define these events, but the goal in national parks remains to find a balance between allowing nature to function without interference and using these natural areas. Research has shown that natural fire is necessary for the health of an ecosystem and that nature cannot always be controlled despite our best, most carefully planned management.

Fire Management

- 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 35,000 acres—mostly in 2 dry years, 1979 and 1981.
- See the next section, Fires of 1988, for information on management changes.

Naturally caused fires have occurred in the Yellowstone area for as long as there has been vegetation to burn. Fire, climate, erosion, and a vast assortment of life forms ranging from microbes to insects to mammals, including humans, have all played roles in the creation of the vegetative landscape of Yellowstone. During several thousand years of intermittent occupation of the Yellowstone area, Native Americans may have influenced the vegetation in many ways, such as setting fires (accidental or intentional), moving seeds, or influencing the numbers or movements of various plant-eating mammals. The arrival of Europeans heightened human influence on vegetation, primarily through suppression of fires that would have burned unimpeded in earlier times.

Virtually no effective fire fighting was done in the newly established park until 1886 when the U.S. Army was placed in charge of protecting the park. The Army, which did not leave 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. In those early days, fire suppression was most effective on the grasslands, shrub lands, and savannas of the park's northern range; fires were not allowed to burn freely on the grasslands and groves of the northern range for nearly a century. Throughout the rest of the park, which is largely covered by forest, reliable and consistent fire suppression had to wait until modern airborne firefighting techniques became available in the last 30 or 40 years.

Ecologists have known for many years that wildfire is essential to the evolution of a natural setting; when fires are suppressed, normal plant succession processes are stagnated, and biological diversity is reduced or altered. Research into Yellowstone's prehistory has shown that on the park's northern range fires occurred one to four times a century, while over the vast extent of the park's subalpine forests the fire interval was more typically 250 to 400 years.

On most public and private lands, maintaining wild processes is not as high a priority as other activities and permitting wildfires to burn may not be appropriate. But in natural areas such as Yellowstone, preserving a state of wildness is a primary goal of management. In 1972, Yellowstone was one of several national parks that initiated programs to allow some natural fires to run their courses. 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. In 1975, an environmental assessment (EA) was prepared on allowing fires to burn on about 1,700,000 acres in the park; the EAwas approved early in 1976, and 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 that naturally caused fires could burn across the boundary between the two federal units.

During the years since 1976, Yellowstone's fire management plan has been gradually revised and updated in accordance with National Park Service guidelines. In 1986, a new revision of the plan was completed and was in the final stages of approval in the spring of 1988. Under these plans, all park fires, whether human-caused or natural, were managed according to criteria in the fire man-

agement plan. Natural fires were continuously monitored, and tactics for monitoring and possible control were updated daily. Fires that threatened adjacent public or private lands and communities, park developments, or other significant resources, were suppressed with the same effort applied to fires on other public lands.

Yellowstone's fire management plan had four goals:

- To permit as many lightning-caused fires as possible 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.

By 1988, scientists had learned much about the occurrence and behavior of fire in the 16 years following the plan's approval. Tens of thousands of lightning strikes simply fizzled out with no acreage burned. While 140 lightning strikes produced fires, most burned only a small area. Eighty percent of the lightning starts in this period went out by themselves. During this 16-year period, 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). During these years, no human lives were lost, and there were no significant human injuries due to fires. No park structures or special features were affected.

The Fires of 1988

Why They Occurred

- Conditions occurred that were never before seen in the history of Yellowstone:
  extended drought
  high winds

Statistics

- 9 fires caused by humans
- 42 fires caused by lightning
- 36% of the park burned (793,880 acres)
- Fires begun outside of the park burned more than half of the total acreage
- About 400 large mammals, primarily elk, perished.
- $120 million spend fighting the fires
- 25,000 people employed in these efforts

Fighting the Fires

- Until July 21, naturally-caused fires allowed to burn.
- After that, all fires were fought, regardless of their cause.
- 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.
- Rrain and snow in finally stopped the advance of the fires.

After the Fires

- Enormous public controversy occurred.
- Several high-level task forces formed to review NPS fire policies.
  Their recommendations reaffirmed the importance of natural fire in an ecosystem
  They recommended additional guidelines be established to manage natural fire in Yellowstone.

Current Fire Management Policy

- suppress fires that humans caused or that threaten life and property
- Permit naturally-ignited fires to burn if 1) they do not threaten human life or property, and 2) if they meet certain conditions pertaining to fire behavior, weather, and the moisture content of the vegetation.
- Review each fire daily to ensure adequate suppression resources available if fire control becomes necessary.

The summer of 1988 was the driest on record in Yellowstone. While April precipitation was 155 percent of normal and May precipitation was 181 percent of normal (in Mammoth), practically no rain fell in June, July, or August, an event previously unrecorded in the park's 112-year written record of weather conditions. In early summer, about 20 lightning-caused fires had been allowed to burn. According to the fire plan, fires were evaluated on a case-by-case basis, each on its own situation and merits, before being allowed to burn. Eleven of these fires burned themselves out, behaving just like fires had in previous years.

But those fires that continued to burn into the extremely dry weeks of late June and July met dramatically changed situations. By late July, moisture content of grasses and small branches in the park reached levels as low as 2 or 3 percent while that of downed trees was measured at 7 percent (kiln-dried lumber is 12 percent). (At 8 to 12 percent, lightning will start lots of fires, many of which will burn freely. At 12 to 16 percent, some fires will burn up to 200 to 300 acres. At greater than 16 percent, there are still some starts, but few fires will burn any significant acreage; 24 percent is saturation, and fires do not start.) Aseries of unusually high winds, associated with dry fronts, fanned flames that even in the dry conditions would not have moved with great speed.

Yellowstone's weather pattern in 1988 was not typical of previous years. Typically, there would be below-average precipitation in winter, but summers would be abnormally wet, sometimes reaching 200 to 300 percent of normal rainfall in July. The statistics on summer rainfall are striking:

	Percent of Normal Rainfall				
	April	**May**	**June**	**July**	**August**
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

At the time, park managers and fire behavior specialists had no reason to expect that the past pattern would not continue. Six consecutive years of significantly above-average July rainfall suggested that July of 1988 would be similarly wet. But, by July 15, it was clear that recent weather patterns were not of use in predicting this summer's weather.

On July 15, the perimeter of fires in the park was about 8,600 acres. Because of the extreme conditions, after that day 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). After July 21, all fires were subjected to full suppression efforts as manpower would allow. (Human-caused fires had been vigorously suppressed from the beginning.) As of July 21, the perimeter of the fires in the park totaled less than 17,000 acres. 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, such as constructing fire lines along the edge of the advancing fires to create fuel breaks and backfiring to reduce fuel accumulations in front of advancing fires 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 cross such major topographic features as the Grand Canyon of the Yellowstone River. Fires routinely jumped traditionally recognized barriers like rivers and roads.

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.

Fire-fighting efforts were directed at controlling the flanks of fires and protecting lives and property in the advancing paths of the fires. The fire experts on site generally agreed that without help from the weather, in the form of rain or snow, there was no technology in existence that could stop the fires.

By the last week in September, about 50 lightning-caused fires had occurred in the park, 8 of which 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 of them. At the operation's peak, 9,000 firefighters (including Army and Marine units), more than 100 fire engines, and dozens of helicopters from many states participated in a huge, complex effort to control the fires and at least protect developments. The fire suppression efforts involved many different federal and state agencies, the largest such cooperative effort ever undertaken in the United States.

The Yellowstone area fires of 1988 received more national attention than any other event in the history of the parks. Unfortunately, many of the media reports were inaccurate or misleading. No topic has caused more confusion in the media and in the public mind than the actual extent of the fires. Confusion resulted from the fact that there were more fires in the region than just those in Yellowstone National Park, however, all of the fires were called the "Yellowstone Park fires." Many reports referred to these fires as part of the park's natural fire program, which was not true. Reports often contained oversimplification of events and exaggeration of burn acreages. In Yellowstone National Park itself, the fires affected 793,880 acres or 36 percent of the park's total acreage. These acres do not represent total devastation, but are part of the burn perimeter.

Anumber 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 and moved in. 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, which threatened Old Faithful, Madison, Canyon, Norris, West Yellowstone, Mammoth Hot Springs, and Tower-Roosevelt Lodge, was probably started by a woodcutter's cigarette in the Targhee National Forest and was the subject of immediate suppression efforts. 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 and was usually reported as a result of Yellowstone National Park's natural fire program.

Additional confusion resulted from continued media and public belief that managers in the Yellowstone area let park fires continue burning unchecked out of devotion to the natural fire plan—long after such fires were, in fact, being fought. All fires, no matter how they started, were fought after July 21. Public confusion was probably heightened by misunderstandings about just what the firefighting strategies were; if crews were observed letting a fire burn an area, it may have seemed to the casual observer that the burn was merely being monitored. In fact, in many instances, fire bosses recognized the hopelessness of stopping fires in certain situations 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 if they really want to, but the raw, unbridled power of these fires 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. Some media attention was given to restrictions routinely placed on firefighting techniques in the park and in surrounding wilderness areas. Contrary to media reports, bulldozers were used in the park when requested by the fire bosses, and fire engines were used regularly off roadways in fire suppression efforts.

Post-fire Response and Ecological Consequences of Fire

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, fire lines, trails, campsites, and other facilities. An estimated 1,000 miles of fire lines, dozens of fire camps, tons of litter, 100 miles of roads, more than 600 miles of trails, and innumerable helispots and other local impacts required restoration. Similarly, programs were developed to interpret the fires and their effects for visitors and for the general American public. And, Yellowstone cooperated with other agencies and state and local governments in promoting the economic recovery of the communities near the park whose businesses were affected by the fires.

The scientific community, both in the private and the public sector, showed great interest in monitoring 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 to take full advantage of this unparalleled scientific opportunity. It is probably safe to say that this research effort has been unparalleled in the history of the national parks, and its impact will be felt throughout the scientific community for many years to come.

The fires of 1988 had an enormous effect on the greater Yellowstone area. The face of the park and surrounding lands has been dramatically changed on a scale not widely anticipated even among fire ecologists. But the change is not without precedent. Research shows that the Yellowstone area has been visited by natural fires on this scale periodically in the past, including comprehensive burns in the early 1700s and in 1850.

Scientists knew that the vegetative setting of Yellowstone was, in large part, the product of fires that burned here freely before the arrival of European man. Each new burn initiates a sequence of events in the plant community that influences all other living forms in the area, especially in terms of the nutrient flow through the ecological systems.

The growth of new biotic communities began immediately following a burn. Temperatures high enough to kill seeds penetrated less than an inch into the soil in most places. Only under logs and in deep litter accumulations where the fire was able to burn for several hours, did the lethal heat pulse penetrate more deeply into the soil. Where water was available, new plant growth was immediate—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. Within a few growing seasons, the forest floor was a mat of grasses, shrubs, and flowers, and seedlings of future forests of fir, spruce, and pine appear. Plant growth is unusually lush after a fire because of the mineral nutrients in the ash and because of increased light levels on the previously shaded forest floor.

The fires of Yellowstone did not annihilate all life forms in their paths. Burning at a variety of temperatures, sometimes as ground fires, sometimes as crown fires, the fires killed many lodgepole pines and other trees, but in fact did not kill most other plants; they merely burned the tops off of them, leaving roots to regenerate. As the fires passed, they created a vegetative mosaic of burns, partial burns, and non-burns that are now the new habitats of plants and animals in Yellowstone.

And the 1988 fires will affect future fires. Vegetation capable of sustaining another major fire will be quite rare for decades, except in extraordinary situations (the 1988 fires actually reburned heavily burned areas in some locations). The mosaic of young and mature plant communities 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.

Smoke, quickly moving fires, and the demands of firefighting logistics made it impossible to monitor mortalities of large mammals during the fires. Preliminary surveys in late September revealed that surprisingly few large mammals were killed by fire or smoke. Though animal movements were sometimes affected dramatically by the passage of fires, relatively few animals succumbed, considering the large size of park wildlife populations. Of Yellowstone's 30,000 to 40,000 large mammals, between 300 and 400 (or roughly 1 percent) perished as a result of the fires. The majority of these animals were elk. Of greater significance are the short- and long-term effects of the fires on wildlife. Portions of the park's northern range burned, which affected winter survival of grazing animals when coupled with summer drought conditions that reduced production of for-

age. In this and many other ways, fires dramatically altered the habitat and food production of Yellowstone.

Wildfire has been regarded as evil for centuries, and the 1988 Yellowstone area fires stimulated greater interest in national park management than any other event in recent times. Public fears (often fueled by media reports) that Yellowstone was being "destroyed" by the fires were unfounded, and in the ten 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. There are still those who feel that the Yellowstone they knew and loved is gone forever. But Yellowstone is not a museum; it is a living functioning ecosystem, and we cannot realistically expect such a place to remain unchanged forever. Through the changes going on around us in Yellowstone comes awareness, through awareness comes knowledge, and with knowledge comes understanding.

Suggested Reading

Barbee, Robert and Paul Schullery. "Yellowstone: The Smoke Clears," *National Parks* 1989: 62:18-19.

Craighead, John J., Frank C. Craighead, and Ray J. Davis. *A Field Guide to Rocky Mountain Wildflowers from Northern Arizona and New Mexico to British Colombia.* Houghton Mifflin, Boston, MA. 1963.

Despain, Don. *Yellowstone Vegetation: Consequences of Environment and History in a Natural Setting*. Roberts Rinehart Publishers, Boulder, CO. 1990.

Houston, Douglas B. "Wildfires in Northern Yellowstone National Park." *Ecology,* Summer 1973: Volume 54, No. 5.

Preston, Richard J. *Rocky Mountain Trees: A Handbook of the Native Species with Plates and Distribution Maps.* Dover Publications, New York, NY. 1968.

Romme, William H. and Dennis Knight. "Landscape Diversity: The Concept Applied to Yellowstone National Park." *Bioscience,* September 1982: Volume 32, No. 8.

Shaw, Richard J. *Trees and Flowering Shrubs of Yellowstone and Grand Teton National Parks.* Wheelwright Press, Salt Lake City, UT. 1964.

Shaw, Richard J. *Wildflowers of Yellowstone and Grand Teton National Parks.* Wheelwright Press, Salt Lake City, UT. 1992.

Varley, John D. and Paul Schullery. "Reality and Opportunity in the Yellowstone Fires of 1988" *The Greater Yellowstone Ecosystem: Redefining American Heritage.* R. Keiter and M. Boyce, eds. Yale University Press, New Haven, CT. 1991.

Wuerthner, George. *Yellowstone and the Fires of Change.* Haggis House Publications, Salt Lake City, UT. 1991.

Color & Name	Location	Time
WHITE FLOWERS		
Marsh marigold	Wet meadows parkwide	May-July
Northern bedstraw	Northern Range	July-August
White geranium	Moist areas parkwide	July-August
Phlox	Parkwide	May-July
Wild strawberry	Parkwide	May-July
Yampa	Parkwide in meadows	July-August
Cow parsnip	Wet areas parkwide	July-August
Woodland star	Meadows parkwide	May-June
Yarrow	Parkwide	June-September
Pussytoes	Parkwide	June-July
Spring beauty	Parkwide	April-June
Ladies tresses	Thermal areas, meadows	July-August
YELLOWFLOWERS		
Arnica	Parkwide	June-August
Yellowbells	Parkwide, open areas	May-June
Glacier lily	Lake area, Dunraven Pass	May-June
Cinquefoil	Parkwide	June-August
Stonecrop	Barren areas, parkwide	June-August
Yellow monkeyflower	Thermal areas, bogs, creeks	May-August
Rabbitbrush	Northern Range	August-September
Balsamroot	Northern Range	June-July
Yellow pond lily	Ponds, slow streams parkwide	July-August
Sulfur buckwheat	Parkwide	June-August
Yellow violet	Moist meadows parkwide	May-June
Helianthella	Dunraven Pass	July-August
RED-PINK FLOWERS		
Shooting star	Meadows parkwide	May-June
Calypso orchid	Parkwide	May-June
Prairie smoke	Meadows parkwide	June-July
Coralroot	Forest floor parkwide	June-July
Bitterroot	Northern Range	May-June
Elephant head	Moist meadows parkwide	June-July
Twinflower	Moist forests	June-July
Indian paintbrush	Parkwide	June-August
Wild rose	Northern Range	June-July
Sticky geranium	Northern Range, meadows parkwide	June-August
Fireweed	Parkwide	July-August
BLUE-PURPLE FLOWERS		
Fringed gentian	Geyser basins, meadows parkwide	May-August
Harebell	Parkwide	July-August
Wild flax	Dry meadows parkwide	June-August
Blue penstemon	Meadows parkwide	June-August
Lupine	Parkwide	June-August
Bluebells	Moist meadows along streams and at seeps	May-July
Clematis	Mammoth/Tower area	May-June
Larkspur	Meadows parkwide	May-July
Monkshood	Moist areas parkwide	June-July
Wild iris	Meadows, Northern Range	June
Pasqueflower	Northern Range	May-June
Aster/fleabane	Parkwide	May-September

Cultural Resources 5

Yellowstone National Park is rich in cultural resources. While much is known about the great diversity of the park's cultural resources, much remains to be done to locate, identify, evaluate, preserve, manage, and interpret those that are significant.

The cultural history of the park dates to at least 10,000 years ago and extends through the present day. It includes prehistoric and historic use by Native Americans and their contemporary descendants. It also includes historical use by Euro-Americans. It is believed that the first Euro-American to enter what is now known as Yellowstone National Park was John Colter, a fur trapper and veteran of the Lewis and Clark Expedition who traveled through the area during the winter of 1807 and 1808. The stories he told upon his return led to an area near present Cody, Wyoming, being described as "Colter's Hell." Following Colter's travels, little attention was paid to Yellowstone until after the Civil War when westward expansion and discoveries of gold in the region led to a renewed interest in the area. Expeditions in 1869, 1870, and 1871 resulted in the wonders of Yellowstone becoming more widely known and contributed to the creation of Yellowstone National Park in 1872.

Administration of the newly created park was first civilian (1872-1886), then military (1886-1918), and finally National Park Service (1916-present). As visitation to the park increased so did associated structures and facilities. The legacy of early park administrations, both civilian and military, and the history of the development of concessions in national parks are preserved in buildings still in use today. Yellowstone's role in the history of the park preservation movement worldwide and the history of how Americans travel and spend their leisure time is also preserved here. For more about the modern history of the park, see Chapter One.

Archeological Resources

The earliest documentation of archeological sites in Yellowstone was made by Philetus W. Norris during his superintendency of the park (1877-1882). The first professional archeological survey was conducted in 1958 and 1959, and 224 sites were recorded. The survey was not systematic; instead it was oriented toward areas where sites were known to occur, mostly along roadways.

Since that time approximately 2 percent of the park has been intensively inventoried, and more than 740 prehistoric and historic Native American archeological sites and historic Euro-American archeological sites have been recorded. Only 5 percent of these sites have been evaluated for eligibility to the National Register. An exception is the Obsidian Cliff quarry site, the premiere obsidian source for western North America, which was designated a National Historic Landmark in June 1996.

Little of the archeological work that has occurred in Yellowstone has been research oriented; the majority of the surveys have been preparatory to park development projects or operational activities. One recent exception to these construction-driven surveys was the survey work associated with studying the effects of the 1988 fires. Another exception occurred in 1995 and 1996, when the NPS Submerged Cultural Resource Unit surveyed portions of Yellowstone Lake for both cultural and natural resources. Vast portions of the park remain unsurveyed, and, through resource impacts, land-use activities, and vandalism, it is suspected that sites that have yet to be recorded are being damaged or destroyed. Most of the known sites are restricted to the surface or near it, therefore, little is known about stratified sites (sites having more then one cultural component) or buried sites.

Archeological information for Yellowstone is recorded on the Cultural Sites Inventory (CSI). The CSI is prepared and updated for Yellowstone by the Midwest Archeological Center (MWAC) and consists of an archeological overview and assessment, chronology of investigations, lists of sites and site conditions, and maps showing site locations and areas inventoried.

Approximately 84 percent of the recorded archeological sites are of Native American origin. Site types in Yellowstone include trails, quarries, hearths, game drives, base camps, chipping stations, rock shelters, wickiups, rocklines, and tepee rings. The majority of these are unevaluated as to cultural affiliation.

Avariety of prehistoric and historic Native American groups have used park resources. (See Chapter 1.) Yellowstone is bounded by four culture areas (or subareas): the Great Basin, Northern Plains, Wind River, and Snake-Salmon Drainage. These areas or subareas are included within larg-

er Grand Areas: Eastern Areas and Intermediate and Intermountain Areas. Further archeological investigations are needed to determine how these cultural areas influenced the Native American presence in the park. The archeological evidence indicates that the majority of use occurred seasonally. Historically, the Crow, Shoshone, Bannock, Nez Perce, and Blackfeet are known to have visited the park. One group of Shoshone, known as the Sheepeaters, were living in the park when the first historic records were made.

Throughout the history of Native Americans in Yellowstone, resource utilization has varied based on the availability of resources and general "livability" of the area. Other factors were undoubtedly at play as well and influenced resource utilization in Yellowstone, such as the arrival of Euro-Americans, the dynamic geology of the park, and dramatic climatic shifts.

Yellowstone also has Euro-American historic archeological sites. The Euro-American presence is comparatively well-documented through written and photographic records, cultural objects, and structures and buildings. However, if something or someone was not photographed, drawn, painted, written about, or discussed in an oral history, the archeological record becomes the primary record. Euro-American historic archeology provides a means to test the historic documentation, record previously unknown historic information, and extend the understanding of the Euro-American presence in Yellowstone.

The majority of the known Euro-American archeological sites date from the late 1800s to the mid-1940s. Generally, they are associated with park administration under both the U.S. Army and the National Park Service as well as with the development of concessions within the park. Many of these sites have not been recorded; few have been evaluated under National Register criteria. These sites include old trapper and poacher cabins, hotel sites, the Norris blockhouse (the park's first headquarters), Camp Sheridan, soldier stations, the Queen's Laundry Bathhouse, graves, Barronett's Bridge and cabin site, and the Blacktail poacher's cabin.

Ethnography

Ethnographic resources are tangible or intangible aspects of cultural systems, past or present, that are identified as significant by a recognized ethnic group. Very little is known about the ethnographic resources of the park. Ethnography encompasses both natural and cultural resources (e.g., traditional uses of obsidian and other minerals, uses of various flora and fauna).

An "Ethnographic Overview and Assessment" is currently being prepared. It will identify resources, resource data gaps, and consultation needs, and will provide the framework for an ethnographic resource study, traditional use study, and ethnographic study, which will be use in developing the ethnographic overview and assessment.

Historic Structures

Yellowstone has more than 952 historic structures associated with Euro-American occupation and management of the park, of which five are National Historic Landmarks. The vast majority of these structures are still in use today. All of these structures are on the List of Classified Structures (LCS). The LCS is an inventory of historic structures that are at least 50 years old; it provides information regarding the significance, condition, use, and proposed treatment for all structures that may be eligible to the National Register. These structures have construction dates ranging from the 1880s through 1940s and represent significant and various architectural styles. Many park structures represent the development of Yellowstone for recreation and tourism, and this context is a significant component of Yellowstone's history.

More types of architectural styles are represented in Yellowstone then in any other park unit within the national park system. However, park rustic architecture is the predominant theme. Within this theme, five buildings have been designated as National Historic Landmarks: the Old Faithful Inn; the Northeast Entrance Station; and the Norris, Madison, and Fishing Bridge museums. Other fine examples of rustic architecture include ranger stations; Civilian Conservation Corps-built residences, barns, and fire caches; a network of 40 historic backcountry cabins and lookouts; and five historic districts: Lake Fish Hatchery, Old Faithful, Roosevelt, Fishing Bridge, and Lamar Buffalo Ranch.

The Fort Yellowstone historic district consists of 40 military structures dating from the 1890s and early 1900s when the U.S. Army administered the park. This district is being considered for national significance not only for architectural style, but also for its historical importance to the development of the park and subsequent evolution of the National Park Service.

The current List of Classified Structures is constantly being updated. Fifty-eight percent of the buildings included on the LCS have been evaluated for eligibility to the National Register; however, most of the buildings were evaluated for exterior significance only, and these evaluations were done before the current contextual and thematic guidelines were approved. All park buildings will eventually be re-evaluated under the new contexts and guidelines.

AHistoric Structure Report (HSR) is to be completed whenever there is proposed intervention into the National Register qualities of a building. Battle and Thompson's HSR for Fort Yellowstone (1972) is a useful guide to existing and historical conditions; however, many changes have occurred in the past 25 years. Historic structure reports have been completed for the Old Faithful Inn (1993), Roosevelt Lodge (1994), Old Faithful Lodge (1995), Mammoth Hot Springs Hotel (1995), and the Fort Yellowstone Powerhouse (1996).

The condition of structures within Yellowstone varies from very good to very poor. Historic buildings have not received appropriate attention in the past. Neglect, lack of funds, a harsh winter environment, natural deterioration, and minimal preventive maintenance have taken their toll on buildings. Nationally significant buildings, as well as many other National Register eligible buildings, were stabilized to varying degrees within the last decade. Other buildings throughout the park are so deteriorated that a major replacement of historic fabric is required, and, in some cases, structural failure is imminent. Unfortunately, funding has not existed to perform all the needed work.

Improvements have been made in maintaining and upgrading park and concessioner facilities through identifying and prioritizing needs. The concession hotel facilities have fared well under a ten-year congressional appropriation to bring visitor services up to a maintainable standard. Although there have been dramatic renovations to many of these historic hotels, a few still have extensive needs remaining. Hamilton Stores has possessory interest in its buildings and, with park approval, decides how to use its funds for building maintenance.

Cultural Landscapes

Acultural landscape is a geographic area, including both cultural and natural resources, associated with a historic event, activity, or person, or exhibiting other cultural or aesthetic values. A "Cultural Landscape Study" has not been done in Yellowstone to formally identify, evaluate, and make nominations to the National Register. However, a study of the 370-mile road system with its associated structures and bridges has been done, and this system is being nominated as a cultural landscape. The Lamar Buffalo Ranch is treated as a cultural landscape. Other cultural landscapes, both Native American and Euro-American, probably exist.

Museum Collections

The Yellowstone museum collection consists of nearly 200,000 cultural objects and natural science specimens representing archeology, ethnology, history, archives, biology, paleontology, and geology. There is no debate concerning the value of the park's collection. Its diversity reflects the unique resource and history of Yellowstone National Park. The collection includes paintings by Thomas Moran, J. H. Renshawe, and J. H. Twachtman; pencil sketches by Moran, William H. Jackson, H.W. Elliot, and W.H. Holmes; photographs by Jackson; historic hotel furnishings; Yellowstone Park Company touring cars and buses; stagecoaches and wagons; NPS uniforms: park souvenirs, postcards, and scrapbooks; archeological objects; prepared birds, insects, mammals, and fish; fossils; geological specimens; and one of the most complete herbarium collections for high altitude environments in the region. Approximately 73,000 of these objects and specimens have been catalogued. The bulk of the museum collection is housed in the Albright Visitor Center basement.

Library and Archives

The park maintains its own archives through a cooperative agreement with the National Archives and Records Administration; Yellowstone's archives constitute a portion of Record Group 79 of the National Archives. Two thousand linear feet of irreplaceable historic documents are housed in a room in the basement of the Albright Visitor Center and Museum and in one other location. The research library, also in the basement of the museum, consists of approximately 14,000 bound publications, 150 linear feet of vertical files, approximately 2,000 manuscripts, and the rare book collection.

The bulk of Yellowstone's historic photograph collection is also considered part of the National Archives. The 80,000-image collection contains a large number of nitrate and diacetate negatives, which are in varying stages of deterioration. Funding to preserve these images is being sought.

Cultural Themes & Studies

Archeological Resources

The development of contexts (studies) for archeological resources has been completed for only one theme (topic). The remaining subject headings represent suggested themes.

Aboriginal Settlement Patterns: The distribution of sites across the landscape tell of past settlement patterns. Analysis shows that this distribution is not random, but reflects placement of sites relative to resources and topographic features. Important resources and topographic features can include terraces, food sources, ecotonal settings where multiple resources could be reached with a minimum of effort, and resources available only at limited locations.

Resource Utilization: Prehistoric and historic Native Americans and historic Euro-Americans utilized the biological and geological resources in the park. Resources utilized include plants, animals, and rocks and minerals (e.g., obsidian, ignimbrite, steatite). Information gained from archeological sites regarding the distribution of plant and animal species may be of interest to biologists. Similarly, some biological studies may be significant to archeologists.

During the early historic era, resource utilization initially focused on furs and pelts. Trapping parties from Native American and Euroamerican communities, as well as parties of mixed groups, came to the Yellowstone area to establish trap lines and to obtain fresh meat provisions. Following the discovery of gold in Montana and the Civil War, Euro-Americans came to the region in increasing numbers. After 1870, resource utilization focused on ranching, mining, and the early tourist trade.

Transportation Systems: The topography of the land channeled prehistoric and historic travel just as it does today. These prehistoric and historic routes most likely followed existing animal trails. The most famous trail in Yellowstone is the Bannock Indian Trail, which passes through the northern half of the park. The Bannocks used the trail historically, but the trail dates back to the Archaic period. The first recorded use of the trail by the Bannocks was in 1840, following the extirpation of bison from Idaho. The Bannocks used the trail for at least 40 years, and sites along the trail can be associated with the historic period. Other trails connect Yellowstone to what is now Grand Teton National Park.

The development of trails and roads increased dramatically with the creation of the park in 1872 and Superintendent Norris'roadbuilding activities (1878-81). Trails and roads were developed to accommodate specific types of conveyances for carrying people, goods, and supplies to various management and concessions facilities. The construction of more substantial roads during the late 19th and early 20th centuries through today has had an impact on various historic and archeological resources.

Trade: Obsidian from the Obsidian Cliff site was traded across the country. Obsidian can be "finger-printed," and this evidence indicates that obsidian from Yellowstone has been traded, off and on, for at least 10,000 years. The Obsidian Cliff quarry site became a National Historic Landmark in June 1996. Additionally, the bighorn sheep in the park may have been a source of horn, which was an important material in the trans-plains trade network. Steatite, commonly known as soap-

stone could be carved into beads, pipes, and bowls and was very likely another important trade item.

Historic Tourism: Tourism is the only context that has been developed. This context developed from the park's legislation, which stated that the park would serve as a "pleasureing ground for the benefit and enjoyment of the people." The park's creation and development is intimately tied to the development of tourism.

Tourism represents the single largest movement of historic human populations outside wartime and, as such, represents a major aspect of culture contact and social change. The short-term demographic changes brought about by this economic activity since 1883 have exerted tremendous pressures for development as well as change in the compositions and economic orientation of local communities.

This approach to historic archeological sites is particularly valid at Yellowstone where: 1) tourism was and is a major management focus; 2) the economics of tourism have had a tremendous impact upon the overall economy of the region; 3) tourism and its associated development have historically had the greatest impact upon the park's and the area's cultural and natural resources; 4) a significant portion of historical sites relate to tourism in some manner. In the latter case, it is estimated that perhaps 95 percent or more of the historic archeological sites in Yellowstone are related to this economic enterprise in some manner.

Historic Resources

The "Historic Resources Study" is a multi-year, phased project. To date, one theme has been prepared, "The Development of the Road System in Yellowstone National Park, 1872-1972." This study documents Yellowstone's unique 370-mile, figure-eight road system developed by the U.S. Army Corps of Engineers. The design, construction methods, and sensitivity to the landscape with which this road was built became the model for many other park's roads. The basic configuration of the road has remained the same, but the roads have been modified to adjust to current visitor needs, vehicle size, safety considerations, and to protect geothermal areas. Property types associated with this theme include road sections, bridges, and buildings (e.g., Northeast Entrance Station, Gardiner Arch).

The following topics (themes) have been identified as other Yellowstone National Park historic contexts (studies):

The Military Role in Yellowstone National Park, 1886—1918: The U.S. Army played an important role in the history of Yellowstone, the development of the National Park Service, and the evolution of protection policies for large natural parks. The U.S. Cavalry was assigned to administer the park in 1886 after civilian administration proved unsuccessful. The cavalry administered the park until 1916 when the National Park Service was established and then stayed for two more years with the NPS. During its tenure, the Army constructed many facilities, such as Fort Yellowstone, ranger stations, and backcountry cabins to facilitate the protection of the park's natural resources. Many of these structures are still in use today. Historic archeological sites, such as the site of the first headquarters, are also related to this theme.

The Administration of Yellowstone National Park, 1872—1956: The development of Yellowstone National Park's administration influenced and coincided with the development of the nation's natural resource policies. Various aspects of this wide-ranging topic include: early civilian superintendents; influence of the U.S. Army; the influence of two world wars; the advent of the automobile; the development of the National Park Service "mission" under the leadership of Horace Albright (the first National Park Service superintendent of Yellowstone and later the director of the National Park Service) and Stephen Mather (the first director of the National Park Service), including their views on development of the park as a "people's playground"; the development of the philosophy of wilderness values and how that affected accommodation of ever-increasing visitation; the management of wildlife resources, such as fisheries and bison, and the facilities built to carry out those programs; and programs such as the Civilian Conservation Corps and the resource protection work they accomplished. Property types associated with this theme include park rustic architecture (museums, ranger stations, cabins, residences, barns, fire caches), the Lake Fish Hatchery and the Lamar Buffalo Ranch historic districts'rustic buildings, post-1930

wood-frame buildings used for road and forestry camps, an extensive trail system, and historic archeological sites.

The History of Concessions in Yellowstone National Park, 1872—1956 : The park's appearance and use has been greatly influenced by a wide variety of concessioners and entrepreneurs through their commercial promotion of Yellowstone's unique natural features. Large historic hotel and lodge complexes were built that still retain both their architectural and historical significance. Most noteworthy is the 1904 Old Faithful Inn, a National Historic Landmark. Others include the Lake Hotel and Lodge, Old Faithful Lodge, Mammoth Hotel, and Roosevelt Lodge. In association with the visitor accommodations are maintenance facilities, stores, service stations, and residences. Other property types include historic archeological sites, such as bathhouses, auto camps, hotels, and hotel dumps.

Canyon Area

The Grand Canyon of the Yellowstone

The Grand Canyon of the Yellowstone is roughly 20 miles long, measured from the Upper Falls to the Tower Fall area, and is 800 to 1,200 feet deep and 1,500 to 4,000 feet wide. The canyon as we know it today is a very recent geologic feature, no more than 10,000 to 14,000 years old, although there has probably been a canyon in this location for a much longer period. The exact sequence of events in the formation of the canyon is not well understood, and the few studies that are available are thought to be inaccurate.

The canyon was formed by erosion rather than by glaciation. After the caldera eruption of about 630,000 years ago, the area was covered by a series of lava flows. The area was also faulted by the doming action of the caldera before the eruption. The site of the present canyon, as well as any previous canyons, was probably the result of this faulting, which allowed erosion to proceed at an accelerated rate. The area was also covered by the glaciers that followed the volcanic activity. Glacial deposits probably filled the canyon at one time but have since been eroded away, leaving little or no evidence of their presence. The canyon is still being eroded by the Yellowstone River today.

The canyon below the Lower Falls was at one time the site of a geyser basin that was the result of rhyolite lava flows, extensive faulting, and heat beneath the surface (related to the hot spot). No one is sure when the geyser basin was formed in the area, although it was probably present at the time of the last glaciation. The chemical and heat action of the geyser basin caused the rhyolite rock to become hydrothermally altered, making it very soft and brittle and more easily erodible. Evidence of this thermal activity exists in the canyon in the form of geysers and hot springs that are still active and visible. The Clear Lake area south of the canyon is probably also a remnant of this activity (Clear Lake is fed by hot springs).

At the end of the last glacial period (about 14,000 to 18,000 years ago) ice dams formed at the mouth of Yellowstone Lake. 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 is a classic V-shaped valley, indicative of river-type erosion rather than glaciation.

The falls are erosional features formed by the Yellowstone River as it flows over progressively softer, less resistant rock. The first falls, Upper Falls, is 109 feet high; it can be seen from the Brink of the Upper Falls Trail and from Uncle Tom's Trail. The Lower Falls is 308 feet high and can be seen from Lookout Point, Red Rock Point, Artist Point, Brink of the Lower Falls Trail, and from various points along the South Rim Trail. The Lower Falls is often described as being more than twice the size of Niagara, although this only refers to its height and not the volume of water flowing over it. The volume of water flowing over the falls can vary from 63,500 gal/sec at peak runoff to 5,000 gal/sec in the fall. Athird falls can be found in the canyon between the Upper and Lower falls. Crystal Falls is the outfall of Cascade Creek into the canyon; it can be seen from the South Rim Trail just east of the Uncle Tom's area.

The colors in the canyon are a result of hydrothermal alteration. The rhyolite in the canyon contains a variety of different iron compounds. When the old geyser basin was active, the "cooking" of the rock caused chemical alterations in these iron compounds. Exposure to the elements caused the rocks to change colors. The rocks are, in effect, oxidizing, or, in layman's terms, the canyon is rusting. The colors indicate the presence or absence of water in the individual iron compounds. Most of the yellows in the canyon are the result of iron present in the rock rather than sulfur, as many people think.

One of the canyon's more popular wildlife attractions is the osprey. These large, black and white birds arrive at the canyon in late April and early May. Their nests can be clearly observed, using a spotting scope, from Grandview, Lookout, and Artist points. There are normally at least three or four active nests visible from these points, giving visitors a rare chance to look down into the nests without disturbing the birds.

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 13,000 years ago. Because the glacial till contains many different grain sizes, including clay and a thin layer of lake sediments, water cannot percolate readily into the ground. This is why the 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 wildlife. It is an excellent place to look for grizzly bears, particularly in the spring and early summer when they may be preying upon newborn bison and elk calves. Large herds of bison may be viewed in the spring, early summer, and during the fall rut, which usually begins late July to early August. Coyotes can almost always be seen in the valley.

Bird life is abundant in and along the river. Avariety of shore birds may be seen in the mud flats at Alum Creek. Apair of sandhill cranes usually nests at the south end of the valley. Ducks, geese, and American white pelicans cruise the river. The valley is also an excellent place to look for bald eagles and northern harriers. Great gray owls can sometimes be seen swooping across the meadows in search of food (these birds are especially sensitive to human disturbance).

Mt. Washburn

Mt. Washburn, named for Gen. Henry Dana Washburn, leader of the 1870 Washburn-Langford-Doane Expedition, is the main peak in the Washburn Range. It rises 10,243 ft. above the west side of the canyon. It is the remnant of volcanic activity that took place long before the formation of the present canyon. It is an excellent example of subalpine habitat and is very accessible to the average visitor. Bighorn sheep and an abundance of wildflowers can be found on its slopes in the summer, and black and grizzly bears are sometimes seen here.

Day Hiking Trails

Canyon Rims: There are numerous trails and viewpoints of the canyon falls, both from the north and south rim. A guide to the Canyon Rim trails is available at numerous locations along the rim.

Mary Mountain Trail: This 21-mile (one way) trail climbs gradually up over Mary Mountain and the park's Central Plateau to the Nez Perce trailhead between Madison and Old Faithful. Elk and bison can sometimes be seen in the distant meadows. The trail through Hayden Valley is often difficult to follow as bison regularly knock down the trail markers. The trailhead is north of Alum Creek pullout, 4 miles south of Canyon Junction. The level of difficulty rating for this trail is "moderately strenuous" due to its length.

Howard Eaton Trail: This moderately easy 3- to 12-mile (one way) hike has little vertical rise and will take 2 to 8 hours, depending on how far you go. It passes through forest, meadow, and marshland to Cascade Lake (3 miles), Grebe Lake (4-1/4 miles), Wolf Lake (6-1/4 miles), Ice Lake (8-1/4 miles), and Norris Campground (12 miles). Most years, this trail remains very wet and muddy through July. Insects can also be very annoying. The trailhead is 1/2 mile west of Canyon Junction on the Norris-Canyon Road.

Cascade Lake: This easy 5-mile (round trip) hike takes 3 hours and is an enjoyable walk for those with limited time. The trail passes through open meadows and over small creeks. Look for wildlife and wildflowers in season. Most years, this trail remains very wet and muddy through July. The trailhead is at the Cascade Lake Picnic Area, 1-1/2 miles north of Canyon Junction on the Tower-Canyon Road.

Observation Peak: Hike to Cascade Lake from either of two trailheads. From the lake, the strenuous, 1,400 foot climb (in 3 miles) will take roughly 3 hours. The 11-mile (round trip) hike takes you to a high mountain peak for an outstanding view of the Yellowstone wilderness. The trail passes through open meadows and some whitebark pine forests. Past Cascade Lake, there is no water available along the trail. This hike is not recommended for persons with heart and/or respiratory problems. One trailhead is located in the Cascade Lake Picnic Area, 1-1/2 miles north of Canyon

Junction on the Tower-Canyon Road. The other is accessed from a pullout 1/4 mile west of Canyon on the Norris-Canyon Road.

Grebe Lake: There is little vertical rise on this moderately easy 3-4 hour, 6-mile (round trip) hike. The trail follows an old fire road through meadows and forest, some of which burned during the fires of 1988. Once at the lake you can connect with the Howard Eaton Trail. The trailhead is 3-1/2 miles west of Canyon Junction on the Norris-Canyon Road.

Seven Mile Hole: This strenuous 11-mile (round trip) hike takes 6-8 hours to complete. Following the Canyon Rim for the first 1-1/2 miles, you will be rewarded with views of Silver Cord Cascade. Continue north another 1/2 mile where you join the Washburn Spur Trail; after another 3 miles, the trail drops off to Seven Mile Hole, a 1-1/2 mile, 1,400 foot drop. Hike it carefully, watch your footing, and conserve your energy. Depending on your condition and the weather, it can be a long hike back out. Be especially careful where the trail passes both dormant and active hot springs. Off-trail travel is prohibited. This trail is not recommended for persons with heart and/or respiratory problems. The trailhead for the hike is the Glacial Boulder Trailhead on Inspiration Point Road.

Washburn Trail/Washburn Spur Trail: This 11-1/2 -mile (one way) hike begins at the Dunraven Pass trailhead, ascends Mount Washburn, and ends at the Glacial Boulder on Inspiration Point Road. This strenuous hike takes 6-8 hours to complete. Starting at the Washburn Trailhead at Dunraven Pass, you ascend Mt. Washburn and may see wildflowers (in season) and bighorn sheep as well as spectacular views. After this three-mile ascent, the Washburn Spur Trail descends very steeply from the east side of the Fire Lookout to Washburn Hot Springs in 3.7 miles. Here you will find some interesting thermal features, including mud pots. Continue past the turnoff to Seven Mile Hole and follow the trail to the Glacial Boulder and the Canyon area. This trail is not recommended for persons with heart and/or respiratory problems. The Washburn Trailhead at Dunraven Pass is 4-1/2 miles north of Canyon Junction.

Lake Area

Yellowstone Lake

Yellowstone Lake is the largest natural freshwater lake at high elevation (7,733 feet) in North America. The lake covers 136 square miles and is 20 miles long by 14 miles wide. It has 110 miles of shoreline. The deepest point in the lake is measured at 390 feet, and it has an average depth of 140 feet. While in a stunning setting with the Absaroka Mountains as a backdrop to the east, the lake has not always been so peaceful. There is geologic evidence that large volcanic eruptions have occurred in Yellowstone approximately every 600,000 years. The most recent of these (630,000 years ago) erupted from two large vents, one near Old Faithful (the Mallard Lake Dome) and one just north of Fishing Bridge (the Sour Creek Dome). Ash from this huge explosion, 1,000 times the size of Mt. St. Helens, has been found all across the continent. The magma chamber then collapsed, forming a large caldera that was partially filled by subsequent lava flows. The caldera includes the basin of Yellowstone Lake. The original lake was 200 feet higher than the present-day lake, extending northward across Hayden Valley to the base of Mt. Washburn.

It is thought that Yellowstone Lake originally drained south into the Pacific Ocean via the Snake River. The lake currently drains north from its outlet, the Yellowstone River, at Fishing Bridge. The elevation of the lake's north end does not drop substantially until LeHardy Rapids. Therefore, this spot is considered the actual northern boundary of Yellowstone Lake.

In the last decade, geological research has determined that the two volcanic vents, now known as "resurgent domes," are rising again. From year to year, they either rise or fall, with an average net uplift of about one inch per year. During the period between 1923 and 1985, the Sour Creek Dome was rising. In the years since 1986, it has either declined or remained the same. The resurgence of the Sour Creek dome is causing Yellowstone 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.

Research using a small submersible robot submarine has revolutionized our understanding of Yellowstone Lake. We now know that the bottom of the lake looks similar to the land surface in Yellowstone, with geysers, hot springs, fumaroles, and deep canyons. The deepest spot in the lake

(390 feet) was measured in a canyon just east of Stevenson Island; previously, the deepest spot (320 feet) had been measured in West Thumb. The following excerpt, which is from a report published in *Yellowstone Science* (v. 8, No. 1), explains the findings from 1999 exploration.

> Recently completed high-resolution surveys of the northern part of Yellowstone Lake show a lake bottom covered with dozens of circular depressions and hundreds of spires and pinnacles protruding from the floor. The circular depressions are 25–800 meters in diameter, have steep inner walls, and may be the remnants of explosive events similar to explosion craters exposed on nearby land. The spires are composed primarily of silica, up to 35 meters high and up to 50 meters in diameter. They occur singularly, in clusters, and in north-south-trending lines up to 400 meters long. These linear features may sit astride fissures on the lake floor. In many areas, spires occur around the margins of circular depressions. In at least one case, spire development appears to have both preceded and followed formation of a circular depression.
>
> Formation of both spires and circular depressions is related to deep-seated fluid circulation, and occurred over the past 12,000 years. Explosions such as those responsible for these craters result from the transformation of water to steam, often due to changes in confining pressure that result from (and accelerate) failure and fragmentation of overlying cap rock (hydrofracturing). Venting processes similar to those that form black smoker chimneys on the ocean floor form the spires in Yellowstone Lake.

Members of the 1870 Washburn party noted that Yellowstone Lake was shaped like "a human hand with the fingers extended and spread apart as much as possible." The large southwestern bay represents the thumb of the hand. Through the years, other names have been applied to this feature, including "West Arm" and "West Bay," but "West Thumb" remains the accepted name. The West Thumb of Yellowstone Lake was formed by a large volcanic explosion that occurred approximately 150,000 years ago. The resulting collapsed volcano (caldera) later filled with water forming an extension of Yellowstone Lake. The West Thumb is about the same size as another famous volcanic caldera, Crater Lake in Oregon. It is interesting to note that West Thumb is a caldera within a caldera, the Yellowstone caldera that formed 630,000 years ago.

During late summer, Yellowstone Lake becomes thermally stratified with each of several water layers having a different temperature. The topmost layer rarely exceeds 66°F, and the lower layers are much colder. Because of the extremely cold water, survival time for anyone who goes into 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. 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.

There is an abundance and diversity of wildlife in this area that attracts many visitors. The lake is home to the largest population of wild Yellowstone cutthroat trout in North America, which are now threatened by illegally introduced 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 ecologically to bears and other wildlife because lake, river, and terrestrial ecosystems merge here to create a diverse natural complex unique both inside and outside the park. There are numerous trout spawning streams in the area that are used by bears in the spring and early summer. Hayden Valley is known for the herds of bison that graze there. 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 quite 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.

The Lake Yellowstone Hotel, situated on the northwestern shore of the lake, is the oldest visitor facility still remaining in the park. It was built in 1891 on a site long known as a meeting place for Native Americans, trappers, and mountain men. At the time it was built, the building was not particularly distinctive, resembling 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 several years as the "Lake Colonial Hotel." A num-

ber of additional changes by 1929, including the addition of the dining room, porte-cochere (portico), and sunroom, as well as the refurbishing of the interior created the gracious landmark we see today. But, by the 1970s, the hotel had fallen into serious disrepair. In 1981, the National Park Service and the park concessioner embarked on a ten-year project to restore the Lake Hotel in appearance to its days of glory in the 1920s. The work was finished in time for the celebration of the hotel's centennial in 1991. The hotel was placed on the National Register of Historic Places that year.

Yellowstone River

The Yellowstone River is the last 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 Yount Peak and flows through the Thorofare region into Yellowstone Lake. It leaves the lake at Fishing Bridge and flows north over LeHardy 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 its largest tributary, 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 the state of Montana and joins the Missouri River just over the North Dakota state line.

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 than the current bridge. The existing bridge was built in 1937. The Fishing Bridge, situated over a cutthroat trout spawning area, was historically a tremendously popular place to fish, but was closed to fishing in 1973. Since that time, the bridge has become a popular place to observe fish.

Another popular spot to view fish is LeHardy Rapids, a cascade on the Yellowstone River three miles north of Fishing Bridge. In the spring, many cutthroat trout can be seen here, resting in the shallow pools before expending bursts of energy to leap up the rapids on the their way to spawn under Fishing Bridge. The rapids were named for Paul LeHardy, a civilian topographer with the Jones Expedition in 1873. Jones and a partner started off on a raft with the intent of surveying the river, planning to meet the rest of their party at the Lower Falls. Upon hitting the rapids, the raft capsized, and many of the supplies were lost, including guns, bedding, and food. LeHardy and his partner saved what they could and continued their journey to the falls on foot.

The rapids—and the leaping cutthroat trout—became a popular visitor attraction when a boardwalk was built in 1984 providing access to the area. Due to increased visitation, a group of harlequin ducks, which once frequented this area in spring, have not been seen for several years. The boardwalk has consequently been closed in early spring to protect this sensitive habitat, but the harlequins have not returned.

Mud Volcano/Sulphur Caldron

When the Washburn Expedition explored the area in 1870, Nathaniel Langford described Mud Volcano as "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 eerily intriguing. Ashort loop trail from the parking lot passes the Dragon's Mouth and the Mud Volcano and is handicapped accessible. The half-mile upper loop trail via Sour Lake and the Black Dragon's Caldron is relatively steep. Aself-guiding trail brochure is available at the beginning of the boardwalk.

The thermal features at Mud Volcano and Sulphur Caldron are primarily mud pots and fumaroles. Fumaroles or "steam vents" occur when the ground water boils away faster than it can be recharged. 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, steam, carbon dioxide, and other gases explode through the layers of mud. The Sulphur Caldron is among the most acidic springs in the park with a pH of 1.3.

Aseries of shallow earthquakes associated with the volcanic activity in Yellowstone struck this area in 1978. Soil temperatures increased to nearly 200° F (93° C). The slope between Sizzling

Basin and Mud Geyser, once covered with green grass and trees, became a barren landscape of fallen trees known as "the cooking hillside." In January 1995, a new feature on the south bank of Mud Geyser became active. It covers an area of 20 by 8 feet and is comprised of fumaroles, small pools, and frying-pan type features. Much of the hillside to the south and southwest of Mud Geyser is steaming and hissing with a few mudpots intermixed.

Two of the most popular features in the Mud Volcano area are the Dragon's Mouth and the Black Dragon's Caldron. The rhythmic belching of steam and the flashing tongue of water give the Dragon's Mouth Spring its name, though its activity has decreased notably since December 1994. The Black Dragon's Caldron exploded onto the landscape in 1948, blowing trees out by their roots and covering the surrounding forest with mud.

Day Hiking Trails

Pelican Creek Trail: This short (1 mile) and easy trail is diverse as it passes through a forest to the lakeshore before looping back across the marsh along Pelican Creek to the trailhead. It is a scenic introduction to a variety of Yellowstone's habitats and a good place for birding. The trailhead is at the west end of the Pelican Creek Bridge, 1 mile east of Fishing Bridge Visitor Center.

Natural Bridge Trail: The natural bridge is a 51-foot cliff of rhyolite rock that has been cut through by the erosional forces of Bridge Creek. The easy 4-mile (round trip) trail from the campground meanders through the forest for 1.2 mile. It then joins the Natural Bridge service road and continues to the right (west) for 1 mile before reaching the Natural Bridge. The short but steep switchback trail to the top of the bridge starts in front of the interpretive exhibit panel. To protect this fragile resource, the top of the bridge is closed to hiking. The trail to the bridge begins just south of the Bridge Bay Marina parking lot near the campground entrance road. The Natural Bridge service road, which begins 1/4 mile south of the Bridge Bay junction, is open to bicyclists and hikers. The trail is closed from late spring to early summer due to bears feeding on spawning trout in Bridge Creek. Inquire at the Visitor Center about trail closures before hiking or bicycling these trails.

Storm Point Trail: This easy, 2-mile loop trail begins in the open meadows overlooking Indian Pond and Yellowstone Lake. The trail passes by the pond before turning right (west) into the forest. It continues through the trees and out to scenic, windswept Storm Point. The rocky area near the point is home to a large colony of yellow-bellied marmots. Following the shoreline to the west, the trail eventually loops through the lodgepole pine forest and returns to Indian Pond. The trailhead is at the Indian Pond pullout, 3 miles east of Fishing Bridge Visitor Center.

Elephant Back Mountain Trail: This moderately strenuous 3-mile long trail climbs 800 feet in 1-1/2 miles through a dense lodgepole pine forest. After a mile, the trail splits into a loop. The left fork is the shortest and least steep route to the top. The overlook provides a sweeping panoramic view of Yellowstone Lake and the surrounding area. The trailhead is at the pullout that is 1 mile south of Fishing Bridge Junction.

Howard Eaton Trail: This easy, 7-mile (round trip) trail begins at the east side of Fishing Bridge and follows the Yellowstone River for a short distance before joining a service road; the trail continues on the road for 1/4 mile. Leaving the road, the trail 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 LeHardy Rapids. To return, follow the same trail back to the trailhead. The trail does continue on for another 12 miles to the South Rim Drive at Canyon, but is not well maintained. This trip would require planning for a full day's hike and a return ride to the trailhead. This area is good grizzly bear habitat, and the trail is closed when bears are known to be in the area. Inquire at the Visitor Center before hiking.

Avalanche Peak Trail: This strenuous, 5-mile (round trip) trail climbs steeply (1,800 feet in 2-1/2 miles) without the benefit of switchbacks. It passes through the forest and into an old avalanche slide area. It continues through the 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. The trail continues up a scree slope along the narrow ridgeline of Avalanche Peak. An unmarked trail drops down the northeast side of the bowl and returns to the meadow. Since whitebark pine cones are a favored

food of grizzly bears in the fall, avoid this trail at that time. The trial begins at the west end of Eleanor Lake across the road to the east of the small creek.

Pelican Valley Trail: This moderately difficult 6-mile (round trip) trail winds through the Pelican Valley providing views of the broad open valley and forest, some of the best grizzly habitat in the lower 48 states. The turn-around point is a footbridge, however, the trail continues on through the valley. Due to grizzly bears in the area, the trail is not open until July 4th, and then it is recommended (not required) for use by groups of four people or more. The trailhead is at the end of a dirt road that is 3 miles east of Fishing Bridge Visitor Center and across the road from Indian Pond.

Grant/West Thumb Area

West Thumb Geyser Basin

The West Thumb Geyser Basin, including Potts Basin to the north, is the largest geyser basin on the shores of Yellowstone Lake. The heat source of the thermal features in this location is thought to be relatively close to the surface, only 10,000 feet down! The thermal features at West Thumb are found not only on the lake shore, but also extend under the surface of the lake. Several underwater geysers were discovered in the early 1990s and can be seen as slick spots or slight bulges in the summer. During the winter, the underwater thermal features are visible as melt holes in the icy surface of the lake. River otters are commonly seen along the thermally melted areas of the lake during the winter months, along with coyotes, bison, and ravens.

The 1869 Folsom-Cook-Peterson Expedition visited the West Thumb Geyser Basin, and David Folsom described the area as follows:

Among these were springs differing from any we had previously seen. They were situated along the shore for a distance of two miles, extending back from it about five hundred yards and into the lake perhaps as many feet. There were several hundred springs here, varying in size from miniature fountains to pools or wells seventy-five feet in diameter and of great depth. The water had a pale violet tinge, and was very clear, enabling us to discern small objects fifty or sixty feet below the surface. Asmall cluster of mud springs near by claimed our attention. These were filled with mud, resembling thick paint of the finest quality, differing in color from pure white to the various shades of yellow, pink, red and violet. During the afternoon they threw mud to the height of fifteen feet. . .

Historically, visitors traveling to Yellowstone would arrive at West Thumb via stagecoach from the Old Faithful area. At West Thumb, 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.

Fishing Cone is a hot spring located in the West Thumb Geyser Basin. The Folsom party probably saw it in 1869, but the first recorded description of Fishing Cone comes from the 1870 Washburn Expedition. Party member Walter Trumball wrote about Cornelius Hedges' experience fishing:

Agentleman was fishing from one of the narrow isthmuses or shelves of rock, which divided one of these hot springs from the [Yellowstone] lake, when, 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.

From that time on, visitor after visitor performed this feat, catching fish from the cold lake and cooking them on the hook. For years, park Superintendent P.W. Norris (1877-1882) demonstrated it to incredulous tourists. Anational magazine reported in 1903 that no visit to the park was complete without this experience, and tourists often dressed in a cook's hat and apron to have their pictures taken at Fishing Cone. Fishing at the cone can be dangerous and is today prohibited. A known geyser, 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.

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, and that is the spelling that has persisted.

The small range of mountains located just west of Heart Lake, the Red Mountains, is completely contained within the boundaries of Yellowstone National Park. In 1871, F.V. Hayden named present-day Mount Sheridan "Red Mountain." In 1872, members of the second Hayden Survey transferred that name to the entire range. In 1878, Henry Gannett reported that there were 12 peaks in the range, with 10,308-foot Mount Sheridan being the highest.

Factory Hill is a 9,607-foot peak in the Red Mountains so named because of an 1871 description by N.P. Langford of the steam vents near the mountain: "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 for the first road between Old Faithful and West Thumb. It was probably Chittenden who named the pass for Ida M. Craig (Wilcox), "the first tourist to cross the pass" on Chittenden's new road, on about September 10, 1891.

Isa Lake is at the pass and was also named by Chittenden. Isa Lake is noteworthy as 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, is located at the head of the Lewis River southwest of West Thumb. It is possible that fur trapper Jim Bridger visited this lake in 1833, and fellow trapper Osborne Russell certainly reached the lake in 1839. In 1863, prospector Walter DeLacy visited the lake and named it "DeLacy's Lake." The lake was also called "Madison Lake" because it was erroneously thought to be the head of the Madison River. Cornelius Hedges of the 1870 Washburn Expedition named the lake after the party's leader, Gen. H.D. Washburn. In 1872, Frank Bradley of the second Hayden Survey gave the lake another—final—name: "Upon crossing the divide to the larger lake, we found it to belong to the Snake River drainage, and therefore called it Shoshone Lake, adopting the Indian name of the Snake [River]."

Shoshone Lake is 205 feet at its maximum depth, has an area of 8,050 acres, and contains lake trout, brown trout, and Utah chub. Originally, Shoshone Lake was barren of fish owing to waterfalls on the Lewis River. The two types of trout were planted beginning in 1890, and the Utah chub was apparently introduced by bait fishermen. This large lake is the source of the Lewis River, which flows to the Pacific Ocean via the Snake River system. Shoshone Lake is thought to be the largest lake in the lower 48 states that cannot be reached by road. No motorboats are allowed on 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. The name, which comes from the Snake (Shoshone) Indians, was applied to the river as early as 1812, making it one of the oldest place names in the park. The Snake name comes from sign language—a serpentine movement of the hand with the index finger extended—that referred to the weaving of baskets or grass lodges of the Snake or Shoshone Indians.

The source of the Snake River 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. Anumber of springs gush forth upon the hillside that is about two miles above sea level. Uniting, they form a small stream, which flows to the Pacific. The Snake River is the nation's fourth largest river; 42 miles of it are in Yellowstone National Park.

Day Hiking Trails

West Thumb Geyser Basin Trail: The trail begins at the West Thumb Geyser Basin parking lot 1/4 mile east of West Thumb Junction. Stroll through a geyser basin of colorful hot springs and dormant lakeshore geysers situated on the scenic shores of Yellowstone Lake. The 3/8 mile (round trip) easy trail and boardwalk are handicapped accessible with assistance (the boardwalk trail has a slight grade as it descends to and climbs up from the lake shore). Atrail guide is available at the beginning of the trail.

Yellowstone Lake Overlook Trail: From the West Thumb Geyser Basin parking lot, cross the road to the west and hike to a high mountain meadow for a commanding view of the West Thumb of Yellowstone Lake and the Absaroka Mountains. The 2-mile (round trip) trail is mostly level terrain with a moderately strenuous 400-foot elevation gain near the overlook.

Duck Lake Trail: On this moderately difficult 1-mile (round trip) hike, you will climb a small hill for a view of Duck and Yellowstone lakes. From here you can see the expanse of the 1988 fires that swept through this area. The trail begins in the West Thumb Geyser Basin parking area.

Shoshone Lake Trail (via DeLacy Creek): The trail follows a forest edge and passes through open meadows to the shores of Yellowstone's largest backcountry lake. Look for wildlife in meadows. The 6-mile (round trip) trial is flat with no steep grades. The trailhead is 8.8 miles east of West Thumb Junction.

Riddle Lake Trail: The level trail 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. Bear Management Area--trail opens July 15. The 5-mile (round trip) trail begins approximately 3 miles south of the Grant Village intersection, just south of the Continental Divide sign.

Lewis River Channel/Shoshone Lake Loop Trail: Get a feel for Yellowstone's backcountry as you hike through a fairly level forested area to the colorful waters of the Lewis River Channel (7 miles round trip). Look for eagles and osprey fishing for trout in the shallow waters. For an all-day hike (11 miles), follow the channel to Shoshone Lake and return via the forested Dogshead Trail. The Lewis River Channel trailhead is approximately 5 miles south of the Grant Village intersection, just north of Lewis Lake on west side of the road.

Old Faithful Area

The Upper Geyser Basin

Yellowstone National Park encompasses nearly 50 percent of the world's geysers. The largest number of geysers in the park are found in the Upper Geyser Basin. Within one square mile, there are at least 150 of these hydrothermal wonders. Five major geysers, Castle, Grand, Daisy, Riverside, and Old Faithful, are predicted regularly by the naturalist staff. There are many frequent, smaller geysers in this basin as well as numerous hot springs and one recently developed mudpot.

The hills surrounding Old Faithful and the Upper Geyser Basin are composed of Quaternary rhyolitic lava flows. These flows, occurring long after the catastrophic caldera eruption of 630,000 years ago, flowed across the landscape like stiff mounds of bread dough due to their high silica content.

Evidence of glacial activity is common in the district. The glacial till deposits underlying the geyser basins provide the storage area for the water necessary for geysers to occur. Many landforms, such as Porcupine Hills north of Fountain Flats, are comprised of glacial gravel and are reminders that as recently as 13,000 years ago, this area was buried under ice.

The Firehole River flows through the Upper, Midway, and Lower geyser basins after originating south of the area on the Madison Plateau. The river is fed by cold springs in its upper reaches. It plunges over the 125-foot Kepler Cascades before reaching the Upper Geyser Basin. The name "Firehole" comes from early trappers in the area who saw all the steam rising from the thermal features surrounding the river and thought it was smoke from fires. Their term for a mountain valley was "hole," and so the river was named. The Firehole River boasts a world-famous reputation for challenging fly-fishing for brown, rainbow, and brook trout.

Thermal basins provide important habitat for wildlife in the Old Faithful District. Bison and elk are found in large numbers here year-round. In the winter, bison and those elk which do not migrate to lower elevations take advantage of the warm ground and thin snow cover. Less frequently seen by visitors are mule deer and moose. During spring and fall, moose are occasionally seen during the early morning or late afternoon. Mule deer are less frequently seen at this elevation, though in past years a small band has been observed wintering in the Upper Geyser Basin. Both black and grizzly bears are seen in the Old Faithful area, especially during the spring when winter-killed carcasses are available. Yellow-bellied marmots are frequently seen near the boardwalk surrounding Old Faithful Geyser. Unfortunately, the colony of marmots here have learned to subsist on human handouts.

There are other wildlife taking advantage of the unique microclimates that the hydrothermal features provide. 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. Birds, like killdeer, enjoy a feast of ephydrid fly adults as well.

The developed area adjacent to Old Faithful Geyser, which contains many historic structures, has been designated the Old Faithful Historic District. Within the district is the Old Faithful Inn, a National Historic Landmark. Built during the winter of 1903-04, the Inn was designed by Robert C. Reamer, who wanted the asymmetry of the building to reflect the chaos of nature. The lobby of the hotel features a 65-foot ceiling, a massive rhyolite fireplace, and railings made of contorted lodgepole pine. Wings were added to the hotel in 1915 and 1927.

Another historic structure is the Old Faithful Lodge. Unlike the Inn, the current Old Faithful Lodge is a result of numerous changes dating back to the early days of tent camps provided by companies like Shaw and Powell Camping Company and Wylie Permanent Camping Company. These camps were erected throughout the park and offered shelter before hotels and lodges were built. Both companies had facilities at Old Faithful. By 1917, auto traffic into the park was increasing, and it was decided that some camps could be eliminated. Yellowstone Park Camping Company emerged and operated on the old site of the Shaw and Powell camp, the present day site of the Lodge. In 1918, a laundry was built on the site and construction continued on the facility until 1928 when the Lodge reached its present configuration.

The Lower Hamilton Store was built in 1897 and is the oldest structure in the Old Faithful area still in use. The "knotty pine" porch is a popular resting place for visitors, providing a great view of Geyser Hill. (The oldest building at Old Faithful was built as a photo studio in 1897 for F. Jay Haynes. Originally located 700 feet southwest of Beehive Geyser and about 350 feet northwest of the front of the Old Faithful Inn, it now stands near the intersection of the Grand Loop Road and the fire lane, near the crosswalk.)

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 in size that constantly discharges more than 4,000 gallons of water per minute into the Firehole River. Also here is Yellowstone's largest hot springs, Grand Prismatic Spring. This feature is 370 feet in diameter and more than 121 feet in depth. Abridge across the Firehole River allows access to the basin.

Lower Geyser Basin

There are two areas to view the activity of the Lower Geyser Basin, Fountain Paint Pots (accessed by a boardwalk trail) and Firehole Lake Drive. The latter is a 3-mile, one-way drive

where you will find the sixth geyser predicted by the Old Faithful staff: Great Fountain. Its splashy eruptions send jets of diamond droplets bursting 100 to 200 feet in the air, while waves of water cascade down the raised terraces. The geyser erupts twice each day and predictions are within 2 hours (+/-) of actual eruptions.

Fountain Flats Drive, a short side road immediately south of the Nez Perce picnic area, follows the Firehole River for 1-1/2 miles to a trailhead. From there, the Fountain Freight Road hiking/biking trail continues along the old roadbed allowing hikers access to the Sentinel Meadows Trail and the Fairy Falls Trail. Also along this path is a handicapped-accessible backcountry site at Goose Lake.

Anumber of famous structures once stood in this geyser basin. The Marshall House, also known as Marshall's Hotel, this was the second hotel to be built in the park. Built by George W. Marshall in 1884, it was located near the present-day site of the Fountain Flat Drive and Grand Loop Road intersection. The hotel was later sold to a Mr. Graham and eventually purchased by the Yellowstone Park Association in 1886; it was renamed the Firehole Hotel. The hotel was torn down between 1892 and 1895. Agrave in the area of the hotel dates back to 1889 when Mattie Culver, wife of the hotel's innkeeper E.C. Culver, died from tuberculosis in March. Because the ground was still frozen, Mrs. Culver's body was placed in a barrel with the assistance of soldiers from the nearby Fountain Soldier Station. Aproper burial occurred later in the spring.

The Fountain Hotel opened for business in 1891 just a short distance south of the Marshall Hotel site in a meadow north of Fountain Paint Pots. Owned by the Yellowstone Park Association, the hotel could accommodate 350 visitors and was a pleasant addition to earlier lodging facilities. Accommodations included hot baths that tapped into nearby hot springs, a practice that was fortunately later stopped. This was one of the first Yellowstone hotels to feed bears for the entertainment of guests. The hotel was torn down in 1927.

In the fall of 1886, after the U.S. Army took over administration of the park, small detachments of soldiers were dispatched to outposts throughout the park. Stations at Nez Perce Creek (also called Fountain) and Old Faithful (also called Upper Geyser Basin) were among the first of these outposts. The Fountain Station was built "on a slight bench and about 200 feet east of the northern junction of the Fountain Freight Road and the main road through the Lower Geyser Basin." (The Old Faithful station was located on the west bank of the Firehole River opposite the Lion group of geysers.) Archeological investigations of the site have revealed foundations and some artifacts.

One structure that still stands is the Nez Perce Creek Wayside. This exhibit tells the story of the flight of the Nez Perce through Yellowstone in 1877. A band of 700 men, women, and children entered the park on the evening of August 23rd, fleeing 600 Army regulars commanded by General O.O. Howard. The Nez Perce had been told to leave their homeland and move to a reservation. They fled their ancestral home in the Wallowa Valley in northeastern Oregon on June 17, 1877, and by the time they entered the park, several battles, including a fight at Big Hole (another NPS site), had occurred. During the two weeks they were in the park, the Nez Perce bumped into all 25 known people visiting the new park at that time, some more than once. Several people were killed or wounded. After leaving the park, the Nez Perce tried reaching the Canadian border but were stopped by General Nelson Miles, who had reinforced General Howard's command. Some Nez Perce were able to slip into Canada, but the remaining 350 tribal members led by Chief Joseph surrendered to General Miles. This is where Chief Joseph gave his famous speech, "I will fight no more forever." The 1,700-mile flight that included Yellowstone National Park had come to an end. Today, Nez Perce Creek and the nearby wayside exhibit are reminders of their visit.

Shoshone Geyser Basin

Shoshone Geyser Basin is reached by a 17-mile round trip hike that crosses the Continental Divide at Grant's Pass. This basin has no boardwalks, and extreme caution should be exercised when traveling through it. Trails in the basin must be used. Remote thermal areas, such as this, should be approached with respect, knowledge, and care.

Day Hiking Trails

Geyser Hill Loop Trail: This easy, 1.3-mile loop trail gives visitors a good chance to see a variety of geysers, from the ever-entertaining Anemone with its short intervals of 5 to 10 minutes to the impressive Beehive with its unpredictable eruptions reaching 100 to 150 feet. The boardwalk begins at the Old Faithful Visitor Center.

Numerous other combination loops or one-way walks can be chosen in the Upper Geyser Basin. Features such as Castle, Grand, Riverside, and Daisy geysers along with Morning Glory Pool are easily accessed using the Old Faithful self-guiding trail map. Details on geyser prediction times may be obtained by stopping by the visitor center.

Observation Point Loop Trail: This 1.1-mile loop trail gains about 200 feet in elevation to a prominent overlook providing a great view of the Upper Geyser Basin. The trail begins at the foot-bridge behind Old Faithful Geyser.

Mallard Lake Trail: This moderately difficult, 6.8-mile (round trip) trail climbs through lodge-pole pine forest (some burned areas from the 1988 fires) and along meadows and rocky slopes before reaching at Mallard Lake. The trailhead is in the Old Faithful Lodge cabin area.

Lone Star Geyser Trail: This easy, 5-mile (round trip) trail follows an old service road along the Firehole River through unburned forests of lodgepole pine. The geyser, which erupts approximate-ly every 3 hours, puts on a delightful show. There is a logbook, located in a cache near the geyser, for observations of geyser times and types of eruptions. This trail can be accessed by bicycle with the final approach to the geyser on foot. The trailhead is 3 miles south of the Old Faithful area, just beyond Kepler Cascades parking area.

Black Sand and Biscuit Basin Trails: Both areas are accessed by easy, 1/2-mile loop boardwalks. Black Sand Basin is 1/2 mile north of the Old Faithful area and Biscuit Basin is 2 miles north. Both areas are included in the Old Faithful area trail guide.

Midway Geyser Basin Trail: The 1/2-mile loop boardwalk leads visitors by impressive features including Excelsior Geyser and Grand Prismatic Spring. The parking area is 6 miles north of the Old Faithful area.

Fountain Paint Pot Trail: Yellowstone's four types of thermal features can be seen in one easy - mile walk along this loop trail: geysers, hot springs, mudpots, and fumaroles. Atrail guide is avail-able for this area, which also includes the Firehole Lake Drive area. The parking area is 8 miles north of the Old Faithful area.

Mystic Falls Trail: This 2-1/2 -mile (round trip) trail follows a lovely creek through a lodgepole pine forest before reaching the 70-foot falls. By following a series of switchbacks, an overlook of the Upper Geyser Basin can be reached before looping back to join the main trail. The trail begins at the back of the Biscuit Basin boardwalk.

Fairy Falls Trail: At 200 feet high, Fairy Falls is an impressive backcountry sight. It can be reached from two different trailheads, both easy hikes. The first trailhead, 1 mile south of the Midway Geyser Basin, begins at a steel bridge across the Firehole River and follows the Fountain Freight Road hiking/biking trail for approximately 1 mile before the hiking-only trail to Fairy Falls branches off on the left (a total of 5 miles). The second trailhead, 1/2 mile south of the Nez Perce picnic area on the Fountain Freight Road, follows the hiking/biking path from the northern end, 1-3/4 miles to the junction with the Fairy Falls trail (a total of 7 miles).

Norris/Madison Area

Norris Geyser Basin

Norris Geyser Basin is the hottest, oldest, and most dynamic of Yellowstone's thermal areas. The highest temperature yet recorded in any geothermal area in Yellowstone was measured in a scientific drill hole at Norris: 459°F just 1,087 feet below the surface! There are very few thermal features at Norris under the boiling point (199°F at this elevation). Norris shows evidence of having had thermal features for at least 115,000 years. The features in the basin change daily, with frequent disturbances from seismic activity and water fluctuations.

Norris sits on the intersection of three major faults. The Norris-Mammoth Corridor is a fault that runs from Norris north through Mammoth to the Gardiner, Montana, area. The Hebgen Lake fault runs from northwest of West Yellowstone, Montana, to Norris. This fault experienced an earthquake in 1959 that measured 7.4 on the Richter scale (sources vary on exact magnitude between 7.1 and 7.8). These two faults intersect with a ring fracture that resulted from the Yellowstone Caldera of 600,000 years ago. These faults are the primary reason that Norris Geyser Basin is so hot and dynamic.

The vast majority of the waters at Norris are acidic, including acid geysers which are very rare. Steamboat Geyser, the tallest geyser in the world (300 to 400 feet) and Echinus Geyser (pH 3.5 or so) are the most popular features. The basin consists of three areas: Porcelain Basin, Back Basin, and One Hundred Springs Plain. Porcelain Basin is barren of trees and provides a sensory experience in sound, color, and smell; a 3/4 mile dirt and boardwalk trail accesses this area. Back Basin is more heavily wooded with features scattered throughout the area; a 1-1/2 -mile trail of boardwalk and dirt encircles this part of the basin. One Hundred Springs Plain is an off-trail section of the Norris Geyser Basin that is very acidic, hollow, and dangerous. Travel is discouraged without the guidance of knowledgeable staff members.

Periodically, Norris Geyser Basin undergoes a large-scale basin-wide disturbance. This change is manifested in water level fluctuations, temperature changes, pH changes, color changes, and eruptive pattern changes in features throughout the basin. Some features become murky; others, like Echinus Geyser, are less predictable. Geologists and water chemists have studied these disturbances, and have several theories about why they occur. Some say the disturbances are a massive fluctuation in the underground reservoirs that provide water to the basin. It is known that Norris has several water systems that supply water to various parts of the area; some call them stacked water systems. Some theorize that because the disturbance usually occurs in the fall there is less surface water mixing with water from deep underground. The water from deep underground holds more silica and clogs the cracks and crevices that supply water, thereby creating a "disturbance" as pressure builds. Exciting things happen during disturbances. For example, a small geyser, Porkchop, became a continuous jet of steam and water in 1985; during the fall of 1989, at the onset of disturbance, Porkchop clogged with silica and blew up. Rocks from the apron around the geyser flew 200 feet into the air! Disturbances usually last for a few weeks, and then the basin returns to a more "normal" state.

The Ragged Hills that lie between Back Basin and One Hundred Springs Plain are thermally altered glacial moraines. As glaciers receded, the underlying thermal features began to express themselves once again, melting remnants of the ice and causing masses of debris to be dumped. These debris piles were then altered by steam and hot water flowing through them.

The area was named for (and by) Philetus W. Norris, the second superintendent of Yellowstone, who provided the first detailed information about the thermal features. The Norris Geyser Basin Museum is one of the park's original trailside museums and was built in 1929-30. It is an outstanding example of stone-and-log architecture and is a National Historic Landmark.

Across the road from the thermal basin at the entrance to the Norris campground is the Museum of the National Park Ranger. The museum is housed in the Norris Soldier Station, one of the oldest, remaining soldier stations in the park. An earlier structure was built in 1886, but it was replaced after a fire in 1897. The building was modified in 1908. After the Army years, 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.

The Norris Campground area and the meadows adjacent to the Gibbon and Madison rivers are prime elk calving areas in the spring. Fall brings bull elk to these same meadows. Bison frequent the same meadows in the spring, summer, and fall and use the thermal areas a great deal in the winter season. Both black and grizzly bears pass through the Norris area, with grizzlies using the thermal areas in the spring to feed on winter-killed elk and bison. Norris is one of the few areas in Yellowstone having lizards. The sagebrush lizard can only survive here due to the influence of thermal activity. They are sensitive to disturbance and are only occasionally seen on the public trails. Chorus frogs may be heard in the area in the spring, mixing their song with the winnowing of the snipe.

The thermal areas are known for their abundant and unusual lifeforms including many species of bacteria, algae, and insects. Because Norris is acidic, some forms of life that are especially suited to life in extremes of heat and acid have been found here. *Cyanidium* (a green algae) is one of the more unusual alga found at Norris; the best locale for viewing is in Porcelain Basin in the runoff channel near Whirligig Geyser. Look for the streak that looks like lime Koolaid. Norris also has a great deal of coloration due to mineral stain, so look closely before assuming it's alive! Killdeer are found in the basin year-round taking advantage of the brine flies and other insects that carry on their lives in the warm waters.

Roaring Mountain

Located just north of Norris on the Norris-Mammoth section of the Grand Loop Road, Roaring Mountain is a large, acidic thermal area (solfatara) that contains many steam vents (fumaroles). In the late 1800s and early 1900s, the number, size, and power of the fumaroles was much greater than today.

Virginia Cascades

Athree-mile section of an older portion of the Grand Loop Road takes visitors past 60-foot high Virginia Cascades, which is part of the rim of the Yellowstone Caldera. This cascading waterfall is formed by the very small (at this point) Gibbon River. A 22-mile swath of lodgepole pine that was blown down by wind-shear action in 1984 is just beyond the entrance to the Virginia Cascades Drive. This "blowdown" was burned during the North Fork fire in 1988, and the landscape is particularly blackened and barren. (This is the site where a famous news anchor said, "Tonight, this is all that's left of Yellowstone.") Aboardwalk trail takes visitors into the middle of the blowdown and a wayside exhibit tells the story.

Artist Paint Pots Area

Artist Paint Pots is a small but lovely thermal area just south of Norris Junction. A1-mile round trip trail takes visitors to colorful hot springs, two large mudpots, and through a section of forest burned in 1988. Adjacent to this area are three other off-trail, backcountry thermal areas: Sylvan Springs, Gibbon Hill Geyser Basin, and Geyser Creek Thermal area. These areas are fragile, dangerous, and difficult to get to; travel without knowledgeable personnel is discouraged.

Monument Geyser Basin is a small, nearly dormant basin that lies at the top of a very steep 1-mile trail just south of Artist Paint Pots. Thermos-bottle shaped geyser cones are remnants of a much more active time. Just south of Artist Paint Pots, the 84-foot Gibbon Falls tumbles over remnants of the Yellowstone Caldera rim. The rock wall on the opposite side of the road from the waterfall is the inner rim of the caldera.

Madison Junction

At Madison Junction, the Gibbon River joins the Firehole River to form the Madison River. (The Gibbon River flows from Wolf Lake through the Norris area to Madison Junction. The Firehole River starts south of Old Faithful and flows through the park's major thermal basins northward to Madison Junction.) The Madison joins the Jefferson and the Gallatin rivers at Three Forks, Montana, to form the Missouri River. The Madison is a blue-ribbon fly fishing stream as is the Firehole River.

Madison Junction lies within the eroded stream channels cut through lava flows formed after the caldera eruption. National Park Mountain is actually part of the lava flows that encircle the Madison Junction area. Near this site, in 1870, the Washburn-Langford-Doane Expedition is said to have camped and discussed the future of the region they were exploring. Legend has it that this was where the idea of the national park was discussed. It should be noted that there is no evidence of the campfire conversation ever taking place, and there is certainly no evidence to show that the idea of a national park was discussed.

The Madison Museum is one of the park's original trailside museums built in 1929-30. It is an outstanding example of stone-and-log architecture and is a National Historic Landmark. Archeological digs in the campground area (and also at Norris Campground) reveal that people have camped in these areas for at least 10,000 years. Campfire remnants, obsidian flakes, and chips and bone fragments show that these campgrounds have always been favorites! The Madison area is used by bison year-round and an excellent place to view herds of the animal.

Terrace Springs lies just north of Madison Junction. There is a short boardwalk around the springs in this small thermal area. 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, a side road, follows the Firehole River upstream from Madison Junction to just above Firehole Falls. The drive takes sightseers past 800-foot thick lava flows. Firehole Falls is a 40-foot waterfall. An unstaffed swimming area here is very popular in the warmest of the summer season. Cliff diving is illegal.

Day Hiking Trails

Norris Area

Grizzly Lake: This 4-mile (round trip) trail passes through a twice-burned lodgepole pine stand (1976 and 1988) and through nice meadows. The hike is moderately difficult with some short, steep climbs. The lake is long, narrow, and heavily wooded. The lake can be difficult to access beyond the trail end of the lake because of a log jam crossing. Marshiness and mosquitos can make travel difficult early in the season. The lake is popular with anglers due to a strong population of small brook trout. The trailhead is 1 mile south of Beaver Lake on the Mammoth- Norris Road.

Solfatara Creek: The fairly easy, 13-mile (round trip) trail follows Solfatara Creek for a short distance to the junction with Ice Lake Trail; it then parallels a power line for most of the way to Whiterock Springs. It climbs a short distance up to Lake of the Woods (difficult to find as it's off trail a bit) and passes Amphitheater Springs and Lemonade Creek (don't drink it). These are small, but pretty thermal areas in the otherwise non-descript lodgepole pine forest. The trail then continues on to meet the road. There is no trail connection back to the campground except the way you came. Parking a car at both ends is desirable. This is a good place to send folks who don't want to see many other hikers, but it can be under bear restrictions so check before you send people. The trail begins in Loop C of the Norris Campground and ends 3/4 miles south of Beaver Lake Picnic Area on the Mammoth-Norris Road.

Ice Lake Trail (direct route): Ice Lake is a lovely, small lake nestled in the thick lodgepole pine forest. Some of the area was heavily burned in 1988. The easy 0.3 mile trail ends at a handicapped accessible backcountry site on the lake (some assistance may be needed to reach the lake). Hikers can continue from Ice Lake to Wolf Lake, Grebe Lake, and Cascade Lake, and then on to Canyon. The trailhead is 3-1/2 miles east of Norris on the Norris-Canyon Road.

Wolf Lake Cut-off Trail: The trail follows the Gibbon River past Little Gibbon Falls and then through dense, partially burned lodgepole pine forest to Wolf Lake. It is 1 mile to the junction with the Wolf Lake trail and about 2 miles on to the lake. The trail crosses the stream several times and may be difficult to follow due to lack of regular maintenance. The trail is accessed from the big pullout about 1/4 mile east of Ice Lake Trailhead on the Norris-Canyon Road (orange trail markers can be seen once hikers cross the road from the parking area.

Cygnet Lakes Trail: This easy, 8-mile (round trip) trail travels through intermittently burned lodgepole pine forest and past small marshy ephemeral ponds to the lush meadows surrounding

Cygnet Lakes (small and boggy). Day use only! Trail not maintained beyond Cygnet Lakes. The trailhead is the pullout on the south side of the Norris-Canyon road approximately 5.5 miles west of Canyon Junction.

Artist Paint Pots: This is one of the overlooked yet wonderful short hikes (1 mile round trip) of Yellowstone. The trail winds across a wet meadow on boardwalk then enters a partially burned lodgepole pine forest. The thermal area within the short loop at the end of the trail contains some of the most colorful hot springs and small geysers found in the area. Two mudpots at the top of the hill allow closer access than Fountain Paint Pots. Caution for flying mud! Remind folks to stay on the trail throughout the area. The trailhead is 4-1/2 miles south of Norris on the Norris-Madison Road.

Monument Geyser Basin: This 2-mile (round trip) trail is deceptively easy as it meanders along a gentle gradient following the Gibbon River, then it turns sharply uphill and climbs 500 feet in one-half mile. Footing is on eroding geyserite and rhyolite, somewhat reminiscent of ball bearings. The geyser basin is a very interesting collection of dormant cones of varying sizes; one resembles a thermos bottle! Most of the thermal activity here has ceased. The trailhead is 5 miles south of Norris just past the Gibbon River Bridge.

Madison Area

Purple Mountain: This 6-mile (round trip) trail ascends the mountain in a steady climb of 1,500 feet through intermittent burned lodgepole pine forest and ends with a nice view of the Firehole Valley and lower Gibbon Valley; some views of the Madison Junction area are also visible. The trial is close to Madison Campground, about 1/4 mile north of the junction on the Madison-Norris Road. There is limited parking.

Harlequin Lake: This easy, 1-mile (round trip) trail is a gentle ascent through burned lodgepole pines to a small, marshy lake popular with mosquitos and waterfowl (but not harlequin ducks). It is a nice, quick hike where visitors can escape the road for a little bit. The trailhead is 1-1/2 miles west of Madison Campground on the West Entrance Road.

Two Ribbons Trail: This 1-1/2 -mile (round trip) trail is a completely boardwalked and winds through burned lodgepole pine and sagebrush communities next to the Madison River. There are good examples of fire recovery and regrowth here as well as buffalo wallows. There are no interpretive signs or brochures other than the wayside exhibits at the trailheads. The unmarked trailhead is in a large pullout approximately 5 miles east of the West Entrance.

Gallatin Area

There are many excellent hiking opportunities in the Gallatin area. Most of these, however, are longer and steeper than the average day hike. They include Daly Creek, the Sky Rim, Black Butte, Specimen Creek, Crescent Lake/High Lake, Sportsman Lake, and Bighorn Pass and Fawn Pass. For more information, consult a Visitor Center or one of the hiking trail guides available from the Yellowstone Association.

Mammoth Area

Mammoth Hot Springs

Even though Mammoth Hot Springs lies outside the caldera boundary, the geothermal activity here is the result of the same magmatic system that fuels other Yellowstone thermal areas. Hot water flows from Norris to Mammoth along a fault line roughly associated with the Norris to Mammoth road. Shallow circulation along this corridor allows Norris' super-heated water to cool somewhat before surfacing at Mammoth, generally to about 170° F.

While most of the geothermal formations you see in the park are made up of sinter, the hot spring terraces are travertine. This difference is the result of the kind of rock underlying the Mammoth area, which is limestone rather than rhyolite. Travertine formations grow much more rapidly than sinter formations due to the softer nature of limestone. Hot water charged with carbon dioxide (one of the gases released from the magma chamber) forms a weak carbonic acid solution. This acidic water rises through the limestone, dissolving large quantities of rock. Once the water reaches the ground surface, some of the carbon dioxide escapes from solution and the white, chalky mineral called travertine is deposited. About two tons of travertine are deposited each day on the terraces.

Although visitors are sometimes confused by the rapidly shifting activity of the hot springs and disappointed when a favorite spring appears to have "died," it is important to realize that the location of springs and the rate of flow in various springs changes *daily*. The overall volume of water discharged by all of the springs together fluctuates little, however.

The Mammoth area has been thermally active for several thousand years, and the evidence of past thermal activity is extensive. Terrace Mountain, northwest of Golden Gate, 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. The Mammoth Hotel, as well as all of Fort Yellowstone, is built upon an old terrace formation known as Hotel Terrace. (There was some concern when construction began in 1891 on the Fort site that the hollow ground would not support the weight of the buildings, but construction proceeded). Several large sink holes (fenced off) can be seen on the Parade Ground.

The Mammoth area also exhibits much evidence of glacial activity from the Pinedale Glaciation. The summit of Terrace Mountain is covered with glacial till, thereby dating the travertine formation there to earlier than the end of the Pinedale Glaciation (15,000 years ago). Several thermal kames, including Capitol Hill and Dude Hill, are major features of the Mammoth area. Ice-marginal stream beds are in evidence in the small, narrow valleys where Floating Island Lake and Phantom Lake are found east of Mammoth. In Gardner Canyon, one can see the old, sorted gravel bed of the Gardner River covered by unsorted glacial till.

Mammoth is much lower in elevation than the rest of the park, and has always been used by elk during winter. Today, however, elk are found in the Mammoth area year-round, a result of the development. In the summer, herds of cows and calves will congregate here to forage on the well-watered lawns. In the fall during the rut, the bulls will also move in and congregate on the lawns. There have been many close calls and some accidents because visitors approach the elk too closely thinking they are tame. Besides the ample supply of forage, the development offers elk refuge from their natural predators, including bears, coyotes, mountain lions, and (now) 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.

Fort Yellowstone

All of the red-roofed, many-chimneyed buildings in the Mammoth area are part of historic Fort Yellowstone. In 1886, after 14 years of inadequate civilian management of the park, the U.S. Army was called upon to manage the park's resources and visitors. Atroop of calvary was ordered to Yellowstone. Because the military only expected to be in Yellowstone a short while, they built a temporary post near the base of the Mammoth Terraces called Camp Sheridan. After five cold, harsh winters, it was apparent that tents were not sufficient to house the troop and construction

began on Fort Yellowstone, a permanent post.

The first building constructed (in 1891) was the guard house, which directly related to the Army's mission—protection and management of the park and its visitors. There were three stages of construction at Fort Yellowstone. The first set of clapboard buildings were built in 1891; the second set in 1897 when the military expanded to a two-troop fort. Finally, in 1909, the stone buildings were built. The military contingent assigned to Yellowstone was now 400 men or four troops. In 1916, the National Park Service was established, and the Army returned control of Yellowstone to civilians. However, the civilian NPS could not be organized quickly enough and the Army returned in 1917; their duty was finally completed in 1918. Fort Yellowstone is one of the best remaining examples of a 1900-era cavalry post. All of the buildings are adaptively used by the NPS today. The Albright Visitor Center and Museum was the bachelor officers' quarters during the military era.

There are many historic structures in the Mammoth area besides the Fort Yellowstone structures, including the Mammoth Hotel, which is actually the remaining wing of one of the early Mammoth Hotels; the Engineer's office ("Pagoda"), designed in 1903 by Hiram Chittenden of the U.S. Army Corps of Engineers; the Scottish Rite Chapel, 1913, still used today for religious services and is the site of many weddings; Reamer House, designed in 1908 by well-known architect Robert Reamer, an example of Prairie-style architecture; and the Haynes Picture Shop, photographic studio used by the Haynes family.

Roosevelt Arch

The first major entrance for Yellowstone was at the north boundary. Before 1903, trains would bring visitors to Cinnabar, Montana, which was a few miles northwest of Gardiner, Montana, and people would climb onto horse-drawn coaches there to enter the park. In 1903, the railway finally came to Gardiner. Robert Reamer, architect of the Old Faithful Inn and other structures in Yellowstone, designed an immense stone archway for coaches to travel through on their way into the park. At the time of the arch's construction, President Theodore Roosevelt was visiting the park and he officially placed the cornerstone for the arch. The Arch was subsequently named for him. The top of the Roosevelt Arch is inscribed with the phase, "For the benefit and enjoyment of the people," which is taken from the Organic Act of 1872, the enabling legislation for Yellowstone National Park.

45th Parallel Bridge & Boiling River

Asign near where the road crosses the Gardner River marks the 45th parallel of latitude. The 45th parallel is an imaginary line that circles 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 in Yellowstone, the line marks the Montana-Wyoming border.

Aparking area on the east side of the road is used by visitors who walk to the "Boiling River." Bathers must walk upstream about a half mile from the parking area to the place where the footpath reaches the river. This spot is also marked by large clouds of steam, especially in cold weather. Here, a large hot spring, known as Boiling River, enters the Gardner River. While it is illegal to bathe or soak in any hot spring in the park, use is allowed here where 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 the springtime due to hazardous high water and often does not reopen until mid-summer.

Mt. Everts

Mt. Everts was named for explorer Truman Everts, the member of the 1870 Washburn Expedition who became separated from his companions, lost his glasses, lost his horse, and spent the next 37 days starving and freezing and hallucinating as he made his way through the untracked and inhospitable wilderness. Upon rescue, he was, according to his rescuers, within but a few hours of death. Everts never made it quite as far as Mt. Everts. He was found near the "Cut" on the Blacktail Plateau Drive and was mistaken for a black bear and nearly shot. His story, which he

later published in *Scribner's Monthly Magazine*, remains one of Yellowstone's best known, lost-in-the-wilderness stories.

Mt. Everts, 7,841 feet high, is a 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 to 140 million years ago.

Bunsen Peak

Bunsen Peak and the "Bunsen burner" were both named for the German physicist, Robert Wilhelm Bunsen. Although most people are familiar with the "Bunsen burner," few people know why his students gave the burner that name. 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.

Bunsen Peak is 8,564 feet high and may be climbed via a trail that starts at the Golden Gate. Another trail, the Bunsen Peak road (which is now closed to autos), skirts around the flank of the peak from the YCC camp to the Golden Gate. This road may be used by hikers, bicyclists, and, in winter, cross-country skiers. The peak is also interesting because it burned in the 1880s and then again in 1988. Aseries of old photos show the creep of trees up Bunsen following the 1880 fires, and the new patterns of open space created by the fires of 1988.

South of Bunsen Peak is Swan Lake Flats, a large open expanse of meadows where visitors often see herds of elk and bison. Grizzly bears are also seen here at times. Swan Lake is an excellent spot for birders to see swans, ducks, herons, cranes, shore birds, and a variety of sparrows (in season. Beyond Swan Lake Flats is Willow Park where moose are often spotted.

Obsidian Cliff

Obsidian Cliff is located 11 miles south of Mammoth Hot Springs and rises 150 to 200 feet above Obsidian Creek. Obsidian is created when lava cools so quickly that it does not have time to form crystals. Amassive outcrop the size of Obsidian Cliff is quite rare because obsidian is usually found as small sections of other rock outcrops. Obsidian Cliff probably formed because the molten rock that erupted from the earth had very little water in it. The absence of water discourages the nucleation of atoms and causes faster cooling. Obsidian can be dated by measuring the hydration rate (absorption of water) of the rock. Because there are so few sources of obsidian in the world, matching a projectile point to a particular outcrop of obsidian is fairly easy.

For centuries, many Native Americans made their projectile points from obsidian. The rock itself is dark and glassy in appearance and, when broken, fractures into round pieces with sharp edges. Projectile points found as far away as Ohio have had their origin traced back to the Obsidian Cliff area. Tracking obsidian from Yellowstone to the Midwest indicates that the quality of obsidian found here was very good. In 1996, Obsidian Cliff was named a National Historic Landmark. The historic wayside exhibit here is one of the first of its kind in Yellowstone, built in the 1920s.

Day-Hiking Trails

Beaver Ponds Loop Trail: This moderately difficult, 5-mile loop trail follows the creek up Clematis Gulch, climbing 350 feet through Douglas-fir trees. The beaver ponds are reached after hiking 2-1/2 miles through open meadows of sagebrush and stands of aspen. Elk, mule deer, pronghorn, moose, beaver dams and lodges, and the occasional beaver and black bear may be sighted in the area. There are spectacular views as you wind your way back to Mammoth. The trail begins between Liberty Cap and the stone house (the Judge's house) next to the Mammoth Terraces.

Bunsen Peak Trail: This moderately difficult trail gradually climbs 1,300 feet to the summit of Bunsen Peak. From here there is a panoramic view of the Blacktail Plateau, Swan Lake Flats, Gallatin Mountain Range, and the Yellowstone River Valley. It is a 2 mile climb to the summit. 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 (now closed to automobiles). Osprey Falls is an additional 2.8 miles (see below). The trail begins at the gate across the Bunsen Peak

Road, 5 miles south of Mammoth (toward Norris).

Osprey Falls Trail: The 8-mile (round trip) trail follows the Bunsen Peak Road (now closed to automobiles) for 2-1/2 miles through grassland and burnt forest. The Osprey Falls trail veers off the road and follows the rim of Sheepeater Canyon before descending in a series of switchbacks to the bottom of Sheepeater Canyon (this portion of the trail results in a rating of difficult for this hike). The Gardner River plunges a 150 feet forming Osprey Falls. Vertical cliffs rise 500 feet above you, making it one of the deepest canyons in Yellowstone. The trail begins at the gate across the Bunsen Peak Road, 5 miles south of Mammoth (toward Norris).

Lava Creek Trail: This moderately difficult, 3-1/2 -mile (one way) trail follows Lava Creek downstream past Undine Falls (50 feet), descending gradually. Lava Creek meets the Gardner River farther downstream. The trail crosses a foot bridge on the Gardner River, and there is one final ascent to a pullout on the North Entrance Road just north of the Mammoth Campground. The trail begins at the Lava Creek picnic area on the Mammoth-Tower Road.

Rescue Creek Trail: This moderately difficult, 8-mile (one way) trail follows the Blacktail Deer Creek trail for the first 3/4 mile until meeting Rescue Creek trail. The trail climbs gradually through aspens and open meadows before beginning a 1,400 foot descent to the Gardner River. The trail crosses a foot bridge over the river and ends 1 mile south of the North Entrance Station. The trail begins at the Blacktail Trailhead 7 miles east of Mammoth on the Mammoth-Tower Road.

Sepulcher Mountain Trail: This strenuous, 11-mile loop trail follows the Beaver Ponds Trail to the Sepulcher Mountain Trail junction. This trail rises 3,400 feet through pine trees and open meadows until the 9,652 foot summit of Sepulcher Mountain is reached. To complete the loop, continue along the opposite side of the mountain through a broad open slope to the junction of the Snow Pass Trail. Continue down until you reach the junction with the Howard Eaton Trail. This will lead you west of the Mammoth Terraces and back to your original trailhead at Clematis Gulch between Liberty Cap and the stone house (Judge's house).

Wraith Falls: This short (1 mile round trip), easy hike takes you through open sagebrush and Douglas-fir forest to the foot of Wraith Falls cascade on Lupine Creek. The trailhead is the pullout 1/4 mile east of Lava Creek Picnic area on the Mammoth-Tower Road.

Blacktail Deer Creek-Yellowstone River Trail: This moderately difficult, 12-1/2 -mile trail follows Blacktail Deer Creek as it descends 1,100 feet through rolling, grassy hills and Douglas-fir forest until it reaches the Yellowstone River. The trail continues across the Yellowstone River on a steel suspension bridge and joins the Yellowstone River Trail. The trail continues downriver, passing Knowles Falls and into arid terrain until it ends in Gardiner, Montana. The trail begins at the Blacktail Trailhead, 7 miles east of Mammoth on the Mammoth-Tower Road.

Tower Area

The geology of the Tower area is incredibly varied. Major landforms are expressions of geologic events that helped shape much of the Yellowstone area. Mt. Washburn and the Absaroka Range are both remnants of ancient volcanic events that formed the highest peaks in the Tower District. Ancient eruptions, perhaps 45 to 50 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.

Later, glacial events scoured the landscape, exposing the stone forests and leaving evidence of their passage throughout the district. The glacial ponds and huge boulders (erratics) between the Lamar and Yellowstone rivers are remnants left by the retreating glaciers. Lateral and terminal moraines are common in these areas as well as in the Hellroaring and Slough creek drainages, on Blacktail Plateau, and in the Lamar Valley.

In the Lamar River Canyon lie exposed outcrops of gneiss and schist which are among the oldest rocks known in Yellowstone, perhaps more than two billion years old. Little is known about their origin due to their extreme age. Through time, heat and pressure have altered these rocks from their original state, further obscuring their early history. Only in the Gallatin Range are older outcrops found within the boundaries of the park.

The (relatively) low elevation valleys of the Yellowstone and Lamar rivers 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 the site for reintroduction of gray wolves into Yellowstone in 1995 after a nearly 60 year absence. Historic accounts indicate that wolves inhabited nearly all portions of the district, especially the Lamar Valley and Hellroaring Creek drainages. Multiple wolf pack territories currently exist in this prime habitat.

Both grizzly and black bears are sighted throughout the area, particularly in the spring. The Antelope Creek drainage on the east slopes of Mt. Washburn is notable for having a high density of grizzly bears, particularly in the spring when elk are calving. From pullouts on the Dunraven Pass road, visitors have an excellent platform from which to view grizzlies.

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. The nearby Bannock Ford on the Yellowstone River was an important travel route for early Native Americans to access the buffalo plains east of the park from the Snake River plains in Idaho as well as for early European visitors and miners. It was extensively used from approximately 1840 to 1876. Alengthy portion of the trail extends through the Tower area from the Blacktail Plateau (closely paralleling or actually covered by the existing road) to eventually where it crosses crossing the Yellowstone River at the Bannock Ford upstream from Tower Creek.

Calcite Springs

This grouping of thermal springs along the Yellowstone River signals the downstream end of the Grand Canyon of the Yellowstone. The geothermally altered rhyolite inspired the artist Moran; his paintings of this scene were among those presented to Congress in 1872, leading to the establishment of the park. The steep, columnar basalt cliffs on the opposite side of the river from the overlook are remnants of an ancient lava flow, providing a window into the past volcanic forces that shaped much of the Yellowstone landscape. The gorge and cliffs provide habitat for numerous wildlife species including bighorn sheep, red-tailed hawks, and osprey.

Roosevelt Lodge

The Roosevelt Lodge was constructed in 1920 and has been determined eligible for the National Register of Historic Places. The Roosevelt National Historic District also includes the Roosevelt cabins. Interestingly, one of the reasons Roosevelt Lodge was nominated for the National Register was due to its important role in early park interpretation. The nearby Tower Ranger Station is a

remodeled reconstruction of the second Tower Soldier Station, which was built in 1907. Pleasant Valley is across the road from the Roosevelt Lodge area. It was the sight of "Uncle John" Yancey's Pleasant Valley Hotel, one of the earliest lodging facilities in Yellowstone. The hotel and outbuildings were built between 1884 and 1893 and served early park visitors as well as miners passing through en route to the mining district near Cooke City. Currently, the site is used by the concessioner for their "Old West" cookouts. None of the original buildings remain.

Specimen Ridge

Specimen Ridge, located along the Northeast Entrance Road east of Tower Junction, contains the largest concentration of petrified trees in the world. There are also 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 easily accessible to park visitors. The interpretive message here also applies to those trees found on Specimen Ridge.

The Buffalo Ranch

The Lamar Buffalo Ranch was built in the early part of the century in an effort to increase the herd size of the few remaining bison in Yellowstone, preventing the feared extinction of the species. Buffalo ranching operations continued at Lamar until the 1950s. The valley was irrigated for hay pastures, and corrals and fencing were scattered throughout the area. Remnants of irrigation ditches, fencing, and water troughs can still be found. Four remaining buildings from the original ranch compound are contained within the Lamar Buffalo Ranch Historic District (two residences, the bunkhouse, and the barn) and are on the National Register of Historic Places. In the early 1980s, old tourist cabins from Fishing Bridge were brought to Lamar to be used for Yellowstone Institute classes. In 1993, the Yellowstone Association funded the replacement of the old cabins with new insulated and heated structures. The facility is also used in the spring and fall for the Park Service's residential environmental education program, Expedition: Yellowstone!

The Northeast Entrance Ranger Station

The Northeast Entrance Ranger Station was constructed in 1934-35 and is a National Historic Landmark. its rustic log construction is characteristic of "parkitecture" common in the national parks of the west during that period.

Day-Hiking Trails

Lost Lake: This 4-mile loop trail offers views of Lost Lake, waterfowl, wet meadows, sagebrush hilltops, wildflowers, and quite often black bears. Parts of the trail are used by horse parties. For your safety when meeting horses, we recommend you move to the downhill side of the trail and remain still until they have passed. The trail begins behind the Roosevelt Lodge and climbs 300 feet onto the bench. Here the trail joins the Roosevelt horse trail and continues west to Lost Lake. (If you take the trail east, you loop back to the Roosevelt corrals on the horse trail or continue on to Tower Fall Campground.) From Lost Lake, the trail follows the contour around the hillside to the Petrified Tree parking area. Cross the parking lot and climb the hill at its northeast end to loop back behind Tower Ranger Station. Cross the creek and return to the Roosevelt Lodge cabins.

Garnet Hill Loop Trail: The Garnet Hill Loop Trail is 7-1/2 miles long. To access the trail, park in the large parking area to the east of the service station at Tower Junction. Walk down the road toward the Northeast Entrance Road (approximately 100 yards) and head west on the dirt stagecoach road about 1-1/2 miles to the cookout shelter. Continue north along Elk Creek until nearly reaching the Yellowstone River. Here the trail divides, with the west fork joining the Hellroaring Trail and the east fork continuing around Garnet Hill and eventually returning to the Northeast Entrance Road where it is a short walk back to Tower Junction.

Hellroaring Trail: The Hellroaring Trail is strenuous and can be reached from the fork of Garnet Hill Trail (see above) or you can start from the Hellroaring parking area 3.5 miles (5.6 km) west of Tower Junction. Follow the trail over the Yellowstone River Suspension Bridge, across a sagebrush

plateau, and drop down to Hellroaring Creek. The Yellowstone River and Hellroaring Creek are both popular fishing areas. Note: This trail can be hot and dry during the summer months. Please remember to take water! Also, watch your footing if you go off-trail and onto the smooth river boulders along the Yellowstone River. If you hike to Hellroaring Creek and back via the Garnet Hill Loop Trail, the hike is 10 miles round trip. If you hike to Hellroaring Creek and back via the Hellroaring Trail, the hike is 4 miles round trip

Yellowstone River Picnic Area Trail: This often overlooked trail (3.7 miles round trip) along the east rim of the Yellowstone River offers views of the Narrows of the Yellowstone, the Overhanging Cliff area, the towers of Tower Fall, basalt columns, and the historic Bannock Ford. Tower Fall itself is not visible, but the store and highway across the river can be seen for reference purposes. The trail ties into the Specimen Ridge Trail above the Bannock Ford. (Continue up to Specimen Ridge only if you are prepared for a longer hike with few trail markers.) Begin at the Yellowstone Picnic Area (1-1/4 miles northeast of Tower Junction on the Northeast Entrance Road). The trail will end at the Specimen Ridge Trailhead where you will then walk west along the road for 0.7 miles back to the Yellowstone River Picnic Area. Watch for bighorn sheep along this trail but please don't approach them! Use caution along the river canyon with its steep dropoffs.

Slough Creek Trail: This is both a scenic walk and a fishing trail, a favorite of catch-and-release anglers from around the country. The trail follows a historic wagon trail up Slough Creek through several meadows and over Plateau and Elk Tongue creeks. From the trailhead, the trail switchbacks up a moderately steep trail and rejoins Slough Creek at the first meadow (2 miles one way). (If you go on to the second meadow, it is 5 miles, one way.) While wildlife do not abound in this meadow during the summer, moose are commonly seen. Grizzly and black bears also use this valley. As on all Yellowstone trails, be alert for the possibility of bears in the backcountry. You may encounter the horse-drawn wagons of Silver Tip Ranch, a private ranch north of the park boundary that has a historic right of access. The trail begins near the vault toilet on the road to Slough Creek Campground. It is moderately strenuous for the first 1-1/2 miles, then easy.

Mt. Washburn Trail: The hike to the top of Mt. Washburn is one of the most popular hikes in Yellowstone. Two trails, each 3 miles in length (one way), switchback to the summit where expansive views of much of Yellowstone unfold below on clear, summer days. An enclosed observation area allows you to get out of the wind. Bighorn sheep are seen quite frequently during the summer on the upper parts of the trails. Harsh alpine conditions contribute to short growing seasons for the fragile alpine vegetation on the mountain. Please stay on the trails and do not approach sheep or other wildlife to help preserve the wildness of this area. The northern trail begins at the Chittenden Road parking area, 8.7 miles south of Tower Junction. The southern trail begins at Dunraven Pass parking area, 13.6 miles south of Tower Junction. More parking is available at the Chittenden Road Trailhead, although hikers using this trail may encounter bicycles and occasionally vehicles accessing Mt. Washburn for maintenance purposes.

Expedition: Yellowstone!

Aresidential environmental education program for students in grades 4–6. Based at the historic Buffalo Ranch in the Lamar Valley. Rangers lead field explorations of the natural and cultural history of the area and the issues associated with the ecosystem.

- Began 1986
- Served 10,739 children so far
- In 1999, 779 students

The Junior Ranger Program

Following suggestions and activities in the program's newspaper, young summer visitors and their parents learn more about the park; children earn patches and public recognition.

- Began 1992
- Served 86,996 children so far
- In 1999, almost 15,000 students participated

Exploring Yellowstone

Seven week summer program providing a variety of classes, usually skill-oriented, to students in grades 1–7 from the communities of Mammoth, Gardiner, Cooke City, and Emigrant.

- Began 1996
- Served 354 students so far
- 1999, 114 students took

Earth Day Yellowstone

Annual celebration and education fair to promote a sense of personal responsibility for the resources of the greater Yellowstone ecosystem.

- Began 1995
- 2,000 attendees so far
- In 1999, 400 students, teachers, and parents attended.

Expedition: Yellowstone!

This residential environmental education program offers fourth through sixth graders an in-depth park experience. Classes are selected by lottery for a spring or fall session. Selected classes, their teacher, and parent chaperons spend three to five days at the historic Buffalo Ranch in the Lamar Valley. Rangers lead the groups on field explorations where they learn about the natural and cultural history of the area and the issues associated with the ecosystem. This curriculum-based program has been in existence since 1986 and serves approximately 900 people annually (with operations limited to spring and fall). The majority of the groups come from Montana, Wyoming, Idaho, and Utah. Originally a free program, this program became fee-based in 1995. Under the current fee schedule, the program is entirely self-supporting.

Junior Ranger Program

The Junior Ranger program offers young summer visitors and their parents the opportunity to learn more about the park in a largely self-guided fashion. This program, for 5 through 12 year-olds, consists of two activity papers available for a small fee at all Visitor Centers. Upon completion of the required activities, participants return to a Visitor Center where a ranger will review their work and award a patch. This program has been in place since 1992 and serves more than 11,000 children annually; the program is being expanded.

Informational Services

A variety of scientific papers, monographs, articles, brochures, posters, and teaching packets are available to educators and students through the Environmental Education Office. These are distributed through the residential program, training sessions, workshops, and on a request basis. There are no fees associated with this program.

The following publications are available for a fee to the general public:

- *Expedition: Yellowstone!* This 265-page curriculum is targeted for fourth through sixth grade students. It is inter-disciplinary and includes both classroom and field activities.
- *Getting to Know Wildland Fire* This 32-page activity book was designed as a supplement to the Expedition: Yellowstone! curriculum. It includes background information as well as classroom and field activities on fire ecology.
- *Getting to Know the Wolf* This 32-page supplement includes background information and student activities on the natural history and political issues surrounding the wolf.
- *Getting to Know Yellowstone's Water* This award-winning supplement, developed by the Watercourse, includes background information and student activities on diverse aspects of water as it has influenced the greater Yellowstone ecosystem, from the region's early exploration (following water routes) to current issues.
- "National Park Discovery Kit" This teaching kit focusing on Yellowstone is targeted at grades 5-8 and is available for check-out through the Environmental Education Office. The kit includes a video, maps, a teacher's guide, and set of 21 photo cards featuring Yellowstone and other national park sites. Using this kit, students explore the national park system, visit the world's first national park, and apply the concept of preservation in their own community. The kit was made possible through funding by Target and the Eureka Company.

An educational services program meets the need for programming outside the realm of that offered through traditional summer programming. This includes programs both in and outside the park and includes programming for academic groups, civic groups, and other interested parties. The Environmental Education Staff serves as program coordinators and brokers for such requests on a park-wide basis. This program handles more than 200 requests annually, resulting in more than 8,000 visitor contacts.

The Yellowstone National Park Film Library provides schools, civic groups, and individuals with films and videos on subjects such as wildlife, U.S. history, and the environment as well as on Yellowstone National Park subjects. The Film Library functions on a subscription basis. An annotated list of titles is available free of charge through the Environmental Education Office.

Exploring Yellowstone Program

The "Exploring Yellowstone" summer program is offered through the Yellowstone Park School in conjunction with the division of Interpretation. The program is offered for seven weeks and is open to students in the communities of Mammoth, Gardiner, Cooke City, and Emigrant who have completed kindergarten; the upper age limit is students who have completed seventh grade. The program is primarily grant-funded. Anominal registration fee is required. Classes are varied, usually skill-oriented, and with an outdoor focus. The program is staffed by various individuals with an interest in sharing knowledge and skills with local children.

The Environmental Education staff also offer a ski program for Gardiner School students in grades 1 through 3. The children receive a half day of instruction in winter ecology by park environmental education staff. Activities occur both in the classroom and in the field and are designed to promote safe outdoor recreation and greater resource appreciation and understanding.

Earth Day Yellowstone!

This annual event is attended by more than 350 students, teachers, and parents from communities surrounding the park. Involving students in grades K-12, this educational fair draws on the expertise of many park personnel. The goal of the program is to both celebrate and promote a sense of personal responsibility for the resources of the greater Yellowstone ecosystem.

Wolf Restoration

History

- 1975: The wolf restoration process in Yellowstone began.
- 1991: Congress appropriated money for an EIS for wolf recovery.
- 1994: Regulations outline managing wolves as a nonessential experimental population. For example, wolves could be chased off private land and could be shot in the act of killing livestock.
- 1994: EIS completed for wolf reintroduction in three areas; Yellowstone, central Idaho, and northwestern Montana (where they occur naturally).
- 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.
- The goal: de-list the gray wolf when there are 10 breeding pairs in each of the three geographic locations for three successive years.

Current Status

- 11 packs
- 115 individuals
- High pup mortality in 1999 was probably due, in part, to parvo virus.
- Approximately 75 wolves have died since they were reintroduced. Anumber of pups did not survive the first few weeks, some wolves were destroyed due to livestock predation, some died of natural causes, some were killed by motor vehicles, and some were shot illegally.

Other Info

- The Defenders of Wildlife has spent $54,450 to compensate ranchers for livestock lost to wolves from 1996–1999.
- Livestock predation by wolves since reintroduction: 100 sheep, 12 cattle
- 90% of a wolf's diet consists of elk. Wolf packs on the northern range kill about 9 elk in a 30 day period in early winter and about 14 elk in a 30 day period in late winter.

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 it is likely that an occasional wolf would wandered into the Yellowstone area. Awolf-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. Until recently, wolves persisted in the lower 48 states only in northern Minnesota and on Isle Royale in Michigan. During the 1980s, wolves began to reestablish breeding packs in northwestern Montana; 50–60 wolves inhabited Montana in 1994. Wolf reports are increasing in Idaho, and wolves are reported occasionally in the state of Washington. The wolf is listed as "endangered" in the lower 48 states except Minnesota, where it is "threatened."

National Park Service (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 out-

side 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. In a 1990 report to Congress, scientists wrote that wolves would likely not greatly reduce populations of mule deer, pronghorns, bighorn sheep, white-tailed deer, or bison. Minor effects were predicted for grizzly bears and mountain lions. Coyotes would probably decline, and red foxes would probably increase. The University of Wyoming predicted reductions of elk (15-25 percent), bison (5-15 percent), moose, and mule deer in Yellowstone. Apanel of 15 experts predicted decreases in moose (10-15 percent) and mule deer (20-30 percent).

In 1991, Congress provided funds to the USFWS to prepare, in consultation with the 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 a nonessential experimental population under section 10(j) of the Endangered Species Act. These regulations took effect in November 1994. Once wolf management plans (based on federal guidelines) are completed for each state, the states and tribes will implement and lead wolf management programs outside the boundaries of national parks and wildlife refuges.

Park staff assisted with soft releases of wolves in the park. This technique has been used to restore red wolves in the southeastern United States and swift fox in the Great Plains; it involves holding animals temporarily in areas of suitable habitat. Temporary penning of the animals is intended to discourage immediate long-distance dispersal. In contrast, a hard release allows animals to disperse immediately wherever they choose; this method was used with wolves in Idaho where there is limited access to the central Idaho wilderness.

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, an additional site on Blacktail Plateau was prepared for use in 1995-96. At each site, approximately 1 acre was 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). Inside each pen were several plywood "security" boxes to provide 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.

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 as well as on elk and deer. Groups included breeding adults and pups ranging 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.

Although concern was expressed about wolves becoming habituated to humans or to captive conditions, the temporary holding period was not long in the life of a wolf. In Alaska and Canada,

wolves are seldom known to develop the habituated behaviors seen more commonly in grizzly bears. Wolves, while social among their own kind, typically avoid human contact. They are highly efficient predators and will not lose their predatory instincts during a short captivity period. Their social structure and pack behavior minimizes their need to scavenge food or garbage available from human sources. Compared to bears, whose diet is predominantly vegetation, wolves have less specific habitat requirements. The wolves'primary need is for prey, which is most likely to be elk, deer, and other ungulates in these recovery areas.

Since being released, Yellowstone's wolves have thrived, setting up residence in and around the park. Some wolves live near the park's southern and western borders, and several range north, northeast, and well south of park boundaries.

The 14 wolves released in 1995 bore two litters with a total of 9 pups. In 1996, wolves had four litters with a total of 14 pups. In 1997, 67 pups were born to 13 females in nine packs. In 1998, 42 pups were born into 7 different packs. As of January 2000, there were at least 115 free-ranging gray wolves in the greater Yellowstone population in 11 packs.

In December 1997, U.S. District Court Judge William Downes (ruling on consolidated lawsuits filed by James R. and Cat D. Urbigkit, the National Audubon Society, and the Wyoming Farm Bureau Federation), found that the wolf reintroduction program in Yellowstone and central Idaho violated the intent of section 10(j) of the Endangered Species Act. He reasoned that 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 was "especially mindful of the concerted efforts of the Government and wolf-recovery advocates to accommodate the interests of stockgrowers and others who may be adversely affected by the wolf recovery program," and 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 Department of the Interior asked the Justice Department to appeal the case, and an appeal was filed with the Tenth Circuit Court of Appeals on February 6, 1998. In January 2000, the decision was reversed.

In January 1998, park staff captured and radio collared 17 wolves from five packs as part of long-standing plans to continue monitoring the progress of the recovery effort. The capture operations were completed without injury to either human handlers or wolves. In January 1999, park staff again captured and radio collared wolves. Twenty-four wolves from seven packs were collared. Unfortunately, one young wolf was injured in the operation and had to be euthanized.

For both central Idaho and Yellowstone (as well as northwest Montana where wolves now occur without the aid of reintroduction), wolf population recovery is defined as having about 100 wolves (approximately 10 breeding pairs of wolves) that produce pups surviving to the end of the year established in each area for three successive years. Due to the initial success of the reintroduction program in Yellowstone and central Idaho and to fiscal realities, no additional transplants of wolves are planned. However, the goal to restore wolves to Yellowstone and central Idaho and begin delisting them by the year 2002 appears within reach, perhaps even ahead of schedule and under budget.

8

Lake Trout

The Issue

- Non-native lake trout have invaded Yellowstone Lake.
- One lake trout can consume up to 90 cutthroat trout per year.
- If no action is taken, cutthroat trout in Yellowstone Lake would decline by 50% within 20 years.
- 42 wildlife species, including the grizzly bear and bald eagle, depend on the cutthroat trout.
- Lake trout are not a substitute food because they live at much greater depths than cutthroat trout.

History

- During the time that the park stocked fish, lake trout were introduced to Lewis Lake 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.

Management Actions

- Remove lake trout by gill netting.
- Encourage anglers to catch lake trout.
- Determined the abundance and distribution of lake trout in Yellowstone Lake.
- Located two major lake trout spawning areas in West

Results

- Over 15,000 lake trout have been gill-netted in Yellowstone Lake since 1994; about 1000 more removed by anglers.
- With continued aggressive control efforts, lake trout numbers can be reduced and the impacts to cutthroat trout minimized.

When Euro-Americans arrived in Yellowstone, many park waters were barren of fish. 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 lakes, rivers, and streams. At that time, lake trout or Mackinaw were brought from the Great Lakes (where they are native) and planted in Lewis Lake, one of the park's lakes that was fishless.

Yellowstone Lake, on the other hand, had a healthy population of Yellowstone cutthroat trout, a native fish of the West that now is limited to the upper Yellowstone River drainage, which represents about 15 percent of its historic range. Lake trout were never stocked in Yellowstone Lake. However, on July 29, 1994, a young girl fishing on Yellowstone Lake reeled in a fish that was not a native cutthroat trout—it was a lake trout. There is no natural way for lake trout to have gotten into Yellowstone Lake, which means that they were illegally introduced

This discovery of lake trout in Yellowstone Lake was alarming. Where lake trout have been introduced into other western waters having native cutthroat trout, the results have been disastrous for the native fish. Cutthroat trout fisheries have been decimated because the lake trout is a large and aggressive predatory fish. But, in Yellowstone Lake, if the lake trout population is not controlled, the result will be far-reaching beyond the impacts to the cutthroat trout population. In fact, some people believe it will be an ecological disaster.

In early 1995, a group of experts was convened to review the situation, exchange information, and make recommendations. The group reached five general conclusions: lake trout have probably been in Yellowstone Lake for at least 10 years (continuing research has moved this estimate back

to at least 20 years), lake trout have reproduced annually since at least 1989, Yellowstone Lake is a favorable environment for lake trout, a rapid population increase of lake trout is imminent, and lake trout are a potential keystone predator in the ecosystem.

The group recommended gill netting for lake trout at "choke point" areas in the lake. The choke points were areas of steep drop offs where lake trout are thought to concentrate. During 1996 and 1997, spawning grounds were discovered in the West Thumb area of the lake, and gill netting is now also targeted here. Some lake trout captured on these spawning grounds were implanted with radio transmitters so that biologists could follow their movements and learn more about their use of the lake.

Through the centuries, the various and diverse species of wildlife (both aquatic and terrestrial) that make up the lake ecosystem evolved together and developed an interconnectedness that, in some cases, is critical to their lives. Cutthroat trout are an important food source for more than 40 different species of birds and animals in the ecosystem, including osprey, eagles, pelicans, river otters, and the threatened grizzly bear. Native Yellowstone cutthroat trout spend the majority of their lives at or near the surface of the water in the lake where they are available as prey, especially to birds and otters. Cutthroat trout also migrate into rivers and streams around the lake to lay their eggs (spawn) in the spring. Grizzly bears, having recently emerged from their winter dens and seeking high-protein food sources, are drawn to these spawning streams. In contrast, the non-native lake trout spend most of their lives in very deep water, and they spawn on rocky substrates in the lake itself in the fall. Consequently, lake trout are rarely available to the predators that feed on the cutthroat trout.

There is no way to eliminate the lake trout from Yellowstone Lake. However, it is believed that ongoing management of the problem can control lake trout population growth, maintain the cutthroat trout population, and, thus, sustain the wildlife populations that depend on the cutthroat trout for food.

Research into the problem began in late summer of 1994. Data collected in 1995 and 1996 have been used in subsequent years to direct control efforts using various intensive gill netting techniques. Three different netting strategies are employed: control, distribution, and spawning. The netting operations not only remove lake trout from Yellowstone Lake, but also determine the distribution of the fish in the lake, provide data to estimate lake trout population size and age structure, and aid in the discovery of spawning areas. Lake trout gill netting begins in late May or early June, depending on when the ice is gone from the lake, and continues into October.

Control netting is primarily comprised of large-mesh (less than two-inch) gill nets strategically placed to capture large lake trout while minimizing both cutthroat trout bycatch and resource effort. Since lake trout control operations began in 1994, 15,000 lake trout have been caught.

Distribution netting, as the name implies, means nets are set throughout the lake 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.

Lake trout spawning begins in mid- to late-September when the lake's waters cool to about 38°F (11°C). During 1996, a lake trout spawning area was discovered in the West Thumb region of Yellowstone Lake at Carrington Island. Fish here were radio-tagged and released so that they could be tracked to learn more about where lake trout go in the lake and to locate other spawning areas. Anew spawning ground was subsequently located in West Thumb between Breeze Point and Solution Creek. Unfortunately, the site is quite deep, around 65 feet. Spawning net strategy targets these spawning grounds during the spawn. Biologists continue to search for other spawning areas.

In 1997, an initial hydroacoustic survey (using electronic fish finders) confirmed the suspected distribution of lake trout, which appear to concentrate in the western portion of the lake. These surveys also revealed the deepwater (deeper than 130 feet) distribution of medium-sized (12-16 inches) lake trout. The real, long-term benefit of hydroacoustics, however, will be in the abundance estimates of both lake and cutthroat trout populations that it can provide. This index of abundance will likely be invaluable for the long-term monitoring of Yellowstone Lake fisheries.

Anglers are an important component in the lake trout management process. Anglers 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 early in the year (June and early July). To date, anglers have taken approximately 15 percent of the lake trout removed from Yellowstone Lake. Fishing regulations require anglers to keep all lake trout caught in Yellowstone Lake and to take the fish to park ranger stations or visitor centers for data collection. In 1998, fishing regulations changed in another effort to further control the lake trout population. Fishing season now opens on Yellowstone Lake on June 1 instead of June 15 in an attempt to catch more lake trout, which are found in shallower waters at this time of year. Recognizing that there will be some cutthroat trout mortality due to this new regulation, cutthroat trout fishing is catch-and-release only until July 14. Catch limits for cutthroat trout (two fish under 13 inches) begin on July 15, instead of June 15 as in past years.

About 80 percent of a lake trout's diet consists of cutthroat trout. Based on lake trout predation studies done elsewhere, fisheries biologists estimate that approximately 50 to 60 cutthroat trout are saved for every lake trout caught. The long-term goal for the lake trout control program is to limit lake trout numbers so that they eat fewer cutthroat trout each year than anglers take home. Currently, mortality from anglers is approximately 40,000 to 50,000 cutthroat trout each year. Continued monitoring of the cutthroat trout population will occur in order to be sure that the lake trout control program is effective in keeping lake trout predation under the angler exploitation rate. Because cutthroat trout are an integral part of the Yellowstone Lake ecosystem and key to many species' survival, it is possible that greater angler restrictions for cutthroat trout will be necessary in the future.

8

Whirling Disease

The Issue

- Whirling disease has been confirmed in 20 states and appears to be rapidly spreading throughout the western United States.
- 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 extremely vulnerable to predation.
- Rainbow trout populations appear to be most susceptible to the disease; recent research suggests that cutthroat may be more susceptible. Lake trout appear to be immune to the disease, and brown trout are highly resistant, but can be infected and act as carriers of the parasite.
- There is no treatment for whirling disease.

History

- 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.
- In fall of 1998, whirling disease was detected in cutthroat trout in Yellowstone Lake.

Current Status

- Testing for the disease continues throughout the park.
- Rangers include messages about whirling disease in interpretive programs.
- People can help prevent spreading the disease by thoroughly cleaning mud and aquatic plants from all equipment, clothes, and gear before moving to another water. Anglers should not transport fish between drainages and should clean fish in the water where they were caught.

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 in portions of the Madison River drainage outside the park and below Quake Lake.

Whirling disease is caused by a microscopic protozoan that can infect trout and salmon; the parasite does not infect humans. The parasite attacks the developing cartilage of young fish and results in deformities of the bony structures. Clinical signs of an infected fish include a deformed head and tail, blackened areas of the tail, and the typical whirling swimming behavior. Once this occurs, fish are unable to feed normally and are extremely vulnerable to predation.

Whirling disease was first described in Europe more than 100 years ago. It probably came to this country in the mid 1950s, possibly in frozen fish products. Its presence has been confirmed in 20 states and appears to be spreading rapidly throughout the western United States. Rainbow trout seem to be most susceptible, although recent research suggest that cutthroat trout may also be extremely vulnerable to the disease. Species such as brown trout and lake trout seem to be relatively resistant to the effects of the disease, but may still carry and transmit whirling disease to other species.

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. AWhirling Disease Task Force was formed to deal with 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 the state of Montana.

In Yellowstone National Park, surveys for whirling disease have been done for a number of years at various sites, including Soda Butte Creek and the Bechler, Firehole, Gibbon, Gallatin, and Gardner rivers; all have tested negative for the parasite. However, surprisingly, whirling disease was discovered in Yellowstone Lake cutthroat trout samples in fall 1998.

There is no known effective treatment 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

Bison Management

Current Issues

- About half of Yellowstone's bison test positive for exposure to brucellosis, a disease that causes domestic cattle to abort their young. This causes great concern to the cattle industry in Montana. (See "Bison and Brucellosis" later in this chapter.)
- Beginning in 1968, the NPS and the Montana Dept of Fish, Wildlife, and Parks made numerous attempts to control bison leaving the park.
- In 1985, the State of Montana began a public hunt to control bison leaving the park.
- In 1990, the Montana legislature halted the public hunt and entered into an agreement with NPS to develop a long-term management plan and EIS. In the interim, government sharpshooters shot the bison leaving the park. (See the next article.)
- In the severe winter of 1996-97, 1,084 bison were shot or sent to slaughter, reducing the population 30% to 2,000 animals.

Current Status

- Until the EIS is adopted, NPS and the State of Montana operate under the Interim Bison Management Plan:

  Haze migrating bison back in the park

  Capture bison that cannot be hazed back into the park and test them for brucellosis.

  Send to slaughter all bison that test positive.

  NPS would temporarily hold all bison that test negative in the Stephens Creek capture facility.

  Allow untested low risk animals—bulls, calves, yearlings, non-pregnant females—to graze during winter on adjacent federal lands on the west side of the park.

  Send all pregnant females to slaughter, even if test negative.
- Number of bison killed each winter:

  1996–97: 1,084; 1997–98: 11; 1998-99: 94; 1999-2000: 0
- In August, 1999, approximately 7,800 acres of winter wildlife habitat adjacent to the northern park boundary was purchased by the federal government or put under easement.
- Preliminary results of NPS research on bison movement in the park suggest that the animals do not travel on groomed roads, but follow rivers and other natural corridors.

Yellowstone National Park is the only place in the lower 48 states to have a continuously free-ranging bison population since prehistoric times. The struggle to save this herd in the early part of the 20th Century is one of the greatest triumphs of the American conservation movement. However, the price of success has been a herd that has grown large enough to seek new ranges. Since the 1970s, bison have attempted to leave the park, especially via the Madison and Yellowstone river valleys. Because some of these animals carry brucellosis, the bison are not welcome outside the park as are all the other wildlife that use the same migratory corridors. Through the 1980s and 1990s, this issue has grown steadily into one of the most heated and complex of Yellowstone's resource controversies.

The History of Bison Management

Market hunting, sport hunting, and a U.S. Army campaign in the late 1800s nearly resulted in the extinction of the American bison. By the turn of the century, there were probably fewer than 50 native bison remaining in Yellowstone National Park, with none on the northern winter range. In 1902, only 23 bison were counted in Pelican Valley. The U.S. Army, which administered Yellowstone at that time, protected these bison from further poaching.

In addition, captive bison from Montana and Texas (the Pablo-Allard herd and the Goodnight herd, respectively) were brought to Yellowstone in 1902 and were intensively managed separately from the native bison. Various management techniques were used in the park from 1902 until the mid-1930s in order to increase the herd size. During that period, very 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. However, bison were still managed, albeit sporadically, through removals until the mid-1960s. In 1968, manipulative management of bison ceased, allowing intensive research on natural ecological processes to begin. By this time, the bison in Yellowstone wintered in three fairly distinct herds, although there is some overlap between the herds at various times of the year. These herds are called the Northern (Lamar Valley) herd, the Mary Mountain (Hayden Valley-Firehole River) herd, and the Pelican Valley herd.

In the 1930s, the Northern (introduced) herd, for which fairly good records were kept, numbered more than 1,000 animals. In January 1954, an aerial survey of the entire park placed the number of bison at 1,477. Subsequent management reductions were carried out on all three herds, and an aerial count in March 1967 indicated there were 397 bison in the entire park. The bison population grew following the end of manipulative management practices in 1968 and reached a peak in summer 1994 of 4,200 animals. The population has declined since the winter of 1994-95, primarily due to management removals and some winterkill. In February 2000, the park's bison population numbered between 2,200 and 2,500 animals.

For an excellent review of the history of bison and bison management in Yellowstone from the late 1800s to 1968, see *The Bison of Yellowstone National Park* by Dr. Mary Meagher (1973, National Park Service Scientific Monograph Series 1).

Habitat Occupation and Migration

In past years, Yellowstone bison have moved, sometimes in large numbers, onto public and private lands beyond the park's boundary. Several factors, most significantly a series of mild winters, combined to increase the population of bison to its peak in 1994. The size of their population, in turn, influences bison distribution.

Just as with other wildlife populations, bison will attempt to occupy all suitable habitat, if allowed to do so. Apopulation, including one that is fully occupying its habitat, is influenced by climate, forage, and other species, including humans. In short, a population and its habitat are in a relationship that is interactive and dynamic. Change is a part of this natural process.

Once Yellowstone's bison occupied all suitable habitat inside the park, they began to migrate onto lands outside of 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.

Bison and Brucellosis

- 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. This is a cause of great concern to the cattle industry in the State of Montana.
- 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.
- Cattle 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, is no longer a public health issue.
- The vaccine (strain 19), which is 65–75% effective for cattle, provides little protection for bison. The current vaccine used in cattle, RB51, is still being studied for its potential use in bison.
- Brucellosis has had no apparent impact on the health of the bison population.
- 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. It regards Yellowstone's bison as a threat to the state's brucellosis-free status and fears the economic impacts this could pose to the livestock industry.
- Elk, which are far more numerous than bison, also carry brucellosis.

Brucellosis, caused by the bacterium *Brucella abortus,* can cause pregnant cattle to abort their calves. The disease is transmitted primarily when non-infected animals come into direct contact with infected birth material. There is no cure for brucellosis, nor is there, at present, a suitable vaccine for the disease in bison like there is for cattle.

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 required by law, humans have virtually no risk of contracting the disease. And if they do, the disease can be treated by antibiotics.

Brucellosis was discovered in Yellowstone bison in 1917. It is believed bison contracted the disease from domestic cattle (which at that time were raised in the park to provide milk and meat for visitors staying at the hotels). Since that time about 50 percent of the park's bison test positive for exposure to the brucella organism. Testing positive for exposure (seropositive) does not mean the animal is infected with the disease and capable of transmitting brucellosis. (A human example may help clarify this: most people in the United States received a smallpox immunization shot during their childhood. Consequently, these people would test positive for antibodies to smallpox, however, that does not mean they are infectious for the disease.) Data collected in 1992 indicate a minimum of 12 percent of Yellowstone's bison actually carry *Brucella abortus*. It has never been documented that bison can transmit the disease to domestic cattle in the wild, although this has been achieved under laboratory conditions.

There are many other issues about brucellosis that are not yet fully resolved. Many people have assumed that scientific data on brucellosis in cattle can be applied to bison. They also assume that the disease manifests itself identically in the two species. A recent review of published and unpublished data shows that infected bison differ from infected cattle in the way they respond to natural infections, vaccines, and even standard testing for the disease. Until additional research is conducted on wild bison, understanding of the bison host/brucella organism relationship will remain limited. Additionally, serologic tests used for cattle may not be accurate for bison.

Elk in the greater Yellowstone ecosystem also test positive for the brucella organism, and there is some concern that this reservoir for the disease could reinfect a bison herd that was culled to be

free of the brucella organism. Avariety 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 are given a status of "brucellosis class-free" and are able to export livestock without restrictions and costly testing. When a single cow in a livestock herd is found to be infected with brucellosis in a brucellosis class-free state, the entire herd is quarantined and slaughtered. The price paid for the entire herd (monies come from federal and state indemnity funds) is generally not sufficient for a rancher to replace the herd. 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 it brucellosis class-free status. Vaccination is a method of disease control practiced by the cattle industry. Approximately 95 percent of cattle that graze in the Yellowstone area during summer are vaccinated. Asafe and effective brucellosis vaccine has not yet been developed for wildlife.

Montana is currently a brucellosis class-free state, having attained its status in 1985. Federal and state animal disease management agencies believe that the best way to protect cattle is to eradicate brucellosis. Montana believes that its brucellosis class-free status is threatened by the bison migrating out of the park. The economic effects of such an action on Montana's cattle industry could be significant. Ranchers could suffer a notable economic impact if they were excluded from worldwide livestock marketing because of the perceived threat of brucellosis transmission.

Nationally, billions of dollars have been spent attempting to eradicate brucellosis from cattle herds. Some people believe wildlife should be subject to the same management protocols as livestock in order to achieve the goal of brucellosis eradication. Others believe that brucellosis eradication is not possible in wildlife, and that bison and livestock can be managed in ways to reduce the risks of transmission.

Status of the Bison and Brucellosis Issues

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 each year 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 1990 Montana Legislature to rescind authorization for the hunt, and the state entered into an agreement with the National Park Service (NPS) and the U.S. Forest Service (USFS) to develop a long-term management plan and environmental impact statement (EIS) for managing bison migrating from Yellowstone into Montana.

While this long-term plan was being prepared, Montana needed an interim management plan in place in order to accomplish three main objectives: to protect private property, to provide for human safety, and to protect Montana's brucellosis class-free status.

In 1990, the NPS completed an environmental assessment (EA) that provided for limited NPS management of bison through hazing and monitoring. Also, NPS personnel could participate in bison-shooting operations outside of park boundaries at the request and under the authority of the Montana Department of Fish, Wildlife and Parks. In 1992, another EA was produced that provided for management actions similar to those described in the 1990 EA.

Since 1990, NPS personnel have monitored, hazed, and (at the request and under the authority of the state of Montana) shot bison that were outside the park along the northern boundary near Reese Creek (which abuts private land owned by the Royal Teton Ranch) and along the western boundary of the park near Duck Creek and the Madison River in the West Yellowstone area.

For a variety of reasons, on January 17, 1995, the state of Montana filed a lawsuit against the National Park Service and the federal Animal and Plant Health Inspection Service (APHIS). The suit was based on concerns that brucellosis could be transmitted from wild bison to domestic livestock and that the presence of bison infected with or exposed to brucellosis in Montana could provide grounds for APHIS to revoke Montana's brucellosis class-free status. On November 13, 1995,

a settlement was reached in which 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:

- Another Interim Bison Management Plan would be completed that called for the NPS to build a facility to capture bison inside Yellowstone National Park at Stephens Creek. All bison captured in the facility would be shipped to slaughter. 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 as well as 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. Any bison migrating north of the park into the Eagle Creek/Bear Creek area (east of the Yellowstone River) would simply be monitored and not captured.
- The draft long-term Bison Management Plan and EIS would be completed by November 15, 1996, with the final EIS and decision due May 1, 1997. Through mutual agreement of all parties, those dates could be modified (and have been).
- Additionally, as part of the settlement, the NPS recognized the right of the Royal Teton Ranch to build a fence on its property (any fence must comply with federal and state laws) to exclude bison from Royal Teton Ranch property. (No fence has been built.)

The draft Interim Bison Management Plan and EAwas written and released for public comment in December 1995. Following a public comment period and analysis of those comments, the plan was approved on August 5, 1996.

The NPS, USFS, and the state of Montana began operations under the new Interim Bison Management Plan during the winter of 1996-97, the most severe winter since the 1940s. Bison migration out of the park was significantly greater than what had been seen in the past, and 1,084 bison were shot or sent to slaughter. Public concern about the situation was high.

In 1997, in response to the public concern, the federal agencies proposed implementing adjustments to the interim plan in order to provide for a generally stable bison population in the event of future severe winter conditions while assisting Montana in its efforts to maintain its brucellosis class-free status. In brief, the federal agencies proposed:

- to increase efforts to haze bison back into the park or onto appropriate public lands where they would be tolerated;
- if hazing was ineffective, to capture all bison exiting the northern park boundary at Stephens Creek and ship only seropositive animals to slaughter (seronegative animals would be temporarily held in the capture facility and released in the spring);
- to assist Montana officials in relocating a capture facility on the western boundary of the park to the Horse Butte area to more effectively capture and test bison and reduce the number of untested bison present in the West Yellowstone area; and
- to provide more management flexibility for Montana by having APHIS determine that Montana did not have to shoot low-risk, untested bison, including bulls, yearlings, and calves, in order to maintain its brucellosis class-free status.

Fortunately, the winter of 1997-98 was mild, and only 11 bison were shot 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 (Duck Creek).

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The Bison Management EIS

- In 1995, the State of Montana sued the federal government over concerns about losing its brucellosis-free status. A settlement called for an environmental assessment that resulted in the construction of capture facilities inside and outside the park, the shipment of captured bison to slaughter, and the establishment of a deadline for the Draft EIS.
- June 1998, the Draft Bison Management Plan and EIS was completed.
- The plan received over 67,500 comments from the public, which are being addressed and analyzed.
- The draft modified preferred alternative of the EIS includes:
  moving bison off grazing allotments 45 days before cattle
  federal protection of Montana's brucellosis-free status
  NPS agreement to vaccinate bison when a safe vaccine and effective delivery method are developed
  payment for vaccination of cattle outside the park
- December 1999, the federal agencies withdrew from a Memorandum of Agreement with the State of Montana to jointly produce an EIS.
- February 2000, a federal judge ordered the state and federal agencies into mediation to work out their differences.
- Afinal EIS and Record of Decision are expected before December 2000.

The draft long-term bison management plan and environmental impact statement was finally released to the public on June 12, 1998. The plan took many years to prepare, and several agencies were involved. When bison migrate out of Yellowstone National Park, they become the management responsibility of the state of Montana; consequently, the state of Montana wanted a voice in how bison are managed. The state was designated a lead agency along with the lead federal agencies, the National Park Service (Department of the Interior) and the U.S. Forest Service (Department of Agriculture) in the preparation of the long-term bison management plan. The federal Animal and Plant Health Inspection Service (in charge of managing/eradicating diseases such as brucellosis) is a cooperating agency. For any plan, the 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.

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 over 67,500 comments from the public which are being addressed and analyzed. Afinal EIS and Record of Decision are expected before December, 2000.

Based on public comment, discussion with lead and cooperating agencies, and additional information from research on the viability of the *Brucella abortus* bacteria, a modified preferred alternative has been developed that minimizes the risk of transmission of brucellosis from bison to cattle, works towards the eradication of brucellosis from the bison herd, and decreases the unnecessary killing of bison. This alternative would include:

- moving bison off grazing allotments 45 days before cattle arrive so that in the unlikely case that a bison did abort, cattle would not come in contact with viable Brucella bacteria.
- APHIS protection of Montana's brucellosis free status
- NPS agreement to vaccinate bison when a safe vaccine and effective delivery method are developed
- payment for vaccination of cattle outside the park

The State is concerned that other states may impose testing requirements on bison that would increase costs for livestock growers. They are calling for all bison to be vaccinated immediately, though no safe vaccine has been found for pregnant female bison. The vaccine effectiveness has not been determined and a safe and effective delivery method currently does not exist. The NPS is working with other agencies on safety studies for a vaccine (RB51) and delivery methods.

Due to apparent impasse between joint-lead agencies (NPS, USDA Forest Service, and the State of Montana), 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 withdrawal from the MOU in February, 2000. The court also ordered the state and federal agencies into mediation to work out their differences and appointed a mediator to facilitate the process beginning in late April.

The NPS is in the 4th year of operations under the adjusted Interim Bison Management Plan:

- Attempts are made to haze migrating bison back in the park.
- Bison that cannot be hazed back and leave the park are captured and tested for brucellosis.
- All bison that test positive, are sent to slaughter. In the Stephens Creek area, the NPS would temporarily hold all seronegative bison in the capture facility.
- Untested low risk animals, bulls, calves, yearlings, and non-pregnant females are allowed to graze during winter on adjacent federal lands on the west side of the park.
- All pregnant females will be sent to slaughter, even if they test negative.

Since 1996-97, the NPS has not killed any bison as part of the interim bison management plan.

Other Management Efforts

The NPS is an active participant in the Greater Yellowstone Interagency Brucellosis Committee (GYIBC). The goal of the GYIBC 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 the GYIBC is to develop and implement brucellosis management plans for elk and bison in the GYA. The objectives of the GYIBC 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 GYAby the year 2010. The NPS fully supports the goal, mission, and objectives of the GYIBC.

The NPS was involved in a Natural Resources Preservation Program (NRPP) project that began research and collection of data on various aspects of 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 aid managers in making sound defensible decisions for the future management of bison and elk in the two parks and possibly the GYA. The much needed research falls under 4 major headings:

- Epidemiology and pathogenesis of brucellosis in wild bison.
- Development and testing of new brucellosis vaccines for use in wildlife
- Risk assessment of brucellosis transmission in a wildland setting.
- Ecology and carrying capacity of bison in Grand Teton and Yellowstone national parks.

The National Park Service 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 of NPS research on bison movement in the park suggest that the animals do not travel on groomed roads as much as some suspected, but tend to follow rivers and other natural corridors.

In August, 1999, an agreement was reached on the purchase and easement of approximately 7,800 acres of winter wildlife habitat just north of the park boundary. The area contains critical wildlife migration and winter range habitat for bison and other species.

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Northern Range Controversy

The Issue

- About 35,000 elk and smaller numbers of deer, bison, pronghorn, bighorn sheep, and moose graze in Yellowstone during the summer.
- The largest of the seven elk herds in the greater Yellowstone ecosystem, known as the northern herd, has generally numbered 15,000–22,000.
- Some people believe that the park has more elk than the northern range can sustain. Elk, along with 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.
- The interaction of ungulates, climate, hydrology, beaver (and possibly others) and aspen or woody shrubs like willows is equivocal and more scientific research is needed.

History

- 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 1986, Congress mandated a major research initiative to answer scientific and public concerns over the condition of the northern range. Results of the research:

1. Traditional interpretation of the range as overgrazed was based on commercial rangeland standards inappropriate for the park.
2. The northern range continues to provide robust nutrition for large, healthy ungulate herds year after year.
3. Despite certain localized effects, elk do not appear to have had any significant adverse effect on the overall diversity of native animals and plants.

- In 1998, Congress called for the National Academy of Sciences to review management of the northern range. This two year study began in 1999.
- In March 2000, in response to great controversy, three independent researchers began a 5-year investigation of Northern Yellowstone elk population responses to wolf restoration.

The northern portion of Yellowstone National Park, "the northern range," 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 assess to forage.

From the time the U.S. Army arrived in 1886 until the 1930s, wildlife management in Yellowstone was mainly seen as protecting the grazing animals and other herbivores 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 predators resulted in 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, elk, pronghorn, and bison numbers were artificially controlled by shooting or trapping and removal by park rangers. More than 13,500 elk were shipped out of Yellowstone to control their numbers and to repopulate areas where elk had been eliminated.

By the 1960s, scientists and wildlife managers had begun to understand that there are complex interconnections among and between living and non-living components in the world around us. Many definitive studies describing the young science of ecology were done.

In Yellowstone, new studies suggested that ungulate populations could be self-regulating, and, as a result, wildlife reductions were discontinued in 1968. Studies of the northern elk winter range began in the 1960s and have continued to the present. To this point these studies have revealed no clear evidence of range 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 showed, in fact, plant production is enhanced by ungulate grazing in all but drought years. Protein content of grasses, yearly growth of big sagebrush, and seedling establishment of sagebrush are all enhanced by ungulate grazing. Neither reduction in root biomass nor an increase in dead bunchgrass clumps has been observed during the studies. (Studies on aspen and willows and their relationship to ungulates on the northern range are not so clear-cut and are continuing.) Despite these scientific results, the belief that elk grazing is damaging northern range vegetation and that grazing accelerates erosion persists among many people, including some scientists.

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. 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 that a person comes from. Many urban dwellers live in 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 quite 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.

In the past decade, the ecological carrying capacity of the northern winter range has increased as elk have colonized new winter ranges north of the park set aside for this purpose. Summers have also been wet (resulting in better plant production) while winters have been (generally) mild. The fires of 1988 also opened many forest canopies, allowing more grasses to grow.

Many scientists believe that the major factor influencing elk populations is winter. Mild winters allow many more elk to survive until spring, but periodically, 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: over-winter 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.

The Grizzly Recovery Plan

- Three goals must be achieved for two consecutive years 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) The known human-caused mortality shall not exceed 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.

- Relisting of the species begins if the population or habitat fall below certain threshold levels.
- The 3 population recovery goals were met in 1994, 1998, and 1999, but not in 1995, 1996, and 1997.

Current Status

- Debates on grizzly recovery center on two points of view:

1. The animal is doomed to extinction.
2. The population has recovered and should be hunted outside the park.

- The grizzly population seems to be improving in the greater Yellowstone area—from a low of approximately 230 animals in 1975 to the current estimated population of 400.
- NPS believes the current numbers may be a temporary peak and could drop at any time.
- Habitat loss and development on land outside the park continue to threaten the survival of the grizzly bear.
- 40–50 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.

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. Aprimary goal of the ESAis 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 population is considered recovered.

The three grizzly bear population recovery parameters are:

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, 300 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 as well as 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. Arunning six-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(1993-1998, 6-year average) is 26. This recovery goal is currently being achieved.

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 recovery zone 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 1993 through 1998 (6-year running sum), all 18 BMUs were occupied at least once with family groups. This recovery goal is currently being achieved.

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. It is thought that grizzly bear populations can sustain 6 percent human-caused mortality without population decline. To facilitate recovery and to 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. This method allows for annual recalculation of the mortality limits based on population monitoring.

Current Status: The allowable, known human-caused mortality limit for 1998 was 13 bears (4 percent of the population estimate of 336 bears). The annual average of known, human-caused grizzly bear deaths (1993-1998) was 9 bears per year or 3 percent of the present minimum popula-

tion estimate of 336 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 13). 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.

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. When all these goals have been met for two consecutive years, the grizzly bear may be considered for "delisting" from its threatened status. Habitat-based recovery criteria as well as a conservation strategy are currently being written for the Yellowstone ecosystem grizzly bear population (see following article). The strategy will reaffirm the commitment of agencies and the means they will use to ensure that the population remains at or above the recovery levels described in the *Recovery Plan.*

The conservation strategy will also contain population and habitat triggers that will initiate relisting of the species if the population or habitat fall below certain threshold levels. If the population and habitat parameters are still being achieved after the conservation strategy has been completed and signed by all cooperating agencies, then the U.S. Fish and Wildlife Service may consider delisting the species in greater Yellowstone.

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Grizzly Conservation Strategy

- Ateam 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.
- The Strategy contains population and habitat triggers that initiate relisting of the species if the population or habitat fall below certain threshold levels. Habitat-based recovery parameters are established and "adequate regulatory mechanisms" are in place to ensure conservation of the bear if and when it is removed from Endangered Species List.
- 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.

- Public meetings are being held in the three surrounding states (Montana, Wyoming, and Idaho) to obtain comments on the strategy.
- When the Conservation Strategy is approved, the delisting process could begin.

Habitat-based recovery criteria and a conservation strategy are being prepared that will define those measures needed to ensure that the Yellowstone grizzly bear population remains at or above the recovery levels described in the *Recovery Plan* if and when the population is removed from the special protections granted under the Endangered Species Act. The strategy will demonstrate and reaffirm the commitment of the respective state and federal agencies to continued maintenance of the Yellowstone grizzly bear and its habitat.

The conservation strategy will be the primary long-term guide for managing and monitoring the grizzly bear population and assuring there is sufficient habitat to maintain recovery. It emphasizes that continued coordination and cooperative working relationships among management agencies, landowners, and the public are essential 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.

As proposed by the team of biologists and managers preparing the draft *Conservation Strategy for the Grizzly Bear in the Yellowstone Ecosystem*, management of the bear and its habitat would remain much the same as it exists at present but with increased flexibility in several key areas.

Similarities to Current Management

- The existing recovery zone would be a Primary Conservation Area (PCA) in which grizzly bear/human conflict management and bear habitat management would be of high priority. Decisions would favor the bear population when grizzly habitat and other land uses are not compatible. 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 GYE, 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 bear 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.
- `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.

Changes from Current Management

- `Under the conservation strategy, managers would have more flexibility to manage nuisance grizzly bears, 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 situations, now used to delineate differences in land-management strategies, would be eliminated. There would be no distinction made across the PCAas 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, incorporating input from affected groups and individuals.

If and when the grizzly bear population goals outlined in the *Grizzly Bear Recovery Plan* are met and habitat goals are established, consideration will be given to delisting the greater Yellowstone grizzly bear population from protection as threatened under the ESA. Completion of a conservation strategy does not in itself propose or accomplish a change in status of the grizzly bear population. However, it is a goal of the ESAand the state and federal wildlife and land managers in greater Yellowstone to work toward recovery and subsequent delisting of the grizzly bear population in the ecosystem. The proposed 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.

The conservation strategy proposes continued monitoring of the biological parameters explained above, with the additional annual recalculation of the population trend estimate based on adult female survivorship. The population trend for Yellowstone grizzly bears appears to be stable to slightly increasing. This is not a requirement under the plan, but a recommendation for future monitoring to help ensure confidence in the status and trend of the bear population.

Management reviews will be conducted when conditions deviate from the desired long-term goals for the grizzly bear population and/or its habitat. If there is a change 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.

The conservation strategy will not contain an environmental impact statement but will primarily incorporate existing laws, regulations, policies, and goals such as those already outlined in the Grizzly Bear Recovery Plan. The Interagency Grizzly Bear Committee and the U.S. Fish and Wildlife Service view some of the topics discussed in the proposed conservation strategy as nondebatable. 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 facilitate desired multiple land uses while meeting mortality goals necessary to maintain a healthy grizzly bear 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

Thermophiles

The Issue

- Yellowstone's geothermal features contain heat-requiring organisms called "thermophiles," which contain many bioactive compounds heretofore unknown to science and thus can sometimes be the target of bioprospectors.
- Results of thermophile research have impacted science and society, and spawned a multi-million dollar industry.
- When profits are made from products or processes discovered during study of thermophilic microbes discovered in Yellowstone, the park should have a share in those profits.
- Some people object to bioprospecting in national parks. They see it as commercialization of research in the park.

History

- 1966, the microorganism *Thermus aquaticus* was discovered in one of Yellowstone's hot springs.
- An enzyme from T. aquaticus is now synthesized to enable a popular DNAfingerprinting process, which has revolutionized biology and medicine. The patent holder turned this discovery into a profit of hundreds of millions of dollars.
- 1997, a benefits-sharing agreement was signed with Diversa Corporation of California, which ensures a portion of future profits will go toward scientific and public education activities and for park resource preservation.
- 1999, a legal challenge put a hold on implementing this and other such agreements. Critics expressed concern that parks would mine resources in exchange for dollars, and sought release of all financial details in the agreement.

Current Status

- Yellowstone research microbiologists have contributed to:
  Insights into the evolution of life
  Planning the search for life on other planets
  Discovering how the global ecosystem cycles elements through microbial action
  Awidely used techniques for DNAfingerprinting
- The NPS is currently writing an EIS concerning the potential management and questions raised by 1) ongoing bioprospecting activities in the parks, and whether they should continue; 2) statutory and regulatory authorities relating to bioprospecting; 3) whether benefits-sharing should be a part of NPS policy for parks.
- More than 50 permits have been granted to scientists, organizations, and companies to study microbes in Yellowstone.

When you look into the deep and colorful thermal pools in Yellowstone, 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 you see forming the yellow, orange, and green rings in the hot springs were the among the first organisms capable of photosynthesis—of taking carbon dioxide and with the help of sunlight, converting it, among other things, to oxygen. In this way, these colorful lifeforms, called cyanobacteria, began to create an atmosphere that would eventually support human life.

For many years, it was thought that no living thing could survive in the extreme temperatures of hot springs and mudpots. But in 1966, Dr. Thomas Brock discovered a microorganism that lived in the superheated waters (more than 176°F/80°C) of Mushroom Pool in the Lower Geyser Basin. In

fact, this bacterium, *Thermus aquaticus* or Taq, proved to be one of the most exciting discoveries of the 20th Century. An enzyme within Taq has the ability to copy and amplify the genes in DNA (which contains the blueprint of life) within living cells. Aprocess called polymerase chain reaction (PCR) was developed from Taq that allows scientists to reproduce any type of DNAat will. This led to the DNA fingerprinting process that allows police to identify a suspect from one tiny cell of blood at a crime scene. It has also given doctors the most accurate test for the AIDS virus. It allows physicians to detect the genes that cause birth defects and genetic diseases. There are many other applications for Taq and the PCR process in medical diagnostics, wildlife management, forensic analysis, and industry.

Many other species of microbes have been found in Yellowstone since 1966. Yellowstone's hot springs contain a vast spectrum of thermophilic (heat-loving) microorganisms, each producing thousands of uncommon, heat-stable proteins. Researchers estimate that more than 99 percent of the species actually present in Yellowstone's thermal features have yet to be identified.

Because much of modern biotechnology is based on the use of enzyme catalysis 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 has the planet's greatest concentration 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 the entire 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 DNAsequencing analysis, the organism most closely related to the primordial origin of life—the earth's most primitive species—resides in a magnesium-rich mineral spring in Hayden Valley. It is a member of the domain Archae and for now is known as PjP78.

There are more than 50 research studies being done on microorganisms from the park today. For example, microbes influencing the growth of hot spring terraces are being studied by NASA to help determine if there is life on Mars. The planet Mars had an ocean when life evolved on Earth four billion years ago. Scientists at NASAbelieve life evolved on the "Red Planet" as well. Yellowstone's stromatolite-forming cyanobacteria are being used as a model in the search for life on Mars. As life influences the formation of hot spring terraces, it imparts a biogeochemical signature that can be seen from overhead satellite imagery. Active volcanos and suspected hot springs on Mars are the focus in this search for evidence of extraterrestrial life. Other microbes have been found that are useful in the breakdown of oil by natural rather than chemical means; in converting corn into the renewable fuel ethanol; in taking the sulfur out of coal, making it a cleaner source of energy; in producing an environmentally friendly road de-icer; in bioleaching gold ore; and a host of other processes.

It is intriguing to think about the opportunities that would have been lost if Yellowstone had not been set aside as a national park in 1872. With this issue, we begin to understand the tremendous importance of biodiversity and the importance of preserving the vast array of species and the processes that connect them. It is becoming more and more obvious that every living thing, no matter how small or seemingly insignificant, may have the capacity to solve some of the world's most perplexing problems.

While some of these microscopic mysteries have proven greatly beneficial to society, many others lie yet undiscovered. 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. Park management assures that the microbes are not "extracted" as the organisms themselves are not used by biotechnology companies, and the organisms remain the property of the U.S. Government. Also, at issue is how the National Park Service can benefit monetarily as the microorganisms discovered in Yellowstone are spawning multi-million dollar industries.

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 $300 million. Since then, PCR has become the cornerstone of modern medical diagnostics, and annual sales of Taq polymerase have grown to $500 million. Yellowstone National Park and the United States public have received nothing from this commercial use of a product developed from a Yellowstone resource.

In 1997, a new agreement was signed with the Diversa Corporation of California, called a Cooperative Research and Development Agreement (CRADA). (The CRADA is based on Material Transfer Agreements/CRADAs that have been developed by the National Institutes of Health, which funds research that may be patented by the private sector, and on the Costa Rican National Biodiversity Institute model of marketing genetic resources from national parks to fund conservation efforts.) The agreement allowed the National Park Service to receive royalties for any profitable products derived from research on Yellowstone microbes.

Under this particular CRADA, Diversa Corporation pays the park $25,000 each year for five years in the expectation that they will owe Yellowstone National Park a royalty fee for profits derived from research on Yellowstone microbes. 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 the preservation of the microbial habitat. Diversa, which also has research sites in Costa Rica, Iceland, Antarctica, and at the bottom of the Pacific and Atlantic oceans, collects DNA from thermal habitats, genetically engineers the genes into "microbial livestock," then screens them for useful enzymes. As with all NPS research specimens, the microbes themselves remain in federal ownership. If Diversa would develop a profitable product from research based on any Yellowstone microbes, the park would be entitled to a royalty based on the profits, minus the $175,000 already paid by the company.

Four entities, including another biotechnical company and an environmental group, sued the National Park Service in 1998, alleging the agreement was a commercialization of public resources without public input. In March 1999 the judge ruled in their favor and ordered the National Park Service to complete an environmental assessment of the impacts of the agreement on the thermal resources of the park and to involve the public in the process.

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 mankind. More than 40 percent of the medicines in use today are based on natural products derived from individual plant species. The bioprospecting agreement initiated by the National Park Service is a tangible demonstration of the value of preserving biodiversity for the secrets they may reveal in the future.

Winter Use

History

- Winter use in Yellowstone grew sporadically with no systematic planning and little thought as to the appropriateness of various types of recreational activities.
- In the winter 1949, 35 visitors entered Yellowstone by snowplane; in 1955, 507 entered by snowcoach; in 1963, six snowmobiles entered the park.
- The previous Winter Use Plan of 1990 established a visitation threshold of 140,000 people per year, which was projected to be met by year 2000. It was exceeded in 1992.
- In 1997, the Fund for Animals sued the NPS alleging that the NPS failed to complete an Environmental Impact Statement on winter use assessing the impacts of road grooming and winter recreation on wildlife and other park resources. The NPS signed an agreement requiring the development of a new winter use plan and EIS.

The Winter Use Plan and Draft EIS

- The Winter Use Plan and Draft EIS was completed in August, 1999. The planning process included the participation of 3 states, 5 counties and the U.S. Forest Service as cooperating agencies. Its seven alternatives, A—G, address visitor access, sound, emissions, wildlife concerns, and affordability.
- The plan received approximately 45,000 public comments.
- In their response to the Draft EIS, the Environmental Protection Agency identified Alternative G (snowcoach access only) as the "environmentally preferred alternative."
- The final EIS and record of decision are due by November 2000.
- The new plan would begin to be phased in during the winter of 2002-03.

Winter visitation in Yellowstone and Grand Teton national parks and the John D. Rockefeller, Jr. Memorial Parkway is currently managed under a *Winter Use Plan* approved in 1990. Winter use has increased dramatically from virtually none 30 years ago to more than 140,000 visits per season in the early 1990s. In the joint *Winter Use Plan* (1990) a commitment was made to establish a Visitor Use Management (VUM) process if winter visitation exceeded certain thresholds. In 1992-93, use exceeded the *Winter Use Plan*'s projection for the year 2000 (140,000 visitors), and the parks established a team to begin the VUM process. About this time, the U.S. Forest Service determined that many of the same concerns the parks'had about winter use were relevant to Forest Service lands, and their staff also began work on a coordinated interagency report on winter use management.

Since 1994, scientific studies and visitor surveys have been undertaken and analyzed. As part of the continuing effort to ensure public input in the planning process, 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. These include, but are not limited to: overcrowding, visitor impacts on natural resources, noise and air pollution, availability of facilities and services, use restrictions, user group conflicts, and the importance of winter visitation to the local and regional economy. An interagency planning team produced a draft report in the summer of 1997 on the results of their work. The preliminary report, *Winter Use Management: A Multi-Agency Assessmen*t (1997), was on public review from June through September 1997. Afinal report is pending interagency review.

In May 1997, the Fund for Animals and other organizations and individuals filed lawsuit in Washington, D.C., against the National Park Service (NPS). The lawsuit identified three primary complaints. The plaintiffs alleged that the NPS had failed to prepare an environmental impact

statement concerning winter use in Yellowstone and Grand Teton national parks and the Rockefeller Parkway, had failed to consult with the U.S. Fish and Wildlife Service on the effects of winter use on threatened and endangered species, and had failed to evaluate the effects of trail grooming in the parks on wildlife and other park resources.

On October 27, 1997, the plaintiffs, the Department of Justice, and the NPS signed a settlement agreement. Under the terms of this agreement, the NPS agreed to prepare a new winter use plan and corresponding environmental impact statement. The NPS also agreed to consult with the U.S. Fish and Wildlife Service on the effects of winter use on threatened and endangered species. Finally, the Park Service agreed to immediately prepare an environmental assessment (EA) that evaluated the effects of temporarily closing one or more segments of winter snowmobile road in Yellowstone in order to study wildlife movements on groomed roads within the park. (An environmental assessment was necessary because it was anticipated that 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 the bison, the negative and positive aspects of snowmobiling, and the importance of snowmobiling and winter use on local economies. Many letters (487) contained comments addressing research concerns, suggesting that there was a lack of scientific evidence to justify a temporary road closure.

After the analysis of comments was completed, Yellowstone National Park officials decided (in January 1998) that a road closure would not be put into effect in the winter of 1997-98 (nor during the next two winters). The rationale behind this decision was the lack of scientific evidence that clearly showed a road closure was necessary. To answer these questions, the NPS identified several areas of additional research. During the next two winters, biologists would research and monitor wildlife movements (particularly bison) in the Gibbon, Firehole, and Madison river areas. The park would also continue to investigate winter visitor use patterns, visitor behaviors, and visitor expectations as well as their opinions on possible road closures. 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.

On February 18, 1998, the Fund for Animals and other organizations filed suit against the National Park Service alleging that the 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 are 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.

Meanwhile, planning 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. These recreational experiences must be offered in an appropriate location or setting, that is, they should not take place where they will 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 compliment the unique aspects of each landscape within the ecosystem.

While Yellowstone and Grand Teton National Parks and the John D. Rockefeller, Jr. Memorial Parkway are the lead agencies preparing the document, five surrounding counties, the three surrounding states, and the U.S. Forest Service have signed Memorandums of Agreement to participate as cooperating agencies.

A90-day public scoping period on the new winter use plan began in April 1998. Atotal of 2,600 letters were received, containing more than 15,000 comments. During the scoping period, 16 public meetings were also held around the region and in major U.S. cities (Salt Lake City, Minneapolis, Denver, and Washington, DC). The primary issues identified during scoping included visitor use, experience, and access; wildlife use of groomed surfaces; wildlife displacement; air quality; snowmobile sound; impacts on local economies; and health and human safety.

The Winter Use Plan and Draft EIS was completed in August 1999. The planning process included the participation of 3 states, 5 counties, and the U.S. Forest Service as cooperating agencies. The plan is comprised of 7 alternatives, A–G, which address 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.

More than 45,000 public comments were submitted. In March, 2000, the NPS met with the cooperators on the plan (state and county representatives). A partial review of public comment letters took place along with a review of studies and additional information gathered since preparation of the draft EIS. The NPS indicated a tentative direction for a preferred alternative for the final EIS. Modified Alternative G seems to meet all requirements of issues addressed. This modified alternative would move the NPS towards using snowcoaches as the only mechanized means to access the interior of Yellowstone. This was also the alternative preferred by the Environmental Protection Agency, which stated that based on impacts to human health, air quality, water quality and visibility, alternative G (snowcoach only) is the “environmentally preferred alternative.”

ARecord of Decision to be signed by Regional Director, Karen Wade, is due by November, 2000. Implementation of the new plan would begin to be phased in during the winter of 2002-03. No major changes will occur for at least two years.